

# JVP

Journal of Vertebrate Paleontology

**Program and Abstracts**

Volume 29, Supplement to Number 3

September 2009



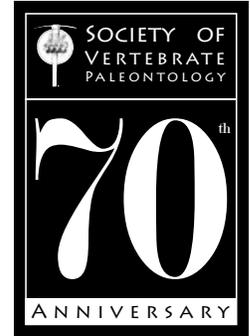
## **69th Annual Meeting Society of Vertebrate Paleontology**

**and the 57th Symposium of Vertebrate Palaeontology and  
Comparative Anatomy (SVPCA)**

University of Bristol  
Bristol, United Kingdom  
September 23-26, 2009

Society of Vertebrate Paleontology  
ISSN 0272-4634

# SVP 70th Anniversary Meeting



October 13–16, 2010 | Hilton Pittsburgh | Pittsburgh, PA USA

# **JOURNAL OF VERTEBRATE PALEONTOLOGY**

VOLUME 29, SUPPLEMENT TO NUMBER 3  
September 2009

**ABSTRACTS OF PAPERS**

## **SIXTY-NINTH ANNUAL MEETING SOCIETY OF VERTEBRATE PALEONTOLOGY**

**AND THE  
FIFTY-SEVENTH SYMPOSIUM OF VERTEBRATE PALAEOLOGY  
AND COMPARATIVE ANATOMY (SVPKA)**

**UNIVERSITY OF BRISTOL  
BRISTOL, UK**

**SEPTEMBER 23-26, 2009**

### **HOST COMMITTEE**

Michael Benton, Emily Rayfield, Phil Anderson, Paul Barrett, Phil Donoghue, Pam Gill, Tom Kemp,  
Liz Loeffler, Angela Milner, Dave Norman, Remmert Schouten

### **EXECUTIVE COMMITTEE**

Blaire VanValkenburgh, President, Catherine Badgley, Past-President; Philip Currie, Vice-President;  
Christopher A. Brochu, Secretary; Ted Vlamis, Treasurer; Ana Baez, Member-at-Large;  
Michael Gottfried, Member-at-Large; Julia Clarke, Member-at-Large

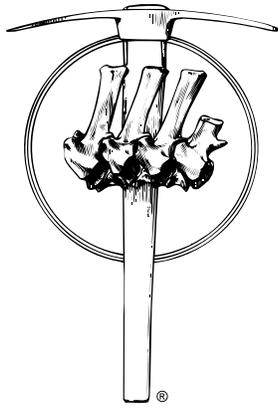
### **SYMPOSIUM CONVENORS**

Kenneth Angielczyk, Robert Asher, Richard Butler, Patrick Druckenmiller, Gareth Dyke,  
Randall Irmis, Christian Kammerer, Max Langer, Larry Martin, Erin Maxwell, Johannes Müller

### **PROGRAM COMMITTEE**

Jason Head, Chair; Jonathan Bloch, Matthew Carrano, Kerin Claeson, Kristi Curry Rogers,  
Ted Daeschler, David Fox, Nadia Fröbisch, Anjali Goswami, Michael Gottfried, Johannes Müller,  
Emily Rayfield, William Sanders, Mary Silcox, Rebecca Terry





# Members and Friends of the Society of Vertebrate Paleontology,

The Palaeobiology and Biodiversity Research Group at the University of Bristol is excited to host the 69th Annual Meeting of the Society of Vertebrate Paleontology. This will be a momentous meeting for the Society, the first time it has met in the 'Old World'. The vertebrate paleontologists of the United Kingdom, and of Europe, welcome the Society, and offer a rich array of experiences.

Bristol is located in south-west England, 100 miles, and less than 2 hours by train, from London. Bristol is a long-established industrial city, with beautiful buildings dating from the past five centuries. Enjoy the Neolithic, Roman, Medieval, and later history of the region – including Bath, which is only 15 minutes away by train. In Bristol, you can see wonders of the industrial revolution, including Isambard Kingdom Brunel's SS Great Britain (1843), the world's oldest iron ship, and the Clifton Suspension Bridge, one of the world's first (1864).



Bristol's high tech industries of today, including British Aerospace and Rolls Royce, together with the University, have earned it the title of a 'Science city'. The University of Bristol, ranked in the top five in the United Kingdom, is young, and it celebrates its centenary in 2009. It is a renowned centre for science engagement.

Within easy reach of Bristol are such prehistoric marvels as Stonehenge and Avebury, as well as rich buildings from the Roman, Saxon, Medieval, Regency, and Victorian periods, spanning more than 5000 years of history. London, Oxford, Cambridge, Stratford, and many other fine cities are linked by regular public transport. Geology and vertebrate palaeontology were born in the south of England, and we will offer field trips to see classic Mesozoic and Cenozoic sites associated with Mary Anning, William Buckland, Gideon Mantell, Richard Owen, and other early heroes of our subject.

2009 is also Darwin year (200th anniversary of his birth, and 150th anniversary of publication of *On the origin of species*). The meeting will be chance for Darwinians to explore the history of evolution, and modern responses to Darwin – we plan special lectures, workshops, and visits to Darwin locations across England.

You are all jolly welcome (in a modest and understated way, of course) to SVP 2009 in Bristol

See you in September!

Sincerely,

2009 SVP Host Committee



# The Palaeontological Association

Registered Charity in England and Wales No 276369

[www.palass.org](http://www.palass.org)

The Palaeontological Association was founded in 1957 to promote the study of palaeontology and allied sciences. The Association is based in the UK and is registered as a UK charity, but its members are drawn from all over the world. Members' interests span invertebrate palaeontology, micropalaeontology, palaeobotany, vertebrate palaeontology, and all other aspects of the subject. There are currently about 1,100 professional, amateur and student members.

The Association publishes the **academic journals** *Palaeontology* and *Special Papers in Palaeontology*. For use in the field, *Field Guides to Fossils* and *Fold-out Fossils* are guides to the faunas and floras of a variety of locations. We also operate several **grant and award schemes**, including the Sylvester-Bradley awards to support research, grants to enable students to attend the Annual Meeting, and grants towards the running costs of scientific meetings. Awards made by the Association include the Lapworth Medal for a palaeontologist who has made significant lifetime contribution to the science; the President's Medal for a highly regarded mid-career researcher; and the Mary Anning Award for amateur palaeontologists. The **Association Annual Meeting** is an international conference at a different UK or European venue every year in December. The Association holds several other meetings, including the annual Progressive Palaeontology for young researchers.

Membership is open to all who are interested in fossils, including students (for whom special membership rates apply) and amateur palaeontologists. There are no membership requirements other than the annual subscription, which is kept as low as possible.

#### **Benefits of membership** include:

- a discount on Association publications, including over 80 back titles in *Special Papers in Palaeontology*
- discounts on some publications from other organisations
- subscription to *Palaeontology* includes online access back to Volume 1 (1957)
- all members receive *Palaeontology Newsletter* as electronic or hard copy
- eligibility for Association grants such as Sylvester-Bradley awards
- online access to all back copies of *Palaeontology & Special Papers*

**Current subscription rates and membership forms (including secure payment) on the website <[www.palass.org](http://www.palass.org)>**

**All *Special Papers in Palaeontology* for sale (many at original prices) through Online Shop at <[www.palass.org](http://www.palass.org)>**

**All enquiries about membership or sales to Tim Palmer at <[palass@palass.org](mailto:palass@palass.org)>.**

## 2009 SVP SCHEDULE OF EVENTS (subject to change)

All events are held at the University of Bristol unless otherwise noted with an \*\*.

Event/ Functions	Tuesday, September 22	Wednesday, September 23	Thursday, September 24	Friday, September 25	Saturday, September 26
Registration Desk	3 pm – 6 pm Chemistry Building – Foyer	7 am – 5 pm Chemistry Building, Foyer	7:30 am – 5 pm Chemistry Building, Foyer	7:30 am – 5 pm Chemistry Building, Foyer	8 am – 5 pm Chemistry Building, Foyer
Plenary Session/ Welcome	7:45 am – 8:00 am Wills Memorial Building, Great Hall	7:45 am – 8:00 am Wills Memorial Building, Great Hall	8 am – 12:15 pm Late Triassic Terrestrial Biotas and the Rise of Dinosaurs Chemistry Building, Lecture Room 1	8 am – 12:15 pm Molecular Tools in Paleobiology: Trees, Clocks and Linking Geno- with Phenotype Chemistry Building, Lecture Room 1	8 am – 12:15 pm New Perspectives on the Early Evolutionary History of the Synapsida Chemistry Building, Lecture Room 1
Symposium	8:00 am – 12:15 pm The Scientific Legacy of Mary Anning – Recent Advances in Marine Reptile Paleobiology and Evolution Chemistry Building, Lecture Room 1	8:00 am – 12:15 pm The Evolution of Birds in the Mesozoic: a Symposium in Honor of Cyril A. Walker Chemistry Building, Lecture Room 2	8 am – 12:15 pm Romer: 8 am – 12:15 pm Wills Memorial Building, Great Hall	8 am – 12:15 pm Technical Session X Wills Memorial Building, Great Hall	8 am – 12:15 pm Technical Session XV Wills Memorial Building, Great Hall
Technical Session Romer Session	8:00 am – 12:15 pm Technical Session I Wills Memorial Building, Great Hall	8:00 am – 12:15 pm Technical Session II Chemistry Building, Lecture Room 2	Preparators': 8 am – 11:45 am Chemistry Building, Lecture Room 3	8 am – 12:15 pm Technical Session XI Chemistry Building, Lecture Room 2	8 am – 12:15 pm Technical Session XVI Chemistry Building, Lecture Room 2
Technical Session Preparators' Session	1:45 pm – 4:15 pm Technical Session III Chemistry Building, Lecture Room 1	1:45 pm – 4:15 pm Technical Session IV Wills Memorial Building, Great Hall	1:45 pm – 4 pm Technical Session VI Chemistry Building, Lecture Room 1	1:45 pm – 5:00 pm Technical Session XII Chemistry Building, Lecture Room 1	1:45 pm – 4:15 pm Technical Session XVII Chemistry Building, Lecture Room 1
Technical Session	1:45 pm – 5:00 pm Technical Session V Wills Memorial Building, Great Hall	1:45 pm – 5:00 pm Technical Session V Wills Memorial Building, Great Hall	1:45 pm – 4 pm Technical Session VII Wills Memorial Building, Great Hall	1:45 pm – 5 pm Technical Session XIII Wills Memorial Building, Great Hall	1:45 pm – 4:15 pm Technical Session XVIII Wills Memorial Building, Great Hall
Technical Session	1:45 pm – 5:00 pm Technical Session V Chemistry Building, Lecture Room 2	1:45 pm – 5:00 pm Technical Session V Chemistry Building, Lecture Room 2	1:45 pm – 4 pm Technical Session VIII Chemistry Building, Lecture Room 2	1:45 pm – 5 pm Technical Session XIV Chemistry Building, Lecture Room 2	1:45 pm – 4:15 pm Technical Session XIX Chemistry Building, Lecture Room 2
Technical Session	1:45 pm – 4 pm Technical Session IX Chemistry Building, Lecture Room 3	1:45 pm – 4 pm Technical Session IX Chemistry Building, Lecture Room 3	1:45 pm – 4 pm Technical Session IX Chemistry Building, Lecture Room 3		
Workshops/ Educational Events	Noon – 5 pm SVP Evolution and Science Education Workshop for Educators For Pre-Registered Attendees Wills Memorial Building, Room G27	Noon – 5 pm SVP Evolution and Science Education Workshop for Educators For Pre-Registered Attendees Wills Memorial Building, Room G27	12:30 pm – 1:30 pm Women in Paleontology Luncheon Chemistry Building, Lecture Room 1		
	9:30 am – 5 pm Conservators' & Preparators' Adhesives Workshop: Choice & Reason For Pre-Registered Attendees Wills Memorial Building, Room G27	12:30 pm – 1:30 pm Town Hall Meeting on Evolution VII Chemistry Building, Lecture Room 1	6 pm – 7:30 pm Sir David Attenborough: A Lecture on Alfred Russel Wallace and the Birds of Paradise For Pre-Registered Attendees Wills Memorial Building, Great Hall		

**2009 SVP SCHEDULE OF EVENTS** (subject to change)

Event/ Functions	Tuesday, September 22	Wednesday, September 23	Thursday, September 24	Friday, September 25	Saturday, September 26
<b>Poster Sessions</b> Set-up: Wed, Fri & Sat: 9 am – Noon Set-up Thursday: 9 am – 11 am	Poster Session I : Noon – 7:00 pm Reception: 5:00 pm – 7:00 pm <b>Victoria Rooms</b>	Poster Session II: 11:00 am – 6:00 pm Reception: 4:00 pm – 6:00 pm <b>Victoria Rooms</b>	Poster Session III : Noon – 7:00 pm Reception: 5:00 pm – 7:00 pm <b>Victoria Rooms</b>	Poster Session IV : Noon – 6:15 pm Reception: 4:15 pm – 6:15 pm <b>Victoria Rooms</b>	No Exhibits on Saturday
<b>Exhibit Viewing</b>	Noon – 7:00 pm <b>Victoria Rooms, Auditorium</b>	11:00am – 6:00 pm <b>Victoria Rooms, Auditorium</b>	Noon – 7:00 pm <b>Victoria Rooms, Auditorium</b>	12:30 pm – 1:30 pm Annual Business Meeting <b>Chemistry Building, Lecture Room 1</b>	12:30 pm – 1:30 pm Open Exec. Comm. Meeting <b>Chemistry Building, Lecture Room 1</b>
<b>Annual Business Meeting/Open Executive Committee Meeting</b>			4 pm – 5 pm <b>Wills Memorial Building, Reception Room</b>		
<b>Press Event</b>					
<b>Social Events</b>	Welcome Reception 7:30 pm – 9 pm **TBA	Student Roundtable Forum & Reprint Exchange 8 pm – 10 pm **Bristol Marriott Royal Hotel, Club Lounge & Terrace Restaurant, Ground Floor	Auction/Reception 8 pm – 11pm <b>Wills Memorial Building, Great Hall</b>	Awards Ceremony 7 pm – 8:30 pm <b>Wills Memorial Building, Great Hall</b> After Hours Party 9:00 pm – 2 am **Bristol Marriott Royal Hotel, Kings Room, First Floor	
<b>Beverage Service</b>	7 am – 8 am & 10 am – 10:15am <b>Chemistry Building Foyer &amp; Wills Memorial Building, Reception Room</b>	7 am – 8 am & 10am – 10:15am <b>Chemistry Building Foyer &amp; Wills Memorial Building, Reception Room</b>	7 am – 8 am & 10 am – 10:15 am <b>Chemistry Building Foyer &amp; Wills Memorial Building, Reception Room</b>	7 am – 8 am & 10am – 10:15am <b>Chemistry Building Foyer &amp; Wills Memorial Building, Reception Room</b>	
<b>Speaker Ready Room</b>	3 pm – 6 pm <b>Chemistry Building, Foyer</b>	7 am – 5 pm <b>Chemistry Building, Foyer</b>	7 am – 5 pm <b>Chemistry Building, Foyer</b>	7 am – 5 pm <b>Chemistry Building, Foyer</b>	7 am – 4 pm <b>Chemistry Building, Foyer</b>
<b>Meetings Rooms: all located in the Wills Memorial Building</b>	9 am – 6 pm <b>G5, G7 and G8</b>	9 am – 6 pm <b>G5, G7 and G8</b>	9 am – 6 pm <b>G5, G7 and G8</b>	9 am – 6 pm <b>G5, G7 and G8</b>	9 am – 6 pm <b>G5, G7 and G8</b>

# PROGRAM AT A GLANCE

NOTE: Lecture rooms are in the Chemistry Building.  
The Great Hall is in the Wills Memorial Building.

	Lecture Room 1	Great Hall	Lecture Room 2	Lecture Room 1	Great Hall	Lecture Room 2	Lecture Room 3	Lecture Room 2	Great Hall	Lecture Room 2	Lecture Room 1	Great Hall	Lecture Room 2	Great Hall	Lecture Room 2	Lecture Room 1	Great Hall	Lecture Room 1	Lecture Room 2
	Mary Anning	Tech 1	Tech 2	Late Triassic....	Romer	Evolution of Birds...	Preparators'	Molecular Tools...	Tech 10	Tech 11	New Perspectives...	Tech 15	Tech 16						
	<b>WED</b>	<b>WED</b>	<b>WED</b>	<b>THURS</b>	<b>THURS</b>	<b>THURS</b>	<b>THURS</b>	<b>FRI</b>	<b>FRI</b>	<b>FRI</b>	<b>SAT</b>	<b>SAT</b>	<b>SAT</b>						
8:00	Taylor	Vavrek	Blick	Fraser	Tulu	Clarke	Hanta	Asher	Whiteside	Hopson	Reisz	Breithaupt	Bolortsetseg						
8:15	Evans	Maguire	Harrison	Parker	Kubo	O'Connor	Padilla	Organ	Xu	Horowitz	Sumida	Manning	Wood						
8:30	A. Smith	Badgley	R. Sansom	Olsen	Loewen	Nudds	Rasal	Bininda-Emonds	Andres	Travouillon	Berman	Fowler	Gill						
8:45	Fernández	Toniya	I. Sansom	Abdala	D'Amore	Bell	Moros	Müller	Osi	Kondrashov	Liu	Morhardt	Bales						
9:00	Druckemiller	Lindsey	Ahlberg	Gower	Kammerer	Chinsamy-Turan	Roth	Donoghue	Unwin	Ting	Kemp	Pittman	Dirks						
9:15	Klein	Rivals	Rücklin	Nesbitt	Bosvert	Zhou	Greenke	Debruyne	Ibrahim	Beard	Rubidge	Kambic	Shockey						
9:30	N. Fröbisch	Polly	Brusatte	Brusatte	Mannion	Stidham	Johnson	Parham	Vullo	Mihlbachler	J. Fröbisch	Allen	Billet						
9:45	Maxwell	Prothero	Kriwet	Irmis	Sigurdson	Harris	Cheney	Brochu	Kellner	Bajpai	Kurkin	Persons	T. Smith						
10:00	COFFEE	COFFEE	COFFEE	COFFEE	COFFEE	COFFEE	COFFEE	COFFEE	COFFEE	COFFEE	COFFEE	COFFEE	COFFEE						
10:15	Páramo	Price	Klug	Langer	Blais	Fiorillo	Fitzgerald	Gatesy	Bennett	Dutchak	Jasinoski	Buckley	Fahlke						
10:30	Scheyer	Fernusquia-Villafranca	Claeson	Benton	DeSantis	Walsh	Fox	Teeling	Marty	Stucky	Vega	Dal Sasso	Coombs						
10:45	Krahl	McGuire	Cuny	Sulej	Habib	Varricchio	Balcarcel	Beck	N. Smith	Hooker	Gebauer	Benson	Deng						
11:00	Kelley	Kelley	Lane	Ezeurra	Biasatti	Lamana	Herzog	Bickelmann	Stevens	Eberle	R. Smith	Makovicky	Theodor						
11:15	Caldwell	Hadly	Shin	Novas	Green	Maragán-Lobón	Jabo	Tucker	Burns	Ducrocq	van den Heever	Norell	Cooper						
11:30	Forrest	Terry	Ehret	Yates	Sakamoto	Lindow	Brown	Meredith Smith	Moratalla	Grossman	Sues	Bever	Ludtke						
11:45	O'Keefe	Hoffman	Brazeau	Butler	Bates	Ksepka	Brown	Buehholz	Norman	Kingston	Sidor	Paulina Carabajal	Bibi						
12:15-1:45	McHenry	Barnosky	Minikh	Barrett	Friedman	Meijer	Brown	Galis	Hübner	Flynn	Luo	Miyashita	Lihoreau						
	LUNCH	LUNCH	LUNCH	LUNCH	LUNCH	LUNCH	LUNCH	LUNCH	LUNCH	LUNCH	LUNCH	LUNCH	LUNCH						
Tech 3	Tech 4	Tech 5	Tech 6	Tech 7	Tech 8	Tech 9	Tech 9	Tech 12	Tech 13	Tech 14	Tech 17	Tech 18	Tech 19						
Zanmit	Köhler	Mutter	Tsuji	Gill	Alroy	Bryk	Bryk	Prasad	Brown	Gilbert	Maier	Upchurch	Janis						
Street	Fisher	Xu	Säliä	Anderson	Terry	Behrensmeier	Behrensmeier	Stocker	McDonald	Larsson	Egberts	Pol	Chritz						
Ketchum	Ka. Smith	López-Arbarello	Carroll	Cobb	Werning	Miller	Miller	Desojo	Redelstorff	Corfe	Angielczyk	Remes	Weston						
Leonhardt	Hutchinson	Hellawell	Wernburg	Colbert	Burch	Moore	Moore	Wilberg	Freedman	Geisler	Huttentlocher	Matetus	Orliac						
Yi	Beatty	G. Smith	Lyson	Holroyd	Rayfield	Kr. Smith	Kr. Smith	Clark	Godefroit	Gunnell	Henrici	Frank	Boisserie						
Moazen	Clementz	Qiao	Wings	Schulz	Boman	Falkingham	Falkingham	Andrade	Prieto-Marquez	Morlo	Clack	D'Emic	Lambert						
Rauhut	Gheerbrant	Zhu	Knell	Bunn	Dufeu	Keenan	Keenan	Martin	Mallon	Goswami	Warren	Whitlock	Goodwin						
Konishi	Ramdarshan	Lu	Jacobs	Croft	Tütken	Noto	Noto	Sertich	Homer	Finarelli	Olori	Christian	Churchill						
Conrad	Harrison	Sanchez	Fara	Rinaldi	Kilbourne	Mamhi	Mamhi	Hastings	Tanoue	Samuels	Geo	Young	Racicot						
Wilson	Almécija	Hutson						Spencer	Dodson	Meloro	Chen	Csiki	Peck						
Bhullar	Alba	Sallan						Gignac	Sissons	Meachen-Samuels									
Lawing	Macho	Anderson						Porro	Sampson	Spaulding									
Head	Groening	Smithson						Drumbeller	Scannella	Orcutt									
5:00																			
5:15																			
5:30																			
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6:00																			
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6:45																			

Poster Session I

Poster Session II

Poster Session III

Poster Session IV

## WEDNESDAY MORNING, SEPTEMBER 23, 2009

### SYMPOSIUM: THE SCIENTIFIC LEGACY OF MARY ANNING — RECENT ADVANCES IN MARINE REPTILE PALEOBIOLOGY AND EVOLUTION

CHEMISTRY BUILDING, LECTURE ROOM 1

MODERATORS: Patrick Druckenmiller, Erin Maxwell

- 8:00 **Taylor, M.** MARY ANNING, THE BRISTOL INSTITUTION, AND THE MARINE REPTILES
- 8:15 **Evans, M.** PLESIOSAUR DISCOVERIES, OLD AND NEW, FROM THE LOWER JURASSIC OF ENGLAND.
- 8:30 **Smith, A.** DIVERSITY OF HETTANGIAN (LOWER JURASSIC) PLIOSAUROIDS FROM SOUTHERN ENGLAND
- 8:45 **Fernández, M., Gasparini, Z., de la Fuente, M.** TITHONIAN (LATE JURASSIC) MARINE REPTILES FROM THE NEUQUEN BASIN (NORTHWEST PATAGONIA, ARGENTINA)
- 9:00 **Druckenmiller, P., Hurum, J., Knutsen, E., Nakrem, H.** A NEW MARINE REPTILE ASSEMBLAGE FROM THE AGARDHFJELLET FORMATION (UPPER JURASSIC; TITHONIAN), SVALBARD ARCHIPELAGO, NORWAY
- 9:15 **Klein, N., Sander, M.** PACHYPLEUROSAURIA - A COMMON GROUP OF MARINE REPTILES FROM THE LOWER MUSCHELKALK OF THE GERMANIC BASIN AND WHAT WE REALLY KNOW
- 9:30 **Fröbisch, N., Fröbisch, J., Klein, N., Schmitz, L., Sander, M.** A LARGE PREDATORY ICHTHYOSAUR FROM THE ANISIAN OF NEVADA AND THE DIVERSIFICATION OF ICHTHYOSAURIA AFTER THE END-PERMIAN EXTINCTION
- 9:45 **Maxwell, E.** A NEW UPPER JURASSIC ICHTHYOSAUR FROM NORTHERN CANADA
- 10:00 BREAK
- 10:15 **Páramo, M., Etayo-Serna, F., Gómez Pérez, M., Padilla, C., Noè, L.** NEW MARINE REPTILES FROM THE CRETACEOUS OF CENTRAL COLOMBIA
- 10:30 **Scheyer, T., Hugi, J., Delfino, M., Sánchez-Villagra, M.** FOSSILIZED ONTOGENIES: OSTEOLOGICAL AND BONE MICROSTRUCTURAL CASE STUDIES OF FOSSIL MARINE REPTILES FROM THE UNESCO WORLD HERITAGE SITE OF MONTE SAN GIORGIO, TICINO, SWITZERLAND
- 10:45 **Krahl, A., Sander, M., Klein, N.** LONG BONE HISTOLOGY OF MIDDLE TRIASSIC EUSAUROPTERYGIANS (NOTHOSAURIA AND PISTOSAURIA) AND ITS IMPLICATIONS FOR PARAXIAL SWIMMING
- 11:00 **Kelley, N., Motani, R., Jiang, D., Rieppel, O., Andrea, T.** RAPID DIVERSIFICATION OF DENTAL AND JAW MORPHOLOGY AMONG MARINE REPTILES DURING THE TRIASSIC RECOVERY
- 11:15 **Caldwell, M., Maxwell, E., Lamoureaux, D.** A HISTOLOGICAL PERSPECTIVE ON THE REPLACEMENT, IMPLANTATION, AND ATTACHMENT OF TEETH IN ICHTHYOSAURS
- 11:30 **Forrest, R.** VERTEBRAL PROPORTIONS IN PLESIOSAURS
- 11:45 **O'Keefe, F., Wilhelm, B.** A NEW RECONSTRUCTION OF PLESIOSAUR PECTORAL MUSCULATURE: PHYLOGENETIC, OSTEOLOGICAL, AND FUNCTIONAL CONSTRAINTS.
- 12:00 **McHenry, C.** FEEDING BEHAVIOR IN A LARGE PLIOSAUR-THE PALEOECOLOGY OF *KRONOSAURUS QUEENSLANDICUS*

### TECHNICAL SESSION I

WILLS MEMORIAL BUILDING, GREAT HALL

MODERATORS: Elizabeth Hadly, Florent Rivals

- 8:00 **Vavrek, M.** NEW METHODS OF NETWORK PALEOBIOGEOGRAPHY WITH AN EMPIRICAL EXAMPLE FROM MIOCENE MAMMALS
- 8:15 **Maguire, K., Matzke, N.** MAXIMUM LIKELIHOOD ESTIMATION OF BIOGEOGRAPHIC HISTORIES USING THE FOSSIL RECORD

- 8:30 **Badgley, C.** TECTONIC HISTORY AND MAMMALIAN DIVERSITY
- 8:45 **Tomiya, S.** BODY MASS AS A CORRELATE OF EXTINCTION RISK IN MAMMALS: A PHYLOGENETIC COMPARATIVE APPROACH TO THE FOSSIL RECORD
- 9:00 **Lindsey, E., Carrasco, M., Barnosky, A., Graham, R.** REASSESSING FAUNAL DYNAMICS DURING THE GREAT AMERICAN BIOTIC INTERCHANGE USING UPDATED DATA AND ADJUSTMENTS FOR SAMPLING BIASES
- 9:15 **Rivals, F., Mol, D., de Vos, J.** THIRTY METERS UNDER SEA LEVEL: DIETARY TRAITS AND PALEOECOLOGY OF WOOLLY MAMMOTHS, RHINOS, AND OTHER LATE PLEISTOCENE UNGULATES FISHED IN THE NORTH SEA
- 9:30 **Polly, P. D., Eronen, J.** PLEISTOCENE MAMMAL ASSOCIATIONS: IMPLICATIONS OF ECOLOGICAL NICHE MODELLING AND A METHOD FOR RECONSTRUCTING PALEOCLIMATE
- 9:45 **Prothero, D., Raymond, K., Sutyagina, A., Molina, S., Syverson, V.** STASIS IN LATE PLEISTOCENE BIRDS AND MAMMALS FROM LA BREA TAR PITS OVER THE LAST GLACIAL-INTERGLACIAL CYCLE
- 10:00 **BREAK**
- 10:15 **Price, G., Webb, G., Zhao, J., Feng, Y., Hocknull, S.** PRE-HUMAN CLIMATIC FORCING FOR LATE PLEISTOCENE MEGAFUNAL EXTINCTION: EVIDENCE FROM THE DARLING DOWNS, EASTERN AUSTRALIA
- 10:30 **Ferrusquía-Villafranca, I., Ruiz-González, J., De Anda-Hurtado, P., Arroyo-Cabrales, J.** MEXICO'S QUATERNARY MAMMALS AND BIOTIC PHYSIOGNOMIC CHANGE: A CASE RESPONSE TO ENVIRONMENTAL CHANGE
- 10:45 **McGuire, J.** *MICROTUS CALIFORNICUS* TOOTH SHAPE AS A POTENTIAL PALEOCLIMATIC INDICATOR
- 11:00
- 11:15 **Hadly, E., Spaeth, P., Li, C.** NICHE CONSERVATISM ABOVE THE SPECIES-LEVEL IN NORTH AMERICAN MAMMALS
- 11:30 **Terry, R., Blois, J., Hadly, E.** SPATIOTEMPORAL DYNAMICS AND THE STRUCTURING OF HOLOCENE SMALL MAMMAL COMMUNITIES IN THE AMERICAN WEST
- 11:45 **Hoffman, J., Clementz, M.** PALEOECOLOGICAL INTERPRETATIONS FROM BIOAPATITE AND COLLAGEN STABLE ISOTOPE VALUES OF LATE HOLOCENE ELK TEETH
- 12:00 **Barnosky, A., Hadly, E.** THE PATH TO THE FUTURE: PALEONTOLOGY MEETS CONSERVATION BIOLOGY

## TECHNICAL SESSION II

CHEMISTRY BUILDING, LECTURE ROOM 2

MODERATORS: Kerin Claeson, Robert Sansom

- 8:00 **Blieck, A., Turner, S., Burrow, C., Schultze, H., Rexroad, C.** ORGANISMAL BIOLOGY, PHYLOGENY AND STRATEGY OF PUBLICATION: WHY CONODONTS ARE NOT VERTEBRATES
- 8:15 **Harrison, L., Larsson, H.** EXPLORING BASAL GNATHOSTOME PHYLOGENY USING COMBINED ANALYSIS OF MULTIPLE DATASETS OF MOLECULAR AND MORPHOLOGICAL DATA
- 8:30 **Sansom, R., Gabbott, S., Purnell, M.** EXPERIMENTAL DECAY OF LAMPREYS AND HAGFISH PROVIDES TAPHONOMIC CONSTRAINTS ON VERTEBRATE ORIGINS
- 8:45 **Sansom, I.** THE ORDOVICIAN RADIATION OF FISH
- 9:00 **Ahlberg, P., Trinajstić, K., Long, J.** THE BODY MUSCULATURE OF ARTHRODIRE PLACODERMS
- 9:15 **Rücklin, M., Donoghue, P., Stampanoni, M.** PLACODERM JAWS AND THE ORIGIN OF TEETH
- 9:30

- 9:45 **Kriwet, J., Klug, S.** NODE AGE ESTIMATES OF ANGEL AND DOGFISH SHARKS (CHONDRICHTHYES, NEOSELACHII) USING CONSTRAINED FOSSIL DATA AND MOLECULAR CLOCKS FOR DATING THE ORIGIN OF HYPNOSQUALEAN AND DERIVED “ORBITOSTYLIC” SHARKS, RESPECTIVELY
- 10:00 **BREAK**
- 10:15 **Klug, S.** INTER- AND INTRARELATIONSHIPS OF EXTINCT SYNECHODONTIFORM SHARKS (CHONDRICHTHYES, ELASMOBRANCHII): WHEN IS A SHARK A NEOSELACHIAN?
- 10:30 **Claeson, K., Underwood, C., Ward, D.** A 3-DIMENTIONALLY PRESERVED FOSSIL GUITARFISH FROM THE TURONIAN OF MOROCCO
- 10:45 **Cuny, G.** EVOLUTION OF SERRATED CUTTING DENTITION IN HYBODONT SHARKS
- 11:00 **Lane, J.** CRANIAL MORPHOLOGY IN TWO CRETACEOUS HYBODONT SHARKS, *TRIBODUS LIMAE* AND *EGERTONODUS BASANUS* (CHONDRICHTHYES: ELASMOBRANCHII), BASED ON DIGITAL RECONSTRUCTIONS
- 11:15 **Shin, J., Motani, R.** FEEDING MECHANISM OF LARGE MESOZOIC FOSSIL CHIMAEROIDS (*CHONDRICHTHYES*, HOLOCEPHALI): HOW LARGE A SHELL COULD THEY CRUSH?
- 11:30 **Ehret, D., MacFadden, B., Jones, D., DeVries, T., Salas-Gismondi, R.** ORIGIN OF THE WHITE SHARK (*CARCHARODON*), BASED ON RECALIBRATION OF THE LATE NEOGENE, PISCO FORMATION OF PERU
- 11:45 **Brazeau, M., Friedman, M.** A CRITICAL APPRAISAL OF DEEP OSTEICHTHYAN INTERRELATIONSHIPS
- 12:00 **Minikh, A., Minikh, M., Mutter, R., Benton, M.** UNIQUE MIDDLE-LATE PERMIAN ACTINOPTERYGIAN FAUNA FROM THE SOUTH URALS AND PRE-URALS

## WEDNESDAY AFTERNOON, SEPTEMBER 23, 2009

### TECHNICAL SESSION III

#### CHEMISTRY BUILDING, LECTURE ROOM 1

**MODERATORS: Bhart-Anjan Bhullar, Oliver Rauhut**

- 1:45 **Zammit, M.** POSTCRANIAL MORPHOLOGY OF THE AUSTRALIAN CRETACEOUS ICHTHYOSAUR *PLATYPTERYGIUS LONGMANI*
- 2:00 **Street, H., O’Keefe, F.** A NEW PARTIAL SKELETON OF THE CRYPTOCLEIDOID PLESIOSAUR *TATENECTES LARAMIENSIS* AND AN INTERPRETATION OF THE NOVEL BODY SHAPE OF A SHALLOW MARINE DWELLING PLESIOSAUR
- 2:15 **Ketchum, H., Benson, R.** GLOBAL INTERRELATIONSHIPS OF PLESIOSAURIA (REPTILIA, SAUROPTERYGIA) AND THE PIVOTAL EFFECT OF TAXON SAMPLING IN DETERMINING THE OUTCOME OF PHYLOGENETIC ANALYSIS
- 2:30 **Leonhardt, A., Sander, M.** CONVERGENT BODY PLAN EVOLUTION IN HYPHALOSAURID CHORISTODERES AND PACHYPLEUROSAURID SAUROPTERYGIANS
- 2:45 **Yi, H., Gao, K.** EVOLUTION OF THE LOWER TEMPORAL FENESTRA IN THE CHORISTODERA (REPTILIA: DIAPSIDA)
- 3:00 **Moazen, M., Curtis, N., O’Higgins, P., Evans, S., Fagan, M.** COMPUTATIONAL MODELING OF THE EVOLUTIONARY CHANGES IN THE LEPIDOSAURIAN SKULL
- 3:15 **Rauhut, O., Heyng, A.** A NEW TAXON OF SPHENODONTIAN WITH UNUSUAL DENTITION FROM THE LATE JURASSIC OF SOUTHERN GERMANY
- 3:30 **Konishi, T.** NEW INSIGHT INTO GLOBAL PHYLOGENY OF PLIOPATECARPINI (SQUAMATA: MOSASAURIDAE)
- 3:45 **Conrad, J., Balcarcel, A., Mehling, C.** MIOCENE ASIAN INVASION OF EUROPE BY *VARANUS* (VARANIDAE)

- 4:00 **Wilson, J., Mohabey, D., Peters, S., Head, J.** A SNAKE-DINOSAUR ASSOCIATION FROM THE CRETACEOUS OF INDIA
- 4:15 **Bhullar, B., Pauly, G., Scanferla, C., Bever, G., Smith, K.** THE FIRST FOSSIL SUNBEAM SNAKE AND THE ANTIQUITY OF MODERN SNAKE CLADES
- 4:30 **Lawing, A., Polly, P. D., Head, J.** ECOMORPHOLOGY AS A PREDICTOR OF MODERN AND PALEOENVIRONMENT IN SNAKES
- 4:45 **Head, J., Polly, P. D., Bloch, J., Cadena, E.** BODY SIZE, PHYSIOLOGY, AND ECOLOGY: PALEOTHERMOMETRIC ESTIMATES FROM THE FOSSIL RECORD OF REPTILES

#### TECHNICAL SESSION IV

WILLS MEMORIAL BUILDING, GREAT HALL

MODERATORS: Mark Clementz, Gabriele Macho

- 1:45 **Köhler, M.** THE EVOLUTION OF LIFE HISTORY TRAITS ASSOCIATED TO DWARFING IN INSULAR LARGE MAMMALS: A PALEONTOLOGICAL APPROACH.
- 2:00 **Fisher, D., Rountrey, A., Tikhonov, A., Buigues, B., van der Plicht, H.** LIFE HISTORY OF A REMARKABLY PRESERVED WOOLLY MAMMOTH CALF FROM THE YAMAL PENINSULA, NORTHWESTERN SIBERIA
- 2:15 **Smith, K., Fisher, D.** FEMALE MASTODONS AT THE BOTHWELL SITE: SIMULTANEOUS OR SUCCESSIVE MORTALITY EVENTS?
- 2:30 **Hutchinson, J., Delmer, C., Miller, C., Pitsillides, A., Boyde, A.** "SIXTH DIGITS" AND THE EVOLUTION OF ELEPHANT FOOT POSTURE
- 2:45 **Beatty, B., Ghobrial, M., Ivanova, V.** DENTAL MICROWEAR AS AN INDICATOR OF RESPONSE TO CLIMATE CHANGE IN MODERN AND FOSSIL SIRENIA
- 3:00 **Clementz, M., Domning, D., Sorbi, S.** EVIDENCE OF CENOZOIC ENVIRONMENTAL AND ECOLOGICAL CHANGE FROM STABLE ISOTOPE ANALYSIS OF SIRENIAN REMAINS FROM THE TETHYS-MEDITERRANEAN REGION
- 3:15 **Gheerbrant, E., Sole, F., Amaghazaz, M., Bouya, B.** THE BEGINNING OF AFRICAN PLACENTALS: NEW DISCOVERIES FROM THE OULED ABDOUN BASIN (MOROCCO, PALEOCENE-EOCENE), AND SIGNIFICANCE
- 3:30 **Ramdarshan, A., Marivaux, L., Merceron, G.** PALEOECOLOGY OF SOUTH ASIAN PRIMATES: PALEOENVIRONMENTAL IMPLICATIONS
- 3:45 **Harrison, T., Jin, C.** A NEW PLIOPIITHECOID (MAMMALIA, PRIMATES) FROM THE LATE EARLY MIOCENE OF CHINA AND ITS ZOOGEOGRAPHIC IMPLICATIONS
- 4:00 **Almécija, S., Alba, D., Moyà-Solà, S.** *PIEROLAPITHECUS*, *HISPANOPITHECUS* AND THE EVOLUTION OF POSITIONAL BEHAVIOR IN MIOCENE APES: PERSPECTIVES FROM THE HAND
- 4:15 **Alba, D., Fortuny, J., Moyà-Solà, S.** RELATIVE ENAMEL THICKNESS IN MIDDLE MIOCENE HOMINOIDS FROM ABOCADOR DE CAN MATA (VALLES-PENEDES BASIN, CATALONIA, SPAIN)
- 4:30 **Macho, G., Spears, I., Leakey, M.** THE EFFECTS OF EXTERNAL AND INTERNAL MORPHOLOGY ON LOAD DISSIPATION IN HOMININ CAPITATES: IMPLICATIONS FOR INTERPRETING HOMININ BEHAVIOR.
- 4:45 **Groening, F., Fagan, M., O'Higgins, P.** VARIATION IN MANDIBULAR MORPHOLOGY WITHIN LATE *HOMO* AND ITS RELEVANCE TO MASTICATORY LOAD RESISTANCE.

**TECHNICAL SESSION V**  
**CHEMISTRY BUILDING, LECTURE ROOM 2**  
**MODERATORS: Jason Anderson, Raoul Mutter**

- 1:45 **Mutter, R.** ACTINOPTERYGIANS FROM THE KAROO BASIN (SOUTH AFRICA) AND THEIR PALEOBIOGEOGRAPHIC CONTEXT
- 2:00 **Xu, G., Gao, K.** A NEW SCANILEPIFORM FROM THE LOWER TRIASSIC OF NORTHERN GANSU PROVINCE, CHINA, AND PHYLOGENETIC RELATIONSHIPS OF LOWER ACTINOPTERYGIANS
- 2:15 **López-Arbarello, A.** HOMOLOGY OF THE INFRAORBITAL BONES AND THE MONOPHYLY OF SEMIONOTIFORMES
- 2:30 **Hellawell, J., Pancost, R., Evershed, R., Gill, F., Nicholas, C.** DEAD IN THE WATER: AN INVESTIGATION INTO EOCENE FISH MASS MORTALITY EVENTS
- 2:45 **Smith, G.** BIOGEOGRAPHY AND PALEONTOLOGY OF WESTERN NORTH AMERICAN FRESHWATER FISHES
- 3:00 **Qiao, T., Zhu, M.** *GUIYU ONEIROS* AND THE CHARACTERS OF BASAL SARCOPTERYGIANS
- 3:15 **Zhu, M., Ahlberg, P., Zhao, W., Jia, L.** A NEW DEVONIAN TETRAPODOMORPH FISH AND ITS BEARING ON THE FISH-TETRAPOD TRANSITION
- 3:30 **Lu, J., Zhu, M.** THE CRANIAL ANATOMY OF A NEW TETRAPODOMORPH FISH FROM THE LOWER DEVONIAN OF CHINA
- 3:45 **Sanchez, S., Tafforeau, P., Clack, J., Daeschler, E., Ahlberg, P.** LIMB BONE HISTOLOGY ACROSS THE FISH-TETRAPOD TRANSITION
- 4:00 **Hutson, J.** A PARSIMONIOUS SOLUTION TO ROMER'S 'PROBLEM': A SYNTHESIS, TEST AND APPLICATION OF THE EVIDENCE FOR AN INTRINSIC MORPHOLOGICAL CONSTRAINT IN THE POSTURAL EVOLUTION OF TETRAPOD FORELIMBS
- 4:15 **Sallan, L.** VERTEBRATE BIODIVERSITY AND LARGE-SCALE TURNOVER DURING THE DEVONIAN-MISSISSIPPIAN TRANSITION
- 4:30 **Anderson, J., Brazeau, M., Carroll, R., Clack, J.** A DIVERSE TETRAPOD FAUNA AT THE BASE OF ROMER'S GAP
- 4:45 **Smithson, T., Wood, S.** BRIDGING ROMER'S GAP: NEW TETRAPODS FROM THE BASAL CARBONIFEROUS OF THE SCOTTISH BORDERS.

**POSTER SESSION I**

Authors must be present from 5:00 - 7:00 p.m.

Posters must be removed by 7:15 p.m.

- 1 **Martin, J., Fernández, M.** SALT GLANDS IDENTIFIED IN A LATE CRETACEOUS POLYCOTYLID PLESIOSAUR
- 2 **Cuthbertson, R., Anderson, J.** A PUTATIVE BASAL ICHTHYOPTERYGIAN FROM THE SULPHUR MOUNTAIN FORMATION OF BRITISH COLUMBIA, CANADA
- 3 **Gómez Pérez, M., Noè, L.** A PLIOSAUR FROM THE LOWER CRETACEOUS OF COLOMBIA: THE IMPLICATIONS OF A NEW GENUS
- 4 **Knutsen, E., Druckenmiller, P., Hurum, J., Nakrem, H.** PRELIMINARY ACCOUNT OF NEW LATE JURASSIC PLIOSAURID MATERIAL FROM SVALBARD, NORWAY
- 5 **Polcyn, M., Jacobs, L., Mateus, O., Schulp, A.** NEW SPECIMENS OF *ANGOLASAUROS BOCAGEI* AND COMMENTS ON THE EARLY RADIATIONS OF PLIOPATECARPINE MOSASAURS
- 6 **Buchy, M.** MESOZOIC MARINE REPTILES OF NORTH-EAST MEXICO
- 7 **Bornsäter Mellbin, B.** INSIDE THE SKULL OF *IOWADIPTERUS HALLI*

- 8 **Quesada, J., Pérez García, A., Ortega, F., Escaso, F., Sánchez Chillón, B.** SIMOSAURUS (NOTHOSAURIA)  
FOSSIL SITE: A NEW SPANISH WINDOW TO THE UPPER TRIASSIC
- 9 **Shimada, K., Tsuihiji, T., Sato, T., Hasegawa, Y.** A REMARKABLE CASE OF A SHARK-BITTEN  
ELASMOSAURID PLESIOSAUR FROM THE UPPER CRETACEOUS OF JAPAN
- 10 **Hugi, J., Scheyer, T., Mitgutsch, C., Sánchez-Villagra, M.** FOSSILISED ONTOGENIES:  
MORPHOLOGY AND OSSIFICATION SEQUENCE STUDIES OF LIMBS IN SAUROPTERYGIAN  
AND ICHTHYOSAURIAN CLADES FROM THE UNESCO WORLD HERITAGE SITE OF MONTE SAN  
GIORGIO, SWITZERLAND, WITH A COMPARISON TO RECENT REPTILES.
- 11 **Wilhelm, B., O’Keefe, F.** A NEW PARTIAL SKELETON OF *PANTOSAURUS STRIATUS*, A  
CRYPTOCLEIDOID PLESIOSAUR FROM THE UPPER JURASSIC SUNDANCE FORMATION OF  
WYOMING
- 12 **Ji, C., Jiang, D., Motani, R., Hao, W., Sun, Z.** NEW SPECIMEN OF *GUIZHOUICHTHYOSAURUS*  
(SHASTASAURIDAE) FROM SOUTHWESTERN CHINA
- 13 **Fischer, V., Guiomar, M., Godefroit, P.** HIGH DIVERSITY OF LATE EARLY CRETACEOUS  
ICHTHYOSAURS
- 14 **LeBlanc, A., Reichel, M.** ENAMEL MICROSTRUCTURE IN *PLATECARPUS* AND THE IMPLICATIONS  
FOR TOOTH BIOMECHANICS
- 15 **Houssaye, A., Tafforeau, P.** VERTEBRAL MICROANATOMY AND HISTOLOGY WITHIN JUVENILE  
“MOSASAURS”. WHERE DID THEY LIVE?
- 16 **Meijer, A., Verding, L., Cornelissen, D., Schulp, A.** TOOTH REPLACEMENT IN *MOSASAURUS*  
*HOFFMANNI*
- 17 **James, M.** INVESTIGATION OF FEEDING MECHANICS IN *CHAMPSOSAURUS*: JAW ADDUCTOR  
CHAMBER RECONSTRUCTION AND CRANIAL FINITE ELEMENT ANALYSIS
- 18 **Ikeda, T., Saegusa, H.** PRERIMINARY REPORT ON FOSSIL LIZARDS FROM THE LOWER CRETACEOUS  
SASAYAMA GROUP OF HYOGO PREFECTURE, SW JAPAN
- 19 **Bolet, A., Evans, S.** A NEW LIZARD (LEPIDOSAURIA, SQUAMATA) FROM THE EARLY CRETACEOUS  
OF THE MONTSEC RANGE (CATALONIA, SPAIN)
- 20 **Nydam, R., Caldwell, M., Fanti, F.** ARTICULATED LIZARD SKULLS FROM THE WAPITI FORMATION  
(UPPER CRETACEOUS) OF WEST-CENTRAL CANADA
- 21 **Chinnery-Allgeier, B., Stucky, R.** DIVERSITY OF LOWER VERTEBRATES ACROSS THE EARLY EOCENE  
CLIMATIC OPTIMUM
- 22 **Kennedy, A., Stidham, T., Lewis, P., DeRuiter, D.** THE NONMAMMALIAN FAUNA FROM THE MIDDLE  
PLIOCENE MATJHABENG SITE, SOUTH AFRICA
- 23 **Moreno, K., Pino, A., Wroe, S., McHenry, C.** BITE FORCE IN *MEGALANIA*
- 24 **Hipsley, C., Müller, J., Claeson, K., Nikolay, K., Hilger, A.** CRANIAL OSTEOLOGY AND POSTNATAL  
ONTOGENY OF THE GLIDING LIZARD *HOLASPIS LAEVIS*
- 25 **Young, K., Stidham, T.** A HIGH-DENSITY SNAKE BONE ACCUMULATION FROM THE LATE  
PLEISTOCENE OF TEXAS: EVIDENCE OF A MULTISPECIES SNAKE HIBERNACULUM?
- 26 **Reinke, B., Casserly, A., Rowe, M., Lawing, A.** INTRASPECIFIC VARIATION IN THE ROSY BOA  
(*LICHANURA TRIVIRGATA*)
- 27 **McCartney, J.** AN ASSESSMENT OF INTRACOLUMNAR VARIATION IN SEVERAL SPECIES OF  
MODERN SNAKES AND ITS IMPLICATIONS FOR THE FOSSIL RECORD
- 28 **Figueiredo, R., Saraiva, A., Moreira, J., Kellner, A.** NEW SUSISUCHID REMAINS FROM THE CRATO  
FORMATION (SANTANA GROUP, ARARIPE BASIN) NORTHEASTERN BRAZIL
- 29 **Hornung, J., Andrade, M., Reich, M.** ARE *GONIOPHOLIS CRASSIDENS* AND *G. SIMUS* DIFFERENT  
SPECIES OF CROCODYLIANS? NEW POSTCRANIAL EVIDENCE SOLVING A TAXONOMIC RIDDLE
- 30 **Hill, R.** THE OSTEODERMS OF *SIMOSUCHUS CLARKI* (CROCODYLIFORMES: NOTOSUCHIA) FROM  
THE LATE CRETACEOUS OF MADAGASCAR

- 31 **Oliveira, C., Santucci, R., Andrade, M., Basílio, J., Benton, M.** A CROCODYLOMORPH NESTING SITE FROM THE UPPER CRETACEOUS ADAMANTINA FORMATION OF BRAZIL
- 32 **Cabral, U., Kellner, A.** A CASE OF ANKYLOSIS IN CROCODYLIFORM VERTEBRAE FROM THE ENTRERRIANA FORMATION, OLIGOCENE OF ARGENTINA.
- 33 **Wu, X., Shan, H., Cheng, Y., Sato, T.** FIRST NEARLY COMPLETE CROCODYLIAN SKELETON (CROCODYLIA: TOMISTOMINAE) FROM TAIWAN, CHINA
- 34 **Fortier, D., Brochu, C., Souza Filho, J.** THE OLDEST RECORD OF *CAIMAN YACARE*
- 35 **Lemberg, J., Porro, L., Reed, D., Ross, C.** 3D VISUALIZATION AND MORPHOMETRIC ANALYSIS COMPARING MANDIBULAR SUTURES IN A HATCHLING AND SUB-ADULT *ALLIGATOR MISSISSIPPIENSIS*
- 36 **Fujiwara, S., Taru, H., Suzuki, D.** STRUCTURE OF UNCALCIFIED CARTILAGES IN CROCODYLIAN (ARCHOSAURIA) ELBOW JOINTS WITH IMPLICATIONS FOR RECONSTRUCTION OF ARTICULAR SURFACES IN EXTINCT ARCHOSAURS
- 37 **Skutschas, P.** NEW INFORMATION ON *KOKARTUS HONORARIUS* (LISSAMPHIBIA, CAUDATA) FROM THE MIDDLE JURASSIC OF KYRGYZSTAN
- 38 **Folie, A., Smith, T., Sigé, B., Smith, R.** EVOLUTION OF THE PALEOGENE SALAMANDRIDS OF EUROPE
- 39 **Gómez, R., Báez, A., Nicoli, L., Muzzopappa, P.** A NEW EOCENE BROAD-HEADED FROG FROM PATAGONIA: TESTING THE EFFECT OF HYPEROSSIFICATION ON THE RECONSTRUCTION OF ANURAN PHYLOGENY
- 40 **Maddin, H.** EVOLUTION OF THE NEUROCRANIUM IN CAECILIIDAE (GYMNOPHIONA)
- 41 **Milner, A., Ruta, M.** THE PHYLOGENY AND INTERRELATIONSHIPS OF NECTRIDIAN AMPHIBIANS
- 42 **Blain, H-A., López-García, J., Cuenca-Bescós, G., Vaquero, M., Alonso, S.** FIRST FOSSIL EVIDENCE FOR *CHIOGLOSSA LUSITANICA* (AMPHIBIA, CAUDATA) IN THE HOLOCENE OF WESTERN EUROPE
- 43 **Mark-Kurik, E.** TWO SMALL SCOTTISH MIDDLE DEVONIAN PLACODERMS IN ESTONIA
- 44 **MacKenzie, L., Wilson, M., Hanke, G.** TWO NEW EARLY DEVONIAN (LOCHKOVIAN) SPECIES OF THE ACANTHODIAN GENUS *BROCHOADMONES* FROM THE MOTH LOCALITY, NWT, CANADA, AND SIGNIFICANCE OF DENTAL VARIATION IN THE GENUS
- 45 **Jerve, A.** MORPHOLOGY AND HISTOLOGY OF ACANTHODIAN FIN-SPINES FROM THE LATE SILURIAN OF SWEDEN
- 46 **Scott, B., Wilson, M.** A NEW CLADE OF OSTEOSTRACANS FROM THE MACKENZIE MOUNTAINS, NWT, CANADA AND EVIDENCE FOR A DISPERSAL OF OSTEOSTRACANS FROM EUROPE INTO NORTHERN CANADA
- 47 **Derycke, C., Goujet, D.** EARLY DEVONIAN VERTEBRATE FROM SOUTH AHAGGAR (SOUTHERN ALGERIA): NEW OBSERVATIONS ON THE HISTOLOGY OF EARLY CHONDRICHTHYAN SCALES
- 48 **Laurini, C., Langer, M., Richter, M.** CHONDRICHTHYAN TEETH FROM THE RIO DO RASTO FORMATION, PERMIAN OF BRAZIL
- 49 **Ivanov, A.** TOOTH MORPHOLOGY AND DISTRIBUTION OF THE LATE PALEOZOIC ANACHRONISTID SHARKS
- 50 **Fack, F., Derycke, C.** DENTAL WEAR ON HOLOCEPHALAN TEETH
- 51 **Popov, E., Ward, D., Lepage, G.** THE DIVERSITY AND NOMENCLATURAL REVISION OF THE HOLOCEPHALIAN FISHES (CHIMAERIFORMES) FROM THE KIMMERIDGIAN (LATE JURASSIC) OF WESTERN EUROPE
- 52 **Fischer, J., Voigt, S., Buchwitz, M., Schneider, J.** THE SELACHIAN FAUNA FROM THE NON-MARINE MIDDLE TO LATE TRIASSIC MADYGEN FORMATION (KYRGYZSTAN, CENTRAL ASIA): PRELIMINARY RESULTS
- 53 **Underwood, C., Cumbaa, S.** CHONDRICHTHYANS FROM A CANADIAN CENOMANIAN BONEBED; IMPLICATIONS FOR FAUNAL PROVINCIALITY OF THE WESTERN INTERIOR SEAWAY.
- 54 **Newbrey, M., Cook, T., Wilson, M., Neuman, A., Takeuchi, G.** GROWTH CHARACTERISTICS OF SOME LATE CRETACEOUS LAMNIFORMS (ELASMOBRANCHII) OF NORTH AMERICA

- 55 **Schroeter, E., Lacovara, K.** *CRETALAMNA APPENDICULATA* (LAMNIFORMES: CRETOXYRHINIDAE) TEETH FROM THE PARI AIKE FORMATION (MAASTRICHTIAN) OF SANTA CRUZ PROVINCE, ARGENTINA
- 56 **Wasson, H., Breed, C., Sankey, J.** PALEOECOLOGY OF *LONCHIDION SELACHOS* FROM THE LATEST CRETACEOUS HELL CREEK FORMATION, NORTH DAKOTA
- 57 **Frampton, E., Hills, L.** TOOTH WEAR OF *MYLEDAPHUS* (CHONDRICHTHYES, RAJIFORMES) AS A RESULT OF DUROPHAGOUS FEEDING FROM THE LATE CRETACEOUS FOREMOST FORMATION, ALBERTA, CANADA
- 58 **Janus, T., Stidham, T.** DIVERSITY AND MASS EXTINCTION OF CHONDRICHTHYANS AT THE K-T BOUNDARY: EVIDENCE FROM EASTERN TEXAS
- 59 **Adolfssen, J.** CROSSING THE BOUNDARY: INSIGHTS ON AN ELASMOBRANCH RECOVERY FAUNA
- 60 **Pimiento, C., Ehret, D., MacFadden, B.** PANAMA AS A PALEO-NURSERY AREA FOR GIANT SHARK BABIES (*C. MEGALODON*)
- 61 **Sun, Z., Hao, W., Tintori, A., Jiang, D., Lombardo, C.** EARLIEST HYPHOSOMATIC NEOPTERYGIANS (PISCES, ACTINOPTERYGII) FROM THE MIDDLE TRIASSIC (ANISIAN) OF YUNNAN PROVINCE, SOUTH CHINA
- 62 **Sferco, E., Rauhut, O., López-Arbarello, A.** THE LATE JURASSIC FISH ASSEMBLAGE FROM THE CANADON CALCAREO FORMATION OF PATAGONIA.1}-->
- 63 **Berrell, R., Alvarado-Ortega, J., Yabumoto, Y., Signore, M., Salisbury, S.** AN ALMOST COMPLETE ICHTHYODECTIFORM FISH FROM THE EARLY CRETACEOUS (ALBIAN) OF PIETRAROJA, SOUTHERN ITALY
- 64 **Ikegami, N.** ACTINOPTERYGIAN FRESHWATER FISHES FROM THE UPPER CRETACEOUS MIFUNE GROUP, KUMAMOTO PREFECTURE, JAPAN
- 65 **Zhang, J.** A LATE CRETACEOUS OSTEOGLOSSOMORPH FISH FROM NORTHEAST CHINA
- 66 **Gulyas, P.** THE FISH FAUNA OF THE LATE CRETACEOUS (SANTONIAN) CONTINENTAL VERTEBRATE LOCALITY OF IHARKUT (BAKONY MOUNTAINS, HUNGARY)
- 67 **Gottfried, M., Ostrowski, S.** A SURPRISING AMIID FISH FROM THE LATE CRETACEOUS OF MADAGASCAR
- 68 **Otero, O.** CENOZOIC FRESHWATER FISH OF AFRICA, FROM THE FOSSIL RECORD TO THE PAST DIVERSITY
- 69 **Odunze, S., Stevens, N., Stevens, N., Obi, G., Eastman, J.** PALEOCENE ICHTHYOFAUNA AND PALEOENVIRONMENTAL SETTING, IMO FORMATION, SOUTHEASTERN NIGERIA
- 70 **Darras, L., Purnell, M., Hart, P., Baines, D., Turingan, R.** MICROTTEXTURAL ANALYSIS OF DENTAL MICROWEAR IN FOSSIL AND EXTANT FISHES
- 71 **Storrs, G., Holland, T.** PRELIMINARY OBSERVATIONS ON A GIANT SARCOPTERYGIAN (RHIZODONTIDA) FROM THE UPPER MISSISSIPPIAN (CHESTERIAN) OF KENTUCKY, USA
- 72 **Vietti, L., Fox, D., Rogers, R.** TAPHONOMIC PATTERNS IN THE MARINE VERTEBRATE RECORD OVER THE PHANEROZOIC: A DATABASE APPROACH
- 73 **Britt, B., Scheetz, R., Eberth, D., Greenhalgh, B., Dangerfield, A.** DEBRIS FLOW-HOSTED BONEBEDS - INSIGHTS PROVIDED BY THE BASAL CEDAR MOUNTAIN FORMATION (APTIAN, LOWER CRETACEOUS) OF UTAH
- 74 **Domingo, M., Alberdi, M. T., Azanza, B., Silva, P., Morales, J.** PRELIMINARY RESULTS ON THE TAPHONOMY OF THE MIOCENE CARNIVORE-TRAP SITE OF BATALLOÑES-1 (LOWER LEVEL; MN10; MADRID BASIN, SPAIN)
- 75 **Browne, I.** A PRELIMINARY REVIEW OF THE ANTHROPOGENIC BIASES INHERENT TO PALEOBIOLOGICAL DATABASES
- 76 **Voss, M.** NEW ASPECTS ON INNERSPECIFIC VARIATION IN THE GENUS *HALITHERIUM* (MAMMALIA: SIRENIA)

- 77 **Vitkovski, T., Beatty, B., Lambert, O.** NEW INSIGHTS ON THE BRAIN, TOOTH DEVELOPMENT, AND FEEDING SPECIALIZATIONS OF THE SIRENIAN *MIOSIREN KOCKI* (TRICHECHIDAE, SIRENIA) AS REVEALED BY CT
- 78 **Lehmann, T., Dunsworth, H., Harcourt-Smith, W., McNulty, K.** A JUVENILE SPECIMEN OF *AFROHYRAX CHAMPIONI* (MAMMALIA, HYRACOIDEA) FROM RUSINGA ISLAND (EARLY MIOCENE, KENYA)
- 79 **Tabuce, R.** EVOLUTION OF ENAMEL MICROSTRUCTURE IN HYRACOIDEA (MAMMALIA, AFROTHERIA)
- 80 **Calandra, I., Göhlich, U., Kaiser, T., Schulz, E., Merceron, G.** FEEDING HABITS OF A PROBOSCIDEAN COMMUNITY FROM THE MIOCENE OF GERMANY: EVIDENCE FROM DENTAL MICROWEAR ANALYSIS
- 81 **Herridge, V., Lister, A.** A CRETAN MAMMOTH? USING MORPHOLOGY TO RESOLVE AN ANCIENT DNA DEBATE
- 82 **Drs. Liscaljet, N.** A PYGMY ELEPHANTS SHADOW IS GREATER WITH THE SETTING SUN A SURVEY OF THE MEDITERRANEAN INSULAR ELEPHANTS AND A BIOMETRICAL COMPARISON OF THE PHILIPPINE ELEPHANT MATERIAL
- 83 **Farrell, A., Shaw, C.** A PRELIMINARY DESCRIPTION OF AN UNUSUALLY COMPLETE SPECIMEN OF *MAMMUTHUS COLUMBI* FROM RANCHO LA BREA, LOS ANGELES, CALIFORNIA
- 84 **Van der Made, J., Gómez de Soler, B., Campeny Vall-Iloera, G., Oms, O., Blain, H.** THE LARGE MAMMALS OF THE NEW PLIOCENE FOSSIL LOCALITY OF CAMP DELS NINOTS (SPAIN)
- 85 **Wagner, J., Cermak, S., Horacek, I., Fejfar, O., Mihevc, A.** NEW MAMMALIAN FOSSIL RECORDS REFINING A VIEW ON EARLY/LATE PLIOCENE FAUNAL TURNOVER IN CENTRAL EUROPE
- 86 **Agustí, J., Blain, H., Furió, M., de Marfa, R., Santos-Cubedo, A.** THE LATE PLIOCENE-EARLY PLEISTOCENE SMALL VERTEBRATE SUCCESSION FROM THE GUADIX-BAZA BASIN (SE SPAIN)
- 87 **Rincón, A., Chávez-Aponte, E., Aguero, A.** FIRST RECORD OF A PLEISTOCENE VERTEBRATE ASSEMBLAGE IN THE LLANOS OF VENEZUELA
- 88 **Kaiser, T., Strait, D., Mangini, A., Rudolph, B., Mwamolowe, K.** NEW FOSSIL-BEARING PLEISTOCENE CAVE BRECCIAS FROM ZAMBIA (CENTRAL AFRICA)
- 89 **Mancheño, M., Agustí, J., Blain, H., Laplana, C., Sevilla, P.** THE SMALL VERTEBRATE ASSOCIATION FROM QUIBAS (MURCIA, SPAIN) AND THE ENVIRONMENTAL CONTEXT OF EARLY HUMAN DISPERSAL IN WESTERN EUROPE
- 90 **Lewis, P., Kennedy, A., de Ruiter, D., Brophy, J.** PRELIMINARY ANALYSIS OF THE SMALL MAMMAL FAUNA FROM MATJHABENG, FREE STATE, SOUTH AFRICA
- 91 **Madurell-Malapeira, J., Alba, D., Moyà-Solà, S.** CARNIVORA FROM THE LATE EARLY PLEISTOCENE OF CAL GUARDIOLA (TERRASSA, VALLES-PENEDES BASIN, CATALONIA, SPAIN).
- 92 **Ramon-del-Rio, D., Cuenca-Bescós, G., Canudo, J.** A SPOTTED HYENA DEN FROM THE MIDDLE PLEISTOCENE OF TERUEL (NE SPAIN)
- 93 **López-García, J., Blain, H., Cuenca-Bescós, G.** BIOTIC RESPONSE TO THE LATE GLACIAL MAXIMUM IN SOUTHERN EUROPE
- 94 **Louys, J., Meijaard, E.** RECONSTRUCTION OF PLEISTOCENE SOUTHEAST ASIAN ENVIRONMENTS THROUGH MEGAFUNA COMMUNITY ANALYSIS

## THURSDAY MORNING, SEPTEMBER 24, 2009

### SYMPOSIUM: LATE TRIASSIC TERRESTRIAL BIOTAS AND THE RISE OF DINOSAURS

CHEMISTRY BUILDING, LECTURE ROOM 1

MODERATORS: Richard Butler, Randall Irmis, Max Langer

- 8:00 **Fraser, N., Sues, H.** AN OVERVIEW OF LATE TRIASSIC TERRESTRIAL FAUNAL AND FLORAL CHANGE
- 8:15 **Parker, W., Martz, J.** CONSTRAINING THE STRATIGRAPHIC POSITION OF THE LATE TRIASSIC (NORIAN) ADAMANIAN-REVUELTIAN FAUNAL TRANSITION IN THE CHINLE FORMATION OF PETRIFIED FOREST NATIONAL PARK, ARIZONA
- 8:30 **Olsen, P.** IMPLICATIONS OF THE NEWARK BASIN ASTROCHRONOLOGY AND GEOMAGNETIC POLARITY TIME SCALE (NBAGPTS) FOR THE TEMPO AND MODE OF THE EARLY DIVERSIFICATION OF THE DINOSAURIA
- 8:45 **Abdala, F.** CYNODONT DIVERSITY TRENDS IN THE TRIASSIC-EARLY JURASSIC
- 9:00 **Gower, D., Butler, R., Hill, T., Brusatte, S., Wilkinson, M.** EARLY MESOZOIC ARCHOSAUR PHYLOGENETICS-PROGRESS AND CONSENSUS?
- 9:15 **Nesbitt, S.** THE ANTIQUITY OF ARCHOSAURIA AND THE ORIGIN OF LATE TRIASSIC ARCHOSAUR ASSEMBLAGES
- 9:30 **Brusatte, S., Lloyd, G., Wang, S., Benton, M., Ruta, M.** TRIASSIC ARCHOSAUR MACROEVOLUTION AND THE ASCENT OF DINOSAURS
- 9:45 **Irmis, R.** EVALUATING HYPOTHESES FOR THE EARLY DIVERSIFICATION OF DINOSAURS
- 10:00 **BREAK**
- 10:15 **Langer, M., Bittencourt, J.** NON-DIAGNOSTIC TRAITS OF DINOSAURIA
- 10:30 **Benton, M., Walker, A.** THE ENIGMATIC LATE TRIASSIC REPTILE *SALTOPUS*
- 10:45 **Sulej, T.** EARLY DINOSAURS WITHIN THE VERTEBRATE ASSEMBLAGES OF THE GERMANIC BASIN, AND THE PALEOECOLOGY OF THE LATE TRIASSIC ECOSYSTEMS OF POLAND
- 11:00 **Ezcurra, M., Novas, F.** GUAIBASAURIDAE, A NEW CLADE OF TRIASSIC BASAL SAUROPODOMORPHS
- 11:15 **Novas, F., Chatterjee, S., Ezcurra, M., Kuttly, T.** NEW DINOSAUR REMAINS FROM THE LATE TRIASSIC OF CENTRAL INDIA
- 11:30 **Yates, A., Wedel, M., Bonnan, M.** THE EARLY EVOLUTION OF POSTCRANIAL PNEUMATICITY IN SAUROPODOMORPH DINOSAURS: NEW EVIDENCE FROM SOUTH AFRICA
- 11:45 **Butler, R., Porro, L., Galton, P., Barrett, P., Norman, D.** THE DIVERSITY AND PHYLOGENETIC POSITION OF HETERODONTOSAURIDAE: IMPLICATIONS FOR THE EARLY ORNITHISCHIAN DINOSAUR RADIATION
- 12:00 **Barrett, P., Butler, R., Nesbitt, S.** HERBIVORY AND THE EARLY EVOLUTION OF DINOSAURIA

### ROMER PRIZE SESSION

WILLS MEMORIAL BUILDING, GREAT HALL

MODERATOR: David Fox, Leon Claessens

- 8:00 **Tulu, Y.** EXPERIMENTAL TAPHONOMY: IMPLICATIONS FOR THE FOSSIL RECORD AND PALEOENVIRONMENTAL INTERPRETATION
- 8:15 **Kubo, T.** EVOLUTION OF LIMB POSTURE IN TERRESTRIAL TETRAPODS INFERRED FROM PERMIAN AND TRIASSIC TRACKWAYS
- 8:30 **Loewen, M.** FUNCTIONAL SHIFTS DURING GROWTH IN THE LATE JURASSIC THEROPOD DINOSAUR *ALLOSAURUS*: THE IMPLICATIONS OF ONTOGENETIC VARIATION

- 8:45 **D'Amore, D.** PREDICTING BODY SIZE IN THEROPOD DINOSAURS USING STRIATED TOOTH MARKS ON BONE: A MODEL BASED ON FEEDING OBSERVATIONS OF THE KOMODO MONITOR, *VARANUS KOMODOENSIS*
- 9:00 **Kammerer, C.** EFFECTS OF THE PERMO-TRIASSIC MASS EXTINCTION ON SYNAPSID DISPARITY OVER TIME
- 9:15 **Boisvert, C.** THE ORIGIN OF TETRAPOD LIMBS AND GIRDLES: FOSSIL AND DEVELOPMENTAL EVIDENCE
- 9:30 **Mannion, P.** A MULTIDISCIPLINARY APPROACH TO ELUCIDATING THE EFFECTS OF SAMPLING BIASES ON DIVERSITY: IMPLICATIONS FOR SAUROPODOMORPH DINOSAURS
- 9:45 **Sigurdson, T.** THE FIRST COMPLETE SKELETAL DESCRIPTION OF THE PUTATIVE STEM LISSAMPHIBIAN *DOLESERPETON* (TEMNOSPONDYLI: DISSOROPHOIDEA) SHEDS NEW LIGHT ON THE ORIGIN OF MODERN AMPHIBIANS
- 10:00 **BREAK**
- 10:15 **Blois, J.** SIGNIFICANT EFFECTS OF THE LATE PLEISTOCENE-HOLOCENE TRANSITION ON SMALL MAMMALS
- 10:30 **DeSantis, L.** EFFECTS OF CLIMATE CHANGE ON AUSTRALIAN MEGAFUNA DURING THE PLEISTOCENE: EVIDENCE FROM STABLE ISOTOPES OF HERBIVOROUS MARSUPIALS AT CUDDIE SPRINGS
- 10:45 **Habib, M.** SKELETAL ARCHITECTURE, LAUNCH DYNAMICS, AND MECHANICAL LIMITS OF FLYING VERTEBRATES
- 11:00 **Biasatti, D.** PALEOENVIRONMENTS AND PALEOECOLOGIES OF CENOZOIC MAMMALS FROM FIVE REGIONS IN WESTERN CHINA BASED ON STABLE CARBON AND OXYGEN ISOTOPES
- 11:15 **Green, J.** THE UTILITY OF ORTHODENTINE MICROWEAR AS A PROXY FOR PALEOECOLOGY IN SYNAPSID
- 11:30 **Sakamoto, M.** MYOLOGY AND FUNCTIONAL MORPHOLOGY OF BITING IN AVIAN AND NON-AVIAN DINOSAURS
- 11:45 **Bates, K.** PREDICTING SPEED, GAIT AND METABOLIC COST OF LOCOMOTION IN THE LARGE PREDATORY DINOSAUR *ACROCANTHOSAURUS* USING EVOLUTIONARY ROBOTICS
- 12:00 **Friedman, M.** ASSEMBLING MODERN BIODIVERSITY: DEEP-TIME PERSPECTIVES ON A FORGOTTEN VERTEBRATE RADIATION

**SYMPOSIUM: THE EVOLUTION OF BIRDS IN THE MESOZOIC:  
A SYMPOSIUM IN HONOR OF CYRIL A. WALKER  
CHEMISTRY BUILDING, LECTURE ROOM 2  
MODERATORS: Gareth Dyke, Larry Martin**

- 8:00 **Clarke, J.** THE MESOZOIC RECORD OF ORNITHURINE BIRDS AND THE ORIGIN OF AVES
- 8:15 **O'Connor, J., Chiappe, L., Bell, A.** A COMPREHENSIVE PHYLOGENY OF MESOZOIC BIRDS
- 8:30 **Nudds, R., Dyke, G.** ESTIMATING THE FLIGHT CAPABILITIES OF EXTINCT MESOZOIC BIRDS FROM THEIR PRIMARY FEATHER MORPHOLOGY
- 8:45 **Bell, A., Chiappe, L., O'Connor, J.** ECOLOGICAL DIVERSITY OF MESOZOIC BIRDS: MORPHOMETRIC ANALYSIS WITH A PHYLOGENETIC PERSPECTIVE
- 9:00 **Chinsamy-Turan, A.** THE BONE MICROSTRUCTURE OF MESOZOIC BIRDS
- 9:15 **Zhou, Z., Zhang, F., Li, Z.** A NEW BASAL ORNITHURINE BIRD FROM THE LOWER CRETACEOUS OF CHINA
- 9:30 **Stidham, T.** LATEST CRETACEOUS PRESBYORNITHIDS (ANSERIFORMES) FROM NORTH AMERICA
- 9:45 **Harris, J., Lamanna, M., Li, D., You, H.** AVIAN CRANIAL MATERIAL AND CRANIAL CERVICAL VERTEBRAE FROM THE LOWER CRETACEOUS XIAGOU FORMATION OF GANSU PROVINCE, CHINA

- 10:00 **BREAK**
- 10:15 **Fiorillo, A., Hasiotis, S., Kobayashi, Y.** BIRD TRACKS FROM THE UPPER CRETACEOUS CANTWELL FORMATION OF DENALI NATIONAL PARK ALASKA: A NEW PERSPECTIVE ON ANCIENT NORTHERN POLAR VERTEBRATE BIODIVERSITY
- 10:30 **Walsh, S., Milner, A.** *HALCYORNIS TOLIAPICUS* (LOWER EOCENE, ENGLAND) INDICATES ADVANCED NEUROMORPHOLOGY IN MESOZOIC NEORNITHES
- 10:45 **Varricchio, D., Moore, J., Jackson, F., Borkowski, J., Erickson, G.** MESOZOIC PATERNITY SUIT: PARENTAL CARE IN AVIAN ANCESTORS
- 11:00 **Lamanna, M., Li, D., Harris, J., Atterholt, J., You, H.** EXCEPTIONALLY PRESERVED ENANTIORNITHES (AVES: ORNITHOTHORACES) FROM THE EARLY CRETACEOUS OF NORTHWESTERN CHINA
- 11:15 **Marugán-Lobón, J., Chiappe, L.** MORPHOMETRICS AS A PROXY FOR DEDUCING THE LIFE-HISTORY OF THE EARLY CRETACEOUS BIRD *CONFUCIUSORNIS SANTUS*
- 11:30 **Lindow, B.** EARLY-MIDDLE EOCENE BIRDS FROM THE LILLEBAELT CLAY FORMATION OF DENMARK
- 11:45 **Ksepka, D., Clarke, J.** A NEW FOSSIL MOUSEBIRD (AVES: COLIIFORMES) WITH FEATHER PRESERVATION: INSIGHT INTO THE ECOLOGICAL DIVERSIFICATION OF THE EOCENE NORTH AMERICAN AVIFAUNA
- 12:00 **Meijer, H., Due, R.** A NEW SPECIES OF GIANT MARABOU FROM THE LATE PLEISTOCENE OF FLORES (INDONESIA)

### PREPARATORS' SESSION

CHEMISTRY BUILDING, LECTURE ROOM 3

MODERATORS: Bill Sanders, Kyle Davies

- 8:00 **Hanta, R., Ratanasthien, B., Jintasakul, P., Kunimatsu, Y.** CONTINUAL DESTRUCTION OF PYRITIZED BONES OF NEOGENE MAMMALIAN FOSSIL FROM NORTHEASTERN THAILAND
- 8:15 **Padilla, C., Parra, M.** ACID PREPARATION OF FOSSILS USING SULFAMIC ACID, A WEAK ORGANIC ACID, AND ITS ADVANTAGES OVER ACETIC AND FORMIC ACID PREPARATION
- 8:30 **Rasal, S., Barco, J., Castilla, D., López, O., Rubio, J.** FUENTESALVO SITE (VILLAR DEL RIO, SORIA), THE FIRST ACCESSIBLE DINOSAUR TRACKSITE TO THE HANDICAPPED IN SPAIN
- 8:45 **Moros, A., Barco, J., Canudo, J., Cuenca-Bescós, G., Sauque, V.** APPLYING TECHNIQUES OF DIGITALIZATION USING STRUCTURED WHITE LIGHT AND MODELLING BY SINTERING TO REPLICATE VERTEBRATE FOSSILS
- 9:00 **Roth, D.** SKETCHING IT: USING DIGITAL PHOTOS, DRAWINGS, AND ARTIST SOFTWARE TO MAP A FIELD JACKET DURING PREPARATION
- 9:15 **Groenke, J.** MITIGATING STRESS AND STRAIN WHILE DE-MOLDING DELICATE SPECIMENS FROM THE LATE CRETACEOUS MAEVARANO FORMATION OF MADAGASCAR
- 9:30 **Johnson, M., Mustansar, Z., Manning, P., Margetts, L., Mummery, P.** VIRTUAL REPAIR OF FOSSIL CT SCAN DATA
- 9:45 **Cherney, M., Sanders, W., Gingerich, P., Zalmout, I., Antar, M.** PRODUCTION OF MULTI-PURPOSE MOLDS FOR VERSATILE, DETAILED REPLICATION OF LARGE-SCALE FOSSILS: THE *BASILOSaurus* *ISIS* CASTING PROJECT AS AN EXEMPLAR
- 10:00 **BREAK**
- 10:15 **Fitzgerald, E., Sereno, P., Keillor, T., Abraczinskas, C., Masek, R.** FOSSIL VERTEBRATE RECONSTRUCTION FOR SCIENCE AND THE PUBLIC
- 10:30 **Fox, M., Fitzgerald, V., Turner, M.** MOVING VERTEBRATE PALEONTOLOGY COLLECTIONS AND PREPARATION LABORATORY AT THE YALE PEABODY MUSEUM
- 10:45 **Balcarcel, A., Conrad, J.** EXTRACTION OF FOSSILS FROM MUCH HARDER, VOLCANICLASTIC MATRIX

- 11:00 **Herzog, L., Shinya, A.** EFFECTIVE MICROPREPARATION WORKSTATION SETUP
- 11:15 **Jabo, S., Brown, M., Reser, P., Holland, M., Smith, M.** STOCKING THE FISHBOWL: A PROGRAM TO TEACH NEW EXHIBIT LAB VOLUNTEERS THE BASICS IN FOSSIL PREPARATION, MOLDING, AND CASTING
- 11:30 **Brown, M., Smith, M., Jabo, S.** TRAINING AND EVALUATION OF VOLUNTEER FOSSIL PREPARATORS IN THE SMITHSONIAN FOSSILAB PROGRAM

## THURSDAY AFTERNOON, SEPTEMBER 24, 2009

### TECHNICAL SESSION VI

**CHEMISTRY BUILDING, LECTURE ROOM 1**

**MODERATORS: Robert Carroll, Emmanuel Fara**

- 1:45 **Tsuji, L., Müller, J.** *DELTAUVJATIA VJATKENSIS* AND THE ANATOMY OF PAREIASAURIA
- 2:00 **Säilä, L.** THE INTERRELATIONSHIPS, PALEOBIOGEOGRAPHY AND THE P-TR EXTINCTION EVENT SURVIVAL RATE OF THE PARAREPTILE CLADE PROCOLOPHONOIDEA
- 2:15 **Carroll, R.** SEARCH FOR THE ANCESTRY OF TURTLES
- 2:30 **Werneburg, I., Hugi, J., Mitgutsch, C., Müller, J., Sánchez-Villagra, M.** EMBRYOLOGICAL EVIDENCE FOR A BASAL POSITION OF TURTLES WITHIN AMNIOTA
- 2:45 **Lyson, T., Joyce, W.** SPECIES LEVEL RESPONSE OF BAENID TURTLES ACROSS THE CRETACEOUS/TERTIARY BOUNDARY
- 3:00 **Wings, O., Joyce, W.** AN EXCEPTIONALLY LARGE JURASSIC TURTLE TAPHOCOENOSIS FROM XINJIANG AUTONOMOUS PROVINCE, CHINA
- 3:15 **Knell, M.** EXPERIMENTS IN ACTUALISTIC TAPHONOMY USING MODERN FRESHWATER TURTLE REMAINS FOR INTERPRETING FOSSIL TURTLE LOCALITIES IN FLUVIAL DEPOSITIONAL ENVIRONMENTS
- 3:30 **Jacobs, L., Polcyn, M., Mateus, O., Schulp, A., Neto, A.** THE CRETACEOUS SKELETON COAST OF ANGOLA
- 3:45 **Fara, E., Feitosa, A.** STRATIGRAPHY AND VERTEBRATE DIVERSITY OF THE SANTANA FORMATION (LOWER CRETACEOUS, BRAZIL) : TWO CENTURIES OF MISAPPRECIATION

### TECHNICAL SESSION VII

**WILLS MEMORIAL BUILDING, GREAT HALL**

**MODERATORS: Darin Croft, Patricia Holroyd**

- 1:45 **Gill, P., Rayfield, E., Purnell, M., Robson-Brown, K., Gostling, N.** A FUNCTIONAL INVESTIGATION INTO THE DIETARY ECOLOGY OF TWO OF THE EARLIEST STEM MAMMALS, *MORGANUCODON WATSONI* AND *KUEHNEOTHERIUM PRAECURSORIS*
- 2:00 **Anderson, P., Gill, P., Rayfield, E.** HOW THE CINGULA OF BASAL MAMMAL TEETH MAY ALLEVIATE STRAIN IN THE ENAMEL CAUSED BY A SOFT FOOD DIET
- 2:15 **Cobb, S., Meloro, C.** FITTING TEETH IN BENDING JAWS: DO THE SPATIAL DEMANDS OF THE DEVELOPING DENTITION AFFECT THE UTILITY OF THE MANDIBLE IN RECONSTRUCTING DIET?
- 2:30 **Colbert, M.** ONTOGENETIC SEQUENCE ANALYSIS (OSA) OF TOOTH ERUPTION AND SUTURE CLOSURE IN *TAPIRUS* (MAMMALIA: PERISSODACTYLA): IMPLICATIONS FOR ASSESSING SEQUENCES IN FOSSIL SAMPLES
- 2:45 **Holroyd, P.** NEW DATA ON DENTAL ERUPTION PATTERNS IN AFROTHERIANS AND PALEOGENE MAMMALS

- 3:00 **Schulz, E., Calandra, I., Kaiser, T.** THREE-DIMENSIONAL MICROTTEXTURE ANALYSIS - A NEW APPROACH FOR DIETARY RECONSTRUCTION
- 3:15 **Bunn, J., Boyer, D., Jernvall, J., Lipman, Y., Daubechies, I.** WHO CARES WHICH WAY IS UP? AN ORIENTATION AND LANDMARK-FREE QUANTIFICATION OF TOOTH SHAPE
- 3:30 **Croft, D., Neimi, K.** DOES INCISOR MORPHOLOGY CORRELATE WITH DIET IN CAVIOMORPH RODENTS?
- 3:45 **Rinaldi, C., Martin, L., Cole III, T., Timm, R.** OCCLUSAL WEAR MORPHOLOGY OF GIANT BEAVER (*CASTOROIDES*) LOWER INCISORS: FUNCTIONAL AND PHYLOGENETIC IMPLICATIONS

**TECHNICAL SESSION VIII**  
**CHEMISTRY BUILDING, LECTURE ROOM 2**  
**MODERATORS: Sara Burch, Sarah Werning**

- 1:45 **Alroy, J.** BAYESIAN ESTIMATES OF ORIGINATION DATES FOR CROWN-GROUP BIRDS, PLACENTALS, AND PRIMATES
- 2:00 **Terry, D., Grandstaff, D.** ARE LANTHANIDE ELEMENT RATIOS IN FOSSIL BONES PALEOCLIMATE INDICATORS IN TERRESTRIAL ENVIRONMENTS?
- 2:15 **Werning, S.** THE INTERPLAY OF LIFE HISTORY AND PHYLOGENY IN THE LONG BONE HISTOLOGY OF LARGE FLIGHTLESS BIRDS
- 2:30 **Burch, S.** THE UTILITY OF OSTEOLOGICAL CORRELATES OF MUSCLE ATTACHMENT IN THE RECONSTRUCTION OF LOCOMOTORY MODES OF EXTINCT BIRDS
- 2:45 **Rayfield, E.** HOW MUCH CAN WE INFER FROM FINITE ELEMENT MODELS OF EXTINCT TAXA? A VALIDATION STUDY OF STRAIN IN THE OSTRICH MANDIBLE
- 3:00 **Bonnan, M., Sandrik, J., Nishiwaki, T., Wilhite, D., Elsey, R.** CALCIFIED CARTILAGE SHAPE IN EXTANT ARCHOSAUR LONG BONES REFLECTS OVERLYING JOINT SHAPE IN LOAD-BEARING ELEMENTS: IMPLICATIONS FOR INFERRING DINOSAUR JOINT SHAPE
- 3:15 **Dufeu, D., Witmer, L.** ANATOMICAL BOUNDARIES OF THE MIDDLE-EAR SPACE OF ARCHOSAURS-PHYLOGENETIC PATTERNS AND IMPLICATIONS FOR AUDITORY FUNCTION
- 3:30 **Tütken, T., Rollion-Bard, C., Sander, M.** ION PROBE INTRA-BONE OXYGEN ISOTOPE ANALYSIS - IMPLICATIONS FOR ARCHOSAUR GROWTH AND BIOMINERALIZATION
- 3:45 **Kilbourne, B.** THE SCALING OF LIMB ROTATIONAL INERTIA IN EXTANT MAMMALS: A FIRST STEP IN RECONSTRUCTING LIMB MORPHOLOGY AND LOCOMOTION IN EXTINCT MAMMALS AND DINOSAURS

**TECHNICAL SESSION IX**  
**CHEMISTRY BUILDING: LECTURE ROOM 3**  
**MODERATORS: Kay Behrensmeyer, Jason Moore**

- 1:45 **Bryk, A., Eccles, L., Kita, Z.** TAPHONOMY OF A FLUVIALLY DERIVED BONE DEPOSIT: A NATURAL EXPERIMENT IN THE SANTA FE RIVER, FL
- 2:00 **Behrensmeyer, A.** BONE BURIAL IN LAND SURFACE ASSEMBLAGES AND ITS IMPACT ON THE VERTEBRATE FOSSIL RECORD
- 2:15 **Miller, J.** COMPARING ECOLOGICAL DATA FROM DIFFERENT DEPOSITIONAL ENVIRONMENTS
- 2:30 **Moore, J.** INSIGHTS INTO THE PRESERVATIONAL PATTERNS OF VERTEBRATE FOSSILS IN A FLUVIAL SYSTEM USING A TWO-DIMENSIONAL COMPUTER MODEL
- 2:45 **Smith, K.** A LIKELIHOOD APPROACH TO THE SECONDARY ASSOCIATION OF ISOLATED VERTEBRATE REMAINS
- 3:00 **Falkingham, P.** DIVERSITY IN FOSSIL VERTEBRATE TRACK ASSEMBLAGES: PRESERVATIONAL BIAS DUE TO SEDIMENT CONSISTENCY AND ANIMAL MASS.

- 3:15 **Keenan, S.** RARE EARTH ELEMENTS AND RATES OF FOSSILIZATION IN VERTEBRATE BONES
- 3:30 **Noto, C.** THE POTENTIAL UTILITY OF AUTHIGENIC MINERALS ON MODERN AND FOSSIL BONES FOR ENVIRONMENTAL AND TAPHONOMIC ANALYSIS
- 3:45 **Manthi, F.** THE TAPHONOMY OF TWO MICROFAUNAL FOSSIL ASSEMBLAGES FROM NORTHWESTERN KENYA

## POSTER SESSION II

**Authors must be present from 4:00 - 6:00 p.m.**

**Posters must be removed by 6:15 p.m.**

- 1 **Carls, P., Moros, A., Perruca, R., Lorente, J., Barco, J.** THE TECHNIQUE OF IMMERSION IN ACID AS APPLIED TO THE PREPARATION OF A PLACODERM FISH FROM THE LOWER GIVETIAN (DEVONIAN) OF LOSCOS (TERUEL, SPAIN)
- 2 **De La Paz, H., Buchy, M.** A COLLECTION OF MODELS OF MEXICAN LATE JURASSIC MARINE REPTILES AT A 1:10 SCALE
- 3 **Potts, R., Pobiner, B.** THE SMITHSONIAN HUMAN ORIGINS INITIATIVE: RESEARCH, EXHIBITION, EDUCATION AND OUTREACH
- 4 **Davidson, A.** TEMPORARY GAP-FILLING TO STABILIZE AN EXPLODED MATRIX FOR FOSSIL PREPARATION: THE SAND AND BUTVAR B-76 TECHNIQUE
- 5 **Evander, R.** ARMATURE DAMAGE IN A MOUNTED SPECIMEN
- 6 **Conway, J.** METHODS OF PALEONTOLOGICAL RECONSTRUCTION
- 7 **Kuizon, L., Matthews, N.** BRINGING BLM RESOURCE USE PERMITTING, RESEARCH, AND MANAGEMENT TOGETHER: DEVELOPING AN INTEGRATED PALEONTOLOGICAL DATABASE SYSTEM
- 8 **Moeller, J., Dzemski, G., Christian, A.** TESTING AN EFFICIENT LASER SCAN METHOD TO DIGITIZE SAUROPOD VERTEBRAE FOR ANATOMICAL AND KINEMATIC NECK MOVEMENT SIMULATIONS
- 9 **Martin, L.** CYRIL WALKER AND THE OTHER HALF OF AVIAN EVOLUTION
- 10 **Zinoviev, A.** NOTES ON HINDLIMB MYOLOGY AND SYNDESMOLOGY OF *HESPERORNIS REGALIS* (AVES: HESPERORNITHIFORMES)
- 11 **Atterholt, J., Lamanna, M., O'Connor, J., Li, D., Ji, S.** PHYLOGENETIC AND ECOMORPHOLOGICAL CONUNDRUMS REVEALED BY AN ENIGMATIC NEW EARLY CRETACEOUS BIRD (ENANTIORNITHES) FROM NORTHWESTERN CHINA
- 12 **Close, R., Vickers-Rich, P.** AUSTRALIA'S MESOZOIC BIRDS: NEW MATERIAL FROM THE EARLY CRETACEOUS OF VICTORIA
- 13 **Galton, P., Dyke, G., Kurochkin, E.** RE-ANALYSIS OF LOWER CRETACEOUS FOSSIL BIRDS FROM THE UK REVEALS AN UNEXPECTED DIVERSITY
- 14 **Dyke, G., Osi, A., Buffetaut, E.** LARGE EUROPEAN CRETACEOUS ENANTIORNITHINES: MORPHOMETRICS, PHYLOGENETICS AND IMPLICATIONS FOR THE BIOGEOGRAPHY OF EARLY BIRDS
- 15 **Kurochkin, E., Averianov, A., Leshchinskiy, S., Zelenkov, N.** A NEW BIRD FROM THE EARLY CRETACEOUS OF WESTERN SIBERIA
- 16 **Weishampel, D., Habib, M.** FLIGHT MORPHOLOGY AND LAUNCH DYNAMICS OF BASAL BIRDS, AND THE POTENTIAL FOR COMPETITION WITH PTEROSAURS
- 17 **Wilson, L., Chin, K., Dyke, G., Cumbaa, S.** A HIGH-LATITUDE HESPERORNITHIFORM (AVES) FROM DEVON ISLAND: PALEOBIOGEOGRAPHY AND SIZE DISTRIBUTION OF NORTH AMERICAN HESPERORNITHIFORMS
- 18 **Stiegler, J., Varricchio, D., Hamrick, M.** PHALANGES, LIMBS, AND LOCOMOTOR BEHAVIOR IN MAMMALS AND THEROPODS: IMPLICATIONS FOR AVIAN ORIGINS

- 19 **Sanchez, J., Cumbaa, S., Schröder-Adams, C.** LATE CRETACEOUS (CENOMANIAN)  
HESPERORNITHIFORMES FROM THE PASQUIA HILLS, SASKATCHEWAN, CANADA
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- 21 **Sullivan, C., Hone, D., Xu, X., Zhang, F.** THE ASYMMETRIC CARPUS OF ADVANCED NON-AVIAN  
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- 91 **Stadlmayr, A., Viola, T., Kullmer, O., Sandrock, O., Seidler, H.** PLIOCENE CERCOPITHECOID SUCCESSION AT THE MOUNT GALILI FORMATION, EASTERN ETHIOPIA
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- 94 **Nelson, E., Rolian, C., Cashmore, L.** PREDICTING THE SOCIAL SYSTEMS OF EXTINCT HOMINIDS USING DIGIT RATIOS (2D:4D)
- 95 **Fitton, L., Groening, F., Cobb, S., Fagan, M., O'Higgins, P.** BIOMECHANICAL SIGNIFICANCE OF MORPHOLOGICAL VARIATION BETWEEN THE GRACILE *AUSTRALOPITHECUS AFRICANUS* (STS5) AND ROBUST *AUSTRALOPITHECUS BOISEI* (OH5)
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- 104 **Tabrum, A., Fostowicz-Frelik, L.** LAGOMORPHS FROM THE EARLY CHADRONIAN MCCARTY'S MOUNTAIN FAUNA OF SOUTHWESTERN MONTANA
- 105 **Mitchell, W., Rybczynski, N., Schröder-Adams, C., Simons, A.** A NEW APPROACH FOR THE TAXONOMIC CLASSIFICATION OF FOSSIL RABBITS (GENUS: *HYPOLAGUS*) USING EIGENSHAPE ANALYSIS
- 106 **Kraatz, B., Bibi, F., Hill, A.** NEW RODENTS FROM THE LATE MIOCENE OF THE UNITED ARAB EMIRATES
- 107 **López-Antoñanzas, R., Mein, P.** *HISPANOMYS BIJUGATUS* (RODENTIA, CRICETODONTINAE) FROM THE MIDDLE MIOCENE OF LA GRIVE-SAINT-ALBAN (FRANCE): BIOSTRATIGRAPHICAL IMPLICATIONS
- 108 **Gomez Cano, A., Hernández Fernández, M., Áelvarez-Sierra, M.** BIOCHRONOLOGY OF THE MIDDLE-LATE MIOCENE RODENT FAUNAS FROM THE IBERIAN PENINSULA
- 109 **Campbell, T., Lewis, P.** HOW USEFUL ARE *OTOMYS* (RODENTIA: OTOMYINAE) IN SOUTHERN AFRICAN PALEOENVIRONMENTAL RECONSTRUCTION OF HOMININ-BEARING LOCALITIES? RESULTS FROM A GEOGRAPHIC INFORMATION SYSTEMS (GIS) ANALYSIS OF THEIR PROXIMITY TO WATER

- 110 **Tamma, K., Ramakrishnan, U.** TRACKING THE EVOLUTION OF MUS SPECIES IN PENINSULAR INDIA USING PLEISTOCENE DEPOSITS
- 111 **Frelik, G., Fostowicz-Frelik, L.** FORERUNNER OF STEPPES: THE PLIO-PLEISTOCENE RECORD OF STEPPE PIKA (*OCHOTONA PUSILLA*, LAGOMORPHA, MAMMALIA) IN EUROPE
- 112 **Rofes, J., Cuenca-Bescós, G.** *CROCIDURA KORNFELDI*: THE TINY AND VERSATILE INTRUDER THAT COLONISED EUROPE
- 113 **Zhang, Y.** NEW PHYLOGENETIC ANALYSIS REVEALS IMPORTANT RELATIONSHIPS AMONG *PARACIMEXOMYS* GROUP, “*CIMOLODON*”, *ANCONODON*, NEOPLAGIAULACIDAE, AND CIMOLOMYDAE
- 114 **Peltonen, H.** ANALYSIS OF DIGESTION DEGREE OF FOSSIL RODENT TEETH FROM LANTIAN, SHAANXI PROVINCE, CHINA
- 115 **Oliver, A., López-Guerrero, P., García-Paredes, I., Álvarez-Sierra, M., Peláez-Campomanes, P.** EVOLUTION OF *MEGACRICETODON* TOOTH PATTERN THROUGH GEOMETRIC MORPHOMETRIC ANALYSIS
- 116 **Paloma, L., Álvarez-Sierra, M., García-Paredes, I., López-Antoñanzas, R., Oliver, A.** CRICETODONTINI (RODENTIA, MAMMALIA) FROM THE UPPER ARAGONIAN AND LOWER VALLESIAN OF THE TORIL-NOMBREVILLA SECTION (MIDDLE AND UPPER MIOCENE, CALATAYUD-DAROCA BASIN, ZARAGOZA, SPAIN)

## FRIDAY MORNING, SEPTEMBER 25, 2009

### SYMPOSIUM: MOLECULAR TOOLS IN PALEOBIOLOGY: TREES, CLOCKS AND LINKING GENO- WITH PHENOTYPE

CHEMISTRY BUILDING, LECTURE ROOM 1

MODERATORS: Robert Asher, Johannes Müller

- 8:00 **Asher, R.** “MOLECULES VS. MORPHOLOGY”: WELCOMING THE END OF AN ERA
- 8:15 **Organ, C., Janes, D., Meade, A., Pagel, M.** MOLECULES AND MORPHOLOGY IN EVOLUTIONARY GENOMICS: COMPATIBLE AND COMPULSORY
- 8:30 **Bininda-Emonds, O., MacPhee, R.** BONES VERSUS GENOMES: JUST WHEN DID PLACENTAL MAMMALS REALLY EVOLVE?
- 8:45 **Müller, J., Hipsley, C., Himmelmann, L., Metzler, D.** DIVERGENCE ESTIMATES, FOSSIL CALIBRATIONS, AND BAYESIAN INFERENCE: AN EXAMPLE FROM LIZARDS
- 9:00 **Donoghue, P., Benton, M., Yang, Z., Inoue, J.** CALIBRATING AND CONSTRAINING THE MOLECULAR CLOCK
- 9:15 **Debruyne, R., Poinar, H.** THE “TIME-DEPENDENCY OF MOLECULAR RATES OF EVOLUTION” REVISITED: HOW WELL-CALIBRATED PALEONTOLOGICAL EVIDENCE CAN CLEAR THE MESS IN THE BAYESIAN DEBATE GENERATED BY POORLY-CALIBRATED UNINFORMATIVE MOLECULAR DATA
- 9:30 **Parham, J.** A REVIEW OF TETRAPOD FOSSIL CALIBRATIONS: PROBLEMS, SOLUTIONS, AND DATABASES
- 9:45 **Brochu, C., Sumrall, C.** PHYLOGENETIC UNCERTAINTY AND CALIBRATION CHOICE: THE IMPORTANCE OF COMPREHENSIVE PHYLOGENETIC ANALYSES AND CONSIDERATION OF COMPETING ESTIMATES
- 10:00 **BREAK**
- 10:15 **Gatesy, J.** THE EVOLUTION OF CETACEA: RECIPROCAL INSIGHTS FROM MOLECULES AND FOSSILS
- 10:30 **Teeling, E.** A MOLECULAR AND MORPHOLOGICAL PERSPECTIVE ON THE EVOLUTION OF ECHOLOCATION IN BATS

- 10:45 **Beck, R.** RESOLVING THE HIGHER-LEVEL PHYLOGENY OF MARSUPIALIA USING MOLECULAR AND MORPHOLOGICAL DATA: PROGRESS, PROBLEMS AND PROSPECTS
- 11:00 **Bickelmann, C., Müller, J., Du, J., Chang, B.** INFERRING EARLY MAMMALIAN PALEOBIOLOGY FROM VERTEBRATE VISUAL PIGMENTS
- 11:15 **Tucker, A.** EVO-DEVO OF THE MIDDLE EAR: FINDING HOMOLOGIES BY LINKING MORPHOLOGY WITH GENE EXPRESSION
- 11:30 **Meredith Smith, M., Johanson, Z.** EVOLUTION OF JAWS AND TEETH
- 11:45 **Buchholtz, E.** EVOLUTIONARY PATTERNS OF VERTEBRAL VARIATION
- 12:00 **Galis, F., Metz, J.** EVOLUTIONARY NOVELTIES: THE MAKING AND BREAKING OF PLEIOTROPIC CONSTRAINTS

## TECHNICAL SESSION X

WILLS MEMORIAL BUILDING, GREAT HALL

MODERATORS: David Unwin, David Norman

- 8:00 **Whiteside, D., Marshall, J.** FAUNAL SUCCESSION OF THE LATE TRIASSIC-EARLY JURASSIC TERRESTRIAL TETRAPOD ASSEMBLAGES FROM THE FISSURE DEPOSITS OF SOUTH WESTERN BRITAIN
- 8:15 Xu, X., Hu, D. AN EXCEPTIONALLY WELL PRESERVED JURASSIC TERRESTRIAL FAUNA IN NORTHEASTERN CHINA
- 8:30 **Andres, B.** THE QUALITY OF THE PTEROSAUR FOSSIL RECORD
- 8:45 **Osi, A.** FEEDING RELATED CHARACTERS IN BASAL PTEROSAURS: IMPLICATIONS FOR JAW MECHANISM, DENTAL FUNCTION AND DIET
- 9:00 **Unwin, D., Lü, J.** BRIDGING A MAJOR EVOLUTIONARY GAP: A LONG-TAILED PTEROSAUR WITH A PTERODACTYLOID SKULL
- 9:15 **Ibrahim, N., Unwin, D., Zouhri, S., Martill, D.** DIVERSITY AND EVOLUTIONARY SIGNIFICANCE OF PTEROSAURS FROM THE EARLY LATE CRETACEOUS OF MOROCCO
- 9:30 **Vullo, R., Marugán-Lobón, J., Buscalioni, Á., Moratalla, J.** THE FIRST TAPEJARID PTEROSAUR FROM EUROPE
- 9:45 **Kellner, A., Wang, X., Tischlinger, H., Hone, D., Meng, X.** THE SOFT TISSUE OF *JEHOLOPTERUS* (PTEROSAURIA, ANUROGNATHIDAE) AND THE STRUCTURE OF THE PTEROSAUR WING MEMBRANE
- 10:00 **BREAK**
- 10:15 **Bennett, S.** THE PECTORAL GIRDLE OF *PTERODACTYLUS ANTIQUUS*-EVOLVING TOWARD THE ADVANCED CONDITION
- 10:30 **Marty, D.** SEDIMENTOLOGY, TAPHONOMY, AND ICHNOLOGY OF LATE JURASSIC DINOSAUR TRACKS FROM THE JURA CARBONATE PLATFORM (NW SWITZERLAND): INSIGHTS INTO THE TIDAL-FLAT PALAEOENVIRONMENT AND DINOSAUR DIVERSITY, LOCOMOTION, AND PALEOECOLOGY
- 10:45 **Smith, N., Turner, A., Irmis, R., Nesbitt, S.** PATTERNS IN EARLY DINOSAUR BIOGEOGRAPHY REVEALED BY QUANTITATIVE METHODS OF ANCESTRAL GEOGRAPHIC RANGE RECONSTRUCTION
- 11:00 **Stevens, K., Wills, E.** NON-PARASAGITTAL YET EFFICIENT: THE ROLE OF THE PECTORAL GIRDLES AND TRUNK IN THE WALK OF *TRICERATOPS* AND *APTOSAURUS*
- 11:15 **Burns, M.** MORPHOLOGY, HISTOLOGY, AND STRUCTURAL MECHANICS OF ANKYLOSAUR OSTEODERMS: IMPLICATIONS FOR FUNCTION AND SYSTEMATICS
- 11:30 **Moratalla, J., Marugán-Lobón, J.** ASSESSING DINOSAUR ICHNO-VARIABILITY WITH GEOMETRIC MORPHOMETRICS. THE ORNITHOPOD TRACKS FROM THE CAMEROS BASIN (LOWER CRETACEOUS, SPAIN) AS A CASE STUDY

- 11:45 **Norman, D., Crompton, A., Butler, R., Porro, L., Charig, A.** THE EARLY ORNITHISCHIAN *HETERODONTOSAURUS TUCKI*: CRANIAL ANATOMY AND RELATIONSHIPS
- 12:00 **Hübner, T.** ON THE POSTCRANIAL ONTOGENY AND PALEOBIOLOGY OF THE ORNITHOPOD DINOSAUR *DYSALOTOSAURUS LETTOWVORBECKI*.

## TECHNICAL SESSION XI

### CHEMISTRY BUILDING, LECTURE ROOM 2

**MODERATORS: Jaelyn Eberle, Matthew Mhlbachler**

- 8:00 **Hopson, J., Rich, T., Vickers-Rich, P., Gill, P., Morton, S.** DID THE CRETACEOUS MONOTREME *TEINOLOPHOS TRUSLERI* POSSESS AN INTERNAL MANDIBULAR TROUGH FOR POSTDENTARY BONES?
- 8:15 **Horovitz, I., 'Early Metatherian Study Group', E.** EXCEPTIONAL FOSSILS OF THE EARLIEST MARSUPIALS AND THE ORIGIN OF OPOSSUMS
- 8:30 **Travouillon, K., Muirhead, J., Beck, R., Gurovich, Y.** AN EXCEPTIONALLY WELL-PRESERVED SHORT-SNOUDED BANDICOOT (*MARSUPIALIA*; *PERAMELEMORPHIA*) FROM RIVERSLEIGH'S OLIGO-MIOCENE DEPOSITS, NORTHWESTERN QUEENSLAND, AUSTRALIA
- 8:45 **Kondrashov, P.** POSTCRANIAL ADAPTATIONS OF EUROPEAN ARCTOCYONIDS (MAMMALIA, ARCTOCYONIDAE)
- 9:00 **Ting, S., Clyde, W., Wang, Y., Koch, P., The, C.** CHRONOSTRATIGRAPHIC CONSTRAINED ASIAN EARLY PALEOGENE STRATA AND MAMMALIAN FAUNAL TURNOVER EVENTS
- 9:15 **Beard, K., Dawson, M.** FAUNAL PROVINCIALISM AND FAUNAL TURNOVER DURING THE PALEOCENE-EOCENE THERMAL MAXIMUM: NEW EVIDENCE FROM THE GULF COASTAL PLAIN OF MISSISSIPPI, USA
- 9:30 **Mhlbachler, M., Solounias, N., Goudiaby, I., El-Neemany, D., Wood, A.** DENTAL MICROWEAR AS AN INDICATOR OF RESPONSE TO CLIMATE CHANGE IN THE CONDYLARTH *ECTOCION* DURING THE PALEOCENE-EOCENE TRANSITION IN THE BIGHORN BASIN, WYOMING
- 9:45 **Bajpai, S., Thewissen, J.G.M., Kapur, V., Tiwari, B.** CREODONTS, ARTIODACTYLS AND CONDYLARTHS FROM EARLY EOCENE CAMBAY SHALE, VASTAN LIGNITE MINE, GUJARAT, WESTERN INDIA
- 10:00 **BREAK**
- 10:15 **Dutchak, A.** A DIVERSE NEW EARLY EOCENE (WASATCHIAN-BRIDGERIAN) MAMMALIAN FAUNA FROM THE UINTA BASIN, UTAH-COLORADO, USA
- 10:30 **Stucky, R., Chew, A., Hailu, M.** ALPHA SPECIES DIVERSITY IN EARLY-MIDDLE EOCENE MAMMALIAN COMMUNITIES (WA5-BR2) OF THE BIGHORN, BRIDGER AND WIND RIVER BASINS, WYOMING: HIGH SPECIES DIVERSITY CORRELATES WITH GLOBAL WARMING DURING THE EARLY EOCENE CLIMATIC OPTIMUM
- 10:45 **Hooker, J.** MAMMALIAN BIOSTRATIGRAPHY OF EUROPEAN LATE EOCENE TO EARLIEST OLIGOCENE CONTINENTAL STRATA: PROBLEMS AND SOLUTIONS
- 11:00 **Eberle, J., Sponheimer, M., Marchitto, T.** BIOGENIC PATTERNING OF SR AND BA IN EARLY OLIGOCENE (ORELLAN) MAMMALIAN TOOTH ENAMEL
- 11:15 **Ducrocq, S., Lihoreau, F., Tiercelin, J., Boisserie, J.** THE LOKONE FAUNA: A NEW OLIGOCENE VERTEBRATE ASSEMBLAGE FROM NORTHERN KENYA (TURKANA BASIN)
- 11:30 **Grossman, A.** NEW FAUNA FROM THE KALODIRR MEMBER, LOTHIDOK FORMATION, EARLY MIOCENE OF NORTHERN KENYA
- 11:45 **Kingston, J., MacLachy, L., Cote, S., Kityo, R., Sanders, W.** PALEOENVIRONMENTS OF EARLY MIOCENE VERTEBRATE LOCALITIES AT NPAK AND MOROTO, UGANDA: LITHOFACIES AND ISOTOPIC ANALYSES
- 12:00 **Flynn, L.** A SYNERGISTIC TIME FRAME FOR EVOLUTION OF GLIRES

## FRIDAY AFTERNOON, SEPTEMBER 25, 2009

### TECHNICAL SESSION XII

CHEMISTRY BUILDING, LECTURE ROOM 1

MODERATORS: Alexander Hastings, Laura Porro

- 1:45 **Prasad, G., Singh, K.** NEW MICROVERTEBRATE ASSEMBLAGE FROM THE CONTINENTAL UPPER TRIASSIC ROCKS OF PENINSULAR INDIA
- 2:00 **Stocker, M.** AN APOMORPHIC ASSESSMENT OF THE VERTEBRATE DIVERSITY AT THE BASE OF THE LATE TRIASSIC SEQUENCE OF TEXAS
- 2:15 **Desojo, J., Rauhut, O.** THE TAXONOMIC STATUS AND PHYLOGENETIC POSITION OF THE LATE TRIASSIC BRAZILIAN RAUISUCHIAN *PRESTOSUCHUS*
- 2:30 **Wilberg, E.** A NEW METRIORHYNCHID (CROCODYLIFORMES) FROM THE MIDDLE JURASSIC OF OREGON AND ITS IMPLICATIONS FOR CROCODYLIFORM PHYLOGENY AND HISTORICAL BIOGEOGRAPHY
- 2:45 **Clark, J., Xu, X.** SHARTEGOSUCHID CROCODYLIFORMS FROM THE LATE JURASSIC OF ASIA AND NORTH AMERICA
- 3:00 **Andrade, M.** SOLVING A CENTURY-OLD MYSTERY: THE STRUCTURE AND FUNCTION OF THE MAXILLARY DEPRESSIONS OF *GONIOPHOLIS* (CROCODYLOMORPHA, NEOSUCHIA)
- 3:15 **Martin, J., Zoltán, C., Rabi, M., Burnaz, S.** A NEW MESOEUCROCODYLIAN TAXON WITH GONDWANAN AFFINITIES FROM THE LATE CRETACEOUS OF ROMANIA
- 3:30 **Sertich, J., Kley, N., Turner, A., Georgi, J., Krause, D.** MORPHOLOGY AND SYSTEMATICS OF THE NOTOSUCHIAN CROCODYLIFORM *SIMOSUCHUS CLARKI* FROM THE LATE CRETACEOUS OF MADAGASCAR
- 3:45 **Hastings, A., MacFadden, B., Rincon, A., Montes, C., Jaramillo, C.** FILLING IN THE CENTRAL AMERICAN CROCODYLIFORM GAP: EVIDENCE FROM THE MIDDLE CENOZOIC OF PANAMA
- 4:00 **Spencer, M.** MODEL-BASED APPROACHES TO PHYLOGENY RECONSTRUCTION WITH MORPHOLOGICAL DATA: CROCODYLIA AS A TEST CASE FOR BAYESIAN INFERENCE
- 4:15 **Gignac, P., Erickson, G.** A NEONTOLOGICAL MODEL OF FEEDING BIOMECHANICS IN EXTINCT CROCODYLIANS
- 4:30 **Porro, L., Lemberg, J., Reed, D., Ross, C., Metzger, K.** FINITE ELEMENT MODELING OF *ALLIGATOR MISSISSIPPIENSIS*: MULTIDIMENSIONAL ANALYSIS, VALIDATION, AND IMPLICATIONS FOR FOSSIL TAXA
- 4:45 **Drumheller, S., Sadleir, R.** THE UTILITY OF CAPTIVE ANIMALS IN BITE MARK RESEARCH: A CASE STUDY OF *ALLIGATOR MISSISSIPPIENSIS*

### TECHNICAL SESSION XIII

WILLS MEMORIAL BUILDING, GREAT HALL

MODERATORS: Peter Dodson, Pascal Godefroit

- 1:45 **Brown, C., Russell, A., Boyd, C.** A NEW SPECIES OF *THESCÉLOSAURUS* (DINOSAURIA: ORNITHISCHIA) FROM THE FRENCHMAN FORMATION (LATE MAASTRICHTIAN) OF SASKATCHEWAN, WITH COMMENTS ON LATE CRETACEOUS ORNITHISCHIAN DIVERSITY
- 2:00 **McDonald, A., Kirkland, J., Bird, J., DeBlieux, D., Madsen, S.** THUMB-SPIKED DINOSAURS LARGE, SMALL, AND STRANGE: NEW INFORMATION ON BASAL IGUANODONTS FROM THE CEDAR MOUNTAIN FORMATION OF UTAH
- 2:15 **Redelstorff, R., Csiki, Z., Grigorescu, D.** THE HERITAGE OF NOPCSA: DWARF STATUS OF HATEG ORNITHOPODS SUPPORTED BY THE HISTOLOGY OF LONG BONES

- 2:30 **Freedman, E.** VARIATION IN NASAL CREST SIZE OF *BRACHYLOPHOSAURUS CANADENSIS* (DINOSAURIA: HADROSAURIDAE): ONTOGENETIC AND STRATIGRAPHIC IMPLICATIONS OF A LARGE NEW SPECIMEN FROM THE JUDITH RIVER FORMATION OF NORTHCENTRAL MONTANA
- 2:45 **Godefroit, P., Bolotsky, Y., Lauters, P.** A NEW *GRYPOSAURUS* SPECIES (DINOSAURIA: HADROSAURIDAE) FROM THE MAASTRICHTIAN (LATE CRETACEOUS) OF FAR EASTERN RUSSIA
- 3:00 **Prieto-Marquez, A., Wagner, J.** A NEW CLADE OF EURASIAN LAMBEOSAURINAE (DINOSAURIA, ORNITHOPODA), WITH A NEW RECONSTRUCTION OF THE CREST OF *TSINTAOSAURUS*
- 3:15 **Mallon, J., Anderson, J.** GENERAL INSIGHTS INTO THE ORGANISATION OF THE MEGAHERBIVORE ASSEMBLAGE FROM THE DINOSAUR PARK FORMATION (LATE CAMPANIAN) OF ALBERTA
- 3:30 **Horner, J., Lamm, E.** METAPLASIA PROVIDED DINOSAUR SKULLS EXTREME MORPHOLOGICAL PLASTICITY DURING ONTOGENY
- 3:45 **Tanoue, K., Grandstaff, B., You, H., Dodson, P.** MANDIBULAR MECHANICS IN BASAL CERATOPSIA (ORNITHISCHIA, DINOSAURIA)
- 4:00 **Dodson, P., You, H., Tanoue, K.** NEW CHINESE FOSSILS REVEAL THE STRUCTURE OF PALATE AND BASICRANIUM IN BASAL CERATOPSIANS
- 4:15 **Sissons, R.** NEW INFORMATION ON THE MORPHOLOGY OF EMBRYONIC PROTOCERATOPSIAN AND HATCHLING ANKYLOSAUR DINOSAURS FROM BAYAN MANDAHU (INNER MONGOLIA, CHINA), USING MICRO-CT.
- 4:30 **Sampson, S., Loewen, M., Farke, A., Smith, J., Roberts, E.** TWO NEW CHASMOSAURINE CERATOPSIDS FROM LATE CRETACEOUS (CAMPANIAN) OF UTAH
- 4:45 **Scannella, J.** AND THEN THERE WAS ONE: SYNONYMY CONSEQUENCES OF *TRICERATOPS* CRANIAL ONTOGENY

#### TECHNICAL SESSION XIV

##### CHEMISTRY BUILDING, LECTURE ROOM 2

**MODERATORS: Anjali Goswami, Hans Larsson**

- 1:45 **Gilbert, C.** CONTROLLING FOR ALLOMETRY IN PHYLOGENETIC ANALYSES OF MORPHOLOGICAL DATA
- 2:00 **Larsson, H., Dececchi, A.** ESTIMATING RATES OF MORPHOLOGICAL EVOLUTION: LARGE DATASETS BEGIN TO FIT NEUTRAL RATE MODELS AND GIVE TIME TO “MORPHOLOGICAL CLOCKS”
- 2:15 **Corfe, I., Seiffert, E., Boyer, D., Säilä, L., Jukka, J.** DISCOVERING DEVELOPMENTAL SIGNALS IN PHYLOGENETIC DENTAL DATA - FROM MICRO- TO MACRO-EVOLUTIONARY VARIABILITY
- 2:30 **Geisler, J., Bolortsetseg, M.** LINKING CHARACTER STATES: A MEANS TO ACHIEVE PROGRESSIVE MORPHOLOGICAL PHYLOGENETICS
- 2:45 **Gunnell, G., Simmons, N., Giannini, N.** SIZE TRENDS IN LIVING BAT (CHIROPTERA) CLADES AND ESTIMATING BODY MASS OF FOSSIL BATS
- 3:00 **Morlo, M., Gunnell, G., Polly, P.** WHAT, IF NOT NOTHING, IS A CREODONT? PHYLOGENY AND CLASSIFICATION OF HYAENODONTIDA AND OTHER FORMER CREODONTS
- 3:15 **Goswami, A., Milne, N., Wroe, S.** MORPHOMETRIC ANALYSIS OF CONVERGENCE IN CRANIAL SHAPE ACROSS CARNIVOROUS MAMMALS
- 3:30 **Finarelli, J.** THE EVOLUTION OF ENCEPHALIZATION IN THE CARNIVORA (MAMMALIA): ARE LIFE HISTORY VARIABLES AND METABOLIC RATE CORRELATED WITH RELATIVE BRAIN SIZE?
- 3:45 **Samuels, J., Bird, D., Meachen-Samuels, J., Van Valkenburgh, B.** TURBINATE SCALING AND STRUCTURE IN CARNIVORANS
- 4:00 **Meloro, C., Elton, S., Louys, J., Ditchfield, P., Bishop, L.** HABITAT ADAPTATION AS PREDICTED BY HUMERUS MORPHOMETRY IN FELIDAE (FISSIPEDIA, CARNIVORA): IMPLICATIONS FOR PALEOECOLOGICAL RECONSTRUCTIONS

- 4:15 **Meachen-Samuels, J., Van Valkenburgh, B.** EXTREME HUMERAL THICKENING IN THE SABER-TOOTHED CAT, *SMILODON FATALIS*, SUGGESTS SPECIALIZATION FOR KILLING VERY LARGE PREY.
- 4:30 **Spaulding, M.** A NEW VIVERRAVIDAE (MAMMALIA: CARNIVORMORPHA) FROM THE EARLY EOCENE OF WYOMING
- 4:45 **Orcutt, J., Davis, E.** THE CARNIVORE FAUNA OF RANCHO LA BREA: AVERAGE OR ABERRANT?

### POSTER SESSION III

Authors must be present from 5:00 - 7:00 p.m.

Posters must be removed by 7:15 p.m.

- 1 **Sears, K.** MOLECULAR DETERMINANTS OF MARSUPIAL MODULARITY AND CONSTRAINT
- 2 **Bärman, E.** BAYESIAN ANALYSIS OF RUMINANTS USING MOLECULAR AND MORPHOLOGICAL DATA
- 3 **Bradley, B., Chester, S., Asher, R.** WHY THE LONG FACE?: RUNX2 TANDEM REPEATS AND THE EVOLUTION OF PRIMATE PROGNATHISM
- 4 **Chen, M., Luo, Z.** HOMOPLASY IN VERTEBRAL SERIAL IDENTITIES IN MESOZOIC MAMMALS AND EVOLUTIONARY DEVELOPMENT BY HOMEBOX GENES
- 5 **Blackburn, J., Ohazama, A., Porntaveetus, T., Herz, J., Sharpe, P.** MAMMALIAN INCISORS RETAIN A CUSPAL MORPHOGENESIS PROGRAMME
- 6 **Buchwitz, M., Voigt, S., Fischer, J.** DORSAL APPENDAGES OF *LONGISQUAMA* RECONSIDERED: ASPECTS OF DEVELOPMENT AND THE LINK TO THE EVOLUTION OF FILAMENTOUS INTEGUMENTARY STRUCTURES
- 7 **Mitchell, J., Heckert, A., Vince, S., Paul, O.** EVOLUTIONARY INSIGHTS FROM PRELIMINARY STATISTICAL ANALYSIS OF TEETH OF THE VENOMOUS MICROVERTEBRATE *UATCHITODON* (ARCHOSAURIFORMES) FROM THE UPPER TRIASSIC (SANFORD SUB-BASIN, CUMNOCK FORMATION) OF NORTH CAROLINA, USA
- 8 **Schachner, E., Dodson, P.** PELVIC AND HINDLIMB MYOLOGY OF THE BASAL ARCHOSAUR *POPOSAURUS GRACILIS* (ARCHOSAURIA: SUCHIA)
- 9 **Bronowicz, R.** OSTEOHISTOLOGY OF THE BASAL PHYTOSAUR *PALEORHINUS* FROM THE LATE TRIASSIC OF SOUTHERN POLAND - A PRELIMINARY RESULTS
- 10 **Montefeltro, F., Langer, M.** A NEW PHYLOGENY OF RHYNCHOSAURIA (DIAPSIDA, ARCHOSAURIFORMES)
- 11 **Heckert, A., Lucas, S., Rinehart, L., Spielmann, J., Celeskey, M.** AN ARTICULATED SKELETON OF THE AETOSAUR *TYPOTHORAX COCCINARUM* COPE (ARCHOSAURIA: STAGONOLEPIDIDAE) FROM THE UPPER TRIASSIC BULL CANYON FORMATION (REVUELTIAN: EARLY-MID NORIAN), EASTERN NEW MEXICO, USA
- 12 **Dilkes, D., Arcucci, A.** REVISION OF *PROTEROCHAMPSA BARRIONUEVOI* AND PROTEROCHAMPSIDAE (REPTILIA; ARCHOSAURIFORMES) FROM THE LATE TRIASSIC OF ARGENTINA AND BRAZIL
- 13 **Small, B.** A LATE TRIASSIC DINOSAURIFORM ASSEMBLAGE FROM THE EAGLE BASIN (CHINLE FORMATION), COLORADO, U.S.A.
- 14 **Rodrigues, T., Kellner, A.** THE PHYLOGENETIC POSITION OF THE PTEROSAUR *BRASILEODACTYLUS* (PTEROSAURIA, DSUNGARIPTEROIDEA)
- 15 **Martill, D., Hyder, E.** A POSSIBLE EXTRA-OSSEOUS AIR SAC PRESERVED IN THE PELVIS OF A TAPEJARID PTEROSAUR FROM THE CRETACEOUS SANTANA FORMATION OF BRAZIL
- 16 **Hing, R., Martill, D.** RE-EXAMINATION OF THREE-Dimensionally PRESERVED PTEROSAUR SOFT-TISSUE FROM THE SANTANA FORMATION OF BRAZIL

- 17 **Wang, X., Kellner, A., Zhou, Z., Meng, X., Jiang, S.** A LONG-TAILED PTEROSAUR FROM THE EARLY CRETACEOUS JEHOL GROUP, CHINA
- 18 **Zhou, C., Zhou, C., Schoch, R.** A NON-PTERODACTYLOID PTEROSAUR FROM THE MIDDLE JURASSIC OF WESTERN LIAONING, CHINA
- 19 **Main, D., Scotese, C., NOTO, C.** JURASSIC & CRETACEOUS PALEO GEOGRAPHIC CONNECTIVITY, DINOSAUR BIOGEOGRAPHY & THE PALEOBIOGEOGRAPHIC INDEX
- 20 **Gates, T., Scheetz, R., Barrick, R.** THE FIRST COMPLETE DINOSAUR FROM THE LATE CRETACEOUS BOOK CLIFFS (NESLEN FM) OF EASTERN UTAH: IDENTIFICATION AND SIGNIFICANCE
- 21 **Eberth, D., Badamgarav, D., Currie, P.** THE BARUUNGOYOT-NEMEGT TRANSITION (UPPER CRETACEOUS) AT THE NEMEGT TYPE AREA, NEMEGT BASIN, SOUTH CENTRAL MONGOLIA
- 22 **Jasinski, S., Sullivan, R., Lucas, S., Spielmann, J.** TAXONOMIC COMPOSITION OF THE ALAMO WASH LOCAL FAUNA FROM THE UPPER CRETACEOUS OJO ALAMO FORMATION (NAASHOIBITO MEMBER) SAN JUAN BASIN, NEW MEXICO
- 23 **Ortega, F., Escaso, F., Pérez García, A., Torices, A., Sanz, J.** THE VERTEBRATE DIVERSITY OF THE UPPER CAMPANIAN-LOWER MAASTRICHTIAN “LO HUECO” FOSSIL-SITE (CUENCA, SPAIN)
- 24 **Montellano, M., Monroy, H., Hernández-Rivera, R., Torres, E.** LATE CRETACEOUS MICROVERTEBRATE FAUNA FROM THE NORTHERN STATE OF COAHUILA, MEXICO
- 25 **Fastovsky, D., Watabe, M., Tsogtbaatar, K., Saneyoshi, M.** PALEOENVIRONMENTS AND DINOSAUR FAUNAS OF THE LATE CRETACEOUS LOCALITY OF KHERMEEN TSAV, NEMEGT BASIN (GOBI DESERT, MONGOLIA): LATERAL FACIES OR TIME?
- 26 **Alcalá, L., Royo-Torres, R., Cobos, A., Luque, L.** UPDATING DINOSAUR RECORD FROM TERUEL (ARAGON, SPAIN)
- 27 **Panades I Blas, X., Baddeley, R.** THE DIVERSITY OF MEGALOOOLITHID PALAEOOÖPECIES IS NOT THE DIVERSITY OF DINOSAUR PALAEO SPECIES.
- 28 **Moreno-Azanza, M., Gasca, J., Canudo, J.** A HIGH-DIVERSITY EGG SHELL LOCALITY FROM THE HAUTERIVIAN-BARREMIAN TRANSITION OF THE IBERIAN PENINSULA
- 29 **Pesquero, M., Luque, L., Alcalá, L., Royo-Torres, R.** MICROBIAL FEATURES IN DINOSAUR BONES FROM UTRILLAS (TERUEL, SPAIN)
- 30 **Castanhinha, R., Araújo, R., Mateus, O.** DINOSAUR EGG SHELL AND EMBRYO LOCALITIES IN LOURINHA FORMATION, LATE JURASSIC, PORTUGAL
- 31 **Belvedere, M., Mietto, P.** THE IOUARIDENE TRACKSITE (HIGH-ATLAS, MOROCCO): EVIDENCE OF A JURASSIC LAND-BRIDGE BETWEEN AFRICA AND EUROPE
- 32 **Kim, K., Lim, J., Kong, D., Lockley, M., Park, G.** THE WORLD’S SMALLEST DINOSAUR TRACKS FROM THE CRETACEOUS HAMAN FORMATION OF CHANGSEON ISLAND, NAMHAE COUNTY, KOREA
- 33 **Richter, A., Böhme, A., van der Lubbe, T.** “CHICKEN RUN”: A NEW UNUSUAL, HEAVILY DINOTURBATED TRACKSITE FROM THE LOWER CRETACEOUS SANDSTONES OF OBERNKIRCHEN, NORTHERN GERMANY
- 34 **Lucas, S., Heckert, A., Rinehart, L., Spielmann, J., Jasinski, S.** VERTEBRATE FAUNA, STRATIGRAPHY AND AGE OF THE WHITAKER QUARRY (GHOST RANCH, NEW MEXICO), THE RICHEST UPPER TRIASSIC DINOSAUR QUARRY IN THE WORLD
- 35 **Lockley, M., Tedrow, A.** ARE *BIPEDOPUS*, *SEMIBIPEDOPUS*, *LACERTIPUS*, *NAVAHOPUS* AND *BRASILICHNIUM* DISTINCT ICHNOGENERA? REEVALUATING JURASSIC TRACKS FROM THE WESTERN USA
- 36 **Allen, T., Lockley, M.** AN IMPORTANT NEW LOWER JURASSIC ICHNOFAUNA FROM THE NAVAJO-NUGGET SANDSTONE OF IDAHO
- 37 **Barroso-Barcenilla, F., Cambra Moo, O., Carenas, B., Coruña, F., Domingo, L.** FIRST MINERALOGICAL AND GEOCHEMICAL OVERVIEW AND INTERPRETATION OF “LO HUECO” VERTEBRATE SITE (UPPER CRETACEOUS, CUENCA, SPAIN)

- 38 **Christiansen, N., Tschopp, E., Pabst, B.** STEGOSAUR INTEGUMENT FOSSILS FROM THE LATE JURASSIC MORRISON FORMATION: THE FIRST DIRECT EVIDENCE FOR A KERATIN COVERING ON THE DORSAL PLATES
- 39 **Ruiz-Omeñaca, J., Piñuela, L., Garcia-Ramos, J., Pereda-Suberbiola, X.** A DACENTRURINE STEGOSAUR FROM THE LATE JURASSIC OF ASTURIAS (NORTHERN SPAIN)
- 40 **Getty, M., Vickaryous, M., Loewen, M.** ANKYLOSAURID DINOSAURS OF THE UPPER CAMPANIAN KAIPAROWITS FORMATION, GRAND STAIRCASE-ESCALANTE NATIONAL MONUMENT, UTAH
- 41 **Stein, M., Sander, M.** LONG BONE HISTOLOGY AND GROWTH PATTERNS IN ANKYLOSAURS
- 42 **Lim, J., Kong, D., Kim, K., Kim, T.** UNUSUAL QUADRUPEDAL ORNITHOPOD FOOTPRINTS AND LARGE MANUS IMPRINT OF PTEROSAUR FROM THE EARLY CRETACEOUS OF KOREA
- 43 **Böhme, A., Stratmann, U., Wiggenghagen, M., van der Lubbe, T., Richter, A.** NEW TRACKS ON THE ROCK: PARALLEL TRACKWAYS OF A NEW TYPE OF *IGUANODONTIPUS-CARIRICHNIUM*-LIKE MORPHOLOGY FROM THE LOWER CRETACEOUS SANDSTONES OF OBERNKIRCHEN, NORTHERN GERMANY
- 44 **Herne, M.** POSTCRANIAL OSTEOLOGY OF *LEAELLYNASAURA AMICAGRAPHICA* (DINOSAURIA; ORNITHISCHIA) FROM THE EARLY CRETACEOUS OF SOUTHEASTERN AUSTRALIA
- 45 **Gasca, J., Canudo, J., Moreno-Azanza, M.** NEW IGUANODONTIAN DINOSAUR REMAINS FROM THE EARLY BARREMIAN OF SPAIN (CASTELLOTE, TERUEL)
- 46 **Poole, K.** A NEW SPECIMEN OF IGUANODONTIAN DINOSAUR FROM THE CEDAR MOUNTAIN FORMATION OF UTAH
- 47 **Campione, N., Evans, D.** LIMB SCALING AND BODY-MASS OF THE ORNITHOPOD *IGUANODON* (ORNITHISCHIA: HADROSAURIFORMES)
- 48 **Paik, I., Lim, J., Kim, H., Kong, D., Gim, H.** THE FIRST DISCOVERY OF A EUORNITHOPOD MANDIBLE FROM THE CRETACEOUS OF KOREA
- 49 **Dalla Vecchia, F.** A NEW AND EXTRAORDINARILY COMPLETE HADROSAUROID DINOSAUR (ORNITHISCHIA) FROM THE UPPER CRETACEOUS OF ITALY
- 50 **Sullivan, R., Jasinski, S., Lucas, S., Spielmann, J.** THE FIRST “LAMBEOSAURIN” (DINOSAURIA, HADROSAURIDAE, LAMBEOSAURINAE) FROM THE UPPER CRETACEOUS OJO ALAMO FORMATION (NAASHOIBITO MEMBER), SAN JUAN BASIN, NEW MEXICO: FURTHER IMPLICATIONS FOR THE AGE OF THE ALAMO WASH LOCAL FAUNA
- 51 **Cruzado-Caballero, P., Canudo, J., Pereda-Suberbiola, X., Ruiz-Omeñaca, J.** NEW LAMBEOSAURINE HADROSAURID FROM THE LATEST CRETACEOUS OF SPAIN (ARÉN HUESCA, SPAIN)
- 52 **Williams, V., Barrett, P., Purnell, M.** HADROSAURID JAW MECHANICS FROM A DIFFERENT ANGLE: A QUANTITATIVE MICROWEAR ANALYSIS APPROACH
- 53 **Gallimore, G., Evans, D.** MORPHOMETRIC ANALYSIS OF HADROSAURID DENTAL BATTERY VARIATION
- 54 **Westerfield, M.** TAPHONOMY OF HADROSAURID SKELETAL ELEMENTS IN THE AGUJA FORMATION OF WEST TEXAS
- 55 **Schott, R., Evans, D., Bell, P.** PERIPHERAL ELEMENTS AND 3D RECONSTRUCTION OF THE CRANIAL DOME OF ‘*PRENOCEPHALE*’ *BREVIS* (ORNITHISCHIA: PACHYCEPHALOSAURIDAE) AND ITS SYSTEMATIC POSITION
- 56 **Williamson, T., Smith, K., Williams, S., Bennett, III, G., Tremaine, K.** PUTATIVE YOUNG PACHYCEPHALOSAUR SQUAMOSALS ARE FROM A LIZARD
- 57 **McNeil, P.** HISTOLOGY AND GROWTH PATTERN OF THE CENTROSAURINE DINOSAUR *PACHYRHINOSAURUS LAKUSTAI* FROM THE LATE CRETACEOUS WAPITI FORMATION OF NORTHWESTERN ALBERTA, CANADA.
- 58 **Zhao, Q., Xu, X.** A STUDY ON ONTOGENETIC CHANGES IN *PSITTACOSAURUS* USING GEOMETRIC MORPHOMETRICS METHOD

- 59 **Clayton, K., Loewen, M., Sampson, S., Farke, A., Irmis, R.** EPIPARIETAL HOMOLOGY WITHIN CENTROSAURINAE (ORNITHISCHIA, CERATOPSIDAE) : A RE-EVALUATION BASED ON NEWLY DISCOVERED BASAL TAXA
- 60 **Morschhauser, E., You, H., Li, D., Dodson, P.** THE TAPHONOMY OF A RICH COLLECTION OF BASAL NEOCERATOPSIAN DINOSAURS (CERATOPSIA: ORNITHISCHIA) FROM THE APTIAN-ALBIAN OF NORTHWESTERN GANSU PROVINCE, CHINA
- 61 **Ryan, M., Evans, D.** THE OLDEST CERATOPSID CRANIAL MATERIAL (FOREMOST FORMATION, MIDDLE CAMPANIAN) FROM NORTH AMERICA
- 62 **Tucker, R.** GEOLOGY AND PALEONTOLOGY OF THE UPPER JURASSIC MORRISON AND LOWER CRETACEOUS CLOVERLY FORMATIONS ALONG THE EASTERN FLANK OF THE BIGHORN MOUNTAINS, NORTHEASTERN WYOMING
- 63 **Southwell, E., Matthews, N., Breithaupt, B.** WANTED! INFORMATION LEADING TO THE DISCOVERY OF OUTLAWS, QUARRIES, AND FOSSIL REMAINS OF THE “DEVIL’S-TAILED” BEAST FROM THE ROBBER’S ROOST QUARRY, COMO BLUFF WYOMING, USA: A REAL “WILD WEST SHOW” OF DINOSAUR PALEONTOLOGY
- 64 **Bamforth, E., Larsson, H.** THE K-T IMPACT ON PALEOBIODIVERSITY; NEW PALEOECOLOGICAL PERSPECTIVES FROM SOUTHERN SASKATCHEWAN, CANADA
- 65 **Menasco-Davis, L., Stidham, T.** EARLIEST PALEOCENE RECOVERY OF MARINE VERTEBRATES: EVIDENCE FROM THE BASAL KINCAID FORMATION, EASTERN TEXAS
- 66 **Clemens, W.** NEW MORGANUCODONTANS FROM EARLY JURASSIC FISSURE FILLINGS IN WALES (UK)
- 67 **Borths, M., Martin, T.** CLAWING THROUGH THE GIUMAROTA: DISTAL PHALANGE DIVERSITY IN A LATE JURASSIC MAMMALIAN FAUNA
- 68 **Parsons, W., Parsons, K.** AN UNUSUAL NEW MAMMAL FROM THE LOWER CRETACEOUS CLOVERLY FORMATION OF CENTRAL MONTANA
- 69 **Badiola, A., Canudo, J., Cuenca-Bescós, G.** SYSTEMATIC REASSESSMENT OF EARLY CRETACEOUS MULTITUBERCULATE FOSSILS FROM GALVE (TERUEL, SPAIN)
- 70 **Rich, T., Vickers-Rich, P.** THE PSEUDOTRIBOSPHENIC CONCEPT, A HISTORY
- 71 **Brewer, P., Archer, M., Hand, S., Godthelp, H.** A NEW GENUS AND SPECIES OF PRIMITIVE WOMBAT (MARSUPIALIA) FROM THE RIVERSLEIGH WORLD HERITAGE PROPERTY IN NORTHWESTERN QUEENSLAND, AUSTRALIA
- 72 **Bennett, V., Goswami, A.** DOES DEVELOPMENTAL STRATEGY DRIVE LIMB INTEGRATION IN MARSUPIALS AND MONOTREMES?
- 73 **Ladevèze, S., Smith, T., Smith, R.** HERPETOTHERIID MARSUPIALS FROM THE EARLIEST EOCENE OF DORMAAL (BELGIUM): THE GENUS *AMHIPERATHERIUM* AND *PERATHERIUM* REVISITED
- 74 **Rodgers, J.** SYMMETRY IN THE SEMICIRCULAR CANALS OF THERIAN MAMMALS
- 75 **Strait, S., Smith, N.** MORE THAN JUST A PRETTY FACET: QUANTIFYING MORPHOLOGICAL VARIATION IN 3D SURFACE DATA
- 76 **Grass, A.** EXAMINING ECOSYSTEM STRUCTURE AND DISPARITY THROUGH TIME USING GEOMETRIC MORPHOMETRICS
- 77 **Furió, M., Agustí, J., Mouskhelishvili, A., Sanisidro, Ó., Santos-Cubedo, A.** A NEW INTERPRETATION ON THE USE OF VENOM IN THE PLIO-PLEISTOCENE SHREW *BEREMENDIA* (INSECTIVORA, MAMMALIA)
- 78 **Klietmann, J., Prost, S., Nagel, D., Hofreiter, M.** THE GROWING OF THE SHREW
- 79 **Calede, J., Davis, E.** INVESTIGATING THE PALEOECOLOGY OF THE TALPIDAE (MAMMALIA:EULIPOTYPHILA) IN THE MIOCENE OF THE NORTHERN GREAT BASIN: PATTERNS AND PROCESSES IN MOLE DECLINE
- 80 **Hoffmann, S., Martin, T., Storch, G., Rummel, M.** SKELETAL RECONSTRUCTION OF A MIOCENE PANGOLIN FROM SOUTHERN GERMANY

- 81 **Missiaen, P., Smith, T.** *CYMBALOPHUS CUNICULUS* FROM THE EARLY EOCENE OF ERQUELINNES (BELGIUM), AND ITS IMPLICATIONS FOR BASAL PERISSODACTYL PHYLOGENY
- 82 **De Bast, E., Sigé, B., Smith, T.** NEW ADAPISORICULID MAMMALS FROM THE EARLY PALEOCENE LOCALITY OF HAININ (BELGIUM)
- 83 **Weinstein, D.** LOWER JAW OF *ALVUGENA* (EARLY PALEOCENE: EUTHERIA), STRATIGRAPHIC DEBT, AND THE ORIGIN OF THE TAENIODONTA
- 84 **Miyata, K., Demere, T.** NEW MATERIAL OF A “SHORT-FACED” *TROGOSUS* (TILLODONTIA, MAMMALIA) FROM THE DELMAR FORMATION (BRIDGERIAN), SAN DIEGO COUNTY, CALIFORNIA, USA
- 85 **Chester, S., Secord, R., Bloch, J.** NEW SPECIES OF *PALAEONICTIS* (MAMMALIA, CREODONTA) FROM THE PALEOCENE-EOCENE THERMAL MAXIMUM, SOUTHERN BIGHORN BASIN, WYOMING
- 86 **Bastl, K., Nagel, D., Morlo, M., Heizmann, E.** TOOTH ERUPTION SEQUENCE IN *HYAENODON* AND IMPLICATIONS FOR THE ORIGIN OF HYAENODONTIDAE (CREODONTA, MAMMALIA)
- 87 **Tsubamoto, T., Egi, N., Tsogtbaatar, K.** NEW LATE EOCENE AMPHICYONID (MAMMALIA: CARNIVORA) FROM MONGOLIA WITH COMMENTS ON “*CYNODICTIS*” AND EOCENE AMPHICYONIDS FROM ASIA
- 88 **Northover, J., Rybczynski, N., Schröder-Adams, C.** PECTORAL GIRDLE AND FORELIMB OF *PUIJILA DARWINI*, A FOSSIL PINNIPED FROM THE HAUGHTON CRATER FORMATION, DEVON ISLAND, NUNAVUT
- 89 **Sanfelice, D., de Freitas, T.** COMPARING SKULL ONTOGENIES: A CASE STUDY USING OTARID SKULLS (PINNIPEDIA, MAMMALIA)
- 90 **Levering, D., Orcutt, J., Davis, E.** LOCOMOTOR ECOLOGY OF *MACHAIRODUS COLORADENSIS*
- 91 **Gosselin-Ildari, A., Boyer, D., Lemelin, P.** INFLUENCE OF A TERRESTRIAL HISTORY ON FOOT MORPHOLOGY IN PRIMATE-LIKE ARBOREAL PROCYONIDS (MAMMALIA, CARNIVORA)
- 92 **Sakai, S., Samuels, J., Meachen-Samuels, J.** POSTCRANIAL MORPHOLOGY AND THE LOCOMOTOR HABITS OF LIVING AND EXTINCT CARNIVORANS
- 93 **Antón, M., Salesa, M., Turner, A., Pastor, J., Morales, J.** FUNCTIONAL ANATOMY OF THE CERVICAL VERTEBRAE OF THE SCIMITAR-TOOTH CAT *MACHAIRODUS APHANISTUS*
- 94 **Schubert, B., Wallace, S., Soibelzon, L.** *PLIONARCTOS* (URSIDAE; TREMARCTINAE) FROM THE GRAY FOSSIL SITE WITH A REEVALUATION OF THE GENUS
- 95 **Nagel, D., Kullmer, O., Sandrock, O., Viola, T., Seidler, H.** CARNIVORES AND THEIR PALEOECOLOGY FROM THE HOMINID SITE GALILI, SOMALI REGION, ETHIOPIA
- 96 **Gensler, P., Meachen-Samuels, J., Samuels, J.** AGRIOTHERIUM (URSIDAE) FROM A BLANCAN NALMA LOCALITY AT HAGERMAN FOSSIL BEDS NATIONAL MONUMENT, IDAHO
- 97 **Prado, J., Azanza, B., Alberdi, M.T.** IBERIAN LATEST MIOCENE-PLEISTOCENE FOSSIL RECORD OF CARNIVORAN: DIVERSITY AND HOME-RANGE-SIZE STRUCTURE
- 98 **Koot, M., Reumer, J., de Vos, J.** TESTING THE POTENTIAL MONOSPECIFICITY OF THE SABRE-TOOTH CAT GENUS *HOMOTHERIUM* USING COMPARATIVE DATA FROM RECENT LARGE CATS
- 99 **García Yelo, B., Hernández Fernández, M., Morales, J.** THE COMMUNITY STRUCTURE OF CARNIVORE MAMMALS, A KEY TO INFER THE CLIMATE
- 100 **Arroyo-Cabrales, J., Polaco, O., Graham, R., Johnson, E.** NORTH AMERICAN LATE PLEISTOCENE FELID (MAMMALIA, FELIDAE) DIVERSITY AND ITS IMPOVERISHMENT AT THE BEGINNING OF THE HOLOCENE - CLIMATE CHANGE, HUMAN IMPACT, AND COMPETITION
- 101 **Tseng, Z., Takeuchi, G., Wang, X.** THE FIRST UPPER DENTITION OF THE SABERTOOTHED *BARBOUROFELIS WHITFORDI* (NIMRAVIDAE, CARNIVORA)
- 102 **Mennecart, B., Scherler, L., Becker, D., Berger, J.** LATE OLIGOCENE CHANGES IN MAMMAL COMMUNITIES OF WESTERN EUROPE: WARMING AND COOLING EVENT ?

- 103 **Maung-Thein, Z., Egi, N., Tsubamoto, T., Uno, H., Wynn, J.** PALEOENVIRONMENT ESTIMATION OF THE CHAINGZAU MAMMAL FAUNA (LATE NEOGENE, MYANMAR) USING STABLE ISOTOPES OF TOOTH ENAMEL
- 104 **Stevens, N., Gottfried, M., Roberts, E., O'Connor, P., Ngasala, S.** VERTEBRATES FROM NEWLY DISCOVERED LACUSTRINE LOCALITIES IN THE LATE OLIGOCENE NSUNGWE FORMATION, RUKWA RIFT BASIN, TANZANIA
- 105 **Wang, Y., Meng, J., Beard, K., Li, Q., Ni, X.** FURTHER BIOSTRATIGRAPHIC SUBDIVISION AND AGE CONSTRAINT OF THE LOWER PALEOGENE IN EASTERN ERLIAN BASIN, INNER MONGOLIA, CHINA
- 106 **Brinkkoetter, J., Martin, T.** THE LAUBENHEIM BED - A NEW LOCALITY OF EARLIEST MIOCENE (MN1) LAND MAMMALS IN THE MAINZ BASIN, NORTHWESTERN GERMANY
- 107 **Liu, L., Eronen, J., Fortelius, M.** SIGNIFICANT MID-LATITUDE ARIDITY IN THE MIDDLE MIOCENE OF EAST ASIA
- 108 **Nakaya, H., Hasumi, E., Miyazato, N., Watabe, M.** MESOWEAR ANALYSIS FOR CHEEK TEETH OF UNGULATE FOSSILS FROM THE LATE MIOCENE MARAGHEH FORMATION, NORTHWESTERN IRAN
- 109 **Fraser, D.** THE PALEOECOLOGY OF THE COFFEE RANCH FAUNA OF TEXAS AND ITS IMPLICATIONS IN THE INTERPRETATION OF LATE MIOCENE CLIMATE CHANGE

## **SATURDAY MORNING, SEPTEMBER 26, 2009**

### **SYMPOSIUM: NEW PERSPECTIVES ON THE EARLY EVOLUTIONARY HISTORY OF THE SYNAPSIDA**

**CHEMISTRY BUILDING, LECTURE ROOM 1**

**MODERATORS: Kenneth Angielczyk, Christian Kammerer**

- 8:00 **Reisz, R.** PHYLOGENETIC RELATIONSHIPS AND PATTERNS OF DIVERSIFICATION OF NON-THERAPSID SYNAPSIDS
- 8:15 **Sumida, S., Pelletier, V., Berman, D., English, L.** NEW INFORMATION ON THE BASAL PELYCOSAURIAN-GRADE SYNAPSID *OEDALEOPS*
- 8:30 **Berman, D., Henrici, A., Sumida, S.** PELYCOSAURIAN-GRADE SYNAPSIDS FROM THE LOWER PERMIAN BROMACKER LOCALITY, CENTRAL GERMANY
- 8:45 **Liu, J., Rubidge, B., Li, J.** NEW BASAL SYNAPSIDS FROM CHINA-A KEY TO UNDERSTANDING THERAPSID ORIGINS
- 9:00 **Kemp, T.** THE EARLY EVOLUTIONARY DIVERSIFICATION OF THERAPSIDA: WAS IT A TRUE POLYTOMY?
- 9:15 **Rubidge, B., Angielczyk, K., de Klerk, W., Abdala, F.** GONDWANAN MIDDLE PERMIAN SYNAPSID RADIATIONS
- 9:30 **Fröbisch, J.** REGIONAL AND GLOBAL PERSPECTIVES ON SYNAPSID DIVERSITY AND THE PERMIAN-TRIASSIC ROCK RECORD
- 9:45 **Kurkin, A.** LATE PERMIAN DICYNODONTS: MORPHOTYPES AND BIOGEOGRAPHY
- 10:00 BREAK
- 10:15 **Jasinowski, S., Rayfield, E., Chinsamy-Turan, A.** DICYNODONT CRANIAL SUTURES AND HISTOLOGY: IMPLICATIONS FOR SKULL FUNCTION
- 10:30 **Vega, C.** DICYNODONTS OF SOUTH AMERICA: AN OVERVIEW OF MORPHOLOGY AND CLADISTIC RELATIONSHIPS
- 10:45 **Gebauer, E.** GORGONOPSIA - PHYLOGENY AND FUNCTIONAL MORPHOLOGY
- 11:00 **Smith, R., Botha-Brink, J.** BURROWING AS A SURVIVAL STRATEGY IN THE EARLIEST TRIASSIC KAROO BASIN, SOUTH AFRICA

- 11:15 **van den Heever, J., Abdala, F., Rubidge, B.** SOUTHERN AFRICAN BAURIIDAE (THERIODONTA, EUTHERAPSIDA): IMPLICATIONS FOR EARLY-MIDDLE TRIASSIC BIOSTRATIGRAPHY
- 11:30 **Sues, H., Schneider, V., Liu, J.** REMARKABLE NEW MATERIAL OF *BOREOFGOMPHODON* (CYNODONTIA: GOMPHODONTIA) FROM THE UPPER TRIASSIC PEKIN FORMATION OF NORTH CAROLINA
- 11:45 **Sidor, C., Kenneth, A., Hopson, J., Kammerer, C., Smith, R.** NEW INFORMATION ABOUT CYNODONTS FROM THE MIDDLE TRIASSIC MANDA BEDS (RUHUUH BASIN) OF TANZANIA
- 12:00 **Luo, Z.** HOMOPLASTIC EVOLUTION IN THE PRECURSOR STATES OF THE DEFINITIVE MAMMALIAN MIDDLE EAR (DMME) CHARACTERS IN THE EARLIEST MAMMALIAN TRANSITION

### TECHNICAL SESSION XV

WILLS MEMORIAL BUILDING, GREAT HALL

MODERATORS: Peter Makovicky, Philip Manning

- 8:00 **Breithaupt, B., Matthews, N.** A GLIMPSE AT THE PALEOECOLOGICAL AND PALEOBIOLOGICAL COMPLEXITIES OF MIDDLE JURASSIC THEROPOD COMMUNITIES IN THE NORTHERN HEMISPHERE: A PHOTOGRAMMETRIC AND MORPHOLOGICAL COMPARISON OF DINOSAUR TRACKS FROM NORTH AMERICA AND THE UNITED KINGDOM
- 8:15 **Manning, P., Margetts, L., Johnson, M., Mustansar, Z., Mummery, P.** A FINITE ELEMENT APPROACH TO THE BIOMECHANICS OF DROMAEOSAURID DINOSAUR CLAWS
- 8:30 **Fowler, D.** THE GRASPING FOOT OF *DEINONYCHUS*: IMPLICATIONS FOR PREDATOR ECOLOGY, EVOLUTION OF THE PERCHING FOOT, AND A NEW HYPOTHESIS FOR THE ORIGIN OF FLIGHT IN BIRDS
- 8:45 **Morhardt, A., Bonnan, M., Keillor, T.** DINOSAUR SMILES: CORRELATING PREMAXILLA, MAXILLA, AND DENTARY FORAMINA COUNTS WITH EXTRA-ORAL STRUCTURES IN AMNIOTES AND ITS IMPLICATIONS FOR DINOSAURS
- 9:00 **Pittman, M., Upchurch, P., Gatesy, S., Goswami, A., Hutchinson, J.** DECREASED DORSOVENTRAL AND MEDIOLATERAL VERTEBRAL JOINT STIFFNESS IN THE TAIL, ALONG THE LINE OF DESCENT BETWEEN NON-AVIAN AND AVIAN THEROPODS
- 9:15 **Kambic, R., Gatesy, S.** LONG-AXIS ROTATION: A MISSING RANGE OF MOTION IN DINOSAUR FUNCTIONAL ANALYSIS
- 9:30 **Allen, V., Hutchinson, J.** THE EVOLUTION OF HINDLIMB MUSCLE MOMENT ARMS AND FUNCTIONAL ANATOMY IN BIRD-LINE THEROPOD DINOSAURS
- 9:45 **Persons, W.** THEROPOD TAIL MUSCLE RECONSTRUCTION AND ASSESSMENT OF THE LOCOMOTIVE CONTRIBUTIONS OF THE M. *CAUDOFEMORALIS*
- 10:00 **BREAK**
- 10:15 **Buckley, L., Buckley, L.** DETERMINING ONTOGENETIC AND INDIVIDUAL VARIATION IN *COELOPHYSIS BAURI* (THEROPODA: COELOPHYSOIDEA) USING MULTIVARIATE ANALYSES AND IMPLICATIONS FOR IDENTIFYING ISOLATED THEROPOD TEETH
- 10:30 **Dal Sasso, C., Maganuco, S.** OSTEOLOGY, ONTOGENETIC ASSESSMENT, PHYLOGENY, PALEOBIOLOGY, AND SOFT-TISSUE ANATOMY OF *SCIPIONYX SAMNITICUS*
- 10:45 **Benson, R.** MIDDLE JURASSIC THEROPODS AND THE EARLY EVOLUTION OF TETANURANS (DINOSAURIA, THEROPODA)
- 11:00 **Makovicky, P., Li, D., Gao, K., Norell, M., Erickson, G.** TWO NEW COELUROSAURS FROM THE EARLY CRETACEOUS XINMINPU GROUP OF GANSU PROVINCE, CHINA.
- 11:15 **Norell, M., Brusatte, S., Carr, T., Bever, G., Erickson, G.** A REMARKABLE LONG-SNOUTED, MULTI-HORNED TYRANNOSAURID FROM THE LATE CRETACEOUS OF MONGOLIA
- 11:30 **Bever, G., Brusatte, S., Carr, T., Norell, M.** THE BRAINCASE OF A NEW TYRANNOSAURID FROM THE LATE CRETACEOUS OF MONGOLIA

- 11:45 **Paulina Carabajal, A.** THE BRAINCASES OF ARGENTINAN THEROPOD DINOSAURS: OSTEOLOGY AND PHYLOGENETIC IMPLICATIONS
- 12:00 **Miyashita, T., Currie, P.** A NEW PHYLOGENY OF THE TYRANNOSAUROIDEA (DINOSAURIA, THEROPODA)

**TECHNICAL SESSION XVI**  
**CHEMISTRY BUILDING, LECTURE ROOM 2**  
**MODERATORS: Joshua Ludtke, Jessica Theodor**

- 8:00 **Bolortsetseg, M.** TWO NEW SPECIMENS OF CIMOLODONTANS AND A PHYLOGENETIC STUDY OF THE POSTCRANIAL ANATOMY OF MULTITUBERCULATA (MAMMALIA, SYNAPSIDA)
- 8:15 **Wood, D.J.** CORRELATION VERSUS CAUSALITY IN THE FOSSIL RECORD: A GLOBAL REEXAMINATION OF THE EXTINCTION OF THE MULTITUBERCULATA
- 8:30 **Gill, F., Crump, M., Schouten, R., Bull, I.** LIPID BIOMARKER ANALYSIS OF *NOTHROTHERIUM SHASTAENSIS* COPROLITE
- 8:45 **Bales, G.** AN APPROACH TO BRAIN SIZES IN THE RHINOCEROTOIDEA: USE AND PROBLEMS OF ENDOCRANIAL LENGTH AS A PROXY FOR BRAIN SIZE
- 9:00 **Dirks, W., Holroyd, P., Anemone, R.** MOLAR FORMATION, LIFE HISTORY AND PHYLOGENY IN THREE ARCHAIC UNGULATES, *MENISCOTHERIUM*, *ECTOZION* AND *PHENACODUS* (MAMMALIA, "CONDYLARTHRA")
- 9:15 **Shockey, B., Flynn, J., Croft, D., Wyss, A., Neinast, A.** PHYLOGENETIC ANALYSIS OF RELATONSHIPS AMONG TRADITIONAL FAMILIES OF NOTUNGULATA USING POSTCRANIAL CHARACTERS
- 9:30 **Billet, G.** NEW OBSERVATIONS ON PYROTHERIA AND NOTOUNGULATA (MAMMALIA): PHYLOGENETIC IMPLICATIONS ON THE ORIGINS OF SOUTH AMERICAN ENDEMIC UNGULATES
- 9:45 **Smith, T., De Bast, E., Sigé, B.** ADAPISORICULID MAMMALS FROM THE PALEOCENE OF HAININ (BELGIUM) SHED LIGHT ON THE PHYLOGENETIC AFFINITIES OF THE ENIGMATIC ARBOREAL CRETACEOUS DECCANOLESTES FROM THE DECCAN TRAPS OF INDIA
- 10:00 **BREAK**
- 10:15 **Fahlke, J., Coombs, M.** IMPLICATIONS FOR THE ECOLOGY OF MID MIOCENE SCHIZOTHERIINAE (PERISSODACTYLA: CHALICOTHERIIDAE) BASED ON NEWLY DESCRIBED MATERIAL FROM SOUTHERN GERMANY
- 10:30 **Coombs, M.** BIOGEOGRAPHY OF EUROPEAN CHALICOTHERES (PERISSODACTYLA, CHALICOTHERIIDAE): OLD AND NEW INTERPRETATIONS AND SYNTHESIS
- 10:45 **Deng, T.** CHINESE NEOGENE ELASMOTHERE RHINOCEROSES: PHYLOGENETIC RELATIONSHIPS AND ECOLOGIC IMPLICATIONS
- 11:00 **Theodor, J.** EAR MORPHOLOGY OF *HOMACODON VAGANS*: ADDITIONAL DATA FROM CT SCAN ANALYSIS
- 11:15 **Cooper, L., Thewissen, J.G.M., Bajpai, S., Tiwari, B.** ANATOMICAL AND LOCOMOTOR SPECIALIZATIONS OF THE EOCENE RAOELLID *INDOHYUS*
- 11:30 **Ludtke, J.** MODELS AND OREODONTS: TESTING METHODS FOR CODING POLYMORPHIC CONTINUOUS CHARACTERS
- 11:45 **Bibi, F.** THE FOSSIL RECORD AND EVOLUTION OF TRAGELAPHINI (BOVIDAE, ARTIODACTYLA)
- 12:00 **Lihoreau, F., Boisserie, J., Mackaye, H., Vignaud, P., Brunet, M.** THE ANTHRACOTHERIIDAE (CETARTIODACTYLA, MAMMALIA) FROM TOROS-MENALLA (NORTHERN CHAD) AND THE NEOGENE SAHARAN PALEOBIOGEOGRAPHY

## SATURDAY AFTERNOON, SEPTEMBER 26, 2009

### TECHNICAL SESSION XVII

CHEMISTRY BUILDING, LECTURE ROOM 1

MODERATORS: Kenneth Angielczyk, Jennifer Olori

- 1:45 **Maier, W., Bonaparte, J., Ruf, I., Schultz, C.** INTERNAL CRANIAL ANATOMY OF BRASILODONTIDS AS DETERMINED BY MICRO-CT
- 2:00 **Egberts, S., Rowe, T., Sues, H., Luo, Z., Jenkins, F.** THE FIRST SEMI-AQUATIC SYNAPSID FROM THE EARLY JURASSIC OF ARIZONA
- 2:15 **Angielczyk, K., Sidor, C., Smith, R., Steyer, J., Gostling, N.** A RE-EVALUATION OF THE DICYNODONTS (THERAPSIDA, ANOMODONTIA) OF THE PERMIAN RUHUHU FORMATION (SONGEA GROUP, RUHUHU BASIN), TANZANIA
- 2:30 **Huttenlocker, A.** AN EARLIEST TRIASSIC THEROCEPHALIAN (THERAPSIDA: EUTHERIODONTIA) WITH PERMIAN AFFINITIES AND A LOOK AT EUTHERIODONT DIVERSITY THROUGH TIME: CONSIDERING EVOLUTIONARY RATES IN THE PROBLEM OF CYNODONT ORIGINS.
- 2:45 **Henrici, A., Martens, T., Berman, D.** A NEW MICROSAAUR FROM AN EXCAVATION SITE IN THE LOWER PERMIAN TAMBACH FORMATION, TAMBACH-DIETHARZ, THURINGIA, GERMANY
- 3:00 **Clack, J.** A PROBABLE MICROSAAUR FROM THE EARLY CARBONIFEROUS OF EAST KIRKTON, SCOTLAND, SHOWING SOFT-TISSUE EVIDENCE
- 3:15 **Warren, A., Rozefelds, A.** ARE BRACHYOPIDS TUPILAKOSAURS?
- 3:30 **Olori, J.** COMPARATIVE ANALYSIS OF POSTCRANIAL OSSIFICATION SEQUENCES ACROSS EXTINCT AND EXTANT TETRAPODS
- 3:45 **Gao, K., Shubin, N.** EARLY FOSSIL RECORD FROM CHINA AND DEEP TIME EVOLUTION OF SALAMANDER NEOTENY
- 4:00 **Chen, J., Gao, K.** THE EARLY CRETACEOUS SALAMANDER *LIAOXITRITON ZHONGJIANI* (AMPHIBIA: CAUDATA) AS A BASAL HYNوبيIID BASED ON REDESCRIPTION OF NEW MATERIAL

### TECHNICAL SESSION XVIII

WILLS MEMORIAL BUILDING, GREAT HALL

MODERATORS: Diego Pol, John Whitlock

- 1:45 **Upchurch, P.** THE SAUROPODOMORPH SUPERMATRIX: TOWARDS A GLOBAL PHYLOGENY OF THE LARGEST TERRESTRIAL ANIMALS
- 2:00 **Pol, D., Rauhut, O., Carballido, J.** SKULL ANATOMY OF A NEW BASAL EUSAUROPOD FROM THE CAÑADON ASFALTO FORMATION (MIDDLE JURASSIC) OF CENTRAL PATAGONIA
- 2:15 **Remes, K., Ortega, F., Fierro, I., Kosma, R., Joger, U.** A NEW BASAL SAUROPOD WITH A SPIKE-BEARING TAIL FROM THE MIDDLE JURASSIC OF NIGER AND THE ORIGIN OF EUSAUROPODA
- 2:30 **Mateus, O.** THE SAUROPOD DINOSAUR *TURIASAURUS RIODEVENSIS* IN THE LATE JURASSIC OF PORTUGAL
- 2:45 **Frank, V., Remes, K.** THE DENTITION OF THE DWARF SAUROPOD *EUROPASAURUS HOLGERI* (DINOSAURIA, SAURISCHIA) FROM THE UPPER JURASSIC OF GERMANY: IMPLICATIONS FOR ONTOGENETIC AND FUNCTIONAL PATTERNS
- 3:00 **D'Emic, M., Whitlock, J., Smith, K., Wilson, J., Fisher, D.** THE EVOLUTION OF TOOTH REPLACEMENT RATES IN SAUROPOD DINOSAURS
- 3:15 **Whitlock, J.** SYSTEMATICS AND PALEOBIOLOGY OF THE DIPLODOCOID SAUROPODS
- 3:30 **Christian, A., Dzemski, G., Möller, J.** POSTURE AND MOBILITY OF THE NECK AND VARIATION IN FEEDING STRATEGY AMONG SAUROPOD DINOSAURS

- 3:45 **Young, M., Rayfield, E., Holliday, C., Barrett, P., Witmer, L.** TESTING HYPOTHESES OF FEEDING BEHAVIOR IN *DIPLODOCUS LONGUS* USING THE FINITE-ELEMENT METHOD
- 4:00 **Csiki, Z., Codrea, V., Godefroit, P., Jipa-Murzea, C.** A NEW TITANOSAUR (DINOSAURIA: SAUROPODA) FROM THE LATE CRETACEOUS OF ROMANIA, AND A PLEA FOR NECESSARY STABILITY IN SAUROPOD SYSTEMATICS

### TECHNICAL SESSION XIX

#### CHEMISTRY BUILDING, LECTURE ROOM 2

**MODERATORS: Jean-Renaud Boisserie, Christine Janis**

- 1:45 **Janis, C., Eronen, J., Ataabadi, M., Puolamäki, K., Fortelius, M.** PATTERNS OF HYPSONDONTY IN UNGULATES SHOW THAT NEOGENE ARIDITY IN NORTH AMERICA PRECEDED THAT IN EURASIA
- 2:00 **Chritz, K., Dyke, G., Zazzo, A., Lister, A., Monaghan, N.** NEW INSIGHTS ON GIANT DEER (*MEGALOCEROS GIGANTEUS*) PALEOBIOLOGY INFERRED FROM STABLE ISOTOPE AND CEMENTUM ANALYSIS
- 2:15 **Weston, E.** CHEEK-TOOTH SIZE AND INSULAR DWARFISM: NEW DATA FROM EXTINCT DWARF HIPPOS FROM MADAGASCAR
- 2:30 **Orliac, M., Lihoreau, F., Boisserie, J., MacLatchy, L.** REVISION OF THE AFRICAN PALAEOCHOERIDS: IMPLICATIONS FOR THE RELATIONSHIPS OF HIPPOPOTAMIDAE (CETARTIODACTYLA, MAMMALIA).
- 2:45 **Boisserie, J., Lihoreau, F., Orliac, M., Fisher, R., Weston, E.** ELUCIDATING HIPPO RELATIONSHIPS WITHIN CETARTIODACTYLA: DENTAL EVIDENCE
- 3:00 **Lambert, O., Bianucci, G., Urbina, M.** A NEW PITHANODELPHININE DOLPHIN FROM THE MIOCENE OF PERU AND THE ORIGIN OF MODERN DELPHINIDAN FAMILIES
- 3:15 **Goodwin, M., Demere, T., Holroyd, P., Wilson, R., Dowker, S.** UNUSUAL PRESERVATION OF FOSSIL BALEEN (CETACEA: MYSTICETI) FROM THE MIOCENE OF CALIFORNIA, USA: COMPARATIVE MORPHOLOGY AND STABLE ISOTOPE EVIDENCE FOR SEASONALITY AND GROWTH
- 3:30 **Churchill, M., Clementz, M.** CETACEAN BULLAE AS BIOGENIC ARCHIVES FOR STABLE ISOTOPE ANALYSIS AND DIETARY INFORMATION
- 3:45 **Racicot, R.** INNER EAR MORPHOLOGY OF BALAENOPTEROID MYSTICETES (CETACEA: MYSTICETI)
- 4:00 **Peek, S., Clementz, M., Fox, D.** BA/CA AND SR/CA AS PROXIES FOR TROPHIC LEVEL AND SALINITY PREFERENCES OF MARINE MAMMALS

### POSTER SESSION IV

**Authors must be present from 4:15 - 6:15 p.m.**

**Posters must be removed by 6:30 p.m.**

- 1 **Pelletier, V.** A POSTCRANIAL RECONSTRUCTION OF THE BASAL EUPELYCOSAUR *AEROSUARUS WELLESI*
- 2 **Atayman, S., Rubidge, B., Abdala, F.** TAXONOMIC REVISION OF TAPINOCEPHALID DINOCEPHALIANS-THE KEY TO UNDERSTAND MIDDLE PERMIAN BIODIVERSITY
- 3 **Norton, L., Tafforeau, P., Rubidge, B., de Klerk, W.** USE OF SYNCHROTRON MICROTOMOGRAPHY TO EXAMINE TOOTH REPLACEMENT PATTERNS IN A TAPINOCEPHALID DINOCEPHALIAN
- 4 **Orr, P., Redelstorff, R., Kearns, S., Benton, M.** TAPHONOMY OF AMPHIBIANS FROM THE NYRANY EXCEPTIONAL FAUNA (CARBONIFEROUS) IN THE CZECH REPUBLIC
- 5 **Sengupta, D.** A NEW, MIDDLE TRIASSIC TEMNOSPONDYL FROM INDIA
- 6 **Dias-da-Silva, S., Cabreira, S., da Silva, L.** OCCURRENCE OF A GIANT STEREOSPONDYL IN THE SANTA MARIA FORMATION (PARANÁ BASIN, SOUTHERN BRAZIL)

- 7 **Wong Ken, N., Reisz, R.** NEW SPECIES OF CACOPS FROM THE EARLY PERMIAN OF OKLAHOMA
- 8 **Polley, B., Reisz, R.** A NEW TREMATOPID AMPHIBIAN FROM THE EARLY PERMIAN OF RICHARDS SPUR, OKLAHOMA
- 9 **Fortuny, J., Galobart, À., De Santisteban, C.** NEW CAPITOSAUR TAXA (AMPHIBIA:TEMNOSPONDYLII) FROM THE MIDDLE TRIASSIC (EARLY-MIDDLE ANISIAN) OF IBERIAN PENINSULA
- 10 **Rinehart, L., Lucas, S., Heckert, A.** LATERAL LINE GROOVE DEVELOPMENT AS AN INDICATOR OF TERRESTRIALITY IN METOPOSAURID AMPHIBIANS
- 11 **Marjanovič, D., Laurin, M.** A CLOSER LOOK AT THREE PUBLISHED DATA MATRICES REVEALS SUPPORT FOR THE “LEPOSPONDYL HYPOTHESIS” ON THE ORIGIN OF EXTANT AMPHIBIANS
- 12 **Chen, D., Ahlberg, P.** A PARTIAL TETRAPOD LOWER JAW FROM “ROMER’S GAP”
- 13 **Klembara, J.** NEW DATA ON *KARPINSKIOSAURUS ULTIMUS*, AN UPPER PERMIAN SEYMOURIAMORPH FROM RUSSIA
- 14 **Witzmann, F., Scholz, H., Müller, J., Kardjilov, N.** DERMAL BONE SCULPTURE AND INTEGUMENT IN BASAL TETRAPODS
- 15 **Hieronimus, T.** OSTEOLOGICAL AND HISTOLOGICAL CORRELATES OF AMNIOTE SKIN STRUCTURES
- 16 **Falconnet, J.** ONTOGENETIC TRENDS IN EARLY SPHENACODONT SYNAPSIDS, AND THEIR BEARINGS ON SPHENACODONT SYSTEMATICS AND INTERRELATIONSHIPS
- 17 **Mazierski, D., Reisz, R.** A NEW DESCRIPTION AND PHYLOGENETIC REASSESSMENT OF *IANTHASAURUS HARDESTIUM* (SYNAPSIDA:EUPELYCOSAURIA), A BASAL EDAPHOSAURID FROM THE UPPER PENNSYLVANIAN OF KANSAS
- 18 **Domnanovich, N., Marsicano, C.** THERAPSID DICYNODONTS (AMNIOTA, SYNAPSIDA) FROM ARGENTINA
- 19 **Camp, J.** MORPHOLOGICAL VARIATION AND DISPARITY IN *LYSTROSAURUS* (THERAPSIDA:DICYNODONTIA)
- 20 **Laaß, M., Hampe, O., Schudack, M., Kardjilov, N., Hilger, A.** NEW DETAILS OF A SKULL OF *LYSTROSAURUS DECLIVIS* AND IMPLICATIONS FOR LIFESTYLE ADAPTIONS
- 21 **McHugh, J.** RAPID DIVERSIFICATION IN THE KAROO: LIFE FLOURISHING DURING THE SOUTH AFRICAN PERMO-TRIASSIC EVENT? WHAT THE THERAPSIDS AREN’T TELLING YOU
- 22 **Malafaia, E., Ortega, F., Escaso, F., Dantas, P., Gasulla, J.** *ALLOSAURUS FRAGILIS* FROM THE PORTUGUESE UPPER JURASSIC
- 23 **Machado, E., Azevedo, S., Carvalho, L., Henriques, D., Kellner, A.** A NEW SPINOSAURID FROM THE CRETACEOUS ALCANTARA FORMATION (MARANHÃO), NORTHEASTERN BRAZIL
- 24 **Company, J., Torices, A., Pereda-Suberbiola, X., Ruiz-Omeñaca, J.** THEROPOD TEETH FROM THE LATE CRETACEOUS OF CHERA (VALENCIA, EASTERN SPAIN)
- 25 **Farke, A., Sertich, J.** A MEDIUM-SIZED THEROPOD FROM THE LATE CRETACEOUS (TURONIAN OR CONIACIAN) OF THE AMBILOBE BASIN, NORTHERNMOST MADAGASCAR
- 26 **Choiniere, J., Clark, J., Xu, X., Han, F.** A NEW BASAL ALVAREZSAUR FROM THE SHISHUGOU FORMATION
- 27 **Ruiz, J., Novas, F.** NEW INSIGHTS ABOUT THE ANATOMY OF THE HAND OF *CARNOTAURUS SASTREI* (THEROPODA: ABELISAUURIDAE)
- 28 **Watanabe, A., Sereno, P.** THE FORELIMB OF A NEW TYRANNOSAURIDAE (DINOSAURIA: THEROPODA) FROM MONGOLIA AND ITS IMPLICATIONS FOR FORELIMB EVOLUTION IN TYRANNOSAURIDS
- 29 **Dececchi, A., Harrison, L., Larsson, H.** UP IN ARMS: AN ANALYSIS OF EVOLUTIONARY TRENDS WITHIN THE MANIRAPTORAN APPENDICULAR SKELETON USING ALLOMETRIC AND BAYSIAN PHYLOGENETIC APPROACHES.
- 30 **Birn-Jeffery, A., Rayfield, E.** FINITE ELEMENT ANALYSIS OF PEDAL CLAWS TO DETERMINE MODE OF LIFE IN BIRDS, LIZARDS AND MANIRAPTORAN THEROPODS

- 31 **Souter, T., Abourachid, A., Hutchinson, J., Baylac, M.** THREE-DIMENSIONAL GEOMETRIC MORPHOMETRICS AND KINEMATICS OF THEROPOD HIP-JOINT FUNCTION
- 32 **Zanno, L., Varricchio, D., Titus, A., Wilkins, N., Knell, M.** A NEW TROODONTID (THEROPODA: PARAVES) SPECIMEN FROM THE UPPER CAMPANIAN KAIPAROWITS FORMATION, SOUTHERN UTAH: ESTIMATING THE TAXONOMIC DIVERSITY OF NORTH AMERICAN TROODONTIDAE
- 33 **Balanoff, A., Norell, M.** ADULT MORPHOLOGY AND VARIATION WITHIN THE OVIRAPTORID *KHAAN MCKENNAI* (THEROPODA: OVIRAPTOROSAURIA)
- 34 **Tsuihiji, T., Watabe, M., Gishlick, A., Barsbold, R., Tsogtbaatar, K.** NEW INFORMATION ON THE PECTORAL GIRDLE, STERNUM, AND FORELIMB OF *AVIMIMUS* (DINOSAURIA: THEROPODA) FROM THE GOBI DESERT OF MONGOLIA
- 35 **Tahara, R., Larsson, H.** NOVEL INTERPRETATION OF THE EVOLUTION AND FUNCTION OF CRANIAL SINUSES IN NON-AVIAN THEROPODS
- 36 **Larson, D.** MULTIVARIATE ANALYSES OF SMALL THEROPOD TEETH AND IMPLICATIONS FOR PALEOECOLOGICAL TURNOVERS THROUGH TIME
- 37 **Hoffman, E., Hwang, S.** IDENTIFYING DIAGNOSTIC CHARACTERS IN THE TOOTH ENAMEL MICROSTRUCTURE OF DROMAEOSAURID DINOSAURS
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- 43 **Bordy, E., Knoll, F.** PRESENCE OF BASAL SAUROPODOMORPHA IN THE LOWER JURASSIC LISBON FORMATION (KAROO SUPERGROUP, ELLISRAS BASIN, SOUTH AFRICA)
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- 45 **Hone, D., Wedel, M., Xu, X., Clark, J.** A SMALL ASIAN BRACHIOSAURID SAUROPOD DINOSAUR FROM THE LATE MIDDLE JURASSIC OF CHINA
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- 47 **Birkemeier, T., Wahl, W.** *CAMARASAURUS* (CAMARASAURIDAE, SAUROPODA) PATHOLOGIES OF THE BESIDE SAUROPOD QUARRY, THERMOPOLIS, WYOMING
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- 101 **Godfrey, S., Geisler, J., Lambert, O.** A NEW GENUS AND SPECIES OF PLIOCENE DOLPHIN (CETACEA: ODONTOCETI: INIOIDEA) FROM NORTH CAROLINA, U.S.A.
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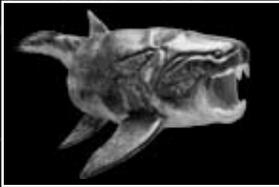


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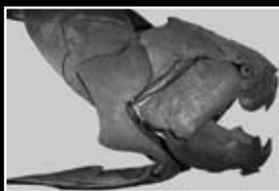
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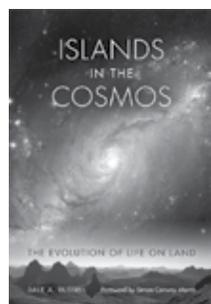


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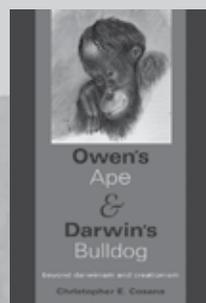
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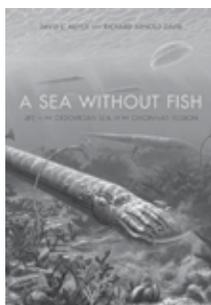


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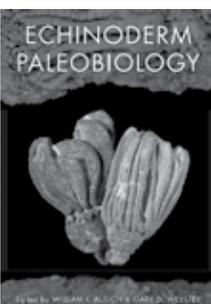
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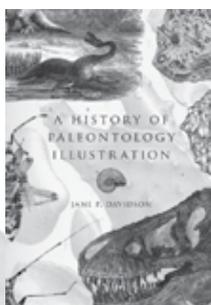
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#### CYNODONT DIVERSITY TRENDS IN THE TRIASSIC-EARLY JURASSIC

ABDALA, Fernando, Bernard Price Institute for Palaeontological Research, University of the Witwatersrand, Johannesburg, South Africa

Cynodonts are an important component of Mesozoic faunas, and, in the Triassic, are frequently the most abundant group. Non-mammaliaform cynodonts are basal representatives of this group first documented in the Late Permian, and with their undoubted younger members from the Early Cretaceous. This paraphyletic group is composed of approximately 104 species/92 genera, 66 sp/59 gen of them represented in Gondwana and 39 sp/33 gen in Laurasia. Of these, only three taxa, the Late Permian *Procyonosuchus*, the Middle Triassic *Scalenodon* and the Early Jurassic *Pachygenelus* are represented in deposits of both subcontinents. Results of an analysis of the diversity of cynodonts (non-mammaliaform cynodonts and basal mammaliaformes) during the Triassic and Early Jurassic indicate that they reach their maximum diversity of 46 genera during the Upper Triassic. Two peaks of diversity are recognized when analyzing the group at the level of temporal stage: the first during the Anisian with 21 genera and the second during the Norian, here considered as including the Rhaetian, with 28. The first peak is probably reflecting a large number of faunas of Anisian age including cynodonts (11, nine of them in Gondwana). The Norian peak is likely reflecting the number of localities (18, 15 of them in Laurasia), the long duration of the Norian stage (16.9 Ma) and an extensive record of isolated teeth representing several taxa, particularly from Europe.

Poster Session I, (Wednesday)

#### CROSSING THE BOUNDARY: INSIGHTS ON AN ELASMOBRANCH RECOVERY FAUNA

ADOLFSSSEN, Jan, Natural History Museum of Denmark, Copenhagen, Denmark

The K/T-boundary is famously known for its major extinction event, but the extent of this event and the resolution of the subsequent recovery suffer in part due to a lack of suitable exposures. The outcrop at Stevns Klint, south of Copenhagen, Denmark is one such a locality. Here, the boundary clay (the marine Fiskeler member [Fish clay] of the Rødvig Formation) has been investigated for its iridium signature and clay minerals, especially over the last three decades, but its content of vertebrate remains has largely been ignored. The Fiskeler ranges in thickness from 2cm to about 30cm, and can be divided into three distinct layers. While data presented here are still preliminary, they give some insights into the faunal recovery shortly after the extinction event. Tens of kilos of clay have been sampled and screen-washed and have yielded several thousand fragmented and whole, shark teeth, as well as remains of bony fishes. The state of preservation of the teeth is, in general, very good and several new species have been identified. In addition, specimens of very rare species from other north European localities have been found, and these offer the possibility of improving our understanding of some rare taxa. The fauna investigated shows an interesting step-wise recovery, with species and specimen-poor lower layers passing into a specimen and species rich upper layer. The fauna is dominated by Triakidae (Carcharhiniformes) and Odontaspidae (Lamniformes) sharks, but there are also less abundant Hexanchiform, Orectolobiform, Heterodontiform and Squaliform sharks. A total of more than 30 species has been recognized, indicating a remarkably shark-rich milieu. The presence in this fauna of some sharks that are usually considered to be deep-water forms could present some obstacles to the assumption that the clay is an allochthonous deposit or that these sharks just were opportunistically foraging into temporarily unoccupied hunting grounds.

Poster Session I, (Wednesday)

#### THE LATE PLIOCENE-EARLY PLEISTOCENE SMALL VERTEBRATE SUCCESSION FROM THE GUADIX-BAZA BASIN (SE SPAIN)

AGUSTÍ, Jordi, ICREA-Institut de Paleocologia Humana i Evolució Social, Tarragona, Spain; BLAIN, Hugues-Alexandre, Institut de Paleocologia Humana i Evolució Social (CSIC associated unit), Tarragona, Spain; FURIÓ, Marc, Institut Català de Paleontologia, Sabadell, Spain; DE MARFA, Roger, Universitat de Barcelona, Departament d'Estratigrafia, Paleontologia i Geociències Marines, Barcelona, Spain; SANTOS-CUBEDO, Andrés, Institut Català de Paleontologia, Sabadell, Spain

The Guadix-Baza Basin (Granada, SE Spain) is characterized by its very complete continental succession which ranges from the latest Miocene to the late middle Pleistocene and records the earliest evidence of human presence in Western Europe (sites of Fuente Nueva 3 and Barranco León). It is composed of fluvial and lacustrine sediments which have yielded dozens of small vertebrate fossiliferous levels, including amphibians, squamates, insectivores, rodents and lagomorphs. In this basin, the late Pliocene rodent communities are not characterized by the European *Mimomys pliocenicus* and *M. ostromensis*, but by local lineages ("Kislangia" *gusii*, *M. medasensis*), which, however, show similar trends towards increasing size and hypsodonty. The first un-rooted microtines making their first occurrence in the earliest Pleistocene of the Guadix-Baza sequence are not members of the genus *Allophaiomys* but archaic ones of the genus *Tibericola*. *T. vandermeuleni* from the Guadix-Baza Basin is accompanied by the last members of the small (*Tcharinomys*) and large *Mimomys* lineages, which finally develop ever-growing molars in a parallel way with the *Allophaiomys* lineage. Early Pleistocene rodent communities are characterized by the vole *A. ruffoi*. A trend to develop nivaloid morphotypes is observed in these southern populations, leading to *A. aff. lavocati*, present in the middle early Pleistocene of Fuente Nueva 3 and Barranco León. As a difference with previous levels,

*Mimomys savini* is now a common element. In these levels *Oryctolagus* replaces *Prolagus* as dominant lagomorph. Late early Pleistocene rodent communities are characterized by the entry of an advanced microtine usually assigned to *Iberomys huescaerensis*. Taxonomic and morphological evolution of amphibians, squamates, insectivores, rodents and lagomorphs will be commented and put in relation with changes in the Eurasian terrestrial ecosystems and the successive climatic pejections of the beginning of the Pleistocene.

Technical Session II, Wednesday 9:00

#### THE BODY MUSCULATURE OF ARTHRODIRE PLACODERMS

AHLBERG, Per, Uppsala University, Uppsala, Sweden; TRINAJSTIC, Kate, Curtin University of Technology, Perth, Australia; LONG, John, Museum Victoria, Melbourne, Australia

The exceptionally preserved Late Devonian (Frasnian) fishes from the Gogo Formation, Western Australia, have recently been recognized to contain, sometimes extensive, remains of musculature preserved in three dimensions. Mapping of preserved muscles in multiple specimens of two closely related arthrodire placoderms, *Compagopiscis* and *Incisoscutum*, enable us to present the first partial map of the body musculature in a stem-group jawed vertebrate. In addition to the expected trunk and tail musculature of segmentally arranged myomeres, these placoderms show two areas of specialized muscular development. Dorsally, extending posteriorly from the rear margin of the skull roof across the nuchal gap and in under the median dorsal plate, are a pair of large muscles that contact each other in the midline and are flanked by a pair of smaller but otherwise similar muscles. These muscles, evidently modifications of the epaxial trunk musculature, must be the head elevators that rotated the head dorsally relative to the trunk armor during swimming. Ventrally, the posterior part of the abdominal musculature shows surprising complexity. Ventral to the ends of the segmental myomeres, an elongate, longitudinal, sharply defined belt of obliquely transverse muscle fibers without segmental arrangement extends along most of the length of the posteroventrolateral plate towards (and possibly reaching) the pelvis. Functionally, this may be linked to movement of the pelvic fin, erection of the clasper (in the male), and/or modulation of the movement of the tail base relative to the trunk armor during swimming. Developmentally, the arrangement of these muscle fibers at approximate right angles to the myomeric muscles suggests that they lie ventral to the "lateral somitic frontier", within the zone (also occupied by paired appendages) where muscles are repatterned by an interaction between somatic and lateral plate mesoderm. This is the first direct evidence for such muscles in a stem gnathostome.

Edwin H. and Margaret M. Colbert Poster Competition (Thursday)

#### NOVEL INSIGHTS ON THE BASICRANIUM OF *BUISNICHTIS CHISOENSIS* WITH IMPLICATIONS FOR ITS PHYLOGENETIC POSITION

AHRENS, Heather, The University of Texas at Austin, Austin, TX, USA

Mephitidae is the well-known carnivorous taxon that includes skunks and stink badgers, yet some relationships within the clade remain ambiguous. The basicranium has been acknowledged as a useful source of phylogenetic characters for mephitid systematics, but the lack of both cranial material and thorough descriptions of the basicranium has prevented the incorporation of these characters into phylogenetic analyses. Thus, the affinities of many taxa within Mephitidae have previously been determined based primarily on dentition. I provide a detailed description of the basicranium of the stem New World mephitid *Buisnictis chisoensis* using high-resolution X-ray computed tomography, which allows for the examination of previously hidden and undescribed cranial morphology. On the cerebellar side of the petrosal, the subarcuate fossa is clearly present and relatively large, filling most of the space between the semicircular canals. As in other basal mephitids, there is communication between the mastoid sinus and the tympanic bulla via an opening in the epitympanic recess. Within the tympanic bulla, two ridges are present, located on the dorsal and ventral surfaces. These ridges may have served as sites of attachment for a transverse septum, which would have divided the bulla into rostral and caudal chambers; however there is no evidence of a complete septum observed in this specimen. A shallow suprameatal fossa is present on the dorsal surface of the external auditory meatus. The base of the paroccipital process, which extends caudoventrally, minimally contacts the posterior wall of the tympanic bulla. The condyloid canal is present and located dorsally on the medial surface of the occipital condyle, within the foramen magnum. The collection of novel observations indicates that the basicranial morphology of *Buisnictis chisoensis* is plesiomorphic for mephitids and may provide insight to the placement of the taxon within mephitid phylogeny.

Technical Session IV, Wednesday 4:15

#### RELATIVE ENAMEL THICKNESS IN MIDDLE MIOCENE HOMINOIDS FROM ABOCADOR DE CAN MATA (VALLES-PENEDES BASIN, CATALONIA, SPAIN)

ALBA, David, Dipartimento di Scienze della Terra, Università degli Studi di Firenze, Florence, Italy; FORTUNY, Josep, Institut Català de Paleontologia, Universitat Autònoma de Barcelona, Cerdanyola del Vallès, Spain; MOYÀ-SOLÀ, Salvador, ICREA at Unitat d'Antropologia Biològica (Dept. BABVE) and Institut Català de Paleontologia, Universitat Autònoma de Barcelona, Cerdanyola del Vallès, Spain

We report 2D relative enamel thickness (RET) measurements for Middle Miocene apes (Primates: Hominoidea) from the Abocador de Can Mata (ACM) local stratigraphic series

(Vallès-Penedès Basin, Catalonia, Spain): the holotype cranium of *Pierolapithecus catalaunicus* (IPS21350) from BCV1 (ca. 11.9 Ma); a maxilla of *Dryopithecus fontani* (IPS35026) from C3-Ae (ca. 11.8 Ma); and a maxilla of a new genus and species (IPS43000) from C3-Aj (ca. 11.9 Ma). RET was computed on the basis of several measurements (c: enamel cap area; e: length of the enamel-dentine junction; and b: dentine area), taken from CT-scan sections through the mesial cusps of upper molars (except in two cases, where distal sections were used for preservational reasons). Martin's formula was employed:  $RET = (c/e)/(b \cdot 0.5) \cdot 100$ . The following results were obtained (mean and range): 19.5 (17.3-21.8) in *Pierolapithecus* (N=6, SD=1.7); 15.5 (14.1-16.2) in *D. fontani* (N=4, SD=1.0); and 18.6 (16.7-20.6) in the new genus (N=5, SD=1.5). The ACM apes thus share a relatively thick-enameled condition, as opposed to the thinner-enameled extant African apes. Like other Middle Miocene Eurasian taxa (the kenyapithecine *Griphopithecus* and the pongine *Sivapithecus*), *Pierolapithecus* and the new genus display considerably thick enamel, while *Dryopithecus* is somewhat thinner-enameled, more closely approaching orangutans. In the latter, thick enamel has been related to the consumption of relatively tough and hard food items. As such, the similar (or even thicker-enameled) condition of Middle Miocene Eurasian hominoids is probably indicative of sclero-carpic harvesting, either habitually or seasonally (as fallback foods). The thick-enameled condition of the ACM hominoids is consistent with a kenyapithecine-hominid sister-taxon relationship, and also with previous assertions that thick enamel might have been the fundamental adaptation that enabled the out-of-Africa dispersal of large-bodied hominoids and its subsequent initial radiation throughout Eurasia.

Poster Session III, (Friday)

#### UPDATING DINOSAUR RECORD FROM TERUEL (ARAGON, SPAIN)

ALCALÁ, Luis, Fundación Conjunto Paleontológico de Teruel-Dinópolis, Teruel, Spain; ROYO-TORRES, Rafael, Fundación Conjunto Paleontológico de Teruel-Dinópolis, Teruel, Spain; COBOS, Alberto, Fundación Conjunto Paleontológico de Teruel-Dinópolis, Teruel, Spain; LUQUE, Luis, Fundación Conjunto Paleontológico de Teruel-Dinópolis, Teruel, Spain

Teruel pioneered the Spanish dinosaur research, including the first new genus ever described in Spain, and recent fossil discoveries are now interesting not only for paleontologists, but also for regional heritage institutions and visitors to Dinópolis. Most findings are placed in Tithonian to Albian age continental sediments. Villar del Arzobispo Fm (Tithonian-Berriasian) is one of the richest in dinosaurs. Ichnites of stegosaurs, ornithopods, big-sized sauropods and theropods are abundant in limestones (El Castellar, Cedrillas, Formiche) but more scarce in lime-sandy facies (Galve). Milestones in this Formation include a giant sauropod partial skeleton and a huge theropod tooth from Riodeva, (and 50 new dinosaur sites there). The giant *Turiasaurus* represents the basal eusauropod clade Turiasauria (reasonably identified in Portugal, France, UK, and, possibly, in Africa). We also recovered there diplodocids, stegosaurids (*Dacentrurus*), ornithopods and theropods (Allosauroida and others small-sized). In El Castellar there are 8 new sites with footprints -highlighting stegosaurs- and 13 with bones. Upper Hauterivian-Lower Barremian alluvial Castellar Fm includes dinosaurs in its lower part: El Castellar (20 sites) -with *Oplosaurus*- and Miravete (7 sites). Same age deposits in Cantavieja (Mirambel Fm) have yielded a muzzel of a small theropod. Lower Barremian red clays and white sands from Camarillas Fm record tridactyl trackways in El Castellar and bones in Gúdar and Maestrazgo Geopark (Iguanodontoida in Aliaga). Upper Barremian-Lower Aptian red/grey marls and bioclastic sandstones in Miravete include some scarce dinosaur remains. The Aptian sauropod *Tastavinsaurus* has recently been proposed as belonging to a new clade: Laurasiformes. Finally, dark grey marls from Aptian Forcall Fm. in El Castellar yielded a new partial Macronaria skeleton. Thus, in the last 6 years, 100 bone and 18 ichnite new sites came to light. Many fossils are still in study and they would complete the Mesozoic scenario in this part of the Iberian Range.

Poster Session III, (Friday)

#### AN IMPORTANT NEW LOWER JURASSIC ICHNOFAUNA FROM THE NAVAJO-NUGGET SANDSTONE OF IDAHO

ALLEN, Tedrow, Rochester Institute of Vertebrate Paleontology, Rochester, NY, USA; LOCKLEY, Martin, University of Colorado at Denver, Denver, CO, USA

Vertebrate tracks from the Navajo Sandstone and its equivalents are rare north of the I 70 corridor that runs east-west through Colorado and Utah. We herein report an important new ichnofauna from the Bear Lake region of Idaho that reveals abundant, well-preserved dinosaur, synapsid and invertebrate traces. Small (4-5 cm long), *Grallator*-like, tridactyl dinosaur tracks represent diminutive theropods (hip height ~18-22 cm). Abundant small (pes length 0.5-5.0 cm) tetradactyl-pentadactyl tracks (cf. *Brasilichnium*) of quadrupedal track makers with moderate to strong heteropody represent a variety of mammaloid or synapsid trackmakers. Enigmatic moderate- to large-sized (>5 cm), tetradactyl tracks (cf. *Batrachopus* and *Navahopus*) may represent prosauropods, other archosaurs or synapsids. Tracks of large spiders (ichnogenus *Octopodichnus*) are also abundant, and indicate a wide range of sizes and gaits. The presence of the shallow-burrowing insect trace, *Entradichnus* is consistent with an arid landscape, with low vegetation and intermittent precipitation. The Bear Lake locality is the most northerly occurrence of tracks in the Navajo-Nugget Sandstone and the first confirmed report from the state of Idaho. The ichnofauna reveals the greatest variety and size range of well-preserved mammaloid (synapsid) tracks yet reported, and together with the Meeker locality in Colorado has the best sample of large

spider tracks and other invertebrate traces. Spider tracks are also known from a third locality north of I 70 but have not been reported to the south. The ichnofauna is an important window into the northern expression of the eolian ecosystem in Navajo times and represents an excellent example of what has variously been labeled as the *Chelichnus* (= *Laoporus*), *Chelichnus-Octopodichnus* or *Brasilichnium* ichnofacies, which has multiple expressions (ichnocoenoses) in eolian facies especially in the Permian through Jurassic.

Technical Session XV, Saturday 9:30

#### THE EVOLUTION OF HINDLIMB MUSCLE MOMENT ARMS AND FUNCTIONAL ANATOMY IN BIRD-LINE THEROPOD DINOSAURS

ALLEN, Vivian, The Royal Veterinary College, London, United Kingdom; HUTCHINSON, John, The Royal Veterinary College, London, United Kingdom

Computer models of theropod dinosaur hindlimbs based on skeletal anatomy and extant soft tissues allow quantified estimation of 3D moment arms (leverage) that may not be directly determined by simple observation and measurement of the fossils themselves. Based on 3D models of 10 representative taxa, we present an analysis of the evolution of moment arms in theropod dinosaurs along the evolutionary lineage of modern birds, normalized to remove size biases.

The results concur with previous findings in that most dinosaur hip muscles were multifunctional, with relatively few muscles highly specialized to rotating the hip in a single degree-of-freedom. Many muscles, particularly those originating close to the acetabulum, were found to switch moment arm polarity dependant on joint angles – muscles of the adductor group, hamstrings and iliobtibialis group in particular were found to be capable of both limb retraction and protraction at different points in the limb's arc. Muscles crossing the knee, ankle and more distal joints were found to be more stereotyped in their function. Trends observed in our sample support some previous hypotheses about the evolution of limb use in bird-line Dinosauria; expansion of the ilium and proximal ischium and pubis is correlated with increasing limb flexion/extension moment arms of associated muscles and expansion of the cnemial crests was found to correlate with increased knee extension leverage. Contrary to previous estimates hip extension leverage of the adductor group were not found to increase. Although previous estimates of the expansion of femoral medial rotation leverage correlated to expansion of the trochanteric crest were well supported, a potential concomitant reduction of the femoral lateral rotation leverage of the caudofemoral muscles was found. We theorize that the caudofemoral muscles of earlier theropods acted as a major lateral rotator antagonist to the medial rotator iliiothrochanteric group and may have hindered stance-phase balancing by medial rotation, which may be a factor in the reduction of the caudofemoral group muscles along the bird-line.

Technical Session IV, Wednesday 4:00

#### PIEROLAPITHECUS, HISPANOPITHECUS AND THE EVOLUTION OF POSITIONAL BEHAVIOR IN MIOCENE APES: PERSPECTIVES FROM THE HAND

ALMÉCJA, Sergio, Institut Català de Paleontologia, Universitat Autònoma de Barcelona, Cerdanyola del Vallès, Spain; ALBA, David, Dipartimento di Scienze della Terra, Università degli Studi di Firenze, Florence, Italy; MOYÀ-SOLÀ, Salvador, ICREA at Institut Català de Paleontologia and Unitat d'Antropologia Biològica (Dept. BABVE), Universitat Autònoma de Barcelona, Cerdanyola del Vallès, Spain

The *Pierolapithecus* partial skeleton (ca. 11.9 Ma) constitutes the earliest record of an unequivocal orthograde body plan in hominoid evolution, thus providing a unique opportunity for understanding the changes in hand anatomy that occurred during the pronograde/orthograde transition. We describe the *Pierolapithecus* manual phalanges and compare their morphology and proportions with those of other Miocene apes, in order to make locomotor inferences. In particular, we test whether the acquisition of vertical climbing and suspension was decoupled during evolution. Our results indicate that Miocene apes primitively retain phalangeal features related to powerful-grasping palmigrady, thus suggesting that above-branch quadrupedalism, inherited from stem hominoids, constituted a significant component of the locomotor repertoires of several hominoid lineages at least until the Late Miocene. Nonetheless, some Miocene apes do significantly differ regarding phalangeal curvature and/or elongation. The Late Miocene *Hispanopithecus* (ca. 9.5 Ma) departs by displaying, like orangutans, highly-curved and elongated phalanges, which together with other features are indicative of orang-like suspensory capabilities. On the contrary, the remaining Miocene apes display low to moderate phalangeal curvature and elongation, which are indicative of the lack of suspensory adaptations. As such, the transition from a pronograde towards an orthograde bodyplan, as documented by *Pierolapithecus*, is functionally related to enhanced vertical-climbing capabilities, but decoupled from the acquisition of suspensory adaptations (not found until *Hispanopithecus*). Our results thus agree with the view that hominoid locomotor evolution took place in a mosaic fashion: just like taillessness antedated the acquisition of orthograde, the latter preceded the acquisition of suspensory adaptations as well as the loss of primitively-retained, palmigrade features. This combination of primitive and derived traits in fossil apes, unexpected based on extant taxa alone, should warn us against inferring the positional behavior of extinct taxa on the basis of single morphological traits from single anatomical regions.

### BAYESIAN ESTIMATES OF ORIGINATION DATES FOR CROWN-GROUP BIRDS, PLACENTALS, AND PRIMATES

ALROY, John, University of California, Santa Barbara, CA, USA

Molecular clock analyses of major Cenozoic vertebrate clades often extrapolate their dates of origin far back into the Cretaceous. These estimates usually treat fossil-based calibration tie points as minima because in most cases no numerical errors are associated with them. Until now the only alternative has been to put confidence limits on first appearances using methods that only examine fossil occurrences of crown-group members and assume that the quality of sampling does not improve through time. Clearly it does, because clades are sampled more frequently as they diversify. It is therefore no surprise that clock studies almost always ignore such confidence limits. These problems can be surmounted by comparing occurrences of stem group and crown members. If both are sampled well and the crown replaces the stem quickly, confidence in the crown's first appearance date should be high. A simple Bayesian method can be used to compute credible intervals around appearance dates. It works with the conditional probability that any one fossil will belong to the stem or crown given each group's standing diversity at the time. It conservatively assumes a uniform prior probability of the crown's appearance going back from its oldest known fossil. Based on equations discussed by Raup, it also assumes linear rates of diversity decrease for the stem and diversity increase for the crown. Finally, it assumes that the relative preservation potential of stem and crown species does not change, even though their relative frequency does. I and others have augmented the Paleobiology Database to include fairly complete and global occurrence data sets for type localities of Cretaceous and Paleogene birds, eutherians, and primates. Stem and group group species are separated using current published phylogenies, and occurrences based on isolated limb bones or teeth are excluded. Deep Cretaceous origination times for these groups are ruled out by Bayesian credible intervals. Biogeography is a factor for primates, but separate New and Old World data sets both strongly suggest a basal euprimate split within the Paleocene. It is hoped that large apparent conflicts between molecular and fossil dates can be resolved using such methods.

Poster Session II, (Thursday)

### INDIVIDUAL DENTAL AGE STAGES IN MAMMALIAN DENTITIONS - A BASIS FOR PALEOECOLOGICAL COMPARISONS INCLUDING FOSSIL AND EXTANT SPECIES

ANDERS, Ulrike, Steinmanninstitut, Paleontology, University of Bonn, Bonn, Germany; SMITH, Holly, The University of Michigan, Ann Arbor, MI, USA; RUF, Irina, Steinmanninstitut, Paleontology, University of Bonn, Bonn, Germany; KOENIGSWALD, Wighart, Steinmanninstitut, Paleontology, University of Bonn, Bonn, Germany

For a number of paleoecological questions it is desirable to quantify the individual age of fossil mammals. The terms juvenile, adult and senile, however, are poorly defined and not always comparable across species. A widely applicable system based on dental characters would be useful because teeth are best preserved in the fossil record. Tooth eruption pattern and wear stages have been described relative to age in years for several extant species, but these data do not allow interspecific comparison. Our aim is to find a more general system of age groups, one which allows the broadest possible comparison of age groups across a variety of mammals despite differences of lifespan or dental adaptation. Based on fossil and recent material, histological serial sections, and data from literature we propose 6 individual dental age stages (IDAS): IDAS 0 comprises the prenatal stages of tooth development. IDAS I implies the stages from birth to the first attritional facets on the M1. IDAS II comprises the later stages until the completion of the permanent dentition. IDAS III applies to complete adult dentitions until the loss of the inner profile in M1, and IDAS IV, until the loss of the inner profile in M2. IDAS V lasts until the complete breakdown of the dentition. This system has the potential to apply broadly to mammals excluding e.g., odontocetes and xenarthrans. Although it is still problematic for elephants and other mammals with elephant-like tooth replacement, many mammalian fossils will be attributable to an IDAS. Moreover, broad-scale dental adaptations can be characterized by modification of the dental IDAS, e.g., in comparison to primates, murids reduced IDAS I&II and elongated IDAS I&II, and survive only exceptionally to IDAS IV. If biological data are related to the IDAS, new possibilities arise to compare mammalian groups, e.g., weaning correlates in many mammals with the end of IDAS I; hypsodonty elongates IDAS III and later stages. Adoption of standardized stages will allow comparing populations of fossil mammals characterized by mortality curves based on IDAS. Preliminary tests of the IDAS classification are made for populations of European cainotheres.

Technical Session V, Wednesday 4:30

### A DIVERSE TETRAPOD FAUNA AT THE BASE OF ROMER'S GAP

ANDERSON, Jason, University of Calgary, Calgary, AB, Canada; BRAZEAU, Martin, Museum Für Naturkunde, Berlin, Germany; CARROLL, Robert, Redpath Museum, McGill University, Montreal, QB, Canada; CLACK, Jennifer, Museum of Zoology, Cambridge University, Cambridge, United Kingdom

It has recently been suggested that low atmospheric oxygen levels in the earliest Carboniferous acted as a constraint upon tetrapod diversification, and that it was not until oxygen levels rose in the mid Viséan that tetrapods were able to radiate. This hypothesis derives from reading the taxic signal as real, and assuming that taphonomy, ecology,

biogeography, and sampling are insignificant. However, most workers consider Romer's Gap a by-product of these latter factors. We describe a diverse tetrapod fauna from Blue Beach, near Horton's Bluff, Nova Scotia, Canada, from the TN3 palynomorph stage in the early Tournasian. These fossils demonstrate the presence of a fauna comprised of most elements of the later Early Carboniferous tetrapod fauna and relictual holdovers from the Late Devonian. An *Acanthostega*-like tetrapod is represented by isolated femora and a scapulocoracoid. Colosteids are known from their distinctive humeral morphology. An *Eoherpeton*-grade embolomere is represented by humeri, one in association with femora and more distal limb elements. A whatcheeriid is known from limb bones, an articulated pelvis, and a lower jaw. Two humeri that represent different ontogenetic stages are also present, but they might also belong to a baphetid or *Crassigyrinus*-like tetrapod. Small taxa are not known, but this is attributed to the winnowing effect of the high energy depositional environment; ichnofossils from Blue Beach suggest the presence of small, terrestrial, and possibly clawed (like amniotes) taxa. New data from the nearby Albert Formation of New Brunswick, also TN3 stage, demonstrates a diverse vertebrate fauna that does not appear to include tetrapods. Combined with faunal data from Blue Beach, this suggests regional or environmental selectivity in Early Carboniferous vertebrate paleobiogeographical distributions. This shows that sampling bias, biogeography, and possibly abundance, are factors limiting the discovery of tetrapods in Romer's Gap, and that tetrapod diversification was well underway during the Tournasian. Thus Romer's Gap is not a phenomenon of low tetrapod diversity, undermining claims that oxygen levels limited tetrapod diversification.

Technical Session VII, Thursday 2:00

### HOW THE CINGULA OF BASAL MAMMAL TEETH MAY ALLEVIATE STRAIN IN THE ENAMEL CAUSED BY A SOFT FOOD DIET

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Vertebrate dentition is in constant conflict with food. Teeth need to fracture and fragment food materials, while resisting their own breakage from strains produced by the food's resistances. However, the type of food masticated will affect the kinds of stresses and strains that teeth undergo. Recent work on physical modeling of fracture mechanics has shown that structures which approximate mammalian dentition (hard enamel shell surrounding a softer/tougher dentine interior) undergo specific fracture patterns dependent on the material properties of the food items. For instance, soft materials resulted in fractures occurring at the base of the stiff shell away from the contact point, possibly due to heightened tensile strains.

The mammalian cingulum is a shelf of enamel which rings the base of the molar crown (fully or partially). Certain non-mammalian cynodonts show precursors of this structure, indicating that it may be an important dental character in the origins of mammals. However, there is little consensus as to what drove the initial evolution of the cingulum. Is it possible that it acted as a protective mechanism to counteract damage caused by soft foods as seen in the physical experiments?

In order to test this proposition, a series of theoretical dentine and enamel Finite Element (FE) models were created. Dome structures, resembling the previous experiments, and generic cone shaped "teeth" were modeled with and without cingula. "Hard" single contact and "soft" pressure forces were applied to the models to examine the relative magnitudes and directions of the maximum principle strains.

Modeling results indicate that applying pressure forces similar to those caused by soft food result in elevated tensile strains around the base of the enamel. The orientations of these strains indicate that the base of the "tooth" is actually spreading due to the multi-directional compression applied to the upper portion of the structure. The addition of a cingulum greatly reduces the maximum principle strain seen in the enamel. A review of cingula morphology among non-mammalian cynodonts and basal mammals is used to explore the effect of these strain patterns.

Technical Session XII, Friday 3:00

### SOLVING A CENTURY-OLD MYSTERY: THE STRUCTURE AND FUNCTION OF THE MAXILLARY DEPRESSIONS OF *GONIOPHOLIS* (CROCODYLOMORPHA, NEOSUCHIA)

ANDRADE, Marco, Department of Earth Sciences, University of Bristol, Bristol, United Kingdom

Since the description of the basal neosuchian *Goniopholis simus* (Berriasian, England and Germany), the function of its maxillary depressions has been a mystery. These structures are located next to the jugal suture in most Goniopholididae (e.g., *Eutretauranosuchus*, *Sunosuchus*, *Calsosuchus*). The internal structure of the depressions was described for *Goniopholis* as complex, with internal divisions. However, the morphology and function of these depressions has been overlooked in the literature. The study of a new well-preserved specimen of *Goniopholis* aff. *simus* allowed the description of its morphology and recognition of the maxillary depressions as housing a sensory organ. The depressions are level with the ventral series of maxillary neurovascular foramina (MNF) and, like these, are bounded by a smooth unornamented bony surface. The internal structure shows three internal chambers separated by septa. In the bottom of each chamber there is an enlarged foramen. The internal foramina are in line with the remaining MNF, either anterior or posterior. The maxillary depressions are interpreted as greatly enlarged MNF, creating the

internal chambers and delimiting the depression itself. This morphology was consistently found in several other goniopholidid specimens. In all living crocodylians, the MNF are directly related to dome pressure receptors (DPRs), integumentary sensory organs present on the skin surface. DPRs are innervated by the trigeminal nerve and are sensitive to pressure differences in the air-water interface. As sensory organs, the DPRs are linked to orientating behavior towards mechanical stimuli in *Alligator*; a behavior is completely abolished when the DPRs are covered. Based on the evidence provided by the extant phylogenetic bracket, the maxillary depressions of *Goniopholis* (and possibly other goniopholidids) were composite sensory organs, equipped with densely-packed DPRs. These organs constituted powerful sensors used to find and capture prey at the air-water interface, and indicate the preferential strategy and medium for prey capture in the extinct Goniopholididae.

Technical Session X, Friday 8:30

#### THE QUALITY OF THE PTEROSAUR FOSSIL RECORD

ANDRES, Brian, Yale Department of Geology and Geophysics, New Haven, CT, USA

Recently, two independent studies of the pterosaur fossil record have been presented with largely contradictory results. These studies primarily assessed either relative completeness or bias in the fossil record of pterosaurs. Ideally, aspects of each should be incorporated into the measurement and the requirements of the particular method to use the fossil record should be referenced. Along these lines, it has been put forward that with random sampling the fossil record of a taxon must be very incomplete before the phylogenetic inference is affected but with biased sampling, phylogenetic analyses can be influenced at lower levels of completeness. To assess the quality of the pterosaur fossil record within this framework, a distinct form of taxon jackknifing was employed using a new phylogeny of pterosaur relationships. Pterosaur species were placed into categories based on known biases in the fossil record, they were sequentially removed from these categories, the resulting matrices analyzed and their similarity measured to the original analysis, and the results compared to analyses with random species removal. Over the entire range and at low and high amounts of taxon removal, removal of species based on potential biases were not significantly different from random sampling. At intermediate levels of taxon removal (15-55%), removal of terrestrial species, larger species, younger species, and more recently described species had less impact on the phylogenetic analysis than removal of marine species, smaller species, and earlier described species. Removal based on ontogenetic stage, and older species were not significantly different from random removal. Removal of species based on relatively more or less species occurring in the same formation were not significantly different from one another, but both contained significantly more of the original phylogenetic structure than random removal. It may be possible to measure the quality of the pterosaur fossil record in such a manner by referencing how many species must be removed before biases begin to affect their phylogenetic results.

Poster Session IV, (Saturday)

#### SEXUAL DIMORPHISM AND BODY-SIZE CLINES IN *GAZELLOSPIRA TORTICORNIS*

ANDRES, Maria, Universidad de Zaragoza, Zaragoza, Spain; ALCALDE, Gema, Museo Nacional de Ciencias Naturales-CSIC, Madrid, Spain; AZANZA, Beatriz, Universidad de Zaragoza, Zaragoza, Spain; HERNÁNDEZ FERNÁNDEZ, Manuel, Universidad Complutense, Madrid, Spain; ALBERDI, María Teresa, Museo Nacional de Ciencias Naturales-CSIC, Madrid, Spain

The strong heterogeneity on size exhibited by the euroasian Pliocene antelope *Gazellospira torticornis* has lead different authors to set out two hypotheses: there were more than one species in the European Pliocene or the existence of a temporal body-size cline within a single species, which presented a strong trend towards size reduction along the Villafranchian. Recently sexual dimorphism has been suggested as an explanation for the differences in size of the metapodials of this fossil bovid. Moreover, studied samples are not often very representative and the possibility of a differential preservation between males and females among localities also exists. In order to clarify this issue, we have applied a tested model which explain the sexual dimorphism in four captive-bred North African bovids, three gazelles (*Nanger dama*, *Gazella dorcas* and *Gazella cuvieri*) and a caprine (*Ammotragus lervia*). All these species displayed sexual dimorphism on size and morphology. Particularly the biggest ones, *N. dama* and *A. lervia*, show sexual differences in all skeletal elements and even in teeth. Since *Gazellospira* is even larger, a similar pattern could be expected. Data of *G. torticornis* from several European localities have been included in the statistical analyses (PCA) that have been carried out. Our results confirm a comparable pattern of sexual dimorphism in *N. dama*, *A. lervia* and *G. torticornis*. Clearly separated sexual groups have been found, among others, for metapodials, humerus, radius, and astragalí and, in a lesser grade, for teeth. Besides, a decrease on body-size has been also observed from the MN16 to MN17 samples, supporting the temporal cline hypothesis.

Technical Session XVII, Saturday 2:15

#### A RE-EVALUATION OF THE DICYNODONTS (THERAPSIDA, ANOMODONTIA) OF THE PERMIAN RUHUHU FORMATION (SONGEA GROUP, RUHUHU BASIN), TANZANIA

ANGIELCZYK, Kenneth, The Field Museum, Chicago, IL, USA; SIDOR, Christian, University of Washington, Seattle, WA, USA; SMITH, Roger, Iziko South African Museum, Cape Town, South Africa; STEYER, Jean-Sebastián, CNRS-MNHN Dept. Histoire de la Terre, Paris, France; GOSTLING, Neil, SUNY Oswego, Oswego, NY, USA

Dicynodont therapsids have been known from the Upper Permian of the Ruhuhu Basin, Tanzania, since the 1930's. Nearly all of these specimens have been collected in the Usili Formation, which is generally regarded as Late Permian in age, although scattered reports place *Endothiodon* in the underlying Ruhuhu Formation. Field observations from 2007 and 2008, as well as the preservation of the supposed Ruhuhu Formation *Endothiodon* material strongly suggest that it actually originated in a conglomerate layer at the base of the Usili. Therefore, no dicynodonts are definitively known from the Ruhuhu Formation. In 2008, our field team made a new collection of fossils from the Ruhuhu Formation. Noteworthy among this material are the first dinocephalian remains from Tanzania, which suggest a Middle Permian age for the formation, as well as fragmentary material representing the oldest known Tanzanian amphibian. In addition, we collected a small, articulated snout and anterior lower jaw that appears to represent the first dicynodont from the Ruhuhu Formation. The dentition of the specimen is unique. A row of five teeth are located in a medial to lateral-trending row on the maxilla, and are flanked laterally by a shelf similar to that in *Endothiodon*. In their unworn state, these teeth are triangular in lateral view, procurved, and bear a strong groove on their anterior surface, but their pointed tips are lost with wear. Posterior and lateral to this tooth row are two larger, rounded teeth potentially in the process of replacement. The structure of the maxilla and vomer, and the placement of the tooth row, suggest possible affinities with endothiodontid dicynodonts. Analysis of high-resolution CT data is currently underway to collect additional data on the palatal and jaw morphologies of this specimen, which in turn hold the potential to further clarify its phylogenetic position. The unexpected nature of the Ruhuhu Formation fauna indicates that further collecting from this unit is needed, and that it has the potential to provide an important new window into Middle Permian tetrapod communities.

Poster Session III, (Friday)

#### FUNCTIONAL ANATOMY OF THE CERVICAL VERTEBRAE OF THE SCIMITAR-TOOTH CAT *MACHAIRODUS APHANISTUS*

ANTÓN, Mauricio, Museo Nacional de Ciencias Naturales-CSIC, Madrid, Spain; SALES, Manuel, Museo Nacional de Ciencias Naturales-CSIC, Madrid, Spain; TURNER, Alan, Liverpool John Moores University, Liverpool, United Kingdom; PASTOR, Juan, Facultad de Medicina, Universidad de Valladolid, Valladolid, Spain; MORALES, Jorge, Museo Nacional de Ciencias Naturales-CSIC, Madrid, Spain

The cervical vertebrae play an essential role in the hypothetical models of the predatory behavior of sabertoothed cats. Derived members of the machairodontine tribes Smilodontini and Homotherini share the possession of strong, elongated cervicals with prominent processes for muscle insertion, traits that have been interpreted as adaptations for a derived type of killing bite known as the Canine Shear-Bite. These features are well known in the Plio-Pleistocene homotherine genus *Homotherium*, but have remained undescribed in the basal genus of the tribe, the Miocene-aged *Machairodus*. The study of abundant, well preserved cervical vertebrae of *Machairodus aphanistus* from the Spanish fossil site of Batallones-1 (Upper Vallesian, MN 10) allows to characterize the morphology of the neck in this early species. We compare the vertebrae of *M. aphanistus* with those of later homotherine genera *Amphimachairodus* and *Homotherium*, as well as with those of other machairodontine and feline cats. We also gather data about muscle insertion placement from dissections of extant felids. Our comparisons show that the atlas-axis complex of *M. aphanistus* is intermediate in morphology between that of felines and that of *Homotherium*. The posterior cervicals, on the other hand, are surprisingly similar to those of *Homotherium* in the degree of elongation of the centra and in the development of processes for muscle attachment. This combination of features reveals a mosaic evolution of anatomical adaptations for the Canine Shear-Bite, but also raises questions about the polarity of characters such as the elongation of posterior cervical centra, since it cannot be ruled out that the cervicals of modern cats are shortened relative to those of an ancestral felid. In functional terms, the combination of feline and machairodontine cervical features in *M. aphanistus* indicates an ability comparable to that of *Homotherium* for positioning the head for biting precise points in the body of large ungulates, and to hold it very strongly in any position, but also a lesser ability to recruit atlanto-axial muscles in the depression of the head, and thus a less efficient version of the Canine Shear-Bite.

Edwin H. and Margaret M. Colbert Poster Competition (Thursday)

**DIGITAL RETRODEFORMATION OF TAPHONOMICALLY DISTORTED ANKYLOSAURID DINOSAUR SKULLS AND THE EFFECTS OF TAPHONOMY ON THE INTERPRETATION OF ANKYLOSAURID CRANIAL MORPHOLOGY**  
ARBOUR, Victoria, University of Alberta, Edmonton, AB, Canada

Taphonomic deformation of fossils results in the loss of shape information, and increases the difficulty of interpreting morphology, taxonomy, and function. Three-dimensional digital models were created to investigate causes of morphological variation in the crania of *Euoplocephalus*, and to investigate the taxonomic validity of the recently named genus *Minotaurasaurus*. Orbit shape was used as an indicator for dorsoventral crushing; a survey of more than 100 extant vertebrate skulls showed that an orbit length:height ratio of more than 1.2 may indicate that crushing has occurred. Ankylosaurid skulls were digitally retrodeformed using the imaging software Geomagic Studio. Retrodeforming *Minotaurasaurus* to restore orbit shape resulted in a more arched lateral profile, less flaring narial osteoderms, and more ventrally-inclined quadratojugal horns. Characters of the palate and braincase were relatively unaffected by retrodeformation. *Minotaurasaurus* may represent a valid genus of ankylosaurid, despite its similar appearance to other Asian taxa, but some of the characters used to diagnose it are taphonomic artifacts. Retrodeforming UALVP 31 (a dorsoventrally crushed *Euoplocephalus* skull) produced overall morphology similar to AMNH 5405 (a relatively uncrushed *Euoplocephalus* skull), suggesting that taphonomy may be a primary cause of variation in similarly-sized *Euoplocephalus* crania. Finally, finite element analysis (FEA) using the software Strand7 was used to investigate how ankylosaurid skulls might deform under taphonomic pressures. Force applied to the dorsal surface of AMNH 5405 resulted in high strain at the squamosal and quadratojugal horns, in front of the orbits, and around the nares. This indicates that these areas are the most likely to deform during dorsoventral compression. The areas of high strain in the FEA analysis correspond to the areas most likely to change shape during retrodeformation of compression, which supports the retrodeformation technique used in this study.

Poster Session III, (Friday)

**NORTH AMERICAN LATE PLEISTOCENE FELID (MAMMALIA, FELIDAE) DIVERSITY AND ITS IMPOVERISHMENT AT THE BEGINNING OF THE HOLOCENE - CLIMATE CHANGE, HUMAN IMPACT, AND COMPETITION**  
ARROYO-CABRALES, Joaquín, Instituto Nacional De Antropología E Historia, Mexico, Mexico; POLACO, Oscar, Instituto Nacional De Antropología E Historia, Mexico, Mexico; GRAHAM, Russell, Earth And Mineral Sciences Museum And Department Of Geosciences, The Pennsylvania State University, University Park, Pa, Usa; JOHNSON, Eileen, Museum Of Texas Tech University, Lubbock, Tx, Usa

During the late Pleistocene, at least 12 cat species inhabited North America, from Alaska through México, including six species over 100 kg each. These species are mountain lion (*Puma concolor*), jaguar (*Panthera onca*), Pleistocene lion (*P. atrox*), and three species of saber-toothed cat (*Smilodon fatalis*, *S. gracilis*, and *Homotherium serum*). Another extinct species, although slightly smaller (95 kg.), is the unique cheetah-like cat, *Miracinonyx trumani*. Furthermore, diverse felid assemblages with up to six species are found at many individual localities. Several patterns are seen in the decrease in diversity during the Holocene. First, available databases (FAUNMAP; CONABIO) show that the decrease in felid diversity was greater in cold and temperate areas than in tropical ones. Today, only three felids occur in Canada and upwards to six in southern México. The southward shift of the jaguar is one contributing factor. This displacement is most likely a response to climate change since it occurred throughout the Pleistocene. However, the most dramatic impact was the disproportionate removal of large species from the felid guild. Their demise is probably a direct result of elimination of their primary prey, megaherbivores, irrespective of the cause of their extinction (e. g., humans or climate). Survival of mountain lion and jaguar may be fortuitous or it may be that these species had a broader prey base than the others. Competition for prey between humans and large cats also may have been an indirect factor. Human extirpation and extermination of some species historically is also a critical factor in modern diversity patterns.

Molecular Tools in Paleobiology: Trees, Clocks and linking Geno- with Phenotype, Friday 8:00

**“MOLECULES VS. MORPHOLOGY”: WELCOMING THE END OF AN ERA**  
ASHER, Robert, University of Cambridge, Cambridge, United Kingdom

The subtitle of Colin Patterson's *Molecules and Morphology in Evolution: conflict or compromise?* suggests a dichotomy that today is no longer valid. The application of both geno- and phenotypic data in paleobiology has become standard, and self-identified paleontologists regularly use the former without pushing the envelope of what was once viewed as a disciplinary boundary. For example, in recent years an unprecedented level of confidence has recently crystallized around how living placental mammals share a pattern of common descent, consisting of four major groups: afrotheres, xenarthrans, laurasiatheres, and euarchontoglires. Compared to previous hypotheses this tree is remarkably stable. More importantly, it enables paleobiologists to ask previously intractable questions. Here, I discuss how the recent identification of northern and southern placental mammal clades illuminates a potential, major division within Placentalia in terms of vertebral patterning and dental eruption, phenotypes that potentially share elements of a common developmental

mechanism. Broadly speaking, the capacity to test hypotheses of character evolution based on a relatively stable tree of extant placental mammals is neither “conflict” nor “compromise”, but a result of synergy between molecular and morphological data applied by paleobiologists unperturbed by antiquated academic divisions.

Poster Session IV, (Saturday)

**TAXONOMIC REVISION OF TAPINOCEPHALID DINOCEPHALIANS-THE KEY TO UNDERSTAND MIDDLE PERMIAN BIODIVERSITY**

ATAYMAN, Saniye, BPI Palaeontology, University of Witwatersrand, PO Wits 2050 South Africa, Johannesburg, South Africa; RUBIDGE, Bruce, BPI Palaeontology, University of Witwatersrand, PO Wits 2050 South Africa, Johannesburg, South Africa; ABDALA, Fernando, BPI Palaeontology, University of Witwatersrand, PO Wits 2050 South Africa, Johannesburg, South Africa

The dinocephalian subfamily Tapinocephalidae was the dominant and most successful herbivorous therapsid group of the Middle to early Late (?) Permian, but for all their early success it appears that dinocephalians became extinct by the start of the Late Permian. Tapinocephalids are most abundantly known from the Beaufort Group in South Africa, with fourteen genera currently recognized. Taxonomically less diverse tapinocephalid faunas are also known from Russia and Zimbabwe. Tapinocephalids are characterized by having moderate to excessive cranial pachyostosis, reduced temporal openings, intermeshing incisor teeth with a talon and crushing heel, heels on the postcanine teeth, and an anterior shift in the position of the jaw hinge. Recent biostratigraphic studies have emphasized the relatively large number of genera of tapinocephalid dinocephalian when compared with the number of genera of all the other major groups of herbivorous therapsids in any particular biozone of the Beaufort Group. This suggests that too many tapinocephalid genera may currently be recognized from the Lower Beaufort of South Africa and that a taxonomic re-appraisal is necessary. A major obstacle to such a study is that most of the tapinocephalid holotypes are based on very fragmentary material making comparison between different specimens difficult. Preliminary assessment suggests that some of these holotypes are based on juvenile specimens, and there are indications of sexual dimorphism as well. Accordingly it appears that of the fifteen currently recognized genera only eight may be valid. Because dinocephalians are a significant component of middle Permian tetrapod biodiversity, it is essential to fully understand the range of variation within different tapinocephalid genera.

Poster Session II, (Thursday)

**PHYLOGENETIC AND ECOMORPHOLOGICAL CONUNDRUMS REVEALED BY AN ENIGMATIC NEW EARLY CRETACEOUS BIRD (ENANTIORNITHES) FROM NORTHWESTERN CHINA**

ATTERHOLT, Jessie, University of Pennsylvania, Philadelphia, PA, USA; LAMANNA, Matthew, Carnegie Museum of Natural History, Pittsburgh, PA, USA; O'CONNOR, Jingmai, Natural History Museum of L.A. County, Los Angeles, CA, USA; LI, Da-qing, Fossil Research and Development Center, Third Geology and Mineral Resources Exploration Academy, Lanzhou, China; JI, Shu-an, Institute of Geology, Chinese Academy of Geological Sciences, Beijing, China

In recent years, the Lower Cretaceous (lower? Aptian) Xiagou Formation has yielded dozens of avian partial skeletons from sites in the Changma Basin of Gansu Province, northwestern China. Although the most abundant taxon among these is the ornithomorph *Gansu yumenensis*, representatives of Enantiornithes have also been identified in the sample. Among the latter, two incomplete, partially articulated appendicular skeletons are referable to a new taxon. One specimen consists of a partial pelvic girdle and complete pelvic limb; the other is comprised of a largely complete pelvic limb. The exceptional, three-dimensional preservation of these fossils provides new information regarding enantiornithian morphology, evolution, and diversity. Phylogenetic placement of the new Changma taxon is difficult, at least partly because this form possesses a unique combination of plesiomorphic and apomorphic character states. Despite the many features that support the inclusion of the taxon within Enantiornithes, our cladistic analysis was unable to substantiate this conclusion. Moreover, attempts to interpret the paleoecology of the Changma bird on the basis of its pedal morphology have also proven problematic. Previous studies that have utilized avian pedal morphology as a proxy for ecology were based on data gathered from extant (i.e., neornithian) birds. It has been noted, however, that the pelvic limb proportions of many enantiornithian taxa differ significantly from those of modern avians. It is therefore reasonable to suspect that the pedal morphology of at least some enantiornithians might extend beyond the range exhibited by modern birds as well, as appears to be the case in the new taxon. The difficulties we have encountered in resolving the phylogenetic position of the Changma bird and in placing this taxon into an established ecomorphological framework underscore the need for new, comprehensive studies of the anatomy, systematics, evolutionary relationships, and paleoecology of Enantiornithes.

**SMALL EQUID REMAINS FROM THE EARLY MIDDLE PLEISTOCENE OF VALLPARADÍS (TERRASSA, BARCELONA, SPAIN)**

AURELL-GARRIDO, Josep, Institut Català de Paleontologia, Sabadell, Spain; MADURELL-MALAPEIRA, Joan, Institut Català de Paleontologia, Sabadell, Spain; ALBA, David, Dipartimento di Scienze della Terra, Università degli Studi di Firenze, Italy, Firenze, Italy; MOYÀ-SOLÀ, Salvador, ICREA at Unitat d'Antropologia Biològica (Dept. BABVE) and Institut Català de Paleontologia, Universitat Autònoma de Barcelona, Spain, Sabadell, Spain

The construction of a railway station in the Parc de Vallparadís (Terrassa, Barcelona, Spain) recently offered the opportunity to undertake a series of paleontological excavations in a 20 m thick Pleistocene section. Twenty fossiliferous levels, originated in an alluvial/colluvial depositional environment and interbedded by catastrophic events were recognized, ranging from the late Early to the Middle Pleistocene (as inferred from the associated fauna and magnetostratigraphic data). The remains reported here were recovered from an early Middle Pleistocene level, being associated with *Cervus elaphus*, *Vulpes* sp. and *Equus* sp. (large form). Several Eurasian Pleistocene sites have yielded equid remains resembling the extant African *E. asinus* (donkeys or asses) and *E. hemionus* (onagers or Asian wild asses), as well as the extinct *E. stenorhinus*, which is thought to be related to zebuline species. The extinct European ass, *Equus hydruntinus*, resembles onagers by the slenderness of its limb bones, and asses by its small dentition; however, its characteristic stenorhinid lower dentition has been used to argue that it is not closely related to either of them. Thus far, the earliest record of *E. hydruntinus* corresponded to the Middle Pleistocene of Lunel Viel (France), further being widely distributed throughout Eurasia until the Holocene. On morphological grounds, *E. hydruntinus* has been considered to be a descendant of *E. altidens* (another stenorhinid 'horse'); cranial morphological analyses have shown that *E. hydruntinus* is closely related to *E. hemionus*, which has been recently confirmed by DNA analyses. Here we report fossil remains of at least two individuals of *Equus* cf. *hydruntinus* from Level 11 of Vallparadís, which would represent the earliest record for that species. The dentition displays classical stenorhinid characters such as V-shaped linguaflexids and deep ectoflexids in the lower teeth and short protocones in the upper teeth, further sharing with asses a microdont condition. Postcranial bones are slender and indicative of cursorial habits, resembling the condition of extant and fossil onagers, and thus confirming a close phylogenetic relationship between them.

Technical Session I, Wednesday 8:30

**TECTONIC HISTORY AND MAMMALIAN DIVERSITY**

BADGLEY, Catherine, University of Michigan, Ann Arbor, MI, USA

Diversity gradients in modern and Cenozoic mammalian faunas show the highest species richness in tectonically active regions. In contrast, tectonically stable environments at the same latitude harbor lower species richness. This pattern has long intrigued biogeographers and ecologists, who have focused mainly on how elevational gradients accommodate high species richness. The close proximity of life zones, each with a different climate and vegetation, explains the high spatial turnover of species in relation to topography, giving rise to high regional richness and ecological diversity.

Evolutionary processes should also differ from tectonically active to stable regions. I evaluate the hypothesis that tectonically active regions (mountain belts and rift valleys of active plate margins) have promoted speciation in excess of extinction of continental mammals over geologic time. High topographic heterogeneity generates new habitat and isolates populations, resulting in diversification of lineages and high species richness. In contrast, tectonically stable regions (passive margins) feature large areas of continuous habitat with few barriers, resulting in low rates of speciation and extinction and lower species richness. The fossil record provides a test of several critical predictions. Data from the Cenozoic mammalian record of North America and Eurasia support this hypothesis—with mammalian faunas in upland environments exhibiting greater species richness than coeval faunas in basin interiors or coastal regions. Also, several persistent but puzzling features of the mammalian fossil record, including low rates of speciation in long fluvial sequences and missing early members of major clades, follow from the tectonic control of diversification. This idea links earth history to geographically varying macroevolutionary processes.

Poster Session III, (Friday)

**SYSTEMATIC REASSESSMENT OF EARLY CRETACEOUS MULTITUBERCULATE FOSSILS FROM GALVE (TERUEL, SPAIN)**

BADIOLA, Ainara, University of Zaragoza, Zaragoza, Spain; CANUDO, José Ignacio, University of Zaragoza, Zaragoza, Spain; CUENCA-BESCÓS, Gloria, University of Zaragoza, Zaragoza, Spain

The Late Jurassic and Early Cretaceous (Tithonian-Barremian) bone-beds of Galve (Teruel, NE Spain) are included in four formations of the Galve sub-basin (Maestrazgo Basin, Central Iberian Range). There are diverse marine and continental vertebrate fossil assemblages distributed along these stratigraphically well-correlated sequences. Moreover, Galve is the type locality of eleven taxa. Multituberculates are the most abundant and diverse mammalian faunas. These come from the late Hauterivian-early Barremian and

early Barremian sites of the El Castellar and Camarillas Fm., respectively: the eobaatarid *Eobaatar hispanicus*, the paulchoffatiids *Galveodon nannothus* and *Parendotherium herroeri*, and the pinheirodontid *Lavocatia alfambrensis*. Here we present a systematic reassessment of isolated multituberculate teeth previously studied by Adrover and Crusafont and Crusafont and Gibert. The fossils were collected during the sixties and seventies by several German and Spanish teams, possibly from the sites of Colladico Blanco (El Castellar Fm.) and Herrero (Camarillas Fm.). Four teeth described by Crusafont and Gibert as Forma 1 (P4) and Forma 5 (P4/5), and Forma 2 (P5) and Forma 3 (I2), which on the basis of the illustrations provided by these authors were assigned to *E. hispanicus* and *P. herroeri*, are missing. The rest of the collection (twenty-four teeth) are here assigned to at least four taxa: *Eobaatar hispanicus*; two different paulchoffatiid taxa, the tiny one being tentatively assigned to *G. nannothus*, while the other one is provisionally described as Paulchoffatiidae indet.; and ?Plagiulacidae gen. et sp. nov. The latter is also present in the late Hauterivian-early Barremian site of La Cantalera, in Teruel (Oliete sub-basin of the Maestrazgo Basin). A new taxon is added to the Early Cretaceous multituberculate faunal list of Galve. This is here tentatively assigned to Plagiulacidae, in which case it would be the first of this family in the Iberian Peninsula. The species *Parendotherium herroeri*, by contrast, is only known by the lost holotype (I2) and should perhaps be considered *nomem nudum*.

Technical Session XI, Friday 9:45

**CREODONTS, ARTIODACTYLS AND CONDYLARTHS FROM EARLY EOCENE CAMBAY SHALE, VASTAN LIGNITE MINE, GUJARAT, WESTERN INDIA**

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In recent years, the early Eocene Cambay Shale (ca. 54 Ma) at Vastan lignite mine, District Surat, western India, has yielded a diverse terrestrial mammal assemblage. This assemblage, the oldest known from the Cenozoic of South Asia, is of considerable biogeographic interest when seen in the context of India-Asia collision (Out-of-India and/or In-to-India dispersal). Ongoing investigations at the Vastan mine have yielded two new taxa (hyaenodontid, condylarth), and additional specimens of the artiodactyl *Gujaratia*. The Vastan hyaenodontid is a small proviverrine that differs from *Paratritemnodon* in its lower trigonid, and narrower M/3 talonid; from South Asian proviverrines *Yarshea* and *Kyawadawia*, by its much smaller size; from European *Proviverra* in having an anteriorly shifted paraconid; cristid obliqua angled towards metaconid rather than protoconid and in progressive size reduction of metaconid from M/1-M/3, and from most North American proviverrines by much smaller size. The Vastan condylarth is known from a single tooth that is reminiscent of arctocyonids such as *Arctocyon* and *Claenodon* in its large size and simple cusp morphology. New specimens of the dichobunid *Gujaratia indica* include a well preserved upper dentition and lower jaws. The two species of *Gujaratia* (*G. indica* and *G. pakistanensis*) are a morphologically homogeneous group. *Gujaratia* differs from the North American *Diacodexis* in having smaller paraconids and shallower and narrower proto-metaconid notch on the lower molars, and in their narrower and longer lower premolars. Upper molars of *Gujaratia* differ from North American *Diacodexis* in being lingually narrower, with the usual absence of any trace of any hypocone. *Diacodexis* species from Europe are relatively diverse, resembling *Gujaratia* in some regards and differing in others. *D. varleti*, for instance, lacks any trace of the hypocone on the upper molars, just like *Gujaratia*, but it has larger paraconids on the lower molars, unlike *Gujaratia*.

Poster Session IV, (Saturday)

**ADULT MORPHOLOGY AND VARIATION WITHIN THE OVIRAPTORID KHAAN MCKENNAI (THEROPODA: OVIRAPTOROSAURIA)**

BALANOFF, Amy, American Museum of Natural History, New York, NY, USA; NORELL, Mark, American Museum of Natural History, New York, NY, USA

Oviraptorosauria, a morphologically distinctive lineage of coelurosaurian theropods from the Cretaceous of Asia and North America, recently has been the focus of numerous phylogenetic studies, most of which reveal conflicting results. These evolutionary hypotheses differ not only concerning the placement of Oviraptorosauria within Theropoda (e.g., placing it alternatively within avialans or as a less derived clade of non-avian theropods), but also produce little resolution about the interspecific relationships within the group as a whole. Despite the large amount written on the phylogenetic history of this group, surprisingly few detailed descriptions are available for oviraptorids. This generalization holds true particularly for the postcranial skeleton. Because of the relatively complete nature of many of the specimens within Oviraptorosauria, it provides the ideal opportunity to document osteological variation within one specific taxon. In this analysis we focus in particular on the osteology of *Khaan mckennai*, a taxon for which multiple complete specimens are available, foremost to provide a detailed description of its cranial and postcranial osteology. We also utilize computed tomographic (CT) scans in the description, which allows for a detailed analysis of the endocranial spaces such as the cranial cavity and temporal recesses. Although only a few examples of interspecific variation are present, this variation is present in all regions of the skeleton. We also present our preliminary hypothesis of phylogenetic relationships within Oviraptorosauria so that the variation revealed within *Khaan mckennai* can be assessed in at least two different levels of inference in order to help discriminate between interspecific and phylogenetic variation.

**EXTRACTION OF FOSSILS FROM MUCH HARDER, VOLCANICLASTIC MATRIX**

BALCARCEL, Ana, AMNH, New York, NY, USA; CONRAD, Jack, AMNH, New York, NY, USA

Collaborative international expeditions to the Main Range of the Chilean Andes have discovered diverse mammal faunas and extremely well-preserved specimens over the past 20 years. The unusual nature of the surrounding volcaniclastic matrix offers unique challenges in fossil preparation. Here, we describe key issues with this matrix, a protocol for preparation, and an embedding technique for complete recovery of all preserved specimen details. The igneous-origin matrix surrounding these fossils is among the hardest and most difficult to work with that we have encountered, both in the field and at the AMNH Vertebrate Paleontology preparation laboratory. It often requires these specimens to be collected in several pieces, frequently with parts of the specimen exposed in section, and with large amounts of encasing matrix. With the matrix being significantly harder than the included fossil, and both being brittle, the exposed fossil surfaces commonly cannot tolerate direct contact from standard preparation tools. Consolidants alone cannot adequately ameliorate this condition. Extremely long preparation time is another issue when removing such large amounts of dense matrix. The best way to prepare these specimens expeditiously, and make them available for long-term study is outlined as follows: A) Use a rock saw to remove bulk amounts of rock to save weeks or months of fine-preparation time. B) Use several airscribes and other tools, ranging widely in strength and accuracy. C) Embed any fragile areas of fossils in a clear epoxy to protect specimen integrity, and use white or gray epoxy to fill natural molds still preserved in the hard matrix. D) Prepare from the reverse side, using a series of specialized mechanical preparation tools. We will fully describe the methods, materials, and tools necessary. In particular, the special embedding technique (an epoxy-catalyst solution poured into a silicone cup around the exposed area of the specimen) will be explained, with its associated problems and solutions. Further applications of this protocol and recommendations for application to other instances of frangible specimens in various matrices will be discussed.

Technical Session XVI, Saturday 8:45

**AN APPROACH TO BRAIN SIZES IN THE RHINOCEROTOIDEA: USE AND PROBLEMS OF ENDOCRANIAL LENGTH AS A PROXY FOR BRAIN SIZE**

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Brain sizes of extant rhinos are usually included in classical logarithmic mouse-to-elephant (shrew-to-whale) curves where they plot near the large end. Log deformation overemphasizes similarity of large mammal brain sizes at similar body sizes. Arithmetic plots (+/- whales) provide insight into brain size diversity among terrestrial mammalian meso- and megafauna. The large fossil record of rhinocerotoid crania plus large collections of extant rhino skulls, gives an opportunity to approach brain size in this clade. As an adjunct to 57 craniometric variables measured in living and fossil taxa, endocranial length (EL) was measured in extant skulls. EL is a direct estimate of brain length (caudal brainstem limit to rostral rhinencephalon limit) where the neuraxis is a straight shot from foramen magnum to cribriform plate. The usefulness of EL as a proxy for brain size is debatable since telencephalons may theoretically overgrow the neuraxis without its necessary extension. Nevertheless, some estimate of brain size is better than none, and brain length may of interest in its own right. Multiple stepwise regression on 57 craniometric variables (independent) against EL (dependent) in 252 extant rhino skulls resulted in three measures with highest r-sqrd: temporal fossa length (TFLN), total face height (TFHT), and binasal breadth (BNAS). TFLN is intuitive (a braincase length) but TFHT and BNAS are less explainable biologically (beneficially, their perpendicularity to skull length remove collinearity as a concern). Multiple linear regression on these measures generated a predictor equation for fossil crania EL (n = 84 skulls with all three measures, spanning the *Hyrachyus* to *Paraceratherium* size range). Plots of EL versus skull length have shown some interesting results (a) *Teleoceras* has longer ELs in its size range than any other group while *Menoceras* has the shortest ELs for its range, (b) remaining groups occupy a band but with increasing EL variation at a given size, (c) smallest fossil adults plot with extant juveniles, (d) simple allometry fitted to living rhinos does not extrapolate to *Paraceratherium*.

Poster Session III, (Friday)

**THE K-T IMPACT ON PALEOBIODIVERSITY; NEW PALEOECOLOGICAL PERSPECTIVES FROM SOUTHERN SASKATCHEWAN, CANADA**

BAMFORTH, Emily, McGill University, Montreal, QB, Canada; LARSSON, Hans, McGill University, Montreal, QB, Canada

For decades, the Cretaceous mass extinction has generated much public and scientific interest, largely due to its most charismatic victims; the non-avian dinosaurs. It is, however, of critical importance to recognize that the dinosaurs, or indeed any fossil groups, were not ecologically isolated, but were part of an interactive, dynamic ecological landscape. It is therefore beneficial to focus on paleobiodiversity as a whole, and the changes that may have been occurring on an ecosystem level prior to and following the extinction event. The Cretaceous-Tertiary (K-T) boundary is better exposed in the Killdeer Badlands of southern Saskatchewan than anywhere else in Canada, and is one of few terrestrial exposures in North America. Our recent pioneering surveys of the Frenchman (Maastrichtian) and Ravenscrag

(Paleogene) formations in Grasslands National Park, Saskatchewan, Canada have revealed a rich plant and vertebrate fossil record, including at least five genera of turtles, fish, crocodiles, champsosaurs, birds, salamanders, lizards, mammals, and dinosaurs. The abundant, diverse, and relatively well-preserved fossil assemblages within the Park have provided an ideal natural laboratory on which to base a paleobiodiversity study. To date, 325 fossil sites have been identified in the Park, within an area of approximately 9km<sup>2</sup>. The location and elevation of each of the sites surveyed was mapped using GPS coordinates, and the condition, type, and abundance of fossil material present within them was documented to generate an extensive fossil database. The integration of the GPS data and fossil database information is allowing for the generation of an interactive 3-D map of the study site that can be used as a tool to resolve spatial and temporal trends in paleobiodiversity above and below the K/T Boundary. Our research to date has indicated small-scale temporal variation in microfossil diversity distribution, as well as suggesting a possible spatial partitioning of crocodile and champsosaur sites. Clustering of sites containing dinosaur material, both ornithischian and theropod, suggests the presence of at least five bone beds, at two different stratigraphic levels.

Poster Session IV, (Saturday)

**NEW DATA ON THE PHYLOGENETIC POSITION OF THE SAUROPOD GALVESAUROUS (TITHONIAN-BERRIASIAN, SPAIN)**

BARCO, José, Universidad de Zaragoza, Zaragoza, Spain; CANUDO, José Ignacio, Universidad de Zaragoza, Zaragoza, Spain; CUENCA-BESCÓS, Gloria, Universidad de Zaragoza, Zaragoza, Spain

The sauropods of the end of the Jurassic and beginning of the Lower Cretaceous of Spain form a singular fauna that includes non-neosauropod eusaurotops, basal macronarians and diplodocoids. The phylogenetic position of some of them differs significantly among different authors. An example is *Galvesaurus herreroi*, which comes from the Tithonian-Berriasian sediments of the Villar del Arzobispo Formation in Galve (Teruel). *Galvesaurus* has been linked equally to Cetiosauridae, Turiasauria and Neosauropoda. This paper presents the results of the cladistic study produced by including *Galvesaurus* in the matrix elaborated by Harris. The Paup application generated six equally parsimonious trees that situate *Galvesaurus* as a non-titanosauriform macronarian neosauropod in a clade together with other Iberian sauropods of the Lower Cretaceous. Its position among the neosauropods or one or another of their internal groups is well supported by the presence of very deep, ramifying pleurocoels in the presacral vertebrae, which are also divided by bony septa in cervical vertebrae and separated from the pneumatic fossae present in the dorsal surface of parapophyses; very elongated mid-cervical centra; pendant triangular lateral processes projecting greatly laterally from distal ends of posterior dorsal neural spines; absence of "crus" bridging proximal margin of haemal canal; and even caudal neural arch located over proximal half of centra in middle caudal vertebrae. The conclusion of this study is that the Villar del Arzobispo Formation (Upper Tithonian – Lower Berriasian) contains representatives of non-neosauropod eusaurotops such as *Turiasaurus* and *Losillasaurus*, together with more derived forms such as *Galvesaurus*.

Poster Session III, (Friday)

**BAYESIAN ANALYSIS OF RUMINANTS USING MOLECULAR AND MORPHOLOGICAL DATA**

BÄRMANN, Eva, Cambridge University, Cambridge, United Kingdom

With their peculiar gut arrangement, the lack of upper incisors and fused metapodials, the ruminants are a well defined group of cetartiodactyls. Sequence data also suggest monophyly of the taxon with good support. However, despite great effort of paleontologists and molecular biologists, the relationships of certain ruminant subgroups remain unresolved. This is particularly so when living ruminants (e.g., Palaeomerycidae) are taken into account. Here, I attempt to estimate phylogeny for living as well as fossil ruminants using a Bayesian method to analyze DNA sequence data and morphological characters of the skull and postcranial skeleton simultaneously. To make up for convergent evolution in many groups of living ruminants, a hierarchical approach is used, where the ancestral character states for smaller monophyla are reconstructed and used as terminal taxa in the second step of analysis. This method will be demonstrated for Antilopinae, for which the reconstructed tree allows the reconstruction of their most recent common ancestor.

Technical Session I, Wednesday 12:00

**THE PATH TO THE FUTURE: PALEONTOLOGY MEETS CONSERVATION BIOLOGY**

BARNOSKY, Anthony, University of California-Berkeley, Berkeley, CA, USA; HADLY, Elizabeth, Stanford University, Stanford, CA, USA

Even if anthropogenic carbon emissions were to stabilize at today's levels, Earth would continue to warm over the next few decades. It therefore seems inevitable that by the 2050s, the planet will be hotter than it has been since humans became a species. This rapid rate and high magnitude of warming means that climate within nature reserves will change outside the bounds required by some species that the reserves are meant to protect, effectively causing those species to go extinct unless land managers intervene to move species to different parts of the globe. This sets up a dilemma for conservation biology: how

do we continue to save species, without turning Earth's remaining wildlands into elaborate zoos? We argue that the answer to this dilemma is to be found by using the fossil record to help redefine the world's concept of nature reserves. Using vertebrate fossil data to define the natural baseline of ecological fluctuation at the community, species, organismal, and genetic levels, in the absence of heavy anthropogenic influence, makes clear the need for two separate-but-equal kinds of reserves: 'species reserves', and 'wildlands reserves.' The explicit goal of species reserves is to save species, even when natural ecosystem processes have to be sacrificed. In contrast, we need to create wildlands reserves to preserve natural ecological processes, even when individual species within them have to be sacrificed. The vertebrate fossil record provides the yardstick to measure what species are most critical to preserve in species reserves, and what spectrum of ecological ebb-and-flow should be considered natural for wildlands preserves.

Late Triassic Terrestrial Biotas and the Rise of Dinosaurs, Thursday 12:00

#### HERBIVORY AND THE EARLY EVOLUTION OF DINOSAURIA

BARRETT, Paul, The Natural History Museum, London, United Kingdom; BUTLER, Richard, Bayerische Staatssammlung für Paläontologie und Geologie, München, Germany; NESBITT, Sterling, American Museum of Natural History, New York, NY, USA

Dinosaurs are usually considered to be primitively carnivorous, a conclusion based on two major assumptions: that the dinosaurian common ancestor was essentially theropod-like; and that the closest dinosaur outgroups (e.g., *Marasuchus*) were carnivores. However, reappraisal of dinosaur morphology and optimization of diets on to evolutionary trees indicates that the distribution of herbivorous character states among these taxa was complex. In addition, herbivory seems to have been acquired contemporaneously in dinosaurs and "silesaurs", perhaps hinting at a common ecological or evolutionary driver. Models of dinosaur origins need to move beyond carnivory to incorporate the possible consequences of omnivory or herbivory on the early radiation of the clade.

Whatever, the primitive condition, omnivory and herbivory were acquired early in ornithischian and sauropodomorph history, with these clades adopting divergent strategies to deal with a plant-based diet. Sauropodomorphs adopted large body sizes and relatively simple feeding mechanisms: they rapidly attained high levels of diversity and abundance during the early Late Triassic. Ornithischians possessed more sophisticated jaw mechanisms: however, paradoxically they remained relatively rare components of Mesozoic ecosystems until the Late Jurassic. Consequently, herbivory can be considered a key innovation for sauropodomorphs, whereas it did not promote the initial diversification of ornithischians. Reasons for this might include physiological differences between these taxa, food plant preferences or competitive exclusion.

Poster Session III, (Friday)

#### FIRST MINERALOGICAL AND GEOCHEMICAL OVERVIEW AND INTERPRETATION OF "LO HUECO" VERTEBRATE SITE (UPPER CRETACEOUS, CUENCA, SPAIN)

BARROSO-BARCENILLA, Fernando, de Ciencias. Universidad de Alcalá de Henares, Alcalá de Henares, Spain; CAMBRA MOO, Oscar, ETSI Informática. UNED, Madrid, Spain; CARENAS, Beatriz, Fac. Ciencias. Universidad Autónoma de Madrid, Madrid, Spain; CORUÑA, Francisco., Ciencias Geológicas. Universidad Complutense Madrid, Madrid, Spain; DOMINGO, Laura, Ciencias Geológicas. Universidad Complutense Madrid, Madrid, Spain

The "Lo Hueco" vertebrate site includes an upper Campanian-lower Maastrichtian interval in "Garumn" facies constituted by a succession of versicolor marly mudstone levels (V, G1, R1, G2, R2 and M), partially cut by a sandy channel structure (C) and a sulphated interval (S). C, G1, G2 and R2 (lower part) contain an exceptional richness and diversity of fossils, and have to date provided more than 8500 macroremains, mainly from titanosaur dinosaurs, although also from lepisosteid fishes, bothremydid turtles, squamate lizards, eusuchian crocodiles and ornithischian, theropod and other sauropod dinosaurs. X-Ray Diffraction analyses show that "Lo Hueco" presents a very high proportion of clay minerals (>85% in the versicolor succession, <40% in C and S). Among them, illite (66.30-34.97%), kaolinite (49.02-22.09%), smectite (21.62-0%) and chlorite (1.99-0%) stand out. It also has a high proportion of gypsum (up to 63.82% in S) and a low proportion of quartz, calcite and feldspar (only outstanding in C: up to 26.73% of quartz, 16.93% of calcite and 7.61% of feldspar). *Stable Isotope* analyses, performed on bulk rock samples, show that  $\delta 18\text{O}$  values ranges between  $-6.55\text{‰}$  and  $0.26\text{‰}$  (VPDB), and  $\delta 13\text{C}$  values between  $-9.18\text{‰}$  and  $-6.45\text{‰}$ . Mean values  $\pm 1$  standard deviation are  $-5.16 \pm 1.96\text{‰}$  and  $-8.34 \pm 0.82\text{‰}$  for  $\delta 18\text{O}$  and  $\delta 13\text{C}$ , respectively. Even though, similar trends in  $\delta 18\text{O}$  and  $\delta 13\text{C}$  curves can be pinpointed across the section, with three well-developed positive spikes in V, R1 (lower part) and M, the variability shown by  $\delta 18\text{O}$  values is higher than that shown by  $\delta 13\text{C}$  values. Interpretation of these mineralogical and geochemical results, complemented with the sedimentological and paleontological data, suggests for "Lo Hueco" a transitional brackish water (estuarine) to continental fresh water (riverine) depositional environment, exposed to intermittent high to low energy intervals, and a possible subsequent diagenetic post-burial moderate alteration. It should however be pointed out that these results are preliminary and complementary analyses are necessary in order to draw further conclusions.

Poster Session III, (Friday)

#### TOOTH ERUPTION SEQUENCE IN *HYAENODON* AND IMPLICATIONS FOR THE ORIGIN OF *HYAENODONTIDAE* (CREODONTA, MAMMALIA)

BASTL, Katharina, Department for Paleontology, University of Vienna, Vienna, Austria; NAGEL, Doris, Department for Paleontology, University of Vienna, Vienna, Austria; MORLO, Michael, Forschungsinstitut Senckenberg, Frankfurt, Germany; HEIZMANN, Elmar, Staatliches Museum für Naturkunde, Stuttgart, Stuttgart, Germany

Two European specimens, one from the cleft fissure Liptingen (Western Swabian Alb, Germany) and one from Quercy (France) give new information on the tooth eruption sequence of European *Hyaenodon*. The p4 erupts after p3 and m3. This contrasts the hitherto described tooth eruption sequence, that was based on North American findings. In North American *Hyaenodon* p4 erupts before p3 and m3. This significant difference indicates divergence between European and North American forms and can be used as taxonomic feature. This leads to the matter of a possible genus separation. Further, the origin of *Hyaenodon* is discussed and considered to have taken place in Asia, with *Propterodon* as possible candidate as predecessor.

Romer Prize Session, Thursday 11:45

#### PREDICTING SPEED, GAIT AND METABOLIC COST OF LOCOMOTION IN THE LARGE PREDATORY DINOSAUR *ACROCANTHOSAURUS* USING EVOLUTIONARY ROBOTICS

BATES, Karl, University of Manchester, Manchester, United Kingdom

What were the limits of locomotor performance in large theropod dinosaurs and how was functional morphology adapted to the engineering demands of increased size? In this study I use rigid-body dynamics and evolutionary robotic optimizations to reverse-engineer locomotion in the Cretaceous theropod *Acrocanthosaurus*. With a mass in excess of 5000kg and the highest femur:metatarsal length of any theropod, *Acrocanthosaurus* represents the extreme of the non-avian theropod hind limb locomotor module. A 3D musculoskeletal model has been constructed which includes body segment mass and inertial properties and 22 hind limb muscles reconstructed using extant phylogenetic bracketing. The muscle activation pattern has been developed by a genetic algorithm optimization system, which generates gaits de novo and alleviates the need to subjectively infer joint kinematics or rely on extant taxa as locomotor analogues. Maximum running speed optimizations using a best estimate model predict a top speed of 6.8m/s, and an erect running gait characterized by a short aerial phase and modest hip flexion. A sensitivity analysis, in which soft tissue parameters were varied over plausible values for *Acrocanthosaurus*, reveals a significant range in possible speeds (3.9-7.5m/s) reflecting uncertainty in muscle contractile properties. However, joint excursions vary surprisingly little across this range; the greatest shift in kinematics occurs when trunk centre of mass is shifted to the cranial extreme, which induces increased femoral protraction in late swing and early stance phases. Optimizing metabolic energy expenditure predicts a reduction in the cost of locomotion with decreasing speed. Optimal walking speeds occur between 2.3-2.7m/s where cost of locomotion is comparable to extant bipeds. These gaits show close agreement with stride lengths and predicted speeds from Paluxy River theropod trackways attributed to *Acrocanthosaurus*. Preliminary results from finite element analysis indicate high bending stresses in flexed femoral postures at the highest running speeds, suggesting large theropods may have been limited to upright limb orientations as predicted here for *Acrocanthosaurus*.

Technical Session XI, Friday 9:15

#### FAUNAL PROVINCIALISM AND FAUNAL TURNOVER DURING THE PALEOCENE-EOCENE THERMAL MAXIMUM: NEW EVIDENCE FROM THE GULF COASTAL PLAIN OF MISSISSIPPI, USA

BEARD, K. Christopher, Carnegie Museum of Natural History, Pittsburgh, PA, USA; DAWSON, Mary, Carnegie Museum of Natural History, Pittsburgh, PA, USA

The earliest Wasatchian Red Hot local fauna (RHLF) samples a community of mammals and other organisms living near the ancient coastline of the Gulf of Mexico in what is now east-central Mississippi, USA. This snapshot of mammalian diversity provides a rare opportunity to gauge the significance of biotic provincialism within North America during the Paleocene-Eocene Thermal Maximum (PETM), a time of dynamic climate change. Faunal endemism with respect to the Rocky Mountain Interior of North America is high (>80%) at the species level, consistent with evidence for substantive differences in the physical environment and flora. Included among the 33 species of mammals currently documented from the RHLF is the first North American record of the cimolestid *Naranius*, otherwise known only from Bumbanian faunas of Mongolia and China. Its unexpected presence in the RHLF indicates that at least some Asian immigrants to North America were restricted to specific biomes and were unable to colonize intermontane basins such as Wyoming's Bighorn Basin. The presence of unusually small species of the hyopsodontid *Haplomylos*, the phenacodontid *Ectocion*, and the miacid *Miacis* and *Vassacyon* in the RHLF supports biostratigraphic correlation with earliest Wasatchian (Wa-M and/or Wa-0) faunas in the Bighorn Basin. This correlation is consistent with evidence from sequence stratigraphy and dinoflagellate biostratigraphy. The small-bodied mammalian taxa in the RHLF suggest an allochthonous, rather than autochthonous, pattern of faunal turnover during the PETM. Seemingly transient episodes of phyletic dwarfing among several mammalian taxa during the PETM in the Bighorn Basin can be explained more readily as the result of shifting taxon ranges coincident with PETM warming.

**THE ORIGIN OF AN OPISTHOTONIC POSTURE IN FOSSIL VERTEBRATES**  
BEARDMORE, Sue, University College Dublin, Ireland, Dublin, Ireland

An opisthotonic posture, the recurvature of the neck and head posteriorly over the dorsal side of the animal, is a recurrent feature in both Recent and fossil vertebrate skeletons (avian, dinosaurian and mammalian). Although various hypotheses have been proposed for its origin, the authors of the most recent review considered it to originate peri-mortem, i.e. at the time of death, via muscular spasms induced by poisoning or disease in the central nervous system. This phenomenon is known from clinical literature, but is exhibited by a carcass only for the period in which rigor mortis is present (i.e. for only a relatively short length of time after death). Critically, it will be lost during any subsequent re-orientation of the carcass, for example as a result of transport. To accommodate this, the occurrence of an opisthotonic posture in fossil vertebrates is attributed to a very specific set of taphonomic circumstances, essentially rapid entombment, at, or very shortly after, death. This prevailing model is tested against the depositional context of three fossil faunas in which vertebrates routinely exhibit an opisthotonic posture: the Jehol Biota, a lacustrine sequence of Early Cretaceous age from China; the Monte San Giorgio reptile-dominated fauna of Middle Triassic age from the border region between Switzerland and Italy; and the lagoonal Upper Jurassic Solnhofen Lithographic Limestone. The sedimentary context of none supports the peri-mortem model; in the Jehol Biota articulated vertebrate carcasses occur in laminated to thin-bedded fine-grained facies, and rarely in the rapidly emplaced medium-thick bedded volcanoclastic deposits. Monte San Giorgio reptiles preserved in an opisthotonic posture are known from fine-grained, dark-colored, hemipelagic shales. In each case, there is evidence for an extended residence time in the water column and/or at the sediment/water interface. The opisthotonic posture can more plausibly be attributed to contraction of ligaments through dehydration and desiccation resulting in shortening of the vertebral column's length. Its origin in fossils is post-mortem, not peri-mortem; clear evidence of this timing is provided by re-orientation of Solnhofen specimens after growth of microbial mats and adherence to the substrate.

Technical Session IV, Wednesday 2:45

**DENTAL MICROWEAR AS AN INDICATOR OF RESPONSE TO CLIMATE CHANGE IN MODERN AND FOSSIL SIRENIA**

BEATTY, Brian, New York College of Osteopathic Medicine, Old Westbury, NY, USA;  
GHOBRIAL, Mark, New York College of Osteopathic Medicine, Old Westbury, NY, USA;  
IVANOVA, Valerie, New York College of Osteopathic Medicine, Old Westbury, NY, USA

The late Miocene changes in climate, ocean currents, and physiography, in part due to the rise of the Isthmus of Panama, came associated with drastic changes in sea level and shallow benthic communities that have been hypothesized to have affected the diversity of marine mammal herbivores in the West Atlantic and Caribbean. Sirenians today feed in a variety of shallow marine habitats, and in order to test these differences we employed dental microwear analysis of modern manatees from a variety of environments, paying particular attention to diet and the composition of the substrate in which these animals fed. Photomicrographs were taken at 100X under a stereomicroscope and standard microwear features (e.g. pits, scratches) were quantified. Preliminary analysis indicates that though microwear in aquarium-raised manatees is variable, microwear of wild manatees appears restricted to different taxa and their environments. Specifically, the relationship between scratch density and pit density appears to allow separation between individuals feeding in environments in which the substrate is dominated by calcareous versus quartz sand. Among sampled fossil dugongids, *Metaxytherium* appears to have microwear much more like manatees that feed from more calcareous dominated sands, like modern *Dugong* does. This makes sense, as many of the phosphate mines from which these fossil dugongids are known represent the ideal nutritional environment for seagrasses. In addition, we studied the wear patterns of captive raised *T. inunguis*, controlling for environmental conditions that appear to indicate that diet plays a role in gross dental wear as well. Ultimately, microwear is a complex of dietary and environmental interactions with teeth, and resolving its meaning will require more sampling and analysis of modern and fossil Sirenia, as well as experimental approaches with living animals. Despite this complexity, it appears that dental microwear allows us to separate dietary and/or substrate interactions among modern and fossil Sirenians and how they responded to changes in the West Atlantic and Caribbean in the late Miocene/early Pliocene.

Poster Session IV, (Saturday)

**POSSIBLE SEXUAL DIMORPHISM IN REMINGTONOCETIDAE (MAMMALIA, CETACEA, ARCHAEOCETI) FROM THE DOMANDA FORMATION OF PAKISTAN**

BEBEJ, Ryan, University of Michigan, Ann Arbor, MI, USA

Remingtonocetidae are semiaquatic archaeocete cetaceans from the early middle Eocene of India and Pakistan. They are characterized by their long necks and long narrow skulls and include the genera *Remingtonocetus* and *Dalanistes*. *Dalanistes* is known from the lower and middle Domanda Formation of Pakistan and has been differentiated from *Remingtonocetus* by its larger size, location of its external nares, height of its sagittal crest, orientation of its braincase, length of its mandibular symphysis, and morphology of its mandibular canals. More recently collected specimens of *Remingtonocetus* show that many of these features do not differ between these genera, and that they are more similar than initially recognized.

This raises the possibility that these genera may instead represent males and females of a single species. Vertebrae from 38 individuals were studied to assess the degree of size variability between taxa. Compared with *Remingtonocetus*, cervical vertebrae of *Dalanistes* are on average 19% larger, close to the 20% difference in published cranial measurements. Lumbar and sacral vertebrae of *Dalanistes* are only 12-13% larger, with a narrower range of sizes among all elements than in the cervical region. Dimensions of dental alveoli indicate that the canines of *Dalanistes* are 18% larger, while their premolars and molars are only about 13% larger. The larger difference in canine size is suggestive of sexual dimorphism, though the disparity is less than that seen in dimorphic protocetids such as *Maiacetus inuus*. Both genera are common in the middle Domanda Formation, but all of the 14 specimens recovered to date from the upper Domanda Formation appear to belong to *Remingtonocetus*. While it is possible that these two taxa comprise a single, sexually dimorphic species, the current evidence indicates that *Dalanistes* and *Remingtonocetus* should continue to be regarded as separate, closely-related species.

Molecular Tools in Paleobiology: Trees, Clocks and linking Geno- with Phenotype, Friday 10:45

**RESOLVING THE HIGHER-LEVEL PHYLOGENY OF MARSUPIALIA USING MOLECULAR AND MORPHOLOGICAL DATA: PROGRESS, PROBLEMS AND PROSPECTS**

BECK, Robin, American Museum of Natural History, New York, NY, USA

Recent molecular and morphological estimates of the higher-level phylogeny of marsupials have been characterized more by consensus than by conflict. Both data types support a fundamental split between Australidelphia (Australian marsupials plus South American microbiotherians), and (the probably paraphyletic) Ameridelphia (South American didelphimorphians and paucituberculatans). However, a number of key nodes remain uncertain. Here, I discuss: 1) an isolated calcaneus from the Australian early Eocene Tingamarra Fauna that suggests that Didelphimorphia ('true' opossums) is the sister-group of Australidelphia, and 2) fragmentary remains of plesiomorphic notoryctemorphians (marsupial moles) from the Oligo-Miocene of Australia that appear to support a Notoryctemorphia-Peramelemorphia (bandicoots) clade. Additional molecular data, particularly rare genomic changes, will be required to test these hypotheses and to clarify other problematic relationships, notably the exact position of Microbiotheria within Australidelphia. Determining the relationships of fossil marsupials and stem-metatherians will inevitably be largely reliant on morphological data, although it may be possible to obtain DNA from Late Pleistocene Australian taxa. Future datasets will need to incorporate a much denser sampling of characters (including data from multiple anatomical systems) and taxa (particularly fossil forms). However, progress may be limited without improvements in the fossil record of marsupials and stem-metatherians, particularly from the latest Cretaceous of South America and Late Cretaceous and early Palaeogene of Antarctica and Australia. Recent molecular timescales for Marsupialia have been relatively uncontroversial, in part because the highly incomplete fossil record is permissive of a wide range of potential divergence dates. I present a molecular timescale based on an 18 kb nuclear and mitochondrial matrix and using the IRDITIME method. These dates suggest that all interordinal divergences within living marsupials took place in the latest Cretaceous or early Palaeogene, congruent with the hypothesis that crown-group Marsupialia is an essentially Gondwanan radiation.

Poster Session IV, (Saturday)

**EARLY RHINOCEROTOIDS (MAMMALIA: PERISSODACTYLA) FROM SWITZERLAND**

BECKER, Damien, Section d'archéologie et paléontologie, Porrentruy, Switzerland

Rhinocerotoids were the most flourishing perissodactyl mammals during Tertiary times, especially in the late middle and late Eocene of North America and Asia. In West Europe, except the occurrences of the cosmopolitan running tropical forest-dwelling *Hyrachyus*, early rhinocerotoids occurred only in the earliest Oligocene and are still poorly documented at this time. The record is so far restricted to two "true" rhinocerotid genera with *Epiacraetherium* and *Ronzotherium*, and two rhinocerotid genera with *Eggyosodon* and *Cadurcotherium*. The appearance of these rhinocerotoids together with other new mammal families (e.g., Entelodontidae, Anthracotheriidae, Gelocidae, Cricetidae) coincides with the extinction/origination event named "Grande Coupure". According to recent literature, this European faunal turnover corresponds to the time interval ca. 33.55–33.20 Ma (ca. MP20/21 boundary of the European Mammal biozones). It reflects both a global climatic change (cooling event) and a major invasion of mammals from Asia, whereas the European and Asian continents fused again after the closure of the Turgai Strait. In the Swiss Molasse Basin, the only pre-"Grande Coupure" faunas are the famous fissure-fills from Egerkingen (MP14) and Mormont (MP16–19), whereas the first post-"Grande Coupure" ones are dated to MP22 and limited to small mammal assemblages (e.g., Balm). Nevertheless, earliest Oligocene rhinocerotid remains from Switzerland are recorded from the Swiss Jura Molasse (NW Switzerland) from Bressaucourt (MP21/22) and Kleinblauen (MP22), localities known a long time ago, but still poorly dated and with a partially reviewed material. This study gives new stratigraphic data from the Jura Molasse and a first complete description of the specimens from Bressaucourt (*Ronzotherium filholi*, *Cadurcotherium minus*) and Kleinblauen (*R. filholi*, *Epiacraetherium magnum*, *E. aff. magnum*, *Eggyosodon osborni*). It reports the first occurrences of rhinocerotoids and of post-"Grande Coupure" large mammals from Switzerland with their paleogeographic and paleoenvironmental implications.

**BONE BURIAL IN LAND SURFACE ASSEMBLAGES AND ITS IMPACT ON THE VERTEBRATE FOSSIL RECORD**

BEHRENSMEYER, Anna, Smithsonian Institution, Washington, DC, USA

The transition of organic remains from biosphere to lithosphere includes a critical step - burial - whose taphonomic impact on the fossil record of attritional land surface bone assemblages is virtually unknown. Analogue studies are showing high fidelity of diversity measures in living populations and their dispersed skeletal remains, but how does this translate into the buried record that ultimately becomes paleontological data? Bones and teeth can be incorporated into land surface soils via 1) processes operating in a stable (non-aggrading) land surface soil and/or 2) active incremental sediment deposition on the land surface. On a stable land surface, burial can occur through physical processes that cause sediment movement (cracking, swelling, shrinking), bioturbation (trampling, soil mixing via root and invertebrate activity), or burrow fill/collapse. These processes result in a time-averaged assemblage where final preservation also depends on the balance of continuing destructive soil processes vs. mineralization within the soil. On an aggrading land surface, such as a floodplain with periodic cm-scale sedimentation, burial of surface bones would be increased and post-burial destructive processes possibly reduced, depending on overall rates of sediment build-up and soil activity. The taphonomic impact of all of these burial processes should vary depending on the size of the skeletal remains on the land surface. It is unclear whether smaller bones, which should be more easily buried, have any size-related preservation advantage over larger bones because they also are more easily destroyed prior to burial and less resistant to destruction in the soil. Data from neotaphonomic study of a stable landsurface in southern Kenya are used to test size related biases by comparing a sub-set of bones buried over 50% with the overall surface assemblage. Preliminary results indicate that the partially buried sub-set retains a high level of fidelity in terms of the abundance distribution of the live populations of major herbivores in spite of expected size-related burial biases.

The Evolution of Birds in the Mesozoic: a Symposium in Honor of Cyril A. Walker, Thursday 8:45

**ECOLOGICAL DIVERSITY OF MESOZOIC BIRDS: MORPHOMETRIC ANALYSIS WITH A PHYLOGENETIC PERSPECTIVE**

BELL, Alyssa, Natural History Museum of Los Angeles County, Los Angeles, CA, USA; CHIAPPE, Luis, Natural History Museum of Los Angeles County, Los Angeles, CA, USA; O'CONNOR, Jingmai, Natural History Museum of Los Angeles County, Los Angeles, CA, USA

Our growing understanding of morphological diversity among Mesozoic birds offers unprecedented opportunities to apply rigorous morphometric techniques to better understand the ecology of basal birds. The continuous discovery of well-preserved Mesozoic bird fossils allows the collection of morphometric data from multiple areas of the skeleton, enabling the generation of large databases containing quantitative information on the forelimbs, hindlimbs, and axial skeleton of early birds. Despite this potential wealth of information, previous morphometric studies of Mesozoic avians have utilized a limited number of measurements for a small number of taxa. In order to take full advantage of the opportunities offered by our growing knowledge of early birds, we present a morphometric database consisting of over 15 skeletal measurements for approximately 500 modern birds and 25 Mesozoic taxa, such as *Archaeopteryx*, *Confuciusornis*, *Sapeornis*, *Apsaravis*, and *Hesperornis*. Principle component analysis of these data and comparison to the known ecologies of the modern birds allows us to extrapolate ecological niches which may have been occupied by the Mesozoic birds in our analysis. Furthermore, by mapping these ecologies onto a comprehensive phylogeny of Mesozoic birds we are able to fully explore the evolutionary pattern and time of origination of diverse ecologies within early birds. The results of this study allow us to differentiate early birds specialized for a particular ecology from more 'generalist' birds. Additionally, the appearance of diverse ecologies within a single clade highlights the ecologic plasticity of early avians.

Poster Session III, (Friday)

**THE IOUARIDENE TRACKSITE (HIGH-ATLAS, MOROCCO): EVIDENCE OF A JURASSIC LAND-BRIDGE BETWEEN AFRICA AND EUROPE**

BELVEDERE, Matteo, Dipartimento di Geoscienze, Università di Padova, Padova, Italy; MIETTO, Paolo, Dipartimento di Geoscienze, Università di Padova, Padova, Italy

The Jurassic Iouaridène tracksite (central High-Atlas, Morocco) has been known since 1937, but only recently its Oxfordian-Kimmeridgian age has been defined. 21 trampled layers have been surveyed in the lower member of the Iouaridène formation. It is characterized by a cyclic alternation of reddish mudstones and reddish to purplish more consolidated mudstone to fine-sandstone layers that bear all the tracks discovered. The trampled part of this member has been interpreted as a coastal flood-basin, cyclically flooded by rapid marine incursions, or seasonal inundations, in an arid/semi-arid climate.

With its 5 km<sup>2</sup> surface and having more than a thousand tracks, the Iouaridène ichnosite is one of the largest of North Africa, and carries a various ichnocoenosis: small to large theropods dominated by tracks with "megalosaurian" affinities, medium to very large sauropods, often showing evidence of a gregarious behavior, and that also include the

reference tracks and trackway of the renowned *Breviparopus taghbaloutensis*, probable small ornithischians, the stegosaurian ichnogenus *Deltapodus*, recognized for the first time in North Africa, and arthropod trails as well.

Compared with the coeval ichnological record, the Iouaridène ichnocoenosis shows great similarities with the Spanish and Portuguese ones; moreover, taking into account not only the tracks assemblage, but also the morphology of the "megalosaurian" track, a high correspondence can even be found also with *Megalosaurus* specimens from the Morrison Formation (Utah, U.S.A.). Therefore, the agreement between the Iberian osteological and the Moroccan ichnological records allows a better identification of the actual faunal assemblage of the area.

A former hypothesis, based on the comparison among dinosaur faunas from central Africa, Portugal and North America, surmised the presence of a passage between northern and southern margins of the Tethys Ocean. This new ichnological evidence supports the possibility of a land-bridge between the continents during the Middle/Late Jurassic.

Technical Session X, Friday 10:15

**THE PECTORAL GIRDLE OF PTERODACTYLUS ANTIQUS-EVOLVING TOWARD THE ADVANCED CONDITION**

BENNETT, S. Christopher, Fort Hays State University, Hays, KS, USA

Large pterodactyls (e.g., pteranodontids, azhdarchids, dsungaripterids) were unique among vertebrates in possessing an advanced pectoral girdle (APG), in which the end of the scapula was rotated inward and articulated with modified neural spines of a notarium formed of fused anterior dorsal vertebrae. APGs are viewed by some as a synapomorphy of a monophyletic Dsungaripteroidea, and by others as convergently evolved in multiple clades. Six years ago I reconstructed the pectoral musculature of representative pterosaurs and suggested that the APG: 1) straightened the pull of *m. pectoralis* to improve its function in wing depression, 2) braced the pectoral girdle against the vertebral column preventing compression of the trunk, which in turn, 3) permitted a stronger *m. latissimus dorsi* for improved function in wing elevation. I also suggested that the pectoral girdle of *Pterodactylus* had evolved in a distinctly different direction to do much the same; i.e., to improve girdle stability and muscle function in wing flapping. However, recent examination of *Pterodactylus antiquus* collections indicated that the previous reconstruction of an elongate scapula extending backward over the 8th dorsal rib is incorrect. Structural changes to the end of the scapula and the neural spines of anterior dorsal vertebrae were identified on large specimens of *Pterodactylus*, which suggest that in life the end of the scapula was held close to the neural spines of the 3rd and 4th dorsal vertebrae, and thus the condition in *Pterodactylus* seems to represent a distinct morphological stage in evolution toward an APG: 1) unmodified girdle of basal pterosaurs; 2) modified end of scapula and neural spines, but no scapular rotation (e.g., *Pterodactylus*); 3) rotated scapula with highly modified end, but no scapulonotarial articulation (e.g., *Nyctosaurus*); and 4) rotated scapula and scapulonotarial articulation (e.g., *Pteranodon*). The interpretation is consistent with the view of APGs as a synapomorphy of a monophyletic Dsungaripteroidea.

Poster Session III, (Friday)

**DOES DEVELOPMENTAL STRATEGY DRIVE LIMB INTEGRATION IN MARSUPIALS AND MONOTREMES?**

BENNETT, Verity, The University of Manchester and University College London, Manchester and London, United Kingdom; GOSWAMI, Anjali, University College London, London, United Kingdom

Mammal limbs show diverse locomotory specialization, but this range is not evenly distributed throughout the three reproductively-distinct clades; placentals, marsupials and monotremes. Marsupials unlike their placental sister group have not evolved true flight or fully aquatic locomotion. Previous studies have shown that the marsupial mode of reproduction constrains forelimb disparity, and that timing of limb development is more modular in marsupials than in placentals. Morphometric studies of limb covariance in placentals have also demonstrated that the fore and hind limbs are significantly integrated in adult morphology. Here, we present morphometric analyses of limb covariance in marsupials and monotremes to test if the three mammalian clades differ in limb covariance pattern and whether the modularity in developmental timing observed in marsupial limbs is reflected in adult morphology. As strong associations among elements within a module may constrain variation of individual elements, identification of limb modularity in adult morphology may also relate to the low disparity observed in marsupial forelimbs. Distinct characteristics of covariance structure are revealed for each mammalian clade. Marsupials have stronger within limb covariance and show particularly strong covariance between radius and humerus, while monotremes show stronger covariance between limbs. Covariance patterns also reflect locomotory mode. Kangaroos, bipeds with functionally independent fore and hind limbs, do not display any covariance between limbs, consistent with the modularity observed in developmental timing. Yet quadrupedal possums show significant covariance between limbs also, potentially reflecting functional integration alongside that controlled by development. These results imply the existence of clade specific patterns of limb covariance, indicating that developmental strategy may relate to constraints on morphological variation in mammalian limbs. Furthermore, adult limb covariance patterns could serve as an osteological indicator of developmental processes that can be applied to early mammals to establish the evolution of mammalian reproductive strategies.

**MIDDLE JURASSIC THEROPODS AND THE EARLY EVOLUTION OF TETANURANS (DINOSAURIA, THEROPODA)**

BENSON, Roger, Department of Earth Sciences, University of Cambridge, Cambridge, United Kingdom

A review of European Jurassic theropods resolves the taxonomy of problematic taxa such as *Duriavenator*, *Magnosaurus* and *Megalosaurus*. This allows clear diagnoses and referral of abundant, but previously problematic, material from the British Middle Jurassic. Coupled with an ongoing review of Chinese basal tetanurans, this results in a significant injection of new data on early tetanurans. A new phylogenetic dataset constructed by critical examination of previous data sets with many novel characters and modified scores based on first-hand examination of most basal tetanurans globally resolves the affinities of many taxa. The results shed light on the early evolution of this hugely successful clade that dominated terrestrial ecosystems from the Middle Jurassic to the end Cretaceous and gave rise to birds. The earliest neoceratosaur, *Berberosaurus*, is known from the ?Pliensbachian-Toarcian (Lower Jurassic) of Morocco, so the most basal members of Tetanurae, the sister clade of Neoceratosauria, must have evolved by this time. The earliest definite tetanuran is *Magnosaurus*, a megalosaurid megalosauroid (spinosauroid) from the lower Bajocian (Middle Jurassic) of the UK. The presence of megalosaurids of this age indicates that other megalosauroid groups must also have been extant in the early Middle Jurassic, alongside basal members of Neotetanurae (the sister clade of Megalosauroida). However, the earliest allosauroid and coelurosaurian neotetanurans are not known until the Bathonian (*Poekilopleuron* and *Proceratosaurus*) and neotetanurans are not abundantly represented in the fossil record until the Late Jurassic. The late diversification of Neotetanurae may represent a genuine diversity signal or result from taphonomic bias limiting the record of small-bodied (coelurosaurs) and uplands (allosauroids) taxa during the Middle Jurassic, which is represented mainly by marine deposits. Nonetheless, the fact that the timing of appearance of major tetanuran clades matches their phylogenetic branching order suggests that surprisingly early occurrences of tetanurans are unlikely future discoveries.

Late Triassic Terrestrial Biotas and the Rise of Dinosaurs, Thursday 10:30

**THE ENIGMATIC LATE TRIASSIC REPTILE *SALTOPUS***

BENTON, Michael, University of Bristol, Bristol, United Kingdom; WALKER, Alick, University of Newcastle, Newcastle, United Kingdom

The Lossiemouth Sandstone Formation (Late Triassic, late Carnian) from north-east Scotland has yielded a diverse fauna of procolophonids (*Leptopleuron*), sphenodontids (*Brachyrhinodon*), rhynchosaurs (*Hyperodapedon*), and archosaurs (the aetosaur *Stagonolepis*, the ornithosuchid *Ornithosuchus*, the stem-group crocodylomorph *Erpetosuchus*, the basal avemetatarsalian *Scleromochlus*, and the reputed dinosaur *Saltopus*).

When *Saltopus* was described, Friedrich von Huene identified it as a basal saurischian dinosaur, and stated that it had four sacral vertebrae. The *Saltopus* holotype consists of part and counterpart of a small, slender reptile, showing dorsal, sacral, and caudal regions of the vertebral column, the left forelimb, the pelvis, and both hindlimbs. New casts and X-rays have revealed more of the anatomy.

The balance of evidence suggests that *Saltopus* is an avemetatarsalian, and possibly a dinosauriform. It could be a dinosaur, but diagnostic characters have not yet been identified. Many characters of *Saltopus* are equivocal because of the remarkable convergences between dinosauromorphs and some crurotarsans such as poposauroids. For example, the casts indicate that *Saltopus* had three sacral vertebrae, but this is not diagnostic of Dinosauria, or some subclade of Dinosauria, as was once thought, but occurs in various crurotarsans ('trausuchids', 'poposauroids') as well as in most Dinosauriformes. Other characters of *Saltopus* seen in both crurotarsans (especially poposauroids) and some or all dinosauromorphs include a first sacral rib that runs to the anterior end of the preacetabular process of the iliac blade, the forelimb considerably shorter than the hindlimb, and a lesser trochanter on the femur.

However, three unequivocal characters identify *Saltopus* as an avemetatarsalian (ornithodiran): the tibia is longer than the femur, the metatarsals are elongate and they are bunched. Further, the calcaneal tuber appears to be rudimentary. *Saltopus* then was part of an apparently wide radiation of small, slender non-dinosaurian dinosauromorphs and basal saurischians that occurred in the late Carnian/ early Norian of South America, North America, and Europe.

Edwin H. and Margaret M. Colbert Poster Competition (Thursday)

**UNDERSTANDING THE RELATIONSHIP BETWEEN FORM AND FUNCTION IN BIRDS TO INFER LIFE HABITS IN FOSSIL TAXA: CORRELATIONS BETWEEN MORPHOLOGY AND BEHAVIOR IN FALCONIFORMES USING A THREE-DIMENSIONAL MORPHOMETRIC APPROACH**

BERG, Holly, University of Iowa, Iowa City, IA, USA

Many assertions explaining function due to form in birds have been proposed, but few have been quantified. Falconiformes is a group (possibly monophyletic) of predatory birds, comprised of both extant and extinct species. They exhibit a variety of feeding behaviors, habitats, and migratory patterns. A three dimensional landmark-based approach was used

to investigate which shape characteristics are optimal for different flight capabilities and requirements within Falconiformes, in order to gain an understanding of behavior in fossil species. Shape variation of the sternum and furcula were examined using 22 extant species of falconiforms that exhibit various feeding and life strategies (e.g. predator vs. scavenger, open grasslands vs. wooded habitat, obtaining their food in the air vs. on the ground, migratory vs. resident). A total of 209 sternum samples and 197 furcula samples were digitized and analyzed for correlations between shape and each life strategy using Principal Component Analyses and MANOVA to test for significance between groups. The correlations were tested for association with phylogeny using the generalized least squares method, applying multiple phylogenies as falconiform relationships are disputed. Results of the furcula analyses show a strong correlation between shape and each life habit studied, while the sternum analyses only show a weak correlation between shape and feeding behavior. This method is now being used to gain a better understanding of behaviors of fossil falconiforms, including *Teratornis merriami*, which when included in the furculae analysis was found to have the shape characteristics of a predator that may have been a piscivore. It also grouped with other falconiforms that inhabit an open air/grassland environment and was non-migratory.

New Perspectives on the Early Evolutionary History of the Synapsida, Saturday 8:30

**PELYCOSAURIAN-GRADE SYNAPSIDS FROM THE LOWER PERMIAN BROMACKER LOCALITY, CENTRAL GERMANY**

BERMAN, David, Carnegie Museum of Natural History, Pittsburgh, PA, USA; HENRICI, Amy, Carnegie Museum of Natural History, Pittsburgh, PA, USA; SUMIDA, Stuart, California State University, San Bernardino, CA, USA

Since 1993 a concerted yearly effort of excavation of the Bromacker quarry locality in the Lower Permian Tambach Formation, lowermost unit of the Upper Rotliegend, central Germany, has yielded a diverse, terrestrial vertebrate assemblage of at least 13 taxa that includes three taxa of pelycosaurian-grade, basal synapsids. They are represented by specimens ranging from isolated elements to complete or nearly complete articulated, postcranial skeletons. Only one of the three pelycosaurs has been described and was assigned to *Dimetrodon* as a new species, *D. teutonis*, the first representative of the genus reported outside of North America. As the smallest recognized member of the genus, it is remarkable for its diminutive size. A large varanopid is represented by a single specimen that includes the greater portion of a largely articulated, postcranial skeleton. Although not distinguishable as new species, a cladistic analysis indicates a relationship with the Lower Permian *Varanops brevirostris* and a varanopid referred to this species from the Richards Spur locality, Oklahoma. This is the first varanodontine varanopid to be reported outside of the North America. The presence of a caseid at the Bromacker is documented by four articulated or loosely articulated sets of postcrania, of which only three have been fully prepared. It can be distinguished from all other members of the family by primitive features of the manus and pes, particularly the long, gracile digits and the retention of the primitive amniote phalangeal formulas. Only one autapomorphy can be identified, the penultimate phalanx of digits 2-5 in both the manus and pes is longer than the preceding phalanges. A cladistic analysis of the Bromacker caseid posits it as the basalmost member of the family. This is in agreement with the Bromacker species being the oldest known caseid, as it is from a lowermost horizon of the Lower Permian, whereas previously earliest records of caseids are from uppermost horizons of the Lower Permian. It may be more than coincidental that the Bromacker varanopid and caseid are closely related to taxa that occur at Richards Spur, as these are the only two Lower Permian localities that have been documented as representing a truly upland terrestrial environment.

Poster Session I, (Wednesday)

**AN ALMOST COMPLETE ICHTHYODECTIFORM FISH FROM THE EARLY CRETACEOUS (ALBIAN) OF PIETRAROJA, SOUTHERN ITALY**

BERRELLI, Rodney, School of Biological Sciences, The University of Queensland, Brisbane, Australia; ALVARADO-ORTEGA, Jesús, Departamento de Paleontología, Instituto de Geología, Universidad Nacional Autónoma de México, Coyoacán, Mexico; YABUMOTO, Yoshitaka, Kitakyushu Museum of Natural History and Human History, Kitakyushu, Japan; SIGNORE, Marco, via Ferrara 4 80143, Napoli, Italy; SALISBURY, Steven, School of Biological Sciences, The University of Queensland, Brisbane, Australia

The ichthyodectiform fish *Cladocyclus* is best known from the Early Cretaceous of Brazil's Araripe Basin. Recently, *Cladocyclus* has been identified in the mid-Cretaceous Kem Kem Beds of Morocco and similarly aged Winton Formation of Queensland, Australia, indicating that this fish was widespread around the coast and adjacent inland river systems of Gondwana. The first ichthyodectiform fish from the Early Cretaceous (Albian) of Pietraraja, near Benevento in southern Italy was described as *Chirocentristes coroninii*. In 2004, a partial specimen of an ichthyodectiform fish, with a complete skull and the first 14 vertebrae was discovered from Pietraraja, and was considered as a new genus of Ichthyodectidae. Excavations in the fine-grained marine/lagoonal limestones at Pietraraja have been ongoing, albeit intermittently, for over 150 years. During this time, the site has produced a rich assemblage of plants, invertebrates (echinoderms, crustaceans, molluscs) and vertebrates, including fishes, amphibians, and reptiles (rhynchocephalians, squamates and theropod dinosaurs). In 2008, a third ichthyodectiform specimen from Pietraraja, similar to *Cladocyclus*, was discovered in the collections of Carnegie Museum of Natural History. The museum acquired the specimen in 1903 as part of the Bayet collection. It is preserved in

six blocks of a very fine-grained cherty limestone, typical of the Pietraraja Plattenkalk. The specimen is fully articulated, missing only the anterior snout area including the upper and lower jaws exclusive of the premaxilla. The pectoral and pelvic fins, along with the posterior end of the upper lobe of the caudal fin, are also missing. Although still under further study and preparation, some general comments can be made. The specimen has 59 vertebrae, with 37 abdominal and 22 caudal centra, differing from *Cladocyclus*, which has 64 vertebrae, 37 abdominal, 25 caudal, and *Chirocentrites*, which has 61-64. Further detail comparison with the other two ichthyodectid specimens described from Pietraraja is necessary to determine the systematic position of the ichthyodectids from Pietraraja.

Technical Session XV, Saturday 11:30

#### **THE BRAINCASE OF A NEW TYRANNOSAURID FROM THE LATE CRETACEOUS OF MONGOLIA**

BEVER, Gabe, American Museum of Natural History, New York, NY, USA; BRUSATTE, Stephen, American Museum of Natural History, New York, NY, USA; CARR, Thomas, Carthage College, Kenosha, WI, USA; NORELL, Mark, American Museum of Natural History, New York, NY, USA

The intimate relationship between the central nervous and cranial vascular systems and their surrounding bony enclosure makes the ossified neurocranium and its associated dermal elements an important source of anatomical data in the vertebrate fossil record. Providing meaningful interpretations of these braincase data in either a phylogenetic or functional context requires both well-preserved specimens and at least some understanding of how the morphology is affected by other sources of variation, such as ontogeny. These requirements are rarely met in most extinct lineages, including Tyrannosauridae, a group that holds considerable scientific and public interest. The holotype specimen of a new species from the Maastrichtian (Late Cretaceous) Nemegt Formation of Mongolia includes what may be the best-preserved braincase of a tyrannosaurid theropod. Detailed physical preparation combined with high-resolution computed tomographic data reveals the braincase is essentially complete (including *in situ* stapes) and that most of the bony sutures are retained, suggesting a relatively early stage of postnatal maturation. Remarkable contrast in the CT data facilitated digital casting of the endocranial cavity, inner ear, and neurocranial sinuses. Notable features include, for example, a highly pneumatic paroccipital process with both rostral and caudal pneumatopores, a tripartite supraoccipital sinus that fails to invade the parietals, a clear midline communication between the right and left recesses of the anterior tympanic sinus, a relatively small inner ear that lies adjacent to a large flocculus, and an unusual fossa in the prootic that houses branches of both the trigeminal and facial cranial nerves. The unique combination of preservational quality, ontogenetic age, and morphological complexity makes this specimen an important discovery in our collective attempt to understand the morphology and evolutionary history of the neurocranium within Tyrannosauridae and Coelurosauria in general.

Technical Session III, Wednesday 4:15

#### **THE FIRST FOSSIL SUNBEAM SNAKE AND THE ANTIQUITY OF MODERN SNAKE CLADES**

BHULLAR, Bhart-Anjan, Harvard University, Cambridge, MA, USA; PAULY, Gregory, University of California, Davis, CA, USA; SCANFERLA, Carlos, Museo Argentino de Ciencias Naturales, Buenos Aires, Argentina; BEVER, Gabe, American Museum of Natural History, New York, NY, USA; SMITH, Krister, Senckenberg Forschungsinstitut und Naturmuseum, Frankfurt, Germany

Alethinophidian snakes represent the majority of snake diversity. They include the familiar boas, pythons, and colubrids; and a scattering of lesser-known 'primitive alethinophidians,' among them the pipe snakes and the so-called sunbeam snakes, named for their striking iridescent scalation. Because of the extreme paucity of the snake fossil record, the 'primitive alethinophidian' grade has not been uncontroversially recognized among extinct snakes, leaving an exceptionally long series of ghost lineages stretching back at least to the late Mesozoic. These lineages are especially important because most of the controversy about alethinophidian relationships involves lack of resolution in early divergences of the clade. We begin to fill this major gap in the snake fossil record with a new fossil snake from the Eocene of Texas. Much of the body is preserved, as well as a partial maxilla, the skull roof, and the entire braincase except for the flooring elements. Preservation is exquisite, as evidenced by a complete *in situ* stapes. CT scanning was used to digitally disarticulate the skull. Several features, including the elongate parietal, the u-shaped frontoparietal suture, the mediolaterally expanded braincase, and the very large stapedia footplate, demonstrate the 'primitive alethinophidian' grade of the fossil. Further, a distinctive parietal morphology and aspects of the braincase unambiguously support a close relationship to the New World sunbeam snake, *Loxocemus bicolor*. The result holds whether a morphological or molecular scaffold approach is used. Thus, the fossil is one of the few fossil crown snakes to be securely placeable within snake phylogeny. Moreover, characters of the fossil and *Loxocemus* support a suggested affinity of these taxa to the python clade. The presence of a fossil sister taxon to *Loxocemus* just north of the distribution of the living snake bespeaks the antiquity of the neotropical squamate fauna. It also shows that the split between pythons and their sister group was ancient and, in conjunction with genetic data and information from other fossils, allows an initial estimate of divergence times for the major snake clades.

Poster Session IV, (Saturday)

#### **A NEARLY COMPLETE SKELETON OF A NEW PILOT WHALE-LIKE DOLPHIN FROM EARLY PLEISTOCENE OF SOUTHERN ITALY**

BIANUCCI, Giovanni, University of Pisa, Pisa, Italy; CHERIN, Marco, University of Pisa, Pisa, Italy; TINELLI, Chiara, University of Pisa, Pisa, Italy; VAROLA, Angelo, University of Lecce, Lecce, Italy

The fossil history of Delphinidae, the largest extant cetacean family, is known prevalently thanks to a great number of significant specimens discovered since the eighteenth Century in the Pliocene strata of Italy. The recent review of the historical collections and the description of new material evidenced that most of these delphinid remains belong to fossil genera. This datum allows us to hypothesize a relatively recent origin of the extant delphinids. Unfortunately, due to a substantial general gap in the Pleistocene fossil record, it is hard to individuate the exact time of origin of the modern fauna. In fact, although Pleistocene cooling and glaciations are often indicated as possible causes of the restriction and separation in the geographical range of cetaceans, favoring antitropical speciation, no hypothesis is strongly supported by the fragmentary Pleistocene fossil record. The nearly complete skeleton of a delphinid recently discovered in the early Pleistocene strata outcropping in the Salento Peninsula (southern Italy), provides a first important contribution to the poorly known post-Pliocene delphinid fauna. The fossil consists of a skull lacking its braincase, ear bones, incomplete mandible, teeth, and the almost complete postcranial skeleton, all from the same animal. The skull is superficially similar to extant *Globicephala* spp. in size and general shape, but it is clearly different from this genus in the narrower and more elongated rostrum. Surprisingly, the premaxillae exhibit a protuberance at half of the rostrum length and they are medially fused, covering a wide portion of the mesorostral groove. Excluding any pathological and traumatic cause, this strange structure can be interpreted as the insertion surface of strong rostral muscles to sustain a large melon. This unequivocal autapomorphy and other distinctive characters permit us to refer the delphinid from Salento to a new genus, supporting the unexpected presence of fossil taxa until a time relatively near to the present days.

Romer Prize Session, Thursday 11:00

#### **PALEOENVIRONMENTS AND PALEOECOLOGIES OF CENOZOIC MAMMALS FROM FIVE REGIONS IN WESTERN CHINA BASED ON STABLE CARBON AND OXYGEN ISOTOPE**

BIASATTI, Dana, Florida State University, Tallahassee, FL, USA

Cenozoic localities in western China have produced a great diversity of well-preserved mammalian fossils. Paleoclimatic and paleoecological records from western China are important to the understanding of the evolution of those mammalian taxa. Few direct paleoenvironmental records are known from this region of China. However, stable carbon and oxygen isotopic analyses of fossil teeth provide proxies for those records. To investigate the temporal and spatial variation in ancient diets and habitats for given taxa and to test previous hypotheses regarding the development of C4 ecosystems in this region, carbon and oxygen isotopic analyses of tooth enamel from 429 mammalian herbivores (including bovids, horses, rhinos, deer, giraffes, pigs, and elephants), ranging in age from 25 Ma to the present, were performed. The specimens used in this study were collected from localities within Gansu, Yunnan, and Shanxi provinces, as well as from Inner Mongolia and Tibet. The oxygen isotopic results indicated that, in general, the paleoclimates of mammals from Yunnan Province and Gyirong Basin, Tibet were wetter and/or colder than those of mammals of equivalent ages from Gansu and Shanxi provinces, Chaidam Basin, Tibet, and Inner Mongolia. Fluctuations in the oxygen isotope data of mammals from Linxia Basin, Gansu, were consistent with previous studies that indicated a general global warming trend from ~26 to 15 Ma and two major cooling phases during the Neogene. The carbon isotope results indicated that all mammals from Gansu, and possibly Yunnan Province, had pure C3 diets throughout most of the Late Cenozoic. A positive shift in  $\delta^{13}C$  values after ~2-3 Ma, indicating a change to a mixed C3/C4 diet, suggests that C4 grasses may have not spread into Gansu or Yunnan provinces until after ~2-3 Ma, which is much later than the proposed global C4 expansion during the Late Miocene. Conversely, a shift from pure C3 diets to mixed C3/C4 diets occurred between ~7-8 Ma in Shanxi Province, Inner Mongolia, and Tibet.

Technical Session XVI, Saturday 11:45

#### **THE FOSSIL RECORD AND EVOLUTION OF TRAGELAPHINI (BOVIDAE, ARTIODACTYLA)**

BIBI, Faysal, Yale University, New Haven, CT, USA

The fossil record of the living African spiral-horned antelopes (Tragelaphini) is reviewed and revised, with new fossils presented. New interpretations of tragelaphin taxonomy, systematics, and phylogeny allow for a synthetic reconstruction of the evolutionary history of this bovid clade. Tragelaphini is an entirely African clade, the oldest representatives of which are just younger than 6Ma in age. The tragelaphin fossil record presents archetypal examples of both phyletic and punctuated evolutionary changes. A newly-described latest Miocene-early Pliocene tragelaphin species exhibits directed gradual changes in skull morphology that make it a likely ancestor for both *Tragelaphus kyaloe* and *T. nakuae*. *Tragelaphus nakuae* exhibits particularly pronounced punctuated changes in its skull morphology at 2.85 and 2.33 Ma leading to the establishment of three evolutionary stages for this species, and to the recognition of its utility as a reliable biochronological index fossil

for the African late Pliocene. The intermediate stage of *T. nakuae* bears strong resemblance to the living bongo, *T. eurycerus*, but phylogenetic, ecological, and biogeographic continuity between the fossil and living species are difficult to corroborate. The lineages of the living greater and lesser kudus (*T. strepsiceros* and *T. imberbis*) extend back to at least the late Pliocene and the fossil record supports the convergent evolution of horn morphology in these two species, as proposed by molecular phylogenetic evidence. Overall, the tragelaphin fossil record reveals good candidate ancestral lineages for several living tragelaphin species, while for at least three of the nine living species the fossil record is basically silent.

Molecular Tools in Paleobiology: Trees, Clocks and linking Geno- with Phenotype, Friday 11:00

#### INFERRING EARLY MAMMALIAN PALEOBIOLOGY FROM VERTEBRATE VISUAL PIGMENTS

BICKELMANN, Constanze, Museum für Naturkunde, Berlin, Germany; MÜLLER, Johannes, Museum für Naturkunde, Berlin, Germany; DU, Jingjing, University of Toronto, Toronto, Canada; CHANG, Belinda, University of Toronto, Toronto, Canada

Visual pigments form the first step in the visual transduction cascade within the photoreceptor cells of the vertebrate eye. Changes in biochemical and biophysical properties of these proteins can therefore have profound consequences for the visual capabilities of an animal, with particular relevance to its ecology and behavior. In recent years, much effort has been put towards functionally characterizing visual pigments from a variety of vertebrates, as well as towards developing efficient *in vitro* and *in vivo* expression systems. In combination with advances in bioinformatics it is now possible to investigate deep-time patterns of selection acting on the visual pigments, reconstruct hypothetical ancestral sequences, and test the function and biochemical properties of these ancestral proteins. Here, we present the first results of a study on the ancient visual capabilities of mammals, which is particularly interesting given the hypothesis that mammals were ancestrally nocturnal. Our main focus is on the rhodopsin, the only visual pigment responsible for vision at night and dim-light. We sequenced the complete rhodopsin gene of the short-beaked echidna. Along with other vertebrate rhodopsin sequences, we then tested for any significant indications of positive selection at the base of mammals, which would suggest major shifts in their visual ecology. While positive selection could not be recorded for the node Mammalia, we did find positive selection on the branch leading to Theria. These results suggest that if mammals were ancestrally nocturnal, then this ecological trait did not result in a different selection pattern relative to other amniotes, thus, questioning if nocturnality was a mammalian novelty. At the same time, a major shift in visual ecology must have occurred on the therian branch, which is supported by recent fossil discoveries suggesting that ecological diversity became notably expanded towards modern Theria. Future work will involve the synthesis and expression of hypothetical ancestral rhodopsins in order to test their function and biochemical properties, which then have to be interpreted in an ecological and paleontological context.

Technical Session XVI, Saturday 9:30

#### NEW OBSERVATIONS ON PYROTHERIA AND NOTOUNGULATA (MAMMALIA): PHYLOGENETIC IMPLICATIONS ON THE ORIGINS OF SOUTH AMERICAN ENDEMIC UNGULATES

BILLET, Guillaume, IPHEP, UMR 6046, Université de Poitiers, Poitiers, France

The Cenozoic South American endemic pyrotheres, mostly characterized by a bilophodont dentition, are one of the most striking and mysterious ungulates ever-known. Even if many specialists have investigated this group, the fascinating question of its origin is still unresolved after more than one century of study. I performed a new description of the only known pyrotherian skull, that of *Pyrotherium* from the Deseadan of Patagonia. Detailed comparison of cranial anatomy indicates strong similarities with the Notoungulata, especially in the auditory region, as already mentioned by some authors. Intriguing similarities are also detected in the anterior dentition of *Pyrotherium* and of the Casamayoran notoungulate *Notostylops*. These resemblances are suggestive of relationships between *Pyrotheria* and *Notostylops*. I tested this hypothesis through a series of phylogenetic analyses of South American ungulate craniodental anatomy, notably focusing on Notoungulata and *Pyrotheria*. These phylogenetic analyses are the first to encompass most of the diversity of South American ungulate taxa. They support the nesting of the pyrotherians within the Notoungulata via an exclusive relationship with *Notostylops*. This relationship is supported by both cranial and dental anatomy. However, this result questions the attribution to the *Pyrotheria* of bunodont to bunolophodont taxa, *Procticia* and *Colombitherium*. My analyses also support the position of Astrapotheria as the sister group of the Notoungulata but does not permit to conclude on the affinities of the Litopterna. The clustering of the *Pyrotheria*, Notoungulata and Astrapotheria supports an endemic evolutionary history of South American ungulates that parallels the situation of Afrotherian mammals in Africa. These results give rise to new perspectives in the research on South American endemic ungulate evolution.

Molecular Tools in Paleobiology: Trees, Clocks and linking Geno- with Phenotype, Friday 8:30

#### BONES VERSUS GENOMES: JUST WHEN DID PLACENTAL MAMMALS REALLY EVOLVE?

BININDA-EMONDS, Olaf, Carl von Ossietzky Universität Oldenburg, Oldenburg, Germany; MACPHEE, Ross, American Museum of Natural History, New York, NY, USA

Together with the Cambrian Explosion, the evolution of placental mammals represents one of the most extreme examples of the conflict between divergence times inferred from fossil evidence versus molecular sequence data. Whereas prevailing paleontological interpretations of the fossil record strongly imply that both the origins and basal divergences within many ordinal crown groups occurred after the Cretaceous-Tertiary boundary, molecular data consistently push at least their origins (and often the early divergences within them) well into the Cretaceous. In this talk, we take a critical look at those factors that could be leading either method astray: generally, the lack of appropriate fossils versus the appropriateness of clock-based analyses, and especially the assumptions inherent to each method. We conclude by examining possible solutions for resolving the conflict between fossil- and clock-based divergence scenarios for placental mammals in the future.

Poster Session IV, (Saturday)

#### CAMARASAURUS (CAMARASAURIDAE, SAUROPODA) PATHOLOGIES OF THE BESIDE SAUROPOD QUARRY, THERMOPOLIS, WYOMING

BIRKEMEIER, Tristan, Wyoming Dinosaur Center, Thermopolis, WY, USA; WAHL, William, Wyoming Dinosaur Center, Thermopolis, WY, USA

The Beside Sauropod (BS) Quarry is a disarticulated bonebed of *Camarasaurus lentus* from Thermopolis, Wyoming, that contains numerous pathological bones. The most pertinent of the pathologies is osteoarthritis, a condition rarely seen in the fossil record. Other pathologies include ossifications in the vertebrae, sacrum and scapulae; thickening of the vertebral centrum margins; two fused dorsal vertebrae; two fused caudal vertebrae; distal caudal vertebrae fused at the neural arch; costovertebral (rib to vertebra) fusions; and an unusual dual-shafted dorsal rib. Recovered from the BS Quarry was a phalanx has a small divot centrally located on the proximal articular surface as well as several pedal phalanges and four nearly articulated metatarsals with osteophytes surrounding the distal articular margins. This is one of the few cases of osteoarthritis in *Camarasaurus*. Osteophytes have previously been reported in the pes of the Sauropoda leading to the suggestion that the hindlimbs provided the main propulsive force. However, ossifications surrounding the glenoid in two scapulae and two large rugose sternal plates suggest a need for strengthening of the shoulder joint and girdle indicating the forelimbs may have been used more for propulsion. Another pathological condition is spondylosis deformans, expressed by a thickening of the vertebral centrum margins on cervical, dorsal and caudal vertebrae and may have caused the fusion of two dorsal and two caudal vertebrae. The former possess costovertebral fusions typically seen in spondyloarthropathy but both the dorsal and caudal vertebrae lack the zygapophyseal fusion making spondyloarthropathy unlikely. The final pathology is a dual-shafted dorsal rib. The dorsal margin surrounding the tuberculum has an uneven, lumpy appearance and divides in two shafts ventrally. The cause of this pathology is unknown but may be due to blunt trauma leading to subsequent dislocation.

Poster Session IV, (Saturday)

#### FINITE ELEMENT ANALYSIS OF PEDAL CLAWS TO DETERMINE MODE OF LIFE IN BIRDS, LIZARDS AND MANIRAPTORAN THEROPODS

BIRN-JEFFERY, Aleksandra, Royal Veterinary College, Hatfield, United Kingdom; RAYFIELD, Emily, University of Bristol, Bristol, United Kingdom

Claws are an important tool for extant birds and reptiles, and previous studies have shown that claw geometry can predict behavior, although there is a spread of data. Here we test if: (1) Finite Element Analysis can reveal differences in stress and strain within the pedal claws of extant lizards and avians and selected non-avian maniraptoran theropods during quasi-functional loading; (2) if stress differences in extant taxa can be partitioned on the basis of mode of life; (3) if so, can we infer with any confidence the mode of life of extinct species such as maniraptorans and *Archaeopteryx*? Extant taxa were assigned one of four behavioral categories based on previous studies and primary habits: ground-dwelling, perching, climbing, and predatory. Two-dimensional Finite Element models were created of digit III (12 ground, 9 perching, 6 climbing, 10 predatory and 5 maniraptorans [one per family]). The proximal claw was constrained, and for all behavioral categories the distal claw tip was loaded with a ground reaction force (GRF) based on body mass estimates. For perching and climbing, claws were additionally loaded in a perch-like pose. Kruskal-Wallis tests were carried out on the stresses and strains between behavioral categories. Extant perchers and climbers showed low stress and strain compared to ground-dwelling and predatory animals. The distinction increased in significance when perchers and climbers were loaded in a perching/climbing stance. Within the perchers and climbers, the proximal claw contained the highest values of stress and strain. Conversely, the highest stress and strain appeared at the claw tip in the predatory category. Ground-dwelling claws possessed very varied claw shapes with dissimilar patterns. The different patterns within the ground-dwelling claws are suggestive of a generalist group where specialization was not necessary for their mode of life. *Archaeopteryx* modeled within an extant perch profile both in stress patterns and values, lending support to the theory of an arboreal evolution of flight.

Poster Session II, (Thursday)

**SILESAURIDS: CLADE, GRADE, DINOSAURS?**

BITTENCOURT, Jonathas, Universidade de São Paulo, Ribeirão Preto, Brazil; LANGER, Max, Universidade de São Paulo, Ribeirão Preto, Brazil

Recent phylogenetic analyses depicted a handful of mid-late Triassic dinosauromorphs within a clade/grade including the nearest sister taxa to dinosaurs. These are informally referred to as silesaurids, after its better-known representative, *Silesaurus opolensis*, from the Carnian of Poland. Other putative silesaurids include *Lewisuchus admixtus* and *Pseudolagosuchus major*, from the Ladinian of Argentina, as well as Norian forms such as *Eucoelophysis baldwini*, from western USA, and *Sacisaurus agudoensis*, from south Brazil. The first-hand examination of most specimens of those taxa, including all type-material, and the rescoring of their character states into the data matrices of each numerical phylogenetic analysis that included them, produced three different outcomes. The above-mentioned taxa may all fit into a polytomy basal to the Saurischia-Ornithischia dichotomy, hence outside Dinosauria. A second scenario depicts *Silesaurus* and *Eucoelophysis* as sister-taxa within a polytomic clade that also includes monophyletic saurischians and ornithischians. Alternatively, *Silesaurus* and *Eucoelophysis* may represent basal ornithischians, with *Pseudolagosuchus* as the sister taxon to Dinosauria. Accordingly, current data does not unambiguously support the non-dinosaur affinity of silesaurids. There is, however, limited evidence that some silesaurids form a monophyletic group, regardless of its phylogenetic position. In conclusion, it is evident that a major revision of the materials referred to both *Pseudolagosuchus* and *Lewisuchus* is needed to establish not only their purported affinity to silesaurids, but also the phylogenetic status of the group as a whole. Further, the inclusion of more silesaurids in updated phylogenetic analyses is crucial to define the inclusivity of Dinosauria and the apomorphic traits that characterize the initial radiation of the group.

Edwin H. and Margaret M. Colbert Poster Competition (Thursday)

**A RE-EXAMINATION OF THE TAXONOMY OF THE RARE TRIASSIC DINOSAUR, *EUCNEMESAURUS* BASED ON AN ARTICULATED SKELETON FROM THE EASTERN CAPE OF SOUTH AFRICA.**

BLACKBEARD, Marc, University of the Witwatersrand, Johannesburg, South Africa

The post cranial material of a new sauropodomorph dinosaur specimen (BP/6234) from the lower Elliot Formation (Late Triassic) of South Africa is described in detail. It consists of the posterior end of the skeleton and includes a number of thoracic vertebrae, the ilia, ischia and pubes, the hind limbs and some poorly preserved caudal vertebrae. Based on autapomorphic characters and a combination of other characters present indicate that this specimen belongs to the rare dinosaur *Eucnemesaurus fortis* (previously known from a few highly fragmentary specimens), a possible riojasaurid. The Riojasauridae is recorded from Southern Africa and South America, supporting the unity of these two continents during the Late Triassic. BP/6234 has a number of riojasaurid synapomorphies of the femur including: a large round tubercle protruding from the proximal end of the femur; the fourth trochanter is rounded rather than sub-rectangular, and is separated from the femoral shaft by a rounded notch. A cladistic analysis shows that *Eucnemesaurus* is the sister taxon of *Riojasaurus*, but when *Riojasaurus* is excluded from the analysis *Eucnemesaurus* forms sister group relationships with either the very basally positioned *Ruehleia* or with the more derived massospondyliids. These results may be explained if the terminal taxon *Riojasaurus* is a chimaera, based on different sauropodomorph taxa of differing systematic positions. A thorough review of the specimens referred to *Riojasaurus* is required to resolve the issue.

Poster Session III, (Friday)

**MAMMALIAN INCISORS RETAIN A CUSPAL MORPHOGENESIS PROGRAMME**

BLACKBURN, James, King's College London, London, United Kingdom; OHAZAMA, Atsushi, King's College London, London, United Kingdom; PORNTAVEETUS, Thantrira, King's College London, London, United Kingdom; HERZ, Joachim, UT Southwestern Medical Center, Dallas, TX, USA; SHARPE, Paul, King's College London, London, United Kingdom

The developmental processes behind the evolution of the mammalian heterodont dentition remain largely elusive. The mammalian dentition is typically comprised of 'blade-like' incisors, 'conical-shaped' canines and 'large-crowned' premolars and molars. The gaining of cusps has been established as a main event during evolution of the mammalian heterodont dentition. However, only premolars and molars possess these adaptations. But do incisors also retain a cuspal morphogenesis programme?

Using the mouse and mouse mutants as a model, we have identified that the highly derived rodent incisors retain a cryptic crown-root axis. We show that the incisors of the *low-density lipoprotein receptor 4* (*Lrp4*) hypomorphic mouse and some glirral species retain the capacity to produce an enamel-free zone – a feature characteristic of the cuspal tips of wildtype glirral molars and piscine teeth. Furthermore, we identify the presence of enamel folding in the incisors of the *Lrp4* null mouse and other wildtype mammalian species – a major feature defining molar cusps.

Taken together, these data suggest that mammalian incisors retain a cuspal morphogenesis programme identical to that found in molar cusp formation. Due to the increase of incisor

phenotype severity between the hypomorphic and null conditions, we also propose an evolutionary role for the *Lrp4* gene in the loss of cusps and enamel-free zones during the evolution of mammalian incisors.

Poster Session I, (Wednesday)

**FIRST FOSSIL EVIDENCE FOR *CHIOGLOSSA LUSITANICA* (AMPHIBIA, CAUDATA) IN THE HOLOCENE OF WESTERN EUROPE**

BLAIN, Hugues-Alexandre, Institut de Paleoeecologia Humana i Evolucio Social (CSIC associated unit), Tarragona, Spain; LÓPEZ-GARCÍA, Juan Manuel, Institut de Paleoeecologia Humana i Evolucio Social (CSIC associated unit), Tarragona, Spain; CUENCA-BESCÓS, Gloria, Universidad de Zaragoza, Ciencias de la Tierra, Paleontología, Zaragoza, Spain; VAQUERO, Manuel, Universidad Rovira i Virgili, Area de Prehistoria, Tarragona, Spain; ALONSO, Susana, Universidad Rovira i Virgili, Area de Prehistoria, Tarragona, Spain

The golden-striped salamander *Chioglossa lusitanica* is an endemic species inhabiting streamside habitats in low and medium elevation mountainous areas in the northwestern Iberian Peninsula. This salamandrid is listed in the IUCN Red Data Book as a threatened species. The only living representative of its genus, it has never been reported in the fossil record. Understanding of the species' historical biogeography has relied on a poor fossil record and on reconstructions from genetic and morphological data. The presence of an extinct species *C. meini* from the Late Oligocene of Germany to the Early-Middle Miocene of France, Austria, southern Germany and the Czech Republic indicates that representatives of the genus once had a wide distribution across western and central Europe. In *C. lusitanica* the largest intra-specific genetic diversity is found within the populations of southern Portugal, suggesting that Spanish populations apparently have a recent origin linked with a post-glacial (<18,000 years BP) expansion from historical refuges. Consequently the few elements reported from the Chalcolithic level (with a radiocarbon age of  $4,490 \pm 40$  years BP) of the Valdavara-1 cave (Galicia, northwestern Spain) constitute the first fossil evidence for this species and suggest that the northernmost expansion took place at least before the Chalcolithic period and probably after the Magdalenian period, because *C. lusitanica* is absent from the rich assemblage of the underlying latest Pleistocene level (radiocarbon-dated to between  $13,770 \pm 70$  and  $14,640 \pm 70$  years BP).

Technical Session II, Wednesday 8:00

**ORGANISMAL BIOLOGY, PHYLOGENY AND STRATEGY OF PUBLICATION: WHY CONODONTS ARE NOT VERTEBRATES**

BLIECK, Alain, CNRS & Université de Lille 1, Villeneuve d'Ascq, France; TURNER, Susan, Queensland Museum, Hendra, Queensland, Australia; BURROW, Carole, Queensland Museum, Hendra, Queensland, Australia; SCHULTZE, Hans-Peter, University of Kansas, Lawrence, KS, USA; REXROAD, Carl, Indiana Geological Survey, Bloomington, IN, USA

Vertebrates are defined by (1) a complex anterior anatomical feature called the skull, and (2) mineralized hard tissues, derived from ecto-mesodermal embryonic structures, which characterize the clade Craniata, grouping hagfishes and vertebrates s.s. that possess either true vertebrae or homologous structures at embryonic stages. These structures apparently appear as early as the Early Cambrian in *Haikouichthys* (syn. *Myllokunmingia*; Konservat-Fossil-Lagerstätte, Chengjiang, south China). The hypothesis that conodonts are vertebrates, first espoused in the 1850s, was revived less than a decade ago through a cladistic analysis based upon interpretation of conodont hard tissues as homologous to vertebrate ones (enamel or enameloid, dentine, bone, cartilage). This analysis resolved all conodonts within the clade *Vertebrata* s.s. in a rather crownward position, and incorporated the 'Total Group Concept' (TGC), thus including conodonts in the TG Gnathostomes (= jawed vertebrates). Following this approach, "agnathans", a paraphyletic group defined by the absence of jaws, as well as the conodonts, become "jawless gnathostomes". However, the small cone-, rasp- or comb-shaped phosphatic conodont elements, interpreted by those workers in 2000 as homologous with teeth, have never been collected in connection with any jaw-like structure. We do not accept the TGC nomenclature and consider that conodont hard tissues (and several other anatomical structures) are in no way homologous to vertebrate ones. Rerunning a cladistic analysis after correcting certain character codings and eliminating the characters that are present only in Recent taxa and not codable in fossils, conodonts appear stemward to craniates and are thus provisionally interpreted as basal chordates at best. To resolve the problem of phylogenetic relationships of conodonts and chordates, the analysis should be remade including non-chordate taxa such as echinoderms, hemichordates, chaetognaths and priapulians.

**NEW OBSERVATIONS ON THE CRANIAL ANATOMY OF PALEOGENE MICROMOMYIDAE (MAMMALIA, PRIMATES) FROM THE CLARKS FORK BASIN, WYOMING**

BLOCH, Jonathan, Florida Museum of Natural History, University of Florida, Gainesville, FL, USA; SILCOX, Mary, University of Winnipeg, Winnipeg, MB, Canada; CHESTER, Stephen, Yale University, New Haven, CT, USA; GUNNELL, Gregg, University of Michigan, Ann Arbor, MI, USA

Micromomyids are among the most primitive known plesiadapiform primates. They are small (15-50 g) and have been reconstructed as committed claw-climbing arborealists similar to extant arboreal treeshrews. We use ultra-high resolution X-ray computed tomography to describe the skull of Paleocene *Dryomomys szalayi*, the most complete known for Micromomyidae. Previously, only two cranial fragments have been described for the family, both tentatively attributed to Eocene *Tinimomys graybulliensis*. These specimens (UM 85176 and USNM 461202) differ in morphology, leading to past controversy regarding their identification. UM 85176 differs from the basicranium of *D. szalayi* in having: 1) a well developed caudal tympanic process of the petrosal that extends rostrally over the fenestra cochleae, 2) only a moderately inflated mastoid region, 3) a restricted epitympanic process of the petrosal that extends laterally to the facial canal, and 4) over-all smaller size. UM 85176 is similar in these details to cranial fragments of a nyctitheriid insectivore recovered from the same deposit and is tentatively identified as such. Conversely, USNM 461202 is very similar to *D. szalayi* in comparable morphology, supporting its original attribution to *T. graybulliensis*. *D. szalayi* has a distinct small groove near the lateral extreme of the promontorium, just medial to the fenestra vestibuli, the size of which suggests that the internal carotid artery was non-functional, as has been inferred for paromomyid and plesiadapid plesiadapiforms, but not Eocene euprimates, carolestids, and microsopids. On the other hand, *D. szalayi* is similar to fossil euprimates and plesiadapoids in having a bullar morphology consistent with a petrosal origin, unlike that of paromomyids and microsopids. Micromomyids differ from all other known plesiadapiforms in having an inflated cochlea and a highly pneumatized squamosal and mastoid region with associated septa within the bulla. The cranial anatomy of *D. szalayi* exhibits a mosaic of primitive and derived characteristics that are best viewed in a phylogenetic context that includes dental and postcranial data, which help resolve areas of disagreement.

Romer Prize Session, Thursday 10:15

**SIGNIFICANT EFFECTS OF THE LATE PLEISTOCENE-HOLOCENE TRANSITION ON SMALL MAMMALS**

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Understanding how communities have responded and will continue to respond to environmental change is a primary goal of both paleoecology and modern ecology. The transition from the Last Glacial Maximum to the Holocene provides a good model for understanding biological response to climatic warming and other types of environmental change. However, much of the paleontological focus has been on the extinct megafaunal community and not on the response of the small mammals that survived the end-Pleistocene extinction event and form the bulk of the present mammalian community. In order to understand the complete community response to environmental change at the Pleistocene-Holocene transition, I excavated a fossil deposit from Samwel Cave in the Shasta-Trinity National Forest in northern California. The deposit, a woodrat midden and sometime carnivore den, contained thousands of bones, primarily from small mammals. Ten AMS-radiocarbon dates show that the deposit was formed in a relatively continuous and constant depositional environment, which provides a glimpse of fine-scale changes to the small mammal community with minimal time averaging. Together with two previous excavations in the region, these deposits provide a rich window into faunal dynamics of the entire mammalian community since the Late Pleistocene. Overall, the small mammal community showed significant responses to environmental change at the Pleistocene-Holocene transition, including a sharp decrease in species richness, diversity, and evenness at the Pleistocene-Holocene transition followed by continuing decreases through the Holocene. I examined these changes in the context of broader changes in the fauna and flora of the region against the changing climates of the Pleistocene and Holocene. These data show that the California small mammal community was significantly impacted by climate change and megafaunal extinction at the end of the Pleistocene, much the same as these animals are impacted today and into the future.

Poster Session IV, (Saturday)

**A FOSSIL PILOT WHALE, *GLOBICEPHALA* SP. (CETACEA: DELPHINIDAE), FROM THE LATE PLIOCENE PURISIMA FORMATION OF CENTRAL CALIFORNIA**

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Extant pilot whales (*Globicephala* spp.) are large (6-8 meter), social, pisci- and teuthivorous predators with a cosmopolitan distribution in tropical and temperate oceans worldwide. A fossil cranium recently collected from the Mio-Pliocene Purisima Formation represents the first fossil record of a pilot whale in the Northeast Pacific Ocean and the best definitive

record of a delphinid from the West Coast of North America. Albeit incomplete, the cranium can be identified as *Globicephala* sp. This specimen exhibits several features characteristic of extant pilot whales such as a large, wide skull; deep, triangular depression anterior to the nares corresponding to the premaxillary sac fossae; wide, flat anterior premaxillae; pronounced ridge on the premaxilla medial to the orbit, and a wide, flat, and dorsoventrally deep rostrum with trapezoidal cross-section. This cranium is approximately three-quarters the size of extant *Globicephala* crania. The skull was collected as float on the beach, and precise determination of its original stratigraphic horizon may be difficult. However, based on associated matrix and mollusks, it likely originated from a late Pliocene section of the Purisima Formation that is paleomagnetically dated to 3.5-2.47 Ma. Two large delphinid periotics from this stratigraphic interval are potentially referable to this taxon. Preliminary analyses of a morphological matrix including extant and extinct taxa indicate that most Italian Pliocene delphinids are members of the Subfamily Globicephalinae. Thus, the current fossil record, although meager, suggests Globicephalinae was the first delphinid subfamily to diversify and disperse across the globe.

Poster Session III, (Friday)

**NEW TRACKS ON THE ROCK: PARALLEL TRACKWAYS OF A NEW TYPE OF *IGUANODONTIPUS-CARIRICHNIUM*-LIKE MORPHOLOGY FROM THE LOWER CRETACEOUS SANDSTONES OF OBERNKIRCHEN, NORTHERN GERMANY**

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In 2008, the Lower Cretaceous ("German Wealden") Obernkirchen Sandstone Quarries (Obernkirchener Sandsteinbrüche) yielded an astonishing amount of new dinosaur tracks in two layers, representing a lagoonal paleo-environment. The stratigraphically lower surface contains hundreds of theropod tracks. The higher one, described here, is app. 2500 m<sup>2</sup> large, shows only faint to no ripple marks, some tree logs, and deep dinosaur tracks with a gross overall similarity to as well *Iguanodontipus* as *Caririchnium*. The new tracks can be discerned from both ichnotaxa by the following characters: Behind the margin of the metatarsal "heel", two extra concavities are visible, usually slightly oblique to the middle toe axis and laterally oriented. These half moon-shaped pits probably represent additional pedal pads. The tracks must have been created by a foot possessing a morphology differing from that of the *Iguanodontipus* and *Caririchnium* track maker. Most of the tracks are large (up to 50 cm track length) and probably represent an adult growth stage, but some are much smaller and must have originated from subadult or juvenile animals. A clear track pattern could be identified: one group of dinosaurs had been walking NW/N' (this group contains the smaller tracks), another group SE/S'. The trackways within both groups are arranged in a strictly parallel way. Thus, the bigger and the smaller individuals walked synchronously in the same direction. Only a few, slightly curved trackways of adults cross the N-S axis. On the very edge of the surface, an unusual structure remains enigmatic. A large, elongated pit of app. 3 m length shows three "compartments": a small one (looking like the shape of a "head"), a longer one ("body") and even longer, but more narrow one ("tail"). For the time being, we hypothesize a crocodylian origin for this impression. Documentation of the whole excavated area was achieved taking app. 1700 images by means of high resolution digital photography. Additional tiepoints were used for geometric transformation of the images into one reference system in order to generate a complete mosaic of images, which provides the basis for the final track map.

Poster Session IV, (Saturday)

**A COMPARATIVE MORPHOMETRIC ANALYSIS OF SAUROPODOMORPH NECKS**

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The long neck is one of the most characteristic features of sauropodomorph dinosaurs. It has been evoked as an important feature in sauropod biology, and several studies on neck posture and use in feeding have been carried out. For a better understanding of the evolution of the neck of sauropodomorph dinosaurs we analyse changes and special adaptations in the bony structure of the cervical vertebral column of selected taxa. A determination of evolutionary trends in the lamina system also allows an interpretation of soft tissue adaptations for a long neck. Using the Extant Phylogenetic Bracket for a reconstruction of the axial musculature of a mid-cervical vertebra of *Plateosaurus*, we trace the osteological trends in the evolution of sauropod necks for a comparison to the conditions in *Plateosaurus* as a basal model. With landmark-based geometric morphometrics and multivariate analysis we can assess the effects of size, taxonomy and muscular strength on the morphology of sauropodomorph mid-cervical vertebra. Digital pictures were landmarked with predefined homologous points using the computer program tpsDig2. Landmarks were chosen on cranial, caudal, dorsal and ventral edges of the vertebra, pre- and postzygapophyses, parapophysis and diapophysis and also in the course of 6 laminae. The data were entered into the geometric morphometric software program tpsRelw to compute the mean shape. The scatter of residuals at each

landmark relative to the consensus configuration after the superimposition (Generalized Procrustes Analysis) shows differences at several landmarks. To display the shape difference of the vertebrae, thin-plate spline deformation grids were generated. The development of the lamination in the cervical vertebral column indicates an improvement of the muscular insertions which mainly results in an improvement of the group of the longissimus muscles and also the hypaxial musculature. Both groups of muscles help to stabilize the neck, especially in its mid-section.

Technical Session XIX, Saturday 2:45

#### ELUCIDATING HIPPO RELATIONSHIPS WITHIN CETARTIODACTYLA: DENTAL EVIDENCE

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For more than 20 years, molecular phylogenies have consistently supported the paraphyly of Artiodactyla, a clade supposedly well defined on morphological grounds. In most cases, Cetacea appears as sister group of Hippopotamidae. Several steps have been made towards achieving more congruence between morphological and molecular phylogenies, notably through new discoveries of early archaeocetes. However, even analyses of large combined datasets have not led to well resolved phylogenies. Recent studies proposed strikingly erratic affinities for the putative molecular sister group of Cetacea: within artiodactyls, Hippopotamidae alternately root closer to anthracotheriids, suoids (and entelodonts), cebochoerids, helohyids, or raocellids. We suggest that this situation results in part from the fact that most phylogenies do not include fossil hippopotamids together with their potential stem taxa, i.e. principally Neogene and late Paleogene bunodont to bunoselenodont artiodactyls from the Old World. This led us to revise and assess the phylogenetic position of the putative oldest, most primitive hippopotamids: the middle to late Miocene *Kenyaipotamus* from eastern and northern Africa. *Kenyaipotamus* is mostly known through partial dentitions. The unique dental characteristics of the Hippopotamidae have confounded efforts to resolve the family relationships within Cetartiodactyla. An origin within Old World anthracotheriids, principally based on craniomandibular morphology, has been debated notably because the latter display dentitions potentially too derived toward selenodonty. In order to perform relevant comparisons with potential hippopotamid stem groups, we have harmonized and revised the dental nomenclatures in use. With this renewed nomenclatural system, we built an original dataset including mostly dental characters. Our analyses of this dataset independently support an origin among Bothriodontinae. Two main alternate scenarios can be proposed, with different implications for the biogeographical context of hippopotamid emergence. In order to investigate cetartiodactyl phylogeny further, efforts are underway to incorporate postcranial elements and more Paleogene taxa.

Romer Prize Session, Thursday 9:15

#### THE ORIGIN OF TETRAPOD LIMBS AND GIRDLES: FOSSIL AND DEVELOPMENTAL EVIDENCE

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The appearance of the first tetrapods (about 375 mya) marked one of the most important events in vertebrate evolution. The fin to limb transition saw the appearance of fingers and a weight bearing pelvic girdle. While very little research has been done on the evolution of the tetrapod pelvic girdle, the question of the origins of fingers has been well studied but some aspects remained controversial. A combination of paleontology, developmental biology and comparative morphology was used in this project to better understand these aspects of the transition. The pectoral fin of *Panderichthys*, a sarcopterygian fish closely related to tetrapods was CT-scanned and modeled in three dimensions and its pelvic girdle and fin were examined with traditional techniques. This information was integrated with comparisons of the development of the Australian lungfish and the axolotl, extant animals representing well the condition of either side of the fish-tetrapod transition. Development of bone and cartilage was studied through clearing and staining and development of skeletal muscles through immunostaining. In situ hybridizations were performed on the lungfish to study the expression of *Hoxd13*, associated with the formation of digits in tetrapods. This work shows that the late expression phase of *Hoxd13* is present in the lungfish and is associated with the formation of radials. Redescription of the pectoral fin of *Panderichthys* reveals that distal radials are present, which, in addition to other information, lead to the conclusion that digits are not novelties in tetrapods but rather have evolved from the distal radials present in the fins of all sarcopterygian fish. As for the pelvic girdle, it is very primitive in *Panderichthys* but comparison of its development in *Neoceratodus* and *Ambystoma* suggest that the ischium evolved through the posterior expansion of the pubis and the ilium, through an elongation of the iliac process already present in sarcopterygian fishes. The results of this research help to better understand the fin to limb transition and show that it is more gradual than previously believed.

Poster Session I, (Wednesday)

#### A NEW LIZARD (LEPIDOSAURIA, SQUAMATA) FROM THE EARLY CRETACEOUS OF THE MONTSEC RANGE (CATALONIA, SPAIN)

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For much of the Mesozoic, the Iberian Peninsula formed a separate landmass between Laurasia and Gondwana. Its fauna is therefore of biogeographical interest. Fossil lizards are known from the Iberian Late Jurassic and Early Cretaceous, but good articulated material is known only from the Spanish Early Cretaceous lithographic limestones of Las Hoyas and Montsec. The oldest locality, and the first to produce squamates (*Meyasaurus*), is the Late Berriasian - Early Valanginian La Pedrera de Meià (Montsec, Catalonia). *Meyasaurus* has subsequently been recovered from Las Hoyas and Uña (Barremian), but Montsec stands apart in yielding material of the Jurassic/Cretaceous Laurasian genus *Eichstaettisaurus*. New lizard material has recently been recovered from La Pedrera de Meià. The specimen consists of a small (snout-vent length: 45mm) partial skeleton and skull, in articulation and exposed in dorsal view. Despite its size, the full ossification of the long bone epiphyses and the presence of a fully formed (co-ossified) scapulocoracoid and astragalocalcaneum suggest it was close to maturity. The combination of bones and impressions shows enough features (shape, size and implantation of the teeth, lack of osteoderms, skull bone shapes, postcranial proportions, pelvic and pectoral girdle shape) to distinguish the new specimen from other lizard genera described from the same locality (*Meyasaurus*, *Eichstaettisaurus*), from paramacelodids (Uña), and from *Hoyalacerta* and *Scandensia* (Las Hoyas). The form of the dentition (pleurodont, anteriorly recurved teeth and straight posterior teeth, with a principal cusp and a tiny anteriorly positioned cusp) is uncommon among described Early Cretaceous lizards. It resembles that of *Meyasaurus*, although teeth are less numerous and higher-crowned, and other characters, such as the shape of the lower jaw and frontal seem to preclude its attribution to this genus. The poorly known *Durotrigia* (Berriasian, England) is described as having tricuspid teeth, but material is too fragmentary to provide a good comparison. The new specimen may represent a new genus, thus increasing our knowledge of the Early Cretaceous squamate faunas of the Iberian Peninsula.

Technical Session XVI, Saturday 8:00

#### TWO NEW SPECIMENS OF CIMOLODONTANS AND A PHYLOGENETIC STUDY OF THE POSTCRANIAL ANATOMY OF MULTITUBERCULATA (MAMMALIA, SYNAPSIDA)

BOLORTSETSEG, Minjin, Institute for the Study of Mongolian Dinosaurs, Ulaanbaatar, Mongolia

The position of Multituberculata within Mammalia and the phylogenetic relationships among multituberculates remain controversial. Previous comparative studies on the postcranial skeletons of multituberculates have suggested that this part of the skeleton is highly conserved and provides little phylogenetic information for resolving relationships within Multituberculata; however, detailed examination of published specimens and anatomical descriptions of two new partial multituberculate skeletons demonstrate that this is not the case. The two new skeletons described are 1) partially articulated skeleton of an undescribed taxon referred to as the Udan Multi, which is closely related to *Tombaatar sabuli*, from the Udan Sayr locality (Late Cretaceous, Mongolia), and 2) a nearly complete and articulated skeleton of *Kryptobaatar dashzevegi* from the locality of Ukhua Tolgod (Late Cretaceous, Mongolia). The skeleton of *Kryptobaatar* includes the only multituberculate manus preserved in 3 dimensions, and it displays a mosaic of features: large centrale, contact of metacarpal V and cuneiform as in monotremes, enlarged trapezium and cranial displacement of metacarpal I as in trechnotherians (symmetrodonts and therian mammals), a fairly minor degree of humeral torsion, and fusion of cervical ribs to form transverse foramina of the cervical vertebrae. The calcaneus of the Udan Multi has a well developed calcaneal crest, reminiscent of the morphology seen in early mammaliaforms. Previous phylogenetic hypotheses for the relationships within Multituberculata were tested with a data matrix of 35 taxa coded for 95 postcranial characters, of which 77 are new. Noteworthy findings include: 1) postcranial evidence for a clade of Late Cretaceous Mongolian multituberculates excluding *Djadochtherium*, 2) discovery of eight new postcranial autapomorphies for Multituberculata, and 3) strong support for a close relationship between two Mongolian multituberculates, the Udan Multi and *Catopsbaatar*.

Technical Session VIII, Thursday 3:00

#### CALCIFIED CARTILAGE SHAPE IN EXTANT ARCHOSAUR LONG BONES REFLECTS OVERLYING JOINT SHAPE IN LOAD-BEARING ELEMENTS: IMPLICATIONS FOR INFERRING DINOSAUR JOINT SHAPE

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How well does calcified cartilage shape in dinosaur long bones reflect the unpreserved epiphyseal articular cartilage? In archosaur long bones, the epiphyseal articular surface overlies a calcified cartilage zone, which is preserved in fossil archosaurs, including

dinosaurs. Previous studies have shown that extant archosaur long bone dimensions change significantly after epiphyseal cartilage removal. However, it remains unclear how much the calcified cartilage retains the shape of the overlying articular cartilage. We tested the hypothesis that calcified cartilage shape will not change significantly from that of the overlying epiphyseal cartilage. An ontogenetic series of long bones with intact epiphyses from American alligators and helmeted guineafowl were measured and digitized for geometric morphometric (GM) analyses before and after epiphyseal cartilage removal. Our linear results confirm previous analyses: most dimensions change significantly after epiphyseal cartilage removal. The picture is more complex for calcified cartilage shape. GM analysis of alligators shows small but significant differences between the epiphyseal cartilage shape and calcified cartilage zone, but a surprising amount of shape information is still retained. In guineafowl, GM analysis shows larger shape differences before and after cartilage removal in juveniles, but adults show no significant shape difference. After epiphyseal cartilage removal, the femur retains more of its overall shape than does the humerus in the juvenile guineafowl. We confirmed this pattern utilizing additional samples of juvenile ostriches and broiler chickens. Our data suggest that differences in long bone size and shape in archosaurs are greater in elements not utilized in weight-bearing. We suggest that for dinosaurs, the calcified cartilage of load-bearing long bones is a generally reliable indicator of the once-living joint shape. Conversely, our data suggest that more dimensional and shape data are missing from the non-weight-bearing forelimb elements in bipedal dinosaurs.

Poster Session IV, (Saturday)

#### **PRESENCE OF BASAL SAUROPODOMORPHA IN THE LOWER JURASSIC LISBON FORMATION (KAROO SUPERGROUP, ELLISRAS BASIN, SOUTH AFRICA)**

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The paleontology of the Lisbon Formation in the Ellisras Basin (a South African continuation of the Botswana Kalahari Karoo Basin) is inadequately known. Recent prospecting in this poorly exposed unit resulted in the discovery of invertebrate ichnofossils and vertebrate remains along the Limpopo River (Lisbon farm). The latter comprises mostly long bones and vertebrae, of which the cervical vertebrae are elongate, not pleurocoelous and non-opisthocelous. The vertebrate material appears consistent with it being from a basal sauropodomorph, which are the most common vertebrates of the Lower Jurassic upper Elliot Formation in the main Karoo Basin (South Africa, Lesotho). The current findings fill a regional distribution gap in the uppermost Karoo strata outside the main Karoo Basin where this Lower Jurassic succession is thinner, less well-preserved, and little fossiliferous. Our sedimentological and paleontological analyses permit a direct litho- and biostratigraphic correlation of the upper Lisbon Formation in the Ellisras Basin with the upper part of the Elliot Formation in the main Karoo Basin as well as other Lower Jurassic continental red bed successions in southern Africa. Rare skeletal remains found in a possibly contemporaneous unit in the Springbok Flats Basin (South Africa) are also probably from basal sauropodomorphs. In the transfontier Tuli Basin (Zimbabwe, South Africa), several localities in the upper levels of the red bed succession have also yielded basal sauropodomorph specimens. Furthermore, sites in the Zimbabwean Mid-Zambezi and Mana Pools-Cabora Bassa basins, which are probably very close in stratigraphic position to our unit, have produced sauropodomorph remains. In Namibia, no dinosaur has been found so far in the uppermost Upper Omingonde Formation (equivalent to the upper Elliot Formation), but the unique dinosaur recovered from the overlying, slightly younger Etjo Formation (Waterberg Basin) is a partial skeleton of *Massospondylus*. We tentatively suggest that the Lisbon Formation was deposited in a dryland setting with well-drained soils that at least episodically supported some flora and was probably dominated by basal sauropodomorphs.

Poster Session I, (Wednesday)

#### **INSIDE THE SKULL OF *IOWADIPTERUS HALLI***

BORNSÄTER MELLBIN, Barbro, Uppsala University, Uppsala, Sweden

*Iowadipterus halli* is a Middle Devonian long-headed lungfish, known from a single specimen from Winton Quarry, Iowa, USA. It comprises a three-dimensionally preserved complete head plus the anteriormost part of the body. The external dermal skeleton of the skull, the only part of the specimen that can be examined, shows a number of apparently primitive characters such as narrow rectangular submandibulars and absence of E bones. This suggests that *Iowadipterus* may occupy a deep position in lungfish phylogeny, but unfortunately there is limited data overlap with other primitive genera such as *Dipnorhynchus*, *Uranolophus* and *Stomiahykus* that are represented principally by braincase, dental and skull roof material. Following CT scanning at University of Texas, Austin, 3D modeling of the internal cranial anatomy of *Iowadipterus* is now in progress. A complete neurocranium is present in the specimen, containing a cranial cavity including well-defined inner ear spaces. Palatoquadrate, lower jaw, dentition and ceratohyals are also well preserved. The dentition consists of tooth plates with well-defined tooth rows, comparable to those of *Stomiahykus* or *Jessenia* but differing from the denticle fields of *Uranolophus* and dentine sheets of *Dipnorhynchus*. The dorsal surface of the palatoquadrate carries a dorsal process similar to that in *Diabolepis*, *Dipnorhynchus*, *Uranolophus* and *Stomiahykus*, supporting the contention that *Iowadipterus* is a very primitive lungfish. Its combination of

complete or near-complete data sets for both dermal and internal skeletons of the head will render *Iowadipterus* highly informative for analyses of lungfish phylogeny.

Poster Session III, (Friday)

#### **CLAWING THROUGH THE GIUMAROTA: DISTAL PHALANGE DIVERSITY IN A LATE JURASSIC MAMMALIAN FAUNA**

BORTHS, Matthew, Stony Brook University, Stony Brook, NY, USA; MARTIN, Thomas, Steinmann Institut für Paläontologie, Universität Bonn, Bonn, Germany

In the last two decades the diversity of Jurassic mammalian ecomorphology has been demonstrated with exceptionally preserved, articulated specimens from China, North America, and Europe. In this study we utilize isolated postcranial material to reconstruct the ecological diversity of the very well sampled Jurassic fauna of the Guimarota mine in Portugal. For almost fifty years, the Guimarota mine has been a significant source of data for understanding Late Jurassic terrestrial faunas. Two partially articulated skeletons were recovered from the Guimarota mine: the scansorial paurodontid *Henkelotherium guimarota*, and the fossorial docodontid *Haldanodon exspectatus*. This articulated postcranial material suggests the mammalian community had radiated into specialized terrestrial niches. We studied the isolated material to understand the extent of this ecological radiation by focusing on distal phalanges. Dozens of isolated distal phalanges were recovered by screenwashing, and have never been described. This is because taxonomic identification is difficult with this isolated material. However, understanding of the ecomorphological diversity of a fauna does not require taxonomic designation. Each complete mammalian terminal phalange was photographed in lateral view. We identified three distinct morphological groups. These were supported through landmark based Procrustes analysis and outline based Eigenshape analysis. Visualized with Cluster analysis, elongate phalanges with elongate, proximal, stops are clustered with known fossorial mammals and phalanges associated with *Haldanodon*. Distally shortened claws with reduced bony stops cluster with scansorial mammals and with the articulated phalanges of *Henkelotherium*. The final group of claws have robust, bony stops and proximal articulations. These are distally relatively short and cannot be assigned to either species recovered with articulated phalanges. This final group is tentatively associated with the terrestrial mammalian guild which may include multituberculates. This study demonstrates that isolated postcranial material can be utilized to reconstruct ecological diversity in Mesozoic mammals.

Poster Session II, (Thursday)

#### **THE EARLY DIVERGENCES OF MODERN BIRDS (NEORNITHES) REVISITED IN THE LIGHT OF KEY FOSSIL TAXA**

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In the last decades, the vast majority of studies, both molecular and morphological, have shown that the first divergence within modern birds separates the Palaeognathae (*Ratitae* and *Tinamidae*) from the Neognathae (all other Neognathae), and that the latter taxon splits into Galloanserae (*Galliformes* plus *Anseriformes*) and Neoaves (all other Neognathae). In contrast, a recent phylogenetic study has shown that the enigmatic pseudo-toothed birds (*Odontopterygiformes*), a group of large extinct seabirds with a huge bill bearing spiny osseous processes along the tomia, are sister to the *Anseriformes*. This study also suggested that the *Galliformes* are not sister to the *Odontoanserae* (*Odontopterygiformes* plus *Anseriformes*). On the other hand, two extinct taxa of controversial affinities have been previously suggested as related to the *Anseriformes*. The *Gastornithiformes*, a group of giant ground birds from the Paleogene of Europe and North America, have been considered as related to various groups, including the Palaeognathae and the extinct South American *Phorusrhacidae*. More recently, it was proposed that the *Gastornithiformes* are sister to the *Anseriformes*. The *Dromornithidae*, a family of large flightless birds known from the Eocene to Pleistocene of Australia, were first regarded as ratite birds, but recent morphological evidence suggests that they are nested within the *Anseriformes*. We present a new phylogenetic analysis for the early neornithine divergences including the *Gastornithiformes* and *Dromornithidae*, based on a revision of the first morphological character/taxon matrix including the *Odontopterygiformes*. The placement of these enigmatic fossils with respect to the *Odontoanserae* is critical for assessing the timing of diversification as well as the morphological and ecological diversity of early neornithines, in general, and the 'anseriform' lineage in particular. Moreover, the inclusion of these key fossil taxa provides important new data for testing the monophyly of the Galloanserae.

Poster Session II, (Thursday)

#### **NEW MATERIAL OF *DECCANOLESTES* (MAMMALIA, EUTHERIA) FROM THE CRETACEOUS OF INDIA: EVIDENCE FOR HABITUS AND RELATIONSHIPS**

BOYER, Doug, Stony Brook University, Stony Brook, NY, USA; PRASAD, Guntupalli, Indian Institute of Science Education & Research, HC-VII, Sector III, Kolkata, India; GOSWAMI, Anjali, University College London, London, United Kingdom; KRAUSE, David, Stony Brook University, Stony Brook, NY, USA; GODINOT, Marc, Muséum National d'Histoire Naturelle, Paris, France

We describe a distal humerus and proximal ulna from the uppermost Cretaceous intertrappean deposits of Naskal, India. We refer this material, along with previously

described astragali and calcanea to *Deccanolestes hislopi* on the basis of its small size and the fact that *Deccanolestes* is the only mammalian dental taxon recovered from this locality. While it is possible that some or all of these bones belong to *Sahnitherium*, another small dental taxon known from intertrappean deposits a few kilometers away, this currently has little bearing on the implications of these fossils. We compare the new material and previously described astragali and calcanea of *Deccanolestes* to other eutherian taxa (condylarths, cimolestans, nyctitheriids, plesiadapiforms, dermopterans, scandentians, and euprimates) qualitatively and quantitatively, using principal coordinates analysis (PCA) of anatomical angles and size-standardized linear measurements, as well as eigensurface analysis of digital models of astragali. The new humerus has a medial epicondyle that is relatively large and projects medially, an ulnar trochlea that has a lateral keel, a distinct zona conoidea separating the trochlea and capitulum, and a spherical capitulum. The ulna has an olecranon process that is canted anteriorly, a shallow trochlear notch, and a radial facet that is flat and faces laterally. These features make *Deccanolestes* similar to euarchontan mammals and strongly suggest an arboreal habit, as previously proposed. Furthermore, PCA of 24 measurements on the astragalus links *Deccanolestes* to plesiadapiform euarchontans. However, both PCA and eigensurface analysis show *Deccanolestes* to be well separated from extant euarchontans and a fossil nyctitheriid (another possible euarchontan). PCA's on six measurements of the humerus and 24 measurements of the calcaneum both link *Deccanolestes* most closely with Late Cretaceous to early Paleocene non-euarchontans and terrestrial taxa (e.g., *Procerberus*, *Protungulatum*, arctocyonids). Phenetic similarity of the limb bones to basal members of various placental clades may indicate that *Deccanolestes* is basal to Placentalia or a basal member of some placental group.

Poster Session III, (Friday)

#### **WHY THE LONG FACE?: RUNX2 TANDEM REPEATS AND THE EVOLUTION OF PRIMATE PROGNAATHISM**

BRADLEY, Brenda, Yale University, New Haven, CT, USA; CHESTER, Stephen, Yale University, New Haven, CT, USA; ASHER, Robert, University of Cambridge, Cambridge, United Kingdom

Small genetic changes can generate striking morphological differences, both within and between species. But the genetic mechanisms underlying variation in anatomical form are hotly debated, with a strong case being made that such variation is almost always due to changes in cis-regulatory elements (regions adjacent to genes that influence gene expression), rather than changes to the gene coding regions and, therefore, the proteins themselves. The genetic basis of variation in facial shape and length in mammals may represent an interesting counterexample to this. The transcription factor Runx2, which is involved in osteoblast differentiation, contains a functionally-important tandem repeat of glutamine and alanine amino acids. The ratio of glutamines to alanines in this protein influences the regulation of bone development, and in domestic breeds of dogs, and in carnivores in general, the ratio of glutamines to alanines is strongly correlated with facial length. In this study we examine whether this same correlation holds for primates, another mammalian order in which facial length is highly variable and evolutionarily important. We measured facial length and examined Runx2 DNA and amino acid sequences for ten primate species representing the major extant clades of the primate order. We found that the ratio of tandemly repeating poly-glutamines to poly-alanines is positively correlated with facial length in primates, but this correlation is not significant when controlling for phylogeny using independent contrasts. This provides a first step toward understanding the proximate mechanisms underlying variation in facial shape, a key diagnostic characteristic in primate paleobiology.

Technical Session II, Wednesday 11:45

#### **A CRITICAL APPRAISAL OF DEEP OSTEICHTHYAN INTERRELATIONSHIPS**

BRAZEAU, Martin, Museum für Naturkunde, Berlin, Germany; FRIEDMAN, Matt, University of Chicago, Chicago, IL, USA

The past decade has seen the exciting discoveries of primitive osteichthyan taxa from the Early Devonian and Late Silurian. These finds have yielded new raw material for inferring the sequence of character transformation at the base of Osteichthyes, while raising challenging questions about the origin of this clade. Despite this welter of new fossils, the osteichthyan stem remains thinly populated. Current consensus views largely limit potential members of this grade to a tenuous assemblage of some "acanthodians". Here we review existing data and propose an alternative scheme of early osteichthyan relationships. This new hypothesis reveals an array of osteichthyan stem taxa that have not been previously recognized, as well as corroborating newer and controversial hypotheses of stem membership. By embracing the osteichthyan total-group concept, we recover a different optimization for widely used characters, particularly those traditionally used to identify actinopterygians. Under our framework, many early fossils assigned to Actinopterygii (e.g., *Dialipina*, *Ligulalepis*) now lie as a series of plesions branching from the osteichthyan stem, crownward of *Acanthodes*. We argue that many previous phylogenetic placements of early osteichthyans are artificial, arising from an implicit (but false) dichotomy in which any osteichthyan (in the apomorphy-based sense) is either an actinopterygian or a sarcopterygian. This interpretive scheme has yielded an equally artificial, and often arbitrary, classification and optimization of synapomorphies for both Actinopterygii and Sarcopterygii. This traditional framework discourages the identification of stem-osteichthyans, which explains a persistent failure to discover them. The approach presented here recovers new stem taxa

and thereby yields a new hypothesis on the emergence of the Osteichthyes. Furthermore, it has important implications for how fossil taxa are placed in phylogeny, particularly where crown-group relationships are well-resolved or un-controversial.

Technical Session XV, Saturday 8:00

#### **A GLIMPSE AT THE PALEOECOLOGICAL AND PALEOBIOLOGICAL COMPLEXITIES OF MIDDLE JURASSIC THEROPOD COMMUNITIES IN THE NORTHERN HEMISPHERE: A PHOTOGRAMMETRIC AND MORPHOLOGICAL COMPARISON OF DINOSAUR TRACKS FROM NORTH AMERICA AND THE UNITED KINGDOM**

BREITHAUPT, Brent, Geological Museum, University of Wyoming, Laramie, WY, USA; MATTHEWS, Nefra, USDOJ-Bureau of Land Management, National Operations Center, Denver, CO, USA

The Middle Jurassic (MJ), an important time in the evolutionary history of dinosaurs, exhibits a paucity of body fossils. Fortunately, a number of significant dinosaur tracksites are known that provide valuable information about the trackmakers, their behaviors, their environments, and their global distribution. To more fully understand the tracks (and thus the dinosaurs) of this time detailed 3D documentation and comparison of ichnites worldwide must occur. Intensive research on the tridactyl theropod tracks (i.e., *Carmelopodus*) from northern Wyoming allows for comparison with other western states and various coastal sites in the United Kingdom. MJ ichnites found in the Sundance and Gypsum Springs formations of Wyoming and the Carmel Formation and Entrada Sandstone of Utah have been compared with those of the Lealt Shale, Valtos, Duntulm, and Kilmaluag formations on the Isle of Skye in Scotland, as well as the Saltwick, Cloughton, and Scalby formations along the Yorkshire Coast of England. A key component of this analysis is the use of close-range photogrammetry (CRP) to capture the proper photographs for the extraction of highly accurate 3D digital data and the creation of a digital archive. CRP allows for qualitative visual comparison and detailed measurements of tracks to be made from image models. Digital spatial data also provides an excellent tool to aid in unraveling ichnological complexities, such as variations in footprint morphology related to trackmaker, substrate, and preservational level. Data indicate that different MJ ichnotaxa are clearly evident, but significant similarities do exist for some of the tracks of small- to medium-sized theropods. Although intercontinental trackmakers of the same species or long distance migrations are not supported, an interesting Northern Hemisphere vertebrate ichnofaunal assemblage may be represented, reflecting a grade of theropod evolution or similar habitat adaptations. Interestingly, not only are analogous dinosaur footprints seen in Wyoming and Scotland, but both areas provide evidence for behavioral interpretations to be made on the gregarious, social nature and family groupings of theropod dinosaurs.

Poster Session III, (Friday)

#### **A NEW GENUS AND SPECIES OF PRIMITIVE WOMBAT (MARSUPIALIA) FROM THE RIVERSLEIGH WORLD HERITAGE PROPERTY IN NORTHWESTERN QUEENSLAND, AUSTRALIA**

BREWER, Philippa, Natural History Museum, London, United Kingdom; ARCHER, Michael, University of New South Wales, Sydney, Australia; HAND, Suzanne, University of New South Wales, Sydney, Australia; GODTHEL, Henk, University of New South Wales, Sydney, Australia

Wombats (Vombatidae, Vombatiformes) are highly specialized fossorial grazing marsupials. Their closest living relative is the koala (Phascolarctidae, Vombatiformes), itself a highly specialized arboreal folivore. The most recent estimated divergence date between these two families is 40 Ma; however, the fossil record of both families is extremely poor and no representative of either is known from deposits older than late Oligocene. Hypothesized phylogenetic relationships within the Vombatiformes (that includes six extinct families) are inconsistent; a result of the presence of highly specialized taxa, a spotty fossil record and lack of a suitable outgroup for comparison. Within this context, the discovery of a new genus of primitive vombatid from early Miocene deposits is particularly exciting. This taxon is known from two partial maxillae and a number of isolated teeth. Until now vombatid cusp morphology had only been described for one of the three living species of wombat and for two isolated molars from the late Miocene of Riversleigh. The teeth and cranial anatomy of the new taxon are here compared with adults and juveniles of both living genera of wombat as well as other Vombatiformes in order to better understand the evolution of this fascinating group. Comparisons reveal that the cheek teeth had a much simpler cusp pattern relative to those of modern wombats and show adaptations to a high degree of tooth wear (particularly on the trailing edge enamel), foreshadowing the later hypselodont morphology of the group. However, paleoenvironmental reconstructions indicate that the sediments in which these specimens were found were deposited in a rainforest environment.

Poster Session II, (Thursday)

#### **HOW MUCH RESOLUTION IS NECESSARY IN FINITE ELEMENT MODELS OF EXTINCT AND EXTANT TAXA?**

BRIGHT, Jen, University of Bristol, Bristol, United Kingdom

Finite Element Analysis (FEA) works on the principle that complicated structures may be divided into a discrete number of smaller, simple shapes (elements), and solved for

equations of stress and strain. FEA is becoming increasingly popular in paleontology to investigate relationships between form and function, as it offers a unique opportunity to recreate biomechanical hypotheses in extinct animals. It is therefore crucial to understand the effect of varying model parameters on stress and strain outputs and model accuracy. This is of utmost importance to ensure that analysis of fossil specimens (which may lack anatomical and material property data) and validation against living taxa may be performed with confidence. A viable model should contain enough elements so that the discrete structure accurately represents (converges upon) the continuum solution. However, the computer power needed to process increasing numbers of elements may become limiting. Physiologically-loaded FE models of a domestic pig (*Sus scrofa*) skull were created with varying mesh densities to determine the minimum number of elements necessary for convergence. The use of four-noded linear (Tet4) and ten-noded quadratic (Tet10) elements was also compared. Tetrahedral elements are traditionally considered to be overly stiff by engineers, but the highly curved surfaces of anatomical structures often necessitate their use over cuboidal elements. Due to the greater number of degrees of freedom they offer, Tet10 elements offer a solution and should be more accurate, although they require greater processing power. Results show that the pig models demonstrate reasonable convergence at around 300,000 elements, a much lower density than is often used in FE-models of a similar size. Tet4 elements did demonstrate higher stiffness, giving model stress values around 0.7 MPa lower than their 10-noded counterparts. These results are part of a larger, ongoing project to validate FE models against *in vitro* strain data taken from the skull of the same animal, and will be compared to determine which modeling practices are more applicable to the recreation of extant and fossil biomechanical models.

Poster Session III, (Friday)

**THE LAUBENHEIM BED - A NEW LOCALITY OF EARLIEST MIOCENE (MN1) LAND MAMMALS IN THE MAINZ BASIN, NORTHWESTERN GERMANY**  
BRINKKOETTER, Janka, Steinmann-Institut für Geologie, Mineralogie und Paläontologie, Bonn, Germany; MARTIN, Thomas, Steinmann-Institut für Geologie, Mineralogie und Paläontologie, Bonn, Germany

A newly discovered vertebrate locality in the Mainz-Laubenheim quarry in the Mainz Basin yielded the most complete terrestrial mammalian fauna recovered from MN1 (Mammal Neogene Zone 1) in Germany so far. The Laubenheim Bed consists of unstratified light grey *Hydrobia*-marl and is situated in the basal part of the Aquitanian Oberrad-Formation formally known as the "Upper Part" of the Upper Cerithium Beds. The Oberrad-Formation consists of intercalated clay marls, marls, calcareous marls, and sandstones with abundant invertebrates that were deposited in a brackish lagoon connected to the Rhine graben. Besides brackish-marine invertebrates and vertebrates the Laubenheim Bed yielded a wealth of disarticulated skeletal material of land tetrapods washed in by rivers from the hinterland. MN1 localities are rare in Central Europe and the Laubenheim locality has produced one of the most diverse assemblages so far. The mammalian assemblage comprises marsupials (*Amphiperatherium frequens*), insectivores (Erinaceidae, Talpidae, Dimylidae, Soricidae), rodents (Sciuridae, Castoridae, Gliridae, Eomyidae, Zapodidae), lagomorphs (Ochotonidae), perissodactyls (Rhinocerotidae), artiodactyls (Cainotheriidae, Moschidae), and carnivores (Amphicyonidae, Mustelidae), each family represented by at least one taxon. This diverse mammalian assemblage indicates an open landscape pervaded by streams with accompanying gallery forests providing a great variety of habitats in the hinterland of the Mainz Basin lagoon.

Poster Session I, (Wednesday)

**DEBRIS FLOW-HOSTED BONEBEDS - INSIGHTS PROVIDED BY THE BASAL CEDAR MOUNTAIN FORMATION (APTIAN, LOWER CRETACEOUS) OF UTAH**  
BRITT, Brooks, Museum of Paleontology, Brigham Young University, Provo, UT, USA; SCHEETZ, Rodney, Museum of Paleontology, Brigham Young University, Provo, UT, USA; EBERTH, David, Royal Tyrrell Museum of Palaeontology, Drumheller, AB, Canada; GREENHALGH, Brent, Questar Market Resources, Salt Lake City, UT, USA; DANGERFIELD, Anne, ExxonMobil, Houston, TX, USA

A taphonomic study of the taxonomically diverse, sauropod dominated, Dalton Wells quarry reveals that the site consists of at least four superimposed debris flow events. The site is posited in the lower Aptian, Yellow Cat Member of the Cedar Mountain Formation. The lower three or more meters of the member consists largely of angular fragments of a paleosol that developed in the top of the Morrison Formation. A comparison of Dalton Wells bonebeds with four other macrofossil bonebeds in the same stratigraphic position near the town of Green River, Utah indicate that most are hosted in debris flow related deposits, consisting of poorly sorted to massive gravelly to silty mudstones, often with angular debris from the underlying Morrison Formation. Each of these Green River sites is broadly to very similar to the Dalton Wells bonebeds in their stratigraphic, sedimentologic, and taphonomic characteristics. Specifically, each (1) occurs at the base of the Yellow Cat Member of the Cedar Mountain Formation; (2) rests unconformably on the Morrison Formation (usually on a distinctive paleosol); (3) is hosted by a poorly sorted, massive-to-vaguely graded, pale-green matrix consisting of silty mudstone or muddy sandstone; (4) contains matrix-supported fossil elements and element fragments, small chert granules and pebbles, and rip-up clasts from the underlying Morrison Formation and locally derived Cedar Mountain Formation intraclasts; (5) includes carbonate nodules and/or locally-developed diagenetically precipitated iron-carbonate-rich zones and horizons; (6) exhibits evidence

for severe trampling and sometimes insect damage; and (7) is overlain by one or more, carbonate-cemented sandstone beds. A review of debris flow hosted bonebeds indicates that the monodominant hadrosaur bonebed at Blagoveschensk, eastern Russia shares many taphonomic features with the aforementioned Yellow Cat Member quarries, suggesting that these kinds of bonebeds may be common in tectonic settings characterized by uplift and the reestablishment of accommodation space following a long depositional hiatus.

Molecular Tools in Paleobiology: Trees, Clocks and linking Geno- with Phenotype, Friday 9:45

**PHYLOGENETIC UNCERTAINTY AND CALIBRATION CHOICE: THE IMPORTANCE OF COMPREHENSIVE PHYLOGENETIC ANALYSES AND CONSIDERATION OF COMPETING ESTIMATES**

BROCHU, Christopher, University of Iowa, Iowa City, IA, USA; SUMRALL, Colin, University of Tennessee, Knoxville, TN, USA

Molecular dating methods are sensitive to the calibrations used for evolutionary rate estimation. Calibrations are subject to error, some of which reflects the fact that a "fossil" calibration is a phylogenetic statement – nodes estimate rates, not fossils – and may change as our understanding of phylogeny evolves. Calibrations taken from standard databases may reflect outdated phylogenetic estimates or, worse, nonphylogenetic scenarios. A survey of calibrations within two different clades – Crocodylia and Echinodermata – using multi-calibration methods reveals the unpredictable nature of phylogenetic error; unlike stratigraphic error, which is primarily unidirectional (first appearances postdate actual originations), changes in phylogeny can radically extend or prune the first appearances of clades, and there is no way a priori to know how names used in the paleontological literature correspond with the same name in a neontological context. While stratigraphic revision may impact ingroup species individually, phylogenetic revisions can impact a wide range of nodes within a tree, and calibrations are less independent of each other. Ironically, because molecular divergence estimates are proportional to calibration age, relatively young calibrations – those with the least amount of stratigraphic error – are more sensitive to phylogenetic error. Calibration selection strategies that appear most robust to phylogenetic error tend to be those rejected by cross-validation tests. Absence of a phylogenetic framework for most fossils precludes their use for rate estimation. Independent consideration of competing calibrations is needed to account for different temporal expectations resulting from different compelling phylogenetic arrangements.

Poster Session III, (Friday)

**OSTEOHISTOLOGY OF THE BASAL PHYTOSAUR PALEORHINUS FROM THE LATE TRIASSIC OF SOUTHERN POLAND - A PRELIMINARY RESULTS**  
BRONOWICZ, Robert, Faculty of Geology, Warsaw University, Warsaw, Poland

Phytosauria is a clade of quadrupedal, semi-aquatic crurotarsal archosaurs morphologically and ecologically resembling extant crocodiles. Worldwide distribution of this relatively fast evolving group makes it useful in biostratigraphy of the end of the Triassic. In 1993 a new locality of the Late Triassic age has been discovered near Krasiejów village (Poland). Since then a few specimens of the basal phytosaur genus *Paleorhinus* have been identified, representing cranial and postcranial material belonging to specimens being at the different level of ontogeny. Five femora have been photographed, measured and cross-sectioned following standard procedures used in osteohistological studies. The deep cortex of the smaller specimens is composed of laminar bone tissue with the woven-fibered bone matrix containing oval bone cell lacunae. This indicates fast growth rates during early ontogeny. The Haversian remodeling has not yet begun and the endosteal lamellar bone is visible, deposited centripetally around the medullary cavity. The transition into parallel-fibered bone matrix (mixed oval and elongated, flattened bone cell lacunae) is visible externally to the deep cortex. Towards the epiphysis the compact coarse cancellous bone can be observed. In more mature specimens bone remodeling is evident, being extensive at the endosteal margin and the deep cortex part of the sections. Resorption cavities are large to moderately large with lamellar bone tissue deposited centripetally inside them. One specimen displays lamellar-zonal bone with annuli, composed of avascular bone, and LAGs (Lines of Arrested Growth). Total number of ~9 LAGs is recorded. The zones decrease in thickness towards the periosteum forming an EFS or OCL (External Fundamental System or Outer Circumferential Layer) like structure. Growth pattern deduced from the femoral cross-sections indicate fast growth rates during early ontogeny and later a turnover into slower rates with cyclical growth.

Technical Session XIII, Friday 1:45

**A NEW SPECIES OF *THESCÉLOSÁURUS* (DINOSAURIA: ORNITHISCHIA) FROM THE FRENCHMAN FORMATION (LATE MAASTRICHTIAN) OF SASKATCHEWAN, WITH COMMENTS ON LATE CRETACEOUS ORNITHISCHIAN DIVERSITY**

BROWN, Caleb, University of Calgary, Calgary, AB, Canada; RUSSELL, Anthony, University of Calgary, Calgary, AB, Canada; BOYD, Clint, The University of Texas at Austin, Austin, TX, USA

The limited amount of cranial material preserved in the type series of *Thescelosaurus neglectus* (USNM 7757, 7758) has hampered previous investigations into the taxonomic diversity of this taxon during the Maastrichtian of North America. Newly discovered

specimens consisting of partial postcranial skeletons and nearly complete skulls (MOR 979; NCSM 15728), and identification of cranial material from the paratype specimen (USNM 7758) has permitted a detailed re-examination of this taxon. Comparison to the smallest known articulated *Thescelosaurus* skeleton (RSM P 1225.1) reveals morphological features distinct from both the type series (USNM 7757, 7758) and all other referred specimens. RSM P 1225.1 is confidently assigned to *Thescelosaurus* based on the presence of one postcranial and three cranial autapomorphies (and two additional putative cranial autapomorphies). It is differentiated from the type species of *T. neglectus* and all known specimens by the following combination of features: dorsal and posterior margins of the squamosal convex; floor of the postorbital suture of the squamosal bearing anteroposteriorly oriented ridges and grooves, and from all other specimens by the supraoccipital bearing a distinct median foramen running from the roof of the myelencephalon through to the dorsal surface of the element. Given the similar size of RSM P 1225.1 and the type series of *T. neglectus*, we propose these differences to be taxonomic, not ontogenetic. In combination, the North American taxa *Parksosaurus* (Early Maastrichtian) and the three species of *Thescelosaurus* (Late Maastrichtian), indicate an increase in diversity of basal ornithomorphs during the Maastrichtian, in contrast with the trend seen in other ornithischian taxa. A similar, though less well-documented, pattern is also seen in Europe, with the basal ornithomorph taxa *Rhabdodon* and *Zalmoxes* showing a diversity increase during the Maastrichtian. This may indicate that these basal ornithomorph taxa were more generalized herbivores that were better able to respond to changing environmental conditions during the latest Cretaceous than more specialized ornithischians, such as ceratopsids and hadrosaurids.

Preparators' Session, Thursday 11:30

#### **TRAINING AND EVALUATION OF VOLUNTEER FOSSIL PREPARATORS IN THE SMITHSONIAN FOSSILAB PROGRAM**

BROWN, Matthew, University of Texas at Austin, Austin, TX, USA; SMITH, Matt, Florida Museum of Natural History, Gainesville, FL, USA; JABO, Steven, Smithsonian Institution, Washington, DC, USA

A six-day course was developed to train volunteer fossil preparators in the basics of technique and materials as part of the Smithsonian Institution FossilLab Training Program, intended to staff the facility with competent workers. Program organizers wished to provide an intensive, hands-on training opportunity and provided course instructors with expectations for topics to be covered, as well as common methods and materials used in the institution. The instructors developed a curriculum for teaching fossil laboratory methods incorporating lecture, reading material, and hands-on guidance. Throughout the class, the instructors recorded their observations of student performance, and on the final day issued both written and practical examinations to the students. Students were also asked to complete a self-assessment, ranking their interest in the tasks that they were exposed to, in addition to ranking their perception of their abilities. The instructors produced written evaluations of each student, assigning letter grades for natural aptitude, grasp of theory, and level of interest; and made recommendations for possible duties in the laboratory or collections. Both organizers and instructors regard the outcome of this program as successful; for instance, laboratory managers still refer to the student evaluations when assigning preparation projects. This type of program establishes a common knowledge base among the volunteer pool, directs inquiry for future learning, reduces the learning curve for new volunteers, reduces staff time-expenditure for training, allows evaluation-based placement of volunteers, and provides all involved with a broader experience base. A formal program provides both the institution and community with consistency in methods and expectations, and is recommended for any laboratory or department charged with the care of fossils.

Poster Session I, (Wednesday)

#### **A PRELIMINARY REVIEW OF THE ANTHROPOGENIC BIASES INHERENT TO PALEOBIOLOGICAL DATABASES**

BROWNE, Ian, Oklahoma State University Center for Health Sciences, Tulsa, OK, USA

Paleobiological databases, e.g. MIOMAP and the Paleobiology Database, allow researchers to conduct large-scale paleoecological studies through meta-analysis of published fossil records. Vertebrate paleontologists have used them to investigate the response of mammals to abiotic factors such as regional tectonism and climate change. Here I review some of the anthropogenic biases inherent to these databases. Three broad categories of anthropogenic bias are identified: collection; reporting; and analytical. Collection biases arise from the relative completeness of sampling, either from differences in the intensity of sampling in one area vs. another (e.g. area effects) or the collection techniques used (e.g. surface collection, quarrying, or screenwashing). I reviewed the family level occurrences of "small" vs. "large" mammals within the MIOMAP database by decade. Not surprisingly, this showed that prior to the widespread adoption of screenwashing techniques "small" mammals accounted for a much smaller percentage of reported occurrences (<30%) than after the advent of screenwashing (between 40-50%) and that the "small" mammals reported in these earlier studies tended to be relatively large (e.g. castorids and mylagaulids) or common (e.g. leporids and heteromyids). This suggests that older sites that have not been resampled by screenwashing are not directly comparable to most recent collections. Reporting bias occurs either from incomplete reporting of the faunal composition of a site, or the complete absence of published data on significant museum collections. Analytical biases may arise from the methods used to bin locality data before comparisons are made. These databases are invaluable resources to researchers and we all owe a debt of gratitude to the teams that

assemble and maintain them. However, when using them to conduct meta-analyses we must be aware of the potential limitations and biases inherent to these data, and constantly vigilant to not draw conclusions beyond what the data support.

Late Triassic Terrestrial Biotas and the Rise of Dinosaurs, Thursday 9:30

#### **TRIASSIC ARCHOSAUR MACROEVOLUTION AND THE ASCENT OF DINOSAURS**

BRUSATTE, Stephen, American Museum of Natural History, New York, NY, USA; LLOYD, Graeme, Natural History Museum, London, United Kingdom; WANG, Steve, Swarthmore College, Swarthmore, PA, USA; BENTON, Michael, University of Bristol, Bristol, United Kingdom; RUTA, Marcello, University of Bristol, Bristol, United Kingdom

The early evolution of dinosaurs has long been a subject of fascination and many evolutionary scenarios have attempted to explain why dinosaurs, and archosaurs more generally, rose to dominance in the Triassic. Many previous hypotheses were constructed on a literal reading of the fossil record, but a broad quantitative toolkit now allows researchers to examine the macroevolutionary patterns of archosaurs in unprecedented detail. We examine the lineage diversity, morphological disparity (range of occupied morphospace), and rates of morphological change of archosaurs from the Middle Triassic to Early Jurassic. Morphological rates are highest in the Anisian and decrease over time, consistent with theoretical predictions of elevated rates during major morphological transitions and suggestive of a rapid archosaur radiation after the Permo-Triassic extinction. Morphological disparity increases over time, indicating that rates of change and amount of morphospace occupation are decoupled. Crurotarsan archosaurs, the "crocodile-line" clade that includes many forms convergent with dinosaurs, exhibit twice the disparity of dinosaurs, and the two clades evolved at indistinguishably similar morphological rates. This strongly contrasts with the long-standing view that dinosaurs outcompeted crurotarsans and other reptile clades during the Triassic, but is consistent with a more opportunistic view of dinosaur origins. Tree shape analysis finds only a few archosaur clades (Dinosauria, Saurischia, Sauropodomorpha) to exhibit a significant diversification shift at their base, indicating that most of archosaur lineage evolution is indistinguishable from an Equal Rates Markov model of random splitting over time. Likewise, a novel likelihood ratio test finds that only a few clades, all within Crurotarsi, exhibit elevated rates of character evolution relative to the entire phylogeny. None of these clades corresponds to those with significant diversification shifts, suggesting that morphological evolution and lineage diversification are decoupled.

Technical Session IX, Thursday 1:45

#### **TAPHONOMY OF A FLUVIALLY DERIVED BONE DEPOSIT: A NATURAL EXPERIMENT IN THE SANTA FE RIVER, FL**

BRYK, Alexander, Penn State University, University Park, PA, USA; ECCLES, Laurie, Penn State University, University Park, PA, USA; KITA, Zack, Penn State University, University Park, PA, USA

Fluvial hydrodynamics bias many fossil deposits and these processes often create graded or 'sorted' accumulations along energy gradients. Flume experiments identify key parameters in fluid transport of bones and sediments but do not accurately reproduce sorted deposits because of scaling problems and simplifications endemic to laboratory work. Therefore we studied a natural system and an incipient fossil deposit that is undergoing sorting along a riverbed, although the fossils are being reworked in a secondary taphonomic event. Our study site, The Graveyard, is a karst depression located in a meander bend of the Santa Fe River in Alachua County, Florida. This depression reduces stream flow velocity, promoting the deposition and sorting of sediments and fossils. The Penn State Science Diving Program collected fossils in 50 X 50 cm units, spread at five foot intervals along a transect parallel to flow. We investigated the role of element, taxon, animal body mass and the shape, size, and density of each bone and bone fragment in determining the final location of any bone in a sorted deposit. Preliminary results show position depends primarily on the physical properties of each bone (shape, size, density) at the time of deposition. These are, in turn, strongly influenced by taxon, element, and body mass. The greatest taxonomic diversity is found in the smallest size fraction of the sorted assemblage because teeth and tooth fragments are more common in this size fraction. This study provides a starting point for paleontologists to recognize and interpret fluvially derived fossil deposits.

Molecular Tools in Paleobiology: Trees, Clocks and linking Geno- with Phenotype, Friday 11:45

#### **EVOLUTIONARY PATTERNS OF VERTEBRAL VARIATION**

BUCHHOLTZ, Emily, Wellesley College, Wellesley, MA, USA

The vertebral column displays extensive variation among its individual vertebrae as well as among its component series. This variation is neither uniform nor global, and its patterns are rich sources of information about the column's evolutionary history. Here I discuss the integration of paleontological and molecular data in the analysis of two longstanding issues of vertebral patterning. Examination of the fossil record led A.S. Romer to propose the serial differentiation of the five mammalian vertebral series from an originally minimally differentiated vertebral column. Recent molecular work suggests that this stepwise regionalization is the product of progressive restriction of *Hox* gene expression domains. Ongoing species-level documentation of vertebral variation across multiple mammalian

orders reported here provides clear evidence of frequent homoplastic homeotic exchanges among the thoracic, lumbar and sacral series, implying their generation via changes in pattern assignment. In contrast the caudal column is dominated by meristic variations, identifying their origin via changes in somitogenesis, and emphasizing the developmental independence of these major column modules. The resistance of the mammalian cervical series to both homeotic and meristic changes dates to the early Triassic. Rare exceptional species with cervical variations exhibit additions or deletions of complete ribs with sternal connections, suggesting possible repatterning of appendicular (lateral plate mesoderm) instead of, or in addition to, axial (somatic) structures. The documentation of rib and sacrum morphology in tree sloths supports both the repatterning of lateral plate structures as the origin of their exceptional cervical morphology and the molecular hypothesis of independent developmental histories for primaxial and abaxial structures. This independence is further supported by current work that identifies abaxial costal fusion, and not primaxial homeotic exchange, as the cause of cervicothoracic disruption in the pygmy right whale.

Poster Session III, (Friday)

#### **DORSAL APPENDAGES OF *LONGISQUAMA* RECONSIDERED: ASPECTS OF DEVELOPMENT AND THE LINK TO THE EVOLUTION OF FILAMENTOUS INTEGUMENTARY STRUCTURES**

BUCHWITZ, Michael, Institut für Geologie, TU Bergakademie Freiberg, Freiberg, Germany; VOIGT, Sebastian, Institut für Geologie, TU Bergakademie Freiberg, Freiberg, Germany; FISCHER, Jan, Institut für Geologie, TU Bergakademie Freiberg, Freiberg, Germany

The elongated dorsal skin projections of the Triassic diapsid *Longisquama insignis* are controversially discussed for their complexity and supposed feather similarity. Comparing the Moscovian type material and new specimens, recovered from the Kyrgyz type locality in 2007, we are providing a redescription of the appendage structure. Indicative for a proximal-distal differentiation, the conspicuous subdivision into a narrow, tripartite proximal section and a broad, asymmetrically bipartite distal section is a principal feature – each appendage fragment can be assigned to the proximal or distal section or comprises both. Most appendages are to some degree curved; the arrangement in the holotype suggests that anterior sides are convex and posterior sides are concave. Apparent from the anterior to posterior longitudinal subdivision and from the distal asymmetry with the narrower anterior lobe comprising a distinct outer rim, the appendages display an anterior-posterior differentiation. Only in the paratype specimen PIN 2584/5 there is marked difference between the middle axis imprints on the left plate and on the right counterplate, suggesting the presence of a left-right asymmetry. We are regarding the longitudinal partition, biconvex-biconcave corrugation pattern, and the middle axis and spine impressions as indicative for a differentiated internal structure, enclosed by a membranous envelope. In analogy to avian remiges which show a likewise differentiation in the proximal-distal and anterior-posterior axes, and a left-right asymmetry, the dorsal appendages of *Longisquama* might have developed from a filamentous primordium in which a collar-like differentiation zone established above a basal zone of cell proliferation. As in the multilayered feather follicle distinct internal and external structures in the appendages indicate that they ascended from a likewise layered epidermal collar. While such parallelizations are in agreement with a set of similar mechanisms of appendage morphogenesis in a diapsid clade including *Longisquama* and certain archosaur groups, they not necessarily require that the *Longisquama* appendages are on a high level homologous with avian feathers.

Poster Session I, (Wednesday)

#### **MESOZOIC MARINE REPTILES OF NORTH-EAST MEXICO**

BUCHY, Marie-Céline, Museo del Desierto, Saltillo, Coahuila, Mexico

Systematic search for marine reptiles in north-east Mexican collections and outcrops started a decade ago, financially supported by the German Science Foundation and Consejo Estatal de Ciencia y Tecnología.

The Upper Jurassic La Caja/La Casita Fms yielded ichthyosaurs, sauropterygians and thalattosuchians as isolated occurrences from Nuevo León and Coahuila and from a Tithonian concentration Lagerstätte at Gomez Farfás, Coahuila. Turtles are yet to be reported.

Ichthyosaurs are numerous but poorly diagnostic - except for a complete skull referred to *Ophthalmosaurus* cf. *icenicus* and a larger skeleton currently under preparation close to *Brachypterygius*.

At least three pliosaurian taxa are documented, including one of the largest individual known, 'The Monster of Aramberri'. All specimens being in preparation or incomplete, their taxonomical status and affinities are unclear. At present, they appear to represent large, poorly ossified, 'longisymphyseal' forms. 'Plesiosaurs' are represented by few isolated centra of elasmosaurian morphology, and a unique, new cryptoelidid.

Prior to statistical study, thalattosuchians appear to represent the most abundant group. Two taxa were named, *Cricosaurus vignaudi* and *C. saltillense*. Additionally, the very first Mexican marine reptile, *Plesiosaurus mexicanus*, was recently reassessed as an indeterminate metriorhynchid. 'Dakosaurs' are few and fragmentary, possibly representing at least one new form.

As for the Upper Cretaceous, few, poorly diagnostic mosasaurian remains are known from the Campanian-Maastrichtian Méndez Fm, including the holotype of *Amphekepubis johnsoni* (now considered an indeterminate Mosasauridae).

However, north-east Mexico has become an exciting area for basal mosasauroids, with the discovery in recent years in the Turonian lithographic limestones of Vallecillo, Nuevo León, of seven of them, ranging in size from less than 700 mm to more than 3 m, including the holotype of *Vallecillosaurus donrobertoi*. Most specimens being under study, the number of taxa represented is unknown at present. Few more aquatic squamates are known from the promising Cenomanian-Turonian Muquiz (Coahuila) Lagerstätte.

Technical Session XV, Saturday 10:15

#### **DETERMINING ONTOGENETIC AND INDIVIDUAL VARIATION IN *COELOPHYSIS BAURI* (THEROPODA: COELOPHYSOIDEA) USING MULTIVARIATE ANALYSES AND IMPLICATIONS FOR IDENTIFYING ISOLATED THEROPOD TEETH**

BUCKLEY, Lisa, University of Alberta, Department of Biological Sciences, Edmonton, AB, Canada; BUCKLEY, Lisa, University of Alberta, Department of Biological Sciences, Edmonton, AB, Canada

Late Cretaceous microfossil localities often include isolated small theropod teeth whose morphologies are difficult or impossible to attribute to known theropod taxa. The relatively small sample sizes for many small theropods provide few opportunities to document the possible spectrum of tooth morphologies that result from individual and ontogenetic variation in one theropod taxon. Multivariate analyses on linear measurement data collected from 848 tooth positions in 23 skulls of *Coelophysis bauri* (Late Triassic: Carnian-Norian) were used to test whether ontogenetic and/or individual variation in tooth morphology would result in some *C. bauri* teeth being classified as a novel tooth taxon if they were recovered as shed elements. The results show that teeth from small (juvenile) and large (adult) specimens, and teeth from premaxillae, maxillae, and dentaries do not form discrete groups using principal components, discriminant, and canonical variate analyses, though Hotelling's pairwise comparisons reveal these *a priori* groupings are significantly different ( $p < 0.05$ ). Multivariate scatter plots reveal that all *C. bauri* teeth occupy a similar morphospace based on measurements alone. The presence of longitudinal enamel ridging on tooth crowns may be ontogenetically controlled as it is restricted to the most anterior tooth positions of juvenile skulls, while the presence of denticulate carinae on premaxillary teeth is variable in both juveniles and adults, though teeth possessing these superficially distinct traits do not form discrete groups in morphospace. Longitudinal ridging and premaxillary serrations may have limited diagnostic power for identifying isolated theropod teeth, while overall morphology in small theropod teeth is conserved during ontogeny.

Poster Session II, (Thursday)

#### **FOSSIL COLLAGEN; A MOLECULAR BARCODE FOR PALEONTOLOGISTS?**

BUCKLEY, Michael, University of York, York, United Kingdom; OSTROM, Peggy, Michigan State University, East Lansing, MI, USA; MANNING, Phillip, University of Manchester, Manchester, United Kingdom; THOMAS-OATES, Jane, University of York, York, United Kingdom; COLLINS, Matthew, University of York, York, United Kingdom

Molecular data can aid in both identification and analysis of evolutionary processes, as evidenced by the expansion of molecular phylogenies and molecular fingerprinting. However, in bone, DNA is thought to persist only for the equivalent of approximately 50 kya at a constant 10°C. We have therefore been exploring another molecule, the bone protein collagen, which appears to survive much longer periods of geological time. Analysis of collagen sequences suggests that the protein has the potential to be a useful phylogenetic tool across the vertebrate kingdom. Collagen peptides can be sequenced using soft-ionization mass spectrometry, an approach which has proved particularly suitable for the analysis of partially-degraded ancient proteins. We have explored the link between the survival of amino acids in bone and the extent of amino acid racemization. Collagen-like amino acid compositions, supported by mass spectrometric sequencing, are observed in British Early and Middle Pleistocene fossils that have low amino acid concentrations. Amino acid compositions which shift away from those typical of collagen also have higher levels of racemization. The results indicate the potential of amino acid analyses as a screening tool for extracting collagen peptides from precious fossil specimens. Perhaps the most remarkable finding is the presence of collagen in almost every Pleistocene fossil analyzed.

Technical Session VII, Thursday 3:15

#### **WHO CARES WHICH WAY IS UP? AN ORIENTATION AND LANDMARK-FREE QUANTIFICATION OF TOOTH SHAPE**

BUNN, Jonathan, Interdepartmental Doctoral Program in Anthropological Sciences, Stony Brook University, Stony Brook, NY, USA; BOYER, Doug, Department of Ecology & Evolution, Stony Brook University, Stony Brook, NY, USA; JERNVALL, Jukka, Institute of Biotechnology, University of Helsinki, Helsinki, Finland; LIPMAN, Yaron, Department of Mathematics and Program in Applied and Computational Mathematics, Princeton University, Princeton, NJ, USA; DAUBECHIES, Ingrid, Department of Mathematics and Program in Applied and Computational Mathematics, Princeton University, Princeton, NJ, USA

Selective pressures from nutritional requirements cause dietary adaptation to drive many evolutionary patterns and processes. Therefore reconstructing dietary preferences of extinct taxa continues to have a central role in paleontology. Because teeth are often the first organs to release food's nutritional content, and the most common elements of the fossil record, dental morphology has often been investigated to determine its relationship with dietary preference. Recent work quantifying tooth shape from 3-D digital models promises to facilitate access to the information locked in these complex surfaces. Metrics such as Orientation Patch Count (OPC) and Relief Index have demonstrated correlations between tooth morphology and dietary preference in a variety of taxonomic groups. While these and other digital methods have fewer assumptions and landmarks than traditional methods for quantifying tooth shape, like shearing quotients, they still rely on, and are sensitive to, a subjective determination of the occlusal plane of the tooth. Here, we present the results of a new metric capable of providing orientation-free quantification of tooth morphology by calculating the Willmore Energy of tooth crowns. Willmore Energy is a geometrical measure of the degree to which a surface deviates from (local) sphericity. Calculating the Energy of an occlusal surface yields a measure of the degree of curvature of the surface independent of any landmarks or orientation. We determined the Energy of high-resolution tooth crown models of a wide variety of primates and other taxa representing a range of dietary preferences. Results show Energy values to vary interspecifically and reflect differences in dietary preference. Finally, correlations between Energy and both OPC and Relief Index are present, as a further indication that its values are tied to diet. The Willmore Energy metric therefore has the potential to be a significant methodological advance in functional and comparative studies of dental morphology.

Technical Session VIII, Thursday 2:30

**THE UTILITY OF OSTEOLOGICAL CORRELATES OF MUSCLE ATTACHMENT IN THE RECONSTRUCTION OF LOCOMOTORY MODES OF EXTINCT BIRDS**  
BURCH, Sara, Stony Brook University, Stony Brook, NY, USA

The size of osteological correlates of muscle attachment (scars, crests, and tubercles) is often used qualitatively to infer the relative development or size of corresponding muscles and thence function and behavior in fossil vertebrates. However, the utility of these osteological correlates in muscular reconstruction and inferences of function is controversial. Whereas not every muscle leaves a scar, it has been suggested that differences in the relative size, strength, or function of a muscle may cause differences in the development of an osteological correlate. This relationship has been systematically studied thus far in extant vertebrates only in an intraspecific context. Birds possess a wide range of functional adaptations for locomotion in their hind limbs, ranging from cursoriality (Paleognathiformes) to diving (Gaviiformes) to predation (Falconiformes), but the musculature of avian hind limbs is relatively conserved across taxa. This makes birds an ideal group for studying functional correlates of muscle attachment site size. The two-dimensional areas of several muscle attachment sites representing functionally relevant muscles or groups of muscles were measured in avian taxa representing eight functional categories of locomotion. Individual regressions of the area of each muscle attachment site against maximum midshaft diameter of the corresponding bone were performed in order to identify taxa that exhibit higher or lower than average attachment site surfaces, indicating specialized functional adaptations that correlate to increased or decreased muscle use at that attachment site. A discriminant function analysis of the size-corrected area of the osteological correlate found significant differences ( $p < 0.05$ ) between the locomotor categories, with climbing, diving, and swimming groups being the most easily distinguished. This suggests that variation in osteological correlates is likely to have utility when reconstructing functional or behavioral categories from bones, including those of fossils. To explore this, extinct birds including *Ichthyornis*, *Hesperornis*, and *Baptornis* were analyzed in order to assess long-held assumptions about locomotor function.

Technical Session X, Friday 11:15

**MORPHOLOGY, HISTOLOGY, AND STRUCTURAL MECHANICS OF ANKYLOSAUR OSTEODERMS: IMPLICATIONS FOR FUNCTION AND SYSTEMATICS**

BURNS, Michael, University of Alberta, Edmonton, AB, Canada

The histology and morphology of osteoderms are valuable characters in amniote systematics. Osteoderms provide the most conspicuous synapomorphy of the Ankylosauria; however, the morphological variation between taxa has often been cited as an impairment to their systematic and paleobiological use. Also, their likely functions, except for those of the derived tail clubs of ankylosaurids, have not been tested. This analysis investigates ankylosaur osteoderms in terms of their internal and external features as well as their mechanical properties. The objective is to quantify variation from multiple sources and identify systematically useful characters. Osteoderms from all North American ankylosaurid taxa (using nodosaurs and Asian ankylosaurids as outgroups) are examined morphologically, histologically, and biomechanically via finite element analysis. Osteoderm shape and external surface texturing have systematic value. Those from the cervical and pectoral regions generally exhibit consistent shapes (dependent on position), and non-pathologic surface texture is taxon-specific. Osteoderm histology is taxonomically informative at least to the family level and possibly lower. Histology supports the traditional ankylosaurid/nodosaurid division within the Ankylosauria but does not imply a monophyletic Polacanthidae. Three-dimensional finite element analysis of common

osteoderm morphologies shows that they are strongest in a vertical direction. Apex/keel placement varies with body position to maximize dorsoventral strength. The type of bone (compact vs. cancellous) had little impact on force distribution in ankylosaur and nodosaur osteoderms. This suggests different histologies evolved to lighten the elements rather than to provide additional multi-directional strength. Finite element analysis also suggests a broad connective tissue insertion across the base of the osteoderms, despite the lack of Sharpey's fibres. A survey of osteoderms suggests that functionally-derived features are likely to be relatively constant across taxa and would not offer systematically valuable characters.

Late Triassic Terrestrial Biotas and the Rise of Dinosaurs, Thursday 11:45

**THE DIVERSITY AND PHYLOGENETIC POSITION OF HETERODONTOSAURIDAE: IMPLICATIONS FOR THE EARLY ORNITHISCHIAN DINOSAUR RADIATION**

BUTLER, Richard, Bayerische Staatssammlung für Paläontologie und Geologie, Munich, Germany; PORRO, Laura, University of Chicago, Chicago, IL, USA; GALTON, Peter, University of Bridgeport, Rio Vista, CA, USA; BARRETT, Paul, The Natural History Museum, London, United Kingdom; NORMAN, David, University of Cambridge Sedgwick Museum, Cambridge, United Kingdom

The Triassic and Jurassic evolutionary history of ornithischian dinosaurs remains poorly understood. Arguably the most important group of early ornithischians are the enigmatic heterodontosaurids, with a stratigraphic range potentially extending from the early Late Triassic to the late Early Cretaceous. We discuss the taxonomic diversity and phylogenetic position of the group, based upon important new material (from the Early Jurassic of southern Africa and the Late Jurassic of the western USA) and new global phylogenetic analyses of Ornithischia. Although heterodontosaurids are generally thought to have been scarce, more than 30 specimens (many undescribed) representing at least eight species are now known. The phylogenetic position of the clade is highly unstable, with some characters supporting a basal position within Ornithischia, while others suggest a link with Marginocephalia (Ceratopsia + Pachycephalosauria). This unstable phylogenetic position results from missing data, genuine character conflict, differences in character scoring between competing phylogenies, and problems with outgroup selection and scoring. The two main alternative phylogenetic positions for Heterodontosauridae have radically different implications for the timing and dynamics of the early ornithischian radiation; most notably, a close relationship with marginocephalians implies a major phylogenetic diversification of ornithischians during the Late Triassic for which there is currently little evidence in the fossil record. By contrast, a basal position for heterodontosaurids is consistent with substantially later first appearances for most major ornithischian clades. Regardless of these alternatives, ornithischian abundance and taxonomic diversity undoubtedly increased in Early Jurassic faunal assemblages compared to those of the Late Triassic; the recognition in the Early Jurassic upper Elliot Formation of at least three (and possibly four or more) heterodontosaurid species, differentiated primarily on the basis of dental characters, is suggestive of an adaptive radiation, with the group possibly occupying ecological space left vacant by the end Triassic extinction events.

Edwin H. and Margaret M. Colbert Poster Competition (Thursday)

**A GEOMETRIC MORPHOMETRIC APPROACH TO DIFFERENTIATING CLOSELY RELATED RODENT SPECIES AND IMPLICATIONS FOR CRYPTIC SPECIES IN THE FOSSIL RECORD**

BYKOWSKI, Richard, University of Iowa, Iowa City, IA, USA

Identifying interspecific variation in fossil species is limited by the amount of information preserved in the rock record. While we possess a greater understanding today of what is a species, the application of criteria defined by several species concepts remains an area of contention. Remains of the extant rodent genus *Peromyscus* are common among many archaeological sites and Native American village sites on the Northern Plains. *Peromyscus* is polytypic, having a cosmopolitan distribution across North America over a range of ecological habitats. This produces problems related to species identification when only skeletal elements are recovered. Species identification within *Peromyscus* is traditionally accomplished through a combination of phenotypic traits, molecular characters, and habitat occurrence, which cannot be easily inferred from the fossil record. Geometric morphometric analyses of both mandibles and lower first molars of *Peromyscus* are employed to test for differences between two of the most common species, *P. maniculatus* and *P. leucopus*. These two species share a recent divergence within the last 500,000 years and great difficulty is encountered attempting to differentiate between the two species in the absence of soft-tissue structures. The results indicate that (1) mandibular morphology plays a significant role in distinguishing between the two species and can be significantly impacted by environmental factors; (2) molar shape is conserved between the two species and is not a strong discriminator; (3) latitude is a proxy for molar size, which is likely controlled by other factors along a latitudinal gradient, and varies among populations; and (4) ecophenotypic effects may play a more significant role in the observed variation in *Peromyscus*.

**A CASE OF ANKYLOSIS IN CROCODYLIFORM VERTEBRAE FROM THE ENTRERRIANA FORMATION, OLIGOCENE OF ARGENTINA.**

CABRAL, Uíara, Museu Nacional/UFRJ, Rio de Janeiro, Brazil; KELLNER, Alexander, Museu Nacional/UFRJ, Rio de Janeiro, Brazil

Ankylosis is the name given to joint fixation and immobility as the result of an injury or disease. During a random examination for pathological features in the reptile collection of the Museo Argentino de Ciencias Naturales five vertebral sequences (MACN Pv 14225) showing morphological features indicative of ankylosis were recognized. The material comes from outcrops of the Entrerriana Formation (Oligocene) located in the city of Paraná, Province of Entre Ríos, Argentina. All belong to an unidentified crocodyliform and it is not clear if they represent the same individual. Despite being broken (possible during the collecting process), the overall preservation of the material is excellent, which can be confirmed by the unfused articulations with preserved cartilaginous intervertebral discs (e.g., annulus fibrosus and nucleus pulposus). Each sequence is composed of three or four elements, most lacking the zygapophyses and neural spines. The length range of the vertebral sequences varies between 80 to 100 mm. The vertebrae are fused by the centrum and where observable present the amphiplatyan condition. The limit between the fused vertebral surfaces is almost imperceptible, but in some there is a slight bone callus in the region where they merge. This may indicate that some of the lesions were in the process of being remodeled (with absorption of the bone callus) at time of the individual (or individuals) death. Based on the vertebral structure of MACN Pv 14225, the ankylosis was possibly caused by spondylitis ankylosing, which is an inflammatory joint disease that affects the spine, producing pain and stiffening as result of inflammation of the sacroiliac, intervertebral and costovertebral joints. To our knowledge this is the first case of pathology in fossil crocodyliforms recorded in Argentina.

**FEEDING HABITS OF A PROBOSCIDEAN COMMUNITY FROM THE MIOCENE OF GERMANY: EVIDENCE FROM DENTAL MICROWEAR ANALYSIS**

CALANDRA, Ivan, Biocentre Grindel and Zoological Museum, University of Hamburg, Hamburg, Germany; GÖHLICH, Ursula, Natural History Museum of Vienna, Vienna, Austria; KAISER, Thomas, Biocentre Grindel and Zoological Museum, University of Hamburg, Hamburg, Germany; SCHULZ, Ellen, Biocentre Grindel and Zoological Museum, University of Hamburg, Hamburg, Germany; MERCERON, Gildas, UMR CNRS 5125 PEPS - University Claude Bernard Lyon 1, Lyon, France

The comparison of European extant and Neogene ecosystems elucidates the fact that the diversity and geographic distribution of megaherbivores and especially proboscideans was much greater during the Neogene. Nonetheless, the dietary traits and the ecological adaptations of Neogene proboscideans are still widely unknown. Therefore, for the first time, feeding traits of three sympatric proboscideans (*Gomphotherium subtapiroideum*, *G. steinheimense*, and *Deinotherium giganteum*, from the Middle-Late Miocene (MN 8-9) of the Molasse Basin in Southern Germany), were evaluated using the dental microwear method. The shearing and grinding facets of the molars were analyzed in order to decipher inter-specific and intra-specific variation of the dietary signature. *D. giganteum* was browsing, while *G. subtapiroideum* and *G. steinheimense* were both mixed feeders. The latter was probably less involved in grazing than the former, a reconstruction also supported by dental morphologies. The data therefore suggest inter-specific food resources partitioning allowing avoidance of direct feeding competition. *G. subtapiroideum* was subsequently tested for intra-specific changes in dietary traits along a time series ranging from the Early-Middle to the Middle-Late Miocene (MN 5 to MN 8-9) where the species appears to maintain a constant but flexible dietary trait which was not influenced by the dramatic drying and opening of the environments during this particular time frame.

**A HISTOLOGICAL PERSPECTIVE ON THE REPLACEMENT, IMPLANTATION, AND ATTACHMENT OF TEETH IN ICHTHYOSAURS**

CALDWELL, Michael, University of Alberta, Edmonton, AB, Canada; MAXWELL, Erin, University of Alberta, Edmonton, AB, Canada; LAMOUREUX, Denis, University of Alberta, Edmonton, AB, Canada

The tradition has long held that most post-Triassic ichthyosaurs show an aulacodont form of tooth implantation; in other words the teeth sit loosely in a dental groove without hard tissue attachment to the pleurae of the tooth-bearing elements. Our examination of the gross morphology of ichthyosaur teeth, their attachment, implantation and replacement, indicates a great deal of variation not reported in the literature. In order to investigate ichthyosaur tooth attachment further, we undertook a histological study of the tooth-bearing elements of several post-Triassic ichthyosaurs (*Ichthyosaurus communis*, *Maiaspondylus lindoei*, *Platypterygius longmani*) and present here the results of our investigations. We recognize the presence of typical vertebrate dental attachment tissues including alveolar bone (adhering to the pleurae of the tooth-bearing element), osteocementum (forming the massive bony base around the root dentine), root osteodentine (forming a labyrinthine or plicidentinuous fabric within the osteocementum bundle), osteodentine in the crown, and infolded enamel (forming the crown). We have not been able to identify any Sharpey's Fiber scarring within

the osteocementum or alveolar bone and thus cannot conclude the presence of a calcified portion of the periodontal ligament. However, considering that both alveolar bone and osteocementum are present, and that there is a significant space between the two tissues as preserved, we suggest that the periodontal ligament was present as uncalcified collagen fibers. An important observation, suggesting unsuspected aspects of growth and replacement in the ichthyosaur dentition, concerns the deposition and growth osteocementum into the pulp cavity of the tooth crown; previous studies have discussed the "reduction" of the pulp cavity in ichthyosaurs – we suggest that this reduction is an artefact of hypertrophic growth of osteocementum and not a real reduction of the size of the pulp cavity by hypertrophic dentine growth as is observed in other vertebrates possessing plicidentine.

**INVESTIGATING THE PALEOECOLOGY OF THE TALPIDAE (MAMMALIA:EULIPOTYPHILA) IN THE MIOCENE OF THE NORTHERN GREAT BASIN: PATTERNS AND PROCESSES IN MOLE DECLINE**

CALEDE, Jonathan, University of Oregon, Eugene, OR, USA; DAVIS, Edward, University of Oregon, Eugene, OR, USA

The taxonomy and morphology of the Miocene moles of eastern Oregon are well understood, but their paleoecology has not yet been fully resolved. Hutchison observed that through the Miocene, Oregon talpids decreased in diversity (number of genera and minimum number of individuals) while shifting ecologically. He suggested a link between faunal and environmental changes, as habitats transitioned from moist woodlands to drier shrublands. We explored this hypothesis with new computational methods, using both published (MIOMAP) and museum data on talpid diversity for the northern Great Basin (parts of OR, NV, and ID), from the early Barstovian (~16 Ma) through the late late Hemphillian (~5 Ma). Faunal data, binned by subunits of NALMAs, were analyzed for changes in relative abundance, evenness, rarefied number of species, and variations in habitat use. Relative abundance of talpids decreases through time, from 73% of the small mammal assemblage in the early Barstovian to 7.5% at the end of the Hemphillian. Most of the change is concentrated in the Barstovian. There are no significant changes between any two consecutive time bins. We observed a significant increase in the evenness of moles between the early and late Barstovian (16-12.5 Ma), but evenness remained relatively stable for the rest of the Miocene. Paleoecological work by Shotwell suggests a relatively uniform sampling of habitat types through this interval, indicating that the observed trends are not simply an artifact of changing environmental sampling. We have investigated several potential biotic and abiotic drivers of these patterns. Analysis of the diversity patterns of potential predators (small carnivores) and competitors (fossorial rodents) indicates that biotic factors are unlikely drivers of talpid diversity. Climate change best explains our observed changes in talpid diversity, while a complex interaction of abiotic (precipitation) and biotic (competitive exclusion) parameters best explains variations in habitat use. Future paleontological fieldwork will be used to test these hypotheses in the Miocene deposits of the northern Great Basin.

**MORPHOLOGICAL VARIATION AND DISPARITY IN LYSTROSAURUS (THERAPSIDA:DICYNODONTIA)**

CAMP, Jessica, University of Iowa, Iowa City, IA, USA

The dicynodont genus *Lystrosaurus* is one of few terrestrial vertebrates known to survive the Permian-Triassic mass extinction. During the Early Triassic ecosystem recovery, the abundance of *Lystrosaurus* increased dramatically until it dominated the ecosystems it was present in. Its utility in studies of mass extinction and biotic recovery are hindered by poorly-resolved species taxonomy. Morphological variation within the genus has been split into as many as 38 species, but modern workers accept 4 species as valid in Gondwanan faunas (*L. murrayi*, *L. declivis*, *L. mccaigi*, and *L. curvatus*). A recent analysis used linear measurements of 112 *Lystrosaurus* skulls to decrease the accepted species from 6 to 4, a number that has been suspected for some time; however, traditional morphometrics are often sensitive to size, interdependence, and non-homology. Here, I quantify 64 skulls from South Africa, Antarctica, China and Russia using the methodology previously outlined as well as 2D and 3D landmark-based geometric morphometrics to test if the traditional approach has introduced biases and to determine if morphological variation among and within species is significant or associated with geologic age, or geography. I used both discrete landmarks and semi-landmarks in the geometric analyses. Preliminary PCA analyses of the 3D data supports that *L. murrayi*, *L. declivis*, and *L. mccaigi* are distinct; driven largely by differences in skull width and snout depth as well as by variable ornamentation. 2D analyses including holotypes of Chinese species show a large separation between *L. mccaigi* and all other species. Chinese specimens fall outside the range of Gondwanan species although the distinction is minimal. Ontogenetic variation has been a factor in the over splitting of *Lystrosaurus*. Analysis including a juvenile specimen distinguished its sutural patterns and overall skull shape, causing adults of different species to group together far from the juvenile in morphospace. This approach can be used to tell juveniles of larger species from older individuals of small species when data on the degree of ossification along sutures is not available.

Poster Session II, (Thursday)

**HOW USEFUL ARE OTOMYS (RODENTIA: OTOMYINAE) IN SOUTHERN AFRICAN PALEOENVIRONMENTAL RECONSTRUCTION OF HOMININ-BEARING LOCALITIES? RESULTS FROM A GEOGRAPHIC INFORMATION SYSTEMS (GIS) ANALYSIS OF THEIR PROXIMITY TO WATER**

CAMPBELL, Timothy, Sam Houston State University, Huntsville, TX, USA; LEWIS, Patrick, Sam Houston State University, Huntsville, TX, USA

Six extant species of *Otomys*, a rodent taxon widely distributed throughout southern Africa, are generally recognized. These modern species are routinely reported from Plio-Pleistocene paleontological and archaeological sites in the region. As some modern members of the genus are often associated with water, fossil otomyines are commonly viewed as indicative of wet conditions or permanent water sources. This analysis uses GIS methodology to assess the validity of *Otomys* as an indicator of water, and to refine reported modern environmental tolerances. Variability and overlap in dental characters make species level identification based on dentition difficult. As such, identifications at the genus level avoid misdiagnosis and distorted paleoenvironmental signatures. By allowing the analysis of spatial components, Geographic Information Systems (GIS) based analyses are currently emerging as a powerful tool in paleoenvironmental reconstruction. GIS models, for example, allow for the prediction of past environments by analyzing the tolerances of modern taxa that have persisted relatively unchanged throughout the Plio-Pleistocene. The tolerance ranges of modern taxa may be applied to fossil bearing localities where these taxa are known to have occurred in the past. Here modern distributions from 271 localities are georeferenced in order to assess their distances from major rivers, lakes and dams. Results from our analysis indicate that 93% fall within 10km of a water source, 72% fall with 5km, 47% fall with 2km and only 29% fall within 1km. Additionally, we examined published taxonomic lists for 14 fossil bearing localities containing either *Australopithecus*, *Paranthropus* or *Homo* and found the presence of *Otomys* reported in all. Preliminary results suggest caution must be exercised when *Otomys* is relied upon as the sole indicator of a nearby water source. Furthermore, due to the ubiquitous nature of this genus in fossil bearing localities containing hominin remains, their use in differentiating the paleoenvironment associated with these taxa is limited.

Poster Session III, (Friday)

**LIMB SCALING AND BODY-MASS OF THE ORNITHOPOD IGUANODON (ORNITHISCHIA: HADROSAURIFORMES)**

CAMPIONE, Nicolas, University of Toronto, Toronto, ON, Canada; EVANS, David, Royal Ontario Museum, Toronto, ON, Canada

Mass estimation in dinosaurs generally relies on scale model reconstructions or on relationships between limb measurements and body-mass in extant mammals. Different methods and models have produced body mass estimates that range from 3.2 to 5.4 tons for the Early Cretaceous ornithomimid *Iguanodon bernissartensis*. In terms of limb length ratios, it has been noted that the forelimb of *I. bernissartensis* is proportionately longer than in other ornithomimids, however a more complete understanding of limb scaling is needed to assess body size evolution in ornithomimids. Here we present the first comparative allometric analysis of limb proportions in *Iguanodon*. Measurements of length and minimum shaft perimeter were taken from the humerus and femur in *Iguanodon* (n=13), hadrosaurids (n=44), other ornithomimids (n=16), and sauropods (n=57). Hadrosaurids, *Camptosaurus*, and *Tenontosaurus* exhibit isometry in the length of the humerus relative to the femur. In contrast, *Iguanodon* has strong positive allometry of the humerus, indicative of the longer forelimb in *I. bernissartensis* than other similarly sized ornithomimids. High positive allometry of the forelimbs suggests a possible shift from facultative bipedalism at small size, to quadrupedality through ontogeny. Isolated humeri (1 m) and femora (1.3+ m) indicate that *Iguanodon* reached surprisingly large body size. The robustness of the humerus and femur is associated with positive allometry; the minimum shaft perimeter at a given length surpasses all the hadrosaurids in this sample and approaches the absolute size and proportions in the sauropod *Camarasaurus* at comparable size. Limb robustness in extant taxa is more strongly correlated with body-mass than other limb measures (e.g. femur length). The robustness of the humerus and femur in *Iguanodon* suggest that estimates of its body mass may be greatly underestimated. Allometric comparisons indicate that *Iguanodon* reached a larger body mass than all known North American hadrosaurids and shows that the evolution of giant body size in ornithomimids occurred early in the Cretaceous, potentially correlating with a decrease in large sauropod diversity in Laurasia during this time.

Poster Session IV, (Saturday)

**PHYLOGENY OF EXTANT RUMINANTS INDICATES THE INFLUENCE OF GLOBAL CLIMATIC CHANGES AND DIETARY ADAPTATIONS ON DIVERSIFICATION RATES**

CANTALAPIEDRA, Juan, Museo Nacional de Ciencias Naturales (CSIC), Madrid, Spain; MOOERS, Arne, Simon Fraser University, Burnaby, Canada; DEMIGUEL, Daniel, Universidad de Zaragoza, Zaragoza, Spain; AZANZA, Beatriz, Universidad de Zaragoza, Zaragoza, Spain; HERNÁNDEZ FERNÁNDEZ, Manuel, Universidad Complutense de Madrid, Madrid, Spain

Many authors have argued that Neogene global climate change triggered radiations within the Mammalia as well as affecting community assembly of continental faunas. One class of mechanism for such large-scale effects are shifts in feeding mode associated with new

habitats. Here, we use Likelihood Analysis of Speciation and Extinction Rates (LASER) and Binary-State Speciation and Extinction modeling (BiSSE) to assess the incidence and correlates of changes in diversification rates across a set of complete dated, bifurcating phylogenies of extant ruminants (Artiodactyla, Mammalia). The LASER analyses point to several periods of increased diversification, two during the relatively stable and warm period of the late Oligocene-early Miocene leading to the radiations of basal groups within Pecora (20-19 ma) and Bovidae (18-17 ma). Later increases in diversification rates appear to be related to increases in the global cooling trend during the Neogene, (15-14, 11-10 and 3-2 ma) and could be associated with periods of vicariance due to climatic forcing. BiSSE analyses suggest that *grazers* and *mixed feeders* diversify at significantly higher rates than lineages that exhibit the presumed ancestral *browsing* mode. Additionally, *mixed feeders* may have higher diversification rates than specialist (*grazer* or *browser*) feeders. Our results show that the Neogene diversification of ruminants can be correlated both with climatic events at the global scale and with different dietary strategies of the lineages. However, further work is required to test to what extent the two patterns are mechanistically related.

Poster Session II (Thursday)

**THE TECHNIQUE OF IMMERSION IN ACID AS APPLIED TO THE PREPARATION OF A PLACODERM FISH FROM THE LOWER GIVETIAN (DEVONIAN) OF LOSCOS (TERUEL, SPAIN)**

CARLS, Peter, University of Braunschweig, Braunschweig, Germany; MOROS, Alfredo, Paleoymás, Zaragoza, Spain; PERRUCA, Rosana, Paleoymás, Zaragoza, Spain; LORENTE, Javier, Paleoymás, Zaragoza, Spain; BARCO, José, Paleoymás, Zaragoza, Spain

What follows below is a description of the tasks involved in the paleontological preparation of the almost complete cranium of a placoderm fish from the Lower Devonian (Barreras Fm, Lower Givetian) of the eastern Iberian Range (Spain). The item in question is a cranium and thoracic plate, 1.35m long and 0.8m wide, belonging to a large-sized specimen. The fossil suffered little transport, so although the cranial plates have been slightly deformed by diagenesis, it is virtually complete. Following its extraction, during which it proved necessary to protect certain parts of the specimen from the sulphuric acid produced by the oxidation of pyrites, it was transferred to the laboratory, where mechanical preparation techniques were ruled out on account of the fragility of the fossil and estimates of the time they would have required. The clayey matrix with carbonated cement made it possible to use a technique that combined corrosion by dilute formic acid, the impregnation and protection of the fossil remains with cyanocrylate, and the mechanical removal of the clayey remnants. The removal of the matrix was carried out by immersing the pieces in dilute formic acid in large stainless-steel tubs. The great weight of the blocks, in conjunction with the fragility of the fossil remnant, made it necessary to install a system of cranes to hold it in place and ensure that it remained undamaged. It was also necessary to establish scrupulous safety measures for the preparators, since they were working with acids and heavy blocks. The steps followed in the preparation of the fossil remnant were the mechanical removal of the sterile remains; impregnation to strengthen bones and cracks; immersion in formic acid for between 1 and 3 days; rinsing to remove remains of acid; drying and repetition of the process. The advantages of this method reside mainly in the improved stability of the fossil remnant, as this is not subjected to vibrations; the improved finish of the pieces, making it possible to observe certain details more clearly; and the optimization of the effective work time of the preparator. Without any doubt, it is a safer, more efficient and more efficacious technique.

Technical Session VI, Thursday 2:15

**SEARCH FOR THE ANCESTRY OF TURTLES**

CARROLL, Robert, Redpath Museum, McGill University, Montreal, QB, Canada

The recent discovery of the earliest known turtle, *Odontochelys*, from the Late Triassic of China, raises new questions of their relationship with other major groups of amniotes. Both the lead article and the accompanying New & Views support a sister-group relationship with diapsids, despite the fact that neither *Odontochelys* nor any other turtles exhibit dorsal or lateral temporal openings, nor do any earlier diapsids share specifically chelonian characters. This is but one of a host of taxonomic affinities for turtles that have been proposed in recent years including pareiasaurs, procolophonids, placodonts and sauropterygians, based on the assumption that evolution proceeds in a parsimonious manner. In fact, early turtles can be recognized by a highly distinctive combination of characters that differentiate them from all other amniotes: a plastron, shortened trunk, elongation of neck and 8 conspicuously flattened trunk ribs. None of the groups recently suggested as putative sister-taxa of turtles have this combination of characters, or other obvious synapomorphies of early chelonians. Extensive research over the past 20 years has demonstrated the absolutely unique anatomical and molecular aspects of development of the carapace and plastron of turtles that must have evolved prior to the appearance of *Odontochelys*, but are not known in any other group of vertebrates. The only fossil from pre-Mesozoic deposits that in any way resembles a turtle is *Eumotosaurus*, from the Upper Permian of South Africa. It has neither a carapace or a plastron, but does have a small, anapsid skull, a long neck, short trunk and the same number of expanded ribs as observed in *Odontochelys*, which are key elements in the development of the carapace. On the other hand, the multiplicity of putative chelonian relationships that have been proposed on the basis of increasingly broad surveys of a vast number of traits and taxa in later clades demonstrates the difficulties of using such procedures for establishing the affinities of highly divergent clades.

**MATHEMATICAL MODELS OF CUSP PATTERNING IN THREE SPECIES OF RODENT**

CARTER, Katherine, New York University, New York, NY, USA

Teeth make up a large proportion of the existing fossil record and are thus frequently used disproportionately when reconstructing fossil phylogenies. It is known that dental traits are not wholly independent from one another, but this presents an impasse as it negates using multiple lines of dental evidence for analysis. To resolve this problem, it is necessary to explore the relative dependence of any one trait to another, so that it can be properly weighted *a priori*. Examining the covariance of hypothesized developmental units such as cusps using different models of dependence is a necessary step in being able to reconstruct trait independence in dental characters. These models can then be tested in other species to determine the effect of phylogeny and allometry. Photographs of the occlusal surface of 120 mandibular molars of each *Mus musculus*, *Mus muscoloides*, and *Maxomys hellwaldii* were taken, and the occlusal surface area, cusp areas, predicted cusp apices and actual cusp apices were measured for all cusps. These measurements were then analyzed using both geometric morphometric and multivariate regression techniques to see how each cusp covaried with one another, and which cusps drove the overall variation in the dentition. These results were then expanded to look at how the cusps of each molar covaried with the cusps of other molars to see if the morphology reflected how the teeth develop. Preliminary results suggest a threshold model as the driving force behind cusp patterning within a particular molar. Surprisingly, these results were consistent in each species sampled, suggesting that the model is conservative and not highly affected by body size or phylogeny.

Poster Session III, (Friday)

**DINOSAUR EGG SHELL AND EMBRYO LOCALITIES IN LOURINHA FORMATION, LATE JURASSIC, PORTUGAL**

CASTANHINHA, Rui, Museu da Lourinhã, Lourinhã, Portugal; ARAÚJO, Ricardo, Museu da Lourinhã, Lourinhã, Portugal; MATEUS, Octávio, Museu da Lourinhã & Universidade Nova Lisboa (CICEG/FCT), Lourinhã, Portugal

Four different localities from the Late Jurassic of Lourinhã formation with eggshells and embryos were studied: Paimogo (lower Amoreira-Porto Novo member), Peralta (Praia Azul member), Porto das barcas (Bombarral member) and Casal da Rôla (Amoreira-Porto Novo member). All but Casal da Rôla have embryonic material. Preliminary results show that eggshells from Paimogo correspond to obliquiprismatic morphotype (0.92mm thick), similar to those from Morrison Formation. Within Paimogo site a different type of eggshell was discovered, having a radial section of 153 µm with a mammillary layer measuring 65 µm. Porto das Barcas eggshells represent a discretispherulitic morphotype (1.23 mm thick). This locality presents a nest 60-cm diameter containing many eggshells but an indeterminate number of eggs. Some embryonic bones were discovered between the eggshells including teeth and skull bones showing that the eggs belong to a saurischian, tentatively a sauropod dinosaur. Peralta nest eggshells are preliminary ascribed to obliquiprismatic morphotype (column: 0.56mm and mammilla: 0.21mm) probably related to Paimogo's nest taxon (Lourinhanosaurus). Peralta site bears embryonic bones namely small theropod teeth associated with bone fragments, and unidentifiable dinosaur vertebra. Only eggshells have been collected at Casal da Rôla (ML1194). The eggshells (0.78mm thick) are prismatic morphotype and it was impossible to determine the pore system, the outer surface is smooth with no ornamentation.

Lourinhã formation has the oldest sauropod and theropod nest with embryos known so far.

Poster Session II, (Thursday)

**THE MESOZOIC AVIAN FOSSILS OF THE IBERIAN PENINSULA**

CHAMERO, Beatriz, Universidad Autonoma de Madrid, Cantoblanco, Madrid, Spain; MARUGÁN-LOBÓN, Jesús, Universidad Autonoma de Madrid, Cantoblanco, Madrid, Spain; BUŞCALIONI, Ángela, Universidad Autonoma de Madrid, Cantoblanco, Madrid, Spain; SANZ, José Luis, Universidad Autonoma de Madrid, Cantoblanco, Madrid, Spain

The Mesozoic fossil record of the Iberian Peninsula has provided significant insights about the early steps of avian evolution. Las Hoyas (upper Barremian, La Huerguina Formation, Serranía de Cuenca), and El Motsec (early Barremian, Tremp Formation, Lleida) are two exceptional deposits, known for yielding almost fully articulated specimens attributed to four species: *Iberomesornis romerali*, *Concornis lacustris*, *Eoalulavis hoyasi*, *Noguerornis gonzalezi*, and other undescribed material. All of these taxa are phylogenetically placed within the Enantiornithes, whereby *Iberomesornis* and *Noguerornis* are among the most basal members of the clade. The discovery of Iberian Enantiornithes gave important keys to understand the early diversification of these animals, and also about their novel aerodynamic achievements. The first evidence of an alular feather in *Eoalulavis* suggested that low-speed flights and manoeuvrability were likely achieved during the Early Cretaceous. On the other hand, morphometric analyses have been carried out in order to underscore insight about their growth patterns, and how could these relate with early avian evolution. Enantiornithes occupy a reduced area of morphospace of forelimb proportions compared to non-avian theropods and Neornithes. Since forelimb disparity in Neornithes is so extensive, accurate inferences about enantiornithine are difficult to reach. Furthermore, Enantiornithine juveniles apparently reach adult limb proportion quite early in ontogeny, a finding which encouraged

us to test growth regimes on paleohistological and bone surface textural ageing bases. Results revealed that the histodiversity of the studied specimen was larger than expected, and perhaps, that growth regimes were quite rapid at early stages, and in essence, that morphometric proxies need to be taken carefully when testing ageing and when inferring evolutionary processes from the fossil record related with ontogeny (e.g. heterochrony). Today, we pursue to understand the paleoecological role of enantiornithes in the Mesozoic.

Poster Session IV, (Saturday)

**A PARTIAL TETRAPOD LOWER JAW FROM "ROMER'S GAP"**

CHEN, Donglei, Uppsala University, Uppsala, Sweden; AHLBERG, Per, Uppsala University, Uppsala, Sweden

The first half of the Mississippian or Early Carboniferous (Tournaisian to mid-Viséan), an interval of about 20 million years, has become known as "Romer's Gap" because of its poor tetrapod record. Recent discoveries emphasize the differences between pre-"Gap" Devonian tetrapods, unambiguous stem-group members retaining numerous "fish" characters indicative of an at least partially aquatic lifestyle, and post-"Gap" Carboniferous tetrapods which are far more diverse and include fully terrestrial representatives of the main crown-group lineages. It seems that many crucial terrestrial features were acquired during "Romer's Gap", which probably also saw the cladogenetic events leading to the origin of the tetrapod crown group. Here we describe a partial right jaw ramus of a tetrapod from the Tournaisian of Scotland. The jaw displays a distinctive character combination, including a significant mesial lamina of the strongly sculptured angular, an open sulcus for the mandibular lateral line, a non-ossified narrow Meckelian exposure, a well-defined dorsal longitudinal denticle ridge on the prearticular, and a mesially open adductor fossa. These features support the establishment of a new genus and species of Carboniferous tetrapod. A phylogenetic analysis places this new taxon in a trichotomy with *Federpes* and *Occidens* in the upper part of the tetrapod stem group, above *Whatcheeria* and below *Greererpeton*. It represents a small but significant step in the closure of "Romer's Gap".

Technical Session XVII, Saturday 4:00

**THE EARLY CRETACEOUS SALAMANDER LIAOXITRITON ZHONGJIANI (AMPHIBIA: CAUDATA) AS A BASAL HYNOBIID BASED ON REDESCRIPTION OF NEW MATERIAL**

CHEN, Jian-Ye, Peking University, Beijing, China; GAO, Ke-Qin, Peking University, Beijing, China

Mesozoic strata in northern China have yielded abundant early salamander fossils, which provided significant insights into the origins, early radiation and biogeographical history of modern salamander clades. Among these fossil salamanders, *Liaoxitriton zhongjiani* is a problematic taxon that has not been thoroughly studied, resulting in its unclear anatomical details and unresolved phylogenetic position. New samples of *Liaoxitriton zhongjiani* collected from the type locality and horizon in Huludao area of Liaoning Province, China, provide the material for a redescription and taxonomic revision of this problematic taxon. Study of the new specimens clarified several previously misidentified features including prefrontal and lacrimal present and posterolateral border of the vomer concave for choana. New knowledge was also supplemented in the otic capsule, mandible, hyobranchial apparatus and limb bones. Phylogenetic analysis was performed based on a data set of 41 morphological characters and 13 taxa including 11 extant cryptobranchoid species and the fossil species *Liaoxitriton zhongjiani* and *Chunerpeton tianyiensis*. The stem-group salamander *Karaurus* was chosen as the outgroup. The branch-and-bound search resulted in three MPTs, in all of which modern hynobiids form a monophyletic group and *Liaoxitriton zhongjiani* stably forms the sister-group with modern hynobiids. The derived character states grouping all hynobiids together include the presence of radial loops in hyobranchium, subarcualis rectus I encasing both the first and second ceratobranchials, transverse vomerine tooth row, and concave posterolateral border of the vomer for choana. Thus *Liaoxitriton zhongjiani* represents the earliest hynobiid record to date, supporting an Early Cretaceous origin of modern hynobiids in northern China.

Poster Session III, (Friday)

**HOMOPLASY IN VERTEBRAL SERIAL IDENTITIES IN MESOZOIC MAMMALS AND EVOLUTIONARY DEVELOPMENT BY HOMEBOX GENES**

CHEN, Meng, University of Washington, Seattle, WA, USA; LUO, Zhe-Xi, Carnegie Museum of Natural History, Pittsburgh, PA, USA

Living mammals have a regional distinction of the cervical, thoracic, lumbar and sacral vertebrae. These regional identities are highly conserved in the majority of extant terrestrial marsupials and placentals, with a total of 19 or 20 thoraco-lumbar vertebrae and a distinctive thoraco-lumbar boundary. Recent fossil discoveries revealed that the thoraco-lumbar vertebral boundary is homoplastic in some Mesozoic mammal lineages. In the Cretaceous eutriconodonts, the thoraco-lumbar vertebrae range from 19 in *Jeholodens* in which the thoraco-lumbar boundary is distinctive, up to 23 in *Yanoconodon* and *Gobiconodontids* in which the thoraco-lumbar transition is gradational and lacks a clear boundary. Similar variation in the thoraco-lumbar boundary also occurs in *Zhangheotherium* and *Akidolestes* in the spalacotheroid clade, and in some Jurassic mammaliaforms. Recent genetic and embryonic studies have shown that shifting of the thoraco-lumbar and lumbar-sacral

boundaries is patterned by mutation in Homeobox genes (Hox 9, 10, 11) in the placental Mus. The patterning of vertebral identities by Hox genes in extant placentals can be extrapolated to account for homoplasies in vertebral identities in early mammal evolution, by the identical bony features in the well-preserved Mesozoic fossils and in embryos of knockout mice, such as mobile lumbar ribs, gradients in rib length and costal plates, and articulation of individual ribs in transition. These genetic, embryological and paleontological observations show the Hox-mediated morphogenesis is a major and recurring mechanism of vertebral evolution of early mammals. Homoplasies of serial vertebral identities in Mesozoic mammals suggest that the distinctive thoraco-lumbar boundary of extant therians is a special case of developmental constraint that happened to be conserved in marsupials and placentals, two surviving lineages of over 20 Mesozoic mammal groups, some showing a much wider evolutionary experimentation in vertebrae. Fossil record informs development that phenotypes of knockout Hox genes expressed ectopically in mutant mice actually existed in normal organisms of a greater morphological disparity in deep history.

Preparators' Session, Thursday 9:45

#### **PRODUCTION OF MULTI-PURPOSE MOLDS FOR VERSATILE, DETAILED REPLICATION OF LARGE-SCALE FOSSILS: THE *BASILOSAURUS ISIS* CASTING PROJECT AS AN EXEMPLAR**

CHERNEY, Michael, University of Michigan Exhibit Museum, Ann Arbor, MI, USA; SANDERS, William, University of Michigan Museum of Paleontology, Ann Arbor, MI, USA; GINGERICH, Philip, University of Michigan Museum of Paleontology, Ann Arbor, MI, USA; ZALMOUT, Iyad, University of Michigan Museum of Paleontology, Ann Arbor, MI, USA; ANTAR, Mohamed, Egyptian Environmental Affairs Agency, Wadi-Al-Hitan World Heritage Site, Fayum, Egypt

Reasons for molding and casting fossils include protection of originals from handling; archiving copies; dissemination of copies; educational exhibition; and generating research copies to facilitate return of fossils to their home institutions. The quality of the fossil material, and intended use of casts, place a range of constraints on the choice of techniques and media. We have undertaken a project to replicate an extraordinarily complete 65-foot-long skeleton of the late Eocene archaeocete whale *Basilosaurus isis*, from Egypt. Because the skeletal material is fragile and copies must be constructed for multiple purposes (display, archive, and research), within a limited budget, materials and methods selected and developed had to be capable of safely molding large, complex bones and producing diverse types of casts. Specimens were blocked in soft, oil-free clay and molded in polyurethane rubber, which is less expensive but stiffer than silicone rubbers, requiring more parts per element to protect the originals from breakage. Molds were made less expensively by laminating rubber on the fossils and supporting them with fiberglass-and-resin mothermolds. A new method of fitting the edge of the rubber under the rim of the mothermold was designed to keep the mold parts in place for casting. Flanges were added to the mothermolds to provide sites for bolting mold pieces together during casting, without drilling into the rubber. A new method of interlocking sprue plugs in molds was developed to accommodate production of casts for overhead mounting: while all casts have surface laminations of talced, pigmented polyester resin, and research copies are hollow and strengthened for handling by internal layers of fiberglass, mount casts are reduced in weight by filling them with urethane foam. The resulting casts are durable, lightweight (research casts weigh about 1/15th of the mass of the originals, and mount casts are half the weight of the research casts), detailed, and dimensionally accurate and stable. They can be painted by water- or oil-based media. Our replication strategy should be applicable to other large-scale casting projects.

Poster Session III, (Friday)

#### **NEW SPECIES OF *PALAEONICTIS* (MAMMALIA, CREODONTA) FROM THE PALEOCENE-EOCENE THERMAL MAXIMUM, SOUTHERN BIGHORN BASIN, WYOMING**

CHESTER, Stephen, Yale University, New Haven, CT, USA; SECORD, Ross, University of Nebraska, Lincoln, NE, USA; BLOCH, Jonathan, Florida Museum of Natural History, Gainesville, FL, USA

Oxyaenid creodonts are a family of extinct carnivorous mammals known from the Paleogene of North America, Europe, and Asia. The genus *Palaenictis*, which spans the late Paleocene to early Eocene of North America and the early Eocene of Europe, is distinctive in its lower premolar and molar morphology. Previously only a single M/2 trigonid of *Palaenictis* sp. was known from the Paleocene-Eocene Thermal Maximum (PETM) in the Clarks Fork Basin, Wyoming. We describe a new species of *Palaenictis* from the PETM in the Cabin Fork drainage, southeastern Bighorn Basin, based on associated right and left dentaries with P/2-M/2. Among North American taxa, the new species is substantially smaller (~50%) than the slightly older *P. peloria* from the latest Paleocene and somewhat smaller than *P. occidentalis* (~20%) from the early Eocene, making it similar in size to that of *P. gigantea* from the earliest Eocene of Europe and the previously described PETM M/2 fragment. The new species is similar to *P. occidentalis*, but differs from *P. gigantea* and *P. peloria* in having a more reduced M/2 relative to M/1, and having a smaller M/2 metaconid. On the other hand, like that of *P. gigantea* and *P. peloria*, the P/3 of the new species is larger relative to M/1 than that of *P. occidentalis*. We suggest that a form similar to the large-bodied late Paleocene *P. peloria* from North America gave rise to two smaller forms in the earliest Eocene of North America (the new species) and Europe (*P. gigantea*) at the beginning of the PETM. Dispersal of *Palaenictis* to Europe coincides with rapid global warming of 5-10°

C and related geographic range shifts in plants and animals during the PETM. It has been shown that several lineages of mammals decrease in body size, or are replaced by smaller, closely related species during the PETM, possibly in response to warming, drying, and/or higher CO<sub>2</sub> levels. As has been previously suggested for at least one other carnivorous mammal, *Palaenictis* also decreases in body size during the PETM. Other than body size, the new species is remarkably similar to later occurring *P. occidentalis* and may have given rise to that species following the PETM in North America.

Poster Session I, (Wednesday)

#### **DIVERSITY OF LOWER VERTEBRATES ACROSS THE EARLY EOCENE CLIMATIC OPTIMUM**

CHINNERY-ALLGEIER, Brenda, University of Texas, Austin, TX, USA; STUCKY, Richard, Denver Museum of Nature and Science, Denver, CO, USA

As part of a joint project to determine faunal composition, species diversity, and habitat change across the Early Eocene Climatic Optimum (EECO), lower vertebrates (including lizards, crocodiles, turtles, snakes, birds, and amphibians) have been collected and identified in sites spanning the Wind River Formation and compared with lower vertebrates from sites in the Bridger Formation. Preliminary results include several interesting patterns of change among lower vertebrates across this time period. Overall diversity of lower vertebrates seems to increase throughout the early part of the Wind River Formation but then decrease towards the end, as diversity is lowest at the sites of "Gardnerbuttean" age even though more specimens have been collected from these sites than from any others. This trend is distinct in lizards, crocodiles, lizards, snakes, and birds, and is less distinct among fish and amphibians. Diversity then increases in all groups during the early Bridger Formation, with some (lizards, turtles, birds, and amphibians) doubling in number of species. A decline in lower vertebrate diversity across the EECO is interesting, as this appears to be a trend opposite to that seen in mammals, and may indicate that lower vertebrates are affected negatively by climatic warming during this time period. Although a range of sizes of various lower vertebrates are found in all sites, one general trend found in this study is a decrease in overall specimen size from the Wind River Formation to the Bridger Formation. However, preservation of large specimens is better at the Wind River sites, and preservation of small specimens is far superior at the Bridger Basin sites, which may be indicative of a preservational bias that will need to be examined.

The Evolution of Birds in the Mesozoic: a Symposium in Honor of Cyril A. Walker, Thursday 9:00

#### **THE BONE MICROSTRUCTURE OF MESOZOIC BIRDS**

CHINSAMY-TURAN, Anusuya, University of Cape Town, Cape Town, South Africa

Despite millions of years of burial and fossilization, the microstructure of fossilized bones of Mesozoic birds is generally well preserved. The nature, organization and texture of the microscopic structure of fossil bone permits deductions regarding various aspects of the biology of the extinct bird, including the qualitative rate at which the bone was deposited, whether the bone was deposited at a sustained or interrupted rate, and adaptations for particular lifestyles. Several Mesozoic bird taxa have been previously studied histologically. These studies together with comparative histological studies of neornithine (extant) birds and nonavian dinosaurs have led to significant insight into the evolution of avian growth and developmental patterns. The bone microstructure of Mesozoic birds considered within a phylogenetic context reveals distinct trends in the histology, and growth patterns of the ornithine and nonornithine birds. All nonornithine taxa have a distinct interrupted pattern of bone deposition, which suggests periodic spurts of growth, while the ornithine birds show an uninterrupted, sustained rate of bone formation. Both the histological data and morphological studies of well represented nonornithine Mesozoic birds suggest that they grew at slower rates than modern birds, while the faster uninterrupted growth rates observed in the more derived ornithine birds may be linked to the loss of developmental plasticity. Ontogenetic trends in bone microstructure are also evident in these analyses, and provide further information about the growth patterns of these taxa. Here a review of previous work will be presented, as well as new preliminary data on collaborative histological research of three Cretaceous bird taxa (*Nanantius valifanovi*, *Gurilynia nessovi*, and an unidentified taxon) from the Nemegt Formation of the Gobi Desert, and *Gansus yumenensis* from the Early Cretaceous, Xiagou Formation of Gansu Province in NW China.

Poster Session IV, (Saturday)

#### **A NEW BASAL ALVAREZSAUR FROM THE SHISHUGOU FORMATION**

CHOINIERE, Jonah, The George Washington University, Washington, DC, USA; CLARK, James, The George Washington University, Washington, DC, USA; XU, Xing, Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China; HAN, Fenglu, Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China

The Alvarezsauridae are a Cretaceous clade of theropod dinosaurs with highly modified forelimbs. The phylogenetic position of the Alvarezsauridae has been uncertain, with initial systematic research positing them as basal avialians, other analyses finding a sister-group relationship between Ornithomimosauria and Alvarezsauridae, and some recent analyses placing the family at the base of Maniraptora. The latter phylogenetic hypothesis implies that a ghost lineage of over 60 million years exists between the Alvarezsauridae and the

oldest-known maniraptorans (Scansoriopterygidae). We report here on a complete specimen of a new basal alvarezsaur from the Shishugou Formation in Xinjiang, China. Extensive radiometric dating of Shishugou volcanic tuffs constrains the age of the specimen to between 158.7 +/- 0.3 mya and 161.2 +/- 0.2 mya, approximately at the beginning of the Late Jurassic. This new taxon extends the stratigraphic range of the Alvarezsauridae by 60 million years, provides new information about alvarezsaur morphological evolution, confirms a basal position for the Alvarezsauridae within the Maniraptora rather than within Avialae or sister to Ornithomimosauria, and indicates that the earliest members of the family were not Gondwanan, as previous studies have suggested.

Edwin H. and Margaret M. Colbert Poster Competition (Thursday)

#### **INTERRELATIONSHIPS OF POLYDOLOPIDAE (MAMMALIA, MARSUPIALIA) FROM SOUTH AMERICA AND ANTARCTICA**

CHORNOGUBSKY, Laura, Museo Argentino De Ciencias Naturales "Bernardino Rivadavia", Buenos Aires, Argentina

Polydolopinae (Family Polydolopidae Ameghino) is a group of marsupials restricted to the Paleogene of Patagonia in Argentina and Chile, and the Antarctic Peninsula. In order to resolve the interrelationships of polydolopine taxa two unweighted (equally-weighted) parsimony analyses based on dental characters were carried out; one including all widely recognized species and a second one including only species represented by both upper and lower dentitions. In both analyses the following species were used as outgroups: *Microbiotherium tehuelchum*, *Prepidolops didelphoides*, *Epidolops ameghinoi*, and *Roberthoffstetteria nationalgeographica*. The expanded analysis included: *Polydolops thomasi*, *P. winecage*, *P. clavulus*, *P. rothi*, *P. serra*, *P. unicus*, *P. mayoi*, *P. abanicoi*, *P. mckennai*, *P. sp. nov. 1*, *P. sp. nov. 2*, *P. sp. nov. 3*, *Pseudolops princeps*, *Amphidolops serrula*, *Amphidolops sp. nov. 1*, *Amphidolops sp. nov. 2*, *Antarctodolops daillyi*, *Antarctodolops mesetaense*, *Eudolops tetragonus*, *E. caroliameghinoi*, *E. hernandezii*, Gen. et sp. nov. 1, and Gen. et sp. nov. 2. *Polydolops winecage*, *P. clavulus*, *P. mayoi*, *P. abanicoi*, *P. mckennai*, *P. sp. nov. 1*, *P. sp. nov. 2*, *P. sp. nov. 3*, *Pseudolops princeps*, *Eudolops tetragonus*, and *E. hernandezii* were excluded in the reduced analysis. Both analyses argue in favor of the exclusion of Epidolopinae from Polydolopidae. The extended analysis results in a polytomy that contains two clades of polydolopines, one consisting of *Amphidolops* species + [*P. serra*, *P. rothi*, and *P. unicus*] and another one consisting of *Antarctodolops* species. The reduced analysis shows a sister-group relationship between *Antarctodolops* and a clade formed by *Amphidolops* and the group [*P. serra*, *P. rothi* and *P. unicus*]. The present analyses, which constitute the first cladistic attempt to clarify the relationships of polydolopine taxa, do not support the monophyly of *Polydolops* as currently understood, whereas, conversely, suggest that *Antarctodolops* and *Amphidolops* are natural groups.

Technical Session XVIII, Saturday 3:30

#### **POSTURE AND MOBILITY OF THE NECK AND VARIATION IN FEEDING STRATEGY AMONG SAUROPOD DINOSAURS**

CHRISTIAN, Andreas, Universität Flensburg, Flensburg, Germany; DZEMSKI, Gordon, Universität Flensburg, Flensburg, Germany; MÖLLER, Jan, Universität Flensburg, Flensburg, Germany

The habitual neck posture of several sauropods, especially *Brachiosaurus brancai*, *Euhelopus zdanskyi*, and *Diplodocus carnegii* is reconstructed by a comparison of stress values in the intervertebral cartilage along the vertebral column of the neck. For each specimen the mean stress in the intervertebral cartilage along the neck is calculated for different hypothetical neck postures. Postures with high variation in stress along the neck are rejected. This method has been shown to yield reasonable results for large recent vertebrates with long necks, giraffes (*Giraffa camelopardalis*) and camels (*Camelus sp.*). In order to reconstruct sauropod neck movements, lever arms of muscles, tendons, and ligaments and the articulation of adjacent neck vertebrae are analyzed. For comparison, neck anatomy and neck movements are studied in long-necked vertebrates like giraffes, camels and ostriches. For some extinct and extant species, neck mobility is reconstructed with the help of virtual 3D-models of neck vertebrae. For sauropods of different sizes the energetic costs of neck movements are estimated and compared with the energy expenditures of locomotion and the basal metabolism. The results indicate considerable variation in neck posture and feeding strategy among sauropods. Some sauropods, like *Brachiosaurus* and *Euhelopus*, used the neck in a similar way as giraffes do, whereas the feeding strategy of *Diplodocus* was more like that in camels or ostriches. In a single sauropod the neck posture may have varied highly during different activities like standing at rest, locomotion, or feeding. The energy cost of vertical movements increases steeply with body size. For very large sauropods feeding with extensive vertical movements of the neck or of the whole body was efficient only if the sources of food were spaced widely apart.

Poster Session III, (Friday)

#### **STEGOSAUR INTEGUMENT FOSSILS FROM THE LATE JURASSIC MORRISON FORMATION: THE FIRST DIRECT EVIDENCE FOR A KERATIN COVERING ON THE DORSAL PLATES**

CHRISTIANSEN, Nicolai, Museu da Lourinhã, Lourinhã, Portugal; TSCHOPP, Emanuel, Sauriermuseum Aathal, Zurich, Switzerland; PABST, Ben, Sauriermuseum Frick, Frick, Switzerland

Over the past 15 years, several well preserved stegosaur specimens including skulls have been collected by the Sauriermuseum Aathal (Switzerland) on the famous Howe Ranch in Wyoming. One of these specimens (SMA 0018), identified as a *Hesperosaurus*, is exceptional in preserving integument impressions *in situ* over a wide area on the anterior right side of the ribcage.

Skin impressions are preserved as patches on a 1x1.2 meter block, containing part of the right side dorsal ribs. The impressions are found in close proximity to the ribs and there are no signs indicating that the skin had moved significantly from its life position before fossilization. The skin impressions exhibit a regular "honeycomb structure", with uniformly small scales (4-5 mm across), on the ventral part of the ribcage. On the dorsal part of the ribcage, the pattern becomes less structured and larger scales (roughly 10 times larger) are present amongst the smaller ones.

A dislocated dorsal plate was found on top of the skin impressions, and an impression of the integument that covered it in life has been preserved. The largest preserved area is approximately 10x15 cm and contains no signs of scales or other skin structures. Instead, it is a flat area with low longitudinal ridges running parallel to each other: all of which is indicative of a keratin sheath. This is the first direct evidence for a keratin sheath covering the dorsal plates of stegosaurs, rather than a skin covering.

This has consequences for the long lasting debate concerning the function of stegosaur plates, as a keratin sheath would make the heat transfer between blood and air less efficient, and thereby reduce the effectiveness of a thermoregulatory function.

Technical Session XIX, Saturday 2:00

#### **NEW INSIGHTS ON GIANT DEER (MEGALOCEROS GIGANTEUS) PALEOBIOLOGY INFERRED FROM STABLE ISOTOPE AND CEMENTUM ANALYSIS**

CHRITZ, Kendra, University of Portland, Portland, OR, USA; DYKE, Gareth, University College Dublin, Dublin, Ireland; ZAZZO, Antoine, Muséum national d'Histoire naturelle, Paris, France; LISTER, Adrian, Natural History Museum, London, United Kingdom; MONAGHAN, Nigel, National Museum of Ireland - Natural History, Dublin, Ireland

The extinct giant deer, *Megaloceros giganteus* (popularly referred to as the Irish elk) was among the largest and most famous of the cervids. Although *Megaloceros* remains have been uncovered across Europe and western Asia, the highest concentrations come from Irish bogs and caves. Over the centuries, *Megaloceros* has enjoyed a great deal of scientific attention; however, little paleobiological study beyond morphometric or distributional work has been done. We report the first stable isotope analysis of Irish *Megaloceros* tooth enamel, which we combine with dental cementum accretion analysis in order to document age, diet, birth and death seasonality for the first time.  $\delta^{13}C$  and  $\delta^{18}O$  measured in the enamel of the second and third molars from seven individual giant deer indicate a mixed diet of water-stressed C3 grass, forb and browse and a season of birth occurring in spring/early summer. Cementum data indicate an age range of 6.5 to 14 years and that they possessed mature antlers by autumn, similar to extant cervids. In addition, we have assembled the first georeferenced Irish distribution map of *Megaloceros* skulls from the National Museum of Ireland Natural History Division, creating opportunities for future quantitative distributional studies. This new quantitative paleobiological data, which has been absent from many previous studies, may aid future research in understanding *Megaloceros*'s sudden extirpation from western Europe during the End Pleistocene, roughly 12,500 calendar years BP.

Technical Session XIX, Saturday 3:30

#### **CETACEAN BULLAE AS BIOGENIC ARCHIVES FOR STABLE ISOTOPE ANALYSIS AND DIETARY INFORMATION**

CHURCHILL, Morgan, University of Wyoming, Laramie, WY, USA; CLEMENTZ, Mark, University of Wyoming, Laramie, WY, USA

Stable isotope analysis (SIA) of tooth enamel bioapatite has provided important insights into the ecology and evolution of early whales because its dense crystalline structure and reduced organic content makes it less prone to diagenesis than bone or dentine. However, SIA of tooth enamel in later diverging whales is difficult; marine mammals show reduction or loss of tooth enamel over time, and later diverging baleen whales lack teeth entirely. To overcome this limitation, new skeletal materials suitable for SIA need to be identified. One likely candidate is pachyostotic bone such as cetacean bullae. The greater density of the bullae may improve their ability to retain original isotopic signatures. To assess the use of cetacean bullae for stable isotope studies, total organic carbon content (TOC), total inorganic carbon content (TIC), and  $\delta^{18}O$  and  $\delta^{13}C$  values of tooth enamel, bone, and bullae were determined for 15 pilot whales (*Globicephalus macrorhynchus*) from one mass stranding and 1 gray whale (*Eschrichtius robustus*). TOC of Bullae ranged from (5-8%) content which

fell between that of teeth (1%) and bone (12-18%). Carbon isotope values for bullae and bone were similar, but enamel values were 1‰ lower, which may reflect differences in the timing formation of these materials. Enamel in odontocetes forms before birth and records only a small sample of the mother's diet whereas bone is remodeled throughout the lifetime of the individual. Any seasonal variation in the isotopic signature of the diet could therefore lead to differences between enamel and bone δ13C values. Teeth and bullae δ18O values were similar, but bone values were 1‰ lower. Higher bone TOC can lead to secondary formation of carbonate during organic oxidation by chemical preparation for SIA, which, if not completely removed may alter measured isotopic values. This preliminary work suggests that the lower TOC of bullae may make them useful archives for SIA. Future work will expand the recent dataset, as well as examine Pliocene/Miocene whale faunas to determine the extent of diagenetic alteration within fossil bullae.

Technical Session XVII, Saturday 3:00

#### **A PROBABLE MICROSUR FROM THE EARLY CARBONIFEROUS OF EAST KIRKTON, SCOTLAND, SHOWING SOFT-TISSUE EVIDENCE**

CLACK, Jennifer, University Museum of Zoology, Cambridge, Cambridge, United Kingdom

A single specimen of a very small (snout-vent length < 50 mm) tetrapod represents the remains of a probable microsauro from the Viséan. Its most distinctive feature is the tail. Its holospondylous vertebrae have short neural arches, with the most anterior three caudal vertebrae having curved postsacral ribs, followed by four bearing long spatulate haemal arches. Dorsally and ventrally the tail bears a deep fin supported by thinly ossified haemal arches revealed by ultraviolet photography, with skin impressions preserved as black sediment. This type of preservation may be unique at the East Kirkton locality. The skin of the ventral fin shows fine striations and regular folding. Striations are also preserved on the dorsal part of the fin. Large, oval scales each with a thickened anterior edge, appear to cover the whole body: they are very finely striated in a radiating pattern. There is a well preserved relatively large pes with five stout digits and a short, broad, ossified tarsus, though individual bones cannot be identified. The short pre-sacral column has room for 22 – 25 holospondylous vertebrae. Ribs are slender and curved. No pectoral limbs or girdles are preserved, though a pelvic girdle has been identified. The skull is very poorly preserved precluding interpretation and description, however two rows of marginal teeth are preserved in occlusion. The margin of a large orbit and the undulating lower posterior margin of the skull can be made out. Judging by its heavily ossified pes, the specimen was not a juvenile, but the deep tail suggests a swimmer. Thus, the following taxa can be ruled out on vertebral construction or proportions: temnospondyls, anthracosaurs, colosteids, aistopods, adelogyrinids, lysorophids, nectrideans, *Casineria*, *Westlothiana* and amniotes. Among microsaurs, a finned tail is present in *Microbrachis*, and a short vertebral column and large feet in *Hyloplezion*, though the internal phylogenetic relationships of 'microsaurs' remain controversial. Identity as a microsauro would make it both the earliest known species and the only one from the United Kingdom.

Technical Session II, Wednesday 10:30

#### **A 3-DIMENSIONALLY PRESERVED FOSSIL GUITARFISH FROM THE TURONIAN OF MOROCCO**

CLAESON, Kerin, The University of Texas at Austin, Austin, TX, USA; UNDERWOOD, Charlie, Birkbeck College, London, United Kingdom; WARD, David, Crofton Court, Orpington Kent, United Kingdom

A new fossil rhinobatoid from the Middle Turonian of the Goulmima region, SE Morocco exhibits exceptional 3D preservation within a carbonate concretion. The fossil is from a concretion level in a marl unit within an otherwise shallow water to peritidal carbonate succession. Fossils like these are seldom encountered, because traditionally the flat bodied animals are preserved in lithographic beds, or more commonly, are only represented by disassociated dentition. The fossil rhinobatoid is represented by a relatively complete axial skeleton partially exposed in ventral view. Compared to other extinct and extant guitarfishes and skates, it possesses a short rostral cartilage and small precerebral fontanelle, the nasal capsule is large and anteriorly directed, and the mandibular arch cartilages are slender and laterally elongate. Teeth are homodont, with a 'rhinobatoid' morphology, possessing a large central uvula but no lateral uvulae. There are no cusps on the teeth, but a weak occlusal crest is present. The synarcual is over 60mm long with many fused vertebrae contributing to it. Between the pectoral and pelvic regions, individual vertebrae are flanked by tessellated cartilage. The more distal vertebrae are a typical spool shape with clover-shaped calcified intermedia cross-section. The pectoral girdle is composed of a gracile fused coracoid bar and a shallow and rectangular scapulocoracoid. The suprascapular region is obscured. A robust propterygium is preserved proximally with few thick proximal radials in articulation. The meso- and metapterygia are difficult to discern in the fossil. The pelvic girdle is primarily missing, but a gracile puboischiatic bar is present with a long and slender left ischial process preserved. Denticles are mostly oval and stud-like, with rare streamlined denticles and larger dermal thorns. Based on these combined morphological characteristics, the fossil specimen is distinguishable from the Lower Cretaceous (Albian) genus †*Iansan* and the Upper Cretaceous (Campanian/Maastrichtian) genus †*Tethybatis*, though it is more like †*Tethybatis* and is probably a member of the Platyrhinidae.

Poster Session II, (Thursday)

#### **AVES 3D: A NEW ONLINE RESOURCE FOR THE SKELETAL ANATOMY OF EXTANT AND EXTINCT BIRDS**

CLAESSENS, Leon, College of the Holy Cross, Worcester, MA, USA; EDWARDS, Scott, Harvard University, Cambridge, MA, USA; DRAKE, Abby, College of the Holy Cross, Worcester, MA, USA; ECKARDT, Mark, College of the Holy Cross, Worcester, MA, USA; KRZYZAK, Michael, College of the Holy Cross, Worcester, MA, USA

Here we report the launch of a new National Science Foundation funded online resource for the skeletal anatomy of extant and extinct birds, [www.Aves3D.org](http://www.Aves3D.org), which offers three-dimensional models of a wide selection of avian skeletal elements. Digital three-dimensional surface models are produced through non-contact laser surface scanning of skeletal material from, amongst others, the Harvard Museum of Comparative Zoology and the Yale Peabody Museum of Natural History. Database growth is fueled by undergraduate student research projects, in collaboration with affiliated and external post-graduate students and researchers, on a variety of ecomorphological, functional, and phylogenetic studies. The online database also serves as a digital archive for the collections of contributing museums and allows for rapid global dissemination of 3D data on common as well as rare and potentially fragile specimens. Data is produced in a format ready for a wide range of computational analyses, including finite element analysis and 3D morphometrics, as well as 3D animation. The size of the database is currently limited, and opportunities exist for initiating new (student-based) projects that will contribute to database growth.

Technical Session XII, Friday 2:45

#### **SHARTEGOSUCHID CROCODYLIFORMS FROM THE LATE JURASSIC OF ASIA AND NORTH AMERICA**

CLARK, James, George Washington University, Washington, DC, USA; XU, Xing, Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China

Shartegosuchid crocodyliforms are small taxa previously known mainly from the Late Jurassic Ulan Malgait Formation of Shar Teeg, western Mongolia. New shartegosuchid remains from the Late Jurassic part of the Shishugou Formation, NW China, prompted a re-examination of the Shar Teeg holotype material of four taxa – *Shartegosuchus asperopalatum*, *Nominosuchus matutinus*, *N. arcanus*, and *Adzhosuchus fuscus*. Both *N. arcanus* and *A. fuscus* are subjective junior synonyms of *S. asperopalatum*. Abundant remains of *Nominosuchus matutinus* occur in the upper part of the Shishugou Formation at Wucaiwan, Xinjiang, which has been radiometrically dated at 158.7 ± 0.3 mya and 161.2 ± 0.2 mya. At three localities multiple associated skeletons were preserved in a small area, the best preserved of these comprising at least 16 skeletons collected in two large blocks. The holotype material of this species at Shar Teeg comprised five specimens in a small area, and together these occurrences suggest that this species was gregarious. A new shartegosuchid is present in the Late Jurassic Morrison Formation at Fruita, Colorado, extending the geographic range of this family to North America. Phylogenetic analysis of shartegosuchids using the revised data set of Pol and Gasparini strongly places the Fruita form with *Shartegosuchus*, based upon a sculpted secondary palate and reduction or loss of the antorbital fenestra. However, the monophyly of *Nominosuchus* and this clade is weaker due to conflicting evidence for a *Nominosuchus-Shantungosuchus-Sichuanosuchus-Zosuchus* clade. Because of this conflicting evidence support for the position of shartegosuchids is weak, but Protosuchia is not monophyletic and *Hsisosuchus* is closer to Mesoeucrocodylia than are shartegosuchids. The occurrence of *N. matutinus* in both the Ulan Malgait Formation and the upper part of the Shishugou Formation suggests a similar age, and therefore a slightly older age for the Ulan Malgait Formation than previous estimates. The occurrence of this family in North America in the Late Jurassic is inferred to be dispersal from Asia, conflicting with the isolation of Asia hypothesized at this time.

The Evolution of Birds in the Mesozoic: a Symposium in Honor of Cyril A. Walker, Thursday 8:00

#### **THE MESOZOIC RECORD OF ORNITHURINE BIRDS AND THE ORIGIN OF AVES**

CLARKE, Julia, The University of Texas, Austin, TX, USA

Ornithurine fossils placed through phylogenetic analyses as part of crown clade Aves are being sought at an unprecedented rate as internal calibration points for molecular divergence dating approaches. These fossils are further cited to support or refute macroevolutionary hypotheses based on resultant divergence dates, on cladogram topology and fossil ages, or on biogeographical distributions. Currently debated hypotheses relate the diversification of Aves to the break up of Gondwana, to the Cretaceous/Tertiary mass extinction and to Paleogene climatic events. Other hypothesized diversification patterns include ecological and morphological constraints on ornithurines prior to an early Paleogene radiation of major crown lineages and subsequent successive waves of diversification and replacement. The fossil record of ornithurine taxa, in particular from the Cretaceous, is essential to approaching these questions. Mesozoic ornithurine taxa are also critical to understanding the evolution of avian flight as well as the emergence of avian life history characteristics. Here, recent advances in our understanding of Mesozoic Ornithurae are reviewed, and a new synthesis of relevant Cretaceous fossil data informing the age of the base of crown Aves is presented.

Poster Session III, (Friday)

**EPIPARIETAL HOMOLOGY WITHIN CENTROSAURINAE (ORNITHISCHIA, CERATOPSIDAE) : A RE-EVALUATION BASED ON NEWLY DISCOVERED BASAL TAXA**

CLAYTON, Katherine, University of Utah, Salt Lake City, UT, USA; LOEWEN, Mark, University of Utah, Salt Lake City, UT, USA; SAMPSON, Scott, University of Utah, Salt Lake City, UT, USA; FARKE, Andrew, Raymond Alf Museum of Paleontology, Claremont, CA, USA; IRMIS, Randall, University of Utah, Salt Lake City, UT, USA

Ceratopsid dinosaurs are characterized by elongate frills, formed by paired parietals and squamosals, ornamented with epiossifications (epiparietals and episquamosals) of hooks, spikes, horns, and other processes. Epiparietal ossifications represent arguably the most diagnostic elements of the skull within the ceratopsid clade Centrosaurinae. Previous authors proposed an epiparietal classification based largely on *Centrosaurus*, with processes numbered sequentially from the midline, and the position of the medialmost elongate spike (p3) in *Styracosaurus* homologized across Centrosaurinae. This homology interpretation (p1-p8) has been translated to more basal members (e.g., *Albertaceratops*, p3-p7, and a new Wahweap Formation centrosaurine, p3-p9) as well as to more derived centrosaurines (e.g., *Pachyrhinosaurus* and *Achelousaurus*, p2-p8). Reexamination of *Avaceratops*, *Albertaceratops*, and two new basal taxa from the Campanian Wahweap and Kaiparowits formations of southern Utah necessitates reassessment of the homology of epiparietals within Centrosaurinae. We here interpret the basal centrosaurine condition (represented by *Avaceratops* and a new Kaiparowits centrosaurine) as p0-p7, with p0 as a midline epiparietal and p1-p7 numbered sequentially along the external margin of the parietal. *Albertaceratops* and the new Wahweap centrosaurine are characterized by p1-p6 and p1-p7, respectively. *Centrosaurus* and *Styracosaurus* exhibit epiparietals along the edge of the frill numbered p1-p7 along with an additional neomorphic process or ossification on the dorsal surface of the parietal. Following this scheme, *Pachyrhinosaurus* and *Achelousaurus* possess epiparietals p1-p7, possibly having secondarily lost the dorsal parietal process. The interpretation of the dorsal parietal process in *Centrosaurus* and *Styracosaurus* as a neomorph is supported by the presence of similarly variable processes on the midline parietal bar of other taxa (e.g., *Pachyrhinosaurus lakustai*). This revised classification for centrosaurine epiparietals is the most parsimonious interpretation of homology, and affects the phylogenetic reconstruction of ceratopsids.

Poster Session III, (Friday)

**NEW MORGANUCODONTANS FROM EARLY JURASSIC FISSURE FILLINGS IN WALES (UK)**

CLEMENS, William, University of California Museum of Paleontology, Berkeley, CA, USA

In southern Wales, early Jurassic fissure fillings in Carboniferous limestones continue to be prolific sources of remains of early mammaliaforms and other microvertebrate fossils. Building on the discoveries of Walter Kühne, Kenneth A. Kermack, associates from University College London, and others have and continue to collect and analyze fossils from these fissures. Initially the fossils recovered documented a fauna of low taxonomic diversity including the mammaliaforms *Morganucodon* and *Kuehneotherium*. In 1968, continuing excavation in Pant Quarry began to expose a fissure, designated Pant 4, which yielded a sample of a more diverse fauna, the *Morganucodon*-sphenodont fauna. Dissertation research on this new fauna by David Pacey unfortunately was not published. Subsequently, studies of some members of the fauna, for example, *Clevoosaurus*, *Oligokyphus*, *Thomasia*, and *Kuehneotherium* were based on the collections available to Pacey and additional material. Pamela Gill and associates at the University of Bristol are continuing research on the faunas of the Welsh fissures. This is a contribution to their project. The mammaliaforms recognized so far in the *Morganucodon*-sphenodont fauna include *Thomasia*, *Morganucodon*, and *Kuehneotherium*. Isolated molariforms document the presence of two new morganucodontan genera. The mean dimensions of molariforms of the more abundantly represented genus are slightly larger than those of *Morganucodon watsoni*. Continuous labial cingula of the upper molariforms resemble those of molariforms of *M. watsoni*. Unlike *M. watsoni* but resembling lower molariforms of *Megazostrodon rudnerae*, cusp g (the Kühnecone) is strikingly large and usually situated lingual to cusp a. The second new genus, based on a single lower molariform, is set apart by its extremely large size, which is greater than any other currently known morganucodontan molariforms. The new Welsh morganucodontans, added to records from other sites, indicate the group achieved considerable taxonomic diversity and a near global distribution during the Late Triassic and Early Jurassic.

Technical Session IV, Wednesday 3:00

**EVIDENCE OF CENOZOIC ENVIRONMENTAL AND ECOLOGICAL CHANGE FROM STABLE ISOTOPE ANALYSIS OF SIRENIAN REMAINS FROM THE TETHYS-MEDITERRANEAN REGION**

CLEMENTZ, Mark, University of Wyoming, Laramie, WY, USA; DOMNING, Daryl, Howard University, Washington, DC, USA; SORBI, Silvia, Università di Pisa, Pisa, Italy

Sirenians (sea cows; manatees and dugongs) have been primary consumers in tropical and subtropical shallow water marine ecosystems for over 50 m.y. Though fossils of the earliest sirenians have been recovered from the West Atlantic and Caribbean (WAC), sirenians are thought to have originated in the Tethys-Mediterranean (TM) region, which experienced significant climate change over the course of the Cenozoic. Stable isotope analysis (SIA) of

tooth enamel from WAC fossil sirenians has been used to interpret ecological change within this region through the Cenozoic and a similar study of fossil sirenians from the TM could provide new insight into how diet and habitat preferences of sirenians were impacted by climate change and, in turn, how these ecological changes correlate with diversity patterns for this region. Tooth enamel was sampled from 57 specimens of sirenians from the TM and adjacent seas spanning the Eocene to Pliocene. Most enamel  $\delta^{13}\text{C}$  values ( $> -2.0\text{‰}$ ) indicated diets of marine seagrasses, whereas enamel  $\delta^{18}\text{O}$  values showed significant change across the region and over time. Sirenians from southern sites (i.e., Egypt, Libya) had significantly higher mean  $\delta^{18}\text{O}$  values than specimens from most European locations, suggesting variation in the evaporation-precipitation conditions or connection to open ocean within the TM. The range in enamel  $\delta^{18}\text{O}$  values increased from the Paleogene through the Neogene, but enamel  $\delta^{13}\text{C}$  values remained steady, indicating that changes in environmental conditions did not necessarily coincide with major changes in diet. Declines in taxonomic diversity in the late Miocene were likely due to the rapid climate and oceanographic changes during the latter half of the Cenozoic and their impacts on available dietary resources. Elevated  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$  values in Mediterranean sirenians during the Messinian Salinity Crisis corroborate the hypothesis of ecophenotypic dwarfing in these animals. Comparison with enamel isotope data from the WAC shows that while both regions experienced similar trends in environmental change, regional differences in seawater composition and coastal marine conditions were pronounced through the Cenozoic.

Poster Session II, (Thursday)

**AUSTRALIA'S MESOZOIC BIRDS: NEW MATERIAL FROM THE EARLY CRETACEOUS OF VICTORIA**

CLOSE, Roger, Monash University, Clayton, Australia; VICKERS-RICH, Patricia, Monash University, Clayton, Australia

Though meagre, the Mesozoic fossil record of birds from Australia is biogeographically significant; with one exception, the Early Cretaceous avian record for southern Gondwana derives from only a handful of sites in eastern Australia, distributed from western Queensland to southern Victoria. Evidence of Mesozoic birds in Australia first emerged in the 1960s, when several small downy feathers were found in lacustrine deposits of the Early Cretaceous (Aptian) Koorumburra Group at Koonwarra, Victoria. The first osteological remains appeared in 1985, when a tibiotarsus, assigned to the Enantiornithes and dubbed *Nanantius eos*, was reported from Early Cretaceous (Albian) marine sediments of the Toolebuc Formation in Queensland. Further enantiornithine material, consisting of a second fragmentary tibiotarsus and a posterior cervical vertebra, were later described from the same site. The middle Albian Griman Creek Formation at Lightening Ridge in New South Wales has also produced a collection of fragmentary elements, including non-enantiornithine tibiotarsi and a purported ichthyornithiform centrum. Recently, we reported on the discovery of an avian furcula from the Aptian-aged Flat Rocks Locality, Victoria (part of the Early Cretaceous Wonthaggi Formation). This furcula shares a number of derived characters with the Enantiornithes. Here, we describe three additional isolated avian elements originating from that locality: a small, heterocoelous cervical vertebra, which has been tentatively identified as an ornithuromorph; a small, slender tibiotarsus (complete except for the proximal epiphysis) that may be an enantiornithid; and an ulna, which represents a much larger individual than either of the former two elements. These recent discoveries represent some of the earliest known osteological evidence for birds in Gondwana, and have implications for global avian biogeography during the Early Cretaceous.

Technical Session VII, Thursday 2:15

**FITTING TEETH IN BENDING JAWS: DO THE SPATIAL DEMANDS OF THE DEVELOPING DENTITION AFFECT THE UTILITY OF THE MANDIBLE IN RECONSTRUCTING DIET?**

COBB, Samuel, Hull York Medical School, Hull, United Kingdom; MELORO, Carlo, Hull York Medical School, Hull, United Kingdom

Dietary inferences about fossil taxa can be made from isotope analyses, dental microwear analyses and or interpretations of the morphology of the dentition and skeletal masticatory system. Mandibular morphology and diet are related via the size and frequency of the muscle forces and bite force reactions necessary to process food. The greater and or more frequent the forces, the stronger the mandible needs to be to maintain function and resist failure. Longitudinal bending of the mandibular corpus occurs in the parasagittal plane and so is effectively reduced by increasing dimensions in this plane, i.e. corpus height and/or thickness of the superior and inferior cortex. However the corpus also houses the dentition during development, eruption and occlusion. Is mandibular height therefore an adaptation to reduce parasagittal bending, the height required to house the developing dentition or a combination of both? This study compared corpus height at the carnassial homologue in a sample of extant and fossil monophyodont (Metatheria) and diphyodont (Eutheria) carnivorous mandibles. The effects of lever arm size and bite force magnitude were assessed using mandibular length and carnassial bite force estimates, respectively. The following hypothesis was therefore tested: if the space required to house the developing dentition influences the corpus height, then corpus height is predicted to be greater in diphyodont rather than monophyodont taxa because the maximal spatial requirements of the dentition includes both the roots of a primary dentition and the crypts of a developing second dentition, as opposed to the single dentition of monophyodonts. The results demonstrate that the scaling relationship of corpus height with both mandibular length and bite force is

consistent across both monophyodont and diphyodont taxa, thus falsifying the hypothesis. Therefore the relative size of the developing dentition does not influence the size of the mandible, and its utility in dietary reconstruction, in the taxa studied here. This finding has important implications for our understanding of the coordinated development and evolution of the dentition and skeletal masticatory system.

Poster Session IV, (Saturday)

**A PARTIAL SKELETON OF *BEHEMOTOPS* (DESMOSTYLIA, MAMMALIA) FROM VANCOUVER ISLAND, BRITISH COLUMBIA**

COCKBURN, Thomas, Royal British Columbia Museum, Victoria, BC, Canada; BEATTY, Brian, New York College of Osteopathic Medicine, Old Westbury, NY, USA

In July of 2007, a partial articulated skeleton of a desmostylian was found in place in siltstone in the streambed at mouth of Sombrio River in Juan De Fuca Provincial Park, Vancouver Island, British Columbia, Canada. The fossils were found in association with late Oligocene Sooke Formation mollusks and an odontocete caudal vertebra. Sombrio Beach is part of the Sooke Formation siltstone "Facies F" and represents a backbench ponded area. Nearby portions of the formation are dated to Chron C6Cr age, 24.1-24.8 Ma. The material preserved includes the left side of the entire skull, including two molars and a premolar and canines, as well as a partial scapula, a nearly complete humerus, and numerous vertebrae and ribs. Molar characteristics and size appear to be the same as material of *Behemotops proteus* from the late Oligocene Pysht Formation of Washington State (LACM 124106), near the type locality of *Behemotops proteus* also from the Pysht. Previous specimens of *Behemotops proteus* were limited to lower jaws and portions of the upper and lower postcanine dentition. The smaller *Behemotops katsui* from Japan is known from more material, yet its cranial material is limited to the posterior cranium and a small portion of the zygomatic arch. This new material allows us to see that *Behemotops cf. proteus* had cranial features much like those seen in *Cornwallius sookensis* of North America. These include a postorbital process of the jugal, with no dorsally expanded zygomatic process of the squamosal, a deeply concave hard palate, enlarged canine tusks that point sharply ventrally, and a narrow, curved incisor arcade. *Behemotops* may be more closely related to desmostylids, making the divergence of the Desmostyliidae and Paleoparadoxiidae further back among fossil taxa yet unknown. Interestingly, the unfused epiphyses of this specimen's limb and vertebral elements appears to indicate that it is a subadult, even though all but its M3 have erupted. This suggests that *Behemotops*, unlike *Desmostylus* and other Afrotheria, did not delay the eruption of its adult dentition, indicating that the most likely primitive state for the Desmostylia is not delayed dental eruption.

Technical Session VII, Thursday 2:30

**ONTOGENETIC SEQUENCE ANALYSIS (OSA) OF TOOTH ERUPTION AND SUTURE CLOSURE IN *TAPIRUS* (MAMMALIA: PERISSODACTYLA): IMPLICATIONS FOR ASSESSING SEQUENCES IN FOSSIL SAMPLES**

COLBERT, Matthew, The University of Texas at Austin, Austin, TX, USA

Deducing sequence heterochrony involves comparison of the relative order of ontogenetic events between species in a phylogenetic context. Such analyses obviously require both a phylogenetic framework, as well as ontogenetic sequences for the considered species. While the difficulties of phylogenetic analysis are well known, the process of determining ontogenetic sequences within species is not trivial. The primary difficulty in establishing ontogenetic sequences relates to inadequate sample sizes that often show biased demographics. These sampling artifacts are further complicated by the widespread occurrence of intraspecific sequence polymorphism, an underreported phenomenon that should be expected as a transitional condition between fixed event-order differences between taxa. In this study, Ontogenetic Sequence Analysis (OSA) is used to establish all most-parsimonious sequences of tooth eruption and suture closure, which are important indicators of mammalian maturity, for the four extant species of *Tapirus*. Results document considerable sequence polymorphism within each tapir species, and also underscore the relationship between sample size and resolution. The implications are obvious for sequence deduction in fossil species that, compared to extant species, are generally represented by smaller samples of individuals that are often fragmentary. Although it is not surprising that small sample sizes yield less-resolved sequences, an interesting finding is that the differences between the poorly resolved sequences of *Tapirus* are consistent with current phylogenetic estimates based on both morphology and molecules. These differences were analyzed by treating all event-pair comparisons in each species as phylogenetic characters. It is hypothesized that the phylogenetic signal within these sequence data is largely epigenetic, with inferred instances of heterochrony reflecting dramatic changes in cranial morphology. These results encourage the analysis of even limited samples to find sequences not only because relatively unresolved sequences may still have phylogenetic signal, but also to allow rough calibrations of individual maturity.

Poster Session IV, (Saturday)

**THEROPOD TEETH FROM THE LATE CRETACEOUS OF CHERA (VALENCIA, EASTERN SPAIN)**

COMPANY, Julio, Universidad Politecnica de Valencia, Valencia, Spain; TORICES, Angelica, Universidad Complutense, Madrid, Spain; PEREDA-SUBERBIOLA, Xabier, Universidad del Pais Vasco/EHU, Bilbao, Spain; RUIZ-OMENACA, José, Museo del Jurásico de Asturias (MUJA), Colunga, Spain

Several exposures of the Late Campanian-Early Maastrichtian palustrine deposits of the Sierra Perenchiza Formation at Chera Basin (Valencia province, Eastern Spain) have provided abundant micro- and macrovertebrate fossil remains. The vertebrate assemblage recovered includes remains of actinopterygians, amphibians, squamates, chelonians, crocodyliforms, pterosaurs and dinosaurs. Among the last ones, there are representatives of sauropods (*Lirainosaurus cf. astibiae*), ornithomorphs (*Rhabdodon priscus*), thyreophorans (*Struthiosaurus* sp.) and theropods, which are presented in this work. Only two of the above-mentioned localities, named Chera-0 and Chera-2, have provided theropod remains, which consist of scarce isolated teeth. Three different morphotypes have been identified in the Chera material. The first one (?Neoceratosauria indet., Chera 0 and Chera 2), corresponds to the largest teeth of the sample (TCH up to 50 mm); these teeth are moderately compressed laterally, and distally recurved, their crowns bear denticles on both mesial and distal margins, and the mesial carina is laterally displaced; the denticles are chisel-shaped, wider labiolingually than they are long mesiodistally; the mesial denticles are slightly smaller than those of the posterior carina (about 3 denticles per mm); the crown enamel is slightly stretch-marked. The second type (Dromaeosauridae: cf. *Pyroraptor* sp., Chera 0 and Chera 2) includes two isolated teeth of much smaller size (TCH of about 10 mm); these teeth are strongly compressed, slightly recurved distally, and both mesial and distal carinae have minute denticles (about 7 denticles per mm). The third morphotype (Coelurosauria indet., Chera 0) corresponds to the smallest teeth of the sample (TCH of about 6 mm); they are distally recurved, strongly compressed laterally, and lack denticles. The association of neoceratosaurians and coelurosaurs, including dromaeosaurids, seems typical of the Campanian-Maastrichtian of the Ibero-Armorican Realm.

Technical Session III, Wednesday 3:45

**MIOCENE ASIAN INVASION OF EUROPE BY *VARANUS* (VARANIDAE)**

CONRAD, Jack, AMNH, New York, NY, USA; BALCARCEL, Ana, AMNH, New York, NY, USA; MEHLING, Carl, AMNH, New York, NY, USA

*Varanus* possess a frustratingly incomplete fossil record. The crown radiation of *Varanus* had begun diversifying by the Early Miocene (~18 million years ago; Ma) as evinced by relatively complete remains of *Varanus rusingensis* from Kenya. Other varanid fossils from the Miocene and later include primarily isolated vertebrae or other non-diagnostic material. We report on the first diagnostic fossil species of *Varanus* from Europe. The specimen (AMNH FR 30630) comes from the Mytilini Formation (Late Miocene, approximately 8.33 Ma) and consists of most of the right side of a braincase, a partial right squamosal, a right quadrate, the right mandibular glenoid and surrounding areas, three cervical vertebrae, and three dorsal vertebrae. The specimen was originally collected with and identified as part of a partial mammal skeleton. We performed a cladistic analysis of 53 extant and fossil varaniforms, including 23 extant *Varanus*, to test the position of the Samos lizard. Our analysis finds the Samos *Varanus* to be nested within an Australasian clade of *Varanus*. Absence of a crista prootica, size and shape of the tympanic crest of the quadrate, presence of a dorsolateral surangular ridge, and relative degree of precondylar vertebral constriction unite the Samos *Varanus* with the Asian *Varanus salvator*-group. The length of the braincase from the tip of the basiptyergoid process to the tip of the paroccipital process is 41 mm, the quadrate is 25 mm tall, the mandibular glenoid is 12 mm wide across its anterior margin, cervical vertebra 4 is 26 mm long along its ventral midline. Based on comparisons with 16 extant species, this suggests a snout-vent length (SVL) of 620-700 mm; thus, the Samos *Varanus* was comparable in size to modern *Varanus niloticus* and *Varanus marmoratus*. Presence of a relatively large *Varanus* in the Mytilini increases our understanding of that Formation's fauna, which is dominated by a variety of mammals. The Samos *Varanus* also suggests a Miocene origin for some Australasian *Varanus* clades and an Asian rather than an African *Varanus* invasion of Europe.

Poster Session II, (Thursday)

**METHODS OF PALEONTOLOGICAL RECONSTRUCTION**

CONWAY, John, Open University, London, United Kingdom

The field of paleontological reconstruction is an old one, probably as old as paleontology itself, yet the literature on the life appearance of extinct animals is rather limited. The information required for accurate paleontological reconstructions is often limited to by-products of science concerned with other areas, such as biomechanics or phylogenetics. There has been little discussion of how the problems related to the field differ from the concerns of mainstream paleontology, or how those differences might be addressed in a systematic way. Previous discussions on the problems of reconstructing the life appearance of extinct animals have tended to focus on the dynamics of scientist/artist collaboration, or been relatively straightforward treatises of comparative anatomy. However the field has moved on, with new methodology and lines of evidence being pursued—some of which are somewhat distinct from the concerns of mainstream paleontology. Here I will discuss the

methods currently in use by paleontological artists and illustrators, in an effort to clarify these methods for critical evaluation, as well as suggest areas of research that are currently under-explored. These methods differ in focus from mainstream paleontology, but are of great concern to artists and illustrators. Some, such as the application of phylogenetic bracketing, are becoming reasonably well established; others, such as animal pattern and coloration, remain unsystematic. Finally, I will discuss the current aims of paleontological reconstruction in its differing contexts, whether that be to communicate, educate, or inspire, and ask whether we should attempt to measure the impact of our work.

Technical Session XVI, Saturday 10:30

#### **BIOGEOGRAPHY OF EUROPEAN CHALICOTHERES (PERISSODACTYLA, CHALICOTHERIIDAE): OLD AND NEW INTERPRETATIONS AND SYNTHESIS** COOMBS, Margery, University of Massachusetts, Amherst, MA, USA

Understanding the distribution of chalicotheres (clawed Perissodactyla) is helpful for reconstructing faunal and ecological changes in the European Cenozoic. Chalicotheres evolution evidently centered in Asia, from which migrants reached Europe, North America, and Africa at different times. The first definite appearance of chalicotheres in Europe was in the Oligocene, when the genus *Schizotherium* spread widely across Eurasia. Around the Oligo-Miocene boundary several important events occurred: the schizotheriine chalicotheriid *Moropus* first reached North America, and at around the same time (MN 2) very similar schizotheriine chalicotheres appeared in Europe. Early Miocene European material has variously been called *Moropus*, *Phyllotillon*, or *Metaschizotherium* and comes from France, Spain, Portugal, Germany, and the Czech Republic. Unfortunately much of it is fragmentary, so correct generic identification is difficult. Excellent material of *Metaschizotherium* from Sandelzhausen (MN 5) and several fissures at Petersbuch (MN 6) have vastly increased our knowledge of this genus, which is best known from MN 5-7 in Germany but probably had a greater temporal and geographic range. Although the very peculiar chalicotheriine subfamily is known from the earliest Miocene in Asia and East Africa, Chalicotheriinae made their European debut late in MN 5 in the form of *Anisodon grande*. From that time onward in the Miocene, both subfamilies coexisted in Europe and occasionally co-occur in the same deposits. The MN 7-8 fauna of La Grive in southern France is of particular interest for understanding chalicotheres faunal changes leading into the later Miocene. Reinterpretations of material from La Grive suggest that *Ancylotherium* (Schizotheriinae) and *Chalicotherium* (Chalicotheriinae) may have first reached Europe about this time. In the late Miocene, *Chalicotherium goldfussi* became the dominant chalicotheres species in Central Europe, while *Ancylotherium pentelicum* is well known from southeast Europe and adjacent Asia. Both subfamilies disappeared from Europe by the end of the Miocene but persisted later in Asia (Chalicotheriinae) and Africa (Schizotheriinae).

Technical Session XVI, Saturday 11:15

#### **ANATOMICAL AND LOCOMOTOR SPECIALIZATIONS OF THE EOCENE RAOELLID INDOHYUS**

COOPER, Lisa Noelle, NEOUCOM, Rootstown, OH, USA; THEWISSEN, J.G.M., NEOUCOM, Rootstown, OH, USA; BAJPAL, Sunil, Indian Institute of Technology, Roorkee, India; TIWARI, B.N., Wadia Institute of Himalayan Geology, Dehra Dun, India

Raoellids are an extinct family of cat-sized artiodactyls. Skeletons of at least 30 individuals of the raoellid *Indohyus* were recovered from middle Eocene streambed sediments of India. For the first time a detailed analysis of anatomical and locomotor specializations has been completed for this population of *Indohyus*. Skeletal morphology of *Indohyus* was compared with the primitive fossil artiodactyl *Diacodexis metsiacus*, members of the earliest family of cetaceans (pakicetids), and an extant artiodactyl of similar body size, *Tragulus*. Metapodial and phalangeal bone morphologies indicate a digitigrade stance based on articular surface morphologies and terminal phalanx shape. *Indohyus* also lacked several adaptations for an aquatic lifestyle seen in pakicetid cetaceans. Like pakicetids, *Indohyus* displayed elongated hindlimbs and an elongated tail. Pakicetids, however, displayed a greater number of osteosclerotic appendicular and axial elements that acted as skeletal ballast. This extensive bone ballast likely allowed pakicetids to forage at depth with less expenditure compared to *Indohyus*. Also, pakicetids displayed more extensive foot interdigital webbing and more robust digital muscles compared to *Indohyus*. Taken together, these results indicate that pakicetids displayed skeletal morphologies that facilitated invasion of the aquatic environment, and the skeletal morphology of *Indohyus* likely represents that of an aquatic wader as it was not as adept at aquatic locomotion.

Technical Session XIV, Friday 2:15

#### **DISCOVERING DEVELOPMENTAL SIGNALS IN PHYLOGENETIC DENTAL DATA - FROM MICRO- TO MACRO-EVOLUTIONARY VARIABILITY**

CORFE, Ian, Institute of Biotechnology, University of Helsinki, Helsinki, Finland; SEIFFERT, Erik, Department of Anatomy, Stony Brook University, Long Island, NY, USA; BOYER, Doug, IDEA, Department of Ecology and Evolution, Stony Brook University, Long Island, NY, USA; SÄILÄ, Laura, Institute of Biotechnology & Department of Geology, University of Helsinki, Helsinki, Finland; JUKKA, Jernvall, Institute of Biotechnology, University of Helsinki & IDEA, Department of Ecology and Evolution, Stony Brook University, Helsinki, Finland

Results from developmental biology can help investigate dental characters used for phylogenetic and evolutionary analyses. We examined a recently published comprehensive data matrix of fossil and extant primate relationships from a developmental perspective. Empirical development and population level variation studies show that features which appear chronologically later during development (those low on the crown or posteriorly located) tend to be more variable intra-specifically. Similarly, features in posterior molars tend to be more variable than in anterior ones. To determine whether these patterns are also true at the macro- rather than micro-evolutionary level, we examined the frequency of polymorphisms scored in the data as a measure of variability. For example, the paraconid cusp of lower molars is coded as an ordered character and scored as; absent or crestiform (0); polymorphic between states 0 & 2 (1); small (2); polymorphic between states 2 & 4 (3); large (4). Small cusps are initialized later in development than large ones and are located lower on the tooth, so we hypothesized that there would be more taxa polymorphic between absent/small cusps than small/large cusps. Results show 8-12% polymorphism in the later developing paraconids (dependent on tooth position) and only 0-2% polymorphism in earlier developing paraconids. Furthermore, a constant decrease in the 'average' character state of the paraconid between m1-m2 and m2-m3 was observed, as predicted by a developmental cascade model of tooth formation where constant tooth-tooth size change is expected. Our results show that a developmental perspective is useful for uncovering patterns in character states across taxa. Conversely, in addition to containing hierarchical information relating to phylogenetic relationships, phylogenetic data may contain information about development, an underlying mechanism of evolutionary change.

Technical Session VII, Thursday 3:30

#### **DOES INCISOR MORPHOLOGY CORRELATE WITH DIET IN CAVIOMORPH RODENTS?**

CROFT, Darin, Case Western Reserve U., Cleveland, OH, USA; NEIMI, Kyle, Case Western Reserve U., Cleveland, OH, USA

Caviomorph rodents represent a remarkable mammalian radiation. They colonized South America prior to the earliest Oligocene, diversified into more than 250 Recent species in 13 families, and presently fill niches occupied on other continents by lagomorphs, artiodactyls, and hyracoids. Despite the importance of caviomorph rodents in modern and fossil ecosystems, comparatively little research has focused on morphological correlates of behavior useful for reconstructing habits of extinct species. Given that the large, ever-growing incisors of rodents have been cited as a key adaptation for the clade, we investigated whether the morphology of these teeth varied in a predictable way with diet. Using Carnegie Museum specimens, our pilot study focused on 11 caviomorph genera classified into one of three dietary categories: fruit-leaf (incl. soft fruit pulp, leaves, twigs, animal material), fruit-seed (mainly seeds), and grass-leaf (grasses, leafy plants). Several specimens of each genus (31 total) were measured for six incisor variables: buccolingual diameter (BD), cord length (CL), buccal enamel extent (EE), mediolateral diameter (MD), outer radius of curvature (RC), and sharpness (SH). BD, CL, EE, and MD were measured with calipers; RC and SH were measured using ImageJ and digital photos. A stepwise discriminant analysis (DA) using all variables except CL correctly classified all 31 individuals according to diet. A DA using only BD, EE, and SH correctly classified all genera (i.e., species averages). Leave-out-one DAs classified ca. 65% of individuals and genera correctly. Hydrochoerus (the largest rodent in the dataset) and Ctenomys (a chisel-tooth digger) were most commonly misclassified. To test the model's general applicability, one specimen of each of five additional extant genera (four non-caviomorphs) were included as unknowns; the DA of individual specimens classified 80% correctly. Incisor morphology thus appears to be highly correlated with diet in extant caviomorphs and, in combination with hypsodonty and enamel microwear, should permit more refined dietary inferences for extinct species.

Poster Session II, (Thursday)

#### **MOLAR MICROWEAR OF INSECTIVOROUS BATS: IMPLICATIONS FOR THE TROPHIC ECOLOGY OF TWO EARLY MAMMALS**

CRUMPTON, Nicholas, University of Bristol, Bristol, United Kingdom; PURNELL, Mark, University of Leicester, Leicester, United Kingdom; GILL, Pamela, University of Bristol, Bristol, United Kingdom; JONES, Gareth, University of Bristol, Bristol, United Kingdom; RAYFIELD, Emily, University of Bristol, Bristol, United Kingdom

*Morganucodon* and *Kuehneotherium* are iconic and historically controversial basal mammals found in Early Jurassic fissure-fill sites within Carboniferous Limestone in Glamorganshire, South Wales. Previous workers have noted marked differences in tooth and jaw morphology between these two taxa, leading to the assertion that each utilized a distinct food source. Tooth microwear supports this hypothesis and the results of this work are presented here, along with a more detailed assessment of diet based on a comparative analysis of microwear in extant insectivorous microchiropteran bats, and analysis of the reaction of teeth to virtual stress loading.

High-resolution 3D data were acquired via focus variation microscopy (Alicona IFM) from functional surfaces of the molars of *Morganucodon*, *Kuehneotherium*, and five genera of bats. Surface roughness was quantified through microtextural analysis, a novel, highly repeatable method of microwear analysis that limits the operator error that hampers traditional approaches. Bat specimens were chosen to represent a continuum of dietary preferences from the 'hard-object' feeding beetle-specialist *Eptesicus serotinus* and mixed forager *Rhinolophus ferrumequinum* to the 'soft-object', moth-specialist *Plecotus auritus*

and the fly-specialist *Pipistrelle pipistrellus*. Analyses revealed a corresponding continuum of microwear textural parameters. Additional support for the interpreted trophic ecology of the two extinct taxa was gained through finite element analysis of gross tooth morphology gleaned from microCT fossil scans. This analysis indicated that *Morganucodon* molars were able to withstand greater loading forces than *Kuehneotherium*, whereas *Kuehneotherium* was specialized to consume more tractable foodstuffs.

Dental microwear has been applied widely to analyze the diet of extinct organisms, but the successful mapping of the microwear of these extinct early mammals onto that from extant animals with known dietary preferences suggest great promise for analyses based on 3D quantification and microtextural analysis.

Poster Session III, (Friday)

#### **NEW LAMBEOSAURINE HADROSAURID FROM THE LATEST CRETACEOUS OF SPAIN (ARÉN, HUESCA, SPAIN)**

CRUZADO-CABALLERO, Penélope, Aragosaurus. University of Zaragoza., Zaragoza, Spain; CANUDO, José Ignacio, Aragosaurus. University of Zaragoza, Zaragoza, Spain; PEREDA-SUBERBIOLA, Xabier, University of the País Vasco/EHU, Bilbao, País Vasco, Spain; RUIZ-OMEÑACA, José, Aragosaurus. Jurassic Museum of Asturias (MUJA), Asturias, Spain

The European hadrosaurid dinosaur fauna of the Maastrichtian is characterized by the presence of basal hadrosaurids, such as *Telmatosaurus transsylvanicus* or *Pararhabdodon isonensis*, and many disarticulated and isolated remains of undetermined species. In 1997 six sites close to the Cretaceous/Tertiary boundary with numerous remains of hadrosaurid dinosaurs were found in the locality of Arén (south-central Pyrenees, Huesca, Spain). These remains are located in coastal and non-marine deposits of the Aren and Tremp Formations. In the Blasi 3 site, a new hadrosaurid has been identified. This is the first species of hadrosaurid with a partial and articulated skull described in Europe; it is based on a partial, articulated skull, mandibular remains and postcranial elements, including vertebrae, girdle and limb bones. This new species is characterized by a very prominent frontal dome; nearly vertical prequadratic (squamosal) and jugal (postorbital) processes, and a deltopectoral crest of the humerus oriented anteriorly. Moreover, it possesses a unique combination of characters: short frontal (length/width approximately 0.5); midline ridge of parietal at level of the postorbital-squamosal bar; parietal excluded from the occiput; squamosal low above the cotyloid cavity. A phylogenetic analysis indicates that this new species is a relatively basal member of Lambeosaurinae and the sister-taxon to *Amurosaurus* and the Corythosaurini-Parasaurolophini clade. The phylogenetic relationships with other lambeosaurines suggest a paleogeographical connection between Asia and Europe during the Late Cretaceous.

Technical Session XVIII, Saturday 4:00

#### **A NEW TITANOSAUR (DINOSAURIA: SAUROPODA) FROM THE LATE CRETACEOUS OF ROMANIA, AND A PLEA FOR NECESSARY STABILITY IN SAUROPOD SYSTEMATICS**

CSIKI, Zoltan, University of Bucharest, Bucharest, Romania; CODREA, Vlad, Babes-Bolyai University, Cluj-Napoca, Romania; GODEFROIT, Pascal, Institut royal des Sciences naturelles de Belgique, Bruxelles, Belgium; JIPA-MURZEA, Catalin, Babes-Bolyai University, Cluj-Napoca, Romania

Titanosaur remains are common in the Upper Cretaceous continental beds of the Hateg Basin, Romania, but are usually represented only by isolated bones or, more rarely, by few associated skeletal remains. Customarily, these are referred to the sole species of the genus *Magyarosaurus* (*Magyarosaurus dacus*), despite historical suggestions concerning the presence of several different taxa. Due to the isolated and disarticulated nature of the titanosaur fossil record from Hateg, both the taxonomic status and osteology of *Magyarosaurus dacus* need a thorough revision. The discovery of a partial articulated titanosaur skeleton in the dark-colored floodplain deposits of Nalat-Vad seemed to offer a good opportunity to clarify the status of *Magyarosaurus*. Study of the preserved remains (dorsal and caudal vertebrae, dorsal ribs, chevrons, a partial pelvic girdle and pedal ungual phalanges) revealed the presence of several autapomorphies (including the presence of an accessory anterior centrodiaepophysal lamina in the posterior dorsals; the presence of amphiplatyan caudal vertebrae in the mid-region of the tail, intercalated within a procoelous series; and the presence of a caudo-lateral buttress on the iliac peduncle of the ischium), none of which was previously used to diagnose *Magyarosaurus*. Accordingly, the partial skeleton is referred to a new taxon of titanosaurian sauropods. Preliminary phylogenetic analysis of the new taxon, using different previously published character-taxon datasets (CTDs), yields divergent results as to its exact phylogenetic affinities, although in all these analyses it clusters within the derived titanosaurs. Moreover, analysis of the only CDT including both *Magyarosaurus* and the Nalat-Vad specimen places them in different titanosaurian subclades, thus supporting their taxonomic distinctiveness. The identification of this new taxon supports a higher titanosaurian diversity in the Hateg assemblage than previously recognized. The preliminary results of the cladistic analyses also suggest that development of a standard CDT to be used in different analyses should represent one of the major tasks for sauropod systematics.

Poster Session IV, (Saturday)

#### **BIODIVERSITY OF IBERIAN EOCENE EQUIDS AND THEIR SIGNIFICANCE FOR EUROPEAN EOCENE MAMMALIAN EVOLUTIONARY AND PALEOBIOGEOGRAPHIC HISTORY**

CUESTA, Miguel Ángel, University of Salamanca, Salamanca, Spain; BADIOLA, Ainara, University of Zaragoza, Zaragoza, Spain; CHECA, Lluís, Institut Català de Paleontologia, Sabadell, Spain; HOOKER, Jerry, Natural History Museum, London, United Kingdom

In Europe, the Middle and Late Eocene was a period of important change in faunal composition as a result of climatic shifts, the presence or absence of land bridges between the different areas of the European archipelago and several immigration waves. Here we report on the Eocene equoid perissodactyl faunas from the Iberian Peninsula and analyze their role in understanding European Eocene paleoenvironments and mammalian paleobiogeography. Eocene equoid faunas of the Iberian Peninsula were highly diverse. In the Western Iberian Bioprovince, including several central and western Iberian basins, five genera and sixteen equoid species, which are unknown in the south-Pyrenean basins, in north-eastern Iberia, or elsewhere in Europe have so far been described. This equoid faunal differentiation is also matched by lophodont perissodactyls and primate and rodent faunas. Isolation from the Central European Island, albeit with intermittent faunal exchange with the rest of Europe and with other continents (probably Asia and possibly Africa), could have caused the endemism of these Iberian faunas, which seems to have existed from the late Early Eocene to Late Eocene. However, the dental adaptations observed in equoids from the Western Iberian Bioprovince suggest that the special paleoecological conditions of this region were the main cause of the faunal differentiation of this bioprovince. The change from a complex forest habitat to a more open environment observed in the Late Eocene in several regions of Europe could have started in the Middle Eocene in the Western Iberian Bioprovince, influencing its faunal composition. The wide diversity of palaeotheriid equoids and the presence of the oldest representatives of some forms in Iberia suggest that some Middle Eocene palaeotheriid taxa could have dispersed into Central Europe from the Iberian Peninsula after the Iberian plate became connected to the Central European Island in the late Lutetian.

Technical Session II, Wednesday 10:45

#### **EVOLUTION OF SERRATED CUTTING DENTITION IN HYBODONT SHARKS**

CUNY, Gilles, Natural History Museum of Denmark, Copenhagen, Denmark

The first hybodont known with any certainty dates back from the Carboniferous, but they might have appeared as early as the Late Devonian. However they did not developed any cutting dentition before the end of the Jurassic with the genus *Priohybodus*, although this kind of dentition is widespread among their sister-group the neoselachian sharks. A comparative study indicates that cutting dentitions with serrated teeth appeared four times independently within the hybodont sharks over a rather short period of time, from the Late Jurassic to the Albian. Moreover, such a dentition occurred only in species spending at least part of their life cycle in fresh waters. Hybodont sharks with a cutting dentition seem to have independently evolved in Southeast Asia (*Mukdahanodus* and *Thaiodus*) and in the Africa-South America continent (*Pororhiza* and *Priohybodus*). *Mukdahanodus trisivakulii* is known from the Lower Cretaceous Sao Khua Formation of Thailand and, after a turnover in hybodont faunas, was apparently replaced in the Aptian/Albian ecosystem by *Thaiodus rucha*, which independently developed a very similar dentition. *Thaiodus* and *Mukdahanodus* belong however to two separate families. Similarly, the Gondwanan genera, *Priohybodus arambourgi* and *Pororhiza molimbaensis* appear very different from each other and are not closely related. Two main kinds of cutting dentition can be identified among hybodonts: high-crowned (*Priohybodus*) and low-crowned (*Mukdahanodus*, *Thaiodus* and *Pororhiza*). On the contrary, serrated cutting dentitions in neoselachian sharks are mostly made of high-crowned teeth. It is proposed that the reason why cutting dentition is so rare among hybodonts compared with neoselachians is because the former lacks the triple-layered enameloid of the latter. The development of these cutting dentitions in hybodont sharks is linked to a compaction of their enameloid microstructure, which appears to favor low-crowned dentitions.

Poster Session II, (Thursday)

#### **TOOTH WEAR AND DENTAL PATHOLOGY IN SUBFOSSIL LEMUR *CATTA* (MAMMALIA: PRIMATES) FROM ANKILITELO, MADAGASCAR: HOW EXTANT SAMPLES AID INTERPRETATIONS OF PRIMATE PALEOBIOLOGY**

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The vertebrate fossil sample from Ankiliteilo, Madagascar preserves a wide range of extant and recently extinct primate species. This fauna dates to the late Holocene (~500 yr BP), and represents one of the latest faunal assemblages including both extant lemurs, and the recently extinct giant lemurs. Among the fossil representatives of extant lemurs at Ankiliteilo is a large sample of *Lemur catta*, the ring-tailed lemur. This species has been extensively studied in Madagascar for over four decades. Recent work at the Beza Mahafaly Special Reserve (BMSR), approximately 100km from Ankiliteilo, illustrates a pattern of frequent, severe dental wear and tooth loss. This pattern of dental pathology suggests that ring-tailed

lemurs living in the tamarind dominated gallery forests at BMSR use a fallback food for which they are not dentally adapted. Thus, our previous dental ecology data indicate that the BMSR ring-tailed lemur population is in evolutionary disequilibrium. To test this hypothesis, we collected data on tooth wear and dental pathology from the Ankiliteo subfossil ring-tailed lemur sample, a habitat on the ecological boundary between the dry spiny and western deciduous forests of Madagascar, neither of which is dominated by tamarind trees. At Ankiliteo, none of the ring-tailed lemur specimens ( $n = 36$ ,  $MNI = 17$ ) displays antemortem tooth loss, which differs significantly from the BMSR living sample ( $n = 148$ ,  $p = 0.0134$ ), and the BMSR skeletal sample housed at the reserve ( $n = 35$ ,  $p = 0.0098$ ). In addition, only one specimen in the Ankiliteo sample displays an apical abscess. At BMSR, apical tooth abscesses correspond to areas of disturbed habitat. These data, from a recent fossil assemblage, illustrate that late Holocene representatives of an extant lemur species were likely exploiting foods within an environment not significantly impacted by human actions, and for which they were dentally adapted, in contrast to that seen for an extant population living within anthropogenically altered environments. Our data illustrate the value of evaluating recent fossil assemblages of extant forms for understanding ecological change and dietary shifts in primate ecology.

Poster Session I, (Wednesday)

#### A PUTATIVE BASAL ICHTHYOPTERYGIAN FROM THE SULPHUR MOUNTAIN FORMATION OF BRITISH COLUMBIA, CANADA

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The Sulphur Mountain Formation (SMF) (Early - Middle Triassic) of B.C. is well-documented for its diverse marine reptile assemblage. Of this material, phylogenetically important specimens of basal ichthyopterygians (i.e., *Utatusaurus*, *Parvinator*, and *Grippia*) have contributed greatly to our knowledge of the osteology and distribution of Early Triassic taxa. A recently collected specimen, recovered from talus attributed to the basal-most Vega-Phroso Siltstone Member of the SMF, provides the basis for one of the most comprehensive cranial descriptions of an Early Triassic ichthyopterygian. The skull is dorsoventrally compressed, but ichthyopterygian features such as an elongated rostrum and large orbits are obvious. The slender premaxilla tapers anteriorly and bears an edentulous distal tip. More posteriorly, an unfused medial suture separates the right and left halves of the premaxilla. As in two other Early Triassic taxa, *Utatusaurus* and *Grippia*, the posterior margin of the premaxilla is concave and projects a dorsal and ventral process. The former contributes to more than half of the dorsal border of the anteroposteriorly elongated external naris, precluding the nasal from contributing to this region of the narial opening. Both the left and right ventral processes are incompletely preserved, but the presence and position of articular facets on the maxillae indicate they contributed to the anterior third of the ventral border of the external naris. The suture between the premaxilla and maxilla is apparent, indicated by a change in the orientation of bone texture. The dorsal maxillary apex is somewhat distorted, but contributes to the ventral margin of the external naris. The right articular facet accommodating the ventral premaxillary process is depressed medial to the rest of the maxilla. The remnant left articular facet preserves a small ridge of bone continuing caudally from the broken base of the ventral premaxillary process, indicating its ventral extent on the underlying maxilla. This specimen is tentatively identified as *Utatusaurus* and provides data critical to understanding the interrelationships and dispersal patterns of early ichthyopterygians.

Romer Prize Session, Thursday 8:45

#### PREDICTING BODY SIZE IN THEROPOD DINOSAURS USING STRIATED TOOTH MARKS ON BONE: A MODEL BASED ON FEEDING OBSERVATIONS OF THE KOMODO MONITOR, VARANUS KOMODOENSIS

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Striated tooth marks are believed to be due to contact between bone surfaces and the serrations, or denticles, of ziphodont teeth. Ziphodont theropods are often linked to Mesozoic striated marks on fossil bones by comparing the striation widths (SW) with the denticle widths (DW) of contemporaneous theropod taxa. Consumer identification and trophic interactions have been speculated upon based on this relationship. The purpose of this study is to determine if the body size of a ziphodont consumer may be determined by the striated tooth marks it leaves behind. Through a combination of actualistic experimentation and morphometrics, three concepts are investigated: 1) the behavior linked with striated mark formation, 2) DW and its relationship to body size, and 3) the accuracy of body size determination based on SW. Komodo monitors (*Varanus komodoensis*) are considered to be the best extant ziphodont analogues for theropods. Eleven captive individuals were fed goat carcasses, which were then evaluated for tooth marks. The SW was determined for all striated tooth marks. *V. komodoensis* and selected theropod dental, cranial, and body morphometrics were taken from museum specimens and published accounts. Striation production is usually the result of mesial denticle contact during defleshing. Rostral motion directly results in the lateral movement of the ziphodont tooth, and striated mark morphology reflects this movement. Concerning morphology, DW correlates with tooth size independent of position in the jaw. DW predicts body size based on negative allometry in both theropods and *V. komodoensis*. A highly similar slope between these groups implies this relationship persists independent of taxonomic distance. SW tends to underestimate, but never overestimates, the DW of the *V. komodoensis* that produced the mark. The mark

with the maximum SW on a particular carcass tended to be a reliable indicator of DW, and body size may therefore be determined by the evaluation of this mark. Due to allometry, this predictive power of this method decreases with increasing body size. Certain theropods deviate from these trends, perhaps due to fundamental niche differences.

Technical Session XVIII, Saturday 3:00

#### THE EVOLUTION OF TOOTH REPLACEMENT RATES IN SAUROPOD DINOSAURS

D'EMIC, Michael, University of Michigan, Ann Arbor, MI, USA; WHITLOCK, John, University of Michigan, Ann Arbor, MI, USA; SMITH, Kathlyn, University of Michigan, Ann Arbor, MI, USA; WILSON, Jeffrey, University of Michigan, Ann Arbor, MI, USA; FISHER, Daniel, University of Michigan, Ann Arbor, MI, USA

Incremental lines of von Ebner are microstructural features that demarcate the daily apposition of dentin, such that the total number of incremental lines in a tooth serves as a measure of that tooth's age. Differences in incremental line counts between successive replacement teeth within an alveolus provide a quantitative estimate of tooth replacement rate. Tooth formation times and rates have been shown to vary substantially among amniotes. We examined tooth replacement rates in two contemporaneous sauropod dinosaurs from western North America: *Diplodocus* and *Camarasaurus*. CT data reveal that each alveolus in *Diplodocus* has up to 5 replacement teeth, whereas *Camarasaurus* has a maximum of 3. Incremental lines of von Ebner are on average ~14 microns apart in *Diplodocus* and ~23 microns apart in *Camarasaurus*. Tooth formation times are about twice as long in *Camarasaurus* as in *Diplodocus*. Average tooth replacement rate in *Diplodocus* is ~35 days, similar to the replacement time of ~30 days found in *Nigersaurus*, which possessed a tooth battery. Tooth replacement rates in diplodocoid sauropods appear to be faster than those in any other dinosaurs, including derived ornithischian herbivores with tooth batteries. Preliminary data for *Camarasaurus* indicate a much slower rate of replacement. In the absence of incremental line counts from thin-sections in other sauropods, successive replacement tooth size was used as a proxy for replacement rate (i.e., a larger size discrepancy between successive replacement teeth suggests a slower replacement rate). Basal sauropods have fewer (1–2) replacement teeth per alveolus, and successive replacement teeth show a larger size difference than in *Camarasaurus*. In derived titanosaurs, which had narrow-crowned teeth, there are small size discrepancies between successive replacement teeth and a relatively large number of teeth per alveolus. Our data suggest that neosauropods are characterized by faster tooth replacement rates than basal sauropods, and that derived titanosaurs and diplodocoids independently evolved very fast tooth replacement rates.

Technical Session XV, Saturday 10:30

#### OSTEOLOGY, ONTOGENETIC ASSESSMENT, PHYLOGENY, PALEOBIOLOGY, AND SOFT-TISSUE ANATOMY OF *SCIPIONYX SAMNITICUS*

DAL SASSO, Cristiano, Museo di Storia Naturale di Milano, Milano, Italy; MAGANUCO, Simone, Museo di Storia Naturale di Milano, Milano, Italy

The remarkably preserved baby theropod *Scipionyx samniticus*, from the Lower Cretaceous (Albian) of Pietraroia, southern Italy, is finally described in detail. The whole osteology of the specimen is revised, described bone by bone. Major cranial novelties include identification of more braincase bones; palatal and mandibular elements are reinterpreted and their topology more clearly understood. Relevant postcranial skeletal features are: fan-shaped dorsal neural spines with beak-like ligament attachments, hair-like cervical ribs, sternal rib attachment, gastral morphology and pathology, carpus composed by only two well ossified bones, manual digit three longer than digit one, iliac preacetabular blade cranially notched, ischiadic obturator process squared distally, and proximal outline of the ischium revealed by CT analysis. The immaturity of the specimen is confirmed by a long list of juvenile characters. Phylogenetic analysis of Coelurosauria (90 taxa, 360 characters), evaluating also ontogeny-related characters, places *Scipionyx* as basal member of a monophyletic Compsognathidae, which results more derived than Tyrannosauroidae. The paleobiology of *Scipionyx* is also investigated, thanks to previously unnoticed remains. Gut contents includes allogenous bones from a swallowed lizard in the stomach region, scales in the cloaca, and a variety of tinier remains in several points of the intestine. The exquisite internal organs and other soft tissue preserved in *Scipionyx* are described in detail. In addition to trachea, intestine, muscles, and horny claws, connective tissue and traces of esophagus are preserved, and, under UV light, cartilaginous areas capping the long bones were found. SEM element micro-analysis confirmed the hematic origin of the reddish macula formerly referred to the liver; SEM imaging revealed striking preservation of sarcomere-related banded pattern in the muscle fibers, as well as capillaries, and possible microvilli foldings, at cellular level. The purported diaphragmatic muscles are a calcite nodule of amorphous structure, non-consistent with the preservation of other muscle tissue in *Scipionyx*.

Poster Session III, (Friday)

**A NEW AND EXTRAORDINARILY COMPLETE HADROSAUROID DINOSAUR (ORNITHISCHIA) FROM THE UPPER CRETACEOUS OF ITALY**

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Iguanodontoids are the best known dinosaurs thanks to the discovery of complete and articulated skeletons of the primitive *Iguanodon* in the Lower Cretaceous (~125 mya) of Europe and the derived hadrosaurids in the Campanian-Maastrichtian (80-65 mya) of North America. Several basal hadrosauroids phylogenetically intermediate between *Iguanodon* and hadrosaurids are reported from the Cretaceous of Asia, North America and Europe, but, excluding the basal *Dollodon*, they are represented by partial or disarticulated skeletons. The first complete and articulated specimen of a hadrosauroid dinosaur close to hadrosaurids, although primitive in many features, comes from the latest Cretaceous (75-68 mya) of Italy. The specimen is the most complete medium to large-sized dinosaur skeleton found in Europe since the 1878 discovery of *Iguanodon* and *Dollodon* at Bernissart, Belgium, and one of the most complete dinosaurs ever found. It represents a new genus and species that lived on a Bahamas-like island of the European Archipelago in the Tethys Ocean between the Afro-Arabian continent and the North European landmass. It is small-sized for hadrosauroid standards and shows many morphological peculiarities possibly related to insularism, including cursorial features. The fossil record suggests that hadrosauroids colonized the European Archipelago during the latest Cretaceous coming from Asia.

Poster Session IV, (Saturday)

**PERISSODACTYL PATELLAE: MORPHOLOGICAL VARIATION AND PHYLOGENETIC SIGNIFICANCE IN A NEGLECTED ELEMENT**

DANAHER, Kimberly, Manhattan College, New York, NY, USA; SHOCKEY, Bruce, Manhattan College and AMNH, New York, NY, USA; MIHLBACHLER, Matthew, New York College of Osteopathic Medicine, Old Westbury, Long Island, NY, USA

The patella aids in tracking the quadriceps tendon-patellar ligament complex through the femoral trochlea and over the joint, thus preventing dislocation of the pulley system of knee extension. Additionally, greater mechanical advantage can be achieved by increasing the caudal-cranial dimension of the patella. Some modifications of the patella may allow it to be temporarily locked into its proximal position upon knee extension such that it serves as a knee lock, allowing the animal to stand economically for considerable periods of time. In this study we obtained qualitative and quantitative data of the patellar morphology of the major groups of perissodactyls. *Immersion Microscribe G2* was used to collect three dimensional data points which were analyzed with *Morphologika*, software that aligned the data points for comparative analysis and performed multivariate statistical analysis (principle components analysis). Some taxa had patellae that were little deviated from the inspiration of the descriptive name, "sesamoid". These included early equids (e.g., "*Hyracotherium*") and the ceratomorph, *Hyrachyus*. This basic form is little modified in the Brontotheriidae, despite the large sizes of some of the taxa examined. The chalicotheres, *Moropus*, however, has a robust, globular patella. True rhinos (Rhinocerotidae) and the "hyracodontid" *Indricotherium* have a distinctive medial process that has been shown to function as the "hook" of a locking mechanism of the knee joint in extant rhinos. A mynodontid rhinocerotids have a small version of this process. Such a hook is absent in modern equids known to have knee locks and in their extinct relatives that are suspected of having knee locks based upon their distal femoral morphology (i.e., their greatly enlarged medial trochlear ridge). The hook of the knee lock in modern horses is cartilaginous, not ossified, as in true rhinos.

Poster Session II, (Thursday)

**INTERPRETATIONS OF SEDIMENT PATTERNS IN FOSSILS BASED ON AN ACTUALISTIC, TAPHONOMIC STUDY OF OSTRICH HEADS DURING AND POST-BURIAL**

DANIEL, Joseph, Ohio University, Athens, OH, USA; WITMER, Lawrence, Ohio University, Athens, OH, USA

To examine how soft tissue affects sediment patterns during burial, we buried 30 ostrich heads of varying decompositional states in two flumes emulating shallow burial in fast-moving water (e.g., sand bar) and deep burial in slow-moving water (e.g., pool). Sediment blocks containing the heads were CT scanned. 16 were reinterred for 7 months and rescanned. Collection of 1150 sediment samples from within and around the heads allows correlation of CT data to known sediment composition, providing detailed data on the sediment patterns. Sediment drapes covered heads retaining feathers in the shallow flume and rotten heads in the deep flume, and remained intact after 7 months. Long-term decay reduced interior soft-tissue signals in the sediment patterns. The dominant pattern was the retention of large quantities of gas within and around the skull leaving large void spaces in every head with significant soft tissue. Sediment only substantially enters the head under high flow conditions. Soft-tissue signals will be limited to superficial preservation, although this may be enhanced in mineral-saturated, bacteria-rich water. Most pneumatic sinuses will either be void of sediment or filled with secondary material, either sediment entering after soft tissue has decomposed and the skull fractures or mineralization in situ. Even in clean skulls, sediment will be limited to the easily accessible sinuses. The specific sinuses collecting sediment are controlled by head position related to water flow, providing orientation information even on a skull with no other sedimentologic context.

Intact skulls that are compressed with little displacement may indicate that significant soft tissue remained after burial, creating a void into which the skull collapsed. The sediment surrounding the skull should be examined carefully for traces of residual integumentary structures before removal of the matrix. Non-compressed skulls, and/or those showing consistently layered sediment, are likely to have been scavenged before burial. Further understanding of these patterns will clarify preservational processes aiding taphonomic and soft-tissue interpretations.

Poster Session I, (Wednesday)

**MICROTEXTURAL ANALYSIS OF DENTAL MICROWEAR IN FOSSIL AND EXTANT FISHES**

DARRAS, Laurent, Department of Geology, University of Leicester, Leicester, United Kingdom; PURNELL, Mark, Department of Geology, University of Leicester, Leicester, United Kingdom; HART, Paul, Department of Biology, University of Leicester, Leicester, United Kingdom; BAINES, David, Department of Geology, University of Leicester, Leicester, United Kingdom; TURINGAN, Ralph, Department of Biological Sciences, Florida Institute of Technology, Melbourne, FL, USA

Analysis of diet and feeding in fossils is generally based on functional morphology, involving anatomical comparison and mechanical modeling of the feeding apparatus and/or its component parts. Unfortunately, in many cases the assumptions that underlie this approach may not be valid. In fishes, for example, recent work has demonstrated that morphological specialization is not tightly linked to dietary specialization, thus weakening the whole functional morphological approach to analysis of feeding in fossil fishes. Quantitative analysis of tooth microwear offers an alternative method for assessing diet and feeding and we illustrate this with an analysis of feeding in fishes interpreted as shell-crushing durophages. Detailed study of sheephead fish (*Archosargus probatocephalus*), which have a 'heterodont' dentition containing 'classic' shell-crushing molariform teeth, reveals that different populations have significantly different diets, especially in the degree to which they are durophagous. Traditional SEM-based microwear analysis of the teeth is not possible because tooth surfaces are damaged to the point where individual pits and scratches are not recognizable. We have employed a new technique based on microtextural analysis of high resolution three-dimensional data acquired with a focus variation microscope (Alicona IFM). Tooth surface roughness was quantified using amplitude, volume and texture parameters, and rapid and automated data acquisition allowed the examination of large samples, with objective, user-independent results. Comparison of surface textures of teeth from two populations of sheephead fish with different diets, one shell-crushing, the other largely herbivorous, reveals statistically significant differences. Application of the same methods to the extinct pycnodontid, *Gyrodus*, indicates that contrary to previous hypotheses it was not a shell-crusher. These results demonstrate that quantitative microtextural analysis of tooth surfaces can provide robust characterization of feeding and paleodiet in a broad range of fossil vertebrates that previously could not be studied.

Poster Session II, (Thursday)

**TEMPORARY GAP-FILLING TO STABILIZE AN EXPLODED MATRIX FOR FOSSIL PREPARATION: THE SAND AND BUTVAR B-76 TECHNIQUE**

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Fossil preparators are often faced with the difficult task of extracting small, delicate elements from sediments that have cracked, expanded and exploded the bone. Open cracks allow the matrix to dislodge and break unpredictably in response to the pressure of the airscribe or needle, and this can damage the bone within. The sand and Butvar B-76 technique was developed to address this problem in a block from Ghost Ranch (New Mexico) containing a dense assemblage of small, partially articulated dinosaur skeletons. The matrix is a mudstone with copious inclusions of fish fragments, concretions, charcoal and other material. The bone is dense and hard but fractured and very thin in places. Cracks throughout the matrix and bone have expanded so that the fragments are separated by gaps. Before preparation it was necessary to stabilize the surface by packing a rigid, gap-filling material into all visible cracks. This material had to be strong enough to resist the force of an airscribe or needle but be easily removable and re-workable. I used a mix of clean children's playbox sand and smaller-grained black aquarium sand. The mixed grain sizes were for tighter packing and the mixed color was aesthetic. The sand was mixed with Butvar B-76 (polyvinyl butyral) in ethanol to form a cement that was pressed into the cracks and allowed to dry overnight. Butvar B-76 is a weak adhesive and is easily removable with a needle or airscribe, is readily soluble in ethanol that has a relatively low toxicity, and it has acceptable aging properties if any remains after preparation. After filling the gaps on the surface the matrix could gradually be removed in a controlled manner, from the top down. The sand and Butvar B-76 mix was applied, removed and re-applied to cracks and gaps in stages as they were revealed. This technique was successful for the preparation of this block and would probably be appropriate and effective for a variety of matrices.

Poster Session III, (Friday)

**NEW ADAPISORICULID MAMMALS FROM THE EARLY PALEOCENE LOCALITY OF HAININ (BELGIUM)**

DE BAST, Eric, Catholic University of Louvain, Louvain-la-Neuve, Belgium; SIGÉ, Bernard, Université Claude Bernard - Lyon 1, Villeurbanne Cedex, Belgium; SMITH, Thierry, Royal Belgian Institute of Natural Sciences, Brussels, Belgium

A recent study of the family Adapisoriculidae from the Early Paleocene deposits of Hainin has led to the description of two new species and four new morphotypes, as well as a more complete description of *Bustylus marandati*. The new species both belong to the pre-dilambdodont adapisoriculids, one to the genus *Afrodon* and one to the genus *Bustylus*. The newly identified morphotypes belong to both dilambdodont and pre-dilambdodont forms, with three morphotypes representing *Adapisoriculus*, *Remiculus* and *Afrodon*, and the fourth one probably belonging to a new genus. All known genera of adapisoriculids thus seem to be present in Hainin except the very particular African genus *Garatherium*.

The presence of several teeth with a robust morphology reminiscent of the dilambdodont *Remiculus*, but still close in other features to the most primitive genus *Afrodon*, suggests an evolution scenario different from those developed by previous authors. Dilambdodonty is commonly thought to have appeared only once, with the split between the two dilambdodont genera *Remiculus* and *Adapisoriculus* occurring later. The new material from Hainin shows that the evolution of adapisoriculids is probably more complex than expected, with dilambdodonty possibly evolving twice.

Poster Session II, (Thursday)

**A COLLECTION OF MODELS OF MEXICAN LATE JURASSIC MARINE REPTILES AT A 1:10 SCALE**

DE LA PAZ, Hector, Museo del Desierto, Saltillo, Coahuila, Mexico; BUCHY, Marie-Céline, Museo del Desierto, Saltillo, Coahuila, Mexico

Systematic investigation of Mexican Mesozoic marine reptiles began few years ago, financially supported by the German Science Foundation and Consejo Estatal de Ciencia y Tecnología, and yielded rich assemblages for both the Late Jurassic and Late Cretaceous. Many of these fossils are kept, prepared and studied at the Museo del Desierto, Saltillo, Coahuila (Mude), a large museum devoted to the deserts of north-east Mexico, their fauna and flora, geology, archaeology, ethnography, which includes areas for art exhibitions and wild living animals rescued from unwanted encounters with humans. The Mude was born from the stubborn vision of Lic. Magdalena Cardenas, who could convince political powers and assemble necessary competencies in the provincial-looking city of Saltillo, capital of Coahuila. The new Direction wished to mark the first decade of existence of the Mude by exhibiting exceptional fossils from the region. Among those are undoubtedly the marine reptiles that populated the Late Jurassic Mexican Gulf, encountered both in Nuevo León and Coahuila. It was decided to produce a diorama at a 1:10 scale. This comprises models of *Ophthalmosaurus* cf. *icenicus* adults (40 cm) and juveniles (7 cm), *Dakosaurus* sp. (40 cm), *Cricosaurus saltillense* (25 cm), cf. *Brachypterygius* sp. (80 cm), an indeterminate pliosaur representing 'The Monster of Aramberri' (150 cm) and a new cryptochlidid plesiosaur (30 cm).

The models were first sketched according to the fossil material and literature, and a silhouette cut out in Styrofoam; this prototype was then coated with epoxy plastilin and hand-finished, including details such as skin ornamentation, eyes and fins, painting and high-gloss varnish coating to suggest an aquatic atmosphere.

At Mude, the visitors view the paleontology laboratory through a window, where they can ask questions and be answered. Some of the models were exhibited in this window, and comments are unexpectedly gratifying, e.g. the ichthyosaurs are correctly depicted by the kids as 'looking like dolphins but still different', and in general, the models help the public connect the raw bones they see in preparation to real, living animals of the past.

Molecular Tools in Paleobiology: Trees, Clocks and linking Geno- with Phenotype, Friday 9:15

**THE "TIME-DEPENDENCY OF MOLECULAR RATES OF EVOLUTION" REVISITED: HOW WELL-CALIBRATED PALEONTOLOGICAL EVIDENCE CAN CLEAR THE MESS IN THE BAYESIAN DEBATE GENERATED BY POORLY-CALIBRATED UNINFORMATIVE MOLECULAR DATA**

DEBRUYNE, Régis, McMaster University, Hamilton, ON, Canada; POINAR, Hendrik, McMaster University, Hamilton, ON, Canada

One of the predictions of the neutral theory of molecular evolution is that the long-term rate of substitution between two lineages can only be inferior to their instantaneous rate of mutation, due to the fixation of transient polymorphisms through time. Accordingly, some recent work supports that a drastic acceleration in the molecular rates as divergence time approaches zero is a general and predictable feature. It has become since then a hotly debated topic in both systematics and evolutionary biology. Although, observations of such 'accelerations' in the molecular rates within recent evolutionary time have been documented, some recent models describe a phenomenon an order of magnitude beyond them. Indeed, it allows a variation within a wide range of rates (beyond 20 fold) during an extended period of time (up to two million years). Although intuitively appealing and explaining well the original data, this model supports a serious and prolonged impact of deleterious mutations

and would thus require large adjustments in the current evolutionary paradigm of genomes. Recently, both the model of the time-dependency and the significance of the rate acceleration phenomenon have been put in question. In this communication, our primary objective is to re-address the nature of the causal factor(s) of the rate acceleration described by previous models, as well as their biological meaning. Based on previously published material, we suggest that the emphasis placed upon the divergence time in the current explanation of this phenomenon has hidden other relevant factors such as the information content of the datasets. In order to compare the performance of the strict "time-dependency" model with a more inclusive "signal-dependency" hypothesis, we examine both the impact of sequence length and the relative advantages & disadvantages of alternative calibration methods over the estimates of the rates. We illustrate the theoretical benefits of well-documented paleontological evidence on the inference of the rates through a case-study of modern and extinct Elephantoids. We thus conclude that the hypothesis for a signal-dependent artifact appears to model the data more accurately and explains some inconsistencies between published reports on evolutionary rates and paleontological data.

Poster Session IV, (Saturday)

**UP IN ARMS: AN ANALYSIS OF EVOLUTIONARY TRENDS WITHIN THE MANIRAPTORAN APPENDICULAR SKELETON USING ALLOMETRIC AND BAYESIAN PHYLOGENETIC APPROACHES.**

DECECCHI, Alexander, McGill University, Montreal, QB, Canada; HARRISON, Luke, McGill University, Montreal, QB, Canada; LARSSON, Hans, McGill, Montreal, QB, Canada

Elongation of the coelurosaurian forelimb is a well accepted trend within theropod dinosaurs. The level of elongation is usually measured by an increase in the relative increase in the humerus to the femur that culminates at a 1:1 ratio at node Aves. However, the use of ratio data without explicit context masks the independent trends in each measurement. This leads to an incomplete picture and possibly misleading assessment of actual morphological change. The implicit assumption in humeral to femora analysis is that the femur length is not under positive selection, and length differences between taxa are caused solely by body mass. Recent analysis in extant avians shows this assumption to be invalid. Using regression analysis we show that although femur length is closely related to snout to vent (SVL) and trunk (dorsal and sacral series) lengths in most theropods, basal deinonychosaurs show significantly longer femora than would be expected. We also find that the humeral to femur ratio, previously designated as a critical character in the diagnosis of Aves, is size dependent. Standardized for size and based on long term trends in maniraptoran, the "critical" ratio of 1:1 is actually the expected value for a SVL of less than 250mm. *Archaeopteryx*, *Microraptor* and *Epidexipteryx* are all within this size range and show a variety of levels of both forelimb and hindlimb elongation relative to body length. Femur length elongation in basal paravians has led researchers to overestimate body mass in these taxa, perhaps by more than 200% in some deinonychosaurs including critical taxa such as *Microraptor*, *Buitreraptor* and *Rahonavis*. Using allometric equations based on body length, (either SVL or trunk) and body mass, (derived from mid-shaft width or whole body silhouette methods) we examine where and to what extent there exist larger than expected deviations in fore- and hindlimb proportions within maniraptorans. Using Bayesian analysis, we further examine the implications for the reconstructions of ancestral states of appendicular morphology and re-evaluate currently proposed paravian behavioral hypotheses, including the origin of powered flight.

Poster Session IV, (Saturday)

**THE CHEWING BIOMECHANICS OF DEER ANALYZED BY FINITE ELEMENT METHOD (FEM)**

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The highly complex geometry of mammalian teeth, and also the diverse material they are made up of, restricts our knowledge of chewing biomechanics. Here we propose that a better understanding of dental morphology may be reached by objectifying the studies using the engineering technique of finite-element (FE) analysis. We advance the results obtained on creating two complex 3D FE upper molar models of extinct (*Procervulus ginsburgi*) and extant (*Cervus elaphus*) deer (Cervidae) in order to reconstruct chewing biomechanics. Evaluating the stress and strain fields in their teeth structures allows us to investigate how teeth respond to mechanical loading. FE models were generated from white light 3D and micro computed tomography (micro CT) scans and then physical-chemical properties of extant ruminant teeth were applied to the models. When bite force was applied by FEM, some unexpected patterns of distribution were seen among the models examined, as a result of differences in dental shape. To obtain more reliable interpretations, a comparison between the stress and strain maps obtained and the dental wear patterns of the molars was realized. The extinct deer model is more extensively strained and stressed, which is particularly notable in the dental cones. In contrast, both strains and stresses are highly restricted on the dental crests for the extant. The models behave differently because the general morphology of molars is much lower, wider and shorter in *Procervulus* than in *Cervus*, and also because there are some significant differences concerning the crescentic-shaped cusps. Our modeling reveals that such differences act by reducing the surface involved in strain and stress distribution in the extant deer model. It was found, however, that regions for both models

with significant stress distribution are the regions observed to have dental folds or wrinkled crests. It is likely that these structures can reduce the stress during occlusion. These results shed light on key structural variations in dental morphology that have evolved in Cervidae through time.

Technical Session XVI, Saturday 10:45

#### CHINESE NEOGENE ELASMOTHERE RHINOCEROSSES: PHYLOGENETIC RELATIONSHIPS AND ECOLOGIC IMPLICATIONS

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The elasmotheres form an extinct rhinoceros group in the Rhinocerotidae, and they are common in the Neogene of Asia, especially China. Eleven valid species have been described from the middle Miocene to the late Pliocene in many localities, mainly in northern China. Among the Chinese elasmotheres fossils, the middle Miocene and Pliocene taxa are known from many isolated teeth and several skulls, while the late Miocene taxa are represented by a lot of complete skulls. All are of importance in understanding the elasmotheres phylogeny and ecology during the Neogene. The middle Miocene elasmotheres have small or medium body sizes, but the late Miocene ones become huge rhinoceroses. The cladistic analyses support the elasmotheres as a monophyletic group. *Hispanotherium* is the most primitive elasmotheres in China. The *Ningxiatherium-Parelasmotherium* clade is the sister group to the *Sinotherium-Elasmotherium* clade, and all of them comprise the most derived clade in the elasmotheres. The classification of elasmotheres rhinoceroses has changed repeatedly during the last two decades. The prevalent view of the history of elasmotheres involves an evolutionary trend from lacking an ossified nasal septum towards having one, which was totally ossified, with a wide variety of intermediate, partially ossified states. The cheek teeth of the most Chinese elasmotheres are very highly crowned, and their strong wear implies that elasmotheres graze on tough grasses in arid habitats. The massive cement filling, well-developed secondary folds, and wrinkled enamel provide a means for elasmotheres cheek teeth to resist the abrasion of high-fiber diets. The giant body size of the late Miocene and Pliocene elasmotheres indicate that they grazed high-fiber grasses in open grasslands, because larger animals required proportionally less protein and were able to tolerate a larger proportion of cellulose.

Poster Session I, (Wednesday)

#### EARLY DEVONIAN VERTEBRATE FROM SOUTH AHAGGAR (SOUTHERN ALGERIA): NEW OBSERVATIONS ON THE HISTOLOGY OF EARLY CHONDRICHTHYAN SCALES

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Abundant chondrichthyan teeth, scales and some acanthodian scales have been extracted from a same sample collected in South Ahaggar (southern Algeria). The histology of Chondrichthyan scales is unusual. The main part of the neck and the base –not clearly histologically separate– corresponds to meandering canals emerging in any part of the scale; it consists of osteodentine a type of dentine more commonly found in teeth. In these scales, osteocytes are concentrating near the scale base. Furthermore, a kind of box-in-box pattern is visible in the crown but some elements of previous generation may appear at the surface. The combination of an unusual high neck and short Sharpey's fibers in the basal part suggest that the scale grew and was inserted deep inside the skin. In some scales two crown growth stages are recognized but do not mark the base. It results in a growth in height difficult to relate to the squamation growth or replacement. More classically, under the crown surface lined by a thin enameloid layer, bushes of pallial dentine are organized. The density and distribution pattern of these two last characters are variable reflecting maybe the maturity and/or the place of the scale. Comparisons of these scales have been made with *Weteldorfia* (considered as an Acanthodian) and *Nogueralepis* (Chondrichthyan) both also present in the Jauf Formation (Emsian) of Saudi Arabia. Thin sections also match with *Elegestolepis*, one of the earliest Chondrichthyan from the Silurian of Tuva. This material raises questions concerning the limits of histological data in the problem of relationships between Chondrichthyans and Acanthodians: some characters are chondrichthyan ones (osteodentine, foramina emerging in the neck and in the base) others are more acanthodian ones (box-in-box, mesodentine). Acanthodian scales accompanying these chondrichthyan remains are assigned to *Milesacanthus* sp. also found in the Emsian of Saudi Arabia reinforcing the Gondwanan faunal affinity.

Romer Prize Session, Thursday 10:30

#### EFFECTS OF CLIMATE CHANGE ON AUSTRALIAN MEGAFUNA DURING THE PLEISTOCENE: EVIDENCE FROM STABLE ISOTOPES OF HERBIVOROUS MARSUPIALS AT CUDDIE SPRINGS

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The Australian megafaunal extinction debate is highly contentious, with some researchers attributing the megafaunal extinctions to the arrival of humans and others to climate change. To properly evaluate if and how climate change affected megafauna we need to first understand the dietary niches of herbivorous megafauna and how these diets changed over

time during the Pleistocene. By comparing the stable isotope ratios of tooth enamel, faunal remains can provide an independent measure of habitat type and help elucidate past climate regimes. Here, stable carbon and oxygen isotopes of Australian megafauna at Cuddie Springs are compared through time from approximately 400 ka to 27-36 ka. Specifically, this work tests dietary hypotheses of extinct marsupials, documents how dietary niches of marsupials are affected by climate change, and assesses relative seasonality through time in southeastern Australia.  $\delta^{18}\text{O}$  values of the extant kangaroo *Macropus* increase in total range and mean over time, demonstrating increased aridity during ~27-36 ka.  $\delta^{13}\text{C}$  values of *Macropus* and *Protemnodon* correspondingly decline, potentially in response to climate change. The macropodids *Macropus*, *Protemnodon*, and *Sthenurus* partition dietary niches differently from one another with each taxa consuming more C3 resources, respectively. The  $\delta^{13}\text{C}$  ranges of the diprotodontids *Zygomaturus* and *Diprotodon* suggest that *Zygomaturus* was an obligate C3 consumer while *Diprotodon* was a mixed C3/C4 feeder. Serial  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$  values of *Diprotodon* incisors demonstrate how dietary resources and climate have changed over the course of a year or more. Serial oxygen isotopes show similar seasonal patterns through time while carbon isotopes demonstrate the consistency of dietary strategies among individuals. These results provide insight into the ecology of Australian megafauna during the Pleistocene, further demonstrating how their dietary niches were affected by increased aridity.

Poster Session II, (Thursday)

#### IS THE OH 8 HOMININ A SUB-ADULT? IMPLICATIONS FOR THE HOLOTYPE OF *HOMO HABILIS*

DESILVA, Jeremy, Boston University, Boston, MA, USA; TOCHERI, Matthew, Smithsonian Institution, Washington D.C., DC, USA; ZIPFEL, Bernhard, University of Witwatersrand, Johannesburg, South Africa; VAN ARSDALE, Adam, Wellesley College, Wellesley, MA, USA

Olduvai Gorge in Tanzania is one of the most important fossil localities in paleoanthropology. In 1960, Louis Leakey discovered at site FLK NN Olduvai Hominid 8 (OH 8), a remarkably complete fossil foot preserving all of the bones except the phalanges. Since that time, the OH 8 fossil has been a critical specimen for interpreting foot evolution and the evolution of hominin locomotion. Though this fossil was originally described as belonging to an adult hominid, it has been recently suggested that the OH 8 foot belonged to a juvenile based on the presence of what has been perceived as unfused epiphyses on the distal ends of the metatarsals. The type specimen of *Homo habilis* (OH 7) was found near the OH 8 foot and is unequivocally from a sub-adult, suggesting that this assemblage of bones may sample a single juvenile individual. If true, the holotype of *Homo habilis* would consist of a mandible, skull fragments, a partial hand, and a foot, making it one of the most complete type specimens in the human fossil record. Accurately assessing the age of the OH 8 foot is therefore important for correctly identifying the number of individuals at the FLK NN site, properly interpreting the functional morphology of these fossils, and thus the locomotion practiced by *Homo habilis*. A study of the original OH 8 fossils, and juvenile feet from modern humans and African apes (n=63), suggest that the original interpretation of the OH 8 foot as an adult individual may be the correct one. Based on the timing of epiphyseal fusion in the ape and human foot, if the OH 8 foot is from a juvenile with unfused metatarsal heads, the epiphysis of the first metatarsal base should also be unfused. Instead, the epiphysis of the first metatarsal of OH 8 is fully obliterated. Other features of the OH 8 foot, including osteophytes along the lateral metatarsals and a facet for the os peroneum are consistent with an older age for this individual. The consequences of these data for interpreting the association between the OH 8 foot and other fossils from Olduvai Gorge are discussed.

Technical Session XII, Friday 2:15

#### THE TAXONOMIC STATUS AND PHYLOGENETIC POSITION OF THE LATE TRIASSIC BRAZILIAN RAUISUCHIAN *PRESTOSUCHUS*

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In the end of the 1920s, Huene excavated the first basal crurotarsan archosaurs from South America from the Late Triassic Santa Maria Formation of southern Brazil. The material was subsequently described as six different taxa of "pseudosuchians": *Rauisuchus*, *Rhadinosuchus*, *Procerosuchus*, *Hoplitosaurus*, and two species of *Prestosuchus*, *P. loricatus* and *P. chiniquensis*. The latter was the best represented taxon, and a complete skull with associated axial material has subsequently been referred to it. A review of the original material of Huene showed that *P. chiniquensis* is a valid taxon, and *Procerosuchus* and the paralectotype of *P. loricatus* can be referred to the same taxon, whereas the lectotype of *P. loricatus* represents a different genus. The referred skull and axial material also represent *P. chiniquensis*, making it one of the best known raiusuchian taxa. A preliminary phylogenetic analysis of basal crurotarsans recovered a monophyletic Raiusuchia, which includes two subclades, the Raiusuchidae and the Popsosauridae. The latter include *Arizonasaurus* as the most basal taxon and *Lotosaurus*, *Poposaurus*, *Sillosuchus*, *Shuvosaurus* and *Effigia* as more derived taxa. Within the Raiusuchidae, *Postosuchus* represents the most basal taxon, followed by *Prestosuchus*, *Stagonosuchus* and *Saurosuchus*. More derived taxa include *Batrachotomus*, *Ticinosuchus* and *Rauisuchus*. Raiusuchia is supported by three unambiguous characters, a stepped postorbital bar, a large ventral astragalocalcaneal articular facet, and large lateral fossae in the cervical vertebrae. Raiusuchidae is currently

only supported by one unambiguous character, the presence of a large subnarial foramen, but raiusuchids more derived than *Postosuchus* share four unambiguous synapomorphies, an exposed quadrate head in lateral view, an oblique ridge on the lateral side of the squamosal, a fully closed acetabulum, and a high, crest-like iliofibularis trochanter on the fibula. The fact that one of the most derived raiusuchids known, *Ticinosuchus*, comes from the Middle Triassic (Anisian-Ladinian boundary), indicates that the major radiation of this clade must have happened before this time.

Poster Session IV, (Saturday)

#### **OCCURRENCE OF A GIANT STEREOSPONDYL IN THE SANTA MARIA FORMATION (PARANÁ BASIN, SOUTHERN BRAZIL)**

DIAS-DA-SILVA, Sérgio, Universidade Federal do Pampa, São Gabriel, Brazil; CABREIRA, Sérgio, Universidade Luterana do Brasil, Cachoeira do Sul, Brazil; DA SILVA, Lúcio, Universidade Luterana do Brasil, Cachoeira do Sul, Brazil

This contribution reports remains of a large stereospondyl in the uppermost levels of the Santa Maria Formation (Middle/Upper Triassic of Paraná Basin). They were collected at the municipality of São João do Polêsine in the State of Rio Grande do Sul, Southern Brazil, which previously had yielded actinopterygian fishes, dipnoan remains, hybodontiform sharks, rhynchosaurs, and aetosaurs. This locality is included in the *Hyperodapedon* Acme Zone and dated as Carnian. The new stereospondyl material is housed at the Universidade Luterana do Brasil (Campus of Cachoeira do Sul) and comprises a right partial clavicular element, two partial dermal skull bones, an appendicular fragment, a partial maxilla, and a small and slender clavicular blade. Most specimens are heavily ossified, so that they belonged to a robust adult individual of large size, excepting for a slender and delicate clavicular blade which probably belonged to a juvenile individual. The heavily ossified specimens are tentatively attributed to *Mastodonsauridae?* *indet.*, since their bone thickness is compatible with that found, for instance, in *Mastodonsaurus giganteus*. One could argue that chigutisaurid brachyopoids also reach a very large size and occur in the Upper Triassic of Argentina. However, chigutisaurid bones of large individuals are not as thick as those herein reported. In fact, one of the dermal elements from Santa Maria Formation is more than 3 cm thick and this measurement is compatible with that found in large mastodonsauroids already described. Unfortunately, the Brazilian material is fragmentary and constrains a more accurate identification. Recently, an interclavicular element was described for the Caturrita Formation (Upper Triassic of Paraná Basin) and also tentatively ascribed to a probable mastodonsauroid. The temnospondyl diversity in South America is considerably increasing and this group is indeed much more diverse in this part of Gondwana than previously thought. Concluding, further prospecting efforts are necessary in order to find more complete and diagnostic material to endorse the presence of advanced mastodonsauroids in this part of South America.

Poster Session III, (Friday)

#### **REVISION OF PROTEROCHAMPSA BARRIONUEVOI AND PROTEROCHAMPSIDAE (REPTILIA; ARCHOSAURIFORMES) FROM THE LATE TRIASSIC OF ARGENTINA AND BRAZIL**

DILKES, David, University of Wisconsin Oshkosh, Oshkosh, WI, USA; ARCUCCI, Andrea, Universidad Nacional de San Luis, San Luis, Argentina

Proterochampsidae is a clade of basal archosauriform reptiles known exclusively from the Chañares Formation (Middle Triassic) and Ischigualasto Formation (Late Triassic) of Argentina and the Santa Maria and Caturrita formations (Middle to Late Triassic) of Brazil. A new study of the skull of *Proterochampsia barrionuevoi* from the Ischigualasto Formation, San Juan Province, Argentina shows the genus is diagnosed by a dorsoventrally flattened skull with the external nares, antorbital fenestrae, orbits, and supratemporal fenestrae dorsal in orientation, dermal sculpturing consisting of highly nodular protuberances and prominent ridges with smaller periodic nodular growths along their length, exclusion of jugal from suborbital fenestra by contact of maxilla and ectopterygoid, absence of teeth along the medial edge of the pterygoid, and nasals extending anteriorly along the medial edges of the external nares between dorsal processes of the premaxillae. *Proterochampsia nodosa* from the Late Triassic of Brazil can be distinguished from *P. barrionuevoi* only by fewer ridges on the skull with protuberances that are typically larger than those of *P. barrionuevoi* and the absence of an elongate anterior depression of the antorbital fenestra that is present in *P. barrionuevoi*. The diagnosis of Proterochampsidae is revised to include dermal sculpturing on the parietals, frontals, and nasals consisting largely of ridges aligned with the long axis of the skull, frontals with an elevated median section of ridges and grooves and raised orbital rim, large lateral projections on the prefrontal and postorbital, elongate external nares located posterior to tip of snout with a prominent depression on premaxilla on the anterior side of each naris, contact between prefrontal and maxilla separating lacrimal from nasal, a notch along the posteroventral margin of the infratemporal fenestra, an external shelf along the dorsal edge of the surangular, transverse processes of caudal vertebrae that are longer than the length of centrum and expanded distally, and reduction of pedal digit 5.

Technical Session XVI, Saturday 9:00

#### **MOLAR FORMATION, LIFE HISTORY AND PHYLOGENY IN THREE ARCHAIC UNGULATES, MENISCOOTHERIUM, ECTOCION AND PHENACODUS (MAMMALIA, "CONDYLARTHRA")**

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Recent advances in molecular and morphological systematics have helped to transform our understanding of mammalian phylogeny. Many workers now posit that the "condylarthran" Phenacodontidae are afrotherians, but relationships within the family remain controversial. Some workers include *Ectocion* in a clade with *Phenacodus* and exclude the highly dentally derived *Meniscotherium*, while others place *Ectocion* as the sister-taxon to *Meniscotherium*. Here we compare estimated body mass and aspects of molar crown formation to help resolve the relationships of *Phenacodus*, *Meniscotherium*, and *Ectocion*, using the relationship of dental development to life history. We use growth increments in standard histological sections of one molar each from *P. trilobatus* and *P. intermedius*, seven molars of *M. chamense*, and two molars of *E. osbornianus*. We compare daily enamel secretion rate (DSR), the number of days between long period increments, the striae periodicity or Havers-Halberg Oscillation (HHO), crown formation time, and extension rate, the rate at which the crown increases in height each day. Estimated body mass and molar size are higher in both species of *Phenacodus* than in *Meniscotherium* and *Ectocion* yet molar crown formation times are shorter. *Meniscotherium* crown extension rates are also slower than in *Phenacodus*. *Ectocion* crown extension rates are intermediate, overlapping with both genera. DSR and HHO are similar in all four species. Striae periodicity has been hypothesized to be related to lamellar bone growth and a similar HHO in the larger *Phenacodus* to the two smaller genera suggests faster bone growth and adult body mass attainment in *Phenacodus*. These data suggest that *Phenacodus* had a faster life history than either *Meniscotherium* or *Ectocion* and lends additional support to the hypothesis that *Ectocion* and *Meniscotherium* form a clade within "Condylarthra." They also highlight how the largely unexplored area of growth rates in fossil taxa can provide important taxonomic and systematic data as well as insights into life history.

Technical Session XIII, Friday 4:00

#### **NEW CHINESE FOSSILS REVEAL THE STRUCTURE OF PALATE AND BASICRANIUM IN BASAL CERATOPSIANS**

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Due to problems of preservation and preparation, deep structures of the skull are rarely adequately described in basal ceratopsians. Only a single paper has focused on the anatomy of the nasal cavity. During the past decade in China, a number of superb new skulls have shed considerable light on the diversity of deep skull structures in basal ceratopsians. In studying the skulls of the psittacosaurids *Psittacosaurus major*, *P. lujiatunensis*, and *Hongshanosaurus houi*, and of the basal neoceratopsians *Liaoceratops yanzigouensis*, *Archaeoceratops oshimai*, and *Auroraceratops rugosus*, we have discovered fundamental differences between the palate and basicranium of psittacosaurids and those of basal neoceratopsians. In psittacosaurids the basioccipital is bilobate; the basiptyergoid processes of the basisphenoid are long and horizontal; the midline junction of the pterygoids is short and located at the midpoint of the skull; the vomers are horizontal; and the relatively enormous choanae are horizontal. By contrast, in basal neoceratopsians the basioccipital is quadrilateral; the basiptyergoid processes are short and directed ventrolaterally; the midline junction of the pterygoid is long and caudally positioned, covering the basioccipital-basisphenoid synchondrosis; the palate is vaulted both longitudinally and transversely due to the rostradorsal orientation of the palatines and the caudodorsal orientation of the vomers; and the relatively small choanae are rostral in position and steeply inclined. These differences underscore the evolutionary separation of the two radiations of early ceratopsians. Understanding the functional significance of these differences will help to elucidate the contrasting biological roles of psittacosaurids and basal neoceratopsians.

Poster Session IV, (Saturday)

#### **ISOTOPIC ANALYSES OF HIPPARION DENTAL ENAMEL FROM THE IBERIAN PENINSULA ACROSS THE MIOCENE-PLIOCENE BOUNDARY**

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The Miocene-Pliocene boundary was characterized by the expansion of C4 grasses, which is regarded as one of the most remarkable biotic events in the Cenozoic era as it profoundly affected biological terrestrial communities. Some Tertiary basins of the Iberian Peninsula are known for containing very complete Miocene-Pliocene sequences of mammalian fossil sites, showing not only a large number of fossil remains, but also a high variety of taxa.

In this study, rare earth element (REE) and stable isotope ( $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$ ) analyses have been performed on tooth enamel from 7 different species of the equid *Hipparion* from 19 localities situated in the Teruel-Alfambra region, the Ebro and Calatayud basins and in the Iberian Range. These localities span a time interval between 10.9 and 2.7 Ma and cover the first appearance of this equid in Spain right up to its extinction. Relatively flat REE patterns in the tooth enamel indicate that diagenesis has not erased the original geochemical signal. Furthermore, similarities in the REE curves in different samples from the same site suggest low time-averaging in the studied assemblages. An increase in  $\delta^{13}\text{C}$  values has been pinpointed at about 4.2 Ma, indicative of a change in diet and a shift towards a more open environment. These isotope results also agree well with changes in the Hypsodonty Index observed around this time period. This significant change in vegetation may be the response to global events occurring at this time period including the uplift of the Himalaya and/or the closure of the Panama Isthmus. However, other authors have suggested that more regional events, like the Messinian Salinity Crisis, may have also contributed to enhance more arid conditions in the Mediterranean area. Despite the current lack of agreement concerning the ultimate reason that gave rise to this event at the Miocene-Pliocene boundary, this study has shown that the event is recorded in the mammalian fossil tooth enamel of the Iberian Peninsula.

Poster Session I, (Wednesday)

**PRELIMINARY RESULTS ON THE TAPHONOMY OF THE MIOCENE CARNIVORE-TRAP SITE OF BATALLONES-1 (LOWER LEVEL; MN10; MADRID BASIN, SPAIN)**

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The Miocene mammal fossil site of Batallones-1 was the first of the localities discovered in the paleontological complex of Cerro de los Batallones (Madrid, Spain). This site comprises several features that distinguish it from other world-wide Miocene mammal fossil localities. First, the geological characteristics of this fossil site reveal that it developed in relation to a unique and poorly-known process in the generation of fossil localities called *piping*. This pseudokarstic process gave rise to cavities where the bones accumulated. Second, the fossil concentration, analyzed in this study, combines several unusual characteristics. More than 20,000 remains have been recovered in Batallones-1 since the first excavation in 1991. The fossil assemblage is mainly composed of carnivore remains (92.48% of the specimens) with two sabertooth felids, *Paramachairodus ogygia* and *Machairodus aphanistus*, as the best represented taxa. Most of the bones were found isolated but some spectacular fully articulated skeletons were also recovered. All Voorhies Transport Groups are present which indicates that Batallones-1 bones did not undergo a significant transport. The fossils show a statistical significant preferred orientation as they lie on the truncated dome-shaped sedimentary filling of the cavity. Bone modifications due to weathering, abrasion, carnivore activity, trampling and roots among other processes are scarce. The main bone alteration took place during diagenesis due to lithostatic pressure as shown by the presence of transverse breakages and flattening and deformation of the remains. A feasible explanation for the accumulation of fossil remains in Batallones-1 is that mammals, mainly carnivores, were trapped while attempting to scavenge and drink in a cavity. Once trapped, these animals were not able to escape and eventually died. The occurrence of isolated bones along with partially and fully articulated skeletons suggests differential burial of carcasses in various stages of soft tissue loss. The particular cavity environment insulated remains from taphonomical (biostratigraphical) modifications although they were doomed to a continuous sedimentary overburden.

Poster Session IV, (Saturday)

**THERAPSID DICYNODONTS (AMNIOTA, SYNAPSIDA) FROM ARGENTINA**

DOMNANOVICH, Nadia, Universidad de Buenos Aires, Buenos Aires, Argentina; MARSICANO, Claudia, Universidad de Buenos Aires, Buenos Aires, Argentina

Therapsid dicynodonts were an important component of the Triassic terrestrial communities in southern South America. Several authors have briefly discussed their taxonomic status but only recently a comprehensive revision of all materials from Argentina was performed and the validity of all taxa discussed. In Argentina, dicynodonts have been collected from several localities and stratigraphic levels spanning most of the Triassic. The basalmost Triassic Quebrada de los Fósiles Formation (southern Mendoza) contains specimens here considered as kannemeyeriiforms *indet.*, previously assigned to the Indian taxon *Rechinisaurus*, as well as a specimen of the shansiodontid *Vinceria*. Until now, shansiodontids were restricted to the Middle Triassic of Gondwana and Laurasia thus this new record rules out the group as useful stratigraphic indicators as was previously proposed. From the same basin, the overlying Río Seco de la Quebrada Formation (Middle Triassic) includes *Vinceria* and *Kannemeyeria* (*K. argentinensis*) a taxon also known from southern Africa. From northern Mendoza (Cuyana Basin) the Anisian Cerro de las Cabras Formation has yielded *Vinceria* and fragments of a kannemeyeriid *indet.* Several dicynodont specimens are known from the Ischigualasto-Villa Unión Basin (La Rioja and San Juan). The Middle Triassic Chañares Formation records the presence of *Dinodontosaurus platyceps* and *D. brevirostris*. Nevertheless, in the present revision the taxon *Jachaleria* is not recognized for this unit as was previously proposed and

the specimen is reassigned to *D. platygnathus*. Late Triassic beds in the basin include large specimens of *Ischigualastia jenseni* (Ischigualasto Formation) and *Jachaleria colorata* (Los Colorados Formation). Accordingly, dicynodonts constituted a diverse group of herbivorous tetrapods during the Triassic in this part of Gondwana and since they first appeared in the earliest Triassic of Argentina they were already diversified and represented by both small (shansiodontids) and large (kannemeyeriids) forms. Also as a result of the present revision, closest affinities of the Argentinian dicynodonts are found with those taxa of the Lower-Middle Triassic of southern Africa and Late Triassic of southern Brazil.

Molecular Tools in Paleobiology: Trees, Clocks and linking Geno- with Phenotype, Friday 9:00

**CALIBRATING AND CONSTRAINING THE MOLECULAR CLOCK**

DONOGHUE, Philip, University of Bristol, Bristol, United Kingdom; BENTON, Michael, University of Bristol, Bristol, United Kingdom; YANG, Ziheng, University College London, London, United Kingdom; INOUE, Jun, University College London, London, United Kingdom

Molecular clocks have rightly usurped the fossil record as the basis of the timescale for evolutionary history. Distinctive anatomical apomorphies of lineages are acquired long after lineages diverge and so the earliest fossil representatives of lineages cannot be recognized as such, and it should come as no surprise therefore that molecular clock estimates of lineage divergences invariably predate fossil estimates. Paradoxically, however, molecular clocks can only be calibrated to evolutionary time using this same seemingly flaky fossil data. Given the nature of fossil minima, these data should not be used directly to calibrate molecular clock analyses but, rather, to provide minimum bounds on lineage splitting events. We have explored the utility of fossil data to derive maximum bounds on lineage divergence events, with minima and maxima enveloping the true time of divergence. To better describe the degree to which these bounds approximate the true date of lineage divergence, we explored the utility of different factors relating to fossil recovery potential and rock record quality, and implemented them as prior probabilities in Bayesian molecular clock analyses. The results of our analyses show that such priors have a major impact on posterior time estimation, highlighting the critical importance of fossil calibrations to molecular dating and the need for probabilistic modeling of fossil depositions, preservations and sampling to provide statistical summaries of information in the fossil record concerning species divergence times.

The Scientific Legacy of Mary Anning — Recent Advances in Marine Reptile Paleobiology and Evolution, Wednesday 9:00

**A NEW MARINE REPTILE ASSEMBLAGE FROM THE AGARDHFJELLET FORMATION (UPPER JURASSIC; TITHONIAN), SVALBARD ARCHIPELAGO, NORWAY**

DRUCKENMILLER, Patrick, University of Alaska Museum, Fairbanks, AK, USA; HURUM, Jørn, Natural History Museum, University of Oslo, Oslo, Norway; KNUTSEN, Espen, Natural History Museum, University of Oslo, Oslo, Norway; NAKREM, Hans Arne, Natural History Museum, University of Oslo, Oslo, Norway

Recent paleontological fieldwork in the Norwegian archipelago of Svalbard reveals the presence of abundant plesiosaur and ichthyosaur remains from the Upper Jurassic Slottsmøya Member of the Agardhfjellet Formation, a 70-100 meter-thick unit of dark grey to black shale and paper shale deposited in an oxygen restricted shallow marine setting on the Barents Shelf. Deposition of the Slottsmøya Member occurred at high paleolatitudes, at or near the Arctic Circle, and molluscan and foraminiferal biostratigraphy indicates a (middle?) Tithonian age for the unit. To date, approximately 40 individual skeletal occurrences have been mapped, of which 10 have been excavated. Interestingly, the specimens are not evenly distributed within the succession; rather, they are restricted to an approximately 30 meter-thick fossiliferous interval in the middle portion of member. Individual skeletons are fully to partially articulated, while bone preservation is variable and often dependent on factors relating to current permafrost conditions. Cranial and postcranial remains of seven ichthyosaurs have been documented, all of which are referable to Ophthalmosauridae. The most abundant remains are those of long-necked plesiosaurs, including two partial skulls and associated postcrania of a *Kimmerosaurus*-like taxon. The partial skeletons of two large individuals (13-15 meters) of the short-necked plesiosaurian taxon Pliosauridae have also been recovered. The Slottsmøya Member assemblage is significant in being one of the most prolific new localities for Mesozoic marine reptiles discovered in recent years, and one of the few known from high paleolatitudes. Temporally, the assemblage is younger than other well known European marine reptile-bearing units of the Callovian and Kimmeridgian (Oxford Clay and Kimmeridge Clay Formations, respectively), and it provides important comparative data with Tithonian-aged marine vertebrates from the Neuquén Basin in Gondwana.

**THE UTILITY OF CAPTIVE ANIMALS IN BITE MARK RESEARCH: A CASE STUDY OF ALLIGATOR MISSISSIPPIENSIS**

DRUMHELLER, Stephanie, University of Iowa, Iowa City, IA, USA; SADLEIR, Rudyard, University of Chicago & Field Museum, Chicago, IL, USA

Captive animals are used extensively in actualistic bite mark studies, but such animals can exhibit novel physical, functional, and behavioral traits that may affect their utility as proxies for wild relatives, much less extinct analogues. Within Crocodylia, qualitative trends toward broader snouts and splayed teeth in captive animals have been reported, and preliminary morphometric analyses have identified other traits reflecting possible paedomorphic tendencies in the ontogeny of the captive cranium. To address how these morphological differences might affect resulting bite marks, eighty-three specimens of *Alligator mississippiensis* representing sixty-three wild and twenty captive animals were observed. Snout shape and individual tooth placement were characterized using 2D, landmark-based techniques and interpreted using a variety of ordination and statistical methods. Results indicate a weak but significant difference between captive and wild individuals, but only if their origin is already known. This implies that at a gross scale, the differences between captive and wild bite marks should not differ with regards to snout shape and tooth spacing. Several attempts to calculate tooth splay were attempted and demonstrated that while tooth angle is being affected by this process, socket location is apparently not. These results indicate that while snout shape and tooth spacing do not introduce significant bias into bite mark studies based on captive specimens, the effects of tooth splay still need further consideration. Until tooth splay can be accounted for, collections of bite marks created by captive crocodylians should be supplemented with and compared to similar bone modifications made by wild animals. This approach provides a case study for future work quantifying differences between captive and wild morphotypes of other taxa used in actualistic taphonomic studies of bite marks.

Technical Session XI, Friday 11:15

**THE LOKONE FAUNA: A NEW OLIGOCENE VERTEBRATE ASSEMBLAGE FROM NORTHERN KENYA (TURKANA BASIN)**

DUCROCQ, Stéphane, IPHEP - UMR 6046 CNRS, Poitiers, France; LIHOREAU, Fabrice, ISEM - UMR 5554 CNRS, Montpellier, France; TIERCELIN, Jean-Jacques, Géosciences Rennes - UMR 6118 CNRS, Rennes, France; BOISSERIE, Jean-Renaud, IPHEP - UMR 6046 CNRS, Poitiers, France

Late Oligocene mammal localities are rare in Africa, being represented only in Ethiopia, Eritrea and Kenya. This part of mammal evolutionary history in Africa is thus still poorly known. Yet, this period is critical because it fills a chronological and evolutionary gap just prior to the Oligo-Miocene faunal turnover, documenting the transition between archaic African and modern Neogene faunas, which resulted from significant exchanges with Eurasian faunas. We report here new Oligocene fossiliferous localities from Lokone in the Lokichar Basin, west Turkana. The Lokone vertebrates belong to at least seven orders of fishes and reptiles and five orders of mammals including phiomysid rodents, hyaenodontid creodonts, saghatherine hyracoids, anthracotheriids artiodactyls and palaeomastodontid proboscideans for which a late Oligocene age has been suggested. Besides the extended geographic occurrence of several taxa and its diversified ecological structure, the Lokone fossiliferous deposits documents the filling stage of the Lokichar Basin as being linked to the earliest stage of the Cenozoic rifting in eastern Africa. The Lokone fauna thus offers a chronological control for the evolution of the Lokichar Basin and will allow us to precise the paleogeographical evolution of eastern Africa during the Oligocene. This fossil assemblage can be considered as a significant landmark in Africa that will help the documentation of the evolutionary history of several groups of vertebrates and will enhance our understanding of the chronology, patterns, and environmental context of faunal exchanges between Eurasia and Africa during the Oligocene.

Technical Session VIII, Thursday 3:15

**ANATOMICAL BOUNDARIES OF THE MIDDLE-EAR SPACE OF ARCHOSAURS-PHYLOGENETIC PATTERNS AND IMPLICATIONS FOR AUDITORY FUNCTION**

DUFEAU, David, Ohio University, Athens, OH, USA; WITMER, Lawrence, Ohio University, Athens, OH, USA

The air-filled epithelial pocket comprising the middle-ear proper has not been well characterized in fossil archosaurs. For many taxa, it is largely an extraosseous structure bounded largely by soft tissues. In contrast, the many named intraosseous pneumatic spaces derived from epithelial diverticula (paratympanic sinuses) are well documented and are characterized by their excavations of the bones of the braincase and suspensorium. Each clade of extant archosaurs displays a different derived condition whereby the middle-ear pocket is enclosed by the bony braincase (birds) or by the braincase and the suspensorium (crocodylians). Within the lineages leading to these crown groups, we see a less-enclosed situation whereby the middle-ear proper is bounded medially by the braincase, laterally by the tympanum, and rostrally by elements of the suspensorium (quadrate and pterygoid), but the rostral, ventral and caudal boundaries of this pocket are less well constrained. We present new data on the form and extent of the middle-ear proper in such focal taxa as ornithischians (e.g., *Stegosaurus*, *Psittacosaurus*, *Triceratops*), basal suchians (e.g., *Desmatosuchus*, *Postosuchus*), sauropodomorphs (e.g., *Camarasaurus*),

and several theropods. In general, the middle-ear sac comprises a space bounded by a bony conch comprised of the wings of the quadrate and pterygoid laterally, and, medially, the braincase caudal to the otosphenoidal crest. The communication between the pharynx and middle-ear sac in crown archosaurs homoplastically occurs via a constricted Eustachian canal. Some stem taxa show a sulcus passing between the basal tuber and the basipterygoid process indicating the Eustachian canal, whereas others show no evidence of a constriction, suggesting a wide passage like that of most squamates. Some clades (theropods) emphasize secondary intraosseous sinuses, whereas others (ornithischians) emphasize having a larger middle-ear proper. The total volume of the middle-ear sac, and the manner in which it communicates with the pharynx has implications for such auditory functional parameters as compliance and resonant frequencies.

Technical Session XI, Friday 10:15

**A DIVERSE NEW EARLY EOCENE (WASATCHIAN-BRIDGERIAN) MAMMALIAN FAUNA FROM THE UINTEA BASIN, UTAH-COLORADO, USA**  
DUTCHAK, Alex, University of Colorado, Boulder, CO, USA

The faunal transition between the early Eocene Wasatchian (Wa) and Bridgerian (Br) North American Land Mammal 'Ages' is characterized by, among other changes, the diversification of several mammalian families, including omomyid primates. This time interval also correlates with the peak of a long-term period of global warming known as the Early Eocene Climatic Optimum (EECO). Fieldwork at Raven Ridge along the northeastern edge of the Uinta basin on the Colorado-Utah border has produced numerous fossil mammal localities in outcrops of the Green River and Colton formations. These localities are distributed through a km of continuous section and document the faunal transition from middle Wasatchian (Graybullian) through early Bridgerian (Br1B) time. The Raven Ridge fauna differs from other known Wasatchian-Bridgerian faunal assemblages in the Greater Green River and Wind River basins of Wyoming in that it is composed primarily of smaller mammals (teeth < 5 mm in length), although larger-bodied taxa such as *Lambdotherium*, *Heptodon*, *Homogalax*, and *Coryphodon* also occur. Preliminary study of nearly 10,000 mammal teeth comprising the Raven Ridge fauna indicates the presence of ~60 mammalian genera representing ~30 families, ranging from equids to miacids to omomyid primates. The hypsodontid 'condylarth' *Hyopsodus* is by far the most abundant taxon in the fauna, comprising roughly 20% of all specimens collected, although ischyromyid and sciuravid rodents and microsyopid primates also are common. The fauna shows a gradual increase in generic diversity throughout the Wasatchian with peak diversity of ~25 genera occurring during the latest Wasatchian (Lostcabinian) and earliest Bridgerian (Br1A). The increase in generic diversity appears to be partly due to a rapid diversification of omomyid primates near the Wa-Br boundary, a scenario also documented in the Green River and Wind River basins. The Raven Ridge fauna presents a unique opportunity to examine a relatively continuous mammalian faunal transition across the Wa-Br boundary, which coincides with one of the warmest intervals of the Paleogene.

Poster Session II, (Thursday)

**LARGE EUROPEAN CRETACEOUS ENANTIORNITHINES: MORPHOMETRICS, PHYLOGENETICS AND IMPLICATIONS FOR THE BIOGEOGRAPHY OF EARLY BIRDS**

DYKE, Gareth, University College Dublin, Dublin, Ireland; OSI, Attila, Hungarian Academy of Sciences - Hungarian Natural History Museum, Budapest, Hungary; BUFFETAUT, Eric, CNRS (UMR 8538), Laboratoire de Géologie de l'École Normale Supérieure, Paris, France

We review historical approaches to the systematics of Enantiornithes, the dominant birds of the second half of the Mesozoic, and discuss the known fossils of several large taxa from the European Late Cretaceous. These fossils, although comprising incomplete specimens, are hugely important to our understanding of avian evolution because of their age and biogeographic implications.

Large enantiornithine taxa are currently known in Europe from Late Cretaceous deposits of southern France and western Hungary. Fossils from the Santonian Csehánya Formation, Bakony Mountains of Hungary plug a temporal gap in the Cretaceous avian record and are referable to Avisauridae, with a largely unfused foot morphology similar to the Argentine Soroavisaurus and to the North American *Avisaurus*. Specimens from the Masecap locality close to the village of Cruzy in Hérault, southern France are euenantiornithine, anatomically indistinguishable to elements from New Mexico (USA) and the Argentine locality of El Brete (Salta Province, Patagonia). European records testify to the global distribution (Gondwana and Laurasia) of large flighted euenantiornithine birds by the Late Cretaceous.

We add the known European records to morphometric and stratigraphic analyses that encompass the fossil record of enantiornithines. Analyses of fossil record dynamics show that enantiornithine 'collectorship' since the work of Cyril Walker in the 1980s approaches an exponential distribution, indicating that an asymptote in proportion of specimens has yet to be achieved. Data demonstrate that the fossil record of enantiornithines is complete enough for the extraction of biological patterns. Comparison of the available fossil specimens with a large data set of modern bird (Neornithes) limb proportions also illustrates that the known forelimb proportions of enantiornithines fall within the range of extant taxa; thus these birds likely encompassed the range of flight styles of extant birds. In contrast, most enantiornithines had hindlimb proportions that differ from extant taxa.

Poster Session II, (Thursday)

**RESOLVING SEASONAL STRESS IN THE LATE MIOCENE HOMINOID  
*HISPANOPITHECUS LAIETANUS* THROUGH THE ANALYSIS OF THE DENTAL  
DEVELOPMENTAL DEFECT LINEAR ENAMEL HYPOPLASIA**

EASTHAM, Laura, University of Toronto, Toronto, ON, Canada; SKINNER, Mark, Simon Fraser University, Burnaby, BC, Canada; BEGUN, David R., University of Toronto, Toronto, ON, Canada

In Western Europe the Vallesian Crisis determined the extinction of several mammalian taxa characteristic of the previous middle Miocene faunas, including most of the hominoids that settled successfully in Europe during the middle and early late Miocene. It is suggested that the extinction of the late Miocene Western European hominoids was not related to the spread of grasses, but to a significant increase in climatic seasonality and subsequently the deciduous component of the vegetation. Both the morphology and life history pattern of *Hispanopithecus laietanus*, a small bodied hominoid from the late Miocene locality of Can Llobateres in the Vallès-Penedès Basin of Northeastern Spain, suggest it would have been susceptible to malnutrition during seasonal fluctuations in resource abundance. Dental enamel provides an indelible archive of metabolic and physiological stress during development. Linear Enamel Hypoplasia (LEH) is the most common hypoplastic defect, and is distinguished by a marked horizontal or nearly horizontal area of decreased enamel thickness. The patterning of LEH in extant hominoids suggests that they experience metabolic disruption seasonally. Here we examine the periodicity and duration of successive LEH defects, in a sample of anterior teeth from *H. laietanus*. Results indicate a regularly occurring annual periodicity of stress experienced by *H. laietanus*, with the duration of physiologically stressful periods comprising approximately 3 months. This suggests that out of every year, approximately 3 months were sufficiently physiologically stressful to impact enamel formation. The annual periodicity of stress shown in this hominoid supports the theory of a 'dietary factor', as the cause of the decline of Western European hominoids during the late Miocene. This study provides new insight into the role of climatic change in early hominoid evolution.

Technical Session XI, Friday 11:00

**BIOGENIC PATTERNING OF SR AND BA IN EARLY OLIGOCENE (ORELLAN)  
MAMMALIAN TOOTH ENAMEL**

EBERLE, Jaelyn, University of Colorado, Boulder, CO, USA; SPONHEIMER, Matthew, University of Colorado, Boulder, CO, USA; MARCHITTO, Thomas, University of Colorado, Boulder, CO, USA

Trace element analysis (e.g., Sr/Ca and Ba/Ca) of mammalian tooth enamel and bone has been used to distinguish amongst dietary niches (i.e., browsing, grazing, and carnivory) in modern and Plio-Pleistocene faunas. However, with growing concerns about diagenesis, it is unclear whether ecological patterning of Ba and Sr is preserved in deep time (i.e., tens of millions of years). To this end, we determined the Sr/Ca and Ba/Ca ratios in early Oligocene (Orellan; ~32–33 Ma) teeth of the horse *Mesohippus*, the artiodactyls *Leptomeryx* and *Merycoidodon* (oreodont), and the small canid *Hesperocyon* from UCM locality 77271 in the Brule Formation, White River Group of Nebraska. Ten specimens of each taxon were sampled for trace element analysis. All taxa (except *Leptomeryx*) are readily distinguishable from one another when both Sr/Ca and Ba/Ca ratios are considered. *Hesperocyon* teeth record the highest Ba/Ca values of the four taxa, which may seem surprising given that modern carnivores typically have lower Ba/Ca than the herbivores they consume. However, based upon its small body size and scansorial habit that others have inferred from skeletal material, *Hesperocyon* seems unlikely to have preyed upon the larger terrestrial herbivores included in this study. The artiodactyls and perissodactyls are also statistically different. This preliminary study suggests that biogenic patterning of Sr and Ba can be preserved in early Oligocene mammals. Interpretation of such biogeochemical signals is complicated given our limited understanding of trace element patterning in modern ecosystems, but these initial results suggest that further investigation of this potential paleoecological indicator is warranted.

Poster Session III, (Friday)

**THE BARUUNGOYOT-NEMEGT TRANSITION (UPPER CRETACEOUS) AT THE  
NEMEGT TYPE AREA, NEMEGT BASIN, SOUTH CENTRAL MONGOLIA**

EBERTH, David, Royal Tyrrell Museum, Drumheller, AB, Canada; BADAMGARAV, Demchig, Mongolian Academy of Sciences, Ulaan Baatar, Mongolia; CURRIE, Philip, University of Alberta, Edmonton, AB, Canada

The Baruungoyot and Nemegt formations interfinger through a minimum of 23 meters of stratigraphic section at Nemegt, the Nemegt Formation type locality. This interfingering interval comprises the lower one-half of the Nemegt Formation's stratigraphic exposure in the area. The interfingering formational contact, as well as an upsection increase in conglomeratic sediments in the Nemegt Formation are evidence for progradation of the Nemegt clastics. We infer that during Nemegt "time," uplift in the paleo-Altan Nemegt source area increased both sediment supply and the depositional gradient, which, in turn, decreased accommodation. Decreased accommodation resulted in a preservational bias for Nemegt channel and sheet flood deposits. During progradation, a multi-kilometer-wide Nemegt channel belt episodically shifted its position to the southeast, and occasionally backstepped to the northwest, thus leaving a succession of interfingering Baruungoyot and

Nemegt tongues in the stratigraphic record. The channel belt hosted medium-size channels (~6 m deep; 75 m wide) in which flow was to the southwest, parallel to the paleo-Altan Nemegt. Southeast of the channel belt, seasonally wet-dry to arid central-basin environments of the Baruungoyot Formation persisted during the time represented by the interfingering interval. The interfingering interval is the most vertebrate-fossil rich part of the stratigraphic section (Nemegt channel belt tongues in particular). Rich fossil occurrences and formation-specific faunas in this interval indicate that the Nemegt and Baruungoyot vertebrates from this interval co-existed in time, but occupied mostly separate habitats.

Technical Session XVII, Saturday 2:00

**THE FIRST SEMI-AQUATIC SYNAPSID FROM THE EARLY JURASSIC OF  
ARIZONA**

EGBERTS, Sebastian, Vertebrate Paleontology Laboratory, The University of Texas at Austin, Austin, TX, USA; ROWE, Timothy, Vertebrate Paleontology Laboratory, Austin, TX, USA; SUES, Hans-Dieter, Smithsonian Institution, National Museum of Natural History, Washington, DC, USA; LUO, Zhe-Xi, Carnegie Museum of Natural History, Pittsburgh, PA, USA; JENKINS, Farish, Museum of Comparative Zoology, Harvard University, Cambridge, MA, USA

A recently discovered new fossil of *Kayentatherium* from the Lower Jurassic Kayenta Formation, Arizona, provides the first evidence for a highly adapted semi-aquatic mode of life in tritylodontid cynodonts (Synapsida, Amniota), and reveals a wider range of ecological diversity in the cynodont-mammal transition. The specimen consists of the articulated posterior skeleton, preserved in situ with the last three trunk vertebrae, the pelvis, both hind limbs, and a complete tail of all 29 vertebrae. The caudal vertebrae show laterally expanded transverse processes and caudals 8 through 16 possess laterally bifurcated transverse processes. The vertebral centra are dorsoventrally flattened and laterally expanded. The posterior end of the tail, including the last eight vertebrae, is bent ventrolaterally, forming a half-circle. The hemal spines are oriented in a 90° angle to the hemal arch, running parallel to the vertebral column. The hemal spines form a long anterior process that underlies more than half of the preceding anterior centrum, and a short posterior process. The morphology and relatively large size of the hemal arches and spines imply major muscle attachments for the ventral tail musculature, permitting a strong down stroke of the tail. Compared to the hemal arches, the dorsal side of the caudal vertebrae shows diminutive neural arches. Overall, *Kayentatherium* is most similar to the placentals *Castor* and *Lutra* in the highly characteristic caudal vertebral features for specialized propulsion by dorso-ventral undulation in swimming. It is also similar to the semiaquatic monotreme *Ornithorhynchus* in certain tail characters. *Kayentatherium* is similar to the docodont *Castorocauda*, which was interpreted to be a swimmer by its broad scaly tail, although it predates the latter by at least 30 million years. Our discovery demonstrates a more diverse range of locomotion and behavior in synapsids than previously expected, and suggests that the mammal-like semiaquatic adaptations evolved convergently, prior to the rise of living mammals.

Poster Session II, (Thursday)

**DOES INTERNAL STRUCTURE OF LIMB BONE ARTICULATIONS CORRELATE  
WITH LOCOMOTOR BEHAVIOR? OBSERVATIONS ON THE DISTAL HUMERI  
OF PRIMATES AND CARNIVORANS**

EGI, Naoko, Kyoto University Primate Research Institute, Inuyama, Japan; NAKATSUKASA, Masato, Kyoto University Graduate School of Science, Kyoto, Japan; OGIHARA, Naomichi, Keio University Graduate School of Science and Technology, Yokohama, Japan

Internal structure, in addition to external shape, of limb bone articulations has been assumed to correlate with animal's locomotion although observations on internal structure have been rare and have been limited to a small number of taxa. This study examined internal structure of the distal humeral articulation of primates and carnivorans, and evaluated correlations between interspecific variations of internal articular structure and locomotor behaviors. The sample consists of 18 and 15 species of small to medium-sized primates and carnivorans, respectively. Distal humeri were scanned using a peripheral Quantitative Computed Tomography scanner with a 0.05 mm voxel size. Observations were made based on the CT images. The following measurements were taken from the capitulum, the trochlear groove, and the anterior trochlea: cancellous and cortical bone volumes, cancellous bone volume fraction (volume-based bone density), and overall orientation and degree of anisotropy of trabeculae. First, our results indicated that cancellous bone volume is greater relative to body mass in cursorial carnivorans and terrestrial primates than in others. On the other hand, lorissid primates, which exhibit slow quadrupedal arborealism, have relatively thicker cortical shell. These suggest that amounts of articular cortical bone and cancellous bone relative to body size are not constant among species, and that they correlate with locomotor behaviors in both carnivorans and primates. Second, high intraspecific variation rather than interspecific variation were found in cancellous bone volume fraction. Third, trabeculae of the distal humeri develop better in the parasagittal plane, reflecting the hinge movement of the elbow joint. Interspecific variation of the trabecular orientation is not prominent in the mono-axial hinge joint, but it is possible that variations in trabecular orientation and anisotropy in tri-axial joints reflect differences in joint movements and locomotor behaviors. These variations of internal articular structure were found in both carnivorans and primates, and they are likely to be applied in other extant and extinct mammals of the similar body size.

**ORIGIN OF THE WHITE SHARK (*CARCHARODON*), BASED ON RECALIBRATION OF THE LATE NEOGENE, PISCO FORMATION OF PERU**  
EHRET, Dana, Florida Museum of Natural History, Gainesville, FL, USA; MACFADDEN, Bruce, Florida Museum of Natural History, Gainesville, FL, USA; JONES, Douglas, Florida Museum of Natural History, Gainesville, FL, USA; DEVRIES, Thomas, Burke Museum of Natural History and Culture, Vashon Island, WA, USA; SALAS-GISMONDI, Rodolfo, Museo de Historia Natural, Peru, Lima, Perú

The phylogenetic origin of the white shark, *Carcharodon*, is a highly debated subject. Based on genetic and morphologic data, previous studies have suggested that the genus is either the sister taxon to the megatoothed (*Otodus* and *Carcharocles*) or the extinct 'mako' sharks (*Isurus/Cosmopolitodus*). The extinction of megatoothed sharks in the late Pliocene, coupled with the generally poor preservation of articulated shark specimens in the fossil record, makes the phylogeny of the extinct lamniforms difficult to resolve. Here we provide strong evidence that *Carcharodon* is the sister taxon to *Isurus/Cosmopolitodus* based on a definitive transition from *Isurus (Cosmopolitodus)* to *Carcharodon*, including an exceptionally well-preserved specimen demonstrating this change. We also provide new age data for the Pisco Formation, Peru using Zircon radiochronology and Strontium-ratio isotopic analysis. Relevant teeth from the Pisco Formation clearly show characters of both *Carcharodon carcharias* and the fossil *Isurus (Cosmopolitodus) hastalis*. Characters diagnostic to *Carcharodon* include the presence tooth serrations and a symmetrical first upper anterior tooth that is the largest in the tooth row, while those indicative of *Isurus/Cosmopolitodus* include a mesially slanted intermediate tooth. The calibration of critical fossil localities (including Sud Sacaco West) within the Pisco Formation places this transition in the late Miocene at 6-8 Ma, not the early Pliocene at 4-5 Ma as previously reported. The results of this study also refute the record of a white shark tooth from the middle Miocene of Maryland, while validating numerous reports of late Miocene/early Pliocene specimens from the Pacific basin. This research therefore revises and elucidates lamnid shark evolution based on the calibration of the nearshore marine sequence of the late Neogene Pisco Formation.

Poster Session II, (Thursday)

**ARMATURE DAMAGE IN A MOUNTED SPECIMEN**  
EVANDER, Robert, American Museum of Natural History, New York, NY, USA

AMNH 11262 is a skeleton of the glyptodont *Hoplophorus ornatus*. This skeleton was mounted, without the carapace, by Adam Hermann in 1918. Although we have a published account of Hermann's mounting technique, it is necessary to reverse engineer the mount in order to understand the condition of the specimen. The mounting process began with the development of internal supports that link the bones of each limb. These internal supports are mostly wires plastered into holes drilled into the articular surfaces between bones. These wire and bone limbs were then stiffened by the addition of plaster to all the joint spaces. A quadrupedal external armature was shaped and attached to a wooden base. Finally, the limbs were attached to the armature using another set of holes drilled through the bones. Importantly, the mounting of this specimen involved generous numbers of drill holes perforating poorly-mineralized bones. A detailed damage report on this specimen reveals some of the resulting problems. Many digits of the feet demonstrate bone breakage away from the wires that run down the axes of the digits. The right ilium displays a wide break that follows the armature in both directions from a screw hole. A break in the third cervical bone passes through a screw hole. The break in the right tibia is maintained at an offset of 10 mm by the armature. A break in the left femur cannot be reduced because of armature offset. The left femur also has a conchoidal fracture placed directly over the bend in bolt that passes through the neck of the femur. A screw head on the left ischium is surrounded by radiating cracks. In sum, this damage report demonstrates an unhappy association between damaged bones and adjacent portions of the armature. A hypothesis of armature damage is the most reasonable explanation for most of the damage that is present in this specimen. Multiple repairs to some of these breaks suggest that this problem is of long standing. The mounting process significantly destabilized this specimen. The armature has caused, and will undoubtedly continue to cause, the deterioration of the bones of this skeleton.

Poster Session II, (Thursday)

**PATTERNS AND CONSTRAINTS IN CARNIVORAN AND RODENT DENTAL COMPLEXITY AND RELATIVE TOOTH SIZE**  
EVANS, Alistair, Monash University, Melbourne, Australia; JERNVALL, Jukka, University of Helsinki, Helsinki, Finland

It has been known for centuries that general tooth shape correlates with diet in mammals. Our previous work quantified one aspect of this relationship, showing that the 3D complexity of cheek tooth rows is a robust measure of broad diet in carnivorans and rodents. This used a measure of tooth complexity termed orientation patch count (OPC). Here, we extend this to investigate patterns of dental complexity of individual teeth along a tooth row.

Within the rodents, there is a consistent pattern of decreasing OPC from anterior to posterior along the tooth row for all of the diet categories. However, the more herbivorous the diet is, the greater the OPC for each single tooth. The story is quite different for the carnivorans, where there is much more diversity in terms of variation within a tooth row and differences in patterns between the diets. This greater diversity in carnivoran tooth form and complexity

is shown even more strikingly from the relative complexity vs relative area data, i.e. the relative density of features on the tooth is quite constant within rodents but very variable in carnivorans.

Therefore, rodent dentitions appear more constrained, not just in the number of teeth in a row but also in variation of dental complexity along the row. This corresponds with the constraint in relative tooth sizes along the row, as illustrated by the inhibitory cascade model. The carnivorans show some deviation from the strict inhibitory cascade rule, with most of the species falling some distance from the line. However, there is a relationship between the strength of the inhibitory cascade and the dental complexity. This relationship is particularly strong for carnivorans, with the *Ursus* species being the main exceptions. We suggest that changes in tooth size and proportions (through the inhibitory cascade) are incidental with respect to ecology, and reflect the way dental complexity changes in response to evolving dietary preferences.

The Scientific Legacy of Mary Anning — Recent Advances in Marine Reptile Paleobiology and Evolution, Wednesday 8:15

**PLESIOSAUR DISCOVERIES, OLD AND NEW, FROM THE LOWER JURASSIC OF ENGLAND.**  
EVANS, Mark, Leicester Museums and Galleries and University of Leicester, Leicester, United Kingdom

Two recent plesiosaur discoveries are described; one of significance in the history of plesiosaur research, and one which aids resolve the structure of the basicranium.

Mary Anning discovered the holotype of *Plesiosaurus dolichodeirus* in 1823, but the genus was established on disarticulated material. The key specimen from this paper, believed to have been collected by Mary Anning, has recently been rediscovered in the Oxford University Museum of Natural History. The specimen confirms Conybeare's later observation that the arrangement of paddle bones was partly artificial; this had influenced his reconstruction of the paddle, and his choice of name for the new genus.

The second discovery, a skeleton about 3 meters long representing a previously undescribed taxon, is from the Luridum subzone (Lower Pliensbachian) Charmouth Mudstone Formation of Blockley, Gloucestershire, UK. The braincase is uncrushed and preserved in 3 dimensions. CT scans show that the parasphenoid sheaths the poorly ossified basisphenoid ventrally, and that an anterior process of the basioccipital is exposed anterior to an interpterygoid suture. The parasphenoid formed robust lateral connections with the basioccipital and pterygoids. This morphology is very similar to that of *Rhomaleosaurus megacephalus*, and is widespread in early plesiosaurs. The posterior extension of the parasphenoid and the anterior basioccipital process have been regarded as the basisphenoid by others. Discrete lateral processes of the parasphenoid contacting the basioccipital and pterygoids have been identified as cristae ventrolaterales, an interpretation has not been universally accepted. Conflicting identities of basicranial bones among plesiosaur workers is hampering a consensus in interpretation of this region. A solution to this is to consider the anterior part of the basicranium as a conjoined parabasisphenoid, as is the practice in the study of some other saurosid groups. The creation of a set of landmarks, the recognition of which is independent on any particular parasphenoid/basisphenoid model of basicranial structure is proposed.

Late Triassic Terrestrial Biotas and the Rise of Dinosaurs, Thursday 11:00

**GUAIBASAURIDAE, A NEW CLADE OF TRIASSIC BASAL SAUROPODOMORPHS**  
EZCURRA, Martin, Museo Argentino de Ciencias Naturales, Buenos Aires, Argentina; NOVAS, Fernando, Museo Argentino de Ciencias Naturales, Buenos Aires, Argentina

The family Guaibasauridae was coined as a monospecific entity composed by *Guaibasaurus candeliariensis* from the Norian Caturrita Formation of Brazil. Since then, the phylogenetic position of *Guaibasaurus* remained controversial, being alternatively interpreted as a basal saurischian or a basal theropod. Nevertheless, a new cladistic analysis depicts *Guaibasaurus* as closely related with *Panphagia*, *Agnosphitys*, *Saturnalia*, and two yet undescribed forms from Argentina and India. We employ the term Guaibasauridae for the monophyletic clade gathering these Late Triassic taxa, which lies at the base of Sauropodomorpha. In particular, *Guaibasaurus* is for the first time included within Sauropodomorpha, supported by the presence of proximal caudal vertebrae with the base of the neural spine anteroposteriorly longer than half the length of the neural arch, ilium with strongly laterally curved blade and elongated pubic peduncle, and ischial shaft triangular-shaped in cross-section. Features supporting the monophyly of Guaibasauridae include: ilium with incipiently open acetabulum, elongated postacetabular process, femur with proximal anterior trochanter at level with femoral head, and tibial distal end with concave posterolateral corner. Contrarily to recent interpretations, *Panphagia* is not depicted as the most basal sauropodomorph, and characters supporting its original assignment are more widely distributed among basal saurischians (distally curved anterior dentary teeth and sub-circular distal ischium) or misinterpreted (symmetric proximal tibial condyles). Accordingly, Guaibasauridae is interpreted as a large monophyletic clade of early dinosaurs, which radiated during late Carnian-Norian times and attained a wide geographic distribution. Furthermore, no large monophyletic clades were previously recognized among basal dinosaurs, and Guaibasauridae constitutes the first evidence of a large clade which radiated apart from the branch leading towards Jurassic and Cretaceous taxa, in this case the sauropod lineage.

#### DENTAL WEAR ON HOLOCEPHALAN TEETH

FAK, Fabrice, 6 carrière Rasson, Wattrelos, France; DERYCKE, Claire, Université Lille 1, Laboratoire Géosystèmes (UMR 8157 CNRS), UFR des Sciences de la Terre, Villeneuve d'Ascq, France

Reconstructing diet of extinct mammals was first based only on dental morphology. But since the middle of the nineteenth century, wear marks on the surface of teeth were observed on SEM. Wear features can be generated on the surface of teeth during food consumption by two types of contacts: tooth/tooth contact and tooth/food contact. We wanted to put in evidence dental wear for the first time among Paleozoic early vertebrates (Tournaisian) with holocephalan isolated teeth belonging to the Cochliodontiformes and Copodontiformes. Contrary to elasmobranchs which present several generations of teeth during life, extant holocephalans have got only one generation of crushing-teeth which grow continuously. Because teeth stay in the mouth during the entire life, we can expect that dental wear will represent a typical diet. There is no tooth/tooth contact and a minimal tooth/food contact among holocephalans. Dental microwear can be generated only by contact with two items: the food or a new item the sediment. Extant holocephalans are durophagous, they eat essentially bivalves and at the same time swallow sediment. Due to their hardness, bivalves shelves (in calcite) cannot scratch the teeth (in apatite), but the sediment must contribute to the creation of wear marks. Wear traces will also depend on tissue density, on microstructural orientation of fibers. For example, abrasion is more rapid when fibers are parallel with the surface and less rapid when perpendicular. First analysis reveal crossed scratches on the surface of teeth which can be correlated to a durophagous diet and a vertical movement of mastication. Then, the distribution of the orientation of features is not homogenous, which indicates a contact with a hard item, like sediment. Finally, this dental microwear can be correlated to a crushing movement of the jaw and associated to the influence of the sediment.

Technical Session XVI, Saturday 10:15

#### IMPLICATIONS FOR THE ECOLOGY OF MID MIOCENE SCHIZOTHERIINAE (PERISSODACTYLA: CHALICOTHERIIDAE) BASED ON NEWLY DESCRIBED MATERIAL FROM SOUTHERN GERMANY

FAHLKE, Julia, Steinmann-Institut für Geologie, Mineralogie und Paläontologie, Universität Bonn, Bonn, Germany; COOMBS, Margery, Department of Biology and Graduate Program in Organismic and Evolutionary Biology, University of Massachusetts, Amherst, MA, USA

Within the Chalicotheriidae (claw-bearing perissodactyls) are two subfamilies, the Chalicotheriinae and Schizotheriinae. In the late early to middle Miocene of Europe, the Schizotheriinae have been represented by *Metaschizotherium bavaricum* (MN 5-6) and the formerly only poorly known *M. fraasi* (MN 7). When new material of *M. fraasi* was discovered in MN 6 karst fissure fillings at Petersbuch, Franconian Alb (Southern Germany), many cranial and postcranial elements could be described for the first time and compared with *M. bavaricum* and other derived schizotheriines. Now that the morphological studies have been completed, more comprehensive analyses of distribution, faunal associations, and dietary reconstruction are possible, allowing new insight into schizotheriine ecology. *M. bavaricum* is known from localities of the Upper Freshwater Molasse (e.g. Häder and Sandelzhausen, MN 5) which are characterized by humid conditions and dense vegetation. *M. fraasi* occurs on somewhat drier karstic limestone plateaus (Petersbuch, MN 6, and Steinheim, MN 7) where the habitat is supposed to have been more open. Thus the occupation of slightly different ecological niches can be expected. This assumption is supported by microwear data. Although the chalicotheriine genus *Anisodon* is also well-known from the European MN 6 and sometimes co-occurs with *Metaschizotherium* (e.g. Stätzling, Thannhausen), large assemblages of either *Anisodon* (Sansan, Neudorf) or *Metaschizotherium* (Petersbuch) seem to exclude the presence of members of the respective other subfamily. Although *Metaschizotherium* had body proportions quite different from those of *Anisodon*, it was probably able to erect itself on the hind limbs and use its hands with the hook-like second digits and large claws to tear down branches or strip off leaves or fruit. Nonetheless, because of partial fusion of the ulna and radius, rotation of the forearm was impossible. The almost unworn lower incisors of *Metaschizotherium* were probably not employed directly in food foraging.

Poster Session IV, (Saturday)

#### ONTOGENETIC TRENDS IN EARLY SPHENACODONT SYNAPSIDS, AND THEIR BEARINGS ON SPHENACODONT SYSTEMATICS AND INTERRELATIONSHIPS

FALCONNET, Jocelyn, Muséum National d'Histoire Naturelle, Paris, France

Sphenacodontia are a major clade of synapsids, including Therapsida, and Sphenacodontidae, as well as more basal members. While the former are Middle Permian in age or younger, all other sphenacodonts were found in Late Carboniferous to Early Permian deposits. These early sphenacodonts were intensively reviewed during the 1940's, but since then, their anatomy and relationships were reanalyzed in a cladistic point of view, leading to major changes in their systematics. Besides, several studies demonstrated the essential role played by ontogeny in these synapsids in intra- and interspecific variations. Notable are the decrease of the premaxillary and precaniniform tooth counts, the enlargement of incisors and caniniforms, and the development of the maxillary step and that of the anterior dentary tip during ontogeny. All these features are indeed correlated to a change in the composition of

the diet during growth. The postcranial skeleton is also interesting because it was frequently used to distinguish the different species of *Dimetrodon*. The height and area of their "dorsal sail" vary considerably in this genus, but always as a function of the size of the specimen. In addition, histological studies revealed that the proximal cross-sectional shape of presacral neural spines changes from a dumbbell to a quadrangular shape in some cases. Few authors, however, used these results to discuss the validity of sphenacodont genera and species. Despite such variations, several of these features are still widely used in phylogenetic analyses of early sphenacodont interrelationships, and were even the basis of recently described species.

A brief review of early sphenacodonts is given. The taxonomic status of each species listed is commented in the light of the ontogenetic, intra- and interspecific variations shown to occur within Sphenacodontia. Further recommendations are proposed for future systematic and phylogenetic works on sphenacodonts: 1) revision of the holotype material and, if necessary, designation of neotypes in order to stabilize sphenacodont taxonomy; 2) using independent non-ontogenetically variable characters to comprehend sphenacodont interrelationships.

Poster Session II, (Thursday)

#### TRACKING CRETACEOUS BIRDS ACROSS THE WORLD

FALK, Amanda, University of Kansas, Lawrence, KS, USA; MARTIN, Larry, University of Kansas, Lawrence, KS, USA; BURNHAM, David, University of Kansas, Lawrence, KS, USA

Early Cretaceous bird tracks have been found in North America, China, South Korea, and Japan. The overall morphological and behavioral similarity to tracks left by modern shorebirds, as well as indicators of ground-to-air takeoff, supports the identification of many of these Early Cretaceous tracemakers as ornithurine birds rather than enantiornithines. Behavioral studies based on tracksites in North America and Asia show that Early Cretaceous ornithurine birds acted similar to modern shorebirds, including their methods of feeding and courtship displays. Various morphologies found in Asia, including webbed-footed tracks, anisodactyl tracks, and zygodactyl tracks, indicate a very high diversity of birds. The most common are anisodactyl shorebird-like tracks, represented by *Aquatilavipes*, *Koreanornis*, *Ignotornis*, *Jindongornipes*, and others. Such ichnogenera as *Aquatilavipes* and, more recently, *Koreanornis* have been discovered on both sides of the Pacific Ocean. *Aquatilavipes* has been considered a taxonomic wastebasket for avian ichnologists; *Koreanornis*, however, is much more specific in its distinguishing criteria. The appearance of the same ichnogenera across great distances implies that either ornithurine birds evolved long-distance migration in or before the Early Cretaceous, or that ornithurine birds arose before the Cretaceous. Molecular data support an Early Cretaceous origin for modern bird families and very shorebird-like trackways have been reported from the Early Jurassic of Africa and North America (e.g. *Trisaurpodiscus*), suggesting an even earlier origin for ornithurine birds. Using morphology and behavior to interpret Early Cretaceous bird tracks has furthered our understanding of Mesozoic birds and some aspects of bird origins. Future behavioral studies of Early Cretaceous bird tracksites are needed to interpret the highly diverse avian faunas of North America and Asia.

Technical Session IX, Thursday 3:00

#### DIVERSITY IN FOSSIL VERTEBRATE TRACK ASSEMBLAGES: PRESERVATIONAL BIAS DUE TO SEDIMENT CONSISTENCY AND ANIMAL MASS.

FALKINGHAM, Peter, University of Manchester, Manchester, United Kingdom

The diversity of fossil vertebrate track assemblages is often relatively low. Is this representative of genuine biological and taxonomic factors, or are there taphonomic and ecological biases at work? Experimental work using computer simulation (finite element analysis) was undertaken to test the sedimentological factors affecting preservation potential of vertebrate tracks, with the aim of elucidating potential bias. As one might intuitively assume, larger (heavier) animals leave larger, deeper tracks irrespective of sediment conditions. Not only are such tracks able to withstand weathering and erosion to a greater degree than smaller tracks in the same substrate (thus increasing the chances of being recorded), but the transmission of force into the sediment is much more extensive, creating undertracks on more subsurface layers than a track made by a smaller (lighter) animal, resulting in more potential tracks to be preserved and subsequently discovered. Exploring the mechanical parameters of the substrate shows why assemblages of tracks may be relatively limited in diversity of track geometry and morphology. Assuming homogeneity, a substrate with the consistency required to record tracks of smaller animals may prove to be untraversable for larger animals. Similarly, if a multi-ton animal is producing tracks, it is unlikely that a smaller individual will produce enough force to deform the substrate. Substrates are rarely homogeneous in consistency however, and simulations using values taken from in-situ modern day sediments were also carried out. Commonly, water-side substrates can be considered relatively homogenous beneath a surface few centimeters that are much softer, especially shortly after rain. This may facilitate a track surface containing numerous ichnogenera, but subsequent undertrack surfaces will still be dominated by the largest animals the substrate can support. As such, the mechanical properties of a sediment may, at any given time, limit the tracks that are formed (and subsequently preserved as fossils) according to which animals can safely traverse the area without becoming stuck, and which animals create enough force to produce a track at all.

**STRATIGRAPHY AND VERTEBRATE DIVERSITY OF THE SANTANA FORMATION (LOWER CRETACEOUS, BRAZIL) : TWO CENTURIES OF MISAPPRECIATION**

FARA, Emmanuel, Biogeosciences, Université de Bourgogne, Dijon, France; FEITOSA, Antônio, Universidade Regional do Cariri, Crato, Brazil

Our research aims at explaining the spatio-temporal relationships between paleocommunities and their paleoenvironments in the Araripe Basin (northeastern Brazil) during Aptian/Albian times. We focused on the Romualdo Member of the Santana Formation, a unit that is famous for the abundance and the exceptional preservation of the fossils found in its early diagenetic carbonate concretions. However, after two centuries of scientific activities, a vast majority of these Early Cretaceous fossils lack precise geographical and stratigraphic data. The absence of such contextual proxies hinders our understanding of the apparent variations in faunal composition and abundance patterns across the Araripe Basin. We conducted controlled excavations in the Romualdo Member in order to provide a detailed account of its main stratigraphic, sedimentological and paleontological features near Crato, Santana do Cariri, and Missão Velha (Ceará State). We found several concretion-bearing horizons, and a sample of about 500 concretions shows that only few of them yield the famous well-preserved vertebrates. We distinguish 3 major fish assemblages, whose stratigraphic sequence corresponds to their ranking in terms of diversity. Previous accounts on fossil occurrences in the Romualdo Member were severely biased toward well-preserved and exotic specimens. They are therefore inappropriate for drawing quantitative and robust paleoecological inferences. The factors responsible for the variations in faunal composition and abundance patterns across the Araripe Basin remain largely unknown, but our results suggest that paleogeography might have been paramount over climate.

Poster Session IV, (Saturday)

**A MEDIUM-SIZED THEROPOD FROM THE LATE CRETACEOUS (TURONIAN OR CONIACIAN) OF THE AMBLOBE BASIN, NORTHERNMOST MADAGASCAR**

FARKE, Andrew, Raymond M. Alf Museum of Paleontology, Claremont, CA, USA; SERTICH, Joseph, Stony Brook University, Stony Brook, NY, USA

Recent discoveries from the Upper Cretaceous (Maastrichtian) Maevarano Formation, Mahajanga Basin, northwestern Madagascar, have greatly improved our understanding of life on the island at the close of the Mesozoic. Yet, the temporally and geographically restricted exposures of the unit, combined with the relatively incomplete nature of older Cretaceous fossils from the Ankazomihaboka sandstones, leave many unresolved questions about the faunal composition and timing of the isolation of Madagascar relative to other Gondwanan landmasses. In 2007, paleontological exploration of Upper Cretaceous strata (terrestrial, marginal marine, and marine units) was initiated in the Ambilobe Basin, located at the northern tip of Madagascar near the city of Antsiranana (Diego-Suarez). An associated partial skeleton of a medium-sized theropod, preserving at least five dorsal vertebrae and three dorsal ribs, was discovered and collected. Initial assessment of vertebral morphology supports a tentative referral to Abelisauridae, and complete fusion of neural arches and centra indicates that the individual was skeletally mature. Four caudal dorsal vertebrae possess apneumatic centra, exhibit pneumatic neural arches with divided infradiapophyseal fossae, and compare favorably with *Majungasaurus* in that the transverse processes have concave caudal and convex cranial margins. A cranial dorsal vertebra (?D1) is distinctive, with a pneumatic centrum wider than tall and a cranio-caudally elongated neural spine. Unlike other abelisaurids, the prezygapophyseal facet is smoothly continuous with its ventromedial supporting lamina. The vertebrae are two-thirds the size of comparable elements in *Majungasaurus*, suggesting an estimated body length of approximately 4.5 meters. Thus, the "Diego Theropod" represents one of the smallest abelisaurids yet reported. The horizon from which the specimen was recovered is between early Turonian and late Coniacian in age, making it the oldest associated dinosaur skeleton from the Cretaceous of Madagascar, and likely older than the assemblage from the Ankazomihaboka sandstones (Coniacian, at oldest) of the Mahajanga Basin.

Poster Session I, (Wednesday)

**A PRELIMINARY DESCRIPTION OF AN UNUSUALLY COMPLETE SPECIMEN OF MAMMOTHUS COLUMBI FROM RANCHO LA BREA, LOS ANGELES, CALIFORNIA**

FARRELL, Aisling, George C. Page Museum, Los Angeles, CA, USA; SHAW, Christopher, George C. Page Museum, Los Angeles, CA, USA

Rancho La Brea is one of the world's richest fossil localities of late Pleistocene terrestrial vertebrates. It is generally characterized by high concentrations of asphalt saturated, disarticulated skeletal elements where carnivores outnumber herbivores. Mammoths are rare at the site with ~35 individuals housed in the Page Museum's collections, many represented by single elements. In addition, most of these elements are from a single locality and are poorly preserved. The first record of a near-complete, semi-articulated skeleton of a Columbian mammoth (*Mammuthus columbi*) from Rancho La Brea was recovered during the construction of an underground parking garage on the western edge of Hancock Park in the summer of 2006. The discovery was part of a larger salvage effort at this site which also included 16 additional fossiliferous asphaltic deposits. The specimen is of particular

interest due to its completeness (~80%), its robustness, its pathological elements, and the unique taphonomy that is atypical for Rancho La Brea. Wear patterns on the teeth suggest that it was between 48-50 years old when it died. Several pathologies including 3 broken and healed ribs, arthritis and facial exostoses are evident. The maximum thickness of the deposit was ~40 inches (~1m) and found within a fluvial channel over 35 sq. ft. (10.7 sq. m). Typical preservation is by asphalt saturation, however, for the first time several ribs and part of the right humerus exhibit permineralization. Thus far, there is no evidence of carcass scavenging. There is coincident recovery of thousands of microfossils consisting of algae, plant material, ostracods, insects, molluscs, fish, salamanders, reptiles, birds and rodents. Freshwater molluscs are the most common of the recovered microfossils. Only a single ulna of the sabertoothed cat, *Smilodon fatalis* was recovered from this mammoth locality. This taphonomic evidence suggests a rapid burial, inaccessible to scavengers along a large stream channel.

Poster Session III, (Friday)

**PALEOENVIRONMENTS AND DINOSAUR FAUNAS OF THE LATE CRETACEOUS LOCALITY OF KHERMEEN TSAV, NEMEGT BASIN (GOBI DESERT, MONGOLIA): LATERAL FACIES OR TIME?**

FASTOVSKY, David, University of Rhode Island, Kingston, RI, USA; WATABE, Mahito, Hayashibara Center for Paleobiological Research, Okayama, Japan; TSOGTBAATAR, Khishigjav, Mongolian Paleontological Center, Ulaanbaatar, Mongolia; SANEYOSHI, Mototaka, Hayashibara Center for Paleobiological Research, Okayama, Japan

Khermeen Tsav is the largest Late Cretaceous vertebrate locality in Mongolia. Fossiliferous continental beds there have been divided into ascending two lithostratigraphic units: "Red Beds" and "Upper White Beds." The "Red Beds" reveal dominantly eolian, sedimentation. This unit is characterized by a dinosaur fauna that is reminiscent of Djadokhta faunas, with protoceratopsids and dinosaur eggs and nests. The "Upper White Beds" transitionally overlie the "Red Beds." Dinosaur footprints are preserved in the transitional zone. The "Upper White Beds" are dominated by fluvial sedimentation, with some intercalated eolian units in the middle to upper horizons. The dinosaur assemblage of the "Upper White Beds" is similar to that of the Nemegt, including *Tarbosaurus* (tyrannosaurid), *Gallimimus* (ornithomimid), oviraptorids, alvarezsaurids, and *Tarchia* (ankylosaurid). The eolian beds of the unit yield protoceratopsid, alvarezsaurid, *Gobipteryx* (avian), Mesozoic mammals, and lizards. Small bird-like eggs are also found. In the "Upper White Beds," the fluvial deposits with the Nemegt-like dinosaur assemblage dominate in the eastern part of the locality, while eolian beds are more common to the west. The relationships between faunas and facies seem to suggest that eolian and fluvial environments coexisted, each with a different dinosaur composition. Yet, the two environments and assemblages have historically been considered to indicate sequential time. Here we propose that these dinosaurs coexisted, at least during the beginning of Nemegt sedimentation.

The Scientific Legacy of Mary Anning — Recent Advances in Marine Reptile Paleobiology and Evolution, Wednesday 8:45

**TITHONIAN (LATE JURASSIC) MARINE REPTILES FROM THE NEUQUEN BASIN (NORTHWEST PATAGONIA, ARGENTINA)**

FERNÁNDEZ, Marta, Museo de La Plata, La Plata, Argentina; GASPARINI, Zulma, Museo de La Plata, La Plata, Argentina; DE LA FUENTE, Marcelo, Museo de Historia Natural de San Rafael, San Rafael, Argentina

As part of a research program of Mesozoic marine reptiles of South America, more than thirty years of prospecting in Tithonian sediments of the Vaca Muerta Formation (Neuquén Basin, Northwest Patagonia, Argentina) has resulted in the discovery of a rich assemblage including ichthyosaurs, pliosaurs, metriorhynchid crocodyliforms, and turtles. Ichthyosaurs are represented by *Caypullisaurus bonapartei* and two new ophthalmosaurid taxa. Pliosaurus are represented by *Pliosaurus*; no elasmosaurid taxa have been documented. Turtles are represented by the pleurodire *Notoemys laticentralis* and the cryptodire *Eurysternum neuquina*. Metriorhynchid crocodyliforms comprise two taxa representing both morphological extremes of the clade's diversity: the bizarre top predator *Dakosaurus andiniensis*, and the relatively gracile *Geosaurus araucanensis*. Fossils from the Vaca Muerta Formation are frequently articulated and some exceptionally preserved metriorhynchid remains include internal natural casts of the snout. The great diversity of finds in the Neuquén Basin are significant in that they fill an important paleobiogeographic gap in our understanding of Tithonian-aged marine vertebrates and are crucial for comparisons with age-equivalent assemblages such as those recently found in the Norwegian archipelago of Svalbard. From a taphonomic standpoint, morphological information provided by exceptionally preserved metriorhynchids, such as internal natural casts of the snout, allow for better understanding of soft anatomy details and bring important insights into the key innovations leading to the unparalleled marine specialization of metriorhynchids among archosaurs.

**MEXICO'S QUATERNARY MAMMALS AND BIOTIC PHYSIOGNOMIC CHANGE: A CASE RESPONSE TO ENVIRONMENTAL CHANGE**

FERRUSQUÍA-VILLAFRANCA, Ismael, Instituto de Geología, Universidad Nacional Autónoma de México, México, Mexico; RUIZ-GONZÁLEZ, José, Instituto de Geología, Universidad Nacional Autónoma de México, México, Mexico; DE ANDA-HURTADO, Patricia, Instituto de Geología, Universidad Nacional Autónoma de México, México, Mexico; ARROYO-CABRALES, Joaquín, Laboratorio de Arqueozoología, Instituto Nacional de Antropología e Historia, México, Mexico

Mexico's Recent Biota's biogeographic distribution is a complex tapestry of communities regionally/locally adapted both to the complicated country's geomorphic makeup and climate regime. Noteworthy, tropical and temperate communities ungradationally transcend the Tropic of Cancer. Yet biotic provinces broadly corresponding to the morphotectonic ones are recognizable. The Pleistocene mammal record analysis suggests that the country's current biotic physiognomy, is a recent phenomenon, strongly influenced by the climate change occurred throughout the Pleistocene. Given this, what are the material basis to reconstruct the biotic physiognomy during the Pleistocene? How intense was the physiognomic change? Was it similar across the country? How did it come about? If the terrestrial mammal record is used as a proxy for the whole biota, some answers could be provided. (1) Mexico's Pleistocene mammal fauna includes 13 orders, 44 families, 147 genera and 278 species; the Recent one consists of 10 orders, 34 families, 161 genera and 479 species. Both are numerically comparable, yet the Pleistocene one is more diverse at ordinal and family levels, and has strong time/space biases in favor of Late Rancholabrean data from a few morphotectonic provinces. (2) The environmental changes elicited physiognomic changes resulting from the aggregate individual species responses, which involved distribution area's expansion/contraction, disjunction, migration and extinction. Post-Pleistocene extinction was very uneven across taxonomic groups, but not overwhelming; greater losses largely involved meso- and megabaryc species. (3) Migration occurred both ways: tropical species moved northward through lowland corridors and temperate species migrated southward along both highland and lowland corridors; the Trans-Mexican Volcanic Belt functioned as a barrier, a corridor, and a speciation region. (4) Greater physiognomic changes occurred in and north of the TMVB, mainly involving a loss of "tropicalness," recognized long ago. (5) The heterogeneity of Mexico's mammal record calls for a multiprovince biogeographic/faunal scheme, thus rendering obsolete the prevalent single-province scheme.

Poster Session I, (Wednesday)

**NEW SISISUCHID REMAINS FROM THE CRATO FORMATION (SANTANA GROUP, ARARIPE BASIN) NORTHEASTERN BRAZIL**

FIGUEIREDO, Rodrigo, Museu Nacional/UFRJ, Rio de Janeiro, Brazil; SARAIVA, Antônio, Universidade Regional do Cariri, Crato, Brazil; MOREIRA, João, Universidade Federal do Ceará, Fortaleza, Brazil; KELLNER, Alexander, Museu Nacional/UFRJ, Rio de Janeiro, Brazil

Recent discoveries from South America and Australia suggest that a relevant part of the evolutionary history of Neosuchia, particularly the eusuchian lineage (including the crown-group Crocodylia and all living forms), has taken place in Gondwana during Cretaceous times. Central to this discussion is the small advanced neosuchian *Susisuchus* (Susisuchidae), presently regarded as lying outside the Eusuchia clade. Here we present a new susisuchid related specimen (MPSC-R1136) that provides new anatomical evidences for this taxon. The material consists of a partial postcranial skeleton from the Crato Formation (Aptian-Albian) recovered near Nova Olinda municipality, Ceará State. It comprises of an almost complete sequence of slightly procoelous cervical vertebrae (including the ribs); sagittally segmented osteoderms from the dorsal shield; amphicoelous dorsal vertebrae from the cranial and caudal parts of the trunk; and bones of the right forelimb. The morphology of dorsal shield is formed by at least two paravertebral rows (contrary to the four reported in *Susisuchus*) of sub-square osteoderms and two accessory rows of ellipsoidal scutes at each side of the trunk. The sagittal segmentation of the paravertebral osteoderms in forms with amphicoelous vertebrae (e.g. *Bernissartia*, Las Hoyas neosuchian) is considered a transformational step in the transition to procoely. MPSC-R1136 shows incipiently procoelous cervical vertebrae (poorly known in the holotype of *Susisuchus*), similar to the basal eusuchian *Isisfordia duncani*. The new specimen shares with *Susisuchus anatoceps* and *Isisfordia duncani* at least one diagnostic feature: the proximal and distal articulations of the ulna have about the same width and are thicker with respect to shaft showing that more work is needed to sort out the relationships of those basal eusuchian or eusuchian-like taxa.

Technical Session XIV, Friday 3:30

**THE EVOLUTION OF ENCEPHALIZATION IN THE CARNIVORA (MAMMALIA): ARE LIFE HISTORY VARIABLES AND METABOLIC RATE CORRELATED WITH RELATIVE BRAIN SIZE?**

FINARELLI, John, University of Michigan, Ann Arbor, MI, USA

Increased encephalization, or larger brain volume relative to body mass, is a repeated theme in vertebrate evolution. The first extensive sampling of encephalization in fossil and extant carnivores (164 extant and 125 fossil species) documented clade-specific transformations in encephalization allometries, including independent encephalization increases and decreases.

Additionally, much of the suborder Feliformia and some taxa in Caniformia characterize a basal allometry, defining the plesiomorphic condition for Carnivora. This provided a reference for comparison of encephalization to life history variables and basal metabolic rate (BMR). I removed the confounding effect of body mass through phylogenetically-corrected regressions for six life history variables (gestation time, neonatal mass, weaning time, weaning mass, litter size, litters/year), two composite variables (total litter mass and maternal investment: gestation+weaning time/litter size) and BMR for extant taxa. I then calculated correlations between variable residuals and encephalization residuals from the basal Carnivora regression. Across Carnivora no significant correlations are recovered between encephalization and life history variables or BMR, contradicting prior empirical studies. Bivariate means among family-level subclades were recentered, to test for clade-specific heterogeneity in the correlation coefficient. Correlation values are homogenous across Carnivora, except for gestation time and litters/year. However, recentering uncovers significant correlations for many variables across Carnivora, including positive correlations for maternal investment and total litter mass and a negative correlation with litter size. BMR is not significantly correlated with encephalization. This confirms that maternal energetics plays a significant determinate role in adult encephalization. Additionally, adaptations localized to specific subclades are responsible for obscuring these patterns across Carnivora, implying that under phylogenetic controls, body mass and relative brain size should be useful indicators for inferring aspects of carnivoran biology not readily preserved in the fossil record.

The Evolution of Birds in the Mesozoic: a Symposium in Honor of Cyril A. Walker, Thursday 10:15

**BIRD TRACKS FROM THE UPPER CRETACEOUS CANTWELL FORMATION OF DENALI NATIONAL PARK ALASKA: A NEW PERSPECTIVE ON ANCIENT NORTHERN POLAR VERTEBRATE BIODIVERSITY**

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A paleontological survey of the Upper Cretaceous Cantwell Formation in Denali National Park has revealed an avian biodiversity not previously recognized from coeval vertebrate-bearing rock units found elsewhere in the state or within any other ancient high-latitude formation. This rock unit, which is thousands of meters thick and was deposited near its current latitude, is exposed throughout much of Denali National Park and elsewhere in the central Alaska Range. The Cantwell Formation comprises a lower, dominantly fluvial sedimentary unit and an upper, mostly volcanic unit. Sedimentation of the lower unit was mainly in alluvial fan, braided stream, and lacustrine environments, at times with a marginal-marine influence. Pollen data suggest that these sedimentary rocks are late Campanian or early Maastrichtian in age; thus, the Cantwell Formation is correlative with the well-known dinosaur localities in Alaska. Bird tracks are preserved in three locations along a 27 km transect in the park in fluvial and lacustrine deposits; they are not preserved as a single track assemblage from one bedding plane. Some bird tracks are found in association with dinosaur tracks and others are found on beds interbedded with dinosaur-bearing layers. Based on criteria such as the presence or absence of a hallux, size, track length/width ratios and morphology, the Cantwell Formation contains footprints that can be assigned to at least five ichnotaxa, many of which are previously unrecognized. The approximate body sizes of the birds based on the size range of tracks shows that the birds were sparrow-sized to something that was 25 to 30% larger than a modern Great Blue Heron (*Ardea herodias*). The presence of *Aquatilavipes* isp. in the assemblage, though uncommon, suggests that at least some birds used Alaska as a bridge between Asia and North America. This diverse assemblage of avian traces, combined with the known fossil bone record and invertebrate trace fossil record, demonstrates that the northern Late Cretaceous polar region contained significant biodiversity, including that of birds.

Poster Session I, (Wednesday)

**THE SELACHIAN FAUNA FROM THE NON-MARINE MIDDLE TO LATE TRIASSIC MADYGEN FORMATION (KYRGYZSTAN, CENTRAL ASIA): PRELIMINARY RESULTS**

FISCHER, Jan, Geological Institute, TU Bergakademie Freiberg, Freiberg, Germany; VOIGT, Sebastian, Geological Institute, TU Bergakademie Freiberg, Freiberg, Germany; BUCHWITZ, Michael, Geological Institute, TU Bergakademie Freiberg, Freiberg, Germany; SCHNEIDER, Jörg, Geological Institute, TU Bergakademie Freiberg, Freiberg, Germany

Field work between 2006 and 2008 in the non-marine Middle to Late Triassic (Ladinian-Carnian) Madygen fossil Lagerstätte (Turkistan Mountains, SW Kyrgyzstan, Central Asia) revealed shark teeth and two different egg capsule types. These new finds represent one of few selachian occurrences in freshwater deposits of the Asian Triassic. Capsule type no. 1 is represented by a multitude of compressed and nearly uncompressed specimens, which are referred to *Palaeoxyris* on the basis of their size, shape, and banding characteristics with a rhomboidal surface pattern in flattened specimens. Fossils of this capsule type come from a massive greyish mudstone within the uppermost part of the Madygen Formation in the SW Madygen outcrop area (Urochishche Madygen). These deposits presumably represent fluvial input into a shallowing freshwater lake. Initialized by foregoing finds of *Palaeoxyris*, which are considered as egg capsules of hybodont sharks, micro paleontological processing of matrix samples in 2008 from adjacent horizons, time equivalent to the *Palaeoxyris*

locality, delivered several tiny teeth of the hybodont genus *Lissodus*. Egg capsule type no. 2 from the NW Madygen outcrop area (Urochishche Dzhaylyau-Cho) possesses a cone-like body, is sectioned by two spiral bands with a broad flange (collar), and displays a fine parallel surface striation. It resembles in some features the capsule type *Fayolia* (which has been convincingly related to xenacanthid sharks) but may as well represent a new taxon. Of several specimens recovered from brownish mudstones representing lake deposits, the half is uncompressed. Teeth of the potential producer are still missing. At least two different selachian taxa, *Lissodus* and maybe a xenacanthid shark, used the Triassic freshwater environments of the Madygen Formation as spawning grounds. The spatial and temporal distribution of these selachians within the Madygen succession, their life style, and hence their implications for basin drainage are not yet completely resolved. They question the current hypothesis of an internally drained upland basin, suggesting connection and outflow to lowland basins, or even to the Paleo-Tethys.

Poster Session I, (Wednesday)

#### HIGH DIVERSITY OF LATE EARLY CRETACEOUS ICHTHYOSAURS

FISCHER, Valentin, Liege University, Liege, Belgium; GUIOMAR, Myette, Reserve geologique de Haute-Provence, Digne-les-bains, France; GODEFROIT, Pascal, Royal Belgian Institute of Natural Sciences, Brussels, Belgium

Considered as the last survivors of a dying group, all Cretaceous ichthyosaurs have traditionally been incorporated within a single genus, *Platypterygius*. This waste-basket genus includes large ichthyosaurs with numerous, large and conical tooth crowns and bulbous polygonal root well anchored in dental grooves. With such a dentition, *Platypterygius* can be included within the "Smash guild". However, the study of new specimens from the Aptian-Albian marls of the Vocontian basin (SE France) reveals an unexpected diversity of late Early Cretaceous ichthyosaurs. Beside "classical" *Platypterygius* specimens, another type of ichthyosaur with very tiny and pointed teeth has been found in the mid-Albian marls of Sisteron, in High-Provence Alps. This new taxon is based on a partial crushed skull, two basioccipitals, 8 teeth, and 15 centra. The teeth range from 20mm to 2cm and are highly compressed labio-lingually, with a thickness/width ratio of the root sometimes as low as 1/4. Crowns are slightly curved and sharply pointed, indicating a diet of small and soft preys. Interestingly, although the rostral bones are slender and delicate – thus radically different from conventional Late Early Cretaceous ichthyosaurs – the basioccipital of this taxon shares many characters with *Platypterygius* and is of the same overall size. Together with the recently named genus *Maiaspondylus* from the Albian of western Canada, these specimens suggest a higher diversity of late Early Cretaceous ichthyosaurs, in contradiction with the current view of ichthyosaur extinction, said to be gradually decreasing in diversity since the Middle Jurassic. In fact, the number of ecological niches occupied by ichthyosaurs apparently even increased from the Late Jurassic until the late Early Cretaceous. Therefore, the ecological impact of the Cenomanian-Turonian boundary on marine reptile faunas was probably more severe than previously thought.

Technical Session IV, Wednesday 2:00

#### LIFE HISTORY OF A REMARKABLY PRESERVED WOOLLY MAMMOTH CALF FROM THE YAMAL PENINSULA, NORTHWESTERN SIBERIA

FISHER, Daniel, University of Michigan, Ann Arbor, MI, USA; ROUNTREY, Adam, University of Michigan, Ann Arbor, MI, USA; TIKHONOV, Alexei, Zoological Institute-RAS, Saint-Petersburg, Russia; BUIGUES, Bernard, International Mammoth Committee, Saint Mandé, France; VAN DER PLICHT, Hans, University of Groningen, Groningen, Netherlands

In May 2007, the body of a female woolly mammoth (*Mammuthus primigenius*) calf was found beside the Yuribe River, on the Yamal Peninsula, northwestern Siberia. This specimen, more complete and better preserved than any previously recovered mammoth remains, yielded 14C age estimates of about 41,800 yrBP. This individual died while in excellent health, as shown by thick subcutaneous fat, a distinctive cervical hump with histological traits of brown fat, and abundant milk residues in its intestine. It therefore likely represents normal development for this species. Histological, isotopic, and elemental concentration studies of its developing dentition, non-dental tissues, and intestinal contents were undertaken to evaluate the relation between its dental record of life history and the direct evidence of diet and physical condition provided by the rest of its anatomy. Time of birth is marked by a neonatal line in the dentin of crowns and roots of dP2s, crowns of dP3s, and the still-separate anterior plates of a developing crown of dP4. Age at death was estimated as one month by counting daily dentin increments from the neonatal line to the surface of the pulp cavity in upper and lower left dP2s. The left deciduous tusk had ceased dentin apposition about the time of birth and did not show a neonatal line (and neither permanent tusk had begun to form). Serial sampling of the dentin sequence from the deciduous tusk and dP2s provided a record (1- to 2-month resolution) of about 1.5 years of prenatal development plus the final month of postnatal life. Carbon and nitrogen isotope profiles from dentin collagen show seasonal patterns of variation ( $\delta^{13}C$  range: -22.2 to -21.1‰;  $\delta^{15}N$  range: 8.9 to 9.6‰) typical for a healthy adult female (the calf's mother) in the last year-plus of gestation, followed by a shift toward values expected of a calf feeding on a diet of rich milk. Carbon and oxygen isotope profiles from structural carbonate of dentin hydroxyapatite show patterns (seasonal in oxygen;  $\delta^{18}O$  range: -11.1 to -9.8‰;  $\delta^{13}C$  range: -10.1 to -9.6‰) indicating a spring birth. These findings help validate dental records as a source of data on life history and health status.

Poster Session II, (Thursday)

#### BIOMECHANICAL SIGNIFICANCE OF MORPHOLOGICAL VARIATION BETWEEN THE GRACILE AUSTRALOPITHECUS AFRICANUS (ST5) AND ROBUST AUSTRALOPITHECUS BOISEI (OH5)

FITTON, Laura, University of York, Hull York Medical School, York, United Kingdom; GROENING, Flora, University of York, Hull York Medical School, York, United Kingdom; COBB, Samuel, University of Hull, Hull York Medical School, Hull, United Kingdom; FAGAN, Michael, University of Hull, Department of Engineering, Hull, United Kingdom; O'HIGGINS, Paul, University of York, Hull York Medical School, York, United Kingdom

Considerable variation exists between the craniofacial form of the robust and gracile australopiths. Many of the craniofacial features associated with the robust australopiths are suggested to be related to increased bite force capabilities. However, further dietary evidence e.g. microwear patterns and isotope data in some cases contradict morphological interpretations. Using finite element analysis (FEA) and warping methods this study examines the way in which strain is distributed throughout the skull of the gracile *A. africanus* (ST5) and robust *A. boisei* (OH5) and investigates the biomechanical significance of several morphological features which vary between them. The first stage of the study required an extensive CT-based virtual reconstruction of ST5 and OH5. FE-models of both specimens were created and loaded under incisal and molar biting conditions. In order to test the mechanical effect of morphological differences between the specimens, isolated features of ST5 were warped to reflect the form of structures present in the robust OH5. These features included the position and shape of zygoma, presence/absence of an anterior pillar and the morphology of the supraorbital region. These hypothetical ST5 models with various robust traits were loaded and the mechanical significance of the features identified. The results of this study support prior hypotheses about functional adaptations within the masticatory apparatus of robust australopiths and indicate that unlike the gracile australopiths, the robusts appear to be more mechanically adapted to molar biting while the graciles possess features which increase their ability to more efficiently distribute incisal loads.

Preparators' Session, Thursday 10:15

#### FOSSIL VERTEBRATE RECONSTRUCTION FOR SCIENCE AND THE PUBLIC

FITZGERALD, Erin, University of Chicago, Chicago, IL, USA; SERENO, Paul, University of Chicago, Chicago, IL, USA; KEILLOR, Tyler, University of Chicago, Chicago, IL, USA; ABRACZINSKAS, Carol, University of Chicago, Chicago, IL, USA; MASEK, Robert, University of Chicago, Chicago, IL, USA

Bone, flesh and graphic reconstruction of vertebrate skulls and skeletons can be extended in new directions beyond the usual level of collaboration of scientist, lab technician, artist, web designer, and film-maker. The aim is to make the role and contribution of all of these participants more accessible and interesting to the public at the moment when new discoveries are presented. We take examples from our recent collaboration on several new dinosaurs and crocodylomorphs that will soon appear in papers and in the press. First, molding, casting and skull reconstruction are useful to the scientist in ways beyond mere reproduction. We show how we used a computed-tomography scan of a skull reconstruction to develop an effective skull cross-section when the preserved bones were disarticulated. Second, the steps involved in generating a skull and flesh reconstruction can be documented by time lapse. Third, skull reconstructions and flesh models ensure accuracy in computer graphics in film documentaries. Fourth, flexible flesh models that permit manipulation are useful for scientific observation and as an effective means to explain function. Fifth, coordinating a news release, a film and the launch of a rich, interactive public website created by a community-based organization offers a new model for providing a window onto science in action and what it means to make science accessible to the public.

Poster Session IV, (Saturday)

#### FINITE ELEMENT ANALYSIS OF UNGULATE JAWS: CAN MODE OF DIGESTIVE PHYSIOLOGY BE DISTINGUISHED BY JAW ROBUSTICITY IN EXTANT AND EXTINCT UNGULATES?

FLETCHER, Thomas, University of Bristol, Bristol, United Kingdom; JANIS, Christine, Brown University, Providence, RI, USA; RAYFIELD, Emily, University of Bristol, Bristol, United Kingdom

In order to efficiently deal with cellulose-rich vegetation, different ungulate mammals utilize either rumination in the foregut (e.g. ruminant artiodactyls) or hindgut fermentation in the large intestine (e.g. perissodactyls and hyraxes). Horses (hindgut fermenters) have been observed to chew their food more thoroughly on initial ingestion than cows (ruminants). This leads to the prediction that jaws of hindgut fermenters may be more robust than those of ruminants, and on this basis extinct hindgut or foregut fermenters may be identified in the fossil record. We tested this hypothesis by creating 2D finite element (FE) models of the mandible of six extant pairings of extant foregut and hindgut and hyraxes) fermenters matched for body mass. All models were scaled to the same size, constrained at the condyle and first molar, and loaded with 100 N of muscle force, divided between the temporalis and masseter in proportion to the size of their relative insertion areas. Mean Von Mises stress through the mandible at a mid-point transect of the tooth row was recorded and the two groups compared with a paired t-test. We validated the 2D FE model predictions with a similarly loaded 3D model of a white-tailed deer (*Odocoileus virginianus*). The mandibles of extant hindgut and foregut fermenters differed significantly in robustness ( $P=0.02$ ) with very

little overlap in mean stress values. Six extinct equids (perissodactyls) of varying degrees of hypsodonty were subjected to FE-analysis and all were attributed to the hindgut fermentation group. This study suggests increased mandibular robustness evolved in hindgut fermenters to compensate for extensive oral processing of cellulose-rich vegetation. Digestive physiology is not only an integral feature of the organism's biology, but also has implications for paleoecology. Therefore, future studies examining the relative predominance of ungulate species of different digestive physiology may reflect aspects of the abundance and quality of available vegetation and climatic conditions.

Technical Session XI, Friday 12:00

#### A SYNERGISTIC TIME FRAME FOR EVOLUTION OF GLIRES

FLYNN, Lawrence, Peabody Museum Harvard Univ., Cambridge, MA, USA

Whereas an individual estimate on the date of origin of a taxon is fraught with a host of uncertainties, an estimate based on multiple lines of evidence is more secure. Paleontological uncertainties involve dating, correct attribution of a fossil, and completeness of the fossil record. Incompleteness means that fossil dates will always underestimate actual originations. A high quality fossil record and an accurate phylogeny tend to minimize uncertainty and make observed first occurrences relevant for estimating originations. Also more secure is an estimate made in concert with originations of close relatives. For a well resolved lineage all internal dates must be consistent, and ages of outgroups may indicate probable maxima for splitting events. Outgroups that antedate ingroups suggest that the ingroups had not evolved yet. For a large set of taxa, and given well resolved relationships (cladistic relationships with a high degree of support), age estimates constrain each other. More derived nodes along a single branch have to be younger than more basal nodes. New discoveries could force greater age estimates for lower nodes. A high degree of support for a phylogenetic tree may be achieved by mapping molecular relationships of living taxa onto the same tree. The molecular data constrain and determine branch relationships, and fossil occurrences supply a temporal scale for the tree. Glires relationships, especially Rodentia, illustrate this process. Internal agreement of fossil dates on nodes is promising. Lagomorpha and Rodentia likely split during the early Paleocene, and extant rodent groups originated near the Paleocene-Eocene boundary or later. Within the first five million years of the Eocene, all major rodent groups had diverged: hystricognaths, squirrels plus dormice, beavers plus geomyoids, dipodoids and muroids. Extant muroids diversified in the last 30 million years.

Poster Session I, (Wednesday)

#### EVOLUTION OF THE PALEOGENE SALAMANDRIDS OF EUROPE

FOLIE, Annelise, Royal Belgian Institute of Natural Sciences, Brussels, Belgium; SMITH, Thierry, Royal Belgian Institute of Natural Sciences, Brussels, Belgium; SIGÉ, Bernard, Université Claude Bernard ? Lyon 1, Villeurbanne Cedex, France; SMITH, Richard, Royal Belgian Institute of Natural Sciences, Brussels, Belgium

The salamandrids of the European Paleogene are generally thought to belong to the classical genera *Salamandra*, *Triturus* and *Chelotriton*. For this reason, the precise systematics and evolution of Paleogene European salamandrids are often ignored. We describe two abundant new species from the early Paleocene locality of Hainin (Belgium) that show vertebrae with a high neural spine, an ornamented dermal plate, and antero-posteriorly continuous zygapophyseal crests. These features are characteristic of the genera *Notophalmus*, *Taricha* and *Koaliella*. The short and thick transversal processes and the ornamentation of the dermal plates with pits and ridges allow us to refer these two new northwestern European species to the extant North American genus *Notophalmus*. The two species are distinguished by the size and shape of the ornamented dermal plates. A third salamandrid from Hainin, differing from all known genera and possibly representing a new genus, presents a more common morphology closest to the genus *Salamandra*. Vertebrae with a dermal plate and antero-posteriorly continuous zygapophyseal crests also occur among the salamandrids of the earliest Eocene locality of Dormaal, Belgium and of the early Oligocene locality of Boutersem, Belgium. This particular morphology thus persists during at least 30 million years and permits to recognize a typical endemic lineage in the European Paleogene faunas that lately disappeared from Europe today.

The Scientific Legacy of Mary Anning — Recent Advances in Marine Reptile Paleobiology and Evolution, Wednesday 11:30

#### VERTEBRAL PROPORTIONS IN PLESIOSAURS

FORREST, Richard, University of Leicester, Notts, United Kingdom

Plesiosaurs are remarkable for the extreme elongation of the neck, a trend which progressed independently in several lineages. Vertebral size, proportion and morphology vary within individuals along the vertebral column, ontogenetically and intraspecifically. Proportions of vertebral centra, most commonly vertebral length index (VLI) have been widely used as taxonomic characters in plesiosaur systematics, but have not always applied consistently, reflecting the considerable difficulties in coding a system to account for such variation.

This study sets out to derive mathematical descriptions of the characteristics of vertebral sequences. A dataset has been compiled from measurements by the author, unpublished measurements by others and from the literature. Two principal methods of analysis are presented.

A plot of VLI against the position on the vertebral column shows a relationship between the incremental rate of VLI change in the posterior portion of the cervical series and vertebral morphology, in particular the location of zygapophyses. As this represents different biomechanical solutions to structural problems it is considered to be of taxonomic significance. This analysis also gives evidence for the mobility of pectoral vertebrae. The application of this method is limited by the relative scarcity of more or less complete vertebral columns, and by a lack of clear information on the correct vertebral sequence in many specimens.

A second method was developed to overcome some of these problems. Bivariate plots of principal dimensions in various combinations can be used with less complete datasets and give mathematical descriptions of the pattern of variation as a set of variables. Analysis shows Cryptoclidids falling into a consistent pattern, unlike elasmosaurs in which there is no clear overall trend. The Cryptoclidid curve for specimens of the genus *Muraenosaurus* of different ontogenetic age supports the hypothesis of heterochrony as an important mechanism in their evolution. The inconsistency of the Elasmosaur data may indicate either that this is a paraphyletic grouping, or that different processes are involved in their evolution.

Poster Session I, (Wednesday)

#### THE OLDEST RECORD OF CAIMAN YACARE

FORTIER, Daniel, UFRGS, Porto Alegre, Brazil; BROCHU, Christopher, University of Iowa, Iowa City, IA, USA; SOUZA FILHO, Jonas, UFAC, Rio Branco, Brazil

Caimans represent an endemic Neotropical crocodylian radiation with a controversial number of living species and a poorly-understood fossil record extending back to the Late Paleocene. The record for caimans referable to living species, or closer to one living species than to another, is especially sparse. A partial skull from the Late Miocene Solimões Formation (Acre, Brazil) at the Niteroi locality (Lower Acre River), near Rio Branco municipality, differs from the living black caiman (*Melanosuchus*) and broad-snouted caiman (*Caiman latirostris*) by the presence of a concavoconvex frontoparietal suture. The lateral quadrate hemicondyle is more expanded than in spectacled caimans (*C. crocodilus*) but resembles that of its closest living relative, the yacare caiman (*C. yacare*). The fossil also resembles *C. yacare* in having comparatively small supratemporal fenestrae, laterally expanded postorbitals, and elongate posterolateral processes of the squamosal adjacent to the paroccipital processes. Phylogenetic analysis places the fossil closer to *C. yacare*, and it might even be referable to the modern species as its oldest fossil record, placing a minimum bound on its divergence from *C. crocodilus* between 9 and 6.8 m.y.a.

Poster Session IV, (Saturday)

#### NEW CAPITOSAUR TAXA (AMPHIBIA:TEMNOSPONDYLI) FROM THE MIDDLE TRIASSIC (EARLY-MIDDLE ANISIAN) OF IBERIAN PENINSULA

FORTUNY, Josep, Institut Català de Paleontologia, Cerdanyola del Valles - Campus de la UAB, Spain; GALOBART, Àngel, Institut Català de Paleontologia, Cerdanyola del Valles - Campus de la UAB, Spain; DE SANTISTEBAN, Carles, Universitat de València, Burjassot (Valencia), Spain

During the Triassic period the capitosaurians were one of the most large and diverse groups of temnospondyls, with a wide distribution all over the world. In the Iberian Peninsula, capitosaurians are known from the Triassic – Jurassic boundary of Portugal and from the Middle Triassic non-marine site of Catalonia (Northeastern of Spain). From this latter site, called La Mora, hundreds of bones (cranial and postcranial) have been recovered and mainly referred to as being capitosaur amphibians although it's possible to recognize some reptilian fauna. The Triassic outcrop of La Mora site belongs to the Montseny-Llobregat geological domain, being a paleogeographic unit identified as one of the most eastern subbasins of the Iberian plate. The Buntsandstein facies of the subbasin is composed mainly by sandstones, mudstones and red clays, although both conglomerates and breccia have been locally described. The published papers regarding the magnetostratigraphy and biostratigraphy refer to this area as an early Middle Triassic (early – middle Anisian). Initially, the capitosaur remains were assigned to the waste-basket genus *Parotosuchus* and later suggested to be a stenosaurid and *Eryosuchus* by different authors. Here we assign the capitosaur remains to a new taxa based on the cranial remains originally described, a complete hemimandible and a new undescribed cranial material. A new reconstruction of the skull, using computed tomography, allow us to describe a complete skull characterized especially by a semi-closed otic notch, tabular horns posterolaterally directed, frontal contacting to the orbits, paired anterior palatal vacuities and a well developed PGA. A preliminary cladistic analysis refers the new taxa to the higher capitosaurioids being more advanced than basal forms as *Parotosuchus* or *Odenwaldia* and more related to forms as *Eryosuchus* and *Xenotosuchus africanus* than to cyclotosaurids and paracyclotosaurids.

Poster Session II, (Thursday)

**EVOLUTIONARY TRENDS IN NORTH AMERICAN LAGOMORPHA (MAMMALIA) NEAR THE EOCENE-OLIGOCENE TRANSITION: HETEROCHRONY OF DENTAL CHARACTERS**

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The North American record of Lagomorpha (defined as a clade including common ancestor of *Arnebolagus* from the Early Eocene of Mongolia, all extant Lagomorpha, and all its descendants) lags ca. 10 million years behind the earliest Asian representatives of the group. Nevertheless, the abundance of a precisely dated material allows tracing evolutionary processes displayed in the dentition, with great accuracy. The time-frame from the late Uintan to Chadronian witnesses the greatest revolution in the dental structure of Lagomorpha, triggered by the major climatic changes near the Eocene-Oligocene boundary. The fossil record of lagomorphs from the Uintan-Chadronian interval fully demonstrates the gradual transition from the primitive low semi-hypsodont dentition, displayed by the first North American taxa such as *Procaprolagus*, *Mytonolagus* or *Tachylagus*, through more advanced species still characterized by unilateral hypsodonty such as *Megalagus brachyodon*, and *Palaeolagus* lineage represented in the Chadronian by *P. primus* and *P. temnodon*, to fully hypsodont advanced species, *Chadrolagus emryi*. The main changes occur in the degree of hypsodonty as expressed by the height of the tooth crown, number and arrangement of the buccal roots and their structure, as well as the occlusal pattern of the teeth, particularly of P3 which shows the rapid transition from nonmolarized (in *Procaprolagus*, *Mytonolagus*, *Megalagus*, and *Tachylagus*) to molarized (in *Palaeolagus* and *Chadrolagus*) condition. The detailed analysis of tooth morphology allowed to detect the microevolutionary changes (intra and inter-specific variability and polymorphism), as well as the major character transitions. The Uintan-Chadronian record reveals strong evolutionary heterochrony in lagomorph dentition, especially marked during the Chadronian, when co-occurring representatives of the ancient lineages are about equally abundant as those of advanced groups.

Technical Session XV, Saturday 8:30

**THE GRASPING FOOT OF *DEINONYCHUS*: IMPLICATIONS FOR PREDATOR ECOLOGY, EVOLUTION OF THE PERCHING FOOT, AND A NEW HYPOTHESIS FOR THE ORIGIN OF FLIGHT IN BIRDS**

FOWLER, Denver, Museum of the Rockies, Montana State University, Bozeman, MT, USA

The notorious hypertrophied "killing claw" on pes digit (D) II of the maniraptoran theropod dinosaur *Deinonychus* was hypothesized by previous workers to have been a predatory adaptation for slashing or climbing. This led to the suggestion that *Deinonychus* and other velociraptorines were cursorial predators specialized for actively attacking and killing prey taxa several times larger than themselves. By making comparisons to modern birds of prey, this study offers a new alternative interpretation: that the enlarged claw of *Deinonychus* was functionally analogous to the enlarged talon also found on D-II of extant Accipitridae (hawks & eagles). Here it is used to maintain grip on prey of subequal body size to the predator, while the victim is pinned down by the body weight of the raptor and dismembered by the beak. Further analysis of predatory behavior and talon function in birds of prey reveals more profound implications. Here I propose a new hypothesis for the origin of avian powered flight: that it was exapted from "stability flapping" executed for positioning during the initial stages of prey immobilization. This behavior is employed by accipitrids (keeping the raptor on top of its prey, so it is better able to use its body weight for pinning), and supported by the low aspect ratio wings seen in accipitrids (where this behavior is most commonly observed), *Archaeopteryx*, and many non-avian maniraptoran dinosaurs. In this new interpretation, the evolution of the flapping stroke is decoupled from the evolution of powered flight. Selection for more efficient stability flapping provides a viable selection pathway to true powered flight. Phalangeal proportions and elongation of digits (especially D-IV) in the foot of *Deinonychus* are adaptations towards a grasping function, further support for the accipitrid model of prey restraint. Selection for more efficient grasping ability provides a viable selection pathway for gradual reversal of the hallux. Placed in context of the evolution of flight, the grasping foot of *Deinonychus* and other terrestrial predatory maniraptorans was an exaptation for the grasping foot of arboreal perching birds.

Poster Session II, (Thursday)

**COMPARISONS OF CRANIAL AND MANDIBULAR SHAPE VARIATION IN THEROPODA (DINOSAURIA) AND CARNIVORA (MAMMALIA) USING 2-D SEMI-LANDMARK OUTLINES**

FOX, David, University of Minnesota, Minneapolis, MN, USA; MCNULTY, Kieran, University of Minnesota, Minneapolis, MN, USA; THOMAS, Andrew, University of Minnesota, St. Paul, MN, USA; HEAD, Jason, University of Toronto at Mississauga, Mississauga, ON, Canada

Theropod dinosaurs and carnivorous mammals were dominant, large-bodied terrestrial predators in most Mesozoic and Cenozoic ecosystems, respectively. We analyzed 2-D landmark-based outlines of crania and mandibles in these clades to determine which clade has greater variation in shape. Shape variation could correlate with duration of evolutionary history and taxonomic diversification; trophic diversity in each clade; presence of cranial ornamentation such as horns or crests; differences in the role of the head in prey acquisition

related to body size, positional behavior, and the size and nature of prey species; or degree of oral processing of prey. Crania of 30 theropod and 31 carnivorous species and mandibles of 25 theropod and 30 carnivorous species were digitized from published photographs or line drawings using a digitizing tablet, and semi-landmarks were placed on the outlines using tpsDig2. Configurations were superimposed by generalized Procrustes analysis allowing semi-landmarks to slide to minimize the bending energy across all specimens. Variance in each clade was calculated separately for crania and mandibles as the mean Procrustes distance between each specimen and its clade consensus configuration. Differences in variance were tested with 10,000 replicates of equal-sample permutation tests. Cranial outline shape is significantly more variable in theropods ( $p=0.0002$ ) and variance in carnivorans is only 39% of that in theropods. Variance in theropod crania is mostly due to contrasts between species with tall posterior crania and short rostra and those with dorsoventrally expanded naso-palatal morphology, rather than cranial ornamentation. Variance in outline shape of mandibles, which more closely approximate 2-D objects, is greater in carnivorans ( $p=0.02$ , theopod variance 63% that of carnivorans), possibly due to greater variation in mode of prey acquisition or trophic diversity among carnivorans or more extensive oral processing by mammals. Our 2-D analyses cannot capture the full morphological range in either clade, but our results suggest that further comparisons of dinosaurian and mammalian clades could reveal macroevolutionary patterns.

Preparators' Session, Thursday 10:30

**MOVING VERTEBRATE PALEONTOLOGY COLLECTIONS AND PREPARATION LABORATORY AT THE YALE PEABODY MUSEUM**

FOX, Marilyn, Yale Peabody Museum of Natural History, New Haven, CT, USA; FITZGERALD, Vicki, Yale Peabody Museum of Natural History, New Haven, CT, USA; TURNER, Mary Ann, Yale Peabody Museum of Natural History, New Haven, CT, USA

The Vertebrate Paleontology Collections and Preparation Laboratory at the Yale Peabody Museum of Natural History have long been housed in the basement areas of the Museum and in the basement of the adjacent Kline Geology Labs. Due to much-needed upgrades to the air-handling plant for the Kline Geology building, it was necessary to move the contents of two of our large collection storage rooms, together with offices and part of the Prep Lab from their original locations. We were able to relocate some specimens within our existing storage areas, but a large part of the collection, including footprints, unprepared jackets, and oversize specimens, has now been moved to Yale's West Campus. This site was formerly a production and research facility for Bayer Pharmaceuticals, and was acquired by Yale in 2007. The former manufacturing building, totaling over 300,000 square feet, will provide offsite storage space for several of Yale's library and museum collections, and will also house conservation, research and specimen digitization facilities. This poster will discuss some of our procedures for packing and moving specimens as disparate as the skull of *Torosaurus*, fragile plaster models, and footprint slabs. In addition, solutions developed to deal with the temporary loss of large specimen preparation, and molding and casting facilities in the prep lab will be described. The poster will also explore some of the opportunities emerging at West Campus, and the challenges of managing collections, collection management, and fossil preparation when these activities are split between physically separated sites.

Poster Session I, (Wednesday)

**TOOTH WEAR OF *MYLEDAPHUS* (CHONDRICHTHYES, RAJIFORMES) AS A RESULT OF DUROPHAGOUS FEEDING FROM THE LATE CRETACEOUS FOREMOST FORMATION, ALBERTA, CANADA**

FRAMPTON, Emily, FMA Heritage Inc., Calgary, AB, Canada; HILLS, Leonard, University of Calgary, Calgary, AB, Canada

The Pinhorn Ranch North (PHRN) site is a multigeneric, vertebrate-invertebrate, parautochthonous and allochthonous microfossil assemblage in the Foremost Formation, Milk River valley, Alberta that includes taxa from marine, brackish water, freshwater and terrestrial environments. *In situ* mapping of the site resulted in observation of areas of intense shell fragmentation surrounded by areas with complete shells. Areas of intense shell fragmentation corresponded to depressions at the base of the fossil assemblage and are interpreted as the feeding trace of the durophagous ray *Myledaphus*. Approximately 3500 teeth of this ray were collected from the PHRN site and approximately 24% of the teeth exhibit a distinct wear pattern on the occlusal surface of the crown. This wear pattern consists of pits, gouges, scratches or combinations of all three, with the degree of wear ranging from light etching to deep gouging. The wear pattern is the result of the repeated impact of angular mollusc shell fragments against the teeth during durophagous predation or scavenging. The feeding traces and the tooth wear are the result of the feeding behavior of *Myledaphus* and is a rare example of the preservation of trace and trace-maker being found in the same assemblage. The teeth of *Myledaphus* are preferentially worn. The genus has a gradient dignathic heterodont dentition with six distinct tooth forms: symphyseal, transitional, indistinct rhombic, hexagonal, distinct rhombic and lateral. Compared to other tooth forms, the hexagonal and distinct rhombic forms have higher numbers of worn teeth. The hexagonal form occurs in two medial zones on either side of the symphysis on the palatoquadrate and the distinct rhombic form occurs across the Meckel's cartilage. These tooth forms occupy a medial position on the upper and lower jaws, suggesting these areas of the dental apparatus are preferentially used for crushing.

**THE DENTITION OF THE DWARF SAUROPOD *EUROPASAURUS HOLGERI* (DINOSAURIA, SAURISCHIA) FROM THE UPPER JURASSIC OF GERMANY: IMPLICATIONS FOR ONTOGENETIC AND FUNCTIONAL PATTERNS**

FRANK, Verena, Steinmann Institute, University of Bonn, Bonn, Germany; REMES, Kristian, Steinmann Institute, University of Bonn, Bonn, Germany

Detailed morphological descriptions of sauropod dentitions are rare in literature. We conducted a thorough morphological analysis of the teeth of *Europosaurus holgeri*, a dwarf sauropod from the Upper Jurassic of Langenberg Quarry, Oker, Northern Germany (Lower Saxony basin). The sauropod fossils, including excellent skull material, come from Kimmeridgian marine beds, and currently comprise a minimum of 20 individuals. We studied the crown morphology of 80 isolated teeth, 20 tooth-bearing jawbones, and two isolated tooth rows ("denches"). The material includes teeth from almost all positions within the jaws, representing different ontogenetic stages within a range of 5.8 mm up to 25.6 mm crown-height. Wear facets could be examined on more than 40 functional teeth. There are two different types: While the caudal teeth of the upper and lower jaw interdigitate in an alternate fashion such that one lower tooth fits between two upper teeth, the rostral teeth do not, but seem to shear past each other in a way such that the lingual side of one upper tooth rubs against the labial side of one lower tooth. However, both types of wear facets indicate that the jaw motion was orthal. The degree of wear can be classified in 5 stages and be used for studies of the replacement patterns. It is conspicuous that the number of teeth with the first type of wear facets increases with a higher wear stage, whereas the number of teeth with the second type of wear facets decreases. This suggests either a lower abrasion or a higher replacement rate in the rostral teeth. Four complete dentaries of different ontogenetic stages show a decrease in the number of dentary teeth from juveniles to adults. The well-preserved replacement teeth still set in the alveoli of the dentaries represent almost all growth stages and provide further information about replacement patterns. In most of these dentaries, Z-spacing is 3, but there is also a single specimen that exhibits a Z-spacing of 2. Denticles are preserved on a number of both juvenile and subadult teeth but are absent in adults. This demonstrates that tooth denticles are not restricted to basal sauropods, but are also developed during ontogeny in derived neosauropods such as *Europosaurus*.

Poster Session IV, (Saturday)

**ORGAN ALLOMETRY AND BODY RECONSTRUCTION DO NOT SUGGEST DIGESTIVE CONSTRAINTS IN SAUROPOD DINOSAURS**

FRANZ, Ragna, Clinic for Zoo Animals, Exotic Pets and Wildlife, University of Zurich, Zurich, Switzerland; HUMMEL, Jürgen, Institute of Animal Science Institute of Animal Science, Rheinische Friedrich-Wilhelms-Universität, Bonn, Germany; GUNGA, Hanns-Christian, Department of Physiology, Center of Space Medicine Berlin, Charité, Berlin, Germany; CLAUSS, Marcus, Clinic for Zoo Animals, Exotic Pets and Wildlife, Vetsuisse Faculty, University of Zurich, Zurich, Switzerland

Sauropods most likely did not masticate their food and did not possess a bird-like gizzard to reduce ingesta particle size, yet probably had high metabolic rates to fuel high growth rates. This makes them without precedent in the extant vertebrate fauna. Therefore, we used allometric equations to estimate whether high "mammal-like" intakes and gut capacities based on allometric extrapolations could be reconciled with a reconstructed sauropod coelomic cavity and presumed digestive efficiency. One important decision when using allometric extrapolation can be whether the equations used should be based on mammal, bird, or reptile data. To address whether this choice will have a relevant influence on reconstructions, we compared allometric equations for birds and mammals from the literature to those for reptiles derived from both literature and hitherto unpublished data. Organs studied included the heart, kidneys, liver, and gut, as well as gut contents. While the available data indicates that gut content mass does not differ between the clades, the organ masses for reptiles are generally lower than those of mammals and birds. In particular, gut tissue mass is significantly lower in reptiles. When applying the results in the reconstruction of a sauropod dinosaur, the estimated volume of the coelomic cavity greatly exceeds the estimated volume of the combined organ masses, irrespective of the allometric equation used (note that a correction of our reconstructed body volume would also lead to a down-scaling of body mass and hence allometric reconstruction of organ volumes). Therefore, substantial deviation of sauropod organ allometry from that of the extant vertebrates can be allowed conceptually. For example, a doubling of gut capacity as compared to extant terrestrial amniotes would be possible. This means that the lack of ingesta particle size reduction and the potential negative consequences on digestive efficiency could have been compensated by increased gut capacities and the corresponding increased ingesta retention times. Because of their apparently unusual bauplan, sauropods were not constrained by a lack of ingesta particle size reduction.

Poster Session III, (Friday)

**THE PALEOECOLOGY OF THE COFFEE RANCH FAUNA OF TEXAS AND ITS IMPLICATIONS IN THE INTERPRETATION OF LATE MIOCENE CLIMATE CHANGE**

FRASER, Danielle, The University of Calgary, Calgary, AB, Canada

Studies of the isotope signatures of late Miocene Equidae have given the impression of a sudden and dramatic transition in plant photosynthetic type approximately 7 Ma. In contrast,

isotopic studies of paleosols indicate a much earlier rise of C4 plants in North America. Today climatic variables (mean annual precipitation, temperature, and seasonality) as well as plant and animal species diversity and abundance vary with latitude. This has led to the prediction that at more southern localities the plant transition may have occurred earlier than at more northern localities due to the combined effects of high temperature, high aridity, and declining atmospheric carbon dioxide. Because the dietary preferences of contemporaneous ungulates are tightly linked to the plant community, a variety of paleoecological proxies can be used to make inferences about climate. A study using hypsodonty, mesowear, microwear, and morphology indicates the occurrence of seven grazing species, five browsing species, and one mixed feeder at the Coffee Ranch, one of the southernmost Hemphillian localities. The distribution of dietary preferences at the Coffee Ranch is suggestive of a grassland savannah. The presence of browsing taxa indicates that aggregations of trees were common. A comparison to published isotope data for the Coffee Ranch Equidae indicates that the equids were transitioning from primarily C3 grazing to the incorporation of open habitat C4 grasses in their diets. A comparison of the Coffee Ranch to some contemporary Nebraska localities indicates the prevalence of more closed ecosystems at these intermediate latitudes as well as the occurrence of C3 dominated grazing in the Equidae. The isotopic differences may result from an earlier C3 to C4 transition at the Coffee Ranch during the late Miocene. It may also be indicative of a behavioral avoidance of C4 grazing in the Nebraska Equidae. The closed ecosystems of Nebraska during the late Miocene may have provided the Equidae with a means of grazing without experiencing the increased tooth wear that results from feeding on the more abrasive C4 grasses. Both alternatives support the occurrence of a clinal response of ungulate taxa to late Miocene climate change.

Late Triassic Terrestrial Biotas and the Rise of Dinosaurs, Thursday 8:00

**AN OVERVIEW OF LATE TRIASSIC TERRESTRIAL FAUNAL AND FLORAL CHANGE**

FRASER, Nicholas, National Museums Scotland, Edinburgh, United Kingdom; SUES, Hans-Dieter, National Museum of Natural History, Washington, DC, USA

The origin of dinosaurs at the end of the Triassic is coincident with marked terrestrial faunal change. Many major groups of extant tetrapods including lissamphibians, turtles, sphenodontians (and by implication lizards), crocodylomorphs, and mammals make their first appearance sometime in the Late Triassic. At the same time many "archaic" lineages such as phytosaurs, stagonolepidids and procolophonids disappeared. The mode and tempo of this faunal turnover has been vigorously debated, but there is a developing trend towards an acceptance of a sudden event, although the precise timing of the event remains equivocal. However, recent discoveries have cast doubt on this assumption. The occurrence of dinosauromorphs together with dinosaurs hints at a rather more gradual turnover. More significantly there is considerable debate concerning absolute ages and correlation of the major vertebrate-producing beds worldwide. This may have far reaching implications for our understanding of Triassic terrestrial faunal change. At the same time new data on insect assemblages indicate that Triassic terrestrial invertebrate turnover might have been more protracted or possibly not co-incident with vertebrate extinctions. In addition there is still uncertainty concerning the nature of any possible floral changes. As a result we are still a long way from a clear understanding of global faunal and floral changes at the time of the origin of dinosaurs. Future work directed toward better constrained dates for major floral and faunal assemblages will be invaluable in gaining a better understanding of the transition to dinosaur dominated biotas in the early Mesozoic.

Technical Session XIII, Friday 2:30

**VARIATION IN NASAL CREST SIZE OF *BRACHYLOPHOSAURUS CANADENSIS* (DINOSAURIA: HADROSAURIDAE): ONTOGENETIC AND STRATIGRAPHIC IMPLICATIONS OF A LARGE NEW SPECIMEN FROM THE JUDITH RIVER FORMATION OF NORTH-CENTRAL MONTANA**

FREEDMAN, Elizabeth, Museum of the Rockies, Bozeman, MT, USA

A large hadrosaurid specimen, MOR 2919, collected from the Campanian (Late Cretaceous) Judith River Fm north of Ruyard, MT, is referable to *Brachylophosaurus canadensis* on the basis of its elongate anterodorsal process of the maxilla, parallel postorbital and quadratojugal processes of the jugal, and nasal crest overhanging the dorsal skull. However, the nasal crest is significantly shorter than in other *B. canadensis* specimens, extending <1cm over the supratemporal fenestrae, and does not flatten, with each nasal remaining triangular in cross section and dorsoventrally thickened medially. *B. canadensis* specimens from Malta, MT, have been previously reported to have two morphotypes: a robust form whose nasals completely overhang the supratemporal fenestrae, and a slender form with shorter nasals covering half of each supratemporal fenestra. Slender forms within the MOR 1071 bonebed are smaller (fibulae 63-94cm) than robust specimens such as MOR 794 (fibula 103cm), suggesting that the robust morphotype is a later ontogenetic stage and the nasal crest grows posteriorly with age. MOR 2919 is larger (fibula 112cm), and likely the latest ontogenetic stage. Minor differences in shape and relative sizes of various skull processes can be attributed to the overall elongation of the skull ontogenetically. However, the posterior nasal crest deviates from this trend, being shorter in this largest specimen than in the subadult slender skulls. Because its short crest is outside the range of individual variation seen among other *B. canadensis* specimens, this unique nasal morphology is hypothesized as representing anagenetic change within the *Brachylophosaurus* lineage. MOR 2919 was collected 22m above a thick coal equivalent to the top of the Foremost Fm, and 6m

below an ash dated at 78.2 Ma. Prior sequence stratigraphic work indicates MOR 2919 is stratigraphically lower than the Malta specimens, although quantifying the time difference is difficult due to lack of radiometric dates within the distal wedge of the Judith River Fm in Malta. Thus, MOR 2919 is an older member of the *Brachylophosaurus* clade, suggesting a trend of increasing nasal crest size through time.

Poster Session II, (Thursday)

**FORERUNNER OF STEPPES: THE PLIO-PLEISTOCENE RECORD OF STEPPE PIKA (*OCHOTONA PUSILLA*, LAGOMORPHA, MAMMALIA) IN EUROPE**

FRELIK, Grzegorz, University of Portsmouth, School of Computing, Portsmouth, United Kingdom; FOSTOWICZ-FRELIK, Lucja, Institute of Paleobiology, Polish Academy of Sciences, Warszawa, Poland

The steppe pika (*Ochotona pusilla*), a representative of the lagomorph family Ochotonidae, is restricted today to Kazakhstan and Russia. According to molecular phylogeny based on cytochrome b and ND4 genes this subspecies-rich form belongs to a morphologically distinct, monospecific Central Asian group of relatively small pikas, inhabiting steppe-like habitat. In the fossil record this species serves as a bioindicator of dry, grassland environment. The steppe pika was abundant and widespread in Europe during the Last Glaciation and it has been reported from there since the middle Pleistocene. However, the record of this species prior to the middle Pleistocene in Europe is debatable. In central Europe it includes only the late Biharian specimens from Honce (Slovakia), originally assigned to *O. horaceki*, and from Gombasek (=Gombaszög; Slovakia) assigned to *O. lazari* but showing morphology typical for *O. pusilla*. In eastern Europe *O. pusilla* was confirmed only from the early Pleistocene (Biharian) Chertkov site in Ukraine, however specimens assigned to *Ochotona* sp. ex gr. *pusilla* were reported from the early Pleistocene of Ukraine and European part of Russia. A new discovery of *O. pusilla*, from Kielniki 3B locality (Poland), dated to the latest Pliocene, moves back the species appearance in Europe about one million years, almost coeval with its first record from the late Pliocene of Kazakhstan (horizon 1 of the Kopalysite =Aktogai). The specimen from Kielniki 3B is a body of the right mandible displaying morphology typical for steppe pika. The mandible and alveolus parameters match values for *O. pusilla*, whereas differ significantly from those typical for other Pliocene and early Pleistocene European and Caucasian pikas, such as *O. antiqua*, *O. polonica*, *O. pseudopusilla*, *O. transcaucasica*, and *O. zabiensis*. Presence of such a typical steppe inhabitant as *Ochotona pusilla* indicates marked climate change towards more arid, continental conditions, which started influencing Europe at 2.6 Ma.

Romer Prize Session, Thursday 12:00

**ASSEMBLING MODERN BIODIVERSITY: DEEP-TIME PERSPECTIVES ON A FORGOTTEN VERTEBRATE RADIATION**

FRIEDMAN, Matt, University of Chicago, Chicago, IL, USA

Acanthomorph ('spiny finned') teleost fishes comprise nearly one in three extant vertebrate species. Persistent uncertainties about the deep history of this clade obscure the evolutionary roots of the modern vertebrate fauna as a whole. Here I show how fossil data yield unique insights into the origins of recent acanthomorph biodiversity at both large and small phylogenetic scales. At the broadest level of investigation, a new morphometric dataset (comprising more than 1,200 specimens and over 600 species) delivers the first glimpse at patterns of morphospace occupation over the 100-million-year history of acanthomorphs. Acanthomorphs show a sharp increase in taxonomic diversity during the early Paleogene, after making only a minor contribution to Late Cretaceous marine faunas. Mirroring this pattern, there is a striking rise in levels of anatomical variety following the end-Cretaceous extinction. Elevated disparity is manifested across a range of scales (global, between-fauna, and within-fauna), and proves robust to sample-standardization and rarefaction procedures. Following this explosive early Paleogene radiation, acanthomorphs maintain comparable levels of disparity throughout the Cenozoic. The anatomical diversification of acanthomorphs as a whole reflects the proliferation of morphologically disparate constituent clades. In many cases, the sequences of anatomical change underlying the origins of these specialized sub-groups remains obscure. With their profoundly asymmetrical skulls, flatfishes represent one of the most morphologically bizarre acanthomorph clades, and questions surrounding the origin of flatfish asymmetry have fueled protracted debates on the mode and tempo of evolutionary change. When integrated into the framework of extant diversity, fossils reveal the anatomical divergence of flatfishes from other acanthomorphs. Three different fishes from the Eocene are shown to branch as successive plesions from the previously barren flatfish stem, documenting the stepwise evolution of the flatfish bodyplan and rejecting earlier claims implicating saltatory change in the origin of this group.

Poster Session IV, (Saturday)

**COMPARISON OF DIFFERENT MODES OF FOOD PARTICLE SIZE REDUCTION IN EXTANT AMNIOTES AND IMPLICATIONS FOR COMPETITION BETWEEN ORNITHOPODS AND SAUROPODS**

FRITZ, Julia, Institute of Physiology, Physiological Chemistry and Animal Nutrition, Veterinary Faculty, University of Munich, Munich, Germany; KIENZLE, Ellen, Institute of Physiology, Physiological Chemistry and Animal Nutrition, Veterinary Faculty, University of Munich, Munich, Germany; HUMMEL, Jürgen, Institute of Animal Science, Animal Nutrition Group, University of Bonn, Bonn, Germany; CLAUSS, Marcus, Clinic for Zoo Animals, Exotic Pets and Wildlife, Vetsuisse Faculty, University of Zurich, Zurich, Switzerland

Between herbivorous dinosaur taxa, profound differences in the degree and way (teeth or gastric mill) of food particle size reduction are discussed in herbivorous dinosaurs. On the one hand, there seems to be some consensus that an important reason for the radiation of ornithomorphs was their effective dental masticatory apparatus, the "dental batteries". On the other hand, many authors have assumed that sauropods compensated the lack of a masticatory apparatus with a gastrolith-containing gastric mill - similar to extant herbivorous birds. However, if the dental batteries of ornithomorphs were to represent an adaptive advantage, then the evident implication is that a gastric mill is less efficient than teeth at comminuting forage material. This assumption has not only never been clearly stated, but also never been tested so far. In this study we quantified the effects of different modes of food particle size reduction, namely practically no particle size reduction (reptiles), gastric mill (birds) and mastication (non-ruminant mammals). Mean faecal particle sizes - representative for ingesta particle size - of reptiles (n=37; 14 species), birds (n=79; 12 species) and non-ruminant mammals (n=452; 115 species) were evaluated by wet-sieving. Faecal particle size in reptiles was considerably larger than that of equally sized homoiotherm animals; no difference was obvious between birds (gastric mill) and mammals (masticating teeth). If, with respect to sauropods, the argument is followed that there is not enough evidence to assume a functional gastric mill, then an important physiological difference between sauropods and ornithomorphs is hypothesized - the particle size at which food is digested - which significantly influences evolutionary scenarios based on ecophysiological niche competition. Assuming no particle size reduction in ankylosaurs, stegosaurs and sauropods, body allometry allows the giant sauropods to compensate for a lack of particle size reduction by increased ingesta retention without compromising metabolic rates. For the smaller ankylosaurs and stegosaurs, such increased retention would only appear feasible at reduced food intake and hence metabolism.

New Perspectives on the Early Evolutionary History of the Synapsida, Saturday 9:30

**REGIONAL AND GLOBAL PERSPECTIVES ON SYNAPSID DIVERSITY AND THE PERMIAN-TRIASSIC ROCK RECORD**

FRÖBISCH, Jörg, The Field Museum, Chicago, IL, USA

The end-Permian biotic crisis represents the most severe extinction event in Earth's history. The current study investigates diversity patterns in Permian-Triassic synapsids, with special focus on anomodonts, through time and in particular across this event. As herbivores and the dominant terrestrial tetrapods of their time, anomodonts play a central role in assessing the impact of the end-Permian extinction on terrestrial ecosystems. On a global scale, taxonomic diversity analysis reveals that anomodonts experienced three distinct phases of diversification interrupted by the same number of extinctions, i.e. an end-Guadalupian, an end-Permian, and a mid-Triassic extinction. However, positive correlation between the number of taxa and the number of formations per time interval shows that global anomodont diversity is significantly biased by the Permian-Triassic terrestrial rock record. Normalized diversity curves indicate that anomodont richness continuously declines from the Middle Permian to the Late Triassic, but also reveals all three extinction events. Origination and extinction rates indicate that the end-Guadalupian and end-Permian extinctions were driven by increased rates of extinction and low origination rates. However, this pattern is not evident at the final decline of anomodont diversity during the Middle Triassic. Therefore, it remains unclear whether the Middle Triassic extinction represents a gradual or abrupt event unique to anomodonts or more common among terrestrial tetrapods. On a regional scale, anomodont diversity in the South African Karoo Basin shows a pattern consistent to that seen at the global scale, with a mid-Permian extinction, potentially reflecting an end-Guadalupian event, and an end-Permian extinction, but lacking the record for the mid-Triassic decline of anomodonts. Nonetheless, the number of anomodont taxa is again strongly correlated with the outcrop area of the respective assemblage zones, also indicating a rock record bias on the regional scale. Moreover, the same relationship between diversity and outcrop area is present in all vertebrates of the Karoo Basin, demonstrating a general rock record bias.

**A LARGE PREDATORY ICHTHYOSAUR FROM THE ANISIAN OF NEVADA AND THE DIVERSIFICATION OF ICHTHYOSAURIA AFTER THE END-PERMIAN EXTINCTION**

FRÖBISCH, Nadia, University of Chicago, Chicago, IL, USA; FRÖBISCH, Jörg, The Field Museum, Chicago, IL, USA; KLEIN, Nicole, University of Bonn, Bonn, Germany; SCHMITZ, Lars, University of California Davis, Davis, CA, USA; SANDER, Martin, University of Bonn, Bonn, Germany

Beginning in the Early Triassic, Mesozoic marine reptiles evolved a large variety of different body forms, feeding adaptations, and reproductive modes accompanying their return to the aquatic environment. The Middle Triassic marine deposits of the Augusta Mountains in Pershing County, Nevada, have in recent years been shown to be a rich site for Middle Triassic marine reptiles. Among these, ichthyosaurs, arguably the taxonomically most successful group of Mesozoic marine reptiles, are particularly well represented in the deposits including a number of new taxa with various body sizes and dentitions. Two common types of feeding adaptations are known among Early and Middle Triassic ichthyosaurs, namely large piscivorous forms with conical, pointed teeth as well as durophagous forms feeding on hard-shelled organisms, such as cephalopods, in which at least portions of the dentition were made up by flattened crushing teeth. Renewed fieldwork in July 2008 has yielded a new ichthyosaur taxon with a distinct type of dentition, previously unknown in Middle Triassic ichthyosaurs. The skull, except for the rostrum, and the majority of the postcranial skeleton of the animal are preserved in articulation, amounting to an estimated body length exceeding ten meters. Most significant is the unique dentition of the new taxon, consisting of large, labiolingually flattened tooth crowns with distinct cutting edges and a root to crown height of about six centimeters. The dentition clearly indicates that this large ichthyosaur was carnivorous and likely preyed on other large marine vertebrates. Indeed, the taxon represents the first large marine predator among secondarily aquatic tetrapods in the fossil record. It thus demonstrates that large predators evolved concurrently with other trophic specializations in marine reptiles during the recovery of marine biota from the end-Permian mass extinction. The fact that the many trophic specializations observable in Middle Triassic ichthyosaurs coincide with the initial diversification of the group may indicate that this trophic partitioning facilitated the successful radiation of the group.

Poster Session I, (Wednesday)

**STRUCTURE OF UNCALCIFIED CARTILAGES IN CROCODYLIAN (ARCHOSAURIA) ELBOW JOINTS WITH IMPLICATIONS FOR RECONSTRUCTION OF ARTICULAR SURFACES IN EXTINCT ARCHOSAURS**  
FUJIWARA, Shin-ichi, The University of Tokyo, Tokyo, Japan; TARU, Hajime, Kanagawa Prefectural Museum of Natural History, Odawara, Japan; SUZUKI, Daisuke, Sapporo Medical University, Sapporo, Japan

Determination of the area and structure of articular surfaces on the limb bones of extinct archosaurs is made difficult by the post-mortem decomposition of the fibrous tissue and articular cartilages that provide the complex three-dimensional joint surfaces in vivo. This study aims to describe the morphology of the articular cartilages in the elbow joints of six crocodylian specimens; to make comparisons with other reptiles and birds; and to compare the superficial structure of the calcified fibrocartilage and the articular cartilage in the elbow joints of an *Alligator* specimen. The epiphyseal structures of the crocodylian elbow joint are shown to resemble those of Aves. The humerus possesses an olecranon fossa positioned approximately at the mid portion of the distal epiphysis, and bordering the caudal margin of the articular surface. The ulna possesses a prominent intercotylar process at approximately the mid portion of its proximal epiphysis. This divides the articular cartilage into an articular surface on the cranial portion, and the olecranon on the caudal portion. The intercotylar process fits into the olecranon fossa to restrict elbow joint extension. Dinosaurs and pterosaurs, bracketed by crocodylians and Aves, may have possessed a similar olecranon fossa and intercotylar process on their articular cartilages. Although these structures are rarely recognizable on the bones, their impressions on the surfaces of the calcified cartilages provide an important indication of the caudal margin of the articular surfaces. This, in turn, controls the maximum angle of extension of the elbow joint in archosaurs.

Poster Session III, (Friday)

**A NEW INTERPRETATION ON THE USE OF VENOM IN THE PLIO-PLEISTOCENE SHREW *BEREMENDIA* (INSECTIVORA, MAMMALIA)**  
FURIÓ, Marc, Institut Català de Paleontologia, Sabadell (Barcelona), Spain; AGUSTÍ, Jordi, ICREA-Institute of Human Paleocology, Tarragona (Spain), Spain; MOUSKHELISHVILI, Alexander, Georgian State Museum, Georgian Academy of Sciences, Tbilisi, Georgia; SANISIDRO, Óscar, Museo Nacional de Ciencias Naturales, Departamento de Paleobiología, Madrid, Spain; SANTOS-CUBEDO, Andrés, Institut Català de Paleontologia, Universitat Autònoma de Barcelona, Sabadell (Barcelona), Spain

The shrews of the genus *Beremendia* were common elements of the Pliocene and the Early Pleistocene terrestrial ecosystems of the Eurasian continent. *Beremendia* includes three valid species, *B. fissidens*, *B. minor*, and *B. pohaiensis*, and it is the type genus of the Beremendiini, an extinct tribe of red-toothed shrews. The absence of an extant close relative

makes difficult the elucidation of its most likely paleoecological profile. A significant detail shared by the three species of the genus is that they display medial grooves in their lower incisors. In extant shrews the presence of such structure is indicative of a venomous bite, and a similar functionality can be deduced for the case of *Beremendia*. Recent publications suggested a correlation between this envenomation apparatus and the uncommon big size of *B. fissidens*, the most frequent species of the genus, as a possible adaptation to hunt large-sized preys. However, the mandibular construction and its muscular attachment points, and the dental traits examined in new fossil material from Dmanisi (Early Pleistocene, Georgia) and Almenara-Casablanca 1 (Late Pliocene, Spain), are in better agreement of a diet based on 'intractable' items, probably coleopterans or gastropods. The possession of venom in shrews specialized to feed on non-struggling preys leads to an apparent incongruence. Nevertheless, there is a reliable explanation if it is considered that the injection of this venom was not lethal, but it induced the victims into a comatose state. In such case, the victims can be hoarded for a longer time in a better state of preservation than if they were dead. The hoarding behavior has been reported in some extant shrews as a solution to reduce the effects of unstable environments. The probability of suffering prolonged starvation periods, undesirably risky for the survival of high-metabolic shrews, is thus diminished. This probable use of venom in *Beremendia* provides a new explanation for the opportunistic profile previously stated for the genus by some authors, and it is in full agreement with the geological context of Dmanisi which evidences repeated destructive volcanic episodes.

Molecular Tools in Paleobiology: Trees, Clocks and linking Geno- with Phenotype, Friday 12:00

**EVOLUTIONARY NOVELTIES: THE MAKING AND BREAKING OF PLEIOTROPIC CONSTRAINTS**

GALIS, Fritson, Leiden University, Leiden, Netherlands; METZ, Johan, Leiden University, Leiden, Netherlands

Disturbances of early development in mammals are frequent and cause common congenital abnormalities, e.g. cervical ribs, extra digits and asymmetry in mammals. During early development all parts of an embryo are interconnected and form part of a large regulatory network. Due to this interconnectivity, mutations that cause these common abnormalities are associated with many negative side-effects (additional malformations and childhood cancers), i.e. pleiotropic effects. The negative pleiotropic effects of these mutations dramatically lower fitness, and consequently, are selected against. Selection against these mutations leads to conservation of body plan traits that are determined during early development, e.g. the number of eyes, ears, lungs, kidneys, limbs, digits, cervical vertebrae. Hence, the interactivity of early development is highly relevant for both the developmental origins of diseases and the conservation of body plans. We argue that the high interactivity is due to the coordinated patterning of the embryonal axes and the interactions between axial patterning processes and morphogenetic processes, such as proliferation and somitogenesis. As examples we have shown selection against negative pleiotropic effects of the mutations that cause slight disturbances of the patterning of the head-to-tail and left-right axis. We discuss the implications for constraints on the evolution of novelties. Finally, we argue for the crucial importance of relaxed selection for the evolution of novelties, because this temporarily allows just arisen novelties to persist, such that pleiotropic constraints can be effectively broken. We illustrate this with several empirical examples.

Poster Session III, (Friday)

**MORPHOMETRIC ANALYSIS OF HADROSAURID DENTAL BATTERY VARIATION**

GALLIMORE, Gillian, University of Toronto, Toronto, ON, Canada; EVANS, David, Royal Ontario Museum, Toronto, ON, Canada

The phylogeny of the hadrosaurid dinosaurs is highly contentious. This issue is complicated by unstandardized and poorly defined characters in most phylogenetic analyses of the group. Characters associated with their complex dental batteries are particularly poorly defined but are important because dental characters form 5-20% of the total characters in published analyses. Virtually all phylogenetic analyses of hadrosaurids include characters related to the total number of tooth rows in the dental battery, tooth crown shape (height/width ratio), and the presence or absence of secondary enamel ridges. Individual and ontogenetic variation in these characters was examined using a morphometric approach for the first time. The dentary dentitions of *Gryposaurus notabilis* and *Corythosaurus* spp. were used as case studies to represent Hadrosaurinae and Lambeosaurinae respectively. A positive correlation was found between dental battery length and number of tooth rows. At analogous tooth positions, tooth crown shape in *Gryposaurus* does not change significantly over the size range in the sample. Conversely, the high degree of variation in adult *Corythosaurus* overlaps with the *Gryposaurus* sample. The presence of secondary ridges is variable within each taxon; secondary ridges are present in juvenile *Gryposaurus*, but absent in adults. The converse appears to be true for *Corythosaurus*. Contrary to previous character scorings for these taxa, hadrosaurines and lambeosaurines do not differ significantly in the number of tooth rows in the dental battery independent of size. There is significant variation in tooth shape such that lambeosaurines can have a tooth crown aspect ratio less than 3, which overlaps with hadrosaurines. Some hadrosaurines have secondary enamel ridges on their teeth, at least early in ontogeny. These results illustrate that hadrosaurid dentition is considerably more variable than previously thought, and indicate that many published definitions and scorings of these widely used characters are problematic.

**RE-ANALYSIS OF LOWER CRETACEOUS FOSSIL BIRDS FROM THE UK REVEALS AN UNEXPECTED DIVERSITY**

GALTON, Peter, University of Bridgeport, Bridgeport, CT, USA; DYKE, Gareth, University College Dublin, Dublin, Ireland; KUROCHKIN, Evgeny, Paleontological Institute of the Russian Academy of Sciences, Moscow, Russia

Bird remains from the UK Lower Cretaceous (LK) are isolated and often fragmentary bones, but reveal an unexpected phylogenetic diversity. The bulk of avian records are from the Late Cretaceous; UK bones are Berriasian to Barremian (Purbeck & Wealden beds, south coast) and Albian (Cambridge Greensand, SE England) in age and thus plug an important temporal gap in the avian fossil record. UK fossils are also interesting for their historical context: adding them to a comprehensive database of Mesozoic taxa highlights their stratigraphic and biogeographic importance.

Most of the identifiable UK LK bird bones are referable to the basal hesperornithiform diving bird *Endliornis* Seeley. With heterocoelous cervicals and thoracics, a rudimentary caput humeri, slender unelaborated femur and enlarged crista cnemialis (tibiotarsus), its addition to phylogenetic analyses suggests that the flightless *Endliornis* (with 3 different sized species) was the earliest diverging lineage within Hesperornithiformes (Ornithurae). Corroborated by the identification of similar, isolated bones of basal Hesperornithiformes in the Berriasian of central Europe (Romania), these birds were likely restricted to northern hemisphere seas, as are many seabirds today.

The non-hesperornithiform UK LK fossils include other Ornithurae (humerus, Cambridge Greensand; *Wyleya valdensis* Harrison & Walker, HT humerus, Upper Weald Clay, Henfield, Sussex), Enantiornithes (humerus, Purbeck beds, Lulworth Cove, Dorset) and Aves indet. [vertebrae (cervical, 3 amphicoelous thoracics, anterior synsacral), an end of a coracoid and of a femur, Cambridge Greensand]. These records reveal an unexpected diversity of lineages by the early Cretaceous.

By LK times, georeferenced records show that birds had achieved a wide distribution, spanning Europe, Asia, Australasia and North Africa. Spatial analyses and estimates of fossil ghost ranges demonstrate that the major lineages of Enantiornithines had diverged and achieved significant diversity by Berriasian-Barremian times. UK fossil avian records were available to Walker in the 1970s: many of his predictions about patterns of avian evolution have stood the test of time.

Poster Session IV, (Saturday)

**DENTAL WEAR PATTERNS IN THE EXTANT UNGULATE FAUNA OF THE GOBI DESERT AND IMPLICATIONS FOR PALEODIET INTERPRETATION OF EXTINCT SPECIES IN ARID CLIMATES**

GANTUMUR, Onon, Institute for the Study of Mongolian Dinosaurs, Ulaanbaatar, Mongolia; MIHLBACHLER, Matthew, New York College of Osteopathic Medicine, Old Westbury, NY, USA; BOLORTSETSEG, Minjin, Institute of the Study of Mongolian Dinosaurs, Ulaanbaatar, Mongolia; SOLOUNIAS, Nikos, New York College of Osteopathic Medicine, Old Westbury, NY, USA

Methods of dental wear analysis, such as mesowear and microwear, are increasingly utilized for interpretation of paleodiet. Dental wear is caused by a variety of animal-environment interactions and is more than a simple reflection of dietary preference. Therefore, accurate interpretation of dental wear in fossil species relies on careful study of the dental wear of extant species and its correlation with dietary preferences and other non-dietary variables, such as grit load. To examine the effect of arid climates on interspecific dental wear patterns, we surface collected the teeth of modern ungulates during fossil collecting expeditions in the Gobi Desert. Mesowear was scored macroscopically, while microwear features (e.g. scratches and pits) were quantified using low-mag stereomicroscopy of dental casts. Taxa include 5 livestock species, bactrian camel, horse, sheep, goat, and cow, as well as a single wild taxon, argali (*Ovis ammon*). Mongolian livestock are free-ranging and feed in wild pasture according to their differential dietary preferences. Within the Gobi ecosystem, camels prefer woody species, horses and cows are predominantly grazers, while goats and sheep, including argali, are mixed feeders. Raw counts of pits and scratches, the microwear variables most frequently used for paleodiet interpretation, showed no differences among the six Gobi ungulates, suggesting that these variables cannot discriminate diets in harsh Gobi-like environments. If non-dietary factors, such as a high grit load, are swamping the dietary signal, these variables may serve as better indicators of habitat rather than diet. However, mesowear and other microwear variables, such as the frequency of large-sized coarsely textured features, show significant differences between the species and appear to be more robust to non-diet factors. We also describe a new dental wear variable that is intermediate in scale between microwear and mesowear and relates to the precision of dental occlusion along wear surfaces. This variable appears to differentiate Gobi ungulates according to their known diets more accurately than any of the mesowear or microwear variables examined.

Technical Session XVII, Saturday 3:45

**EARLY FOSSIL RECORD FROM CHINA AND DEEP TIME EVOLUTION OF SALAMANDER NEOTENY**

GAO, Ke-Qin, Peking University, Beijing, China; SHUBIN, Neil, University of Chicago, Chicago, IL, USA

Salamanders (Urodela) are a vertebrate group of great interest in many fields of modern biological sciences, especially evolutionary-developmental biology. A key component of salamander life history is neoteny, the retention of larval somatic morphology in reproductively mature adults. Among extant salamanders, four families are exclusively neotenic, while six others include some species or populations within species that exploit a neotenic life-history strategy. Until recently, paleontological evidence enabling rigorous study of neoteny as an evolutionary-developmental dynamics in the early history of salamanders has been unavailable; consequently, the origin and evolution of neoteny-related morphological features in salamanders are still poorly understood. Recent discovery of a wealth of exceptionally well-preserved salamander fossils from the Jurassic and Cretaceous deposits in China provides the richest record of early salamanders now known, documented by both neotenic and metamorphosed forms. Large samples from a number of localities across a range of horizons open a unique window into the early evolution of true salamanders, and furnish otherwise unavailable evidence to study life-history features in early salamanders. An overview of this extraordinary record indicates that neoteny, as an alternative developmental pathway in relation to metamorphosis, was already established in the earliest phase of urodele evolution, by Middle Jurassic time (fossil beds dated as 164-165 Ma), thereby playing a key role in governing the initial phylogenetic and ecologic diversity of salamanders. Multiple independent acquisitions of neotenic traits in Mesozoic and extant salamanders make parallel evolution of morphological characters a major biological feature for this modern amphibian clade.

Poster Session III, (Friday)

**THE COMMUNITY STRUCTURE OF CARNIVORE MAMMALS, A KEY TO INFER THE CLIMATE**

GARCÍA YELO, Blanca, Consejo Superior de Investigaciones Científicas, Madrid, Spain; HERNÁNDEZ FERNÁNDEZ, Manuel, Universidad Complutense de Madrid, Madrid, Spain; MORALES, Jorge, Consejo Superior de Investigaciones Científicas, Madrid, Spain

In the present study we studied the relationship between the environment (climate type, biome) prevailing in a locality and the community structure of the carnivoran fauna (Mammalia, Carnivora) that inhabit in such locality. We used the climatic and faunal data from 100 modern localities uniformly distributed all around the world, pertaining to the ten biomes found in the Earth today and including 184 species. In order to describe the community structure for each locality we defined ecological groups based on body size, hunting locomotor adaptation and feeding adaptation. Thus, all modern species of carnivores (237 species) were included in the nine groups ecologically distinctive defined by means of cluster analysis. Subsequently, the carnivoran ecological spectra of the 100 localities were calculated. Finally, a discriminant analysis allowed us to establish a relationship between the type of biome and the carnivorous ecological spectrum present in a locality. The proportion of correctly classified cases for the 100 localities as a whole was of 61%. This analysis was repeated grouping the localities by continents, which produce a substantial improvement in the percentage of correctly classified cases, with 88,9% in Eurasia, 89,3% in North America, 89,5% in South America and 100% in Africa. Our results confirm the existence of a relationship between the environment and the community structure of carnivore faunas, represented as their ecological spectra. Nevertheless, a major modulating role of the biogeography is also observed. This study allows us the development of new methodologies of paleoclimatic inference based on the carnivore faunas, which have been usually omitted in paleoenvironmental studies.

Poster Session II, (Thursday)

**BONE HISTOLOGY ON EXTANTS GLIRIDS. PROSPECTS FOR THE STUDY OF FOSSIL GLIRIDS**

GARCÍA-MARTÍNEZ, Rubén, Catalan Institute of Paleontology, Cerdanyola del Valles, Spain; KÖHLER, Meike, Catalan Institute of Paleontology, Cerdanyola del Valles, Spain

Though bone histology has become a powerful tool to reconstruct life history strategies and physiology in living and extinct reptiles, it is of limited use in mammals because of their determinate growth and important bone remodeling. Dormice (Gliridae) are, in theory, a good candidate group for assessing the relation between bone microstructure and life history due to their long life span, marked physiological cycles and negligible bone remodeling. Nevertheless, bone histology has not yet been studied in this group.

We carried out the most comprehensive study so far analyzing 15 wild individuals of unknown age belonging to two different species of dormice, *Glis glis* and *Eliomys quercinus*. Because of their annual physiological cycles, these species are expected to arrest growth once a year, forming characteristic lines of arrested growth (LAGs) in their bone cortices that are used for age assessment.

We prepared thin sections of all long bones and the mandible of each specimen. The slices were observed under polarized transmitted light. 6 individuals were younger than a year because they did not present LAGs in any of their bones. All other specimens showed LAGs,

being 5 the maximum number. Not all bones of one individual presented the same number of LAGs, none of the limb elements was consistently more reliable for ageing than the other elements, and mandibles, which are the only bones used for ageing in some previous studies, are rather unreliable because they show less LAGs than the limb bones of the same individual. We observed two different tissue patterns in the limb bone cortex, fast growing fibrolamellar and slow growing lamellar-zonal bone. This variable-rate growth is unexpected for small mammals, which are hitherto found to show exclusively lamellar-zonal bone. It likely reflects the important physiological plasticity of dormice in response to environmental fluctuations. Our results, though preliminary, suggest a strong relation between growth pattern, physiology, and ecological conditions in extant dormice. Further analyses will provide a firm basis for interpreting bone microstructure in fossil dormice and other small mammals.

Poster Session III, (Friday)

#### **NEW IGUANODONTIAN DINOSAUR REMAINS FROM THE EARLY BARREMIAN OF SPAIN (CASTELLOTE, TERUEL)**

GASCA, José Manuel, Grupo Aragosaurus. Universidad de Zaragoza, Zaragoza, Spain; CANUDO, José Ignacio, Grupo Aragosaurus. Universidad de Zaragoza, Zaragoza, Spain; MORENO-AZANZA, Miguel, Grupo Aragosaurus. Universidad de Zaragoza, Zaragoza, Spain

The Aragosaurus Group research team of the University of Zaragoza is currently carrying out a macrovertebrate excavation near the village of Ladruñán, Castellote (Maestrazgo Basin, north-eastern Spain). The dinosaur remains have been collected from dark-brown clays within the Mirambel Formation, Wealden facies, early Barremian in age. These remains are disarticulated elements, though there is no evidence of significant transport. The accumulation took place in a low-energy environment, probably a swamp with abundant organic matter. The most relevant taphonomic feature is the presence of gypsum as coatings on bone and teeth surfaces or partial bone replacement. Almost all the vertebrate fossils are ornithomimid remains from at least three individuals. These include cranial material such as two right dentaries, a partial left dentary, and isolated teeth with the root preserved, and also postcranial material such as anterior and middle caudal vertebrae and a juvenile right ischium. The dental morphology is typical of Iguanodontidae. The maxillary teeth are lozenge-shaped in labial view with a very prominent primary ridge, which is displaced distally, and several subsidiary ridges mesially. The dentary teeth are diamond-shaped in lingual view with a primary ridge distally and a secondary ridge mesially separated by a median groove. The dentary morphology reveals differences from other Lower Cretaceous European iguanodonts. The most significant character is the slightly convex ventral margin of the dentary. One of the right dentaries, 50 cm in length and 11.5 cm in depth, represents a medium- to large-sized ornithomimid. It shows relatively large-sized teeth (20 tooth positions approximately), a broad Meckelian canal and the buccal shelf well-developed between the coronoid process and the tooth row. These remains may belong to an undescribed member of Iguanodontidae. The dentary remains represent the most complete record of iguanodontian cranial material from the Barremian of the Iberian Peninsula.

Poster Session III, (Friday)

#### **THE FIRST COMPLETE DINOSAUR FROM THE LATE CRETACEOUS BOOK CLIFFS (NESLEN FM) OF EASTERN UTAH: IDENTIFICATION AND SIGNIFICANCE**

GATES, Terry, Lake Forest College, Lake Forest, IL, USA; SCHEETZ, Rodney, Museum of Paleontology, Brigham Young University, Provo, UT, USA; BARRICK, Reese, College of Eastern Utah Prehistoric Museum, Price, UT, USA

The Book Cliffs of central Utah and western Colorado contain a series of Late Cretaceous sediments representing an overall regressive sequence by which the underlying fully marine Mancos Shale gives way to several fully terrestrial formations across several thousand feet of elevation. Deposition of the Neslen Fm occurred under a mixed regime of marine and terrestrial influences as evidenced by sedimentology, presence of coal seams, and preservation of the trace fossil *Teredolites*. Despite the extensive nature of the Cretaceous sediments, the Book Cliffs have had limited paleontological surveys and even fewer significant discoveries that could aid in the identification of its constituent fauna. One important discovery is that of a nearly-complete hadrosaur from the Neslen Fm (BYU 13258) close to the Colorado border with exceptional impressions of integument. The specimen was discovered in the early 1990's within an estuary sandstone. Although its soft tissue anatomy was described in detail, the taxonomic affinity of the only substantial dinosaur remains from the Book Cliffs of Utah has remained unknown. Preparation of the mostly complete articulated skull is still in preliminary stages, yet several important characteristics can be observed that provide valuable clues to its identification. The broad skull roof confidently places the specimen within the hadrosaurine subclade, bearing more resemblance to *Gryposaurus* spp. than to *Brachylophosaurus* or *Maiasaura*. Correspondingly, the jugal is quite similar to that of *Gryposaurus* spp., much more so than the unique jugal of *Brachylophosaurus* and its relatives. Morphological comparisons of BYU 13258 are restricted here to contemporaneous taxa. The Neslen Fm, and therefore this specimen, has been correlated to the Capping Sandstone of the Wahweap Fm, the middle Two Medicine Fm, and Judith River Fm. More specific biogeographic comparisons, especially those with the Wahweap Fm a few hundred kilometers south, will begin to yield important insights into environmental preferences of various hadrosaurid species.

Molecular Tools in Paleobiology: Trees, Clocks and linking Geno- with Phenotype, Friday 10:15

#### **THE EVOLUTION OF CETACEA: RECIPROCAL INSIGHTS FROM MOLECULES AND FOSSILS**

GATESY, John, University of California Riverside, Riverside, CA, USA

Phylogenetic information from fossils and from the genome does not always agree when analyzed separately. Synthesis of these diverse data, however, can provide synergistic insights into evolutionary history and rapid scientific advances. Darwin speculated on the evolution of Cetacea (toothed and baleen whales) in *On the Origin of Species*, but evidence bearing on cetacean phylogeny was limited until recent decades, which have seen a rapid influx of information. Combination of genomic and paleontological data now permits detailed hypotheses on the origin and diversification of whales. In particular, this synthesis has generated a robust phylogenetic hypothesis for living species of Cetacea, placed critical fossil taxa relative to extant lineages, predicted the discovery of fossil cetaceans with particular combinations of character states, revealed the sequence of synapomorphies on the stem lineage to modern whales, and predicted the presence of molecular fossils (pseudogenes) in the genomes of crown cetaceans. The transition from an ancestral terrestrial ancestor to semi-aquatic forms to fully-aquatic whales required major reorganizations of anatomy and genes. A detailed reconstruction of this history cannot be achieved without integration and reconciliation of molecules and morphology in phylogenetic analysis.

New Perspectives on the Early Evolutionary History of the Synapsida, Saturday 10:45

#### **GORGONOPSIA - PHYLOGENY AND FUNCTIONAL MORPHOLOGY**

GEBAUER, Eva, Senckenberg Research Institute and Museum, Frankfurt, Germany

Gorgonopsia, a group of carnivorous therapsids from the Upper Permian are characterized by enormous saber-like canine teeth and an almost cat-like appearance. The group was revised by Sigogneau, who disentangled the rather confusing systematics and reduced the recognized diversity to a clearly arranged number of 22 genera. However, despite these remarkable efforts uncertainties concerning alpha-taxonomy still exist. On the basis of the gorgonopsian material from the Nowack-Collection in the Geologisch-Paläontologisches Institut Tübingen, a re-assessment of gorgonopsian alpha-taxonomy was made. One of the best-preserved specimens is the almost complete skeleton GPIT/RE/7113 from the Usili Formation, Ruhuhu Basin, Tanzania. It was initially allocated to the genus '*Scymnognathus*' by von Huene but was later assigned to the taxon *Aelurognathus? parringtoni* by Sigogneau. A renewed investigation of the skull revealed that the specimen could not be allocated to any South or east African taxon, but rather to the Russian genus *Sauroctonus*. Thus, a true connection between the African and Russian biozones is established for the first time. The alpha-level taxonomy of the other specimens in the Nowack-Collection is resolved as a result of a re-assessment of all Gorgonopsia. A comparison of functional aspects of gorgonopsians and the saber-toothed cat *Smilodon* revealed that the enlarged canines imply further similarities in the skull and postcranial skeleton of both taxa, which may indicate a similar mode of taking prey.

Poster Session IV, (Saturday)

#### **DIETARY OPTIONS OF THE SAUROPODS**

GEE, Carole, University of Bonn, Steinmann Institute, Division of Paleontology

Plant-herbivore relationships are relatively easy to discern in living organisms, but are much harder to recognize between organisms in the fossil record, especially if one or both groups have gone extinct. In the case of herbivory in sauropod dinosaurs, the selection or preference of certain plant groups as fodder by the sauropod dinosaurs has been a puzzling and sometimes contentious issue. From a botanical perspective, it seems that the thick-cuticled conifers, toxic cycads, and low-biomass ferns would have offered little in terms of palatable, sustaining fodder to the Mesozoic sauropod dinosaurs, yet we know that giant sauropods existed and must have thrived on these plant groups. Given experimental results which compared digestibility of the nearest living relatives of these plant groups, the Mesozoic flora as potential sauropod food plants can be looked at in a new light. This talk will survey the pre-angiosperm Mesozoic flora in regard to these results, as well as to growth habit and preferred habitat of the living relatives and the accessibility of these plants to sauropods based on the fossil record. Each taxon is then comparatively evaluated as an accessible, dependable, plentiful, renewable, and nutritious food source for sauropods. Based on these criteria, the best food plants would have been horsetails, ginkgophytes, araucarias and other conifers; the worst would have been cycads and many ferns.

Technical Session XIV, Friday 2:30

#### **LINKING CHARACTER STATES: A MEANS TO ACHIEVE PROGRESSIVE MORPHOLOGICAL PHYLOGENETICS**

GEISLER, Jonathan, Georgia Southern University, Statesboro, GA, USA; BOLORTSETSEG, Minjin, Institute for the Study of Mongolian Dinosaurs, Ulaanbaatar, Mongolia

Morphological phylogenetics is progressive when systematists add new characters and observations to published data. However, unlike automated sequence alignment for molecular data, published morphological data can only be combined through laborious,

manual, and often highly subjective means. Furthermore, such “total evidence” studies require collaborators to agree upon a common character list. Given how elusive such agreement is, it is not surprising then that for a given phylogenetic problem, either only a small part of the systematic community is working on it or multiple groups are working independently. In the latter circumstance, often much effort is duplicated. One solution to broadening collaboration among morphological systematists is to employ technology to ease the integration of previously published datasets into ongoing work. If done effectively and on-line, this could engage the efforts of the entire systematic community to solve systematic problems, much in the way Genbank has revolutionized molecular systematics. Here we propose that software be developed that allows for “homologous” characters and character states in different matrices to be linked. Once such linkages exist, supermatrices could be automatically generated from existing data matrices by 1) including all unique characters from each matrix, 2) combining redundant character into “new” more completely coded characters, and 3) resolving incompatible codings from different matrices by creating polymorphisms or other user-specified means. Agreement on a single character list is not required, and researchers could choose among all published permutations for redundant characters. Importantly, once such linkages are made, systematists could easily recognize problematic characters by noting frequencies of incompatible character codings across separate matrices. Given that the linkages themselves could become controversial, the software should allow for alternative linkages to be made and for the user to be able to select among these alternatives when generating supermatrices. A supermatrix of Odontoceti will be used to illustrate how linkages are made.

Poster Session IV, (Saturday)

#### PALEOGENE BUNODONT UNGULATES FROM SOUTH AMERICA: ALTERNATIVE HYPOTHESES

GELFO, Javier, División Paleontología de Vertebrados, Museo de La Plata., La Plata, Argentina; CHORNOGUBSKY, Laura, Sección Paleontología de Vertebrados, Museo Argentino de Ciencias Naturales “Bernardino Rivadavia”, Buenos Aires, Argentina

The earliest known therian fossil records from South America show a predominance of bunodont ungulates. In the traditional view, these comprised ‘archaic ungulates’ such as the Mioclaenidae Kollpaniinae and Didolodontidae, plus the litoptern Protolipternidae. Since the Kollpaniinae were related to a North American family, the last two were the only strictly bunodont and low-crowned, endemic ‘ungulates’ from the Paleogene of South America. Didolodontids and protolipterns were recognized as different groups because the assignment of postcranial remains, with ‘condylarth-like’ and ‘litoptern-like’ morphologies respectively. However, these assignments were questioned in the case of the didolodontids, particularly because no complete skeleton or associated postcranium is yet known for any of them. So, the phylogenetic position of didolodontids is still controversial. A data matrix of 89 dental and tarsal characters for 26 species (*Protoungulatum donnae* as an out-group + 7 Kollpaniinae + 14 Didolodontidae + 4 Protolipternidae) was analyzed under parsimony, firstly considering the didolodontid tarsal assignment as valid, and secondly codifying these conflictive characters as missing data. Both analyses were carried out, with and without implied weighting. As a result, the Kollpaniinae were recovered as monophyletic and basal to the remaining groups in all the analyses. The analysis performed with the complete tarsal information recovered the Didolodontidae as monophyletic using implied weighting. In contrast, for this matrix, Protolipternidae were always recovered as a natural group, even when the two species of *Asmithwoodwardia* seem not to be related to them. When the conflictive tarsal characters were not included in the analysis, Didolodontidae resulted monophyletic in contrast to Protolipternidae. These analyses emphasize two hypotheses. The postcranium of didolodontids could be ‘condylarth-like’, but their monophyly needs to be verified in a wider context including the rest of the native South American ‘ungulates’. Or, didolodontids may have had a ‘litoptern-like’ postcranial anatomy, and Protolipternidae are an artificial group.

Poster Session III, (Friday)

#### AGRIOTHERIUM (URSIDAE) FROM A BLANCAN NALMA LOCALITY AT HAGERMAN FOSSIL BEDS NATIONAL MONUMENT, IDAHO

GENSLER, Phil, Hagerman Fossil Beds NM, Hagerman, ID, USA; MEACHEN-SAMUELS, Julie, University of California Los Angeles, Los Angeles, CA, USA; SAMUELS, Joshua, University of California Los Angeles, Los Angeles, CA, USA

Through recent field work at Hagerman Fossil Beds National Monument, Idaho a partial dentary of the large ursavine bear, *Agriotherium cf. schneideri*, has been recovered from a mid Blancan NALMA locality. *Agriotherium* has been known previously only from mid-late Hemphillian aged sites in North America and has been considered a biostratigraphic indicator of Hemphillian NALMA deposits. Found in the Glenns Ferry Formation, the age of this specimen can be inferred from its stratigraphic position relative to radiometrically dated ash layers as between 3.79 Ma and 4.0 Ma. The Hagerman occurrence of *Agriotherium* from the mid-Blancan suggests that the species should not be used as a biostratigraphic indicator for the Hemphillian NALMA. The Hagerman fauna is very diverse, as is this specific locality, which included at least 27 vertebrate and invertebrate species. Species consist of a mixture of taxa that originated prior to the Blancan and some species known exclusively from the Blancan. Among taxa that first occurred in the Hemphillian and persisted into the Blancan are an unidentified gomphothere, a horse (*Equus simplicidens*), a beaver (*Castor californicus*), and the rabbits (*Alilepus* and *Hypolagus*). *Castor californicus* is among

the most abundant species in the Hagerman fauna and, like *Agriotherium*, it immigrated to North America from Asia in the Hemphillian. The jackrabbit-like *Alilepus vagus* and *Hypolagus vetusare* commonly found throughout the Hagerman section. The presence of other taxa known primarily from the Hemphillian but at this site suggests that the persistence of *Agriotherium* into the Blancan is surprising. The Blancan age of this site is further supported by the presence of several species whose biostratigraphic ranges are confined to the Blancan, including the microtine rodents *Pliopotamys minor*, *Cosomys primus*, and *Ophiomys taylori*, as well as the large shrew *Paracryptotis gidleyi*.

Poster Session III, (Friday)

#### ANKYLOSAURID DINOSAURS OF THE UPPER CAMPANIAN KAIPAROWITS FORMATION, GRAND STAIRCASE-ESCALANTE NATIONAL MONUMENT, UTAH

GETTY, Mike, Utah Museum of Natural History, Salt Lake City, UT, USA; VICKARYOUS, Matthew, Ontario Veterinary College, Guelph, ON, Canada; LOEWEN, Mark, University of Utah, Salt Lake City, UT, USA

Our long-term field program in the Campanian Kaiparowits Formation of Utah has produced the first ankylosaur specimens from the formation, including seven localities with associated material. The most complete specimen to date consists of a disarticulated but virtually complete right forelimb (fused scapula-coracoid, humerus, radius, ulna, metacarpals and phalanges), one cervical and three caudal vertebrae, a cervical half-ring, and more than 50 associated osteoderms. This specimen was deposited in a small bonebed, together with a partial ceratopsid skull. Another site preserves a more fragmentary specimen, consisting of an associated distal tail along with several broken ribs, two dorsal centra and seven osteoderms, including one enlarged plate pertaining to the tail club. The tail section includes four disarticulated caudal vertebrae and a fused series of caudal vertebrae. This fused “handle” series, consists of five fused caudals in articulation with three sequential, laterally-paired spikes, surrounded with ossified tendons. Another locality produced the only associated ankylosaur cranial material collected thus far, including a fused spike-like facial scute and a partial dentary with an un-erupted tooth. Four other localities are dominated by associated assemblages of ankylosaur osteoderms, interpreted as sections of armored integument preserved separately from the rest of the carcass. Although a genus-level taxonomic identification of any of the specimens is not possible at this time, the morphology of all diagnostic elements recovered from these localities are consistent with their referral to the clade Ankylosauridae and are very similar to the contemporary genus, *Euoplocephalus*. To date, no definitive nodosaurid ankylosaur material has been identified. Ankylosaur remains represent less than 5% of associated dinosaur localities (n=32) in the Kaiparowits, and are thus interpreted to represent a relatively small component of the fauna. Isolated ankylosaur teeth and small osteoderms are rarely encountered in vertebrate microfossil sites, in contrast to their relative abundance contemporary northern formations of Western Interior Basin.

Technical Session IV, Wednesday 3:15

#### THE BEGINNING OF AFRICAN PLACENTALS: NEW DISCOVERIES FROM THE OULED ABDOUN BASIN (MOROCCO, PALEOCENE-EOCENE), AND SIGNIFICANCE

GHEERBRANT, Emmanuel, Museum National D’Histoire Naturelle/CNRS-UMR 7207, Paris, France; SOLE, Floreal, Museum National D’Histoire Naturelle/CNRS-UMR 7207, Paris, France; AMAGHZAZ, Mbarek, OCP, Khouribga, Morocco; BOUYA, Baâdi, OCP, Khouribga, Morocco

Mammals were discovered in 1996 in the Ouled Abdoun phosphate basin (Morocco), in the early Ypresian of Grand Daoui (GD) quarries, with the earliest proboscidean *Phosphatherium*. The GD quarries yielded other Ypresian mammals such as the large proboscidean *Daouitherium*, the hyracoid *Seggeurius*, and the hyaenodontid *Boualitomus*. The condylarth-like taxa *Abdounodus* and *Ocepeia* were also found in Southern GD quarries, but from lower Thanetian beds.

New major Paleocene discoveries were made recently South to GD area. An early Thanetian bone-bed from Sidi Chennane quarries, ca. 60 my, yielded new material of *Abdounodus* and *Ocepeia*, and the oldest hyaenodontid and proboscidean discussed here. Sidi Chennane is the oldest known placental site in Africa.

The new hyaenodontid *Lahimia* is closely related to *Boualitomus*, described as a Provierrinae “close to *Prototomus*”. Striking synapomorphies with *Boualitomus* (shortened anterior dentition, reduced and simplified molar talonid) evidence a precociously specialized early African lineage, distinctive from primitive “provierrines.” The molar occlusal pattern, e.g. an original prevallum/postvallid shearing, suggests close relationship with the early Eocene *Koholia* and inclusion in the Koholiinae, as an old African endemic lineage. With *Lahimia*, the Koholiinae evidences the antiquity of the African evolution of the Hyaenodontidae.

A new archaic proboscidean is evidenced by dental and cranial remains. Cladistic study among lophodont “ungulates” (incl. paenungulates), supports its proboscidean relationships, as a stem lineage. It is extraordinarily primitive and condylarth-like, and shows first reported dental reminiscences (e.g., bunodont incipient lophodonty) of Proboscidea and Paenungulata with macroscelideans and louisinines. Its primitive grade suggests rapid paenungulate radiation at KT transition, probably favored by early endemic African niches. As one of the

earliest of extant orders, it provides new major basal calibration point of the placental tree. The Ouled Abdoun basin is a key placental site to elucidate phylogeny and early evolution of paenungulates and related endemic African lineages.

Technical Session XII, Friday 4:15

#### A NEONTOLOGICAL MODEL OF FEEDING BIOMECHANICS IN EXTINCT CROCODYLIANS

GIGNAC, Paul, Florida State University, Tallahassee, FL, USA; ERICKSON, Gregory, Florida State University, Tallahassee, FL, USA

Bite force capacities are the function of factors (e.g. muscle anatomy and behavior) absent from the fossil record. To deal with this, a number of indirect methods have been used to estimate bite forces (e.g. muscle vector analysis, beam theory, scaling, and tooth indentation simulations) for a variety of fossil taxa. Although, these approaches have loosely referenced modern analogues, none have relied on well-understood, tested neontological models. As a result, the ecological meaningfulness of these bite-force values remains unclear. This is a significant setback for understanding the evolution of feeding in fossil taxa generally and crocodylians in particular, whose remarkably high bite forces in concert with dentition and snout morphology (along with absolute size) allow them to exploit sizable and robust prey. Moreover, it is thought that this suite of dental, cranial, and musculoskeletal anatomy has tracked available niche space within a narrow range of ecomorphology and has been the driving engine of crocodylian diversification. Unfortunately, it is not even understood how bite forces are generated in living crocodylians, which is a predicate to understanding the bite-force capacities of their fossil relatives. To address this problem we have recently developed a mathematical model of bite force generation throughout ontogeny in the American alligator, *Alligator mississippiensis*, based on quantification of the cranial skeleton and jaw adductor muscle anatomy. We tested the model ( $n = 23$ ;  $y = 45.0x - 2676.3$ ;  $R^2 = 0.92$ ) against a diversity of living, adult crocodylians (12 species;  $n = 23$ ;  $y = 45.4x - 2600.3$ ;  $R^2 = 0.83$ ) for which bite forces were experimentally measured. Our results show that we can accurately ( $p = 0.471$ ) predict bite forces for a majority of living taxa. Here we apply this model to a diversity of fossil crocodylians to estimate absolute values of bite force and provide the data needed to address further questions about crocodylian evolutionary niche transitions and the mechanisms of their subsequent diversification.

Technical Session XIV, Friday 1:45

#### CONTROLLING FOR ALLOMETRY IN PHYLOGENETIC ANALYSES OF MORPHOLOGICAL DATA

GILBERT, Christopher, Yale University, New Haven, CT, USA

At its most basic definition, allometry is defined as a change in shape that is correlated with a change in size. The effects of allometry have been well documented and long noted in studies of vertebrate evolution; however, the effects of allometry are rarely accounted for in phylogenetic analyses of morphological and paleontological data. Common size-adjustment methods employed in the phylogenetic analysis of quantitative (continuous) morphological data are generally isometric and do not adjust for allometric effects. The effects of allometry on vertebrate anatomy may lead to the appearance of homoplasy and result in the phylogenetic grouping of similar-sized taxa because allometrically influenced characters are, by definition, correlated with size. These characters violate the assumption of character independence that is critical in phylogenetic analysis. To better account for the effects of allometry in phylogenetic analysis of morphological data, two coding methods are presented: the narrow allometric coding method, applicable to taxa that fall in discrete body-size categories, and a more general allometric coding method that adjusts for allometry across all taxa, no matter their body size distribution. The methods are then applied to extant and fossil data including two mammalian tribes: the primate tribe Papionini and the bovid tribe Hippotragini. Results suggest that the allometric coding methods help detect phylogenetically informative aspects of shape in allometrically influenced characters and result in trees that are different from those obtained without the employment of such methodology. In the two examples given, the trees are also broadly congruent or more consistent with molecular estimates of phylogeny and suggest that the effects of allometry have the potential to obscure homologies and mask the underlying congruence of morphological and molecular data. Future morphological studies in vertebrate evolution should apply one of the presented coding methods when analyzing quantitative morphological/paleontological character data.

Technical Session XVI, Saturday 8:30

#### LIPID BIOMARKER ANALYSIS OF *NOTHROTHERIUM SHASTAENSIS* COPROLITE

GILL, Fiona, University of Bristol, Bristol, United Kingdom; CRUMP, Matthew, University of Bristol, Bristol, United Kingdom; SCHOUTEN, Remmert, University of Bristol, Bristol, United Kingdom; BULL, Ian, University of Bristol, Bristol, United Kingdom

Biomarkers are molecules that can be unequivocally attributed to a specific biological source or process on the basis of their chemical structure. Many lipid biomarkers are recalcitrant molecules that are frequently preserved in the geological record in sediments or associated with macrofossils, including coprolites. Coprolites have already been shown to provide a unique insight into the paleoecological relationship between one animal and the organisms

that constituted its diet. However, biomarker analysis has the potential to extend the utility of coprolites as repositories of paleobiological information by identifying specific dietary items which may not be preserved as morphologically identifiable remains, as well as providing insights into the digestive processes and digestive tract microbial communities of ancient animals. To test the utility of the lipid biomarker approach to coprolite analysis, lipid biomarkers were extracted from a coprolite of the Pleistocene ground sloth *Nothrotherium shastaensis* from Gypsum Cave, Nevada, USA. Analysis of the lipid extract by gas chromatography-mass spectrometry (GC-MS) revealed diagnostic faecal sterols including coprostanol, but the dominant component was a spiroketal sapogenin lipid. This molecule was identified using nuclear magnetic resonance (NMR) analysis as the compound epismilagenin. Epismilagenin is interpreted to have formed as a result of digestive processing leading to structural modification of smilagenin, a secondary metabolite abundant in some plant taxa including the genus *Yucca*. The biomarker evidence therefore supports previous interpretations of a *Yucca*-rich diet for *Nothrotherium shastaensis* based on genetic and other evidence. The conversion of smilagenin to epismilagenin by the sloth is considered analogous to that observed in modern sheep, supporting interpretations of *Nothrotherium shastaensis* as a foregut fermenter. This study suggests that lipid biomarker analysis is a promising approach for coprolite research in the future and is likely to be particularly appropriate for analysis of herbivore coprolites to distinguish between digestive strategies such as foregut and hindgut fermentation.

Technical Session VII, Thursday 1:45

#### A FUNCTIONAL INVESTIGATION INTO THE DIETARY ECOLOGY OF TWO OF THE EARLIEST STEM MAMMALS, *MORGANUCODON WATSONI* AND *KUEHNEOTHERIUM PRAECURSORIS*

GILL, Pamela, University of Bristol, Bristol, United Kingdom; RAYFIELD, Emily, University of Bristol, Bristol, United Kingdom; PURNELL, Mark, University of Leicester, Leicester, United Kingdom; ROBSON-BROWN, Kate, University of Bristol, Bristol, United Kingdom; GOSTLING, Neil, State University of New York at Oswego, Oswego, NY, USA

Mammalian jaws are of pivotal importance in studies of early mammal evolution. Here we present a comparative study of the functional morphology of the lower jaw of two of the first mammals, *Morganucodon* and *Kuehneotherium*, to test hypotheses that differences in jaw morphology and function reflect dietary adaptation and subtle niche differentiation. As no complete mandibles exist, sections of partial mandible were scanned using either synchrotron radiation  $X\mu$ CT (SRXTM) or  $\mu$ CT to generate a complete 3D virtual jaw for each taxon. These were transformed into finite element (FE) models, with appropriate material properties applied to the mandible and tooth roots. FEA was used to reconstruct stress and strain within the digital models, after the application of a biting loading regime. The jaw was constrained at the condyle and either the large ultimate premolar or a mid-row molar, and muscle loads applied to each model to simulate temporalis and deep and superficial masseter contractile force. Using identical muscle loading, peak stresses are several times greater in *Kuehneotherium* than in *Morganucodon*, indicating that the latter could withstand much greater biting forces. The *Morganucodon* mandible is more robust and the pattern of stress produced indicates greater stiffness, with discrete stress concentrations, whereas the *Kuehneotherium* mandible undergoes more torsional flexure. Greater localized stress is found in the ventral jaw below the biting tooth in *Kuehneotherium* than in *Morganucodon*. This may relate to the greatly expanded root apices in *Morganucodon*, spreading the stresses transferred from the roots. Tooth microwear analysis provides independent support for this result. High resolution 3D data were acquired from molar functional surfaces via focus variation microscopy (Alicona IFM). Surface roughness and microtextural quantification revealed statistically significant differences between the two taxa in diet-related tooth microwear. This supports the hypothesis that *Morganucodon* fed on 'hard-object' prey, whereas *Kuehneotherium* was specialized to consume more tractable foodstuffs, thereby indicating early ecological diversity within basal mammals.

Poster Session II, (Thursday)

#### FUNCTIONAL MORPHOLOGY OF THE CLAWS OF PREDATORY AND NON-PREDATORY BIRDS, AND INFERENCES FOR FOSSIL THEROPODS

GLEN, Christopher, University of Queensland, Brisbane, Australia; BENNETT, Michael, University of Queensland, Brisbane, Australia

Pedal claws of extant birds are mainly involved in locomotion and feeding, where they engage and, just as importantly, disengage living or non-living substrates. As simple hard structures, claw shape cannot be modified between tasks. Thus claw shape, particularly claw curvature, must allow effective engagement of important substrates, yet not hinder intentional disengagement. Claw curvatures that satisfy both these requirements differ between species depending on habit or lifestyle and the substrates involved. In many non-predatory birds the pedal claw is adapted for locomotion on substrates upon which they forage, as this is the primary active use of the hind-limb. Using claw angle as a reliable measure of claw curvature that is largely independent of scale and phylogenetic constraints, our initial comparative analysis of >250 species supports the hypothesis that greater claw angles will be found in non-predatory birds that forage more often in trees than on the ground. Careful *a priori* ecological/behavioral categorisation of living species that captures or reflects differences in specific functions of the structures of interest is important. We found fossilized claws of 12 genera of Mesozoic birds and non-avian theropods with suggested close links to avian ancestry show similar claw angles to ground based and ground

foraging modern birds, with little evidence for adaptation to arboreal habits. The current analysis compares the claws of extant carnivorous birds (predators and scavengers) to those of non-predatory birds to explore adaptations for procurement and rendering of prey. Robustness and greater claw angles are important to carnivorous birds, with some 'division of labor' between digits. Radius of claw curvature for most groups of predatory and non-predatory bird scales isometrically with body mass.

Poster Session II, (Thursday)

#### **MIOCENE CERCOPITHECOIDEA FROM THE TUGEN HILLS, KENYA**

GOBLE, Emily, Yale University Department of Anthropology, New Haven, CT, USA; GILBERT, Christopher, Yale University Department of Anthropology and Yale Institute for Biospheric Studies, New Haven, CT, USA; HILL, Andrew, Yale University Department of Anthropology and Yale Institute for Biospheric Studies, New Haven, CT, USA

Miocene – Pleistocene paleontological sediments in the Tugen Hills span the time period from 15.5 Ma to 0.25 Ma. Among the specimens collected from this region are a number of discoveries important to the understanding of primate evolution, including a partial skeleton of the ape *Equatorius*, late-occurring specimens of *Victoriapithecus*, the earliest colobine monkey, one of the earliest members of the *Theropithecus* radiation, and a nearly complete skeleton of the Pliocene colobine *Paracolobus chemeroni*. With the exception of fragmentary primate remains from the Ngorora Formation, incomplete primate specimens from the Tugen Hills have not yet been described. Here, we present preliminary descriptions of the rest of the primates from the well dated sites in the Muruyur Beds (16-15 Ma), the Mpesida Beds (7-6.2 Ma) and the Lukeino Formation (6.2-5.6 Ma). Identified taxa include *Victoriapithecus*, cf. *Parapapio lothagamensis*, and at least two colobine taxa. Specimens attributed to *Parapapio lothagamensis* extend the species geographic range as it was previously only known from its type locality. The split between the major tribes within the colobine subfamily (Colobinae) are estimated to have occurred between 8.2-12.3 Ma and, as might be expected, members of one of the major tribes appear to be represented in the fossil material from the Tugen Hills. The colobine specimens are of particular importance due to their shared derived characters with modern African colobines (Tribe: Colobina). Thus, the colobine taxa from the Tugen Hills represent some of the earliest known members of the modern African colobine radiation and, in contrast to previous hypotheses, suggest that early African colobines were mainly arboreal and that the semi-terrestrial Late Miocene and Plio-Pleistocene colobine taxa were secondarily derived in their locomotor adaptations.

Technical Session XIII, Friday 2:45

#### **A NEW GRYPOSAURUS SPECIES (DINOSAURIA: HADROSAURIDAE) FROM THE MAASTRICHTIAN (LATE CRETACEOUS) OF FAR EASTERN RUSSIA**

GODEFROIT, Pascal, Royal Belgian Institute of Natural Sciences, Brussels, Belgium; BOLOTSKY, Yuri, Amur KNII FEB RAS, Blagoveshchensk, Russia; LAUTERS, Pascaline, Royal Belgian Institute of Natural Sciences / Université Libre de Bruxelles, Brussels, Belgium

A new species of the hadrosaurine hadrosaurid *Gryposaurus* was discovered in the Maastrichtian Udurchukan Formation of Kundur, in Far Eastern Russia. This new species is characterized by a shortened caudal plate on the nasal, a high coronoid process on the dentary, and a straight preacetabular process on the ilium. This is the only Asian representative of this successful genus (5 or 6 species recognized so far) and it underlines its remarkable geographical distribution: Alberta (Canada), Montana, southern Utah, Texas, and Far Eastern Russia. *Gryposaurus* had also an exceptional longevity, probably spanning over more than 12 million years (~80 to ~68 Mya). A new phylogenetic analysis suggests that the genus *Gryposaurus* forms the sister-group of this sauroloph + edmontosaur clade. The high diversity and mosaic distribution of Maastrichtian hadrosaurid faunas in the Amur region is the result of a complex paleogeographical history and implies that many independent hadrosaurid lineages dispersed without any problem between western America and eastern Asia at the end of the Cretaceous.

Poster Session IV, (Saturday)

#### **A NEW GENUS AND SPECIES OF PLOCENE DOLPHIN (CETACEA: ODONTOCETI: INIOIDEA) FROM NORTH CAROLINA, U.S.A.**

GODFREY, Stephen, Calvert Marine Museum, Solomons, MD, USA; GEISLER, Jonathan, Georgia Southern Museum, Statesboro, GA, USA; LAMBERT, Olivier, Institut Royal des Sciences Naturelles de Belgique, Bruxelles, Belgium

A new species of extinct odontocete is based on ten small partial crania of Pliocene age, from the marine Yorktown Formation in North Carolina, U.S.A. They were collected from the Meherrin River, a tributary of the Chowan River. Ossification of the mesethmoid, at least in the facial region, indicates that these specimens represent mature individuals. Neither the dorsally convex premaxillary sac fossae nor the supraorbital processes are elevated to the same degree as they are in the extant pontoporiid *Pontoporia blainvillei* (La Plata 'river' dolphin) and the extant iniid *Inia geoffrensis* (Amazon river dolphin). The slightly left-skewed vertex is intermediate in height between the low and high vertices in *Pontoporia blainvillei* and *Inia geoffrensis*, respectively. On the vertex, the supraoccipital is deeply wedged between the frontals and maxillae. This odontocete has not yet been assigned to either the Pontoporiidae or the Iniidae, sister-groups and the sole occupants of the clade

Inioidea. Inioidea is supported by anatomical and molecular data and in more recent molecular analyses is placed as the sister group to Lipotidae. Initial comparisons suggest that this Pliocene odontocete is either a stem-inioid or a plesiomorphic iniid. Supporting its position as a stem-Inioidea is that it lacks the distinctly knob-like vertex of *Inia* + *Ischyrorhynchus* and the (possibly derived) very low vertex of the pontoporiids (not so marked in *Brachydelphis* and *Stenasodelphis*). If this odontocete derives from the Iniidae, it would represent its first marine member and substantially increase the prehistoric geographic range of this family, because previously, the only fossil genera confidently assigned to Iniidae were found south of *Inia*'s present range, occurring in the fluvial Ituzaingó Formation (Late Miocene or Early Pliocene), Paraná basin, Argentina.

Poster Session II, (Thursday)

#### **A NEW, EARLY MIOCENE CORMORANT SPECIES (AVES, PHALACROCORACOIDEA) FROM SOUTHEASTERN GERMANY**

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Cormorants are aquatic, piscivorous birds of the Old and New World. Today they are most diversified in the Southern Hemisphere, where they inhabit both marine and freshwater environments. The fossil record of phalacrocoracoidea (cormorants and anhingas) might date back to the Eocene, but is assured from the Early Oligocene on in Europe and indicates a European origin. We present a new cormorant species, which is tentatively referred to the genus *Borvocarbo*, a genus which was known from deposits of the Late Oligocene in France and Germany, so far. The new species comes from brackish deposits of early Miocene age (border Ottangian/Karpatian, Mammal Neogene Unit MN4b) from the locality of Rauscheröd in southeastern Germany, situated in the North Alpine Foreland Basin. These brackish sediments (Ortenburg Schotter) are interpreted as delta deposits that have been discharged in the western Paratethys at about 17.5 my ago. The new species is represented only by a few isolated bones, a tibiotarsus and proximal halves of an ulna and a radius. However, even if the osteological information is limited, a number of plesiomorphic features compared to the other European cormorant taxa of the Neogene, support the affiliation to *Borvocarbo*. The new species is the largest within this genus *Borvocarbo* so far. With an estimated size between that of the Great Cormorant (*Phalacrocorax carbo*) and the European Shag (*Phalacrocorax aristotelis*), the new species is distinctly larger than both fossil species of *Borvocarbo*, ?*B. stoeffelensis* and *B. guilloti*. This new record extends the stratigraphical range of *Borvocarbo* from the Late Oligocene into the Early Miocene of Europe.

Poster Session I, (Wednesday)

#### **A NEW EOCENE BROAD-HEADED FROG FROM PATAGONIA: TESTING THE EFFECT OF HYPEROSSIFICATION ON THE RECONSTRUCTION OF ANURAN PHYLOGENY**

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We report on the discovery of anuran remains in the lacustrine layers of the Ventana Formation that have yielded the highly diverse flora of Río Pichileufú (RP), Río Negro Province, northwestern Patagonia, Argentina. Radiometric ages of tuff beds from this succession indicate a depositional age of  $47.46 \pm 0.05$  Ma (middle Eocene, Lutetian). A single specimen that consists of an incomplete articulated skeleton (SVL ca 110 mm) is considered to represent a new taxon. One of the most conspicuous features of this frog is its wide, heavily ossified skull whose roofing bones have a pit-and-ridge sculpture. The combined presence of eight presacral vertebrae bearing equally developed transverse processes, bicondylar articulation between the sacrum and urostyle, slightly dilated sacral diapophyses, and a long scapular shaft precludes referral to an "archeobatrachian" taxon and, conversely, is consistent with neobatrachian affinity. The overall morphology of the skull recalls that of other broad-headed hyperossified frogs, such as the extant ceratophryines, *Calyptocephalella*, and *Pyxicephalus*, and several fossil taxa including the Late Cretaceous *Baurubatrachus* from Brazil and *Beelzebubo* from Madagascar, and the Paleogene *Thaumastosaurus* from Europe. However, the ornamentation pattern and different cranial and postcranial characters readily differentiate the anuran from RP from the aforementioned taxa. These taxa share many features, such as cranial exostosis and squamosal with extensive otic plate and zygomatic ramus, which have been widely used in morphology-based phylogenetic analyses. Notwithstanding, results of recent molecular analyses have made evident that this suite of characters may produce a misleading phylogenetic signal, calling for a more critical use of such characters; some of them may have developed in association with a broad, highly ossified skull. In order to assess the systematic position of the new taxon from Patagonia, we conducted several parsimony analyses based on available matrices based on morphology, and preliminarily explored the impact of some of the characters that a priori might reflect hyperossification rather than phylogeny.

**BIOCHRONOLOGY OF THE MIDDLE-LATE MIOCENE RODENT FAUNAS FROM THE IBERIAN PENINSULA**

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In order to develop paleoecological studies involving many localities is important and necessary to establish a consistent time frame, which enables to arrange the localities according to the sequence of biotic events and compare then with environmental changes. The nature of the continental fossil record has generated a wide range of controversies surrounding the establishment of general biostratigraphic scales. Therefore, sometimes is preferable to develop biochronologic scales. The primary goal of the present work is to present a time sequence for the micromammalian fossil sites from the Iberian latest Middle Miocene to the earliest Pliocene, spanning around 8.6 millions of years (approx. 13.6-5.0 Ma). We studied here more than a hundred faunal lists of rodents (close to two hundred taxa) because this group of mammals is very useful in biochronological studies. After an exhaustive work of bibliographic compilation, we revised the taxonomy of all taxa in the fossil sites following the latest systematic reviews. Numerical dates for a quarter of the sites were available for later calibration. We performed the maximum likelihood appearance event ordination (MLAEO) methodology developed by Alroy, applying it to the whole database compiled. Finally, we obtained a calibrated ordination for all localities. The results obtained are roughly coherent with previous studies (MN scale and local scales) and allows us to estimate the numerical ages for the entire set of fossil sites included in the study. This work is the basis on which we will be able to develop new broad paleoecological studies based on the mammalian communities of the Iberian Miocene.

**A PLIOSAUR FROM THE LOWER CRETACEOUS OF COLOMBIA: THE IMPLICATIONS OF A NEW GENUS**

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Recently, the remains of a large number of marine reptiles have been recovered from Lower Cretaceous rocks around Villa de Leiva, Central Colombia. Here, we present an analysis of one specimen - a new but as yet unnamed genus and species of pliosaurid plesiosaur. The specimen was recovered from Quebrada Pavachoque, Lomo de Yuca, in the Municipio de Sutamarachán, Boyacá. The skeleton was found in bituminous shales and marls at the base of the Arcillolitas Abigarradas Member of the Paja Formation, encased in a calcareous concretion containing *Nicklesia cf. karsteni* ammonites indicating a Lower Barremian age. Acid preparation exposed an exceptionally well-preserved, three-dimensional specimen with superb anatomical detail, allowing full description of previously poorly known areas of the plesiosaur skull such as the olfactory wings, otic capsules, sclerotic plates and basicranium. The unique suite of characters in this specimen includes: four premaxillary teeth, maxilla-parietal contact, unequivocal presence of a lacrimal, olfactory wings formed by the prefrontals, a prominent 'post-symphysal vacuity' in the mandible, and double rib-facets on the anterior cervical vertebrae. A new phylogenetic hypothesis, focusing on the interrelationships of the pliosauromorphs, was implemented by analyzing 31 taxa and 155 characters, with results supporting the independent evolution of Pliosauridae and Polycotylidae. The Strict Reduced Consensus tree resolved the Colombian taxon as deeply nested within Pliosauridae. The new taxon was found to be closely related to the middle Jurassic European *Liopleurodon*, the late Jurassic *Pliosaurus* and the late Cretaceous North American *Brachauchenius*, rather than the coeval Australian '*Kronosaurus*' (a problematic taxon based on a non-diagnostic jaw fragment). Thus the Colombian taxon is vital for understanding phyletic links between the well-known Jurassic and the late Cretaceous pliosaurids. In this respect, the Lower Cretaceous Colombian fauna will prove critical in deciphering unresolved problems in plesiosaurian anatomy, evolution and palaeobiogeography, and is opening up important new directions in the study of plesiosaurs.

**NEW SAUROPOD DINOSAURS FROM THE LATE CRETACEOUS OF MENDOZA PROVINCE, NEUQUEN BASIN, ARGENTINA**

GONZÁLEZ RIGA, Bernardo, IANIGLA, CONICET-CCT / ICB-Univ. Nac. Cuyo, Mendoza, Argentina

In the last year, new sauropod species were discovered in Mendoza Province, northern Neuquén basin. In this region, the Neuquén Group and the Loncoche Formation represent two Late Cretaceous different paleoecological scenarios. In the first scenario, the Neuquén Group (Albian-early Campanian) comprises a thick fluvial, playa-lake and eolian deposits. In this facies we found two new sauropods: *Mendozasaurus neguyelap* and *Malguesaurus florencae*. *Malguesaurus* is a robust somphospondylid titanosauriform recovered in Paso de las Bardas and has an unusual morphology: procoelous distal caudal centra associated with procoelous-opisthoplatan proximal caudals. *Mendozasaurus* was discovered in Cerro Guillermo area. It is an armored lithostrotian titanosaur collected in a taphonomic mode named oberbank bone assemblage, associated to crevasse splay facies. *Mendozasaurus* shows a relatively short, wide and robust neck and shares cervical characters

with *Futalongkosaurus dukei* from Neuquén Province. Moreover, articulated pes of new specimens discovered in this area, give us information about the progressive reduction of size and number of pedal phalanges, in comparison with other titanosaurs exceptionally preserved (La Invernada unnamed species, Allen Formation, Neuquén Province, and *Epachthosaurus sciutoi*, Chubut Province). In the second scenario, the Loncoche Formation (late Campanian-early Masstrichtian) includes lacustrine and marine marginal facies related to a first Atlantic incursion that covered Patagonia. In a level of Agua del Choique site, 14 km west of Malargue City, we located a mega tracksite that includes more than 250 sauropod footprints and some theropod tracks. This finding is an excellent example of wide-gauge style of locomotion produced by derived titanosaurs (probably middle size saltasaurine or aeolosaurine titanosaurs). Moreover, most of trackways analyzed show the same direction, suggesting that Late Cretaceous titanosaurs from Mendoza traveled in social group.

**UNUSUAL PRESERVATION OF FOSSIL BALEEN (CETACEA: MYSTICETI) FROM THE MIOCENE OF CALIFORNIA, USA: COMPARATIVE MORPHOLOGY AND STABLE ISOTOPE EVIDENCE FOR SEASONALITY AND GROWTH**

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An exceptional example of fossil baleen (UCMP 86438) from the upper Miocene (~5.8 Ma) Purisima Formation in northern California (USA) consists of a partial right rack with 16 permineralized plates. Individual plates are slightly compressed mediolaterally by stratigraphic load and have a maximum transverse width proximally of ~50mm, that rapidly decreases distally to ~5 mm over an average plate length of ~180mm. Individual plates are acutely triangular, resembling anterior plates in baleen racks of balaeopteroid mysticetes. The fact that only main plates and no minor plates are represented is consistent with an anterior position in the original rack. Interplate spacing averages 2.9mm suggesting a plate density of 24 plates/100mm, a density value similar to that of extant *Balaenoptera acutorostrata* and twice that of other extant balaeopteroids. Unlike most examples of fossil baleen, the plates of UCMP 86438 are three-dimensional and preserve a high level of internal detail, including calcified keratinous tubules. The external cortical layer of each plate is intact and preserves the longitudinal striations seen in modern baleen. Although fringing tubules along the medial margin of the plates have been lost to erosion, the terminal fringing tubules are well-preserved and extend up to 45mm from the tip of each plate. XRD analysis found an apatitic structure similar to that in modern baleen. The original hydroxylapatite is altered to francolite, a calcium phosphate apatite with considerable substitution of hydroxyl by fluoride ions and partial substitution of phosphate by carbonate ions. FTIR analysis estimates a carbonate content of ~8 wt.%, just beyond the upper range for mineral apatites. Two and 4 mm sampling along the continuously growing fossil baleen records a cyclical carbonate  $\delta^{13}C$  and  $\delta^{18}O$  signal. These cycles likely reflect a seasonal signal influenced by migratory behavior and feeding on isotopically variable zooplankton. Other possible influences include seasonal exposure to mixed water, either from estuarine/fresh water inputs or upwelling zones. These isotopic cycles may also represent yearly fluctuations and can be used to estimate baleen growth rates and age of death based on different extant models.

**INFLUENCE OF A TERRESTRIAL HISTORY ON FOOT MORPHOLOGY IN PRIMATE-LIKE ARBOREAL PROCYONIDS (MAMMALIA, CARNIVORA)**

GOSELIN-ILDARI, Ashley, Stony Brook University, Stony Brook, NY, USA; BOYER, Doug, Stony Brook University, Stony Brook, NY, USA; LEMELIN, Pierre, University of Alberta, Edmonton, AB, Canada

Modern primates have unusual foot morphology possibly reflecting aspects of their arboreal lifestyle. Some authors have suggested that this morphology may be explained by their habitual use of diagonal-sequence gaits in an arboreal setting. This explanation is supported by the observation that the woolly opossum is convergent on primates in these gait features and also differs from its close relatives in having a larger hallux and longer toes. Here we test the association of gait parameters and foot morphology by examining the foot of the basal procyonid carnivoran *Potos flavus*. *P. flavus* has been historically recognized as convergent on primates in its arboreal lifestyle, forward facing orbits, prehensile tail, and predominately frugivorous diet. It has recently been shown to also be convergent with primates in the use of diagonal-sequence walking. Specifically, we took a series of measurements on pedal digits one and three of *P. flavus*, other procyonids, and members of procyonid outgroups, Mustellidae and Mephitidae. We predict that if the primate-like gait of *P. flavus* has affected its foot morphology, this taxon should at least differ from terrestrial outgroups of the Procyonidae in the following ways: 1) relatively more robust and longer hallux, 2) greater prehensibility of the digits, and 3) more elongated digits and reduced claws. In comparison to the basal mustellid, *Taxidea*, and Mephitidae, *P. flavus* has a more robust hallux, elongated proximal phalanges, and reduced claws, features that may be considered convergent on primates. However, it does not exhibit greater prehensibility than *Taxidea*. Compared to other procyonids, *P. flavus* does not have a more robust hallux metatarsal or reduced distal phalanges. However, it does exhibit greater prehensibility of the digits, and

more elongated proximal phalanges than at least the more terrestrial procyonids *Nasua* and *Procyon*. Taking into account phylogenetic relationships among taxa in the comparative sample, results suggest some convergences between *P. flavus* and primates.

Technical Session XIV, Friday 3:15

#### **MORPHOMETRIC ANALYSIS OF CONVERGENCE IN CRANIAL SHAPE ACROSS CARNIVOROUS MAMMALS**

GOSWAMI, Anjali, University College London, London, United Kingdom; MILNE, Nicholas, University of Western Australia, Nedlands, Australia; WROE, Stephen, University of New South Wales, Sydney, Australia

Carnivory has evolved independently several times in mammals. We use geometric morphometrics to study convergences in cranial morphology associated with the evolution of carnivory in mammals. 30 3-D landmarks were digitized on 81 specimens, representing all terrestrial carnivorous clades, including Nimravidae and Amphicyonidae, hyaenodontid creodonts, and three clades of marsupial carnivores, as well as some of their close insectivorous and omnivorous relatives. Principal components analysis was used to assess major axes of shape variation. PC1 represented 35.5% of the total variance and primarily showed a shift from a short-faced, rounded skull to a narrow, elongate skull. The negative end of PC1 was dominated by cats, particularly sabre-toothed forms, while insectivorous marsupials defined the positive end. There was also a large amount of overlap between canids, hyaenodontid creodonts and the most carnivorous marsupials, including thylacines and borhyaenids on PC1. PC2 represented a shift from the flat, pointed faces of herpestids and viverrids on the negative end to the high, broad face, increased nasal and maxilla bones and reduced frontals of *Thylacosmilus* on the negative end. Sabre-toothed felids, including *Smilodon* and *Homotherium*, represented an intermediate morphology along this axis, but the false sabre-toothed cats, nimravids *Dinictis*, *Hoplophoneus*, and *Nimravis*, fell with most of the other carnivorous mammals. PC3, representing 8.25% of the variation, separates marsupials from placentals, with features such as a more posteriorly placed temporomandibular joint and elongate, posteriorly wide nasal bones. Marsupial carnivores, despite common comparisons to felids, are generally more similar in cranial morphology to caniforms. This is surprising for taxa such as *Thylacosmilus*, which converges with sabre-toothed cats in increasing facial height, but apparently not in shortening the rostrum. The clustering of nimravids with more carnivorous bears, such as *Arctodus* and *Agrotherium*, and non-sabretoothed felids, but not with sabretoothed felids is consistent with previous studies of cranial integration.

Poster Session I, (Wednesday)

#### **A SURPRISING AMIID FISH FROM THE LATE CRETACEOUS OF MADAGASCAR**

GOTTFRIED, Michael, Michigan State University, East Lansing, MI, USA; OSTROWSKI, Summer, Michigan State University, East Lansing, MI, USA

Amiid fishes occupy a critical position in actinopterygian phylogeny as the putative sister-taxon (in many analyses) to teleosts, and they have also figured prominently in discussions of historical biogeography. The fossil record of amiids is geographically broad and fairly dense from the Jurassic to the Paleogene, but the clade is at present restricted to a single extant species, the North American form *Amia calva*. Fossil amiids are far more common in the Northern Hemisphere, with only a few scattered Gondwanan records to date (from the Cretaceous of Brazil and the Cretaceous and Paleogene of west Africa). We report here on fossil amiid material collected in recent years from the Upper Cretaceous (?Coniacian/Santonian) Ankazomihaboka beds of northwestern Madagascar, which have previously produced ceratodontid lungfish (*Ceratodus madagascariensis*) toothplates, coelacanth cranial material assigned to *Axelrodichthys*, and diverse tetrapods currently under study. This is the first amiid (fossil or extant) from Madagascar. The most distinctive amiid elements from the Ankazomihaboka are trunk region vertebral centra that are dorsoventrally compressed and bear prominent ventrolateral excavations, resulting in a pronounced invaginated appearance along the ventrolateral margins of the centra. This feature has been considered diagnostic for the vadalamiine amiid *Melvius*, which is represented by two Late Cretaceous species from western North America. This (initially) seems strikingly counterintuitive, as Madagascar's Late Cretaceous biotic links are consistently hypothesized as being with other Gondwanan landmasses. At least three possible explanations can be posited: (1) the distinctive vertebral morphology is more common in amiids than previously realized and not diagnostic for *Melvius*; (2) the morphology of the Malagasy centra is convergent with that of the North American species and not indicative of close relationship; or (3) the genus *Melvius* was in fact geographically widespread, possibly utilizing shallow Cretaceous seaways to facilitate a broad but previously unrecognized distribution.

Late Triassic Terrestrial Biotas and the Rise of Dinosaurs, Thursday 9:00

#### **EARLY MESOZOIC ARCHOSAUR PHYLOGENETICS-PROGRESS AND CONSENSUS?**

GOWER, David, The Natural History Museum, London, United Kingdom; BUTLER, Richard, Bayerische Staatssammlung für Paläontologie und Geologie, München, Germany; HILL, Tobias, The Natural History Museum, London, United Kingdom; BRUSATTE, Stephen, American Museum of Natural History, New York, NY, USA; WILKINSON, Mark, The Natural History Museum, London, United Kingdom

Archosaur phylogeny underpins many aspects of the understanding of Late Triassic biotas and the rise of dinosaurs. In 1996, two of us claimed that the (by then) four numerical analyses of 'basal' (mostly Triassic) archosaurs agreed on several substantial points, and we presented a supertree to illustrate this agreement. Since 1996, many more numerical analyses have been published but no new appraisals of consensus or progress have been undertaken. In addition, many studies on non-phylogenetic aspects of archosaur biology have presented their own, summary framework archosaur trees based seemingly on individual perception or derived from merging selected numerical analyses together using unexplained supertree methods. We quantified agreement/congruence among 35 phylogenies derived from explicit numerical analyses and 35 framework trees for 'basal' archosaurs published between 1989 and 2009 using a range of tree-tree distance/similarity measures. Various supertree methods were used to synthesise consensus trees. Agreement was assessed through time, and between as well as within the numerical analysis phylogenies and framework trees. Other aspects of how the numerical analyses have changed through time were also identified, such as differences in analytical methods, and taxon and character sampling. Our results are interpreted in light of the understanding that differences in agreement among trees can be explained by differences in character and taxon sampling, and in differences in the scoring of common cells in taxon-character matrices. For example, given that increased work might be expected to resolve taxon-character scoring disagreements, we test the hypothesis that agreement among phylogenetic hypotheses has increased through time.

Poster Session III, (Friday)

#### **EXAMINING ECOSYSTEM STRUCTURE AND DISPARITY THROUGH TIME USING GEOMETRIC MORPHOMETRICS**

GRASS, Andy, University of Iowa, Iowa City, IA, USA

Functional morphology and morphometric studies on various mammalian groups have shown marked differences in crania and mandible shape based on dietary preferences and feeding habits. In this study I used three-dimensional geometric morphometric methods to measure the shape of crania and mandibles of herbivorous and omnivorous mammals from three formations in northwestern Nebraska to explore the structure and disparity of ecosystems through time: The White River Group (Chadronian/Orellan), the Harrison Formation (Arikarean), and the Ogallala Group (Hemingfordian). Throughout the time period comprising these formations the climatic conditions were becoming more arid, grasslands were expanding and the large mammalian faunal compositions were shifting from browser dominated to grazer dominated. Relative warps analysis show a visible separation of faunas between the three formations that cannot be attributed to phylogeny in plots based on either the crania or the mandibles. Phylogenetic effects were taken into account using independent contrasts. Disparity measurements show similar disparities between the fauna from the three formations. These results indicate that it may be possible to differentiate fossil taxa from different formations and environments based on the shape of cranial and mandibular elements as well as to infer the environment or diet of a fossil if other unequivocal data are not available.

Romer Prize Session, Thursday 11:15

#### **THE UTILITY OF ORTHODENTINE MICROWEAR AS A PROXY FOR PALEOECOLOGY IN SYNAPSIDS**

GREEN, Jeremy, North Carolina State University, Raleigh, NC, USA

Mastication produces dental scar patterns (microwear) linked to diet in extant mammals, providing a baseline for reconstructing paleodiet in extinct taxa. Although microwear on enamel is a well-accepted proxy for dietary inference, microwear on orthodentine has received less attention. Because some synapsids lack enamel on teeth in maturity (e.g., xenarthran teeth, proboscidean tusks), inference of paleodiet from microwear in these animals is restricted. Here, I address the central question: are orthodentine microwear patterns reliable indicators of ecology in synapsids? The correlation between microwear and feeding ecology was quantified for enamel-free teeth and tusks in 3 extant mammal groups [xenarthrans (255 teeth, 21 taxa), *Loxodonta* (5 tusks), *Odobenus* (6 tusks)] to test 2 hypotheses: 1) microwear on xenarthran teeth is correlated with diet, and 2) tusk microwear is significantly different between taxa that use tusks for feeding (*Loxodonta*) versus those that do not (*Odobenus*). Significantly higher numbers of scratches were observed in extant xenarthran folivores and frugivore-folivores than in carnivore-omnivores or insectivores, supporting hypothesis 1. Orthodentine microwear was then examined in the Pleistocene ground sloth *Nothrotheriops shastensis* (4 teeth) to extend this correlation to extinct taxa. Statistically, microwear in *N. shastensis* was most similar to extant folivores, corroborating independent evidence for herbivory in this taxon. Consistently oriented coarse/hypercoarse scratches on extant *Loxodonta* tusks were statistically correlated with tusk-use in feeding, supporting hypothesis 2. Tusk microwear in extinct proboscideans (*Mammuthus*, 3 tusks) and

Permo-Triassic dicynodonts (24 tusks, 6 taxa) was then compared to extant analogues to test hypotheses of tusk-use in feeding. Results support orthodontine microwear in teeth and tusks as a paleoecological proxy in synapsids, although taphonomic loss of microwear is problematic for fossil specimens. Large samples of fossil teeth are needed to compensate for this loss. Overall, this study expands the ability of dental microwear to reconstruct feeding ecology in extinct synapsids.

Technical Session IV, Wednesday 4:45

#### **VARIATION IN MANDIBULAR MORPHOLOGY WITHIN LATE *HOMO* AND ITS RELEVANCE TO MASTICATORY LOAD RESISTANCE.**

GROENING, Flora, University of York, Hull York Medical School, York, United Kingdom; FAGAN, Michael, University of Hull, Hull York Medical School, Hull, United Kingdom; O'HIGGINS, Paul, University of York, York, United Kingdom

The craniofacial morphology of the genus *Homo* shows a strong trend of decreasing robusticity during the Middle and Late Pleistocene. This gracilization trend is frequently explained by advances in food processing and tool use during this time period, which probably resulted in a reduction of masticatory loads. Although this is a plausible hypothesis, it is difficult to test with conventional methods. In order to examine whether the observed morphological changes do indeed represent adaptations to decreased masticatory loads, this study used 3D finite element (FE) analysis. FE models were generated based on medical and microCT scans of modern human, *H. neanderthalensis* and *H. heidelbergensis* mandibles. Different biting tasks were then simulated using muscle force data from modern humans as well as muscle force estimates for the respective fossil specimens. In order to distinguish between the effect of external shape and overall cortical bone thickness, hypothetical models with equal cortical thickness were created and loaded in the same way as the original ones. The results indicate that the simulated masticatory loads induce smaller strains in the *H. neanderthalensis* and even more so in the *H. heidelbergensis* mandibles compared to the anatomically modern humans. Thus they support the idea that changes in the mandibular morphology of late *Homo* reflect adaptations to decreasing masticatory loads. Interestingly, these strain differences are only partly due to the external shape of the specimens. The variation in cortical bone thickness also has a major impact on the strain magnitudes. In general, the results stress the importance of larger sample sizes for comparative FE studies, since intraspecific variation in external and internal bone morphology can have a marked effect on the resistance to loads.

Preparators' Session, Thursday 9:15

#### **MITIGATING STRESS AND STRAIN WHILE DE-MOLDING DELICATE SPECIMENS FROM THE LATE CRETACEOUS MAEVARANO FORMATION OF MADAGASCAR**

GROENKE, Joseph, Stony Brook University Department of Anatomical Sciences, Stony Brook, NY, USA

Well-preserved and delicate specimens present a special case for the capture and replication of external morphological data, especially with the increasing accessibility of CT scanning in the field. When the decision to mold is made on such specimens, it is the burden of the preparator to minimize specimen damage. I report on lessons learned during seven years of molding several hundred extremely well-preserved and sometimes delicate vertebrate specimens from the Late Cretaceous of Madagascar. Most importantly, I present a methodology and broader rationale for avoiding poured or block molds in favor of thinly layered molds. Ideally, de-molding any specimen with the aim of minimizing the forces applied to it entails removing catalyzed molding material at a vector 1) approaching the contact tension between specimen and material in magnitude, and 2) near to perpendicular in direction to every contact point on the specimen. The need for a molding material thickness great enough to withstand tearing and complex specimen morphology make this impossible, inflicting necessary stresses during de-molding. A thin mold can be pulled from the surface of a specimen with less likelihood of a force overload, since excess forces are not indirectly applied to the specimen through large amounts of silicone above the mold/specimen contact. To avoid damaging delicate specimens while still making an effective mold, I generally use 4-5 layers of a slow-setting RTV silicone, then a layer or two catalyzed with thixotropic catalyst, and finally a poured plaster mothermold to complete a mold part. I will also demonstrate a plaster mothermolding technique I use for temporarily immobilizing mold parts, so that counterparts can be removed with a minimum of force applied at the mold/specimen contact. Thin layers can increase data capture if external plugs are used to prevent undercuts in circumstance where poured molds require internal plugs. Volumetric data from CT scanning will demonstrate the extent to which layered molds are also economical if time is not a factor, since poured block silicone wastes far more material than the layered approach.

Technical Session XI, Friday 11:30

#### **NEW FAUNA FROM THE KALODIRR MEMBER, LOTHIDOK FORMATION, EARLY MIOCENE OF NORTHERN KENYA**

GROSSMAN, Ari, Midwestern University, Glendale, AZ, USA

The Kalodirr Member of west Turkana is well known for its unique primate fauna. In contrast, the rest of its mammalian fauna has rarely been systematically studied. This study seeks to address this deficiency. The study addresses the following questions: 1) What mammals were present at the sites of Kalodirr and Moruorot during the early Miocene? 2) How do these compare to fauna from other early Miocene sites in Kenya? 3) Can these similarities and/or differences inform us about habitat, environment, regional biogeography, and mammal evolution? I examined and revised all the fossils from the sites of Kalodirr and Moruorot located at the NMK-Nairobi, and the Moruorot fossils located at the UCMP-Berkeley. I used taxonomic similarity indices to compare the fauna from the Kalodirr member with known Miocene faunas in other regions of Kenya that are either geographically or temporally different. I also used Ecological Structure analysis to reconstruct the habitats at these sites. About 40 genera and 50 species from 10 orders were recognized at Kalodirr and Moruorot. Of these more than 10 are new. Novel taxa include macroscelids, bovids, rodents, carnivores, and others. The taxonomic similarity indices reinforced the high degree of endemism previously suggested for early Miocene sites from different regions. The ecological structure analysis indicates that Kalodirr and Moruorot were woodlands while other early Miocene sites were forests. Therefore, the proposed endemism may well represent environmental differences. Finally, some taxa at Kalodirr and Moruorot represent the first arrival dates of some Eurasian immigrants into sub-Saharan Africa.

Poster Session IV, (Saturday)

#### **NEW GIRAFFE ORBITAL MUSCLES AND THE EVOLUTION OF THE COMBAT ADAPTATIONS OF THE GIRAFFE**

GUIGOVA, Adriana, New York College of Osteopathic Medicine, Old Westbury, NY, USA; RUVO, Anthony, New York College of Osteopathic Medicine, Old Westbury, NY, USA; SOLOUNIAS, Nikos, New York College of Osteopathic Medicine, Old Westbury, NY, USA

The sister taxon of the giraffe is *Bohlinia attica*, which also has a long neck and long metapodials. It has been found among localities at the late Miocene of Pikermi in Greece. The fighting adaptations of the giraffe differ from those of *Bohlinia*. In the giraffe the metapodials are supported by strong fascial sheaths rather than muscles. Dissections of the eye of the giraffe show that it possesses an enlarged dorsal retractor bulbi muscle. The giraffe also has a second small ventral retractor bulbi which is unique. Both of these muscles are newly discovered. These muscles seem to have been derived from the dorsal and ventral recti. They are not homologous to the known retractor bulbi found in other species, which are derived from the medial recti. The giraffe retractors pull the eyes in during impact of intraspecific male combats. Other combat adaptations involve an overall pyramidal body shape which is essential for the pendulous swinging of the neck observed in fighting. Two giraffes lean on each other while in combat, preventing each other from falling to the ground. C7 is the primary pivot vertebra of the swinging motion. Furthermore, an asymmetry develops in the posterior articular facets of C7 indicating that adult animals have a preference for swinging to one side. Another feature is that the skull has large frontoparietal and nasal sinuses with ossicones that are blunted. Secondary bone growth covers the skull surface with layers of irregular bone, along with embedded air pockets in dorsal skin of the head all acting as impact protective cushions. *Bohlinia attica* has strong muscular support of the metapodials suggesting different fighting strategies, a long neck but with a simple C7 without the asymmetry as well as minimal head sinuses with minor secondary bone growth located only at the ossicone apices. *Bohlinia* shows that the elongation of the neck preceded other specializations.

Poster Session I, (Wednesday)

#### **THE FISH FAUNA OF THE LATE CRETACEOUS (SANTONIAN) CONTINENTAL VERTEBRATE LOCALITY OF IHARKUT (BAKONY MOUNTAINS, HUNGARY)**

GULYAS, Peter, ELTE, Department of Paleontology, Budapest, Hungary

Since the year 2000 the Iharkut continental vertebrate locality yielded 24 vertebrate taxa so far. Among these the most common fish remains belong to Pycnodontiformes and Lepisosteiformes genera. The pycnodont remains are composed of fragmentary prearticulars and isolated teeth. On the basis of morphological differences between well-preserved remains, two morphotypes can be distinguished. Prearticulars of the first type contain three longitudinal tooth rows. The size of the teeth decreases in anterior direction in each row. The teeth of the main row are the largest, transversally elongated and slightly bean-shaped in occlusal view, with their width being 2.5 times larger than their length. The teeth of the first lateral row are transversally elongated and oval-shaped in occlusal view, while the teeth of the second lateral row are the smallest, with circular outline in occlusal view. The surface of the tooth crowns of this morphotype shows no sign of ornamentation. The second type is basically the same, but with some important differences. First, it contains four tooth rows: besides the others, a medial row is also present. The teeth of the medial row are rounded in occlusal view and are the smallest ones in the dentition. Second, the teeth of the first lateral row are, though transversally elongated, rather rounded rhomboidal. Third, on the occlusal surface of the teeth a transverse groove is visible. From the edges of this groove, minute, bumped ridges originate and run radially to the edges of the tooth crown. Based on most

recent examinations, these pycnodontiform remains belong to the genus *Coelodus*. They represent the second known freshwater occurrence of the order after the Las Hoyas locality (Spain). The Lepisosteiformes remains are only isolated teeth, vertebral centra and scales. The well-preserved teeth are conical with longitudinal ridges and lanceolate apex. The centra are opisthocoel and the scales are rhomboidal with ganoin layer. These characters are typical of lepisosteiforms, moreover the morphology of the entire teeth is typical of the genus *Atractosteus*. These remains from Itharkut represent the geologically oldest known occurrence of the group in Laurasia.

Technical Session XIV, Friday 2:45

#### SIZE TRENDS IN LIVING BAT (CHIROPTERA) CLADES AND ESTIMATING BODY MASS OF FOSSIL BATS

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Body mass is an important parameter for assessing ecology of mammals. It is closely tied to metabolic rate in most mammals and directly influences dietary habits and locomotor activities. Relationships between skeletal proportions and body mass rarely have been studied in bats. To assess allometric relationships and to develop metrics for estimating body mass in fossil taxa, we measured 1160 extant bat specimens encompassing 15 families, 67 genera, and 156 species. Measurements included: long bone length and midshaft diameter; skull length and width; tooth length and width. Body mass was recorded from specimen tags or from the literature. Additional body masses were gathered for extant species of Phyllostomidae, Rhinolophidae, and Hipposideridae. Mass was mapped on molecular and combined phylogenies and optimized as a continuous character. Trends within phyllostomids include: all ancestral state body masses are reconstructed as small (10-27 g); more subclades (60%) show size increase than decrease; large terminal taxa achieve large size differently. Frugivorous *Artibeus lituratus* inherited successive small increases that accumulated along several ancestral branches whereas carnivorous *Vampyrum spectrum* increased 600% in mass from its nearest insectivorous ancestor, just two nodes removed. Rhinolophoids are similar to phyllostomids in having small ancestral masses (c. 10 g) but differ in having more subclades (70%) decreasing in size. Small size apparently typified the ancestry of both families. Humerus and femur midshaft diameters correlate well with body mass in living bats. Allometric scaling reconstructed ancestral size in the archaic *Onychonycteris* as relatively large (42-45 g) with *Icaronycteris* being smaller (c. 24 g) but still large compared to most reconstructed values in backbone nodes among extant bats. The putative hipposiderid *Tanzanycteris* weighed c. 14 g, similar to the estimated ancestral mass of c. 10 g for rhinolophoids. *Vampyravus*, often compared to phyllostomids, weighed 120 g, much larger than the reconstructed ancestral mass of that family (c. 12 g). Lack of congruence between fossils and ancestral reconstructions remains to be explained.

Poster Session IV, (Saturday)

#### BISON FROM LONDON AND LOS ANGELES - A TALE OF TWO CITIES

GUST, Sherri, Cogstone Resource Management, Santa Ana, CA, USA; GEE, Henry, Nature, London, United Kingdom

Paleontologists in Europe assign most Late Pleistocene bison specimens to *Bison priscus*, steppe bison, while in North America most Late Pleistocene bison specimens are assigned to *Bison antiquus*, ancient bison. Ancient DNA analysis has demonstrated that bison were genetically diverse for most of the Pleistocene and that late Pleistocene bison throughout Beringia are descended from North American bison with genetic influx from Asia. On the other hand, the same analysis found that there are no significant genetic differences between modern North American bison (wood and plains) in spite of seemingly large phenotypic differences. We wondered whether *B. priscus* and *B. antiquus* exhibited morphological differences. We used analysis of postcranial remains, in particular the metacarpals (cannon bones of the forelimb), to answer our question. Unlike skulls and horncores, metacarpals have the benefit of sample sizes sufficient to undertake serious statistical analysis. Metacarpal dimensions have also been demonstrated to reflect body weight including sexual dimorphism. Using univariate and multivariate techniques, we compared metacarpals of *Bison antiquus* from Rancho La Brea, Los Angeles, California dating 40-11 thousand years ago to those of *Bison priscus* from various sites in and around London, England dating about 125,000 thousand years ago. The combined samples exhibit classic bell curves of a normally distributed population and all statistical tests revealed no significant differences. We then partitioned the individual samples by sex and examined the effect of removing this factor by analyzing males and females separately. Again, there were no significant differences.

Poster Session IV, (Saturday)

#### A NEW BIZARRE TOOTHED WHALE FROM THE NEOGENE OF BAHIA INGLESA FORMATION (ATACAMA REGION, CHILE)

GUTSTEIN, Carolina, Universidad de Chile, Santiago, Chile; COZZUOL, Mario, Universidade Federal de Minas Gerais, Belo Horizonte, Brazil; CANALS, Mauricio, Universidad de Chile, Santiago, Chile

The Bahía Inglesa F. is already known by a great diversity and abundance of vertebrates. The specimen was recovered from "Las arenas" locality, assigned to the Late Miocene as minimum age, by Sr-Sr methods in overlying beds. The specimen consists in skull fragment (MPC222) including the vertex, nasal passage and premaxillary plate, associated to an occipital shield fragment including the condyles. The specimen presents a completely dorsal nasal passage anteriorly surrounded by the premaxilla and posteriorly to the nasals, as in odontocetes. The premaxillae are inflated in the region between the premaxillary foramina and the nasal passage, forming the premaxillary plate, as in Iniidea. The nasals are triangular in shape resembling that of Pontoporiidae and the premaxillary foramina presents posterolateral and anteromedial sulcus as in Pontoporiidae *sensu lato* (including *Brachydelphis*). Nevertheless, there are accessory premaxillary foramina placed more posteriorly and without associate sulci, lying just anterior to the nasal passage. Interestingly, the maxilla has no contact with the nuchal crest, and presents a rugose suture with the frontal just posterior to the nasal passage, at mid-length of the nasals posterior extension. Additionally, at this portion, the frontal becomes dorsally exposed and forms, medially, a very elevated crest that is rostro-caudally expanded. This crest resembles the sagittal crest of most mammals, but it is formed by the frontals, and by its position it is comparable to the "knob" process of the Iniidae, although it is not squared in shape. Additionally the dorsal posterior maxillary foramina are wide (9mm) and lay at the posterior maxilla-frontal suture. The combination of features, in the vertex and premaxillary plate, not known for any odontocete, and the fragmentary nature of this record only allow us to refer the specimen, in a preliminary way, to the Iniidea. The overall configuration of MPC222 probably implicates in a different pattern for the distribution of the facial organs and musculature. With this in mind, the scheme for the evolution of the skull telescoping in odontocetes could be more complex than previously thought.

Romer Prize Session, Thursday 10:45

#### SKELTAL ARCHITECTURE, LAUNCH DYNAMICS, AND MECHANICAL LIMITS OF FLYING VERTEBRATES

HABIB, Michael, Johns Hopkins University, Baltimore, MD, USA

The vertebrate clades that have evolved powered flight share numerous convergent characteristics, but also differ in many respects, including an apparent differential in maximum size. The largest pterosaurs far exceeded the size of any birds or bats, reaching body masses as high as 250 kg. The largest known flying bird reached 75 kg in mass, while no known bats are larger than 1.25 kg. Utilizing comparative analyses of long bone structural strength, trabecular bracing, and muscle attachment expansion in pterosaurs, birds, and bats, I demonstrate several important structural trends that explain the difference in observed maximum size in flying vertebrates. Residuals from the regression of length-corrected section modulus against body weight strongly relate to characteristics of locomotion. Ranges of potential body mass were utilized to confirm that the structural trends are robust to assumptions of weight and size. The results indicate that pterosaurs utilized a quadrupedal, leaping launch habit, which explains their large maximum size. In pterosaurs, forelimb bone strengths scale faster than the strength of the hindlimb, yielding large humeral:femoral strength ratios in large species. In birds, hindlimb elements average greater strength than forelimb elements at body sizes above 0.55 kg. Based on reconstructed scaling rates of power capacity and structural strength, I predict that no known pterosaurs reached the mechanical limits for the clade. I find no evidence for a running launch in pterosaurs, and I find that running launch in birds is not related to body mass. Running launch in birds is correlated with aquatic habits; the combined effects of phylogeny and diving explain the majority of the variance in avian launch habits. This suggests that running launch in birds is a secondarily derived character that has evolved to accommodate a bipedal takeoff from water. The analysis does not support a running launch dynamic as the basal state for birds, and *Archaeopteryx* likely launched by leaping. Finally, based on analyses of long bone mass and loading, it appears that pneumaticity is more important for increasing skeletal strength than for lowering skeletal weight.

Technical Session I, Wednesday 11:15

#### NICHE CONSERVATISM ABOVE THE SPECIES-LEVEL IN NORTH AMERICAN MAMMALS

HADLY, Elizabeth, Stanford University, Stanford, CA, USA; SPAETH, Paula, National Evolutionary Synthesis Center, Durham, NC, USA; LI, Cheng, Stanford University, Stanford, CA, USA

Climate space encompassed by the geographic range of a species often is used as a proxy for reconstruction of the species' ecological niche. This approach is used both retrospectively, to reconstruct paleoclimate, and predictively, to model where species will move given scenarios of future warming. This technique, called environmental niche modeling, relies of niche conservatism. Niche conservatism refers to the presumption that species inherit ecological traits that permit persistence through time. Typically it is climatic tolerances that

are assumed to be conserved and are most frequently used in the reconstructions. However, environments change much faster ( $10^2$  to  $10^5$  yrs) than new species evolve ( $10^6$  yrs), and closely related species are most likely to share similar environmental tolerances. Thus, we investigated whether niches were conserved within lineages using the dynamics of geographic range size of North American mammals over the past 120,000 years. Our hypothesis was that the size of the geographic range of a genus should remain relatively constant, regardless of the stability of the environment or how much the boundaries of the species' range moved spatially. We assumed that intrinsic biotic traits and within-community ecological interactions ultimately control maintenance of the geographic range, not simple changes in climate. Relevant traits include life history attributes important for maintaining a geographic range (i.e., intrinsic growth rates, dispersal ability, whether species are specialists or generalists, etc.). We calculated mean and variance of range sizes for mammalian genera and families in North America ranked them by range size during the Pleistocene and Holocene. Our analyses demonstrated that geographic range size is indeed an emergent property above the species-level. These results were not influenced by the number of species within a genus or by within-genera extinction. We conclude that stability in range size is determined by the traits of higher-level taxa and that environmental niche modeling may be more appropriately used above the species-level for both retrospective and predictive scenarios.

Preparators' Session, Thursday 8:00

#### CONTINUAL DESTRUCTION OF PYRITIZED BONES OF NEOGENE MAMMALIAN FOSSIL FROM NORTHEASTERN THAILAND

HANTA, Rattanaphorn, Research Institute of Petrified Wood and Mineral Resources, Muang, Thailand; RATANASTHIEN, Benjavun, Chiang Mai University, Muang, Thailand; JINTASAKUL, Pratueng, Research Institute of Petrified Wood and Mineral Resources, Muang, Thailand; KUNIMATSU, Yutaka, Primate Research Institute, Kanrin, Japan

A number of mammalian fossils were discovered from mined sand pits in Nakhon Ratchasima, northeastern Thailand. The mammalian fossils were composed largely of proboscidean; Middle Miocene *Prodeinotherium* and *Protanancus*, Late Miocene *Gomphotherium*, *Sinomastodon*, and *Stegolophodon*; and Plio-Pleistocene *Anancus*, *Stegodon*, and *Elephas*. At least two new taxa of other mammalian fossils were recognized from this area, anthracotheriid *Merycopotamus thachangensis* and hominid *Khoratpithecus piriyai*. The voids and bone apatite were largely to completely replaced with pyrite during diagenesis. Other replacing minerals were sodium chloride and calcium sulfate derived from adjacent salt dome. The bones seemed to be well-preserved but soon after submerged aerially, bones become cracked as the result of oxidation of pyrite due to the expansion of sulfate salts. The destruction is continuous and currently not possible to stop the hydration processes lead to completely damage to the fossils. This is a major problem in preservation and conservation the fossils in this area. The ideal condition is to prevent the bones from being prone to oxygen. At present, the bones were saturated and flooded in lubricating oil until the appropriate treatment can be available.

The Evolution of Birds in the Mesozoic: a Symposium in Honor of Cyril A. Walker, Thursday 9:45

#### AVIAN CRANIAL MATERIAL AND CRANIAL CERVICAL VERTEBRAE FROM THE LOWER CRETACEOUS XIAGOU FORMATION OF GANSU PROVINCE, CHINA

HARRIS, Jerald, Dixie State College, St. George, UT, USA; LAMANNA, Matthew, Carnegie Museum of Natural History, Pittsburgh, PA, USA; LI, Da-qing, 3rd Geology and Mineral Resources Exploration Academy, Lanzhou, China; YOU, Hai-Lu, Chinese Academy of Geological Sciences, Beijing, China

Recent exploration of the Lower Cretaceous (Aptian) Xiagou Formation in the Changma Basin (northwestern Gansu Province, China) has produced scores of new avian fossils, ranging from isolated bones to nearly complete, articulated skeletons with feathers and other soft tissues. The majority of these specimens, including the most complete, pertain to the ornithuromorph *Gansus yumenensis*. Despite this abundance of avian specimens, fewer than a dozen preserve cervical vertebrae cranial to the caudalmost three or four, and only four preserve cranial elements. All cranial specimens also include cranial-middle cervical vertebrae, but no other postcranial elements; only one specimen that has middle cervicals is articulated with more caudal elements. While it is likely that all of these specimens pertain to *Gansus*, affiliation with one of the Xiagou enantiornithians or an as-yet unknown taxon cannot be completely ruled out at present. Of the four cranial specimens, one preserves a caudal fragment of the braincase that exhibits an intricate series of curvilinear impressions that may correspond to portions of the brain or neural vasculature. The other three consist primarily of the caudal halves of crania, one exposed in dorsal view and one each in right and left lateral views. The latter specimen also preserves portions of dentaries that, although toothless, may possess very small alveoli. Overall, the skulls appear transversely narrow, with large orbits and dorsoventrally compressed rostra of moderate length. Most well-preserved cervicals are in articulated sequences and visible only in dorsal or ventral view. Where present, the atlas plesiomorphically lacks fused hemiarches. In some specimens, the postaxial cranial-middle cervicals do not appear to be heterocoelous, as in enantiornithians, the ornithuromorph *Yixianornis*, and the caudal cervicals of *Gansus*, but in at least one other specimen, these cervicals do appear to be heterocoelous. Ribs are fused to the cranial, but not middle, cervicals. The Xiagou specimens provide new data on Mesozoic avian evolution; any that pertain to *Gansus* bear on the origin of ornithuromorph, and ultimately neornithian, traits.

Technical Session II, Wednesday 8:15

#### EXPLORING BASAL GNATHOSTOME PHYLOGENY USING COMBINED ANALYSIS OF MULTIPLE DATASETS OF MOLECULAR AND MORPHOLOGICAL DATA

HARRISON, Luke, Redpath Museum, McGill University, Montreal, QB, Canada; LARSSON, Hans, Redpath Museum, McGill University, Montreal, QB, Canada

The phylogenetic interrelationships between the extant basal gnathostomes remain contentious. In particular, the extant sister group of Tetrapoda has been variously inferred to be Dipnoi, *Latimeria*, or neither. Some studies have further questioned the basal position of Chondrichthyes among gnathostomes and the phylogenetic position of the Polypteridae. While morphology-based phylogenetic analyses have more or less converged to place Chondrichthyes basally and lungfish as the extant sister group of tetrapods, molecular studies have been equivocal. While some are congruent with morphological analyses, some molecular analyses have placed Tetrapoda as the sister group to a monophyletic clade consisting of all other extant gnathostomes, including Chondrichthyes. To attempt to resolve these conflicts, mitigate methodological bias and recover a phylogeny that best reflects all available data, we analyzed a large, partitioned dataset with extensive taxon sampling. The dataset consisted of a supermatrix of morphological phylogenetic data from published studies of extinct and extant taxa as well as a large molecular dataset drawn from annotated and unannotated sequence data. By first applying a total information approach, and then using current phylogenetic methodologies, we present the most thorough analysis of basal gnathostome phylogeny to date. Both Bayesian Inference and Maximum Likelihood analyses were used in conjunction with multiple models of morphological and molecular evolution; the dataset was further pruned for sites/characters exhibiting excessive variability. Preliminary results confirm the lungfish as the living sister group of Tetrapoda and the basal actinopterygian affinities of the Polypteridae. Furthermore, the branching events about Eugnathostomata and all basal osteichthyan appear to have been extremely rapid. We also discuss the problems of outgroup selection and long branch attraction in molecular phylogenies of deeply divergent groups.

Technical Session IV, Wednesday 3:45

#### A NEW PLIOPTHECOID (MAMMALIA, PRIMATES) FROM THE LATE EARLY MIOCENE OF CHINA AND ITS ZOOGEOGRAPHIC IMPLICATIONS

HARRISON, Terry, New York University, New York, NY, USA; JIN, Changzhu, Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China

A diversity of pliopithecoids is known from Miocene localities in Europe, but until recently this group was relatively poorly represented in China. However, recent discoveries have shown that Chinese pliopithecoids were taxonomically diverse and geographically widespread. The earliest pliopithecoids in China (and Eurasia) are represented by *Dionysopithecus* and *Platodontopithecus* from the early Miocene of Sihong, Jiangsu (~17-18 Ma). During the middle Miocene (~12-15 Ma), several species of pliopithecids are recorded at localities in Gansu Province (Laogou), Inner Mongolia (Damiao), Xinjiang Autonomous Region (Teiersihabahe) and Ningxia Hui Autonomous Region (Tongxin). Finally, a late-surviving crouzeline pliopithecoid, *Laccopithecus robustus*, is known from the late Miocene (~7 Ma) of Shihuiba in Yunnan, which postdates the extinction of pliopithecids in Europe (during MN 10).

Paleontological investigations at the late early Miocene locality of Fanchang in Anhui Province have yielded a sample of isolated teeth (more than one hundred) of a previously unknown species of pliopithecoid. The associated micromammals indicate an age contemporaneous with Shanwang, Shandong Province (MN 5, ~16-17 Ma). All of the permanent teeth are represented, except for i2. The Fanchang pliopithecoid is slightly larger in overall dental size than *Pliopithecus zhanxiangi*, *Laccopithecus robustus* and *Anapithecus hemyaki*. With its unique suite of dental features it clearly represents a new species and genus. Shared derived features of the molars confirm that the Fanchang pliopithecoid has its closest affinities with the European crouzelines, but a number of primitive traits indicate that it is a stem member of the clade. Contrary to previous zoogeographic scenarios, the occurrence of a stem crouzeline in China implies that the Pliopithecinae and Crouzeliinae may have diverged from a stem pliopithecoid in East Asia during the early Miocene prior to their arrival in Europe.

Technical Session XII, Friday 3:45

#### FILLING IN THE CENTRAL AMERICAN CROCODILE GAP: EVIDENCE FROM THE MIDDLE CENOZOIC OF PANAMA

HASTINGS, Alexander, University of Florida, Gainesville, FL, USA; MACFADDEN, Bruce, Florida Museum of Natural History, Gainesville, FL, USA; RINCON, Aldo, Smithsonian Tropical Research Institute, Panama City, Panama; MONTES, Camilo, Smithsonian Tropical Research Institute, Panama City, Panama; JARAMILLO, Carlos, Smithsonian Tropical Research Institute, Panama City, Panama

Fossil crocodylians are exceedingly rare within Central American fauna. A few localities are known from the Pliocene and Pleistocene of northern Mexico, the late Pliocene-early Pleistocene of Costa Rica, and several sites in Panama. As a result of recent expansion of the Panama Canal, new crocodylian fossils have come to light which, in combination with collections that date back almost 100 years, reveal evidence of the nature of the

crocodilian fauna in Central America. Crocodilian fossils have been recovered from the late Oligocene/early Miocene Las Cascadas Formation, the early Miocene Culebra Formation, the early to middle Miocene Cucaracha Formation, and the late Miocene Gatun Formation. Most material is limited to isolated teeth, vertebrae, and osteoderms. However, three mandibular fragments have been recovered from a distinctly longirostrine morphotype. Longirostrine crocodilians are known from South America during the Miocene by the gavialid *Gryposuchus* and the crocodylid *Charotosuchus*. Due to the close spacing of *Gryposuchus* mandibular alveoli from South America and the highly emarginated mandibles of *Charotosuchus*, both of which are absent in the Panamanian fauna, we assign these crocodilians instead to the moderately-spaced, smooth margined *Gavialosuchus*, known from eastern North America. Comparison of alveolar size and spacing are also most similar to *Gavialosuchus*. Moreover, the preserved osteoderm fragments all possess shallow pitting without large ridges and a smooth ventral surface, again consistent with those of *Gavialosuchus*. This means the Panamanian crocodilian fauna can for the first time be compared alongside the mammalian fauna, which has an exclusively North American affinity. In addition, the large number of very small crocodilian teeth (< 0.5cm) may suggest the area at one time was used for nesting by these ancient crocodilians. Despite the relatively near connection of Panama to South America at this time, and the propensity of crocodilians to disperse across short seaways, it is interesting that the crocodilian fauna bears more resemblance to those known from North America rather than South America.

Poster Session IV, (Saturday)

#### MODIFIED METATARSALS IN *TAPIRUS POLKENSIS*: AN IMPORTANT PHYLOGENETIC CHARACTER BASED ON FORM AND FUNCTION

HAWKINS, Patrick, ETSU, Johnson City, TN, USA; WALLACE, Steven, ETSU, Johnson City, TN, USA

Tapirs are found in fossil sites around the world, but usually in small numbers. The Gray Fossil Site (GFS) in northeastern Tennessee, USA however has produced the largest number known of tapiroids (MNI>75), many with articulated postcrania. This unique sample provides an unprecedented opportunity for population-level analyses. Though all GFS individuals have been identified as the late Miocene dwarf tapir, *Tapirus polkensis*, a wide variety of phenotypes has been observed in this population, including mastication muscle attachments, the number and location of foramina, and novel articulations in the feet. Such variation is suggestive of temporally or phylogenetically important adaptation. Specifically of interest is the articulation of the vestigial first metatarsal with the proximal end of the fourth metatarsal (MT4). This unusual bone touches the third metatarsal (MT3) posteriorly in all species, but also articulates with the MT4 in some taxa: 1) present in the extant Asian *T. indicus* and the extinct *T. webbi*, 2) absent in the other three extant and most of the fossil New World species, and 3) polymorphic in the GFS population. The articulation has already been used in phylogenetic analyses. However, such polymorphism had not been previously documented in any other member of Tapiridae, and its functional significance is unclear. Our research suggests that the MT4 articulation is correlated to smaller size of the distal facet on the MT3, probably because of a smaller range of joint motion. Such changes may reflect behavior, preferred substrate or developmental differences. Fortunately, *T. indicus* can be compared to the other extant new world tapirs (as well as GFS *T. polkensis*) to evaluate the character. Moreover typical sources of polymorphism, such as sexual dimorphism, do not appear to explain this feature. Results may help resolve phylogenetic and biogeographic questions within the Tapiridae as the relationships between Old and New World tapirs are investigated, and will shed light on the ecological interpretation of sites all over the world.

Technical Session III, Wednesday 4:45

#### BODY SIZE, PHYSIOLOGY, AND ECOLOGY: PALEOTHERMOMETRIC ESTIMATES FROM THE FOSSIL RECORD OF REPTILES

HEAD, Jason, University of Toronto, Mississauga, Mississauga, ON, Canada; POLLY, P. David, Indiana University, Bloomington, IN, USA; BLOCH, Jonathan, Florida Museum of Natural History, University of Florida, Gainesville, FL, USA; CADENA, Edwin, Florida Museum of Natural History, University of Florida, Gainesville, FL, USA

Poikilothermic tetrapods are dependant upon a critical minimum ambient temperature to maintain maximum body size for a given mass-specific physiology, and the relationship between environmental temperature and body size in extant taxa allows the use of fossils as paleothermometric proxy data. Size changes across different latitudes within modern squamates and turtles are consistent with a model that predict body size increases to be proportional to temperature increases at known metabolic rates. The model can be derived to calculate past temperatures by comparing body sizes in fossil reptiles with maximum sizes in extant reptiles at a given Mean Annual Temperatures (MATs), assuming similar ecologies and appropriate mass-specific metabolic rates for both modern and fossil taxa. Phylogenetic and isotaphonomic comparisons minimize such assumptions, and multi-taxon sampling increases the robustness of estimates for a given depositional environment. We estimated Cenozoic equatorial paleotemperatures by comparing maximum body sizes of extant podocnemidid and trionychid turtles as well as boid snakes from aquatic environments at known mass-specific metabolic rates for modern MATs with Paleogene and Neogene herpetofaunas from fluvial depositional environments in northern South America, North America, and Pakistan. Large body sizes in fossil taxa indicate high tropical MATs during the Paleogene and late Miocene, with poleward temperature gradient magnitudes similar to modern values. These results do not support hypotheses of a climatic thermostat during

greenhouse intervals. Comparisons of paleotemperature estimates based on physiology with those based on species richness provide the opportunity to develop the fossil record of reptiles into a precise tool for paleoclimatic reconstruction.

Edwin H. and Margaret M. Colbert Poster Competition (Thursday)

#### ABOUT THE LIFETIME OF A SPINOSAUR TOOTH-NEW HISTOLOGIC INVESTIGATIONS OF TOOTH FORMATION RATES

HECKEBERG, Nicola, Bayerische Staatssammlung für Paläontologie und Geologie, München, Germany

The great number of spinosaur teeth found in Morocco gives reason to believe that these dinosaurs had a frequent presence. Since the tooth frequency depends strongly on the replacement rate, it is important to get more information about the time for tooth formation and how often a tooth was replaced.

By counting the daily formed incremental lines of the dentine using thin sections, one can give a statement how long the development of one tooth took. Consequently, it is possible to get a better idea of the real number of individuals.

The five teeth used for histologic investigations are referred to spinosaurs from Albian to Cenomanian sediments of Morocco and were shed while the dinosaur was still alive, recognizable by the resorption of the teeth's roots.

With the investigated data an average tooth development time of 250 to 300 days is assessed for the wider teeth and for the conical, slender teeth a shorter time span of about 200 to 250 days.

Looking at the size of a spinosaur (estimated length about 14 meters), the time for the tooth development seems few in comparison with development times of theropods with similar sizes, e. g. *Tyrannosaurus* (13 m) or *Albertosaurus* (over 10 m) with a tooth development time of 933 days respectively 519 days. Comparable tooth formation rates are given in some Hadrosaurs ranging from 225 to 281 days or in juvenile *Tyrannosaurus* with a formation rate of 264 days.

This low formation rate is likely connected to tooth specialization due to the piscivorous diet of the spinosaurs. So, the teeth had not to be as massive, which took longer to develop, as in "active" predators like *Tyrannosaurus*, where they were affected with enormous physical forces while catching and tearing apart prey. Therefore it was probably more economical for *Spinosaurus* to develop teeth for a relatively short time, that queue in the otherwise also highly specialized anatomy of *Spinosaurus*.

The high replacement rate and the low formation rate explain the high number of spinosaur teeth found in Morocco, but the present work leaves the door open for further scrutinizing, e.g. comparisons with other biomineralizations that reflect daily growth lines (e.g. otoliths).

Poster Session III, (Friday)

#### AN ARTICULATED SKELETON OF THE AETOSAUR *TYPOTHORAX COCCINARUM* COPE (ARCHOSAURIA: STAGONOLEPIDIDAE) FROM THE UPPER TRIASSIC BULL CANYON FORMATION (REVUELTIAN: EARLY-MID NORIAN), EASTERN NEW MEXICO, USA

HECKERT, Andrew, Department of Geology, Appalachian State University, Boone, NC, USA; LUCAS, Spencer, New Mexico Museum of Natural History, Albuquerque, NM, USA; RINEHART, Larry, New Mexico Museum of Natural History, Albuquerque, NM, USA; SPIELMANN, Justin, New Mexico Museum of Natural History, Albuquerque, NM, USA; CELESKEY, Matthew, New Mexico Museum of Natural History, Albuquerque, NM, USA

A largely complete, articulated postcranial skeleton of *Typhorax coccinarum* from the Barranca Creek badlands, Bull Canyon Formation, eastern New Mexico is preserved nearly in life position and, with the previously described Revuelto Creek specimen, is one of the most informative aetosaur specimens from North America. The articulated armor confirms the distinctiveness of *T. coccinarum* from *T. antiquum* and *Redondasuchus*. Cervical vertebrae are tiny, with the corresponding reduction in armor length accomplished by a reduced number of cervical osteoderms, the third row of which bears a thin, elongate, lateral spike. Ventral armor consists of 10 thoracic columns and four caudal columns of osteoderms, and spinose osteoderms near the cloaca are the first spikes reported in aetosaurian ventral armor. The forelimb is short (~0.65 hind limb length) and was held in a sprawling to 'semi-erect' position, and possesses some adaptations found in digging taxa. In contrast the hind limb is much more robust, 'pillar-erect,' and functionally mesotarsal. The articulated pes, including unguals, has the phalangeal formula 2-3-3?-4?-3? with relative digit lengths III>II>IV>I>V, a laterally divergent digit V, and other characteristics of the footprint ichnogenus *Brachychirotherium*, which some have attributed to an aetosaurian trackmaker.

A new reconstruction based on these specimens demonstrates that *Typhorax* has only ~46 rows of osteoderms (~22 presacral-sacral, ~24 caudal), the tail is approximately half the length of the body, the thoracic armor is broadly arched, and the head was held low with the pelvis significantly higher than the shoulder girdle. Both specimens are ~2.5 m long and the preserved elements are as large or larger than other *Typhorax* fossils, suggesting that they approximate the upper size limit of *T. coccinarum*. We calculated body mass estimates of ~100-104 kg for both specimens, which is much smaller than older taxa from the Chinle

Group (e.g., *Desmatosuchus*) and may indicate a reduction in herbivore size during the Revueltian-Apachean corresponding to a known 'drying upward' trend during Chinle Group deposition.

Technical Session V, Wednesday 2:30

#### DEAD IN THE WATER: AN INVESTIGATION INTO EOCENE FISH MASS MORTALITY EVENTS

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Fossil fish from the Green River Formation of southwest Wyoming have been collected by paleontologists and amateur collectors since the early 19th century. In Fossil Lake the late Early Eocene fish are found in mass mortality beds throughout a 6 m succession of the paleolake sediments and have been reported to contain as many as 500 fish per square meter. The mainly monospecific fossil fish assemblages are enclosed in alternating kerogen-rich to kerogen-poor finely laminated micrites interspersed by frequent thin volcanic ash layers, with a notable absence of any bioturbation or soft sediment disturbance. The micrites split easily along the sub-millimeter laminations and have yielded millions of fossil fish over the last two centuries, as well as many plants, insects, reptiles, birds and small mammals. Flora and fauna are found so well-preserved and in such abundance that this lagerstätten is one of the most extensive known in North America. To date, theories for the cause of death of the Fossil Lake fish mass mortality assemblages have been based on scholarly assumptions rather than definitive evidence. Here we discuss the major mechanisms of fish mass mortality and assess their probability of having been a causative agent in Fossil Lake. A thorough sedimentological investigation of the paleolake coupled with geochemical analyses indicated no environmental perturbations concurrent with the regularly occurring, possibly cyclical, mass mortalities of the fish. However, it was possible to rule out many hypotheses regarding cause of death using the evidence available, with toxicification of the water column by microorganisms remaining as the most likely cause, potentially coupled with related environmental stressors. Further analyses revealed that the sediments contain abundant algal biomarkers, including particularly high concentrations of 4-methylsteranes. These are likely derived from dinoflagellates, indicating an abundance of these protists at time of deposition. This is consistent with harmful algal blooms being a key causal mechanism for the recurrent fish mass mortality events in Eocene Fossil Lake.

Technical Session XVII, Saturday 2:45

#### A NEW MICROSAUR FROM AN EXCAVATION SITE IN THE LOWER PERMIAN TAMBACH FORMATION, TAMBACH-DIETHARZ, THURINGIA, GERMANY

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A nearly complete microsauroid skull was discovered in the spring of 2008 in an excavation site for a supermarket in Tambach-Dietharz, Thuringia, Germany. The skull was found on a large, isolated block of siltstone that also contained a nearly complete skeleton of a diadectid. The block was derived from a meter thick siltstone unit within the lowermost portion of the Finsterbergen Conglomerate of the Lower Permian Tambach Formation, lowermost formation of the Upper Rotliegend Group. The microsauroid skull represents a new genus of Ostodolepidae, a group previously known from the North American Lower Permian, Clear Fork Group of Texas and Oklahoma, USA. Of the three genera comprising this family, only two, *Micraroter* and *Pelodosotis*, are represented by skulls. Initial study of the new microsauroid reveals that it possesses a mix of characters that occur in either *Micraroter* or *Pelodosotis*. The new microsauroid shares with *Micraroter* raised ridges along the orbital margins and a small pineal foramen. As in *Pelodosotis* the premaxilla forms most of the ventral border of the external nares, the maxilla is excluded from the orbital rim by the lacrimal-jugal contact, and the tabular possesses an embayment. Unique features that distinguish the new microsauroid from other ostodolepids include: narrow entrance of postfrontal into orbital rim, palpebral cup formed by one large and several small ossifications, and absence of teeth on the pterygoid. The highly terrestrial, superbly preserved vertebrate assemblage of the nearby Bromacker locality represents the only other known occurrence of vertebrate fossils in the Tambach Formation. The Bromacker locality occurs in the Tambach Sandstone, which underlies the Finsterbergen Conglomerate, thereby indicating the microsauroid occurrence is slightly younger than the Bromacker fauna. Not only is the new microsauroid the first known from the Tambach Formation, but it is the first ostodolepid recorded outside of North America and, thus, represents the oldest known ostodolepid.

Poster Session IV, (Saturday)

#### FUNCTIONAL GROUPS IN RUMINANTS AS ENVIRONMENTAL PROXIES

HERNÁNDEZ FERNÁNDEZ, Manuel, Universidad Complutense de Madrid, Madrid, Spain; ALCALDE, Gema, Consejo Superior de Investigaciones Científicas, Madrid, Spain; DEMIGUEL, Daniel, Universidad de Zaragoza, Zaragoza, Spain; GARCÍA YELO, Blanca, Consejo Superior de Investigaciones Científicas, Madrid, Spain; AZANZA, Beatriz, Universidad de Zaragoza, Zaragoza, Spain

The suborder Ruminantia (Mammalia, Artiodactyla) includes nearly 200 extant species, and is the most important group of large terrestrial herbivorous mammals. They are commonly found in all the continental environments of the World, both today and during their fossil record of 50 million years. Because of this, ruminant communities are usually used as paleoenvironmental proxies. Here we attained a new approach to this issue by developing a classification of all the extant ruminant species into functional groups, which were assumed to have environmental significance. 10 functional groups were defined by weighted multifactorial cluster analysis based on variables related to body size, feeding style and locomotor adaptations. Subsequently, we calculated the proportions of such functional groups in modern ecological communities from all around the World, for which the environmental conditions were known. Discriminant analysis of the whole dataset was able to classify correctly the biomes for 62% of the communities. Most of the wrongly classified communities belonged to savanna or dry tropical forest which are usually considered to be very closely related both ecological and phylogenetically. A model differentiating tropical from temperate faunas classified successfully 78% of them. The model discriminating open from forest environments attained 72% of success. Finally, the model separating humid climate regimes from arid and semiarid areas obtained a correct classification for 78% of the communities. The omission of South American communities increased the classification success in most of the models (68% for biomes; 82% for tropical-temperate communities; 71% for open-forest habitats; 84% for humid-arid climate regimes), which is probably related to the evolutionary effects at the continental scale that the Great American Biotic Interchange had on the mammalian fauna from South America. Therefore, we obtained a series of statistical models based on functional groups that can be used to confidently differentiate the type of environment in which inhabited past ruminant faunas, specially those from the Holarctic and Palearctic biogeographic realms.

Poster Session III, (Friday)

#### POSTCRANIAL OSTEOLOGY OF *LEAELLYNASAURA AMICAGRAPHICA* (DINOSAURIA; ORNITHISCHIA) FROM THE EARLY CRETACEOUS OF SOUTHEASTERN AUSTRALIA

HERNE, Matthew, The University of Queensland, Brisbane, Australia

*Leaellynasaura amicagraphica*, a small bipedal ornithischian dinosaur from the Early Cretaceous (late Aptian-early Albian) of Victoria, Australia, is based on an articulated partial upper jaw and infratemporal region (the holotype). A skull roof (including a partial cranial endocast) and a partial, articulated postcranium have also been referred to this taxon, and have been regarded as belonging to holotype individual. Another partial postcranium, NMV P186047, is also considered to be referable to *L. amicagraphica*. The taxon was originally assigned to 'Hypsilophodontidae', but more recently has been considered a non-dryomorph an iguanodontian. Of the postcranium, only isolated referred femora and a tibial pathology have been described.

In this work I describe the osteology of two articulated postcrania referred to *L. amicagraphica*. Autapomorphies in the haemal arches unite individuals. A caudoventrally expanded postpubic process is shared with *Macrogyphosaurus* and *Camptosaurus*, and asymmetrically expanded terminal haemal arches with *Macrogyphosaurus*, *Gasparinisaura* and *Parksosaurus*. Iguanodontian affinities are further supported by the caudoventral expansion of the ischium and femoral morphology. Pes morphology and the lack of ossified caudal tendons in *L. amicagraphica* is plesiomorphic at the level of Ornithischia. The lack of a tab-shaped obturator process, extended ischial shaft symphysis and high caudal vertebrae number with protracted vertebral body elongation are shared with basal thyreophorans; thus, past referral of *L. amicagraphica* postcrania to Ornithischia may be problematic, and the postcranial material is at best referable to Genasauria. Caudal vertebral count in *L. amicagraphica* (>70) is the highest recorded for a non-hadrosaurid ornithischian. Dorsal and cranial expansion of postzygapophyses (up to 44% of vertebral body length) on vertebrae in the terminal half of the tail of *L. amicagraphica* suggests an alternative to ossified tendons to provide caudal axial rigidity. Caudal vertebral morphology suggests a hyper-extended tail of approximately three times estimated pre-caudal body length.

Poster Session I, (Wednesday)

#### A CRETAN MAMMOTH? USING MORPHOLOGY TO RESOLVE AN ANCIENT DNA DEBATE

HERRIDGE, Victoria, Natural History Museum, London, United Kingdom; LISTER, Adrian, Natural History Museum, London, United Kingdom

The consensus view that Mediterranean dwarf elephants are derived from mainland populations of the straight tusked elephant, *Palaeoloxodon antiquus*, has recently been challenged. A rib fragment from Cape Maleka, Crete, the type locality of '*P. creticus*,

was identified as *Mammuthus* on the basis of ancient DNA (aDNA) evidence, but validity of this finding has been questioned and debate is ongoing. Despite (i) broad similarities between '*P. creticus*' and *M. meridionalis* identified by various authors and (ii) clear morphological differences between *Palaeoloxodon* and *Mammuthus*, morphological data has not been employed in this debate, until now. We compared '*P. creticus*' type- and referred material with full-sized European and North African Pleistocene elephant taxa, as well as Mediterranean dwarf taxa from Sicily, Malta and Tilos, to establish if a morphological approach could succeed where aDNA failed. We show that '*P. creticus*' is indeed a mammoth, with *M. meridionalis* its likely sister-taxon, and should be revised to the genus *Mammuthus creticus* accordingly.

Preparators' Session, Thursday 11:00

#### EFFECTIVE MICROPREPARATION WORKSTATION SETUP

HERZOG, Lisa, The Field Museum of Natural History, Chicago, IL, USA; SHINYA, Akiko, The Field Museum of Natural History, Chicago, IL, USA

An array of tools and equipment are essential for micropreparation including microscope with light box, air scribes, grinding tools, various chemicals, foot pedals, manual tools, and compressed air supply. Setup and organization of equipment as well as maintaining a clear working surface is essential for effective micro-preparation. An adjustable microscope boom stand with ball bearings helps to easily focus on specimens of variable size and shape. In a well-equipped station, multiple air supplied tools can cause disorganization and clutter with tangled tubing and foot pedal supply lines. Air scribes and grinding tools can be connected with multiple hose couplings and kept off the workspace while not in use with spring clips mounted next to a microscope. Using a three-way gang valve mounted on the microscope arm to connect a dental drill, modular adjustable air hose, and pinvice helps to keep all three items ready to be used at any time. Clearly labeled consolidants and solvents are also kept at hand in uniform containers. Compressed air supply can be fitted with two pressure control valves: one set for air scribes requiring 100+ pounds per square inch (psi) pressure and another for dental drills and foot pedals set at a lower pressure.

Poster Session IV, (Saturday)

#### ECOMORPHOLOGY OF CERVID UPPER MOLAR OCCLUSAL SURFACES

HEYWOOD, James, LCHES, University of Cambridge, Cambridge, United Kingdom

Previous studies have demonstrated that molar occlusal surface morphology in bovids varies consistently with dietary preferences. This study attempts to assess whether the same level of morphological divergence exists in cervids. Multivariate statistics reveals that whilst similar broad morphological generalizations between cervids operating at opposite ends of the browser-grazer continuum exist as they do in bovids, the degree to which this is so is limited. Interspecific comparisons demonstrate that cervid occlusal morphology is more conservative, whereas they show more intraspecific variation than do bovids. Consequently, the use of occlusal surface morphology in cervids would seem to be much less useful in determining dietary preferences in the group, a fact reinforced by the observation of high intraspecific variation in dietary habits within the family. These results also support the newly proposed 'cusp fusion hypothesis' and together go some way to explaining why grazing in ruminants is primarily the domain of the Bovidae.

Poster Session IV, (Saturday)

#### OSTEOLOGICAL AND HISTOLOGICAL CORRELATES OF AMNIOTE SKIN STRUCTURES

HIERONYMUS, Tobin, Ohio University, Athens, OH, USA

Common amniote skin features, such as scales, beaks, and horn sheaths, are often inferred in extinct taxa on the basis of associated bony features. This study presents a systematic approach to identifying osteological correlates for common skin features by testing for consistent associations between skin and bone morphology in a sample of 83 amniote taxa. Representative areas of skin from the sampled taxa were grouped into one of eight categories using data taken from dissections, preserved specimens, and published accounts. The corresponding bone surface beneath each sampled skin area was identified on a separate skeletal specimen of the same taxon, and the surface morphology of the underlying bone was described by six categorical variables. Skin categories to bone morphology association was tested using a Recursive Partitioning Analysis (RPA), a robust non-parametric algorithm that plays a role similar to discriminant function analysis. The relationship of each skin category to underlying bone was also characterized using classical anatomical and histological techniques. RPA recovered significant relationships between skin and bone features for two skin categories: (i) epidermal scales and (ii) cornified sheaths (e.g., bovid horn sheaths and avian horny beaks). The relationships recovered by RPA for these two skin categories, together with characteristic anatomical and histological features, provide robust osteological and histological correlates for inferring unpreserved skin structures. Three other skin categories showed low-confidence relationships to specific bone variables by RPA, including (iii) projecting skin structures, (iv) armor-like dermis, and (v) thick cornified pads. The osteological and histological structures associated with these three skin categories are sufficient to provide less robust correlates for inferring unpreserved skin structures. The complete RPA and associated osteological and histological characters thus provide a decision tree for inferring unpreserved skin structures in extinct amniotes.

Poster Session II, (Thursday)

#### MINERALIZATION AND GROWTH RATE OF HYPSELODONT CHEEK TEETH: INSIGHTS INTO THE PALEOBIOLOGY OF NOTOUNGULATES

HIGGINS, Pennilyn, University of Rochester, Rochester, NY, USA; CROFT, Darin, Case Western Reserve University, Cleveland, OH, USA; SIMPSON, Scott, Case Western Reserve University, Cleveland, OH, USA

Hypsodonty in mammal teeth is considered an adaptation to grazing and open habitat feeding. Diets of grass tend to be highly abrasive, and taller teeth compensate for faster wear, ensuring that the grazer's teeth will remain functional for the duration of the animal's life. A further adaptation to gritty foods is the development of rootless, ever-growing teeth, termed hypselodonty. Incisors of modern gnawing mammals like rodents and lagomorphs are typically hypselodont (as well as cheek teeth in many groups), but no extant ungulates possess hypselodont cheek teeth. Many notoungulates, a group of extinct South American ungulate mammals of uncertain affinity, possessed hypselodont incisors and cheek teeth, leading to interpretations that all were grazers. Mesowear and microwear analyses, however, have provided varying dietary evidence for hypsodont and hypselodont notoungulates. We hypothesize that hypselodonty was retained in notoungulate lineages that were formerly grazers, but that later shifted to browsing diets. Hypselodont browsers likely had slower dental growth rates than their grazing ancestors to compensate for the decrease in tooth wear rates. To test this hypothesis, we estimate rates of growth of notoungulate teeth in two ways. First, using serial isotopic analysis, we measure the distance between consecutive peaks or troughs in annual cycles of oxygen isotopic values, providing an estimate of annual growth. Second, we investigate perikymata ("growth lines") on the surface of teeth, which occur at regular temporal intervals in modern and fossil mammals. With scanning electron and optical microscopic analyses of cross-sections of tooth enamel, we determine the daily periodicity for notoungulate perikymata (based on the number of cross-striations) and calculate the growth rate by measuring the distance between adjacent perikymata.

Poster Session I, (Wednesday)

#### THE OSTEODERMS OF *SIMOSUCHUS CLARKI* (CROCODYLIFORMES: NOTOSUCHIA) FROM THE LATE CRETACEOUS OF MADAGASCAR

HILL, Robert, New York College of Osteopathic Medicine, Old Westbury, NY, USA

The initial description of *Simosuchus clarki* focused on the remarkable cranial adaptations of this bizarre, pug-nosed crocodyliform. Further preparation of the holotype and discovery of additional specimens have yielded nearly all postcranial bones and an extraordinary complement of osteoderms. As in other crocodyliforms, the osteoderms of *Simosuchus* are organized into discrete 'shields,' each covering a major region of the body. The dorsal shield in *Simosuchus* comprises a tetraserial paravertebral shield and accessory ranges of osteoderms in at least four parasagittal rows bilaterally. These osteoderms are tightly sutured to one another at their medial and lateral margins, and imbricate cranially and caudally. An extensive gastral shield includes broad, subrectangular osteoderms interspersed with smaller, irregular intercalary osteoderms. Nuchal and caudal osteoderms are also present. Appendicular osteoderms are also considerably developed, more so than in any notosuchian. Humeral and femoral osteoderms are quadrilateral or ovoid, and articulate via sutures on all sides or are imbricated. Radioulnar osteoderms include a thick discoid element near the ulnar midshaft. Tibiofibular osteoderms are striking elements, with prominent keels that point distally. Paleohistology reveals porous, lightly built osteoderms in the dorsal and appendicular regions, and diploë-like construction in gastral osteoderms. Foramina connect internal spaces of these osteoderms with both superficial and deep surfaces. Details of the growth and longevity of *Simosuchus* are equivocal when assessed using osteoderms. The extreme sagittal segmentation of *Simosuchus* osteoderms results in a broad dorsal shield otherwise known only in eusuchians. This represents a dramatic instance of convergence and permits some interpretation of notosuchian evolution and functional morphology. *Simosuchus* probably exhibited enhanced flexibility with respect to ancestral forms, but the presence of many tightly sutured accessory rows suggests that lateral undulation and swimming were likely restricted. New morphological characters of osteoderms may be informative in studies of crocodyliform phylogeny.

Poster Session III, (Friday)

#### RE-EXAMINATION OF THREE-Dimensionally PRESERVED PTEROSAUR SOFT-TISSUE FROM THE SANTANA FORMATION OF BRAZIL

HING, Richard, University of Portsmouth, Portsmouth, United Kingdom; MARTILL, David, University of Portsmouth, Portsmouth, United Kingdom

A number of pterosaur specimens preserving details of their wing membranes have been reported from Lagerstätte around the world, but few preserve three-dimensional details of the wing-membrane histology. A notable exception to this is DGM 1475-R, a specimen thought to represent a portion of three-dimensionally preserved wing membrane from the Lower Cretaceous Santana Formation of Brazil. The specimen has been reported to reveal several important details of the internal structure of the pterosaur wing membrane, including differentiated layers of epidermal tissue, a stratum vasculosum, stratum spongiosum and a layer of striated muscle. The identification of this specimen as a fragment of wing tissue has not gone unquestioned, however, with some workers suggesting it represents a portion of body-wall tissue. In an effort to resolve this controversy, the specimen is currently undergoing a considerably more detailed and comprehensive analysis than previously

attempted. Further etching of the specimen in acetic acid and SEM analysis have revealed additional histological details not reported previously, including the presence of fibres thought to be analogous with the wing fibres found in other specimens of pterosaur wing membrane. These fibres are located directly beneath the epidermis in the layer previously interpreted as the stratum vasculosum and, if correctly identified, support the interpretation of the specimen as representing a fragment of wing membrane. In addition, the presence of epidermal tissue, stratum spongiosum and a layer of striated muscle are confirmed, the latter of which consists of obliquely-orientated filaments that form a mesh-like sheet continuous across the membrane.

Poster Session II, (Thursday)

#### **PATELLA AND ITS USE FOR INTERPRETATION OF AQUATIC LOCOMOTION IN EXTINCT BIRDS**

HINIC-FRLOG, Sanja, Carleton University, Ottawa, ON, Canada

Extant avian underwater swimmers typically have an enlarged patella, which is often the most developed in foot-propelled birds in aquatic environments. It is hypothesized that in combination with associated features of the knee, patella can be particularly useful for functional inferences about extinct birds that may have been associated with aquatic habitats. I examined patella and cnemial process of tibiotarsus in 124 species of extant birds. The examined species included both the underwater swimmers such as some ducks, grebes, penguins, cormorants, and alcids, and species that do not explore underwater habitats. Length of the patella in comparison to the length of cnemial process effectively distinguishes between non-swimming and surface and underwater swimming locomotion. Additionally, these two features separate foot-propelled from wing-propelled and foot-and-wing-propelled underwater swimmers. However, there is a notable exception: all examined wing-propelled penguins group with foot-propelled underwater swimmers. Specifically, they cluster with underwater swimmers that are limited to mostly dorsoventral movement of the hind limb. Hesperornithiform birds, *Baptornis*, *Hesperornis*, and *Parahesperornis*, plot among extant underwater swimmers, which use either mostly dorsoventral (cormorant-like) or mostly lateral (grebe-like) movement of the hind limb. Enlarged patella and cnemial process of tibiotarsus may be functionally important for increasing the surface area of the muscles governing movements of the tarsometatarsus, which is used by foot-propelled underwater swimmers for locomotion. Furthermore, the association of patella and cnemial process may determine a degree of immobilization of the knee joint, which can be particularly important for underwater swimmers. Although both patella and cnemial process have been qualitatively recognized for their significance in locomotion of swimming birds, this study provides quantitative examination of patellar function with further insight into its possible phylogenetic importance, as indicated by the close morphological association of the patella in wing-propelled penguins and some underwater foot-propelled swimmers.

Poster Session I, (Wednesday)

#### **CRANIAL OSTEOLOGY AND POSTNATAL ONTOGENY OF THE GLIDING LIZARD *HOLASPIS LAEVIS***

HIPSEY, Christy, Museum für Naturkunde, Berlin, Germany; MÜLLER, Johannes, Museum für Naturkunde, Berlin, Germany; CLAESON, Kerin, University of Texas, Austin, TX, USA; NIKOLAY, Kardjilov, Hahn-Meitner Institute, Berlin, Germany; HILGER, André, Hahn-Meitner Institute, Berlin, Germany

Gliding flight in reptiles involves a unique array of morphological adaptations transforming a cylindrical, elongate body into an effective aerofoil. The extant African lizard genus *Holaspis* (Lacertidae) is one of few known examples of gliding flight in squamate reptiles. Unlike other gliding lizards with elaborate membranes or expansions of skin that aid in lift, members of *Holaspis* exhibit extreme dorsoventral flattening over the entire body. Numerous morphological apomorphies distinguish *Holaspis* from other lacertids, particularly around the skull which is highly kinetic and thin-boned. Because many of these traits are seen in crevice-dwelling lizards, *Holaspis* is thought to have initially evolved to exploit narrow crevices under bark, and only secondarily developed the ability to glide between trees. Despite these unique features, the cranial anatomy of *Holaspis* has not been studied in detail, mainly due to their rarity in museum collections. Because African lacertids also have a poor fossil record, identifying growth patterns and functional morphology in this species is important for the study of early lacertid history, particularly when fossil specimens are rare or incomplete. Here we describe ontogenetic changes in the cranium of *Holaspis laevis* for the first time, based on 3D digital CT reconstructions of a postnatal growth series. In comparison to other lacertids, *H. laevis* skulls show several paedomorphic features, such as posteriorly emarginated nares, large orbits, a simple frontoparietal suture, and a low degree of ossification resulting in the lack of separate cranial osteoderms. Frontal bones are paired in juveniles and females but are fused in adult males, while still retaining large gaps between other adjacent skull elements. This separation of cranial bones most likely acts to keep body weight down while still allowing for flexibility and large body size. The high number of derived traits in *Holaspis* species suggests rapid evolution in response to an arboreal lifestyle. However, poor species richness in this genus indicates a great deal of extinction, possibly due to changes in equatorial forest habitat.

Poster Session IV, (Saturday)

#### **IDENTIFYING DIAGNOSTIC CHARACTERS IN THE TOOTH ENAMEL MICROSTRUCTURE OF DROMAEOSAURID DINOSAURS**

HOFFMAN, Emma, Rondout Valley High School, Accord, NY, USA; HWANG, Sunny, New York College of Osteopathic Medicine, Old Westbury, NY, USA

Previous studies of dinosaur enamel microstructure have focused on general patterns seen among large clades of dinosaurs and trends in enamel evolution among Dinosauria as a whole. However, little attention has been paid to differences in enamel between genera or species of the same clade, despite the success of finding such differences in mammalian enamel. It would be valuable to find diagnostic enamel characters for dinosaur genera or species, as these characters can be used in phylogenetic analyses and as a way to identify isolated teeth. The enamel microstructure of dromaeosaurids was scrutinized to determine if there are discernible differences in the enamel of closely related taxa. Dromaeosaurids were chosen as the study taxon because their enamel is so simple; if diagnostic enamel characters could be found between dromaeosaurid genera, then it would suggest that finding diagnostic enamel characters for taxa with more complex enamel should be a relatively simple task. After examining the enamel of seven dromaeosaurid genera, distinct differences were found between them. For example, a basal unit layer was not found in all species. Enamel tubule density was not consistent between species and tubules were sometimes not present. Incremental lines were rare but occasionally present. Furthermore, although all dromaeosaurids have parallel crystallite enamel, the exact angle at which the crystallites are set is not identical, as some are not perfectly perpendicular to the enamel-dentine junction. Multiple specimens for some genera were available, and all specimens of the same genera were found to have identical enamel. Therefore, there is evidence that these distinguishing characteristics are genus-specific and not individual-specific. Enamel microstructure has been used to identify isolated dinosaur teeth to a suprageneric level (e.g., the "family" level), and this study shows that it may be used to differentiate isolated teeth to the generic or even species level. Enamel microstructure could prove to be a valuable tool in creating more detailed faunal lists for microfossil localities.

Technical Session I, Wednesday 11:45

#### **PALEOECOLOGICAL INTERPRETATIONS FROM BIOAPATITE AND COLLAGEN STABLE ISOTOPE VALUES OF LATE HOLOCENE ELK TEETH**

HOFFMAN, Jonathan, University of Wyoming, Laramie, WY, USA; CLEMENTZ, Mark, University of Wyoming, Laramie, WY, USA

Dietary reconstructions for extinct species have benefited from the stable isotope analysis (SIA) of fossil materials, particularly carbon and oxygen isotope analysis of tooth enamel. For younger, well-preserved specimens (<50 kya), SIA can be performed on the bioapatite and collagen components of bone and tooth dentin, which can provide additional insight into the diet of extinct species. First, SIA of organic and inorganic fractions of bone or dentin allows for the calculation of the carbon isotope offset between these components ( $\Delta^{13}\text{C}_{\text{bioapatite-collagen}} = \delta^{13}\text{C}_{\text{bioapatite}} - \delta^{13}\text{C}_{\text{collagen}}$ ), which can yield information on diet quality as well as be used to identify different diet groups (carnivores, omnivores, herbivores). Second, collagen contains sufficient nitrogen for SIA, which can provide further information on trophic level and environmental conditions. When combined, these analyses can supply a much richer record of the dietary preferences and digestive physiology of extinct species than can be achieved through SIA of enamel alone. Here we examine the usefulness of this approach by performing SIA on 16 elk (*Cervus elaphus*) teeth found in a 2,000-year-old midden in Albany County, Wyoming, which experienced decreasing mean annual temperatures and increasing precipitation throughout the late Holocene. The carbon isotope ( $\delta^{13}\text{C}$ ) and oxygen isotope ( $\delta^{18}\text{O}$ ) composition of enamel and dentin biapatite, along with the  $\delta^{13}\text{C}$  and nitrogen isotope ( $\delta^{15}\text{N}$ ) composition of tooth collagen, were analyzed to provide insight into the diet for this Holocene population. Enamel and dentin  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$  values suggest that this population consisted primarily of high-elevation C3 consumers with one individual that had a significant low-elevation C4 component. This interpretation is supported and expanded by the collagen SIA and  $\Delta^{13}\text{C}$  values, which indicate that diet quality, which most likely reflects fiber content, was lower for the pure C3 consumers than the single mixed feeder. These findings demonstrate the level of diet information available through combined SIA of organic and inorganic components of well-preserved fossil specimens.

Poster Session III, (Friday)

#### **SKELETAL RECONSTRUCTION OF A MIOCENE PANGOLIN FROM SOUTHERN GERMANY**

HOFFMANN, Simone, Steinmann-Institut für Geologie, Mineralogie und Paläontologie, Universität Bonn, Bonn, Germany; MARTIN, Thomas, Steinmann-Institut für Geologie, Mineralogie und Paläontologie, Universität Bonn, Bonn, Germany; STORCH, Gerhard, Senckenberg Forschungsinstitut und Naturmuseum, Frankfurt, Germany; RUMMEL, Michael, Naturmuseum der Stadt Augsburg, Augsburg, Germany

So far, the Miocene pangolin *Necromanis franconica* was represented by a limited number of isolated postcranial bones and a rather incomplete skeleton. Miocene (MN 3 and 6) fissure fillings of Petersbuch near Eichstätt in Southern Germany have yielded a wealth of new material, comprising two partial skeletons and more than 400 cranial and postcranial remains representing about nine individuals. The extraordinarily well preserved material allowed

for a redescription and a skeletal reconstruction of *Necromanis*. Compared to the North American Eocene pangolin *Patriomanis*, *Necromanis* exhibits stronger digging adaptations. Adult *Necromanis* specimens have very strong deltopectoral and supinator crests at the humeri indicating a powerful musculature in the front legs. An ontogenetic series of ten humeri shows an allometric growth pattern of these crests which are very weak in juvenile specimens, but are well developed before epiphyseal closure. The olecranon comprises about 34 % of the entire length of the ulna, in contrast to 25 % in *Patriomanis*. The first phalanges of the hand of *Necromanis* are strongly shortened and are shorter than the second phalanges. Recent fossorial pangolins such as *Manis gigantea* also have shortened first phalanges whereas in *Patriomanis* they are not shortened. In contrast to *Patriomanis*, where all ungual phalanges are of equal length, *Necromanis* has elongated terminal phalanges in the third digits of the hands as in the Recent pangolins. In the feet, the size differences of the terminal phalanges are less expressed. Besides these fossorial adaptations, *Necromanis* retains a number of plesiomorphic features such as a femoral third trochanter (less proximal than in *Patriomanis*), convex astragalus head, and a less pronounced fusion of the scapholunatum. On the other hand, *Necromanis* exhibits more derived features such as a narrower incisura acetabuli, which is wider in *Patriomanis* and completely closed in the extant pangolins. This unique combination of primitive and derived features corroborates that *Necromanis* and *Patriomanis* belong to different evolutionary lineages.

Poster Session IV, (Saturday)

**OBSERVATIONS ON CRANIAL CHARACTERS OF CHALICOTHERES (MAMMALIA, PERISSODACTYLA) WITH EMPHASIS ON THE EAR REGION**  
HOLBROOK, Luke, Rowan University, Glassboro, NJ, USA; COOMBS, Margery, University of Massachusetts, Amherst, MA, USA

Chalicotheres, members of an extinct group of perissodactyls, are known mainly for their distinctive postcranial features, including possessing claws rather than hooves. Although skulls, dentitions, and postcrania all provide excellent sources of character information, several recent analyses of chalicotheres phylogeny have emphasized craniodental morphology and have focused on one subfamily of Chalicotheriidae, the Chalicotheriinae. The present cranial study is part of an ongoing effort to examine broad aspects of chalicotheres morphology across the entire superfamily, integrating information on both subfamilies of chalicotheriids (Chalicotheriinae and Schizotheriinae), as well as the earlier “eomoropids.” Most, if not all, chalicotheres possess a distinct supraorbital notch or foramen, as well as a posttympanic process that is short relative to the postglenoid process. In addition, all chalicotheres except *Litolophus* preserve an auditory bulla. For example, the bulla of the “eomoropid” *Eomoropus* is very well developed in comparison with those of other Eocene perissodactyls. The form of the bulla varies across taxa. The bulla of *Eomoropus* does not fully cover the petrosal, as it does in chalicotheriids, but it has a crescent shape that is shared with chalicotheriines. Schizotheriines, on the other hand, possess a more globose, cancellous bulla, similar in shape to that of *Equus*. The shape of the bulla in schizotheriines may be a synapomorphy for the subfamily.

Technical Session VII, Thursday 2:45

**NEW DATA ON DENTAL ERUPTION PATTERNS IN AFROTHERIANS AND PALEOGENE MAMMALS**  
HOLROYD, Patricia, University of California Museum of Paleontology, Berkeley, CA, USA

Dental eruption patterns are an understudied aspect of mammalian evolution. Extensive data exist for select medium to large eutherian mammals, but data on small mammals is especially lacking. Based on existing data, the pattern and timing of dental eruption is known to correlate with life history parameters and recently has been recognized as having important implications for elucidating phylogenetic relationships. In particular, the pattern of dental eruption characterized by early eruption of molars and late or delayed eruption of premolars has been suggested to be a morphological synapomorphy for the Afrotheria, a clade initially only recognized from molecular studies. For this reason, it is key to develop a more extensive set of data on dental eruption patterns among afrotherians and early mammals in order to establish the range of dental eruption patterns and test hypotheses of character polarity.

Here I present new data on extant macroscelideans (sengis or elephant shrews) that builds on a recent study on *Macroscelides* and new data for tillodonts that complements a prior report on several “condylarths”. Using digital radiography, detailed dental eruption patterns are established for the extant *Macroscelides proboscideus*, five species of *Elephantulus*, and *Petrodromus tetradactylus*. All macroscelidean taxa examined share a similar pattern of dental development and eruption with rapid early growth of the molars and later, temporally-overlapping eruption of the premolars and canine-incisor complex. Only minor differences were found among taxa, suggesting relative conservatism of dental eruption patterns among related taxa and supporting the potential phylogenetic utility of these patterns. Among fossil taxa, a similar pattern to that of macroscelideans and other afrotheres is also found in Paleocene *Pleurospidotherium*. The tillodont *Esthonyx* and the “condylarths” *Meniscotherium*, *Phenacodus*, and *Ectocion* also show late eruption of premolars, but the relative sequence of tooth emergence differs from that of macroscelideans.

Poster Session IV, (Saturday)

**A SMALL ASIAN BRACHIOSAURID SAUROPOD DINOSAUR FROM THE LATE MIDDLE JURASSIC OF CHINA**

HONE, David, Institute of Vertebrate Palaeontology & Palaeoanthropology, Beijing, China; WEDEL, Mathew, College of Osteopathic Medicine of the Pacific and College of Podiatric Medicine, Pomona, CA, USA; XU, Xing, Institute of Vertebrate Palaeontology & Palaeoanthropology, Beijing, China; CLARK, James, George Washington University, Washington, DC, USA

Here we describe the first brachiosaurid from Asia based on a cervical vertebra from the lower part of the Shishugou Formation at Wucuiwan in the Junggar basin of Xinjiang, western China. The horizon that yielded the specimen is below a tuff radiometrically dated at  $161.2 \pm 0.4$  ma, correlated approximately with the Middle-Upper Jurassic boundary, making this the oldest known brachiosaurid. The Shishugou has yielded several sauropod taxa, including *Mamenchisaurus sinocanadorum* from the early Late Jurassic upper part and the enigmatic *Klamelisaurus* and *Bellusaurus* from the late Middle Jurassic lower part. The new specimen differs from cervical vertebrae of mamenchisaurids in having an anteroposteriorly short neuropophysis, and pneumatic excavations in the lateral arch and spine. It differs from *Klamelisaurus* which has a convex ventral face on its cervicals and from *Bellusaurus* which lacks the pneumatic fossae of the new taxon. Both possess short forelimbs uncharacteristic of brachiosaurids. The specimen resembles the anterior cervicals of known brachiosaurids in having a high neural arch, low neural spine, and sharp-lipped pneumatic cavities in the centrum, arch, and spine. The specimen differs from known brachiosaurids in having prominent epiphyses that strongly overhang the postzygapophyses. Together with the proportions of the vertebra and its biogeographic and stratigraphic location, they suggest that the specimen represents a new taxon. Based on the closure of the neurocentral suture this specimen is thought to be close to adult size, yet is about half the size of the comparable bone in *Brachiosaurus*, suggesting that this was the smallest brachiosaurid known so far with an estimated total length of 11 m. The new taxon is important as brachiosaurids are otherwise known from the Late Jurassic and Early Cretaceous of the Americas, Europe and Africa, and this significantly extends both the geographic and stratigraphic ranges of this clade. Brachiosaurids and titanosauriforms as a whole must have originated before the Callovian, and given the isolation of Asia from other continents in the Middle Jurassic this suggests an even older divergence for these clades.

Technical Session XI, Friday 10:45

**MAMMALIAN BIOSTRATIGRAPHY OF EUROPEAN LATE EOCENE TO EARLIEST OLIGOCENE CONTINENTAL STRATA: PROBLEMS AND SOLUTIONS**

HOOKER, Jerry, Dept of Palaeontology, Natural History Museum, London, United Kingdom

The use of mammals to define time slices in the European Tertiary dates from the time of Cuvier. Stehlin formalised an Eocene and Oligocene faunal succession based on the Paris Basin and complemented by richer but less clearly superposed sites elsewhere in Europe, most faunas being given a site name. Thaler and Hartenberger developed Stehlin's approach introducing the “reference level” concept, where faunas were ordered temporally according to the evolutionary grade of their component taxa, i.e. chronospecies on a morphocline without the independent evidence of superposition. Each reference level was given a reference locality and later, at the Mainz conference in 1987, a number prefixed “MP”. The reference levels were regarded as points in time, not intervals, and therefore not biozones. The rationale was to avoid the problem of defining boundaries in what was judged a continuum. Independence from rock successions and reliance on evolutionary grade do not sit well with current phylogenetics or the division of time through Global Standard Stratotype-sections and Points. Although not zones, MP levels are usually treated as such in charts because of the difficulty in treating them any other way. Thus, by avoiding the boundaries problem, a new problem has arisen, that of deciding whether a fauna is the same age as that of the reference locality, slightly older or slightly younger. Alongside the reference level system, conventional biozonations have been erected for parts of the Paleogene in Spain, Switzerland and the UK, some local, others with broader European application. With new data it is proposed here to modify an example of the latter for the Headonian European Land Mammal Age, spanning Late Eocene to earliest Oligocene (up to the Grande Coupure) to cover the majority of European mammal sites, using available stratified successions, some of which now have magnetostratigraphies. Key amongst these is the UK Hampshire Basin succession, which spans almost the entire interval. Others that are less complete or have a less dense record are in the Aquitaine and Alès basins in France and the Ebro and La Poblá de Segur basins in Spain.

**DID THE CRETACEOUS MONOTREME *TEINOLOPHOS TRUSLERI* POSSESS AN INTERNAL MANDIBULAR TROUGH FOR POSTDENTARY BONES?**

HOPSON, James, University of Chicago, Chicago, IL, USA; RICH, Thomas, Museum Victoria, Melbourne, Australia; VICKERS-RICH, Patricia, Monash University, Melbourne, Australia; GILL, Pamela, University of Bristol, Bristol, United Kingdom; MORTON, Steven, Monash University, Melbourne, Australia

The Early Cretaceous mammal *Teinolophos trusleri* is known from the Aptian Flat Rocks locality of Victoria, Australia, from 17 incomplete lower jaws. It is identified as a monotreme on the basis of characteristic bilophodont molars resembling those of the ornithomorphid *Obdurodon*. A particularly well-preserved jaw (Museum Victoria: NMV P212933) was described in 2005 as possessing a shallow internal mandibular trough, resembling the trough in *Morganucodon* and docodontids that houses a rod of postdentary jaw bones, including the homologs of certain mammalian middle ear elements. The possible connection of ear bones to the mandible in an early monotreme suggested that the definitive mammalian middle ear, in which the ear bones no longer contact the lower jaw, evolved independently in living monotremes and therians (marsupials and placentals). In a 2008 study, in which three mandibles of *Teinolophos*, including NMV P212933, were scanned using high resolution x-ray computed tomography (HRXCT), it was concluded that HRXCT data show no evidence of a postdentary trough or postdentary bones, suggesting that *Teinolophos* had a standard mammalian middle ear in which the auditory ossicles were separate from the lower jaw. We have reexamined all of the *Teinolophos* specimens and conclude that, because of breakage and abrasion due to postmortem transport, unequivocal evidence of the internal mandibular trough is absent in many of the specimens, including two of the HRXCT scanned jaws, nor is evidence of postdentary bones present in any specimen. The latter is not surprising because in 400 isolated jaws of *Morganucodon*, only two retain postdentary fragments in the trough. However, the best preserved *Teinolophos* jaw (NMV P212933), when examined both optically and with computed tomography, shows the presence of a shallow trough bounded above by a low ridge similar to, though less prominent than, that in *Morganucodon*. The resemblance of the trough in *Teinolophos* to that of *Morganucodon* suggests the retention of postdentary ear elements in the trough of basal monotremes and, therefore, a diphyletic origin of the definitive mammalian middle ear in monotremes and therians.

Technical Session XIII, Friday 3:30

**METAPLASIA PROVIDED DINOSAUR SKULLS EXTREME MORPHOLOGICAL PLASTICITY DURING ONTOGENY**

HORNER, John, Museum of the Rockies, Bozeman, MT, USA; LAMM, Ellen, Museum of the Rockies, Bozeman, MT, USA

Arguably, one of the most interesting characteristics of the Dinosauria is the incredible morphological variety of their skulls. Numerous species in both the Ornithischia and Saurischia sport some sort of cranial display feature on one or more of their cranial elements. In addition, these features undergo considerable alteration during ontogeny, so much so that ontogenetic stages of some species have been described as different species. In each case these major alterations appear to have occurred very rapidly during late stages of ontogeny. In an attempt to determine how such changes could occur in short periods of time, numerous dinosaur skull bones were histologically examined. Surprisingly, every ornamented bone revealed tissues produced by metaplasia. Metaplastic bone is the result of fibrous tissues having been transformed directly into bone without the presence of a periosteum or osteoblasts. The metaplastic tissues observed in this study revealed a wide variety of tissue types, most often extremely fibrous, acellular and/or avascular, or sometimes highly cellular (fibrocytes rather than osteocytes) and highly vascularized. Mature metaplastic tissues are much denser than ordinary bone. Because these tissue types do not contain cells with canaliculi their initial thickness is limited, although at depth they are often remodeled by secondary reconstruction. In many of the bones sectioned there was evidence of deposition, erosion, and subsequent deposition indicative of continuous shape change. Metaplastic tissues found in the skulls of extant avian taxa form and alter very quickly, a characteristic apparently acquired from their dinosaurian ancestors.

Poster Session I, (Wednesday)

**ARE *GONIOPHOLIS CRASSIDENS* AND *G. SIMUS* DIFFERENT SPECIES OF CROCODYLIANS? NEW POSTCRANIAL EVIDENCE SOLVING A TAXONOMIC RIDDLE**

HORNUNG, Jahn, Department of Geobiology, Geoscience Centre, University of Göttingen, Göttingen, Germany; ANDRADE, Marco, Palaeobiology & Biodiversity Research Group, Department of Earth Sciences, University of Bristol, Bristol, United Kingdom; REICH, Mike, Museum, Collections & Geopark, Geoscience Centre, University of Göttingen, Göttingen, Germany

The genus *Goniopholis*, as currently accepted, includes a considerable number of species, ranging from the Late Jurassic through Early Cretaceous of Europe, Americas and Asia. The type species, *G. crassidens* (Berriasian, England), was based upon a fragmentary postcranial skeleton and partial mandible (BMNH 3798-99). The putative association of a skull-rod with the type material cannot be demonstrated. Another specimen from the same strata, the isolated skull BMNH 41098, was made the type of a second species of *Goniopholis*, *G.*

*simus*. However, relations between both materials remained dubious. As *G. simus* included skull material, *G. crassidens* was either largely ignored or considered a *nomen dubium* and *G. simus* served widely as a reference for the genus. *Goniopholis* material from the Berriasian of Germany includes a skull and postcranium (GZG.BA.0061), which allows direct comparison to the British *Goniopholis* specimens. The German skulls is remarkably similar to BMNH 41098, and all comparable postcranial elements show a very high degree of compliance with BMNH 3798-99. The pelvic girdle of both specimens, GZG.BA.0061 and BMNH 3798-99, share a potential autapomorphy of *G. crassidens*: the preacetabular edge of the ilium is narrow and dorsally excavated, lacking a distinct preacetabular process. Further, the first sacral rib articulates anterodorsally with a short acute anterior process of the ilium, here considered as not homologous to the preacetabular process of basal Crocodyliformes. Based on the data provided by the new German material, we regard *G. crassidens* as a diagnosable species, including *G. simus* as junior synonym, and restricted to the Berriasian of Southern England and Northwestern Germany. Contrary to previous referral in the bibliography, material from the Barremian through Aptian of England and Belgium and the Late Jurassic of Germany cannot be referred to *G. crassidens* or *G. simus*. This example illustrates the potential of postcranial morphology to provide meaningful systematic/taxonomic data in Crocodyliformes, particularly regarding the ilium morphology, which exhibits a high degree of interspecific variability.

Technical Session XI, Friday 8:15

**EXCEPTIONAL FOSSILS OF THE EARLIEST MARSUPIALS AND THE ORIGIN OF OPOSSUMS**

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The early evolution of living marsupials has been poorly understood because the early offshoots of this group are mostly known only from skeletal fragments. Examples of this are new jaws and teeth from the Fayum in Egypt, which deliver new information on biogeography but little on phylogeny. There has been a major gap of knowledge about the relationships of clades that lie phylogenetically between the Cretaceous metatherians from China and the diverse and well-known Neogene marsupials from Australia and South America. We summarize the results of anatomical and phylogenetic analyses of major new discoveries that fill that gap. The first skull of a peradectid marsupial from the earliest Eocene of the Clarks Fork Basin in North America is remarkably similar to living opossums and is the basis for a newly described species. Exceptionally well-preserved partial skeletons of the Early Oligocene fossil *Herpotherium* from the White River Formation in Wyoming suggest a terrestrial lifestyle for this taxon. Among the many anatomical transformations documented by the new fossils are a gradual increase in the number of cochlear turns and an increase of the size of the alisphenoid ossification covering the middle ear floor. Some ecological diversity characterized early marsupial evolution, as reflected in size and arboreal versus terrestrial adaptations. A comprehensive phylogenetic analysis of Metatheria including the new fossils, shows that peradectids are the sister group of living opossums and that *Herpotherium* is the sister-group to the crown-Marsupialia. African marsupials known to date are related to European and not to South American forms, in spite of dental features suggesting otherwise. North America played a very important role in early Cenozoic marsupial evolutionary history. The well-supported new phylogeny suggests that all crown marsupials known to date are post-Cretaceous in age.

Poster Session I, (Wednesday)

**VERTEBRAL MICROANATOMY AND HISTOLOGY WITHIN JUVENILE "MOSASAURS". WHERE DID THEY LIVE?**

HOUSSAYE, Alexandra, Muséum National d'Histoire Naturelle, Paris, France; TAFFOREAU, Paul, European Synchrotron Radiation Facility, Grenoble, France

Juvenile "mosasaur" remains are considered scarce in the fossil record. However, relatively numerous specimens were discovered in the Mooreville Chalk of Alabama and the Niobrara Chalk of Kansas. The discoveries of these juvenile specimens in the same layers as adults challenge the previous hypothesis stating that mosasaurs were giving birth in sheltered nurseries and suggest that, on the contrary, birth occurred in adult life environment. Within mosasauroids, vertebral microanatomy appears as a good mode of life indicator. Indeed, whereas plesioepedal and plesioelvic mosasauroids living in shallow water environments, display osteosclerosis (increase in inner bone compactness) with possible addition of pachyostosis (increase in cortical bone deposit), these osseous specializations are absent in hypopedal and hypopelvic mosasauroids living in open-water environments, which display vertebrae characterized by a particularly tight network of trabecular bone. One question concerned the possibility that life environment may change during growth within hypopedal and hypopelvic mosasauroids, from a shallow water environment in juveniles to an open marine one in adults, and that this change would be reflected in the inner vertebral microanatomy. The investigation of this question required the microanatomical and histological study of juvenile vertebrae illustrating various growth stages in some hypopedal and hypopelvic mosasauroids. The sample consisted in isolated vertebrae from *Clidastes*, *Halisaurus*, and *Tylosaurus*. Because of the rarity of the material and of its diagenetic pattern, high energy phase contrast X-ray synchrotron microtomography was used in order to non-destructively reconstruct the vertebral inner microanatomy. In addition, thin sections were made on two selected vertebrae to obtain complementary histological data.

This study suggests that ecology remains constant throughout growth within hydropedal and hydropelvic mosasauroids and therefore contradicts the hypothesis of sheltered nurseries.

Poster Session II, (Thursday)

#### A NEW ENANTIORNITHINE BIRD FROM THE LOWER CRETACEOUS OF WESTERN LIAONING, CHINA

HU, Dongyu, Paleontological Institute of Shenyang Normal University, Paleontological Museum of Liaoning, Shenyang, China; HOU, Lianhai, Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China; XU, Xing, Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China

So far the Early Cretaceous Jehol Group has produced spectacular fossil remains of enantiornithines. These discoveries demonstrate a surprisingly high diversity of enantiornithine birds in terms of not only taxonomy, but morphology and ecology as well. A new enantiornithine, *Bohaiornis guoi* gen. et sp. nov. is reported here based on a complete, fully articulated skeleton specimen (LPM-B00167) with feather impressions from the lacustrine beds of the Early Cretaceous Yixian Formation of Jianchang County, western Liaoning, China. *Bohaiornis* closely resembles to *Eoenantiornis* from the same time in general morphology, e.g., a short and deep skull with six-seven teeth on each side of upper and lower jaws, forelimbs sub equal to hindlimbs in length and alular digits with a robust and curved unguis extending distally to the level of the distal end of major metacarpal, etc., but it has a much bigger body size than most known enantiornithines including *Eoenantiornis*. Some unique features distinguish it from other known enantiornithines including *Eoenantiornis*, e.g., cervical centra with a strongly keeled ventral surface, sacral centra strongly compressed transversely, scapular with a robust and extremely elongated acromion process (more than twice as long as the glenoid facet), clavicular ramus straight with a prominent ridge along the medioventral margin and a laterally expanded proximal end. Except of the above features, the lateral margin of the coracoid of *Bohaiornis* is slightly convex only near the distal end as in *Longipteryx*, and the laterocaudal processes of the sternum extend more posteriorly than in *Eoenantiornis* close to the level of the distal end of the xiphoid process and its distal end expands to appear to be arrow-shaped as in *Cathayornis*. Our numerical cladistic analysis suggests that *Bohaiornis* is more derived than *Protapteryx*, but is more basal than most other enantiornithine taxa including *Eoenantiornis*. The discovery of this new enantiornithine demonstrates that Eoenantiornithines were already highly diversified in middle Early Cretaceous.

Technical Session X, Friday 12:00

#### ON THE POSTCRANIAL ONTOGENY AND PALEOBIOLOGY OF THE ORNITHOPOD DINOSAUR *DYSALOTOSAURUS LETTOWVORBECKI*.

HÜBNER, Tom, Bayerische Staatssammlung für Paläontologie und Geologie, Munich, Germany

*Dysalotosaurus lettowvorbecki* is a basal iguanodontian ornithomimid from the Tendaguru Beds (Upper Jurassic) of East Africa. It was found in two closely related, monodominant bonebeds of a single quarry, 2.5 kilometers northwest of the famous Tendaguru Hill in Southeast Tanzania. The fossil content comprises thousands of mostly isolated bones representing many ontogenetic growth stages. In the presented study, numerous measurements were taken from appendicular skeletal elements for bivariate statistics and size distributions. Combined with the data obtained from the histological examination of several long bones, an ontogenetic model was created for *Dysalotosaurus*. All known fossils of this small ornithomimid probably belongs to a single herd. Two groups of individuals dominate the size distribution and are delimited from each other by a distinct minimum. One group consists of juvenile to subadult individuals, the other group of mature adults, which is also indicated by the occurrence of medullary bone. None of the examined long bones have revealed an external fundamental system, so none of the animals was fully grown. In contrast to earlier studies, resting lines (LAG's) were found in the fibrolamellar bone tissue, even though there are only one or two lines in one sample. In many cases, there are no resting lines at all. Nevertheless, an unusual and, up to date, apparently not yet described zonation pattern has provided an age estimation of 9 to 11 years for the oldest individuals. After all, *Dysalotosaurus* was a cursorial and gregarious small dinosaur, where the precocial hatchlings were probably able to follow their herd very early in their life. No differences in the locomotion pattern between juveniles and adults were found. The apposition rates are comparable with lowest estimates for sauropods, and the achieved ages are comparable to other small dinosaurs. Finally, *Dysalotosaurus* is another dinosaur species, where the important, maturity indicating medullary bone tissue was found.

Poster Session I, (Wednesday)

#### FOSSILISED ONTOGENIES: MORPHOLOGY AND OSSIFICATION SEQUENCE STUDIES OF LIMBS IN SAUROPTERYGIAN AND ICHTHYOSAURIAN CLADES FROM THE UNESCO WORLD HERITAGE SITE OF MONTE SAN GIORGIO, SWITZERLAND, WITH A COMPARISON TO RECENT REPTILES.

HUGI, Jasmina, Paleontological Institute and Museum of University of Zürich, Zürich, Switzerland; SCHEYER, Torsten, Paleontological Institute and Museum of University of Zürich, Zürich, Switzerland; MITGUTSCH, Christian, Paleontological Institute and Museum of University of Zürich, Zürich, Switzerland; SÁNCHEZ-VILLAGRA, Marcelo, Paleontological Institute and Museum of University of Zürich, Zürich, Switzerland

The Unesco World Heritage site of Monte San Giorgio in Switzerland has yielded excellently preserved specimens of several basal sauropterygians and ichthyosaurs, in some cases even growth series from embryo to adult. These findings do not only provide information on adaptations of reptiles secondarily adapted to life in water, they also provide interspecific data of ossification sequences. Limbs are highly adaptive showing convergences for similar habitats and modes of life and also contain phylogenetic information. Limb ossification sequences were studied in five sauropterygians (pachypleurosaurs: *Serpianosaurus mirigiolensis*, *Neusticosaurus pusillus*, *N. peyeri*, *N. edwardsii*, nothosaurs: *Ceresiosaurus* spp.) and one ichthyosaur genus (*Mixosaurus* spp.). In addition, limb morphology was studied in placodonts, pachypleurosaurs, and nothosaurs, as well as in two ichthyosaur taxa (*Mixosaurus* spp., *Cymbospondylus* sp.). The aim of this study was to elucidate basal or derived adaptations to life modes in early marine reptiles such as a change in the predominance of the ossification sequence, a shortening of the stylo- and zeugopods, hardening of joints, and decrease/increase of the phalangeal formula. Results were compared to limb morphology and ossification sequences of modern marine reptiles, e.g. cryptodiran and pleurodiran turtles, and non-marine squamates (e.g., *Liopholis whitii*, Scincidae). Results of the ossification sequences of the genera *Neusticosaurus* and *Serpianosaurus* are: (1) acceleration of the hind limb compared to the forelimb. (2) ossification with a postaxial dominance in the sequential formation of metapodials. (3) ossification with a preaxial dominance in the sequential formation of phalanges. The first two observations confirm previous stated characteristics of amniotes, whereas (3) is a characteristic of anamniotes. Swimming *Neusticosaurus* spp. and *Serpianosaurus* sp. use their hind limbs for steering while propulsion is provided by axial movement. Preaxial dominance of ossification of phalanges is regarded as derived adaptation to a life in water; preaxial digits (especially digit I), have first to be strengthened for resisting water flow.

Poster Session IV, (Saturday)

#### FIRST REPORTS OF CRETACEOUS SAUROPOD AND BIRD FOOTPRINTS FROM THE YEOSU ISLAND ARCHIPELAGO, KOREA

HUH, Min, Korea Dinosaur Research Center, Gwangju, Korea, South; LOCKLEY, Martin, University of Colorado at Denver, Denver, CO, USA; KIM, Kyung-Soo, Jinju National University, Jinju, Korea, South; KIM, Jeong-Yul, Korea National University of Education, Cheongwon, Korea, South; GWAK, Se-Geon, Korea Dinosaur Research Center, Gwangju, Korea, South

Five small islands in the Yeosu city region (Chudo, Sado, Jeockgeumdo, Mokdo and Nagdo) were designated, in 2003, as Korean Natural Monument no. 434 because of their multiple dinosaur track-bearing levels. Previous, preliminary reports outlined the clastic and volcanoclastic sequences ranging in age from ~92-65 Ma based on K-Ar dating. The sequences on Chudo and Sado respectively contain at least 11 and 15 track-bearing levels, and were provisionally dated at >77 Ma (Chudo) and >65 Ma (Sado). Initial surveys indicate a dominance of ornithomimid trackways (65) compared with only 16 theropod and 1 sauropod trackway. Ongoing studies have revealed the presence of additional track horizons including one with three, parallel well-preserved sauropod trackways and other horizons with high densities of bird tracks. The sauropod tracks (cf. *Brontopodus*), are all the same size (pes l/w 60/45 cm; manus l/w 30/45 cm) with well-preserved pes claw impressions and a relatively large out-turned manus. Size, consistent inter-trackway spacing (2.25-2.50m) and parallel, eastward orientations all suggest three adults traveling as a gregarious group. Tridactyl, (*Aquatilavipes*-like) bird tracks from other horizons average about 4 cm wide with no visible hallux or webbing traces. Provisionally this excludes them from the smallest known ichnogenus (*Koreanaornis*) as well as from larger, morphologically-distinct ichnogenus known from Korea. Thus, they may represent a morphotype hitherto unknown in Korea. The Yeosu islands represent one of many areas of coastal Korea where new ichnites are regularly found. The potential for further discovery is extremely high.

Poster Session IV, (Saturday)

#### PLANT MORPHOLOGY DETERMINES CROPPING EFFICIENCY: WHY HERBIVORES MIGHT ASSOCIATE WITH CONIFERS

HUMMEL, Jürgen, University of Bonn, Institute of Animal Science, Bonn, Germany; STREICH, W. Juergen, Leibniz-Institute for Zoo and Wildlife Research, Berlin, Germany; CLAUSS, Marcus, University of Zurich, Clinic for Zoo Animals, Exotic Pets and Wildlife, Zurich, Switzerland

The very large body sizes of sauropods give rise to speculations how these animals were able to fulfill their daily energetic requirements. An allometric increase in foraging time is among the constraints on daily foraging demonstrated in large mammalian herbivores. In this study we intended to evaluate a potential influence of plant morphology on plant mass per bite, a factor obviously influencing feeding time. Differences between plant groups could potentially be relevant for explaining associations between certain dinosaur and certain plant groups. Very limited studies in mammalian herbivores demonstrated that animals can maximize intake rates when choosing plants of a particular morphology that facilitates high biomass intakes per biting event. In an attempt to mimic sauropod feeding, we collected samples of the first 30 cm of twigs (separated in leaves and twigs and in first and second 15 cm) of different plant groups (4 perennial conifers, three deciduous gymnosperms, 6 angiosperm trees and one herbaceous fern), and compared their weight after drying at 60 °C. Leaf biomass of the first 30 cm was significantly higher in perennial conifers (average 17.6 g dry matter) compared to the angiosperm trees (average 4.2 g dry matter); leaf biomass of

the first 30 cm was also significantly higher in *Ginkgo* and *Metasequoia* (average 7.8 g dry matter) compared to the angiosperm trees. *Larix* (deciduous conifer) and *Dryopteris* (fern) had lower values (2.1 and 1.9 g dry matter, respectively). Patterns were similar for total biomass (leaf and twig) and for leaves only, thus being equally relevant for animals feeding in a “cropping” or a “raking” mode. Our results indicate that differences in biomass per bite due to morphological differences between plant groups can be considered as an additional relevant factor in scenarios on dinosaur feeding ecology. In particular, considerations on intake rate maximization might be relevant for animals whose intake rate is not constrained by the process of mastication (in chewing animals, chewing time rather than available biomass per bite soon is the intake-rate limiting factor).

Technical Session IV, Wednesday 2:30

**“SIXTH DIGITS” AND THE EVOLUTION OF ELEPHANT FOOT POSTURE**  
HUTCHINSON, John, Structure and Motion Lab, The Royal Veterinary College, Hatfield, United Kingdom; DELMER, Cyrille, The Natural History Museum, London, United Kingdom; MILLER, Charlotte, Structure and Motion Lab, The Royal Veterinary College, Hatfield, United Kingdom; PITSILLIDES, Andrew, The Royal Veterinary College, London, United Kingdom; BOYDE, Alan, School of Medicine and Dentistry, Queen Mary, University of London, London, United Kingdom

Elephants have long been known to have a “cartilaginous rod” (prepollex/prehallux or “predigits”) on the medial border of their manus and pes that has been speculated to act as a supportive strut within their fatty footpad, and was originally thought to be a sixth digit. Using an integration of medical imaging, histology, ontogenetic data, functional anatomy, biomechanics and paleontology we show how this structure forms, how it functions in living elephants, and how it evolved. The predigits are actually expanded radial/tibial sesamoid elements, much like the “false thumbs” of anurans, pandas, moles and other taxa. They are only cartilaginous in younger elephants, showing progressive mineralization, multiple segments and potential joint structures. The predigits rotate caudodorsally as the footpads compress early in the step, and seem to modulate footpad stiffness. Osteological correlates on the metapodials and carpals/tarsals reveal that the predigits evolved into expansive strut-like structures in basal Elephantiformes (e.g., *Phiomia*) and deinotheres. This reciprocally indicates the evolution of an expanded footpad in Elephantiformes. Although still poorly known, carpals/tarsals of more basal proboscideans display sizes, shapes and articulation that suggest a fully plantigrade manus/pes that should only have had plesiomorphic, unexpanded footpads and sesamoids (as in other mammals). Thus, much like in giant pandas, the predigits are remarkable exaptations that serve somewhat digit-like functions; but in the case of elephants, all four feet have functional, expanded predigits. The predigits took over the role of supporting the “heel” as the proximal carpals/tarsals were reduced and as the skeletal elements became more digitigrade with increasing size and terrestriality in proboscideans. The apparent absence of similar structures in other large, digitigrade/unguligrade mammals (e.g., rhinos, hippos) can at least partly be ascribed to their ancestors’ loss or reduction of digit I and thereby the sesamoids, although such animals tend to have intermediate conditions with moderately-expanded footpads.

Technical Session V, Wednesday 4:00

**A PARSIMONIOUS SOLUTION TO ROMER’S ‘PROBLEM’: A SYNTHESIS, TEST AND APPLICATION OF THE EVIDENCE FOR AN INTRINSIC MORPHOLOGICAL CONSTRAINT IN THE POSTURAL EVOLUTION OF TETRAPOD FORELIMBS**

HUTSON, Joel, Northern Illinois University, DeKalb, IL, USA

Many fossil tetrapods converged upon the evolution of parasagittal hindlimb retraction, but retained sprawling forelimb rotation. Examples include various dicynodont, rhynchosaur, pareiasaur and archosaur clades. Romer hypothesized that instead of solving the ‘problem’ of efficient parasagittal quadrupedalism via forelimb “improvement”, dinosaurs abandoned their forelimbs for bipedalism, and noted that, after secondary reversions to quadrupedalism, their forelimbs were always less parasagittal than their hindlimbs. This shared divergence in limb anatomy poses one fundamental question: why did the postural evolution of the tetrapod forelimb differ from that of the hindlimb? Romer suggested that some postural issues must originate from rhipidistian fish. A tendency to apply mammalian anatomy to tetrapod forearms has inadvertently obscured the evidence that basal tetrapods inherited forelimbs from rhipidistians that were morphologically canalized for locomotion on aquatic substrates. Perpendicular juxtaposition of the elbow and wrist joint planes of action constrained the amniote forelimb to retain sprawling rotation at the shoulder and elbow, limiting its role in terrestrial locomotion, while a hindlimb with functionally uniplanar joint alignment became the dominant propulsive organ. A test using osteological comparisons of articulated forelimb joint ranges-of-motion confirmed that ornithischian dinosaurs with obligate quadrupedalism reverted to sprawling forelimb rotation with perpendicular joints, while some mammals overcame the ‘problem’ in a manner convergent with chameleons, by evolving hindlimb-like forelimbs with uniplanar joint alignment for arboreal narrow surface locomotion. This supports Romer’s hypothesis that dinosaurs initially bypassed modifying their forelimbs, and instead adopted cursorial obligate bipedalism using long counterbalancing tails. These data also help explain the amplified limb disparity and archosaurian trend towards bipedalism debated during Romer’s career, and shed light on why disputes surrounding the forelimb postures of quadrupedal dinosaurs keep reoccurring, by detailing why fossil tetrapods tended to retain sprawling forelimbs.

Technical Session XVII, Saturday 2:30

**AN EARLIEST TRIASSIC THEROCEPHALIAN (THERAPSIDA: EUTHERIODONTIA) WITH PERMIAN AFFINITIES AND A LOOK AT EUTHERIODONT DIVERSITY THROUGH TIME: CONSIDERING EVOLUTIONARY RATES IN THE PROBLEM OF CYNODONT ORIGINS.**  
HUTTENLOCKER, Adam, University of Washington, Seattle, WA, USA

Eutheriodonts (therocephalians and cynodonts) were a speciose group of ‘mammal-like’ therapsids who first diversified during the Permo-Triassic transition and produced the lineage that gave rise to mammals. New interest in therocephalians has emerged due to their ecological significance at the Permo-Triassic extinction boundary (PTB) and their relevance to the origin of cynodonts. Recent collecting in the PTB Palingkloof Member, Balfour Formation, of South Africa has produced a diversity of eutheriodonts, including a specimen previously reported as an Early Triassic record of the baurioid therocephalian *Ictidosuchoides* (SAM-PK-10014). This material is reexamined and incorporated into an established character matrix with the addition of several new characters. Cladistic analysis of 32 therapsid taxa and 121 characters supports that SAM-PK-10014 is closely allied to Permian akidnognathids. Phylogenetically-augmented range extensions indicate that several PTB eutheriodont lineages exhibit a Late Permian antiquity, but with modest survivorship (50%). Previous attempts to reconstruct PTB eutheriodont diversity are revisited in light of the new data. Two topologies are chosen [(1) monophyletic and (2) paraphyletic Therocephalia with a whaitsiid+cynodont clade] to study the effects of differing topologies on interpreting diversification and evolutionary rates in early eutheriodonts. Alternative topologies do not greatly affect relative changes in predicted evolutionary rates. High rates of character state changes over short intervals (and, thus, high homoplasy) during the early Late Permian (ca. 260 Ma) have likely confounded interpretations of cynodont origins. Both topologies suggest that, in therocephalians, rates of character evolution were greater during the Late Permian, but shorter lineage durations and high origination/extinction in earliest Triassic eutheriodonts are consistent with post-PTB ecosystem disruption. In general, high disparity and high rates of character evolution during early radiations were followed by more modest rates in Triassic cynodonts even in the face of high taxonomic turnover following the PTB.

Technical Session X, Friday 9:15

**DIVERSITY AND EVOLUTIONARY SIGNIFICANCE OF PTEROSAURS FROM THE EARLY LATE CRETACEOUS OF MOROCCO**

IBRAHIM, Nizar, University College Dublin, Dublin, Ireland; UNWIN, David, University of Leicester, Leicester, United Kingdom; ZOUHRI, Samir, Université Hassan II, Casablanca, Morocco; MARTILL, David, University of Portsmouth, Portsmouth, United Kingdom

African pterosaurs have a relatively incomplete fossil record and their evolutionary history is only poorly understood. During recent fieldwork, in what is currently the most productive sequence on the continent, the early Late Cretaceous Kem Kem beds of South Eastern Morocco, jaw fragments, isolated teeth and postcrania of pterosaurs were recovered from several sites, including Boumrade, Begaa and Gara Sbaa, near the Algerian border. The new finds, combined with a reappraisal of published records, reveal greater taxonomic diversity than previously realized. The assemblage contains at least one ornithocheirid, ‘*Siroccopteryx moroccensis*, a tapejarid with a tall cranial crest, and a new genus of azhdarchid characterized by long, low, narrow jaws. This new form represents the earliest reasonably certain record for Azhdarchidae, extending the range of this taxon to the late Albian/early Cenomanian. Previously, other slightly recurved edentulous jaw fragments were tentatively assigned to the Pteranodontidae, but their overall shape, notably the rapid deepening of the jaws posteriorly, and the distribution of nutrient foraminae suggest that these remains more probably belong to a chaoyangopterid. New specimens indicate the presence of slender and robust morphs. Our reassessment of the taxonomic composition of the Kem Kem assemblage reveals closer affinities with late Early Cretaceous South American pterosaur assemblages (e.g. Crato and Santana Formations), which also contain ornithocheirids, tapejarids with tall cranial crests, chaoyangopterids, and possibly azhdarchids, rather than, for example, to those from Europe (Cambridge Greensand) or Asia (Jehol Series). This hints at a broad paleobiogeographical distribution pattern similar in some respects to that proposed for other groups, such as dinosaurs. At the same time, the occurrence of some of these clades in east Asia (e.g. Ornithocheiridae, Tapejaridae and Chaoyangopteridae in the Jiufotang Formation) suggests, as might be expected, that continental dispositions played a relatively minor role in pterosaur evolutionary history.

Poster Session I, (Wednesday)

**PRERIMINARY REPORT ON FOSSIL LIZARDS FROM THE LOWER CRETACEOUS SASAYAMA GROUP OF HYOGO PREFECTURE, SW JAPAN**

IKEDA, Tadahiro, Museum Nature and Human Activities, Hyogo, Sanda, Japan; SAEGUSA, Haruo, University Hyogo, Sanda, Japan

In 2006 and 2007, two terrestrial vertebrate fossil assemblages were found from the red mudstone of the Lower Cretaceous formation of the Sasayama Group, Hyogo Prefecture, Southwest Japan. The Lower Cretaceous Formation of the Group is composed mainly of conglomerate, sandstone and mudstone intercalating several tuff beds which yield zircon FT ages of ca 120 Ma to 140 Ma. One of these fossil assemblages which occurred in the red mudstone on the bank of the Sasayama River in Tanba City is characterized by a partial

skeleton of a titanosauriform sauropod, shed teeth of theropods and ornithomorphs, and microvertebrates. The other fossil assemblage found from the red mudstone of the formation in Sasayama City is composed of macrovertebrate remains such as mammalian lower jaws, cranial and postcranial elements of lizards, and teeth and postcranials of theropods. Lizard specimens consist of some vertebrae, humerus, fragmental lower jaws, a braincase etc. The vertebrae of lizard are divided into three groups: varanid type vertebrae presenting narrow centrum, undetermined lizard vertebrae representing developed zygosphenes and zyganchtra, and other type undetermined lizard vertebrae. Fragmental lower jaws of lizard show some scincomorph characters such as the pleurodont teeth, the large subdental shelf, and an open Meckel's groove. Moreover, one of these lower jaws shows some morphological features of *Pachygenys thalstesa* such as great shortening and mesial confinement of dentary tooth. Although the excavation of the site is still in an early phase, the fossil materials obtained so far exhibit moderate morphological diversities which suggest the large potential of the site as one of new lizard assemblages of the Early Cretaceous, which are relatively rare compared with these of the Late Cretaceous.

Poster Session I, (Wednesday)

**ACTINOPTERYGIAN FRESHWATER FISHES FROM THE UPPER CRETACEOUS MIFUNE GROUP, KUMAMOTO PREFECTURE, JAPAN**  
IKEGAMI, Naoki, Mifune Dinosaur Museum, Kumamoto, Japan

The fossil records of the Late Cretaceous freshwater fishes are poorly known in Japan. To better understand the freshwater fish fauna of the Upper Cretaceous Mifune Group (Cenomanian-Santonian), preliminary examination of remains from the microfossils in the upper part of this Group were conducted. As a result, vidaliamiine and lepisosteoid freshwater fishes were found to exist in the Mifune Group. These fossils occurred from the fluvial sediments accompanied by various terrestrial vertebrates remains. Vidaliamiine materials consist of anterior left dentary, small individual left dentary, a large number of isolated teeth, and vertebral centra. Left anterior dentary is well preserved, robust, wider than high. The lateral surface of dentary is marked with numerous small pits. The shelf medial part of the tooth row is broad. The alveolus of dentary have crenulated margin. The tooth crown of jaw teeth are strongly keeled as in other vidaliamiines. The vertebral centra are amphicoelous. The dorsoventrally compressed anterior vertebral centra (W/D=2) represent an oval outline in articular view. The ganoid scales and vertebral centra are referable to Lepisosteidae. These ganoid scales are nearly rhombic. The ultrastructure on the ganoin surface was analyzed using scanning electron microscope (SEM). The tubercles are arranged regularly on the ganoin surface. The average size of tubercles is 4µm, the average distance between the tubercles is 4.7µm as in other lepisosteid. This situation is different from Lepidotes, close to *Lepisosteus* and *Obaichthys*. The centrum is opisthocelous, an autapomorphic feature of Lepisosteidae, lateral oval fossae exist on the lateral side of centrum. Although the Lower Cretaceous sediments have many fossil records of freshwater fishes in East Asia, the Late Cretaceous records of the freshwater fishes are fairly limited. These new materials are the first records of Vidaliamiinae and Lepisosteidae from the Upper Cretaceous of Japan, Far East Asia.

Poster Session IV, (Saturday)

**POSTCRANIAL SKELETONS OF *ASHOROA LATICOSTA* AND ADAPTIVE EVOLUTION OF THE DESMOSTYLIDAE (MAMMALIA: DESMOSTYLIA)**  
INUZUKA, Norihisa, University of Tokyo, Tokyo, Japan

Postcranial skeletons of *Ashoroo laticosta* from the Upper Oligocene of Morawan, Ashoro town, Hokkaido, Japan are described. This species is the most primitive found on the furthest geological horizon among the order Desmostylia. The *Ashoroo* is compared with *Desmostylus* of the Desmostylidae. Comparison of ontogenetic changes of *Desmostylus* with phylogenetic changes from *Ashoroo* to *Desmostylus* shows recapitulation of several characteristics. In the burial posture of *Ashoroo*, the thorax lies sideways with the left ribs lying on the right ones, which, unlike other Desmostylia, is peculiar to *Ashoroo*. The hind limbs lay on the back as in other desmostylians, in spite of the poor preservation. Normal posture of *Ashoroo*, based on their osteology and burial posture, is thought to have forelimbs of the inferior-limb type and hind limbs of the lateral-limb type. The body size in life restoration is estimated as about 1.7m in length, 80 cm in height, and 450 kg in weight. The skeleton of *Ashoroo* is characterized by distally wide, stout ribs, and forelimbs of the inferior-limb type. In *Desmostylus*, the ribs are generally thick and bent and the forelimbs and hind limbs are of lateral-limb type. Considering the adaptive significance of these morphologies, the life of desmostylids required stability of the body in a subtidal habitat, and evolution from *Ashoroo* to *Desmostylus* is assumed to be a shift in the method to lower the center of gravity of the fore-half of the body, from ballast in the basal thorax, to widening of the forelimbs. The degree of aquatic adaptation of *Ashoroo* is compared with those of the primitive tethytherians, *Moeritherium* and *Pezosiren*. The results show that *Ashoroo* is more adapted for aquatic life than *Moeritherium* or *Pezosiren* with more numerous vertebrae, a longer trunk and shorter legs. Consequently, it is estimated that an assigned ancestral desmostyliian, *Anthracobune* came close to shore first, the descendant *Ashoroo* adapted for amphibious life there, and thereafter an ancestral sirenian, *Pezosiren* and an ancestral proboscidean, *Moeritherium* reached the shore to adapt to amphibious life.

Late Triassic Terrestrial Biotas and the Rise of Dinosaurs, Thursday 9:45

**EVALUATING HYPOTHESES FOR THE EARLY DIVERSIFICATION OF DINOSAURS**

IRMIS, Randall, Utah Museum of Natural History and Department of Geology & Geophysics, University of Utah, Salt Lake City, UT, USA

Mechanisms for the early diversification of dinosaurs are poorly understood. Previous hypotheses have implicated Late Triassic mass extinctions, bolide impacts, climate change, competition and physiological differences among terrestrial tetrapods, and historical contingency in the rise of dinosaurs. To evaluate these hypotheses, I examined the occurrences, species diversity, and abundance of early dinosaurs at both regional and global scales to determine patterns of their early evolutionary history. Four main patterns are clear: 1) sauropodomorph dinosaurs became abundant during the late Norian-Rhaetian of Gondwana and Europe; 2) Triassic dinosaurs of North America have low species diversity and abundance that does not increase until the Triassic-Jurassic boundary; 3) sauropodomorphs and ornithischians are completely lacking in the Triassic of North America; and 4) ornithischian dinosaurs maintain a low species diversity, relative abundance, and small body size until after the Triassic-Jurassic boundary. No one existing hypothesis fully explains these data. There is no evidence for a Carnian-Norian extinction event that provided ecological release for dinosaurs, but sauropodomorphs did become abundant during the Norian, possibly after rhynchosaurs and dicynodonts became extirpated in Gondwana. No clear connection exists among increasing aridity, falling atmospheric oxygen levels, and early dinosaur diversity, but environmental stress at the Triassic-Jurassic boundary is consistent with changes in North American dinosaur assemblages. Elevated growth rates in dinosaurs are consistent with their gradual phyletic increase in body size, but this does not clearly correlate with increases in diversity or abundance. This study demonstrates that early dinosaur diversification was a complex process that was diachronous across Pangaea and probably had several causes. Studies of the rise of dinosaurs should explicitly separate different paleoecological, biogeographic, temporal, and phylogenetic data that are brought to bear on the question of dinosaur origins.

Poster Session I, (Wednesday)

**TOOTH MORPHOLOGY AND DISTRIBUTION OF THE LATE PALEOZOIC ANACHRONISTID SHARKS**

IVANOV, Alexander, St. Petersburg University, St. Petersburg, Russia

Sharks of family Anachronistidae is an oldest neoselachians described by the isolate teeth. The family includes the genera, well known *Cooleyella* and lately reported *Ginteria*. *Cooleyella* was recorded from the Early Carboniferous (Late Viséan) to the Middle Permian (Capitanian) of USA, Brazil, England, Belgium and Russia (Moscow Region and Urals). *Ginteria* occurs in the Early Carboniferous (Late Viséan - Serpukhovian) of England, Belgium and Russia (Moscow Region). Recently the teeth of new anachronistid genus were found in the Early Carboniferous (Serpukhovian) of Moscow Region, Russia. Teeth of those genera possess several differences but demonstrate same design of structure which is distinguished from other fossil sharks. The anachronistid teeth are characterized by the smooth crown with occlusal crest separated the short lingual face from the extended, sloping labial ones, with well-developed labial flange; the incised crown/base junction; and the base possessing the extended lingual face and narrow labial face with basal tubercle located under labial flange. The anachronistid sharks appeared in the Viséan of modern Europe and fast extended in the Serpukhovian. However, only *Cooleyella* was widely distributed outside the area of anachronistid origins during the Late Carboniferous - Permian.

Preparators' Session, Thursday 11:15

**STOCKING THE FISHBOWL: A PROGRAM TO TEACH NEW EXHIBIT LAB VOLUNTEERS THE BASICS IN FOSSIL PREPARATION, MOLDING, AND CASTING**

JABO, Steven, Smithsonian Institution, Washington, DC, USA; BROWN, Matthew, University of Texas, Austin, TX, USA; RESER, Peter, Paleo-Tech, Albuquerque, NM, USA; HOLLAND, Michael, Michael Holland Productions, Bozeman, MT, USA; SMITH, Matthew, Florida Museum of Natural History, Gainesville, FL, USA

During the fall and winter of 2008 the Smithsonian Institution, through a grant from the SI Women's Committee, implemented a program to teach the basics of fossil preparation, molding, and casting to potential volunteers. The intent of the program was to establish a body of preparators to work in the National Museum of Natural History's exhibit preparation lab, called FossilLab. To preserve the research and collections duties of the permanent staff in the behind-the-scenes Vertebrate Paleontology Prep Lab, four outside preparators were contracted to conduct the instruction; two instructors taught two five-day sessions on molding and casting, two other instructors taught two six-day sessions on preparation. The Department of Paleobiology's curatorial staff instructed the groups in paleobotanical preparation and microfossil processing and picking. All instruction took place in FossilLab during public hours. The instructors were required to teach basic techniques, use the materials and equipment consistent with those found at NMNH, and conduct an evaluation of skills at the end, but were allowed to be fairly autonomous and teach to their strengths. Registration for the program was conducted via the department's web page where a detailed description of the work and the lab familiarized prospective students with the type of work they would be performing. They were also asked a series of self-evaluative questions in an

attempt to filter out those who might not have had the innate motor skills or temperament needed for the job. Those who were confident in their decision to volunteer were interviewed in FossilLab, and the majority of those then registered for the program. Twenty eight people, some new and some experienced, were trained. FossilLab is now staffed by as many as six volunteer preparators performing a variety of tasks for Paleobiology every weekday. Weekend days are starting as well. The number of weekly man-hours has more than tripled since the training. Continued, focused training on individual projects is carried on by the VP Lab staff. Eighteen hours of videotape was recorded during the training and is on course to be edited and available via DVD and online.

Poster Session IV, (Saturday)

**A STUDY OF A *TROODON* EGG CONTAINING EMBRYONIC REMAINS USING EPIFLUORESCENCE MICROSCOPY AND OTHER TECHNIQUES**

JACKSON, Frankie, Montana State University, Bozeman, MT, USA; HORNER, John, Museum of the Rockies, Bozeman, MT, USA; VARRICCHIO, David, Montana State University, Bozeman, MT, USA

A partial *Troodon* egg from the Late Cretaceous (Campanian) Judith River Formation of central Montana contains disarticulated limb bones, vertebral centrum, and a single tooth. Histological sections of a limb bone reveal six to eight layers of vascular canals, profuse vascular space, abundant osteocytes, and evidence of initial osteonal development. Histologically, the embryonic skeletal elements represent an earlier ontogenetic stage than similar bones in a *Troodon* egg from the contemporaneous Two Medicine Formation in Montana. The 1 mm-thick eggshell consists of mammillary, prismatic, and external layers. The external layer fluoresces brightly when viewed by epifluorescence and cathodoluminescence microscopy; however, this color intensity does not extend into the underlying prismatic layer, thus indicating a transition occurs between layers 2 and 3. The presence of three structural layers in this eggshell further supports the evolutionary relationship between *Troodon* and birds. Although commonly used in the study of carbonates, epifluorescence microscopy is rarely employed in the study of fossil eggs. This technique offers several advantages over cathodoluminescence analysis, including minimal sample preparation, lower cost, and greater structural definition of some features.

Technical Session VI, Thursday 3:30

**THE CRETACEOUS SKELETON COAST OF ANGOLA**

JACOBS, Louis, SMU, Dallas, TX, USA; POLCYN, Michael, SMU, Dallas, TX, USA; MATEUS, Octávio, Museu da Lourinhã, Lourinhã, Portugal; SCHULP, Anne, Natuurhistorisch Museum Maastricht, Maastricht, Netherlands; NETO, André, Universidade Agostinho Neto, Luanda, Angola

Cretaceous coastal sediments of Angola present a rich and diverse fauna of marine amniotes, including turtles, mosasaurs, and plesiosaurs. The abundance of mosasaurs in particular suggests a highly productive coastal area. Angola today lies at the northern limit of the Namibian Desert, the so-called Skeleton Coast, which results from prevailing southeasterly winds of the descending limb of the southern Hadley Cell sweeping across the African coast. The Benguela upwelling and a highly productive sea are found today off the Namibian Desert coast. However, the Benguela upwelling system, based on results of DSDP studies, is said to have originated in the late Neogene and therefore cannot explain the productivity found along the length of the West African coast. The explanation is found in the northward drift of Africa through the arid climate zone, and is demonstrated by the tracing of the paleogeographic position of fossil localities through time.

Poster Session I, (Wednesday)

**INVESTIGATION OF FEEDING MECHANICS IN *CHAMPSOSAURUS*: JAW ADDUCTOR CHAMBER RECONSTRUCTION AND CRANIAL FINITE ELEMENT ANALYSIS**

JAMES, Michael, University of Alberta, Edmonton, AB, Canada

*Champsosaurus* has long been thought to have occupied a niche similar to that of gharials. Both share many piscivorous features, such as an elongate snout and needle-like teeth. *Champsosaurus* differs in the structure of the jaw adductor chamber, it being larger and surrounded by gracile temporal arches. Gharials have a smaller chamber in relation to the size of the skull and surrounded by robust temporal bones. Because no choristoderes are living, reconstructing the muscles of *Champsosaurus* done using extant phylogenetic bracketing, with lepidosaurs and crocodylians being the brackets. When the jaw musculature of *Sphenodon* was mapped on to a *Champsosaurus* skull the pterygoideus ventralis originated on an unusual position on the palate and the largest muscle is the adductor mandibulae externus medialis, which originates on the large squamosal. The force that the adductor muscles exert is calculated using the formula  $F = ASCA \cdot ST$ , where ASCA is the actual cross-sectional area of the muscle, and ST is the specific tension of the muscle, which ranges from 15 to 24 N•cm<sup>-2</sup>. The ASCA was interpreted to be equal to the area of the opening of the adductor chamber. Calculations show that an adult *C. natator* (UALVP 47243) could exert between 1194 (ST = 15) to 1910 N (ST = 24) of force with the jaw adductor muscles. *C. lindoei* (UALVP 33928) could exert muscle forces ranging from 310 to 497 N. *Gavialis gangeticus* was calculated to have a range of muscle forces between 739 and 1182 N. *Crocodylus cataphractus* was calculated to have a range of 1498 to 2396 N.

Finite element analysis indicates that *Champsosaurus* had little stress in the temporal arches, with the most compressive stress concentrated between the orbits, with the most tension on the palate below that. In crocodylians, the stress generated from a bite was found to be far more evenly spread throughout the skull. The jaw adductor muscles of *Champsosaurus* were similar to lepidosaurs rather than crocodylians, in a large *Champsosaurus* they were capable of exerting more force than a gharial, and that stress during a bite was concentrated around the orbits leaving the temporal arches with little stress.

Technical Session XIX, Saturday 1:45

**PATTERNS OF HYPSONDONTY IN UNGULATES SHOW THAT NEOGENE ARIDITY IN NORTH AMERICA PRECEDED THAT IN EURASIA**

JANIS, Christine, Brown University, Providence, RI, USA; ERONEN, Jussi, University of Helsinki, Helsinki, Finland; ATAABADI, Majid, University of Helsinki, Helsinki, Finland; PUOLAMÄKI, Kai, University of Helsinki, Helsinki, Finland; FORTELIUS, Mikael, University of Helsinki, Helsinki, Finland

Previous work has shown that the mean hypsodonty of the large herbivorous mammals in fossil communities can serve as a proxy for paleoprecipitation, and thus may illustrate changing climatic patterns through the course of the Neogene. For the Recent, mean hypsodonty alone explains 65% of global precipitation, but it performs relatively poorly for the Eurasian high latitudes, and for the Neotropics, both areas that have relatively recently (late Pleistocene) lost many of their large mammals. Mean hypsodonty maps for Eurasia show that patterns of rainfall were quite different prior to 11 million years ago, when the continent was much more humid than today, and that progressively modern rainfall distributions developed around 7 to 5 million years ago. Here we compare mean hypsodonty patterns of Eurasia with newly derived ones for North America, and show that modern patterns of aridity appeared much earlier on the North American continent. North America and Eurasia appear fairly similar in the early Miocene, with estimates of paleoprecipitation much greater than today for both continents, although North America shows slightly greater aridity, especially in the southwest regions. By the middle Miocene this aridity had spread across the Great Plains in North America, but in Eurasia such aridity is seen only in a few places at this time. The most profound change in North America is seen in the early late Miocene, when the entire continent appears moderately arid. At this same time a similar degree of aridity appears in central Asia and southern Europe, although other areas remain mesic. North America retains this pattern throughout the rest of the Neogene, with the southwestern areas tending to become somewhat even more arid over time. Although aridity continues to increase in Eurasia through the late Miocene, it does not come to match the patterns in North America until the Pliocene. These differences in predicted paleoprecipitation from faunal hypsodonty levels probably reflect differences in patterns of uplift and tectonics on the two continental masses, which in turn affected the local climate and vegetation and hence the diets of the herbivorous mammals.

Poster Session II, (Thursday)

**DIVERSE TURTLE FAUNA (REPTILIA, TESTUDINES) FROM THE UPPER JURASSIC OF NORTHERN GERMANY AND ITS IMPLICATIONS FOR TURTLE PHYLOGENY**

JANSEN, Maren, University of Bonn, Steinmann-Institut für Geologie, Mineralogie und Paläontologie, Bonn, Germany; KLEIN, Nicole, University of Bonn, Steinmann-Institut für Geologie, Mineralogie und Paläontologie, Bonn, Germany

Taxonomy of Upper Jurassic turtles is still controversial, and most taxa are difficult to compare because separated shells and isolated skulls historically have mostly been described independently. Furthermore, the majority of the so far described specimens have been united in common taxa for which the phylogenetic position is not entirely resolved yet. A phylogenetic analysis of the newly described material will contribute to a better understanding of the relationships within Jurassic turtles. The Langenberg Quarry (Kimmeridgian) near Oker, Niedersachsen (Lower Saxony basin), northern Germany, yields a rich fauna of marine and terrestrial tetrapods, mainly including theropods, sauropods, pterosaurs, crocodyles, and turtles. Most of the turtle material consists of disarticulated shell fragments but more complete specimens have also been found. A nearly complete skull from the Lower Kimmeridgian as well as a complete specimen from the Middle Kimmeridgian were discovered in 2007. The latter consisting of a carapace with the plastron partially visible between the fontanelles of the ribs and a partial skull attached. These more complete specimens as well as an additional skull from the same locality, but a different layer, were described, and morphological characters are included into the latest phylogenetic analyses. Both skulls display significant morphological differences which support an assignment to different taxa, even though they are of similar size. However, a close resemblance to the Plesiochelyidae is indicated for both skulls. The rich disarticulated shell material represents different ontogenetic stages in a range from 7 cm to nearly 50 cm carapace length, but at the moment it remains unclear if this shell material belongs to a single taxon or different taxa.

Poster Session I, (Wednesday)

**DIVERSITY AND MASS EXTINCTION OF CHONDRICHTHYANS AT THE K-T BOUNDARY: EVIDENCE FROM EASTERN TEXAS**

JANUS, Tracey, Texas A&M University, College Station, TX, USA; STIDHAM, Thomas, Texas A&M University, College Station, TX, USA

Previously unstudied bone accumulations within the so-called "tsunami" deposits of the K-T Boundary in Eastern Texas contain thousands of teeth and bone fragments of a variety of marine vertebrates, including sharks, batoids, and bony fish. Those deposits of the Kincaid Formation contain the Iridium anomaly, purported impact ejecta, and fossils solely from the latest Maastrichtian, and they appear to represent sediments deposited at the very end of the Cretaceous contemporaneous with the Chixulub impact and global mass extinction. At present, our sampling of those deposits has produced at least 16 genera and 19 species of elasmobranchs, including members of *Rhinobatos*, *Rhombodus*, *Ptychotrygon*, *Squalicorax*, *Carcharias*, *Heterodontus*, and *Pararhincodon*. The most common elasmobranch taxon is Scyliorhinidae, represented by at least 3 species and composing 40% of individual chondrichthyan specimens. Batoids are much less common (0.05% of specimens), but are represented by 7 species. Our specimens of *Pararhincodon* are the first records of that taxon in the Maastrichtian of North America.

This K-T chondrichthyan fauna includes benthic and pelagic forms that likely inhabited shallow, warm to temperate waters, but some taxa (hexanchids) occur in deeper waters today. While 73% of the genera present in the sediments are known from post-Cretaceous deposits, none of the identified species are known to occur in the Paleogene. This Texas K-T Boundary fauna is most similar to those found in the Maastrichtian Kemp Clay (Texas) and Arkadelphia Formation (Arkansas), and it shares fewer taxa with sites along the Atlantic Coast. Our data is highly suggestive of the presence a relatively high diversity of chondrichthyans at the very end of the Cretaceous that suffered a mass extinction coincident with the bolide impact and extinctions of other taxa.

New Perspectives on the Early Evolutionary History of the Synapsida, Saturday 10:15

**DICYNODONT CRANIAL SUTURES AND HISTOLOGY: IMPLICATIONS FOR SKULL FUNCTION**

JASINOSKI, Sandra, University of Cape Town, Cape Town, South Africa; RAYFIELD, Emily, University of Bristol, Bristol, United Kingdom; CHINSAMY-TURAN, Anusuya, University of Cape Town, Cape Town, South Africa

Finite element (FE) analysis is used to assess the patterns and magnitude of cranial strain in response to masticatory loads in the dicynodonts *Oudenodon* and *Lystrosaurus*. During orthal bite simulations, the magnitude of strain is lower in the skull of *Lystrosaurus* than in *Oudenodon*. Despite this difference, moderate to high strain accumulates in similar areas of the skull of both taxa. We investigated the sutural morphology and bone microstructure in areas that have moderate to high FE-predicted strain in *Lystrosaurus* and *Oudenodon* through the examination of histological sections, serial sections, and CT scan slices. Comparison of the observed patterns of sutural morphology and bone histology to the FE-strain plots can determine if these features correlate to the type, magnitude and/or orientation of bone strain. Scarf sutures in the infraorbital bar, zygomatic arch, and postorbital bar of *Oudenodon* and *Lystrosaurus* may have dissipated the moderate to high compressive and tensile strain in those regions. Sutures that have a different morphology between the two taxa may reflect a difference in the magnitude of masticatory strain. The tongue and groove morphology of the postorbital-parietal suture in *Oudenodon* may have provided better resistance to the higher FE-predicted tensile strain than the same suture in *Lystrosaurus*. The morphology of the premaxilla-nasal suture of the two taxa is fundamentally different, and the additional region of sutural mobility in the anterior surface of the snout of *Lystrosaurus* suggests it employed a different biting regime than *Oudenodon*. Variation in bone microstructure between cranial elements of both taxa may reflect differences in growth patterns and/or biomechanical function. The morphology of the sutures sampled in this study compares well with the FE-predicted strain confirming that sutural morphology reflects cranial strain, which can be detected by appropriately constructed FE-models.

Poster Session III, (Friday)

**TAXONOMIC COMPOSITION OF THE ALAMO WASH LOCAL FAUNA FROM THE UPPER CRETACEOUS OJO ALAMO FORMATION (NAASHOIBITO MEMBER) SAN JUAN BASIN, NEW MEXICO**

JASINSKI, Steven, State Museum of Pennsylvania, Harrisburg, PA, USA; SULLIVAN, Robert, State Museum of Pennsylvania, Harrisburg, PA, USA; LUCAS, Spencer, New Mexico Museum of Natural History and Science, Albuquerque, NM, USA; SPIELMANN, Justin, New Mexico Museum of Natural History and Science, Albuquerque, NM, USA

For over a century, Late Cretaceous fossil vertebrates have been intermittently collected from the lower part of the Ojo Alamo Formation (Naashoibito Member = Ojo Alamo beds [in part] of earlier workers). The first attempt to characterize the vertebrate fauna from the Naashoibito Member was by Lehman, who dubbed the fauna the "Alamo Wash local fauna." Unfortunately, a few of the vertebrates listed by Lehman came from the underlying De-na-zin Member (Kirtland Formation) and were erroneously included in the Alamo Wash local fauna, due to their mistaken stratigraphic provenance. In an attempt to straighten out the biostratigraphic occurrences of the fossil vertebrates (micro and macro) from both the

Naashoibito and De-na-zin members, the State Museum of Pennsylvania launched an annual field program in 1995 to resample these units in order to properly assess the taxonomic composition of both stratigraphic intervals. As a result of this renewed investigation, we now have a better understanding of the two faunal assemblages and have begun to redefine the taxonomic composition of the "Alamo Wash local fauna" (AWlf). The AWlf includes fishes, amphibians, lizards, at least seven species of turtles, crocodylians, dinosaurs and mammals. The dinosaur taxa are especially noteworthy: the sauropod *Alamosaurus sanjuanensis*, the nodosaurid *Glyptodontopelta mimus*, an ankylosaurid, a new ceratopsid, a new caenagnathid, a new dromaeosaurid, a hadrosaurine, a lambeosaurine and a large tyrannosaurid, among others. The age of the AWlf is "early" Maastrichtian, or "pre-Lancian" LVA, estimated to be 69 Ma. Further study of the AWlf will allow for critical comparisons, both temporally and geographically, to other vertebrate faunas from the Late Cretaceous Western Interior of North America.

Poster Session I, (Wednesday)

**MORPHOLOGY AND HISTOLOGY OF ACANTHODIAN FIN-SPINES FROM THE LATE SILURIAN OF SWEDEN**

JERVE, Anna, Uppsala University, Uppsala, Sweden

Fin-spines are dentinous elements associated with dorsal and paired fins in chondrichthyans and acanthodians. Fin-spine morphology has been used in taxonomy and for assessing skeletal maturity of individuals. While there has been speculation regarding spine growth and early evolution, efforts to resolve their origin have been scant. Recently discovered fossils exhibiting a mixture of chondrichthyan, acanthodian and placoderm characteristics have generated interest in how fin-spine evolution may relate to gnathostome evolution. Paired fin-spines, a characteristic once known only for acanthodians, have been identified on an early chondrichthyan (*Doliodus*), and dorsal and pectoral fin-spines were also recently described in a basal sarcopterygian fish (*Psarolepis*). Much of our knowledge of basal gnathostome evolution is in flux, with the monophyly of certain groups (acanthodians, placoderms) now being questioned. As such, detailed investigation of fin-spine histology may provide insight for elucidating gnathostome phylogeny and origins. The data presented here are from acanthodian fin-spines collected from the Ramsåsa locality (Late Silurian) in Skåne, southern Sweden. Specimens were thin-sectioned for histological study and scanned using phase-contrast at the ESRF synchrotron facility in Grenoble to reveal the three-dimensional architecture. The geometry of the vascularization indicates that new material was principally added to the proximal end of the spine, with a minor contribution internally from the top of the central soft-tissue papilla. Straight vascular canals extend the length of the spine from near the tip to the proximal end, occasionally bifurcating as the diameter of the spine increases; this suggests that the soft-tissue organization of the growth zone was essentially static. The vascular arrangement of fin-spines is a feature that has been previously observed in thin-sections but has not yet been rigorously investigated. Vascularization varies among taxa and its pattern yields information about the internal organization of fin-spines. Such differences provide new data related to growth processes and their broader evolutionary implications.

Poster Session I, (Wednesday)

**NEW SPECIMEN OF GUIZHOUICHTHYOSAURUS (SHASTASAURIDAE) FROM SOUTHWESTERN CHINA**

JI, Cheng, Peking University, Beijing, China; JIANG, Da-Yong, Peking University, Beijing, China; MOTANI, Ryosuke, University of California, Davis, Davis, CA, USA; HAO, Weicheng, Peking University, Beijing, China; SUN, Zuo-yu, Peking University, Beijing, China

*Guizhouichthysaurus tangae* from southwestern China is a long-bodied ichthyosaur represented by articulated skeletons. However, detailed anatomy of its postcranium has yet to be reported and the relationship among the genera within Shastasauridae is still controversial. We describe a nearly intact skeleton of *Guizhouichthysaurus* (based on its postcranial features) from Wusha Distinct, Xingyi City of Guizhou Province, China to supply more information in solving these problems. Based on the study of conodont and ammonite, the specimen is from the upper Ladinian (Middle Triassic), suggesting the stratigraphic range of the genus spanned from the upper Ladinian to lower Carnian (type horizon). The presacral length is 3.19m, of which 0.92m is in the skull. It has shastasaurid features such as the squarish humerus with a small anterior margin and the radius that is about 1.5 times wider than the ulna with notch on the anterior margin. It also has features that are found in *Besanosaurus* but unknown in *Shastasaurus* or *Shonisaurus*, namely the scapula with a thin anterior margin that almost forms half a circle and the almost circular radiale with a straight preaxial margin without a notch. It also shares some features with *Shastasaurus*. The most noteworthy is the fan-shaped coracoid that is asymmetrical. This feature is also seen in a species from Guanling, China (Carnian) described as *Callawayia wolonggangensis*. The present specimen questions the validity of *C. wolonggangensis* because postcranial features are almost identical between this species and *Guizhouichthysaurus*. *C. wolonggangensis* was referred to *Callawayia* based on its scapular shape which is "mostly covered in matrix", whereas the prepared part is indeed similar to corresponding part of that of *Guizhouichthysaurus*. Another used diagnosis is the parietal table which could be easily caused by preservation. Thus, *C. wolonggangensis* may be a junior synonym of *G. tangae*. Phylogenetic analysis suggests *Guizhouichthysaurus* is the sister taxon of (*Shonisaurus*, *Shastasaurus*) and they together form the sister taxon of *Besanosaurus*, which is consistent with their stratigraphic sequence.

Poster Session II, (Thursday)

**CORRESPONDENCE OF PALEOENVIRONMENTAL-PALEOECOLOGICAL CHANGES WITH BIODIVERSITY SEQUENCE OF THE MIDDLE TRIASSIC PANXIAN MARINE REPTILE FAUNA, GUIZHOU PROVINCE, CHINA**

JIANG, Da-yong, Department of Geology and Geological Museum, Peking University, Beijing, China; MOTANI, Ryosuke, Department of Geology, University of California, Davis, Davis, CA, USA; HAO, Wei-cheng, Department of Geology and Geological Museum, Peking University, Beijing, China; RIEPEL, Olivier, Department of Geology, The Field Museum, Chicago, IL, USA; TINTORI, Andrea, Dipartimento di Scienze della Terra, Università degli Studi di Milano, Milano, Italy

Three diverse Triassic marine reptile faunas were identified in Guizhou and Yunnan Provinces, including: the Carnian (Late Triassic) Guanling *Guizhouichthosaurus-Xinpusaurus* Fauna with large ichthyosaurs and thalattosaurs; the Ladinian (Middle Triassic) Xingyi-Fuyuan *Keichousaurus hui* Fauna; and the Anisian (Middle Triassic) Panxian-Luoping *Mixosaurus panxianensis* Fauna. The Panxian Fauna contains abundant marine reptiles and fishes associated with bivalves and brachiopods. It provides a physical marker of the rapid recovery of the Triassic marine ecosystem following the Early Triassic stagnant stage after the end-Permian Mass Extinction. Ten marine reptile taxa were collected in the 1.82m-2.10m thick fossiliferous level in the Upper Member of Guanling Formation, which can be subdivided into three marine reptile beds. The Lower Reptile Bed yielded the sauropterygians *Placodus inexpectatus* and *Lariosaurus hongguoensis*, the ichthyopterygians *Xinminosaurus cactates*, *Phalarodon cf. P. fraasi*, and *Mixosaurus panxianensis*, thus representing a time during which durophagous taxa were predominant. In this bed, large complete skeletons may reach up to 2.3m in length, and lithofacies and chemostratigraphic analysis indicate a relatively deep carbonate platform, which had an oxic environment near the bottom, along with a rising sea level. The Middle Reptile Bed yielded the sauropterygian *Nothosaurus yangjuanensis*, and the archosaur *Qianosuchus mixtus*, associated with *Mixosaurus panxianensis*. The fossils in this bed are characterized by a pincering dentition and large overall body sizes, the largest individuals possibly exceeding 3.0m in length. This bed might represent a time when the basin reached its greatest depth, with relatively anoxic conditions near the bottom. The Upper Reptile Bed yielded the sauropterygians *Wumengosaurus delicatmandibularis* and *Keichousaurus* sp., the protosaur *Dinocephalosaurus orientalis*, and the ichthyopterygian *Mixosaurus panxianensis*. In this bed, reptilian taxa performing suction feeding appeared, and most individuals are less than 1.0m long. This bed corresponds to a period of decreasing water depth.

Poster Session II, (Thursday)

**IMPLICATIONS OF THE NEWLY DISCOVERED GIGANTOPITHECUS FAUNA FROM THE EARLY PLEISTOCENE OF GUANGXI, SOUTH CHINA**

JIN, Changzhu, Key Laboratory of Evolutionary Systematics of Vertebrates, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China; WANG, Yuan, Key Laboratory of Evolutionary Systematics of Vertebrates, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China; HARRISON, Terry, Center for the Study of Human Origins, Department of Anthropology, New York University, New York, NY, USA; ZHANG, Yingqi, Key Laboratory of Evolutionary Systematics of Vertebrates, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China; DENG, Chenglong, Paleomagnetism and Geochronology Laboratory, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, China

Among the most important faunas in the Late Cenozoic, the *Gigantopithecus* faunas have received much attention. There has been considerable progress in research on the *Gigantopithecus* fauna owing to recent discoveries of important *Gigantopithecus* sites in South China from different periods of the Quaternary. The *Gigantopithecus* fauna recently discovered in Sanhe Cave, Guangxi, South China consists of more than 80 mammal species, including some Neogene remnant genera (e.g., *Sinomastodon*, *Dicoryphochoerus* and *Cervavitus*) and many Pleistocene extinct genera (e.g., *Gigantopithecus*, *Procyonocephalus* and *Stegodon*). The Sanhe fauna is the southernmost *Gigantopithecus* fauna found so far in China, and is also the most typical tropical Quaternary mammalian fauna in South China. Paleomagnetic dating of the fossil-bearing strata in Sanhe Cave gives an age of approximately 1.2-1.6 Ma (middle Early Pleistocene), corresponding well with the biostratigraphic correlation. Based on comparison between the different faunas, the *Gigantopithecus blacki* fauna in southeast Asia can be divided into three temporal stages. The early stage (2.58-1.8 Ma) is represented by the faunas from Wushan, Chongqing, Liucheng and Mohui, Guangxi. This stage is characterized by *G. blacki* of relatively small body size, and an associated fauna with Neogene relic species, and primitive species that first appeared in the Pleistocene, such as *Ailuropoda microta*, *Cuon dubius*, and *Tapirus sanyuanensis*. The middle stage (1.77-1.07 Ma) is represented by the faunas from Longgudong, Hubei and Sanhe, Guangxi. This stage is characterized by the increased body size of *G. blacki*, *Ailuropoda* and *Tapirus*, the disappearance of primitive species, such as *A. microta*, *C. dubius*, and *T. sanyuanensis*, and the first appearance of *A. wulingshanensis*, *C. antiquus*, and *T. sinensis*. The late stage (1.07-0.42 Ma) is represented by the faunas from Tahsin, Bama and Wuming, Guangxi and Tham Khuyen, Vietnam. This stage is characterized by the smallest body size of *G. blacki*, more advanced species (e.g., *A. baconi*) replace the Neogene relic species, and a higher proportion of extant species.

Preparators' Session, Thursday 9:30

**VIRTUAL REPAIR OF FOSSIL CT SCAN DATA**

JOHNSON, Mark, The University of Manchester, Manchester, United Kingdom; MUSTANSAR, Zartasha, The University of Manchester, Manchester, United Kingdom; MANNING, Phillip, The University of Manchester, Manchester, United Kingdom; MARGETTS, Lee, The University of Manchester, Manchester, United Kingdom; MUMMERY, Paul, The University of Manchester, Manchester, United Kingdom

X-ray micro-computed tomography (micro-CT) and 3D image-based modeling software has unlocked the ability to digitally repair distorted or broken fossil specimens, thus opening the way for interpretation of previously unusable finds. A fossilized terminal ungual phalanx from the manus of the dromaeosaur *Velociraptor mongoliensis* (Manchester Museum, University of Manchester, specimen LL.12392) was micro-CT scanned at the Henry Moseley X-ray Imaging Facility. Inspection of low-resolution fast-scans, revealed the *Velociraptor* manual ungual specimen was broken in several places, previously going unnoticed due to cement repair of the fossil. After conducting a longer high-resolution scan of the ungual the high sensitivity of the apparatus enabled separation of areas of differing density, in this case the fossilized bone and cement. Image-based modeling software produced by Simpleware allowed slice-by-slice repair in 3 planes, resulting in a complete, fully stitched 3D digital model of the ungual, whilst maintaining internal cavities and the micrometer reconstruction of trabecular architecture. This software also has the potential capability to reinflate specimens that have been compressed during fossilization, restoring skeletons to their true shape and dimension as in life. 3D dissections on geometrically precise reconstructions allows the interpretation of previously unusable specimens and reinterpretation of already described fossils. Further, use of Simpleware's software to convert repaired fossils into micron level finite element meshes will enable the biomechanical testing of these repaired structures. Testing of fossil structure and function is already underway at the University of Manchester and is adding to our knowledge of extinct animals.

Poster Session IV, (Saturday)

**DIFFERENCES IN THE DIETARY RESPONSES OF THE PERISSODACTYL PLAGIOLOPHUS AND THE ARTIODACTYL DIPLOBUNE TO THE EOCENE/OLIGOCENE TRANSITION EVENTS IN EUROPE**

JOOMUN, Sarah, Royal Holloway University of London, Egham, United Kingdom; HOOKER, Jerry, Natural History Museum, London, London, United Kingdom; COLLINSON, Margaret, Royal Holloway University of London, Egham, United Kingdom

A major mammalian faunal turnover called the Grande Coupure occurred in the earliest Oligocene of Europe. This event took place during the period of global climatic change from the greenhouse conditions of the Late Eocene to the icehouse conditions of the Early Oligocene. The climate transition occurred in a series of steps ending with the first Oligocene Antarctic glaciation (Oi-1), which coincided with the Grande Coupure. Most of the endemic European mammal fauna became extinct and there was a large number of incoming taxa from Asia. Of the larger mammals, the perissodactyls and artiodactyls were the most affected by this event. The perissodactyl *Plagiolophus* and the artiodactyl *Diplobune* were two of the few ungulate genera which survived the Grande Coupure. Dental mesowear and microwear are used as dietary proxies to determine changes in the diet and help reconstruct the paleoenvironment. They are produced by the interaction of ingested material with the teeth. Dental mesowear encompasses the occlusal relief and shape of the cusps of the tooth and dental microwear takes the form of pits and scratches on the tooth enamel which are only visible under a microscope. *Plagiolophus* and *Diplobune* both fit into the dietary category of browsers however within that category the diets are significantly different. The mesowear of *Diplobune* showed only round cusps and high occlusal relief and did not change throughout the period studied. The occlusal relief of *Plagiolophus* decreased during the Eocene/Oligocene transition and both sharp and round cusps were found in different proportions during this time. The microwear of *Diplobune* showed significantly fewer scratches than *Plagiolophus*. Both *Diplobune* and *Plagiolophus* showed an increase in pits before the Grande Coupure and a second increase across the Grande Coupure. This indicates that there was an increase in abrasive material in the diet of both taxa during the Eocene/Oligocene transition. The large numbers of small pits and small numbers of scratches suggest that *Diplobune* is a leaf browser and does not consume fruit like *Plagiolophus*.

Poster Session II, (Thursday)

**PLASTOMENIDAE, A NEGLECTED FOSSIL LINEAGE OF NORTH AMERICAN SOFTSHELL TURTLES (TRIONYCHIDAE), FILLS A MAJOR GAP IN THE FOSSIL RECORD**

JOYCE, Walter, University of Tübingen, Tübingen, Germany; LYSON, Tyler, Yale University, New Haven, CT, USA

The fossil record of softshell turtles (Trionychidae) is generally well understood because even fragments will clearly diagnose the presence of the group. Yet, the known record of the two primary subclades is exceedingly asymmetric, due to a ghost lineage of African and Indian flapshelled turtles (Cyclanorbinae) that is estimated at 80 Ma. Herein we present a phylogenetic analysis of Trionychidae that includes for the first time representatives of the poorly studied and circumscribed fossil taxon Plastomenidae, which is only known from the Campanian to Eocene of North America. The analysis reveals that plastomenids are stem representatives of the cyclanorbine crown, thus significantly reducing the apparent ghost lineage of the group. Yet, this result demands a biogeographic explanation as to

how the stem lineage of a southern Old World clade could occur in North America. In the context of an Asiatic origin of Trionychidae, two primary hypotheses exist that can explain this conundrum and that are supported to varying degrees by the available fossil evidence. However, though abundant, the fossil record is still too poorly understood to rigorously distinguish between these two primary hypotheses.

Poster Session I, (Wednesday)

#### **NEW FOSSIL-BEARING PLEISTOCENE CAVE BRECCIAS FROM ZAMBIA (CENTRAL AFRICA)**

KAISER, Thomas, Biocentre Grindel and Zoological Museum, University of Hamburg, Hamburg, Germany; STRAIT, David, Dept. of Anthropology, University at Albany, Washington, USA; MANGINI, Augusto, Heidelberg Academy of Sciences, Heidelberg, Germany; RUDOLPH, Barbara, Biocentre Klein Flottbek, University of Hamburg, Hamburg, Germany; MWAMOLOWE, Kagosi, National Heritage Conservation Commission, Lusaka, Zambia

Central Africa almost completely lacks depositional environments preserving fossils and environmental records. The deep history of the Zambezi Ecozone is therefore severely understudied in terms of the temporal context of climate-environment-biome interactions. Newly discovered Middle Pleistocene fossiliferous cave deposits in Zambia allow, for the first time, integrated analysis of vertebrate faunal and floral (pollen from speleothems) fossil evidence within a tight temporal framework derived from uranium rich speleothems interbedded with fossiliferous sediments. The Kalenda Hill Cave system (KHC) contains huge amounts of fossiliferous clastic and chemogenous deposits including large masses of soil-buried calcified and de-calcified breccia in front of the existing cave mouth. The Middle Pleistocene mammalian assemblage includes skull fragments, teeth and postcranial elements of suids, bovids, equids and many other mammalian orders. So far predominantly open habitats are indicated by these mammals. Fossil speleothems are preserved as sediment inclusions as well as fossil flowstone sheets covering and underlying the fossil bearing breccias. High uranium contents of speleothems allow recovery of mass spectrometric U-series dates indicating rarely sampled Middle Pleistocene (OIS 6-11; 169.9 ka  $\pm$  4.3; 256 ka  $\pm$  34 -26; 265 ka  $\pm$  32 -25; 358 ka  $\pm$  19 -17; 384 ka  $\pm$  28 -23) which is consistent with the mammal fauna and corresponds tightly to the monsoon index as calculated according to several models (insolation 23°N+a insolation 23°N-0°, caloric half year, and ice volume). Flowstone layers also contain well preserved pollen floras including Salicaceae, Flacoutiaceae, Fabaceae, all of which are indicative of humid climates. The KHC complex is geographically close to the hominid-bearing Kabwe (Broken Hill) site, which is among the very few hominid sites in the Zambezi Ecozone and which may be broadly contemporaneous to the KHC complex.

Technical Session XV, Saturday 9:15

#### **LONG-AXIS ROTATION: A MISSING RANGE OF MOTION IN DINOSAUR FUNCTIONAL ANALYSIS**

KAMBIC, Robert, Brown University, Providence, RI, USA; GATESY, Stephen, Brown University, Providence, RI, USA

Measuring joint ranges of motion is a logical first step in reconstructing locomotion and other behaviors in extinct taxa. Although maximum angles of flexion/extension and abduction/adduction are typically reported for limb joints, these values do not fully characterize range of motion. This study addresses the third rotational degree of freedom, long-axis rotation (LAR), which can significantly impact limb kinematics and kinetics. For example, at proximal joints such as the hip and shoulder, small rotations about the femoral/humeral axes can impart large displacements on the distal limb. LAR moments (torques) can equal or even exceed those of flexion/extension, thereby acting as a critical influence on bone loading and joint morphology. We explored the full rotational range of hip motion in a de-muscle guineafowl preparation with intact ligaments and cartilage. Using a rod attached to the femur, the hip was moved through extremes of flexion/extension, abduction/adduction, and internal/external rotation while being recorded by dual fluoroscopic video systems at 60 Hz. Sets of three radio-opaque markers implanted in the ilia and femur were digitized to calculate 3-D coordinates and accurately animate CT-based bone models. A joint coordinate system (JCS) was set up to quantify each joint angle for over 12,500 poses. When plotted as a 3-D graph, these data map out a volume of angular space in which the joint could operate. Superficial points form a complex surface that reveals considerable interaction among LAR and other rotational degrees of freedom. Illustrations of extreme bone position alone may be appropriate for hinge-like, ginglymal joints, but most others require more thorough sampling of coordinated rotations at movement maxima. Range of motion studies could benefit from a well-defined JCS that fosters measurement and communication of LAR and other angles with an explicit rotation order. *In vivo* 3-D kinematic/kinetic studies of extant taxa will reveal the role of LAR in locomotion and serve as much needed reference data for extinct tetrapod analysis.

Romer Prize Session, Thursday 9:00

#### **EFFECTS OF THE PERMO-TRIASSIC MASS EXTINCTION ON SYNAPSID DISPARITY OVER TIME**

KAMMERER, Christian, University of Chicago, Chicago, IL, USA

The Permo-Triassic mass extinction had devastating effects on both species richness (taxonomic diversity) and disparity (morphological diversity). The relationship between these quantities at and following the extinction has been heavily studied in marine invertebrates, but relatively little attention has been given to disparity patterns in terrestrial vertebrates. Non-mammalian synapsids, the dominant group of terrestrial vertebrates in the Permian, have been central to studies of tetrapod survivorship and ecosystem remodeling across the P-Tr boundary. However, previous studies have generally been limited to using richness metrics, rather than quantifying disparity directly to provide a more complete view of the extinction and its results. Here I present a broad scale quantitative analysis of synapsid disparity before and after the Permo-Triassic extinction event. Disparity metrics were calculated based on geometric morphometric analysis of synapsid crania representing all major taxa at a global scale (including faunas from all continents except Australia). In the Upper Permian peak of synapsid morphological disparity (both in breadth and density of morphospace occupation), background species turnover results in an only temporary loss of disparity, with other synapsids colonizing the morphospace occupied by extinct taxa. Following the extinction, there is a significant reduction in total occupied morphospace as well as increased clustering, with the formerly broadly occupied area being split into two discrete clusters. Furthermore, there is evidence for a fundamental shift in the pattern of synapsid cranial morphospace occupation in the Triassic, with Triassic turnover resulting in morphospace contraction and increased marginalization even in those taxa with high richness. Areas lost as a result of species turnover are generally not recolonized by other synapsids. No geography-specific signal is recovered: different faunas display similar patterns of turnover when scaled for sample size, suggesting that the factors underlying synapsid morphospace reduction in the Triassic were operating globally.

Edwin H. and Margaret M. Colbert Poster Competition (Thursday)

#### **A SIMPLE METHOD FOR ESTIMATING BRAIN VOLUME OF BIRDS AND ITS SIGNIFICANCE FOR PALEONEUROLOGY**

KAWABE, Soichiro, Ehime University, Matsuyama, Japan

Brain volume gives us very useful information to discuss the behavior and the cognition of animals. But it is difficult to obtain accurate brain volume from extinct species because fossils are often partly or largely broken. The purpose of this study is to estimate brain volumes of birds from little osteological information. Brain volumes of extant birds were calculated from MRI or CT images. Then the correlations among brain volume and maximum brain width, length and height were assessed by multiple regression analysis and correlation analysis. Values between brain volume and maximum brain width showed a strong linear correlation. In the extant birds, it is thus possible to estimate brain volume accurately from maximum brain width by using a standard line. Brain volumes of fossil Neornithes were also calculated using this estimating method. In consequence, the brain volume values estimated by the foregoing method satisfactorily fitted with the reported values. I also examined whether this method can be used for other taxa including *Archaeopteryx*, the most primitive bird. The brains of *Archaeopteryx* and some theropod dinosaurs were not estimated accurately because they have more or less the elongated reptile-type brain. Animals being the more distant from Neornithes in phylogeny tend to have the more primitive reptile-type brain. Even in *Archaeopteryx*, the estimated value was approximately 35% smaller than the reported value. However, pterosaurs showed the wide bird-type brain. Thus this brain volume estimating method might be applicable for not only extant but also extinct Neornithes and it can be a powerful tool to obtain more information that never before available from fossil specimens.

Poster Session II, (Thursday)

#### **EVOLUTION OF GIGANTIC TORTOISES FROM THE NEOGENE OF EUROPE**

KEAR, Benjamin, La Trobe University, Melbourne, Australia; GEORGALIS, Giorgios, Aristotle University of Thessaloniki, Thessaloniki, Greece

Gigantic tortoise fossils have been recorded from the Neogene strata of Mediterranean Europe (Greece, France, Spain) for over 130 years; however, their phylogenetic relationships have never been examined. Comparative morphological observations based on postcranial elements have prompted provisional assignment of all current remains (representing up to 11 species) to a single genus, *Cheirogaster*, and hypothesized a sister taxon relationship with the African giant tortoise *Centrochelys*. This implies dispersal of a common ancestor into Europe sometime prior to the late Eocene (the oldest occurrence of *Cheirogaster*) and a long period of subsequent diversification culminating in a speciation maximum during the Miocene (7 recognized taxa). Significantly, this evolutionary scenario contrasts with paleogeographical reconstructions and recent molecular analyses of modern European testudonans (*Testudo*+*Eurotestudo*), which suggest the absence of an Arabian-Anatolian land bridge until the Early Miocene and thus a probable Asian origin for European fossil tortoise taxa prior to the influx of testudonans from Africa <10 million years ago (Late Miocene). A preliminary re-examination of Upper Miocene-Lower Pliocene *Cheirogaster* remains from Greece (Samos, Lesbos and mainland Attica, Macedonia) supports taxonomic separation from other European species including the type, *C. maurini* from the Upper Eocene of

France, thus raising doubts about genus-level homology. Interestingly, the most massive European fossil tortoises (carapace length ~2 m) are known from the Miocene-Pliocene transition and coincide with the appearance of other equally gigantic tortoises in Africa and the near East (India). This time interval is marked by the onset of cooler, dryer climates in the Afro-Eurasian region and the spread of open woodlands/grasslands throughout Mediterranean Europe. Selection for gigantism might therefore represent an adaptation for maintaining higher metabolic activity (through inertial homeothermy) in the face of unfavorable environmental conditions.

Technical Session IX, Thursday 3:15

#### **RARE EARTH ELEMENTS AND RATES OF FOSSILIZATION IN VERTEBRATE BONES**

KEENAN, Sarah, University of Bristol, Bristol, United Kingdom

The process of fossilization is a complex and poorly understood suite of events transforming biogenic apatite into fossil apatite. Advances in molecular paleontology have allowed for investigations into the nature of bones, from archaeological to fossil material, including crystallinity, trace element composition, collagen content, and histology. The incorporation of trace elements, specifically rare earth elements (REEs), into bone during diagenesis and the resulting profiles from the outer cortex inwards towards the center of the bone provide an indication of relative rates of pore closure or the point of fossilization. Focusing on mammal bones still containing original collagen from the Pleistocene of the North Sea, and completely recrystallized dinosaur bones from two sites in the Cretaceous of Montana, greater insight into the process of fossilization can be gained. The use of multiple analytical techniques, including XRD, FTIR, LA-ICP-MS and mass spectrometry towards geochemical investigations of bone provides a means of assessing changes during recrystallization, and whether these changes are linked to age of material as well as host sediment. Bones hosted in fluvial sandstones with a greater host sediment porosity exhibited shallower REE profiles, while overbank mudstones resulted in steeper profiles, implying a depositional control on fossilization. Pleistocene material displayed a distinct crystallinity profile, reflecting the presence of collagen, while Cretaceous samples differed from younger material and between the two sites. At this time, the link between the age of material, REE profile reflecting rates of fossilization, and apatite crystallinity do not appear to be strongly correlated. Future studies examining a multitude of localities from well-constrained depositional environments may provide more robust correlations between the resulting geochemistry and the microstructure of fossil apatite. The use of a wide range of analytical techniques towards vertebrate bones aids traditional taphonomic interpretations, and provides insight into processes and the potential applications of information stored within bones.

The Scientific Legacy of Mary Anning — Recent Advances in Marine Reptile Paleobiology and Evolution, Wednesday 11:00

#### **RAPID DIVERSIFICATION OF DENTAL AND JAW MORPHOLOGY AMONG MARINE REPTILES DURING THE TRIASSIC RECOVERY**

KELLEY, Neil, University of California, Davis, Davis, CA, USA; MOTANI, Ryosuke, University of California, Davis, Davis, CA, USA; JIANG, Da-yong, Peking University, Beijing, China; RIEPPEL, Olivier, The Field Museum, Chicago, IL, USA; ANDREA, Tintori, Università degli Studi di Milano, Milano, Italy

The Panxian Fauna (Pelsonian, Anisian, Middle Triassic) from the Upper Member of the Guanling Formation offers a unique window into the early evolution of Mesozoic marine reptiles. The diversity of feeding strategy among Triassic marine reptiles has not been analyzed quantitatively. In a study of post-Triassic marine reptiles, Massare identified six functional feeding guilds based on tooth morphology. We investigated the cranial and dental morphology and jaw function of Panxian marine reptiles to examine if a similar ecological division already existed in the Middle Triassic, about 15 million years after the end-Permian extinction. A principle component analysis of 10 cranial and dental measurements of Panxian marine reptiles suggests that differences in skull proportions, anterior dentition and jaw mechanics are the factors that differentiate among feeding strategies and/or diets within this guild. Principal components reveal substantial morphological variation among Panxian reptiles comparable to the diversity seen in later Mesozoic forms. Nevertheless, several distinctions can be drawn between this Triassic fauna and its Jurassic and Cretaceous counterparts. A greater diversity of Triassic marine reptiles occupied the “crush” guild, characterized by robust, flattened posterior dentition. This guild was vacant in many post-Triassic marine reptile faunas. Conversely, there appear to be fewer representatives showing intermediate dental morphology characteristic of the “general” guild, which was well-occupied by post Triassic forms. Another characteristic of the Panxian Fauna is the higher abundance of taxa showing considerable heterodonty, suggesting functional partitioning along the tooth row, and possibly adaptation toward feeding on an array of prey types. Finally, some Middle Triassic marine reptiles exhibit dental and cranial morphologies distinct from any known Jurassic or Cretaceous forms. Overall, the high diversity in tooth and skull shape of Middle Triassic marine reptiles indicates that a rapid adaptive radiation of multiple lineages of marine reptiles took place synchronously with the recovery of marine ecosystems from the end-Permian extinction.

Technical Session X, Friday 9:45

#### **THE SOFT TISSUE OF *JEHOLOPTERUS* (PTEROSAURIA, ANUROGNATHIDAE) AND THE STRUCTURE OF THE PTEROSAUR WING MEMBRANE**

KELLNER, Alexander, Museu Nacional/UF RJ, Rio de Janeiro, Brazil; WANG, Xiaolin, Key Laboratory of Evolutionary Systematics of Vertebrates, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China; TISCHLINGER, Helmut, Eichstaedt, Tannenweg, Germany; HONE, David, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China; MENG, Xi, Key Laboratory of Evolutionary Systematics of Vertebrates, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China

Fossil deposits with pterosaur soft tissue are quite rare in the geological record. Despite the fact that some specimens with remnants of the soft anatomy of those flying reptiles have been known for quite a long time and even been described (and re-described) in detail, there is considerable disagreement on their interpretation, particularly the nature of the patagium and some filamentous structures covering the epidermis, the so-called “hair-like” fibers (or pycnofibers). Here we describe in detail the wing membrane preserved in the holotype of *Jeholopterus ningchengensis* (IVPP V12705) from the Daohugou Bed (Late Jurassic or Early Cretaceous) of China, including investigation under ultraviolet light. The patagium can be divided into the distal and comparatively more rigid actinopatagium extended until the articulation between the humerus and the forearm, and a proximal, more tensile tenopatagium. The actinopatagium shows the presence of at least three layers containing actinofibrils. In each layer the actinofibrils are parallel to sub-parallel but this direction diverges from layer to layer. A particular reticular pattern is observed in several areas indicating that layers with different orientated actinofibrils were widespread in this pterosaur. A well developed integumental covering formed by thicker fibers, called pycnofibers, is present. Although the understanding of the mechanical properties of the wing membrane are hampered by the lack of knowledge regarding the composition of the actinofibrils, this configuration observed in *Jeholopterus* might have allowed subtle changes in the membrane tension during flight resulting in more control of flight movements and the organization of the wing membrane when the animal was at rest. The presence of pycnofibers are not exclusive of *Jeholopterus* but were also present in the primitive non-pterodactyloid *Sordes pilosus*. Although those structures have been reported in more derived pterosaurs, none display the extensive integumental covering than *Jeholopterus* and *Sordes*. Comparisons with other specimens suggest that there was a great variation in integumental covering among pterosaurs.

New Perspectives on the Early Evolutionary History of the Synapsida, Saturday 9:00

#### **THE EARLY EVOLUTIONARY DIVERSIFICATION OF THERAPSIDA: WAS IT A TRUE POLYTOMY?**

KEMP, Tom, Oxford University Museum of Natural History, Oxford, United Kingdom

Therapsida is a strongly supported clade. Of its six major subtaxa, Biarmosuchia lacks significant shared derived characters and may be plesiomorphic. The others (Dinocephalia, Gorgonopsia, Anomodontia, Therocephalia, and Cynodontia) are all well supported clades, but cladistic analysis of the interrelationships amongst these six has not generated a strongly supported cladogram. One possible reason for this is that a true polytomous split occurred at a taxonomic level below the resolution of the morphological evidence. As cladistic methodology only admits as evidence of relationship the positive occurrence of shared unique characters, it is logically unable to test hypotheses of polytomy because these imply only the absence of shared characters. To escape the impasse in which polytomy may be true but cladistics cannot reveal it requires acceptance of extrinsic evidence and application of a non-cladistic model of character evolution. The timing of appearance of the major therapsid subtaxa supports a fourfold polytomy, and a mid-Permian paleoclimatic shift opening up higher latitudes to the ancestral therapsid provides a plausible trigger for the radiation. Polytomy also predicts that no two lineages shared an identical intermediate functional stage. The functional morphology of the feeding complex is analyzed from the perspective of the correlated progression model of character evolution, which adopts the view that characters are functionally integrated within the organism as parts of a system and do not meaningfully exist as arbitrarily atomized elements. The probable correlated suite of character changes inferred to have occurred in each lineage from the hypothetical ancestral therapsid is reconstructed. These respective sequences of hypothetical stages are compared to see if there is coalescence between any of them. Biarmosuchia is functionally very close to ancestral in structure. Dinocephalia, Gorgonopsia, Anomodontia, and Therocephalia do not coalesce which therefore supports a four-way polytomy. Therocephalia and Cynodontia do coalesce and therefore the taxon Eutheriodontia is corroborated.

**THE NONMAMMALIAN FAUNA FROM THE MIDDLE PLIOCENE MATJHABENG SITE, SOUTH AFRICA**

KENNEDY, Alicia, Sam Houston State University, Huntsville, TX, USA; STIDHAM, Thomas, Texas A&M University, Bryan, TX, USA; LEWIS, Patrick, Sam Houston State University, Huntsville, TX, USA; DERUTTER, Darryl, Texas A&M University, Bryan, TX, USA

Recent excavations at Matjhabeng, a fluvial deposit in the Free State Province of South Africa, have yielded a rich fossil assemblage estimated to be ~ 3.5 Ma. This site fills a spatial and temporal gap in the South African record between the better known Langebaanweg (5.0 Ma) and Makapansgat (2.5 Ma) localities. Data from Matjhabeng will allow a broader understanding of the south African paleoenvironment relevant to the rate and pattern of animal evolution in the region. In addition to a diversity of recovered mammalian taxa, fossils recovered from the Matjhabeng deposit include many nonmammalian fossils attributed to avian, reptilian, amphibian, and actinoptergian taxa. As may be expected in a fluvial deposit, the most numerous of these fossils belong to Actinoptergii (ray-finned fishes). The fish taxa recovered are represented by several tooth-bearing elements and fin spines. At present, two amphibian fragments, a urostyle and a dentary, are identified as anurans (frogs and toads). Several reptilian fragments are identified as turtle, snake and lizard. Turtles are represented by carapace and plastron fragments, while snakes are represented by a single trunk vertebra. Several cranial and postcranial elements can be attributed to lizards. Among these, distinctive osteoderm impressions on one small lizard maxilla identify it as a gerrhosaur (plated lizard), making it the oldest known record of that taxon in southern Africa. Birds are represented by relatively few skeletal elements, including fragments of a tibiotarsus, a jaw, a tarsometatarsus, and a furcular symphysis. The multiple taxa recovered at Matjhabeng include the first record of a merganser (fish-eating duck) in Africa. The non-mammalian fauna from Matjhabeng bridges southern African faunas from the early and late Pliocene, demonstrating that the middle Pliocene was a distinctive period of evolutionary change among non-mammals, occurring across a background of significant climatic and mammalian faunal change.

Technical Session III, Wednesday 2:15

**GLOBAL INTERRELATIONSHIPS OF PLESIOSAURIA (REPTILIA, SAUROPTERYGIA) AND THE PIVOTAL EFFECT OF TAXON SAMPLING IN DETERMINING THE OUTCOME OF PHYLOGENETIC ANALYSIS**

KETCHUM, Hilary, Natural History Museum, London, United Kingdom; BENSON, Roger, Department of Earth Sciences, University of Cambridge, Cambridge, United Kingdom

Plesiosauria was one of the longest-lived groups of obligately aquatic tetrapods and its members were abundant and ecologically diverse in Mesozoic marine ecosystems. Several studies have attempted to unravel the relationships of higher plesiosaurian clades but these differ in a number of key areas. We present the largest phylogenetic data set of plesiosaurs to date. This includes 179 characters (eight new) assembled from a critical reassessment of previous data sets, and 66 taxa (material of 46% was examined directly).

Five Lower Jurassic plesiosaurs are recovered outside of the clade comprising Plesiosauroidea and Pliosauroidae. Plesiosaurian taxa have never before been recovered in this position. This indicates that the fundamental split between these two superfamilies does not encompass all of the diversity of early plesiosaurs. A monophyletic Plesiosauroidea is supported for the first time by phylogenetic analysis. Elasmosauridae is shown, at present, only to comprise 'middle' and Late Cretaceous taxa, although ghost lineages indicate that earlier members of the clade must exist but remain undiscovered.

Subsampling our data set allows us to 'simulate' the taxon samples of previous authors. The resulting 'simulation' analyses closely replicate the results of previous analyses. This shows that depauperate or patchy taxon sampling, and not scoring differences, is the likely cause of key controversies in plesiosaurian phylogenetics. These results support the existence of basal plesiosaurs noted above. They also suggest that Rhomaleosauridae is a monophyletic clade and that Polycotylidae and Leptocleididae form a monophyletic clade within Plesiosauroidea, and not Pliosauroidae. This indicates that the 'pliosauroform' body plan of polycotylids was independently derived from 'plesiosauroform' ancestors.

Technical Session VIII, Thursday 3:45

**THE SCALING OF LIMB ROTATIONAL INERTIA IN EXTANT MAMMALS: A FIRST STEP IN RECONSTRUCTING LIMB MORPHOLOGY AND LOCOMOTION IN EXTINCT MAMMALS AND DINOSAURS**

KILBOURNE, Brandon, University of Chicago, Chicago, IL, USA

Recent biomechanical studies have revealed that the metabolic cost of swinging the limbs is a significant portion of the total metabolic cost of locomotion. Such studies suggest that the rotational inertia of limbs is relevant to understanding the mechanics and energetics of terrestrial locomotion in both extant and extinct taxa. Insight into limb inertia in extinct taxa requires data on limb inertial properties for extant species; however, scant data on limb inertial properties currently exist. Data on limb inertial properties – moment of inertia, center of mass position, and limb natural frequency – were collected from the fore- and hindlimbs of 15 species of quadrupedal mammals (representing nine families) in order to understand how limb inertia varies with body size. Muscles were left *in situ* on limb bones in order to

measure limb inertial properties for the entire appendicular musculoskeletal system. As a function of body mass, limb moment of inertia scales with negative allometry, indicating that larger mammals have limbs with relatively less rotational inertia than smaller species. Forelimb center of mass position scales isometrically with body mass. Hindlimb center of mass position scales with negative allometry, revealing that hindlimb mass is more proximally concentrated as mammals increase in body size. In both the fore- and hindlimbs, limb natural frequency also scales with positive allometry when compared to body mass, although the correlation between limb natural frequency and body mass is negative, paralleling the scaling of stride frequency between small and large mammals. The data on limb inertial properties collected in this study will be combined with data on the proportions and geometry of the appendicular skeleton for the purposes of reconstructing limb inertia in extinct mammals. Data gathered from extant mammals would additionally serve as an appropriate first-order model for non-avian dinosaurs, due to the similarities in posture, limb proportions, and locomotor biomechanics between mammals and non-avian dinosaurs.

Poster Session III, (Friday)

**THE WORLD'S SMALLEST DINOSAUR TRACKS FROM THE CRETACEOUS HAMAN FORMATION OF CHANGSEON ISLAND, NAMHAEE COUNTY, KOREA**

KIM, Kyung-Soo, Department of Science Education, Chonju National University of Education, Jinju, Gyeongnam, Korea, South; LIM, Jong-Deock, Natural Heritage Center of Korea, National Research Institute of Cultural Heritage, Daejeon, Korea, South; KONG, Dal-Yong, Natural Heritage Center of Korea, National Research Institute of Cultural Heritage, Daejeon, Korea, South; LOCKLEY, Martin, University of Colorado at Denver, Denver, CO, USA; PARK, Geun Sil, Namhae History Research Group, Namhae-gun, Gyeongnam, Korea, South

The smallest dinosaur tracks known from the ichnogenus *Minisauripus* were discovered from the Cretaceous Haman Formation of Changseon Island on the southern coast of Korea. The island vertebrate ichnofauna consists of *Minisauripus* cf. *zhenshounani*, *Dromaeosauripus hamanensis*, *Ignotornis yangi*, *Koreanaornis hamanensis*, pterosaur trackways, and other sauropod, theropod, and ornithomimid footprints. A total of 12 *Minisauripus* tracks include one trackway which comprises 4 tracks ranging from 1.27 to 1.51 cm long and 1.06 to 1.30 cm width. The tracks are characterized by asymmetric, very small, well-preserved pads, with prominent claw traces. The ichnogenus *Minisauripus* represents a diminutive theropod footprint with two ichnospecies: *M. chuanzhuensis* and *M. zhenshounani*. The latter is narrower than the former with digits less-divergent and digit II relatively shorter. Therefore, these tracks resemble *M. zhenshounani* rather than *M. chuanzhuensis*.

The ichnogenus *Minisauripus* is known from Sichuan and Shandong Provinces, China and Changseon and Sinsu Islands, Korea. *M. chuanzhuensis* from Sichuan Province and *M. zhenshounani* from Shandong range from 2.3 cm and 2.5-6.1 cm long, respectively. Eight Korean tracks assigned to *M. cf. chuanzhuensis* and *M. cf. zhenshounani* are 2.3-3.5 cm long. Previously, the smallest known dinosaur footprint was a 1.78 cm long theropod track discovered on the Isle of Skye, Scotland and recorded in the Guinness Book of World Records. The dinosaur tracks from Changseon Island are between 15 and 29% smaller than those from Skye. The smallest footprint from Changseon Island is thought to have been made by a baby dinosaur right after hatching, because height at the hip of the track maker by Thulborn's allometric equation is roughly estimated at only 4 cm. Thus the track maker's total height is estimated at less than 10. In comparison *Microraptor*, the smallest known dinosaur was a giant at 42-83 cm long.

Edwin H. and Margaret M. Colbert Poster Competition (Thursday)

**PHYLOGENY OF HETEROSMINTHUS (RODENTIA, MAMMALIA): AN APPLICATION OF NON-PARAMETRIC ANALYSES OF DENTAL VARIATION WITHIN TWO TIME-ORDERED POPULATIONS**

KIMURA, Yuri, Southern Methodist University, Dallas, TX, USA

*Heterosminthus* is a genus of birch mouse endemic to central to East Asia and includes eleven species from the late Oligocene to Late Miocene. Previous non-phylogenetic studies found that *H. gansus* is a derived species of *Heterosminthus*. However, a recently proposed cladistic analysis showed monophyly of the primitive Saudi Arabian *Arabosminthus* and "*H.*" *gansus*, indicating that *H. gansus* is basal to *Heterosminthus*. They actually showed that "*H.*" *gansus* is basal to (*Parasminthus*, *Heterosminthus*), not directly basal to *Heterosminthus*. A cladistic analysis was performed based on an assumption that frequency changes of a variable within time-ordered populations of a species indicate polarity of a character. The polarity of certain characters of *Heterosminthus* was determined, using non-parametric analyses of dental variation in *H. orientalis* within two time-ordered populations. Abundant specimens of *H. orientalis* from Quantougou (Gansu, China; 16.6-15 Ma) and Moergen (Inner Mongolia, China; 12.4 Ma) allowed evaluation of twenty-nine characters on the first and second molar. The chi-square test was applied to categorical data, and the Cochran-Mantel-Haenszel test was applied to ordinal data unless composed of two variables (Fisher's Exact Test). When variables are ordinal (such as absent to distinct), the CMH test is more appropriate in order to detect an ordinal trend association. Four characters were shown to be statistically significant: anteroloph and protostyle on M1, anterostyle on M1, and posterior arm of the protoconid on m2. Phylogenetic analysis recovered a single most parsimonious tree. *Heterosminthus gansus* nests with other *Heterosminthus* species and is

a derived species of the genus, contrary to previous results. Superimposing phylogeny on chronological ranges and geographic distribution of *Arabosminthus* and *Heterosminthus*, *H. gansus* is most reasonably derived from Asian *Heterosminthus* and is not a primitive species of *Arabosminthus*.

Technical Session XI, Friday 11:45

**PALEOENVIRONMENTS OF EARLY MIOCENE VERTEBRATE LOCALITIES AT NAPAK AND MOROTO, UGANDA: LITHOFACIES AND ISOTOPIC ANALYSES**  
KINGSTON, John, Emory University, Atlanta, GA, USA; MACLATCHY, Laura, University of Michigan, Ann Arbor, MI, USA; COTE, Susy, Harvard University, Cambridge, MA, USA; KITYO, Robert, Makerere University, Kampala, Uganda; SANDERS, William, University of Michigan, Ann Arbor, MI, USA

Early Miocene vertebrate fossil assemblages in eastern Uganda chronicle the early stages of a faunal transition from archaic to modern African taxa. Reconstructing the paleoenvironmental context of these faunal communities is critical for interpreting the nature of this transition, which includes the evolution and diversification of catarrhines. The fossil sites occur in carbonatite eruptive sequences associated with early stages of rifting in East Africa, documenting the paleoecological heterogeneity that characterized the slopes of developing volcanic complexes. Lithofacies analyses of sites associated with the dissected Napak volcanic edifice and those flanking Mount Moroto indicate variable depositional regimes and environments. Sites forming in the early stages of volcanism, at or near the interface with the underlying basement metamorphic rocks by fluvial and alluvial processes, preserve vertebrate communities foraging in potentially more open and arid woodland ecosystems. Such ecosystems would have dominated the gentle slopes of the early volcanic dome and surrounding peneplains. Relatively younger sites have been found in minimally reworked volcanoclastic lenses and primary ash falls within thick sequences of lavas and agglomerates. These sites formed in more forested montane habitats higher up along steep flanks of the volcanoes. Although arboreal preferences of extinct taxa at these upland sites suggest forest/woodland habitats, specific independent data relating to the paleovegetation physiognomy is limited to two macrofloral genera indicating humid forest conditions. Consequently, isotopic analyses of fossil herbivore enamel were used to further constrain specific environmental factors such as canopy effect, relative evapotranspiration, and water stress, as well as differentiate foraging behavior of taxa represented at different sites. Collectively these data, in conjunction with more detailed assessments of site formation, reinforce the need to carefully consider local ecological heterogeneity when contrasting faunal assemblages or in developing causal links between environmental change and lineage transitions.

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The Scientific Legacy of Mary Anning — Recent Advances in Marine Reptile Paleobiology and Evolution, Wednesday 9:15

**PACHYPLEUROSAURIA - A COMMON GROUP OF MARINE REPTILES FROM THE LOWER MUSCHELKALK OF THE GERMANIC BASIN AND WHAT WE REALLY KNOW**

KLEIN, Nicole, Steinmann Institut für Geologie, Mineralogie und Paläontologie, Bonn, Germany; SANDER, Martin, Steinmann Institut für Geologie, Mineralogie und Paläontologie, Bonn, Germany

Pachypleurosauria are among the most abundant fossils in numerous Lower Muschelkalk localities of the Germanic Basin. Main problem is the isolated nature of all these finds and the predominately undiagnostic postcranial skeleton of early Eosauroptrygia. Opposite to thousands of isolated postcranial bones are two articulated pachypleurosaur specimens with their skulls attached: The incomplete holotypes of the valid genera, *Anarosaurus* and *Dactylosaurus*. The exceptional early Anisian locality of Winterswijk (The Netherlands) yields abundant material of different ontogenetic stages of articulated or associated skeletons as well as numerous skulls of the pachypleurosaur *Anarosaurus heterodontus*. The well preserved material allowed a detailed diagnostic description of skull and postcranial morphology and yielded interesting results concerning intra-specific and ontogenetic variation. The comparison of *A. heterodontus* with *A. pumilio* and *Dactylosaurus* confirms the valid status of all three taxa. Detailed studies of these taxa and isolated material from Winterswijk and other Lower Muschelkalk localities allows for the first time a taxonomical assignment of isolated bones and suggests a more diverse pachypleurosaur fauna in the Lower Muschelkalk of the Germanic Basin than was known before. Furthermore, our study resulted in new and important insights into the interrelationship of Pachypleurosauria and the phylogeny of early Sauropterygia. A new phylogenetic analysis no longer supports the monophyly of Eosauroptrygia.

Poster Session IV, (Saturday)

**NEW DATA ON KARPINSKIOSAURUS ULTIMUS, AN UPPER PERMIAN SEYMOURIAMORPH FROM RUSSIA**

KLEMBARA, Jozef, Comenius University in Bratislava, Faculty of Natural Sciences, Bratislava, Slovakia

The Upper Permian seymouriamorph tetrapod Karpinskiosaurus from the European Russia includes two species: *K. secundus* and *K. ultimus*. The skull length of two largest specimens of Karpinskiosaurus secundus is about 75 mm. All skulls of *K. ultimus* are smaller than those of *K. secundus*. The revision of the cranial anatomy of previously known and several new specimens of Karpinskiosaurus indicate that the specimens of *K. secundus* and most of the specimens of *K. ultimus* represent the ontogenetic series of one species - *K. secundus*. The holotype specimen of *K. ultimus* requires revision. The cladistic analysis shows *K. secundus* to form a sister taxon to Discosauriscidae. The clade comprising *K. secundus* plus Discosauriscidae forms a sister group to Seymouriidae. The distinctive features of *K. secundus* include: presence of interpremaxillary fenestra; posterior process of parietal wedged between tabular and postparietal; intertemporal-squamosal suture oblique; lateral process of supratemporal wedged into squamosal; otic notch encroaches posterolateral margin of skull table; anterolateral corner of tabular extends into a distinct process fitting between parietal and supratemporal; absence of tabular process; presence of small ascending process on anterodorsal margin of maxilla fitting into a deep notch in ventral margin of lacrimal; long, equally running jugal-postorbital suture; external surface of dentary bears many longitudinal grooves divided by ridges. Karpinskiosaurus secundus has a large postorbital and a short preorbital regions of the skull and the orbits are placed in the posterior portion of the anterior half of the skull length. Within seymouriamorphs, such cranial proportions exhibit only the largest known specimens of Discosauriscus austriacus. None of the specimens attributed to *K. secundus* exhibits the presence of the sensory grooves, hence this seymouriamorph is considered to be the terrestrial dweller.

Poster Session III, (Friday)

**THE GROWING OF THE SHREW**

KLIETMANN, Johannes, University Vienna, Department of Palaeontology, Vienna, Austria; PROST, Stefan, Max-Planck Institute for Evolutionary Anthropology, Leipzig, Germany; NAGEL, Doris, University Vienna, Department for Palaeontology, Vienna, Austria; HOFREITER, Michael, Max-Planck Institute for Evolutionary Anthropology, Leipzig, Germany

In the Late Glacial Period of Austria, numerous findings of *Sorex* shrews were assigned to new species named *S. "macrognathus"* and *S. "cf. coronatus"*, based on the morphology and especially on the size of the mandibles. Specimens from the Nixloch (about 10.5 kyr), the Gamssulzen cave (14 to 10 kyr), the Merkenstein cave (14 to 10 kyr) (Austria) and the Kleinen Scheuer ( about 13.3 kyr) (Germany) are used in a current genetic and paleontological study. The genetic results show that *S. "macrognathus"* and *S. "cf. coronatus"* belong to the extant species *S. araneus* and *S. tundrensis*, respectively. Specimens from the Nixloch and the Gamssulzen cave are of bigger size than the modern specimens of these species. This may be the result of the cold climate and surprisingly good food supply or of isolated habitats, where some sort of island effect could have occurred.

Technical Session II, Wednesday 10:15

**INTER- AND INTRARELATIONSHIPS OF EXTINCT SYNECHODONTIFORM SHARKS (CHONDRICTHYES, ELASMOBRANCHII): WHEN IS A SHARK A NEOSELACHIAN?**

KLUG, Stefanie, State Museum of Natural History Stuttgart, Stuttgart, Germany

The well-defined monophyletic clade Neoselachii (living sharks, skates, rays) is one of the most successful groups of chondrichthyes, but their definition rests solely of living members. Fossil taxa are only considered to be neoselachians, if they are nested phylogenetically within a living clade. The systematic position of most extinct sharks is unresolved and remains one of the major challenges in reconstructing the phylogeny and evolutionary history of sharks in general. Although great progress has been accomplished in the last years resolving the interrelationships of Neoselachii, a comprehensive phylogeny identifying the systematic position of problematic or entirely fossil taxa is still lacking. According to phylogenetic and fossil record analyses, only few living lineages were present in the Early Jurassic (none in the Triassic). However, only few extinct taxa were considered.

The inter- and intrarelations of extinct sharks traditionally assigned to Synechodontiformes (Permian–Thanethian) are unclear. Their monophyly and systematic position within Elasmobranchii was debated for decades due to dental similarities, scarcity of skeletons and lack of comparable extant taxa. In recent years, several holomorphic specimens were discovered allowing a re-assessment of these problems.

Phylogenetic analyses employing robust cladistic principles are presented for the first time to evaluate their monophyly and interrelationships. According to these results, synechodontiforms are monophyletic including four well-supported clades and some taxa of uncertain relationships. They display a suite of neoselachian characters but form the sistergroup of all living sharks. Consequently, the framework of neoselachian systematics needs to be expanded to include not only living (crown-group) but also extinct clades (stem-group). According to the synechodontiform fossil record, the origin of Neoselachii can be

traced back into the Permian. Batoidea is member of the neoselachian crown-group and not sister to synchodontiform plus living sharks. Their systematic position within living neoselachians remains unresolved due to discrepancies of morphological and molecular phylogenies.

Technical Session VI, Thursday 3:15

**EXPERIMENTS IN ACTUALISTIC TAPHONOMY USING MODERN FRESHWATER TURTLE REMAINS FOR INTERPRETING FOSSIL TURTLE LOCALITIES IN FLUVIAL DEPOSITIONAL ENVIRONMENTS**

KNELL, Michael, Montana State University, Bozeman, MT, USA

Fossil freshwater turtles are abundant in many terrestrial vertebrate assemblages around the world. In some instances turtles greatly outnumber dinosaur and mammal remains. A taphonomic bias selects for the preservation of turtle remains, particularly in fluvial systems. Exactly how this taphonomic bias operates is poorly understood. The disarticulation, transport and burial of freshwater turtle remains in fluvial systems has never been fully documented. These taphonomic processes will be observed in an experimental setting using a variety of modern turtle specimens. The data gathered through these experiments will be used to make inferences regarding the depositional environments of fossil turtle localities to explain their high preservation potential. Several whole turtle carcasses and skeletal elements from a variety of living turtle species have been donated for use in this research. In order to observe the processes of decay and disarticulation several turtles were placed into small, freshwater aquariums and allowed to rot without interruption in a closed laboratory for a period of several weeks. Daily observations and water temperatures were taken and recorded. On average the turtles were observed to bloat and float for several days before sinking and disarticulating. The skull, neck, and distal limb elements were often the first to decay and separate. Observations of bone transport and burial were observed using a mechanical flume to model the flow of an actual fluvial system. A fine to medium sand was used as the flume bed and the velocity was varied to recreate reasonable flow regimes. Various turtle bones were placed into the flume and observed as they were transported along the flume bed. As with similar mammal studies, lighter elements, such as the skull and vertebrae, were transported quickly. Portions of the carapace and plastron often remained still and were quickly buried. For whole turtle shells a preference for carapace up seemed prevalent. The results of these experiments reveal that the carapace and plastron elements, with their high density and low profile, have the lowest transport potential and highest potential for preservation.

Poster Session I, (Wednesday)

**PRELIMINARY ACCOUNT OF NEW LATE JURASSIC PLIOSAURID MATERIAL FROM SVALBARD, NORWAY**

KNUTSEN, Espen, Natural History Museum, University of Oslo, Oslo, Norway;  
DRUCKENMILLER, Patrick, University of Alaska Museum, Fairbanks, AK, USA;  
HURUM, Jørn, Natural History Museum, University of Oslo, Oslo, Norway; NAKREM, Hans Arne, Natural History Museum, University of Oslo, Oslo, Norway

In 2006, the remains of two gigantic pliosaurs were found in a dark grey shale facies of the Upper Jurassic Slottsmøya Member of the Agardhfjellet Formation on the Norwegian archipelago of Svalbard. The Slottsmøya Member was deposited in shallow marine settings at high paleolatitudes, and biostratigraphic analyses of macro- and microfossils indicate a (middle?) Tithonian age for the fossiliferous portion of the unit. Excavation of the first specimen in 2007 revealed a partial, semi-articulated skeleton including the anterior tooth-bearing elements of the rostrum, two cervical and numerous dorsal vertebrae, a nearly complete coracoid and right forelimb, and several dorsal ribs and gastralia. Excavation of the second, conspecific individual in 2008, revealed new portions of the posterior skull region and anterior cervical vertebrae. Based on the presence of massive teeth (? 60 mm crown diameter), cervical vertebral proportions, and coracoid and propodial morphology, the specimens are referred to the Pliosauridae. Tooth crown cross-sectional shape is trihedral, suggesting affinities with Pliosaurus. Epipodial morphology of the Svalbard taxon, being very much wider than long, most closely resembles that of Pliosaurus brachydeirus and P. brachyspondylus, but differs from those of Callovian taxa such as Liopleurodon ferox and Simolestes vorax. Cervical centrum morphology is most similar to that of Pliosaurus rossicus. However, the coracoid differs in overall shape from that of both P. brachydeirus and Pliosaurus rossicus. Comparative measurements of the vertebrae, limbs, and pectoral girdle with individuals of other large pliosaurid taxa (Liopleurodon, Pliosaurus, and Kronosaurus) suggest an estimated body length of 13-15 meters for the Svalbard specimens. The Svalbard material not only sheds new light on the morphology of large Late Jurassic pliosaurs, but it also helps to fill a temporal gap between the older, better known Callovian/Kimmeridgian taxa and those of the Early Cretaceous, such as Kronosaurus.

Technical Session IV, Wednesday 1:45

**THE EVOLUTION OF LIFE HISTORY TRAITS ASSOCIATED TO DWARFING IN INSULAR LARGE MAMMALS: A PALEONTOLOGICAL APPROACH.**

KÖHLER, Meike, Institut Català de Paleontologia, Bellaterra, Spain

The effects of insularity on the evolution of life-history traits in large mammals remain largely unknown. Based on the co-variation of life-history traits with body mass, it has been

hypothesized that life-histories of insular dwarfed mammals should be accelerated with an increased investment in reproduction. However, the classical r-K selection theory predicts that insular ecosystems should generate slow life-histories. Intrigued by this apparent contradiction, I investigated the evolution of life-history traits in an insular dwarfed bovid (Myotragus, Plio-Pleistocene, Balearic Islands). Histological and morphological analyses revealed a slow and flexible growth rate, cyclical growth arrest, a short gestation period associated with a tiny size at birth, an early age at weaning, a delayed onset of maturity and a long life span. Contrary to predictions from body mass scaling but in agreement with life-history theory, dwarfing was associated with a shift towards the slow end of the slow-fast life-history continuum. The trait combination, however, is unusual for long-lived mammals in that it associates a late onset of reproduction with small size at birth, slow growth and early weaning, traits that compromise fitness under continental conditions. Insular ecosystems, however, are governed by a different selective regime that is characterized by limited food supply and lack of predators. My study suggests that low resource levels constrained rates of energy conversion (metabolic, growth and reproductive rates; maternal metabolism), while release from predation led to compensatory changes in the timing of life-history events (age at maturity, lifespan).

Technical Session XI, Friday 8:45

**POSTCRANIAL ADAPTATIONS OF EUROPEAN ARCTOCYONIDS (MAMMALIA, ARCTOCYONIDAE)**

KONDRASHOV, Peter, A.T. Still University of Health Sciences, Kirksville, MO, USA

Arctocyonids were common mammals in the late Paleocene of Europe. Three different size groups existed, the larger *Arctocyon* and *Mentoclaenodon*, the medium-sized *Arctocyonides*, and small *Landenodon*. Postcranial remains are known for all these genera except *Landenodon*. Postcranial evidence suggests that different size groups of European arctocyonids had different locomotory adaptations. The larger *Arctocyon* and *Mentoclaenodon* had a very robust postcranial skeleton that shows adaptations for scratch-digging, especially in the forelimb. The scapulae of *Arctocyon* and *Mentoclaenodon* are wide with well-developed acromion and coracoid processes and a tall scapular spine. The caudal margin of the scapula is thickened for the attachment of the teres major muscle. The humeri of *Arctocyon* and *Mentoclaenodon* are very robust and wide, especially distally. The deltopectoral crest is extremely well developed and forms an elevated "platform". Both medial and lateral epicondyles are enlarged for the insertion of the muscles that rotate the hand. The lateral supracondylar crest is very well developed. The ulna is very robust and has a large, deep, and medially curved olecranon. The skeleton of the hand is very similar to that of expert diggers in having extremely enlarged and flattened ungual phalanges. The smaller species of the genus *Arctocyonides* show very different adaptations. Their skeleton is not robust, but lightly built. The humerus is slender and slightly bowed proximodistally. The major tubercle does not project above the humeral head. The deltopectoral crest is sharp and extends far distally, but is not robust. The medial and lateral epicondyles are slightly enlarged. The ulna is long, slender, and slightly bowed laterally. The well-developed olecranon is inclined anteriorly as in some climbing mammals. The articular surface of the head of the femur extends onto the neck, indicating an abducted position of the hind limb. The ungual phalanges are claw-like, laterally compressed and deep, with well-developed flexor tubercles. The postcrania indicate a mixture of features found in terrestrial and climbing mammals.

Technical Session III, Wednesday 3:30

**NEW INSIGHT INTO GLOBAL PHYLOGENY OF PLIOPATECARPINI (SQUAMATA: MOSASAURIDAE)**

KONISHI, Takuya, University of Alberta, Edmonton, AB, Canada

Mosasauridae is generally characterized as large to enormous aquatically adapted lizards that exhibited a worldwide distribution during the Late Cretaceous (ca. 93 to 65Ma). Here, I provide new insight into global taxonomy and diversity of one of the most numerous found mosasaur groups, plioplatecarpines, based on osteological data over 400 specimens of plioplatecarpines and rasselosaurines, a more inclusive group to which the former belong to. Incorporating all the known species of plioplatecarpines and genera of rasselosaurines, the cladistic analysis based on 98 osteological characters and 17 ingroup taxa yielded a new phylogenetic hypothesis. Within plioplatecarpines, Ectenosaurus was basal to all the other members of the clade and not a sister taxon to Selmasaurus as recently postulated. The latter taxon instead either became a sister taxon to Angolasaurus to form a clade sister to that consisting of (Platecarpus planifrons+(Plat. ictericus)+(Plioplatecarpus spp.)), or to be the sister to the latter clade. Although monophyly of the clade containing Platecarpus and Plioplatecarpus was repeatedly demonstrated, Plat. planifrons and Plat. ictericus formed a consistent paraphyly with approximately 10 character changes occurring at the node separating the two; the latter has a nomenclatural seniority and the former is now recognized as a distinct genus. As well, of the six species comprising Plioplatecarpus spp., as many as 17 synapomorphies define a terminal clade (Plioplatecarpus primaevus+(Plio. houzeaui+Plio. marshi)), but this clade is either a sister group to 'Platecarpus' somenensis, Plio. nichollsae, or a clade consisting of the two. Finally, a newly recognized early Campanian taxon becomes a sister taxon to the above five, and seven characters define the node separating them from Platecarpus ictericus. Within Rasselosauria, the basal position of three Turonian, trans-Atlantic (likely plesioepedal) genera is clearly shown, which forms the sister clade to (tylosaurines+plioplatecarpines), two hydro-pedal (flipped) rasselosaurines.

Poster Session III, (Friday)

**TESTING THE POTENTIAL MONOSPECIFICITY OF THE SABRE-TOOTH CAT GENUS *HOMOTHERIUM* USING COMPARATIVE DATA FROM RECENT LARGE CATS**

KOOT, Martha, University of Plymouth, Plymouth, United Kingdom; REUMER, Jelle, Natuurmuseum Rotterdam, Rotterdam, Netherlands; DE VOS, John, Naturalis, National Museum of Natural History, Leiden, Netherlands

Fossil remains of the sabre-tooth cat *Homotherium* (Pliocene-Pleistocene) have been found on multiple continents. Since the early 19th century, they have been attributed to many different species, which often seem to have similar stratigraphic occurrences and morphologies. This research tests whether the genus consisted of only one or a couple of species, in which case observed variation could be due to broad geographic range, individual variation, sexual dimorphism, or age. Descriptions, figures, and measurements from literature were analysed and the results indicated that all species must likely be united into one single species, as the morphological differences are quite trivial. In order to better establish this unlikely conclusion of a single, widespread species existing unchanged for a long period of time, additional comparative data were required. For this, measurements of the dentition, mandible, and cranium of recent lions (*Panthera leo*) and tigers (*Panthera tigris*) from a variety of geographic regions were obtained. The results demonstrated convincing differences between lions and tigers, and also between the recent cats and *Homotherium*. However, the intraspecific variation found in lions and tigers is very similar to the variation in the sabre-tooth cats, supporting the previous hypothesis that the genus *Homotherium* is monospecific.

Poster Session II, (Thursday)

**NEW RODENTS FROM THE LATE MIOCENE OF THE UNITED ARAB EMIRATES**

KRAATZ, Brian, American Museum of Natural History, New York, NY, USA; BIBI, Faysal, Yale University, New Haven, CT, USA; HILL, Andrew, Yale University, New Haven, CT, USA

The fluvial Baynunah Formation has produced the only record of a Late Miocene (~6–8 Ma) terrestrial community from Arabia. In the 2008 field season we reestablished screen-washing efforts and succeeded in the recovery of several elements new to the Baynunah fauna. Previously, an isolated thryonomyid tooth was described from the Baynunah, a group recognized today as a purely African clade. Adding to this now are new upper and lower thryonomyid teeth that show the Baynunah form has strong affinities to *Paraulacodus*, known from the Middle Miocene of Pakistan and Late Miocene of Africa. Specifically, the occurrence of *Paraulacodus* in the Lower Nawata at Lothagam lends further support for chronological contemporaneity and biotic continuity between this fossil assemblage and that from the Baynunah. We also report the earliest (and first) fossil record of Sciuridae from the Arabian Peninsula. Although sciurids are known from this time within nearby European, Asian, and African fossil assemblages, the rarity of these taxa allows for the Baynunah squirrel to provide revised biogeographic assessments of the fauna. Combined, these new discoveries contribute to more precisely determining the age of the Baynunah fauna, and to better reconstructing the mosaic biogeographical influences characteristic of this unique Late Miocene locality.

The Scientific Legacy of Mary Anning — Recent Advances in Marine Reptile Paleobiology and Evolution, Wednesday 10:45

**LONG BONE HISTOLOGY OF MIDDLE TRIASSIC EUSAUROPTERYGIANS (NOTHOSAURIA AND PISTOSAURIA) AND ITS IMPLICATIONS FOR PARAXIAL SWIMMING**

KRAHL, Anna, Steinmann-Institut für Geologie, Mineralogie und Paläontologie, Universität Bonn, Bonn, Germany; SANDER, Martin, Steinmann-Institut für Geologie, Mineralogie und Paläontologie, Universität Bonn, Bonn, Germany; KLEIN, Nicole, Steinmann-Institut für Geologie, Mineralogie und Paläontologie, Universität Bonn, Bonn, Germany

Nothosaur and *Pistosaurus* humeri and femora from of Germany and France were sampled histologically to detect possible locomotory adaptations. The morphologically differentiated humerus is the most diagnostic bone in the postcranium of stem-group sauropterygians. Furthermore, it is biologically significant because the humeri of Pachypleurosauria, the sistergroup of Eusauropterygia, are sexual dimorphic. Lower Muschelkalk nothosaurs have a unique humerus morphology, including a nearly triangular diaphyseal cross section, and were assigned to different morphotypes. Compared to early eosauropterygians, humerus morphology of crown-group sauropterygians is simplified due to increasing adaptations to the marine habitat. Cortices of the sampled nothosaur long bones are composed of lamellar-zonal bone tissue which is typical for reptiles and indicates rather slow cyclical growth. However, in contrast to the humeri of small Lower Muschelkalk nothosaurs, humeri of large Upper Muschelkalk nothosaurs, namely *Nothosaurus giganteus* and *N. mirabilis*, have an extremely thin-walled cortex and a large open medullary cavity. This newly described peculiar histology is interpreted as an adaptation to an increasingly pelagic habitat. As a consequence, the humeri are very light, supporting dynamic buoyancy control as well as faster and more energy-efficient swimming. The large, triangular, and thin walled cross section of the humeri results from torsional loading. This suggests that the forelimb played an important role in locomotion, contradicting the conventional view that nothosaurs swam

by tail undulation. The femur of *Pistosaurus* is composed of lamellar-zonal bone tissue, too, but the cortex of the humeri consists unexpectedly of fibro-lamellar bone. This bone tissue type is linked to faster growth and also to a higher metabolic rate. Fibro-lamellar bone among Sauropterygia has only been known in Upper Cretaceous plesiosaurs, which are the sister taxon of pistosaurs. Our results clearly show that fibro-lamellar bone had already evolved by the Middle Triassic, well before the radiation of Plesiosauria, possibly being the cornerstone for their success.

Poster Session II, (Thursday)

**AVIAN AND MAMMALIAN FOOTPRINTS FROM THE CENOZOIC OF SOUTHERN SOUTH AMERICA**

KRAPOVICKAS, Veronica, Universidad de Buenos Aires, Buenos Aires, Argentina; MARSICANO, Claudia, Universidad de Buenos Aires, Buenos Aires, Argentina; MANGANO, Maria, University of Saskatchewan, Saskatoon, Canada

Three consecutive fossil tetrapod footprint assemblages were studied from Cenozoic non-marine strata of the Vinchina Basin in northwestern Argentina (La Rioja). The footprint assemblages are preserved at the Vinchina (Oligocene to Early Miocene) and Toro Negro (Miocene to Early Pliocene) formations. The oldest assemblage (I) occurs at the base of the Upper Member of the Vinchina Formation at Quebrada de La Troya. In contrast, Assemblage II corresponds to specimens recorded by Bonaparte in the 60's close to the top of the Vinchina Formation, at the nearby Quebrada del Yeso. The youngest assemblage (III) was documented in the Lower Member of the overlying Toro Negro Formation at Quebrada de La Troya. All three assemblages contain footprints representing the activity of large cursorial birds, such as Rheiformes and phororhacids, as well as those of macraucheniiids. Furthermore, assemblages II and III also share footprints most-likely produced by shorebirds and by large tardigrad mammals. By contrast, the oldest assemblage (I) records several distinct footprints not present in the other assemblages i.e. *Gruipedon* isp., small tridactyl rodent-like footprints and large tetradactyl rodent-like footprints. Similarly, assemblage II only records footprints attributable to Ralliformes. The youngest assemblage (III) is the most diverse, including perching birds, medium heteropod rodent-like mammals, medium-small tardigrads, and proterotheriids, besides those shared with the other two assemblages. Although, these tetrapod fossil footprint assemblages are preserved in slightly different depositional environments, they are spatially closely related. Thus, they represent, at least partially, the evolution and composition of the local fauna and therefore adding valuable information unexpressed by the scarce Cenozoic tetrapod body fossil record in the region.

Poster Session IV, (Saturday)

**A THERMOREGULATORY ESTIMATE FOR THE THRESHOLD BODY SIZE OF THE EVOLUTION OF FEATHERS IN DINOSAURS**

KRAUSS, David, Borough of Manhattan Community College, New York, NY, USA; HIRSCH, Jenna, Borough of Manhattan Community College, New York, NY, USA; SAMUELS, Jason, Borough of Manhattan Community College, New York, NY, USA; SANCHEZ-BRAVO, Gabriela, Tufts University, Medford, MA, USA; NGUYEN, Peter, Borough of Manhattan Community College, New York, NY, USA

It is generally agreed that feathers evolved in dinosaurs as a thermoregulatory mechanism. As dinosaurs exploited ecological niches of smaller animals it would have been necessary to maintain their internal body heat with some form of integumentary insulation in order to avoid hypothermia. We have used birds as an approximation for dinosaur bodies and used modern bird carcasses to calculate the cooling constant for body tissue approximating that of dinosaurs. The cooling constant derived from our experiment is .3 degrees centigrade per minute. Using literature values for dinosaur body mass and estimates of dinosaur temperature we were able to calculate both cooling curves for dinosaur bodies and hypothetical metabolic heat production curves for dinosaurs. The point at which the curves intersect represents the point at which metabolic heat production is lower than the rate of cooling for an animal and at which hypothermia would be a significant risk. At this point feathers would be necessary as insulation to prevent hypothermia. This point varies depending on the environmental temperature and dinosaur body temperature, but based on a 20 degree Celsius difference we estimate that the threshold body mass at which feathers would have evolved is approximately 20kg. As environmental temperatures rise and body temperatures drop the threshold body size at which feathers would be necessary for insulation drops. The threshold body temperature also varies with estimates of metabolic rate. A bird-like metabolism produces a lower threshold body size than a reptile-like metabolic rate.

Technical Session II, Wednesday 9:45

**NODE AGE ESTIMATES OF ANGEL AND DOGFISH SHARKS (CHONDRICHTHYES, NEOSELACHII) USING CONSTRAINED FOSSIL DATA AND MOLECULAR CLOCKS FOR DATING THE ORIGIN OF HYPNOSQUALEAN AND DERIVED "ORBITOSTYLIC" SHARKS, RESPECTIVELY**

KRIWET, Juergen, Staatliches Museum für Naturkunde, Stuttgart, Germany; KLUG, Stefanie, Staatliches Museum für Naturkunde, Stuttgart, Germany

Different molecular clock approaches are currently in use to infer divergence times between major groups of living organisms although it remains ambiguous, which methods are

accurate. For calibrating molecular clocks, the fossils have provided the timescale from the very beginning. The use of fossil occurrences (single vs. multiple) and the assignment of specific dates to these fossils often are, however, unsatisfactory or cause problems. Phylogenetic bracketing and stratigraphic information have been used recently to provide constrained divergence times of major vertebrate lineages. One group, however, that has received surprisingly little attention so far includes living sharks, rays, and skates (the Neoselachii). The rare published information uses either single fossil occurrences from outdated literature or incorrect taxonomic assignments for inferring origin dates. Neoselachians doubtless form a monophyletic group, which is well supported by both morphological and molecular data, and which comprises two clades, the Galeomorphii and Squalomorphii. The interrelationships of a third group, the Batomorphii (rays and skates) remains ambiguous. Morphological data suggest that batoids are derived sharks, joined with saw and angel sharks in a clade named Hypnosqualea within Squalomorphii, whereas molecular data support the classic separation of sharks and batoid, restricting Squalomorphii to "orbitostylic" sharks. Either interpretation has tremendous impact on the origination date of major squalomorph clades and the length of ghost-lineages. Here we present "hard" minimum and "soft" maximum dates for the divergence between angel and dogfish sharks, which are sister within Squalomorphii, using the oldest-secure occurrences of holomorphic fossils and stratigraphic and phylogenetic bracketing data. The inferred node age estimates are compared to molecular clock estimates for living angel sharks using rRNA sequences and memctree methods. This information enables us to reconstruct the ages of the Hypnosqualea and "orbitostylic" sharks, respectively. Ghost-lineage lengths are used for identifying the most likely hypothesis of derived squalomorph interrelationships.

The Evolution of Birds in the Mesozoic: a Symposium in Honor of Cyril A. Walker, Thursday 11:45

**A NEW FOSSIL MOUSEBIRD (AVES: COLIIFORMES) WITH FEATHER PRESERVATION: INSIGHT INTO THE ECOLOGICAL DIVERSIFICATION OF THE EOCENE NORTH AMERICAN AVIFAUNA**

KSEPKA, Daniel, North Carolina State University, Raleigh, NC, USA; CLARKE, Julia, The University of Texas at Austin, Austin, TX, USA

We report a nearly complete skeleton with soft tissue preservation representing a new species of Coliiformes (mousebirds) from the early Eocene Fossil Butte Member of the Green River Formation of Wyoming. Coliiformes, represented by just six extant species (all restricted to sub-Saharan Africa) possess short, rounded wings poorly suited for sustained flight and are among the most sedentary of extant birds. Previously described fossil Coliiformes preserving feather traces suggest this wing shape, and by inference weak capacity for sustained flight, characterized stem portions of Coliiformes as well. Carbonized feather traces in the new fossil specimen indicate an elongate, tapering wing shape more similar to that of extant aerial insectivores such as swallows. The Green River mousebird also possesses proportionally longer distal wing bones than any previously reported mousebird. This apomorphic wing morphology implies a novel aerial foraging ecology for the Green River mousebird not present in other parts of the clade. Phylogenetic analysis utilizing the largest character matrix to date for mousebirds places the new species as a stem representative of Colii, the clade including all taxa more closely related to the crown clade Coliidae (*Urocolius* and *Colius*) than to the extinct Sandcoleidae. Biogeographic reconstructions based on this phylogeny demonstrate significant interchange between Cenozoic European and North American avifaunas, indicating a minimum of 5 intercontinental dispersals by Coliiformes. All sampled fossil taxa, however, fall outside the crown clade Coliidae, suggesting the restricted African range of extant mousebirds is a recent phenomenon. In addition to documenting unexpected morphological specialization within stem lineage Coliiformes, the Green River mousebird adds yet another taxon to the emerging reconstruction of the diverse Paleogene avifauna from tightly dated and nearly synchronous deposits of the Fossil Butte Member.

Romer Prize Session, Thursday 8:15

**EVOLUTION OF LIMB POSTURE IN TERRESTRIAL TETRAPODS INFERRED FROM PERMIAN AND TRIASSIC TRACKWAYS**

KUBO, Tai, The Royal Tyrrell Museum of Palaeontology, Drumheller, AB, Canada

Evolution of an erect limb posture is a key innovation in the evolution of terrestrial tetrapods. According to studies based on body fossils, this evolutionary process occurred independently during the Late Permian to Middle or Late Triassic in both therapsids and archosaurs. The attainment of erect limb postures was a key factor in the subsequent success of mammals and dinosaurs. I used Permian and Triassic fossil trackways to study limb posture evolution. Although trackways are abundant from these time periods, they had not been used to assess limb posture evolution. To confirm that trackways reflect the limb posture of trackmakers, I conducted kinematic analyses of eight species of extant crocodiles and lizards. Pace angulation (angle made by three successive foot prints) and three potential determinants of pace angulation, namely femoral abduction angle (a quantitative index of limb posture), speed, and pelvic rotation were measured from videos in dorsal view of these reptiles. Correlations between pace angulation and the latter three factors were assessed by multiple regression analysis. The results show that femoral abduction angle is the primary determinant of pace angulation and explains 47% of the variation in pace angulation; this indicates an animal with a more erect limb posture will make a trackway with a higher pace angulation. These findings were applied to fossil trackways by compiling pace angulations of Permian and Triassic trackways and grouping those by Epochs to assess patterns of

chronological change. This analysis revealed that the shift to an erect limb posture occurred rapidly and tetrapods with erect posture began dominating terrestrial assemblages in the Early Triassic. Most of the trackways that can be attributed to erect tetrapods were made by archosaurs and therapsids trackways are less common. There is clear evidence that erect postures were attained by both groups by the Early Triassic, which is earlier than previous estimates of Middle or Late Triassic that were based solely on body fossils. This study demonstrates the potential value of using trace fossils in conjunction with body fossils and kinematic studies of extant animals.

Poster Session II, (Thursday)

**BRINGING BLM RESOURCE USE PERMITTING, RESEARCH, AND MANAGEMENT TOGETHER: DEVELOPING AN INTEGRATED PALEONTOLOGICAL DATABASE SYSTEM**

KUIZON, Lucia, Bureau of Land Management, Washington, DC, USA; MATTHEWS, Nefra, Bureau of Land Management, Lakewood, CO, USA

The Bureau of Land Management (BLM) is charged with managing nearly 260 million acres of America's public lands. These lands comprise 13 percent of the total land surface of the United States (or more than 40 % of all land managed by the Federal government) that includes a vast and unique array of paleontological resources. While BLM has managed these resources through agency policy and guidance for a number of years, the newly enacted Paleontological Resources Preservation Act provides legal authority for preserving and protecting all aspects of these resources. Historically, records relating to permits, localities, and research (collected specimens) were maintained in hardcopy by the respective state in which they were collected. With the support of initiatives such as BLM's Geospatial Services Strategic Plan, development of a relational database management framework is now underway to convert these paleontological records. This integrated system will provide managers, resource specialists, analysts, researchers, and policy makers access to multiple levels of this data from a single location, thereby greatly increasing availability of records, accuracy, and completeness. Development of this integrated paleontology database systems has been conducted in consultation with a parallel database system in development by the U.S. Forest Service, and with review of data standards in USGS, NPS, and other Federal systems. A web-based system is planned for final implementation, and will support online permit application and reporting. The needs of BLM's paleontology leads and field office personnel, as well as those of the external users (permittees), who will have a high level of interaction with the system, are of principal consideration. Also of paramount importance is security for protecting paleontological locality information as required by the Act, as well as any intellectual property contained in the system. Transforming current practices by transferring data and information now maintained in hardcopy into electronic and automated formats that are readily available will greatly improve and streamline outdated business practices.

New Perspectives on the Early Evolutionary History of the Synapsida, Saturday 9:45

**LATE PERMIAN DICYNODONTS: MORPHOTYPES AND BIOGEOGRAPHY**

KURKIN, Andrey, Palaentological Institute, Moscow, Russia

Several new dicynodonts (*Australobarbarus*, *Delectosaurus*, *Elph*, *Idelisaurus*, *Interpresosaurus*, *Vivaxosaurus*) were described from eastern Europe in the last decade. When combined with previously known Russian dicynodonts ("*Dicynodon*" *amalitzkii*, "*Dicynodon*" *trautscholdi*), these taxa substantially improve our picture of dicynodont diversity and evolutionary trends within the clade. Comparison of the composition of Upper Permian dicynodont faunas in the biozones of South Africa and eastern Europe suggests that contact between these faunas occurred after *Pristerognathus* Assemblage Zone times. Alternatively, different dicynodont families may have had distinct centers of origin. For example, South Africa appears to represent the likely center of origin for Pristerodontidae, Endothiodontidae, Diictodontidae, Emydopidae, Cistecephalidae, whereas western Europe or north Africa are potential centers of origin for Oudenodontidae and Dicynodontidae with the subsequent dispersal into India, South Africa, eastern Europe, and China. The multiple centers of origin hypothesis is corroborated by the diachronous appearance of the sister taxa *Tropidostoma* and *Australobarbarus* in eastern Europe and South Africa, the greater diversity of basal dicynodonts in South Africa, the apparent absence of many common South African families in eastern Europe apparently, and the diachronous of dicynodontids in eastern Europe and South Africa. The absence of diictodontids in eastern Europe remains particularly obscure considering their abundance in South Africa and their presence in China. A potential morphological and ecological analogue for this clade in eastern Europe may be the clade containing *Elph* and its nearest relatives, which are comparable in size to the diictodontids and possess similarly short snouts.

Poster Session II, (Thursday)

**A NEW BIRD FROM THE EARLY CRETACEOUS OF WESTERN SIBERIA**

KUROCHKIN, Evgeny, Borissiak Paleontological Institute of RAS, Moscow, Russia; AVERIANOV, Alexandr, Borissiak Paleontological Institute of RAS, Moscow, Russia; LESHCHINSKIY, Sergey, Tomsk State University, Tomsk, Russia; ZELENKOV, Nikita, Borissiak Paleontological Institute of RAS, Moscow, Russia

Numerous findings in recent years from the Early Cretaceous of China have essentially changed our conceptions about the variety and ways of evolution among the most ancient

Aves. A big variety of Enantiornithes is established, some indeterminate Sauriurae are described, Confuciusornithidae has been discovered (primitive, but specifically advanced birds), and the existence of Ornithurae by the Early Cretaceous is confirmed. At the same time, some forms that are of uncertain affinities and which cannot be carried into one of the known higher taxa of Aves have also been described alongside. Also many Mesozoic birds have been discovered from other regions of Asia, Europe, North and South America, Africa, Australia and even Antarctica. The Aptian-Albian locality of Shestakovo-1, in Western Siberia, Russia is characterized by numerous finds of dinosaurs, early mammals, crocodiles, pterosaurs and lizards. One unique find of a metatarsus belongs to a bird; this is characterized by almost full coplanar fusion of metatarsals II-IV, but has separated proximal ends of metatarsals III and IV. Each cotylar facet of the proximal metatarsals II-IV is isolated and longitudinal ridges run lengthways along the dorsal surfaces of these metatarsals. The fossa infracotylaris dorsalis of this bone is not developed and the canalis interosseus distalis begins on the distal area of the sulcus extensorius and leaves through the proximal wall of the foramen vasculare distale, which itself opens onto the plantar face. We compare this specimen with Archaeornithes, Enantiornithes, Neornithes, Vorona, Confuciusornithidae, Sapeornis, Alvarezsauridae, Rahonavis and Dromeosauridae, but phylogenetic analysis shows that it occupies an isolated position within Aves, as a representative of a new high taxon. These data testify again to the variety of morphologies seen in the early evolution of birds, about their numerous attempts to master the aerial environment, and about parallel evolution of the different groups of feathered vertebrates.

Poster Session IV, (Saturday)

#### NEW DETAILS OF A SKULL OF *LYSTROSAURUS DECLIVIS* AND IMPLICATIONS FOR LIFESTYLE ADAPTIONS

LAAß, Michael, Martin-Luther-Universität Halle-Wittenberg, Halle (Saale), Germany; HAMPE, Oliver, Museum für Naturkunde Berlin, Berlin, Germany; SCHUDACK, Michael, Freie Universität Berlin, Institut für Geologische Wissenschaften, Fachrichtung Paläontologie, Berlin, Germany; KARDJILOV, Nikolay, Helmholtz Zentrum für Material und Energie, Berlin, Germany; HILGER, André, Helmholtz Zentrum für Material und Energie, Berlin, Germany

For the first time internal structures of a skull of *Lystrosaurus declivis* were examined by neutron tomography. The result of these examinations is the first evidence of complex builded cartilaginous lamellae in the nasal cavity of *Lystrosaurus* and the existence of pneumatized bones. As to their structure and position in the line of respiratory airflow in the nasal cavity the cartilaginous lamellae of *Lystrosaurus* resemble extremely the maxilloturbinals of mammals. Maxilloturbinals are an attribute of mammals in general and entirely unknown in reptiles. Maxilloturbinals emerged together with elevated ventilation rates and endothermy and are complex builded cartilaginous or bony structures. These are covered by a respiratory mucosa, which has the function of thermoregulation and reduction of respiratory water loss. As the observed lamellae in the nasal cavity of *Lystrosaurus* resemble strongly the maxilloturbinals of mammals, the same function can be assumed for both structures. This hypothesis is supported by the fact that *Lystrosaurus* has a secondary palate similar to that of mammals. The secondary palate separates air and food passage to ensure continuous breathing during mastication. Furthermore, an evolutionary trend to extended air passages and increasing volume of the nasale chamber and pneumatized bones of *Lystrosaurus* can be observed. These features strongly suggest that *Lystrosaurus* had an efficient respiration and an endotherm metabolism. This seems to be a useful adaptation to the extreme continental climate of Pangaea with cold winters. In addition, pneumatized bones as premaxilla, maxillae and dentary are connected by canals to the nasale chamber, the external nares and the oral cavity. It seems probable that these structures were responsible for secretion, moistening and protection of the respiratory air passages, lungs and the oral cavity of *Lystrosaurus* against dust. These results support the hypothesis of an terrestrial and fossorial lifestyle of *Lystrosaurus*.

Poster Session III, (Friday)

#### HERPETOTHERIID MARSUPIALS FROM THE EARLIEST EOCENE OF DORMAAL (BELGIUM): THE GENUS *AMPHIPERATHERIUM* AND *PERATHERIUM* REVISITED

LADEVÈZE, Sandrine, Royal Belgian Institute of Natural Sciences, Brussels, Belgium; SMITH, Thierry, Royal Belgian Institute of Natural Sciences, Brussels, Belgium; SMITH, Richard, Royal Belgian Institute of Natural Sciences, Brussels, Belgium

The earliest Eocene of Dormaal (Belgium) provided the oldest marsupials of Europe with the possible exception of a single upper molar reported from the upper Cretaceous of the Belgian/Dutch border. The systematics of the herpetotheriid marsupials of Dormaal was formerly based on only ten dental specimens, and has long been discussed, whether these fossils represent a single species of *Peratherium*, two species of *Peratherium* or even two genera *Peratherium* and *Amphiperatherium*. Here we report a large sample of about 400 new dental remains that allow testing the presence of the genus *Amphiperatherium* at Dormaal. The analysis of the morphological variability leads us to reconsider the diagnosis and validity of "*Amphiperatherium brabantense*". Three forms are distinguished and exhibit only few differential characters. This study highlights that the primitive species *Peratherium constans* and "*Amphiperatherium brabantense*" are hardly distinguishable from each other, and suggests that the *Amphiperatherium* clade could not yet have appeared at the earliest Eocene in Europe

The Evolution of Birds in the Mesozoic: a Symposium in Honor of Cyril A. Walker, Thursday 11:00

#### EXCEPTIONALLY PRESERVED ENANTIORNITHES (AVES: ORNITHOTHORACES) FROM THE EARLY CRETACEOUS OF NORTHWESTERN CHINA

LAMANNA, Matthew, Section of Vertebrate Paleontology, Carnegie Museum of Natural History, Pittsburgh, PA, USA; LI, Da-qing, Fossil Research and Development Center, Third Geology and Mineral Resources Exploration Academy of Gansu Province, Lanzhou, China; HARRIS, Jerald, Dixie State College, UT, USA; ATTERHOLT, Jessie, Department of Earth and Environmental Science, University of Pennsylvania, Philadelphia, PA, USA; YOU, Hai-Lu, Institute of Geology, Chinese Academy of Geological Sciences, Beijing, China

Initiated in 2004, renewed paleontological explorations of exposures of the Lower Cretaceous (Aptian) Xiagou Formation in the Changma Basin of northwestern Gansu Province, China have yielded approximately 80 partial to nearly complete fossil avian skeletons, many with associated soft-tissues. Though the majority of these specimens are referable to the ornithuromorph *Gansus yumenensis*, at least 11 pertain to Enantiornithes, a group that is widely recognized as the dominant clade of Cretaceous landbirds. None of the enantiornithian specimens from Changma preserves cranial material or an association of pectoral and pelvic elements, frustrating attempts to decipher their taxonomy; nevertheless, at least two taxa appear to be represented in the collection. Although several of the Changma enantiornithian specimens are fragmentary (e.g., a recently described, isolated partial pectoral limb), others are more complete and anatomically informative. The most remarkable of these are two partial postcranial specimens that are complete and articulated caudal to the caudal thoracic region and that show extraordinary preservation of soft-tissue structures. Both specimens preserve numerous feathers of multiple morphologies; one specimen includes the keratinous sheaths of the pedal unguis as well. The other specimen exhibits a pair of extremely elongate, "streamer-like" rectrices that are at least superficially similar to those of selected theropods from northeastern China, including the peculiar maniraptoran *Epidexipteryx hui*, some specimens of Confuciusornithidae, and several enantiornithians (e.g., *Dapingfangornis sentisorhinus*, *Paraprotopteryx gracilis*, *Protopteryx fengningensis*). Analysis of the Changma specimens promises to clarify the taxonomic and systematic affinities of the taxa to which they pertain, as well as to advance understanding of integumentary morphology, evolution, and function within Enantiornithes.

Technical Session XIX, Saturday 3:00

#### A NEW PITHANODELPHININE DOLPHIN FROM THE MIOCENE OF PERU AND THE ORIGIN OF MODERN DELPHINIDAN FAMILIES

LAMBERT, Olivier, Institut royal des Sciences naturelles de Belgique, Brussels, Belgium; BIANUCCI, Giovanni, Università di Pisa, Pisa, Italy; URBINA, Mario, Museo de Historia Natural, Lima, Perú

Extant Delphinida are represented by the river dolphins *Inia* (Iniidae), *Pontoporia* (Pontoporiidae), and *Lipotes* (Lipotidae), together with a large number of delphinoid genera belonging to the families Delphinidae, Monodontidae, and Phocoenidae. The fossil record of most modern delphinidan lineages goes back to the Middle-Late Miocene. If the phylogeny inside some of these lineages is rather well defined, the relationships between the main fossil and extant delphinidan groups are still conjectural. It has often been proposed that the ancestry of modern delphinoids has to be sought among the kentriodontids, a probably paraphyletic and diversified family of Miocene dolphins. However, up to now there is no consensus and even the relationships between kentriodontids and other delphinidans (inioids and lipotids) are unclear. Several subfamilies have been erected inside the Kentriodontidae and some proved to be better diagnosed than the family. A new kentriodontid has recently been discovered in late Middle to early Late Miocene layers of the Pisco Formation, in the southern coast of Peru. The specimen, consisting in the skull, the mandible, teeth, and ear bones, belongs to the subfamily Pithanodelphininae, based on the large inflated nasals and the narrow exposure of the frontals on the vertex, pinched between the nearly medially contacting maxillae. The new taxon differs from other pithanodelphinines in, among others, the loss of the contact between premaxilla and nasal, a feature absent in other kentriodontids but observed in some of the modern delphinoids, inioids, and lipotids. Interestingly, apart from the vertex and ear bones, several regions remind members of the two latter groups. The dorsally closed mesorostral groove, the outline of the mandible, and the deep apex of the zygomatic process of the squamosal are strikingly similar to the Amazon river dolphin *Inia*. Convex premaxillary sac fossae are present in inioids, but also in several modern delphinoids (e.g., phocoenids). This mosaic of characters indicates that the new Peruvian pithanodelphinine is potentially important for elucidating the relationships between modern delphinoids and other delphinidans.

Technical Session II, Wednesday 11:00

#### CRANIAL MORPHOLOGY IN TWO CRETACEOUS HYBODONT SHARKS, *TRIBODUS LIMAE* AND *EGERTONODUS BASANUS* (CHONDRICHTHYES: ELASMOBRANCHII), BASED ON DIGITAL RECONSTRUCTIONS

LANE, Jennifer, Division of Paleontology, American Museum of Natural History, New York, NY, USA

Cranial morphology in two Lower Cretaceous hybodont sharks, *Tribodus limae* and *Egertonodus basanus*, is examined using high-resolution CT scanning, and internal and

external braincase structure in these two taxa is reconstructed and compared based on three-dimensional digital imaging (using the software program Imaris). This study represents the first in-depth examination of a hybodont braincase using CT scanning and digital imaging technology. The inner ear of *Egertonodus basanus* is also reconstructed and described for the first time. A reconstruction of cranial nerves and blood vessels in *Tribodus* is presented on the basis of preserved foramina and comparison with other elasmobranchs. The basicranial arterial system in *Tribodus* differs considerably from that of *Egertonodus* in the number and position of the internal carotid foramina, indicating a considerable degree of variation in the basicranial arterial arrangement in hybodonts. A similar degree of variation in the cranial arterial circuit is found among extant neoselachians. The braincase of *Tribodus* shares many features with those of *Egertonodus* and neoselachians, providing further support for the sister-group relationship between hybodonts and Recent elasmobranchs. CT scans confirm the presence of several potential hybodont synapomorphies (e.g., glossopharyngeal and vagus canals converge and exit from a common foramen; trochlear nerve exits the braincase anterior to the optic nerve) and a potential new synapomorphy (separate foramina for the anterior and posterior rami of the octaval nerve). Both *Tribodus* and *Egertonodus* are interpreted as having three separate foramina for the trigemino-facial complex, including an individual foramen for the superficial ophthalmic complex. The median ventral basicranial process in *Tribodus* is similar in structure and position to median ventral processes seen in some extant neoselachians (e.g., *Etmopterus*) and in embryonic *Torpedo*, and may have had a similar ontogenetic origin. Positions of the embryonic cartilages in *Tribodus* and *Egertonodus* are also reconstructed and discussed.

Late Triassic Terrestrial Biotas and the Rise of Dinosaurs, Thursday 10:15

#### NON-DIAGNOSTIC TRAITS OF DINOSAURIA

LANGER, Max, FFCLRP-USP, Ribeirao Preto, Brazil; BITTENCOURT, Jonathas, FFCLRP-USP, Ribeirao Preto, Brazil

Recent phylogenetic analyses placed various mid-late Triassic dinosauriforms basal to the Saurischia-Ornithischia dichotomy, some of which may group together as silesaurids, forming the sister-clade to Dinosauria. However, most features purported to set these forms apart from dinosaurs do not stand a close inspection of the relevant specimens. This is the case of various dinosaur traits also seen in *Silesaurus opolensis* such as hyposphenohypantra articulations in trunk vertebrae, more than two sacral vertebrae, a long deltopectoral crest, an iliac antitrochanter, and a ventral ligament sulcus extensive to the posterior side of the femoral head. In addition, various herrerasaurs and/or basal sauropodomorphs lack supposed apomorphic features of Dinosauria, such as a reduced pectoral epipodium, a straight to convex dorsal margin of the ilium, a brevis fossa, an ischium with separated pubic and ilial peduncles, and a femoral head that lacks a lateral tuber and a proximal transverse groove. Likewise, basal members of the theropod and ornithischian lineages respectively lack an asymmetrical fourth trochanter and an acute anteromedial corner of the astragalus. In addition, *Marasuchus lilloensis* bears putative apomorphies of the dinosaur femoral head, such as a distally extensive articular surface and a facies articularis antitrochanterica, so that the opposite conditions may be apomorphic for silesaurids. Besides, some anatomical elements that may enclose further dinosaur apomorphies, such as the post-temporal fenestra and the deltopectoral crest are composed of parts with ambiguous homology relations. Nonetheless, some traits do seem to represent apomorphies of Dinosauria exclusive of silesaurids; e.g., epiphyses in postaxial cervical vertebrae, straight to concave ventral margin of the iliac acetabulum, femoral head distinctively set from the shaft, and small fibular articular surface in the astragalus. In conclusion, this untidy distribution of features may restrict the status of several of them as dinosaur apomorphies, or could lead, if properly coded into phylogenetic analyses, to a revised and perhaps more inclusive circumscription of the clade.

Poster Session II, (Thursday)

#### SOUTHERNMOST RECORD OF *OCHOTONA* (LAGOMORPHA, MAMMALIA) IN EUROPE

LAPLANA, César, Museo Arqueológico Regional de la Comunidad de Madrid, Madrid, Spain; SEVILLA, Paloma, Univ. Complutense, Madrid, Spain; ARSUAGA, Juan-Luis, Centro Mixto UCM-ISCH de Evolución y Comportamiento Humanos, Madrid, Spain; LÓPEZ-MARTÍNEZ, Nieves, Univ. Complutense, Madrid, Spain; BLAIN, Hugues-Alexandre, Institut de Paleocologia Humana i Evolució Social, Tarragona, Spain

Pikas of the genus *Ochotona* are one of the most characteristic elements of the cold-climate adapted small mammals from the Pleistocene of Eurasia. Nowadays, the species of this genus inhabit the steppes from the Middle Volga East through North Kazakhstan and the south-western slopes of the Altai Mountains to the border of China, but during the cold-periods of the Pleistocene their range expanded west and southwards in Europe, reaching the British Isles and the northern slopes of the Pyrenees. Excavations conducted in 2008 in Buena Pinta Cave, a small cave in Central Iberia (Madrid), have led to the discovery of remains of this genus 600 km southwards from its previously known distribution limits. A fragmentary mandible with complete cheek-teeth series except the third lower premolar, was found at level 3 of this site, dated by TL at 63451±5509 BP (middle of Late Pleistocene). This mandible shows the typical size and morphology of the genus, the third molar with a single lobe and a characteristic enamel interruption at the lingual side in the lobes of all the cheek-teeth. The size and shape of the mandible are compatible with those of the European late Pleistocene *O. pusilla* species. Unfortunately, the most diagnostic element for

species determination in the group (the third lower premolar), is missing in our specimen, thus hampering the accurate determination of the particular species represented at this site. During the cooler periods of the Late Pleistocene, a number of north-eastern small mammal immigrants are known to have reached the Iberian Peninsula such as *Microtus oeconomus*, *Microtus gregalis*, *Spermophilus superciliosus* and *Lagurus lagurus*, recorded at several northern Iberian sites, and some of them even extending towards central Spain, following an important increase of the extension of cold steppe habitats in the Iberian Peninsula. The record of *Ochotona* in Buena Pinta Cave adds a new species to this list of cold immigrants.

Poster Session IV, (Saturday)

#### MULTIVARIATE ANALYSES OF SMALL THEROPOD TEETH AND IMPLICATIONS FOR PALEOECOLOGICAL TURNS THROUGH TIME

LARSON, Derek, University of Alberta, Edmonton, AB, Canada

Small theropod shed teeth are often abundant in microvertebrate assemblages, making them popular subjects in the microvertebrate literature. However, the taxonomic affinities of these teeth are often problematic due to an absence of diagnostic associated skeletal material. Descriptions of theropod teeth have resulted in the referral of specimens widely disparate in age to taxa represented by few skeletal specimens at specific points in time. Species such as *Saurornitholestes langstoni*, *Dromaeosaurus albertensis*, and *Richardoestesia gilmorei* are known from skeletal remains exclusively from the Campanian Dinosaur Park Formation, and it is unlikely that teeth from differing localities previously referred to these taxa have been properly identified. Tooth types without any associated skeletal material, such as *Paronychodon lacustris* and *Richardoestesia isosceles*, have also been identified throughout the Late Cretaceous. In this study, measurements of small theropod teeth from several North American formations ranging from Santonian through Maastrichtian in age were compared using multivariate analyses. All putatively identified taxa from each formation were compared and analyzed using pairwise Discriminant Function Analysis (DFA). Where possible, measured teeth associated with skeletal remains were compared with referred isolated teeth from the same formation using DFA. The results indicate that teeth previously referred to the same taxon from different formations are often numerically distinct from each other. In contrast, shed teeth compared to skeletally identified material from the same formation are not numerically distinguishable. These results support the hypothesis that small theropod taxa, like many other dinosaurs in these assemblages, are changing recognizably among different rock units. This suggests that isolated theropod teeth from one formation should not necessarily be referred to a taxon known from skeletal material in a different formation. This method provides an accurate means of assessing small theropod diversity and faunal turnover in the absence of more diagnostic material, and has applications for temporally and geographically wider datasets.

Technical Session XIV, Friday 2:00

#### ESTIMATING RATES OF MORPHOLOGICAL EVOLUTION: LARGE DATASETS BEGIN TO FIT NEUTRAL RATE MODELS AND GIVE TIME TO "MORPHOLOGICAL CLOCKS"

LARSSON, Hans, Redpath Museum, McGill University, Montreal, QB, Canada; DECECCHI, A., Redpath Museum, McGill University, Montreal, QB, Canada

Neutral rates of change formed the basis for the development of molecular clocks. These calibrated rates of change allow for temporal estimations of divergence times for molecular sequence data. However, more recent assessments of molecular change suggest there are few, if any, neutral regions within the genome. Intense natural selection appears to act genome-wide. Yet, molecular sequence data still follows a relatively clock-like pattern of evolutionary change. We examined a range of large discrete morphological data sets of fossil amniote vertebrates to assess the evolutionary rates of morphological characters. All datasets incorporated large time scales (10s of millions of years), taxonomic sampling (100s), and character sets (100s). Evolutionary changes were estimated from phylogenetic reconstructions and evolutionary times were derived from known geologic ages. In all cases, evolutionary rates of morphological characters were best explained with linear regressions. In most cases,  $r^2$  values were 0.7 or greater and compare well to linear regression fits of molecular data. The clock-like pattern of morphological evolution has tremendous value. We estimate how evolutionary rates evolve throughout the evolution of Theropoda and present a significant increase in evolutionary rate near the origin of birds. The morphological clock (Morphoclock) is used to estimate divergence times for all major nodes of theropod dinosaurs and reveals significant nonrandom patterns of rapid rates of divergence approximately 200 million years ago and approximately 160 million years ago. The novel Morphoclock method has potential to be widely applied to paleontological data to estimate divergence times and absolute evolutionary rates.

**CHONDRICHTHYAN TEETH FROM THE RIO DO RASTO FORMATION, PERMIAN OF BRAZIL**

LAURINI, Carolina, FFCLRP-USP, Ribeirão Preto, Brazil; LANGER, Max, FFCLRP-USP, Ribeirão Preto, Brazil; RICHTER, Martha, Natural History Museum, London, United Kingdom

The fossil sites of the continental Rio do Rasto Formation (Morro Pelado Member) in the Serra do Cadeado, Paraná State, Brazil, offer one of the most important paleontological windows into the Mid-Late Permian of South America. They have yielded plant, conchostracan, bivalve, and fish remains, along with a diverse tetrapod fauna, which includes temnospondils and synapsids that provides a Capitanian age for those deposits. The “cladodont”, chondrichthyan teeth dealt with here were collected from a railroad cut, at S 24° 00' 17" and W 51° 06' 49", along with a temnospondil occiput, and associated intercentra and pleurocentra. The sample includes seven practically complete teeth and eight tooth fragments. The teeth are mesio-distally elongated, varying between 18 and 3 mm in length. The crowns are composed of a central, more prominent cusp and up to three cusplets on each side, all being pyramidal in shape. The cusp and cusplets are disposed in line and some are slightly labio-lingually compressed, their lower part being fused together. The crowns are ornamented with strong, straight to slightly curved ridges, which radiate from the tip of the cusps. The central cusp is sub-circular in cross section. In some teeth the principal cusp is slightly curved lingually. The cusplets are subequal in size and form, corresponding in average to one third of the height and one fourth of the length of the central cusp. Tooth bases are mesio-distally elongated, and there is a lingual torus at the base. Numerous small foramina form a row right below the crown-base junction, while irregular, large pores perforate the lingual surface of the tooth base. The morphological features of these teeth are reminiscent of those ascribed to sphegnacanthid sharks and to the otherwise typically Devonian genus *Protacrodus*. In the latter case, this would represent the youngest putative record of protacrodontids.

Edwin H. and Margaret M. Colbert Poster Competition (Thursday)

**A REVISION OF RAUISUCHUS TIRADENTES - NEW INFORMATION ON THE ANATOMY OF RAUISUCHIAN ARCHOSAURS AND PHYLOGENETIC IMPLICATIONS**

LAUTENSCHLAGER, Stephan, Bayerische Staatssammlung für Paläontologie und Geologie, Munich, Germany

The Triassic Period constitutes an important time in the origin and evolution of the archosaur lineages. Among those, the “rauisuchian” archosaurs form one of the most interesting and yet enigmatic groups. Although they were globally distributed and have been known for nearly 150 years, our knowledge about these reptiles is still limited. Interrelationships, taxonomy and the systematic position within the Archosauria often remain unclear and the monophyly of Rausisuchia has been debated for a long time. Over the years a plethora of different families and taxa has been erected within this clade, leading to more confusion than clarification. Fragmentary and sometimes composite specimens have also contributed to this problem, so that a thorough and up-to-date morphological description of “old” and new taxa is necessary.

A revision of the type species *Rauisuchus tiradentes* from the Late Triassic (Carnian) of the Santa Maria Formation of Brazil reveals new or formerly unrecognized characters. These include caudal vertebrae with an accessory neural spine and postspinal laminae, a squamosal with an anteriorly notched, flap-like ventral process, a stepped postorbital/jugal bar and chevron bones with a single articular facet and distal, lateral expansion. Alongside other elements, an ilium, originally assigned to *Rauisuchus tiradentes* is excluded from the holotype material.

Data and new characters collected from the study of *Rauisuchus tiradentes* and comparable specimens, including *Ticinosuchus ferox*, *Prestosuchus* sp. and *Batrachotomus kupferzellensis* were used in a preliminary phylogenetic analysis. It suggests two possibly monophyletic families within Rausisuchia. The Poposauridae, containing e. g. *Poposaurus gracilis* and *Arizonasaurus babbitti*, share three or more sacral vertebrae, parallelogram-shaped cervical centra, a supra-acetabular crest on the ilium and the loss of body osteoderms. The Rausisuchidae, among them *Rauisuchus tiradentes*, *Saurosuchus galilei*, *Postosuchus kirkpatricki* and *Ticinosuchus ferox*, are joined by a subnarial fenestra between premaxilla and maxilla, cervical vertebrae with spine tables and the possession of body osteoderms.

Technical Session III, Wednesday 4:30

**ECOMORPHOLOGY AS A PREDICTOR OF MODERN AND PALEOENVIRONMENT IN SNAKES**

LAWING, A. Michelle, Indiana University, Bloomington, IN, USA; POLLY, P. David, Indiana University, Bloomington, IN, USA; HEAD, Jason, University of Toronto, Mississauga, Mississauga, ON, Canada

Anatomical variation that is correlated with variation in the environment can be used as a predictor of paleoenvironment (an ecomorphological variable). Snakes are a diverse group of vertebrates that are differentiated morphologically for different substrates. There are terrestrial, fossorial, arboreal, aquatic, desert, and generalist species. Arboreal snakes, for example, typically have long prehensile tails and laterally compressed bodies; aquatic snakes

also tend to be laterally compressed, but are more so in the tail than in the body regions. These morphological specializations can serve as a tool to reconstruct paleoenvironment from the snake taxa at a fossil locality. To explore how well ecomorphologic indices can predict substrate use in snakes, two datasets were used. One dataset was compiled from literature for 271 North American species. Tail and body lengths were recorded as mean measurements and a tail-to-body ratio was calculated as the first ecomorphological index. The second dataset consists of length and width measurements of all the vertebrae of individual snakes representing an ecologically and taxonomically diverse set of 31 species. The mean length-to-width ratio of all the vertebrae in the skeleton was used as the second ecomorphological index. We classified each species as fossorial, semifossorial, terrestrial, aquatic, semiaquatic, arboreal, and semiarboreal. The tail-to-body index was highly correlated with substrate category ( $n = 271$ ;  $R = 0.717$ ), as was the vertebral length-to-width ratio ( $n = 31$ ;  $R = 0.638$ ). The strong correlation of these indices to substrate suggests that snake morphology can be used as taxon-free indicators of the dominant, large scale paleolandscapes, not only as indicators of paleotemperatures.

Poster Session I, (Wednesday)

**ENAMEL MICROSTRUCTURE IN PLATECARPUS AND THE IMPLICATIONS FOR TOOTH BIOMECHANICS**

LEBLANC, Aaron, University of Alberta, Edmonton, AB, Canada; REICHEL, Miriam, University of Alberta, Edmonton, AB, Canada

Studies of the phylogenetic and biomechanical characteristics of reptilian tooth enamel microstructure patterns are scant compared to extensive mammalian studies. Reptiles generally lack the complex and often diagnostic enamel prisms seen in mammals. Nevertheless, it has been shown that they have highly variable enamel microstructures and crystallite arrangements. This variability has significant phylogenetic and functional implications. In this study, we analyzed an isolated *Platecarpus* tooth that had been prepared for petrographic sectioning. The specimen was longitudinally sectioned along its labio-lingual axis. The anterior portion was analyzed under a scanning electron microscope (SEM) to observe enamel thickness and crystallite organization. The enamel thickness is 20µm, which is similar to that of tyrannosaurid dinosaurs. However, the enamel near the base of the labial side is up to 70µm thick. The microstructure resembles the columnar organization found in tyrannosaurid dinosaurs, although the crystallites in the *Platecarpus* tooth run parallel to each other. The crystallites diverge towards the external surface of the tooth in tyrannosaurids and converge in *Mosasaurus*. Four 3D models of the isolated tooth were made using the software ZBrush®. With these models, we tested the stresses generated by forces applied to a *Platecarpus* tooth under a realistic scenario generated by Finite Element Analyses with the software Strand7®. Material properties of dentine were given to the tooth. The results show high levels of tension, and a low amount of compression distributed along the tooth surface when a force is applied. The biomechanical properties of a tooth have two aspects: the morphology of the tooth (tested in the 3D analyses), and the composition of the tooth (observed in detail with the SEM scans). The unique combination of these techniques gives us a better understanding of how this type of crystallite arrangement contributed to the function of the tooth as a whole. In addition, the differences found in the enamel microstructure of *Platecarpus* and *Mosasaurus* suggests that differences in mosasaurid enamel microstructure patterns could have phylogenetic utility.

Poster Session I, (Wednesday)

**A JUVENILE SPECIMEN OF AFROHYRAX CHAMPIONI (MAMMALIA, HYRACOIDEA) FROM RUSINGA ISLAND (EARLY MIOCENE, KENYA)**

LEHMANN, Thomas, Senckenberg, Forschungsinstitut und Naturmuseum, Frankfurt am Main, Germany; DUNSWORTH, Holly, Northeastern Illinois University, Chicago, IL, USA; HARCOURT-SMITH, William, American Museum of Natural History, New York, NY, USA; MCNULTY, Kieran, University of Minnesota, Minneapolis, MN, USA

Rusinga Island (Kenya) is one of the most important Early Miocene mammal localities in Africa. Beside famous fossil primates like the putative stem hominoid *Proconsul*, more than 85 species of fossil mammals have been recorded from Rusinga, which make it an essential source for studies of African mammalian evolution. Analysis of a new specimen of *Afrohyrax championi* presented here derives from new field work started in 2006 as part of our ongoing research on the paleontology and paleoecology of Rusinga Island. This species is the best represented of all Early Miocene hyracooids from East Africa. Nonetheless, the new discovery is only the third known skull of the species and the first ever to be indisputably associated with post-cranial elements (scapulae, ribs and vertebrae in anatomical connection). Although the skull is crushed on the right side, most of the teeth and structures are preserved. According to the tusk-like and rather mesially ridged I1 and incompletely erupted M3, this individual is a young male. The following characters support its assignment to the species *A. championi*: trapezoidal bunodont upper molars with a relatively upright and strong W-shaped ectoloph, well-developed parastyle and mesostyle but greatly reduced metastyle, and reduced or absent buccal ribs of the paracone and metacone; molariform upper P with the presence of hypocone on P1-4, and the presence of a distinct mesostyle on P2-4; a long and low skull with a large facial fossa above the anterior cheek teeth. Moreover, this skull presents characters not preserved in other known specimens, like the possible closing of the post-orbital bar. This specimen thus enables us to discuss the validity and affinities of the newly created genus *Afrohyrax* in re-establishing characters like the presence of small spurs on the lingual side of the paracone and metacone of the upper

molars of this species, and showing that its hypocone is only slightly smaller than the stout protocone. Finally, this young individual enables us to explore the ontogeny and locomotion of *A. championi*, as well as study potential new traits of the scapula and cervico-thoracic vertebral column of that taxon.

Poster Session I, (Wednesday)

### 3D VISUALIZATION AND MORPHOMETRIC ANALYSIS COMPARING MANDIBULAR SUTURES IN A HATCHLING AND SUB-ADULT *ALLIGATOR MISSISSIPPIENSIS*

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Recent advances in CT imaging and 3D visualization software have created new opportunities to analyze the cranial morphologies of extant and extinct vertebrates. In particular, the morphology and functional significance of mandibular sutures is poorly understood since they are difficult to isolate or visualize in dissections and standard CT scans. *Alligator mississippiensis* is an ideal candidate for the study of sutural morphology because its sutures remain patent throughout ontogeny, and because its phylogenetic position among crown group archosaurs allows for meaningful comparisons to many extinct taxa. Using 3D visualization software, individual sutures and periodontal ligament from each side of the lower jaw were identified and segmented from high-resolution CT scans of an ontogenetic series of *Alligator*. Separate bones and teeth could then be isolated. Our techniques for reconstructing the mandibular sutures will be applicable to any specimen, including fossils, for which high-resolution CT scans are available. Mandibular sutures show a 23% decrease in relative volume during ontogeny, while bone shows a 19% increase. The relative volume of periodontal ligament in the sub-adult is less than 1/3 that measured in the hatchling, while the teeth contribute twice the relative volume in the hatchling than in the sub-adult. The symphysis shows over a 60% increase in volume during ontogeny due to increased interdigitation in the sub-adult. Although the relative volume of the splenial and dentary do not change substantially, the post-dentary bones (angular, surangular, and articular) show a 20-30% increase in relative volume in the sub-adult, corresponding to dramatic increase in the size of the retro-articular process. Understanding the relationship between sutural morphology and sutural biomechanics has broader implications for understanding mandibular function in terrestrial vertebrates that retain multiple bones in the lower jaw. Studies on the sutures of extant *Alligator* will benefit work on extinct Crocodylomorpha and Dinosauria in which mandibular morphology more closely resemble *Alligator* than extant Aves in form.

Technical Session III, Wednesday 2:30

### CONVERGENT BODY PLAN EVOLUTION IN HYPHALOSAURID CHORISTODERES AND PACHYPLEUROSAURID SAUROPTERYGIANS

LEONHARDT, Anja, Steinmann Institute, University Bonn, Bonn, Germany; SANDER, Martin, Steinmann Institute, University Bonn, Bonn, Germany

Hyphalosaurus (Archosauromorpha?, Diapsida) is known in high abundance from the Early Cretaceous Jehol Group in Liaoning Province, Northwestern China. The small aquatic reptile is popular on the legal and illegal fossil trade as "swimming dinosaur", and forgeries are common. In contrast, there are only a few published scientific works on the two species described, *Hyphalosaurus lingyuanensis* and *H. baitaigouensis*. However, Hyphalosauridae are markedly distinct from all other choristoderes, and convergently evolved a body form resembling the Triassic Pachypleurosauridae (Sauropterygia, Diapsida). Hyphalosaurus exhibit aquatic adaptations like an elongated neck and tail, small head and enlarged autopodium. These characters are acquired by strong allometric growth, while there are only little changes in morphology. Two size classes and three ontogenetic stages can be discerned. This is surprisingly little and indicates that neonate juveniles and adult hyphalosaurus lived in different niches. The third ontogenetic stage is represented by an embryo, evidenced by its convoluted pose and weakly ossified bones. Histological investigations imply ages from under one year for the neonate juveniles, and seven years for an adult at time of death, but also pachyostosis in adult stage. The ontogenetic development visible in the morphology and morphometry leading to adult stage is surprisingly similar to pachypleurosaurids. There are indications for epiphyseal growth of long bones in adults, what would be extraordinary for reptiles. Even though eight fossils turned out to be partly forgeries, our results show that the value of these samples for analyzing ontogenetic changes in morphology and morphometry is not diminished. The study provides insights into the biology of the Hyphalosauridae and shows that morphological characters and their ontogenetic development occurred convergently at least two times in Triassic and Cretaceous secondary aquatic tetrapods.

Poster Session III, (Friday)

### LOCOMOTOR ECOLOGY OF *MACHAIRODUS COLORADENSIS*

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Understanding an organism's locomotor capabilities gives valuable insight into aspects of behavior and functional morphology. Locomotor type can be used as a proxy for behavioral and ecological characters that could otherwise not be studied in extinct organisms, such as

habitat utilization and food acquisition. By measuring the length of proximal and distal limb bones in several extant and extinct taxa, we have constructed a locomotor ecomorphospace map that may be used to estimate cursoriality and associated variables in extinct ungulates and carnivores. This technique has been used previously as a proxy for community structure, predator/prey dynamics, and locomotor ecology in Oligocene North America. Here we examine the locomotor ecology of the Miocene machairodontine felid *Machairodus coloradensis*. Machairodontines, along with other saber-toothed predators, represent a morphotype with no modern analog, and as such understanding their role in paleoecosystems has proven difficult. Most research has focused on *Smilodon*, a late and highly derived machairodontine. Analysis of *Machairodus coloradensis* provides information on predation strategies early in the evolution of the group. Our results indicate that *Machairodus* filled an ambush predator niche comparable to that of the modern lion. If this is the case, ambush predation appeared very early in machairodontine evolution and may characterize many members of the group.

Poster Session I, (Wednesday)

### PRELIMINARY ANALYSIS OF THE SMALL MAMMAL FAUNA FROM MATJHABENG, FREE STATE, SOUTH AFRICA

LEWIS, Patrick, Sam Houston State University, Huntsville, TX, USA; KENNEDY, Alicia, Sam Houston State University, Huntsville, TX, USA; DE RUITER, Darryl, Texas A&M University, College Station, TX, USA; BROPHY, Juliet, Texas A&M University, College Station, TX, USA

While the Province of Gauteng in South Africa is well known for its rich fossiliferous deposits, Plio-Pleistocene localities outside Gauteng are comparatively rare. Placing the fossil hominins of Gauteng in an evolutionary context, however, requires an understanding of the regional paleoenvironment. The Matjhabeng locality of the Free State of South Africa, dated to ca. 3.5 Ma, is temporally and geographically intermediate to Langebaanweg (5.0 Ma) and Makapansgat (2.5 Ma), thereby providing a data point critical in reconstructing the past habitat of southern Africa. Small mammals, long known as powerful environmental indicators, are an important part of this fauna. Matjhabeng possesses a fossiliferous riverine deposit that, after two seasons of excavation, has produced approximately 75 identifiable small mammal fossils. The majority of these specimens are either lagomorph or springhare molars, indistinguishable from modern forms. Springhares are attributed to the modern genus *Pedetes*, while the Lagomorphs are currently diagnosed to the family Leporidae. Neither taxon is associated with any particular regional habitat, although springhares generally prefer grasslands. Many isolated murine rodent teeth are also diagnosable, all to extant taxa. These include a lower third molar of *Tatera* (naked-soled gerbils). While gerbils are wide spread in southern Africa today, they are generally found in arid to savanna habitats. Several molars and incisors belong within the Otomyinae (groove-toothed rats). Otomyine dentition is particularly important, as Langebaanweg and Makapansgat each reportedly have different taxa from this group. Unfortunately, dental characters used to diagnose these different taxa are overlapping and present in modern forms, limiting their use in dating Matjhabeng. Otomyines, however, are often indicative of marsh or riverine habitats, consistent with Matjhabeng's depositional environment. In general, the small mammal fauna reflects a mixed wetland/grassland environment, consistent with the reconstruction based on the large mammal component of the assemblage.

Technical Session XVI, Saturday 12:00

### THE ANTHRACOTHERIIDAE (CETARTIODACTYLA, MAMMALIA) FROM TOROS-MENALLA (NORTHERN CHAD) AND THE NEOGENE SAHARAN PALEOBIOGEOGRAPHY

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Anthrotheriids occurred on the African landmass since the late Eocene. We report here the anatomic description of the last African representatives of this family discovered by the Mission Paléanthropologique Franco-Tchadienne in the Toros-Menalla fossiliferous area, Djurab desert, northern Chad. One species was recognized in the Anthrotheriid Unit, which also yielded the earliest known Hominidae, *Sahelanthropus tchadensis*. The age of this unit is bracketed between 7.2 Ma - 6.8 Ma (mammalian biochronology and cosmonuclide absolute dating). All these anthrotheriid specimens are attributed to *Libycosaurus petrocchii*, also recognized at Sahabi, Libya. The material from Toros-Menalla is the largest known sample attributable to a *Libycosaurus* population. It allows describing the constant occurrence of five permanent upper premolars within this population, which is exceptional in Eutherian, and investigating its large intraspecific variation, particularly sexual dimorphism. Cranial anatomy displays morphological traits of semi-aquatic mammals such as orbit elevation above the cranial roof, premaxillary symphysis dorsal extension displacing external nares dorsally, petrosal and tympanic bony densification. Those features

indicate an advanced specialization in aquatic lifestyle. A phylogenetic reconstruction of Bothriodontinae including *Libyosaurus* indicated a recent Asian origin for these late Neogene African anthracotheres. Anthracotheriids dispersed at least three times from Asia to Africa (late Eocene, early Miocene, middle Miocene). Their geographical distribution in Africa by the end of Miocene, constrained by their aquatic habits, supports aquatic late Miocene faunal exchanges between the Sirt Basin (Libya) and the Lake Chad Basin. Their extinction might be correlated to aquatic habitat fragmentation in the context of the Messinian aridification in central and northern Africa.

Poster Session III, (Friday)

**UNUSUAL QUADRUPEDAL ORNITHOPOD FOOTPRINTS AND LARGE MANUS IMPRINT OF PTEROSAUR FROM THE EARLY CRETACEOUS OF KOREA**

LIM, Jong-Deock, Natural Heritage Center of Korea, Daejeon, Korea, South; KONG, Dal-Yong, Natural Heritage Center of Korea, Daejeon, Korea, South; KIM, Kyung-Soo, Chonju National Univ. of Education, Jinju, Korea, South; KIM, Tae-Hyeong, Natural Heritage Center of Korea, Daejeon, Korea, South

Korean dinosaur tracksites are well-known for preservation and diversity of Cretaceous dinosaurs. Major ornithopod trackways of Korea have been discovered from the Jindong Formation of Gyeongsang Basin and the Uhangri Formation of Haenam Basin. All known ornithopod tracks indicate bipedalism. The new ornithopod footprints were discovered from the Jindong Formation. It is the first quadrupedal record in Korea. Unlike other footprints of quadrupedal ornithopods, the distance between manus and pes is very short. The manus consisted of three toes which are clearly identified. The lengths of manus are 34 mm (right) and 40 mm (left) while the widths are 98 mm (right) and 100 mm (left). The ornithopod tracks which were excavated from the Jindong Formation of Masan city are identified typical *Caririchnium*. Korean Cretaceous sediments have produced three pterosaur tracksites. *Haenamichnus uhangriensis* from the Late Cretaceous (Uhangri Formation) is reported as the largest pterosaur footprint and the first pterosaur ichnotaxon in Asia. Other ichnotaxa (*Pterachnus koreanensis* from the Hasandong Formation and *P. isp.* from Haman Formation) are smaller than *Haenamichnus uhangriensis*. In 2009, a new pterosaur track was discovered in the Jinju Formation (Lower Cretaceous). The manus imprint is very large and typical tridactyl. The length of the manus is 320.60 mm and the width is 143.02 mm. The tridactyl manus, a typical pterosaur hand print, is strongly asymmetric and the depth decrease toward the tips of digit I and II. The digit III impression is much longer than other two digits. The digits I and II are directed laterally. The pterosaur track is the first record from the Jinju Formation and indicates different characteristics from the three known Korean pterosaur footprints. Recent discoveries of several Korean pterosaur remains including bones and tracks suggest that Korean Peninsula represents diversity of pterosaurs.

The Evolution of Birds in the Mesozoic: a Symposium in Honor of Cyril A. Walker, Thursday 11:30

**EARLY-MIDDLE EOCENE BIRDS FROM THE LILLEBAELT CLAY FORMATION OF DENMARK**

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The marine Lillebaelt Clay Formation of central Denmark is of early-middle Eocene age (late Ypresian – middle Lutetian; microfossil zones NP 13-NP 15). Over 20 bird fossils collected by amateur paleontologists have been acquired through the Danish national 'Danekrae' fossil treasure trove legislation. The fossils are preserved in clay ironstone concretions and almost two-thirds are isolated skulls preserved three-dimensionally. Bird fossils of this age and degree of preservation are rare in an international context. The fossils indicate a very diverse assemblage consisting of both marine and terrestrial forms. These include at least one pelagornithid or 'pseudo-toothed bird'; two or three taxa with charadriiform affinities (shorebirds and allies); a massive, narrow-beaked psittaciform (parrots and allies); a large rallid (rail) and one lithornithid (extinct, volant palaeognaths). The Lillebaelt Clay Formation deposits derive from just after the Early Eocene Climate Optimum, a period of global elevated temperatures resulting from rapid greenhouse warming. Comparison between this bird assemblage and the recently revised assemblage from the older (earliest Ypresian) Fur Formation of Denmark, allows investigation of the effects of prehistoric greenhouse warming on a single zoological group (birds) within a delimited biogeographic area.

Technical Session I, Wednesday 9:00

**REASSESSING FAUNAL DYNAMICS DURING THE GREAT AMERICAN BIOTIC INTERCHANGE USING UPDATED DATA AND ADJUSTMENTS FOR SAMPLING BIASES**

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The Great American Biotic Interchange (GABI), which reached its peak around 2.5 MA following the formation of the Panamanian isthmus, resulted in a dramatic reorganization of mammal communities on the North and South American continents. Today, there are disproportionately more native North American mammal taxa surviving in both North and

South America than there are taxa of South American origin on either continent. Previous studies have attributed this imbalance to differential in-situ speciation of native North American taxa following the Interchange, rather than differences in initial immigration success. However, these inferences are based on calculations of pre- and post- Interchange faunal dynamics using weak temporal controls and uneven spatial sampling. In addition, new research has improved our resolution of North American Pliocene fauna and shifted the boundaries for some North American Land Mammal Ages. To test the robustness of previous interpretations given those constraints, we re-evaluated analyses for late Cenozoic North American mammals using updated chronologies and taxon lists, and standardizing for time interval and sampling intensity using a variety of techniques. Total numbers of genera, originations and extinctions were 12%-46% higher using current data from the FAUNMAP II database than were previously reported. Standardization of this data by adjusting for temporal interval and number of localities results in relatively higher diversity and turnover rates in North American mammals in the Irvingtonian than was previously believed (the highest in any of the sampled time periods). These initial analyses support the idea that the GABI resulted in both increased turnover and initial increased diversity in North American mammals, and suggests that application of different methods to adjust for sampling biases will be useful in reconstructing details of this event.

Poster Session I, (Wednesday)

**A PYGMY ELEPHANT'S SHADOW IS GREATER WITH THE SETTING SUN A SURVEY OF THE MEDITERRANEAN INSULAR ELEPHANTS AND A BIOMETRICAL COMPARISON OF THE PHILIPPINE ELEPHANT MATERIAL LISCALJET, Nike, National Museum of Natural History Naturalis, Leiden, Netherlands**

For a broader perspective on pygmy elephants and island evolution, comparisons between the islands and their elephants are necessary. My thesis is the first to give a detailed synopsis of the information that has been collected since the first finds of dwarf elephants in the Mediterranean area in 1842. A description is given on the bone material that was actually excavated and to which extent the Mediterranean elephants fit anatomically together. Seven Mediterranean islands contain definite evidence for a Pleistocene pygmy elephant. Size difference due to sexual dimorphism is under consideration and in line with the expectation that any given island of a certain areal size cannot hold multiple elephant populations. To test the usefulness of this survey the second part of the research consists of a biometrical comparison of seven metacarpal bones from one elephantid from the Philippines. As a normal-sized mainland reference, measurements of *Mammuthus primigenius* from Geisertal were added to the database. Biogeographical differences were set aside for now. The Philippine material corresponds to the high range of measures of dwarfed Mediterranean elephants and it does seem to fit in with the rest. So it definitely is a pygmy elephant, but not as small as *Elephas falconeri* from Malta, with a possible withers height of around 200cm. There is agreement on the idea of parallel evolution occurring simultaneously on different islands, but the existence of multiple migrations and their consequences cannot be excluded. For the comparative study on endemic elephant material this is only the beginning.

New Perspectives on the Early Evolutionary History of the Synapsida, Saturday 8:45

**NEW BASAL SYNAPSID FROM CHINA - A KEY TO UNDERSTANDING THERAPSID ORIGINS**

LIU, Jun, Key Laboratory of Evolutionary Systematics of Vertebrates, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China; RUBIDGE, Bruce, Bernard Price Institute for Palaeontological Research, University of the Witwatersrand, Johannesburg, South Africa; LI, Jinling, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China

A major problem in synapsid evolution is the morphological and temporal gap (Olson's Gap) between earliest therapsids and sphenacodonts. At their first appearance in the fossil record therapsids had already diversified into several distinct groups including small and large herbivores and predators. The Middle Permian Dashankou fauna from Gansu Province, China has produced a wide variety of basal tetrapods, but the importance of the therapsid fauna, which includes the basal anteosaurid dinocephalians *Stenocybus* and *Sinophoneus*, is not fully recognized. Two new therapsid specimens cast light on basal therapsid origins. A new skull of *Biseridens qilianicus* has a short snout; an elevated zygomatic arch; and septomaxilla lacking elongated posterodorsal process between nasal and maxilla, indicating it is an anomodont and not a eotitanosuchian as previously described. Cladistic analysis indicates *Biseridens* to be the most basal anomodont. The other specimen is a well preserved, slender snout. The presence of a greatly elongated dorsal process of the premaxilla, septomaxilla with a long facial process and high maxilla contacting the prefrontal, distinguish the specimen as a therapsid. It also has a number of sphenacodontid characters unknown in any other therapsid. If *Tetraceratops* is indeed a sphenacodont as recently suggested, our phylogenetic analysis shows the new specimen to be the most basal therapsid. The co-occurrence of very basal therapsids together with the dissorophoid *Anakamacops*, the bolosaurid *Belebey* (both families occur together only in the Early Permian) support an Early Roodian age for this locality, and helps to close Olson's Gap.

### SIGNIFICANT MID-LATITUDE ARIDITY IN THE MIDDLE MIOCENE OF EAST ASIA

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The East Asian climate history during the Neogene is a complicated and contentious issue, in particular because of its bearing on the development of the East Asian monsoon and Tibetan uplift chronology. Here we present a paleoprecipitation analysis based on mean molar tooth height (hypsodonty) of large herbivorous mammals to investigate the spatial pattern of climate zonation in East Asia during the middle Miocene. We show a generally humid and uniform situation before the late middle Miocene, replaced by a mid-latitude arid belt from the late middle Miocene, into the earlier part of the late Miocene. These findings are concordant with the global phenomena of the middle Miocene climate optimum and the subsequent cooling, and suggest that the predominant climate in East Asia for most of the Miocene was planetary rather than monsoonal. Our results support a late initiation of the East Asian summer monsoon, coincidentally with the beginning of eolian red clay deposition in the later late Miocene at 7-8 Ma.

### ARE *BIPEDOPUS*, *SEMIBIPEDOPUS*, *LACERTIPUS*, *NAVAHOPUS* AND *BRASILICHNIUM* DISTINCT ICHNOGENERA? REEVALUATING JURASSIC TRACKS FROM THE WESTERN USA

LOCKLEY, Martin, University of Colorado at Denver, Denver, CO, USA; TEDROW, Allen, Idaho Museum of Natural History, Pocatello, ID, USA

*Bipedopus*, *Semibipedopus* and *Lacertipus* are ichnogenera proposed for Lower Jurassic vertebrate tracks from near Meeker, Colorado. The tracks, which occur in eolian facies of the Navajo-Nugget Sandstone, are similar to the larger ichnogenus *Navahopus* and the smaller South American ichnogenus *Brasilichnium*. Both names are presently applied to tracks from the Navajo Sandstone in southern Utah. However, the former three names, with potential priority, have never been used, nor have detailed comparisons been made between these ichnogenera. Diagnostic track features are evaluated in order to determine whether: 1) the track names are valid, 2) the named ichnogenera differ from one another, 3) the ichnogenera suggest diagnostic track makers. Preliminary results indicate that *Lacertipus* is valid and different from the other ichnogenera due to its tetradactyl elongate track shape and large manus (slight heteropody). It is of probable lepidosaur affinity, but very similar to *Dolichopodus* from the Permian. *Bipedopus* and *Semibipedopus* are short, wide tetradactyl tracks with pes larger than manus (moderate heteropody). They differ only in the sporadic presence of the smaller manus track. So *Bipedopus* could be an extra-morphological variant of *Semibipedopus* caused by pes on manus overprinting, or the consistently faint manus traces may indicate a trackmaker placing very little body weight on forelimbs. In the latter case *Semibipedopus* is a fair descriptor. *Brasilichnium* and *Navahopus* have pes tracks very similar to *Bipedopus* and *Semibipedopus* (and the Permian ichnogenus *Chelichnus* and its junior synonym *Laoporus*). *Navahopus* is larger than *Brasilichnium* but both have a small manus (strong heteropody). All are of probable synapsid affinity, although *Navahopus* has also been attributed to a prosauropod. Clear differentiation of manus and pes track morphology and heteropody in well-preserved specimens are crucial for differentiating these ichnogenera both within the Jurassic and in Mesozoic-Paleozoic comparisons. Distinct patterns of heteropody may help reliably differentiate ichnotaxa.

### FUNCTIONAL SHIFTS DURING GROWTH IN THE LATE JURASSIC THEROPOD DINOSAUR *ALLOSAUROS*: THE IMPLICATIONS OF ONTOGENETIC VARIATION

LOEWEN, Mark, University of Utah, Salt Lake City, UT, USA

Paleobiological studies must often cope with small sample sizes, so for most taxa, it is unclear what effect ontogeny and intraspecific variation have on functional morphology during an organism's lifetime. The large theropod dinosaur *Allosaurus*—known from numerous associated and articulated specimens and thousands of individual elements—currently provides the best opportunity to address this critical, unresolved issue. I focused my study on the skull and hindlimb, completing a morphometric analysis of over 570 bivariate comparisons for 1,300 specimens. Analysis of the skull, combined with stratigraphic assessments of individual specimens, indicates the presence of two temporally-separated species of *Allosaurus* in the Late Jurassic Morrison Formation: *A. fragilis* (Brushy Basin Member) and *A. n. sp.* (Salt Wash Member). Cranial elements reveal an increase in skull height vs. skull length during growth for both species, suggesting that these ontogenetic trends are conservative across the two taxa. In *A. fragilis*, but not in *A. n. sp.*, the caudal portion of the skull exhibits extreme positive allometry, substantially increasing in transverse breadth and ventrally displacing the jaw joint relative to the tooth row, an unusual condition among theropods that mirrors the ontogenetic trajectory of *T. rex*. Significant increases in skull height and breadth, as well as an overall increase in robustness and re-organization of skull architecture, are postulated to be functionally linked with heightened stress and loading associated with adult predation and feeding. Analysis of hindlimb allometry reveals significant growth-related changes in both species, including: relative shortening

and thickening of the entire limb, reduction of the femoral medullary cavity, and distal movement of the insertion point for the major limb retractor muscles. These patterns are interpreted as indicative of an ontogenetic shift in locomotor strategy from more agile, cursorial juveniles to a more graviportal adult condition. Taken together, cranial and hindlimb changes during the growth of *Allosaurus* suggest a shift in lifestyle from agile, generalist juveniles to graviportal, specialist adults.

### *HISPANOMYS BIJUGATUS* (RODENTIA, CRICETODONTINAE) FROM THE MIDDLE MIOCENE OF LA GRIVE-SAINT-ALBAN (FRANCE): BIOSTRATIGRAPHICAL IMPLICATIONS

LÓPEZ-ANTOÑANZAS, Raquel, Museo Nacional de Ciencias Naturales - CSIC, Madrid, Spain; MEIN, Pierre, Université Claude Bernard - Lyon I, Villeurbanne, France

La Grive-Saint-Alban is the name used to refer to various Upper Aragonian pits located on the territory of the municipality of Saint-Alban-de-Roche (Isère, France). All pits have yielded micromammals, but remains of *Hispanomys* have been only recovered from La Grive L (pit Lechartier, with eight fissure-fillings numbered from L1 to L8) and La Grive M (pit Milliat). Two species of this genus have been identified at La Grive-Saint-Alban: *H. bijugatus* from La Grive L (fissures L3 and L5) and *H. decedens* from La Grive L (fissure L5 and maybe L7), La Grive M as well as from an unnamed fissure-filling. *H. bijugatus* shows some of the typically primitive dental characters of the Aragonian species of *Hispanomys*, such as the unreduced M3. However, it also presents progressive features: the absence of labial and lingual cingula surrounding the upper and lower molar valleys respectively, the increase of the number of roots on the second lower molar, and the loss of mesoloph on the upper molars. All these characters are lacking in *H. decedens*. All in all, *H. bijugatus* appears as a relatively derived species with respect to the coeval congeneric species. The age of the different fissure-fillings of La Grive-Saint-Alban is controversial. Because *H. bijugatus* and *H. decedens* are believed to be closely related species within the same lineage, the fact that the former shows a more progressive dental morphology than the latter suggests that the unnamed fissure-filling from La Grive and La Grive M (with *H. decedens* only) are older than La Grive L3 (with *H. bijugatus* only). The coexistence of the two species at La Grive L5 may indicate an intermediate age for this locality. Should the extremely low percentage of *H. decedens* in the sample from L7 not be due to "contamination", this locality may be older than La Grive L3 and L5.

### HOMOLOGY OF THE INFRAORBITAL BONES AND THE MONOPHYLY OF SEMIONOTIFORMES

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The monophyly of Semionotiformes (including the gars, semionotids and macrosemiids) is supported by several characters, in particular the presence of anterior infraorbital bones, which constitute a unique synapomorphy of this group. The term 'anterior infraorbitals' refers to the infraorbital bones placed anterior to the anterior border of the orbit (preorbitals, lacrimals, or antorbitals of other authors). Similarly, the 'toothed infraorbitals', placed between the antorbital and the anterior infraorbitals, constitute a synapomorphy of the Lepisosteidae. Postorbitals and suborbitals, subinfraorbitals and postinfraorbitals, and a jugal have been identified among the series of dermal bones associated with the infraorbital sensory canal in actinopterygians. However, the number of infraorbital bones is highly variable and individual homologies cannot be established. The association of each of these bones with particular neuromasts of the infraorbital line does not provide a valid criterion of homology because the number of neuromasts in this sensory canal is variable between species of the same genus, between specimens of the same species, and sometimes even between the left and right sides of the same specimen. Nonetheless, developmental studies have shown that all the ossifications associated with the infraorbital line occur in connection with one or more neuromasts and through the same process. Therefore, serial homology can be inferred for the whole series from the rostral to the dermosphenotic. Within the series of infraorbital bones in the Semionotiformes, the anterior infraorbitals and toothed infraorbitals can be distinguished clearly on the bases of their morphology and position. These bones complete the infraorbital series between the antorbital and the orbit and, although individual homologies cannot be proposed, the subseries of 'toothed infraorbitals' and 'anterior infraorbitals' are shown to be homologous and uniquely derived in the Lepisosteidae and the Semionotiformes respectively.

### BIOTIC RESPONSE TO THE LATE GLACIAL MAXIMUM IN SOUTHERN EUROPE

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Until now, the biotic response to one of the harshest periods of the Pleistocene (called the Late Glacial Maximum = LGM) has been known in Europe from a few marine or lake

palynological sequences. A number of caves in northern Spain provide new insights into the continental sequences with a continuous record of small vertebrates, some of them with pollen as well. The el Portalón cave in the Sierra de Atapuerca (Burgos, northwestern Spain) provides a long, continuous continental sequence divided into sixteen lithostratigraphical sublevels (P16 to P1), with a set of radiocarbon dates from 30 kyr BP to 17 kyr BP. This sequence has already yielded a rich assemblage of small-vertebrates (more than 18,000 bones), mainly composed of small-mammals, amphibians and squamate reptiles. The faunal list includes at least 25 species: 4 amphibians (*Alytes obstetricans*, *Bufo bufo*, *Bufo calamita* and *Rana temporaria*); 3 squamates (an indeterminate lacertid, an indeterminate colubrine and *Vipera* sp.); 6 insectivores (*Sorex* gr. *coronatus-aranus*, *Sorex minutus*, *Neomys fodiens*, *Neomys anomalus*, *Talpa europaea* and *Galemys pyrenaicus*); 2 chiropters (*Myotis myotis* and *Myotis* gr. *myotis-blythi*); 10 rodents (*Microtus arvalis*, *Microtus agrestis*, *Microtus oeconomus*, *Iberomys cabrerai*, *Chionomys nivalis*, *Terricola duodecimcostatus*, *Arvicola sapidus*, *Arvicola terrestris*, *Apodemus sylvaticus* and *Eliomys quercinus*). Within this sequence, P6 to P3 sublevels are related with the LGM and are characterized by a strong decrease in summer temperature with an important increase in winter precipitation and a diminution of woodland areas. This period corresponds to the disappearance of “thermophilous” and water-stream taxa such as *I. cabrerai*, *T. duodecimcostatus*, *A. sapidus*, *N. fodiens* and *G. pyrenaicus* as well as woodland-edge taxa such as *E. quercinus*, *A. sylvaticus* and *M. myotis*. Nevertheless, more than a decrease in biodiversity, this period is characterized by a very strong decrease in the number of individuals (i.e. biomass). The biotic response to this coldest period is analyzed separately for small-mammals, squamate reptiles and amphibians permitting a scenario in accordance with their different ways of life and biological plasticity.

Poster Session IV, (Saturday)

**MONOSPECIFIC ASSEMBLAGES OF SMALL OVOID THEROPOD EGGS FROM THE UPPER CRETACEOUS OF THE AREN FORMATION (SOUTH CENTRAL PYRENEES, LLEIDA, SPAIN)**

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Small ovoid eggs with prismatic eggshells are recorded in two rich, monospecific concentrations from a correlated single level of upper Cretaceous (upper Campanian-Maastrichtian) coastal deposits of the Aren Formation (South-central Pyrenees, Lleida, Catalonia, Spain). Many other egg assemblages with different prismatic and tubospherulitic egg types appear in other levels of similar coastal facies in the Aren Fm and in other lithostratigraphic units of different facies in the Pyrenean and Provençal region as well; however this new, isolated egg type has been only recorded up to now in these two sites. Its overall egg size and shape are similar to modern hen eggs, which is unusual in the egg world record of this age. Its shape resembles to smaller Campanian avian eggs from the Bajo-de-la-Carpa Formation (Argentina), however the new eggshell microstructure differs by having a peculiar pattern of interlocking palisade prisms with an incipient squamatic texture, instead of the thick squamatic layer commonly present in true avian eggshells. A preliminary egg morphospace analysis situates both fossil ovoid eggs midway between modern bird eggs and non-avian theropod eggs. This new egg type is attributed to a small theropod, probably owing a single oviduct like birds and having a mosaic distribution of primitive and derived features between non-avian theropods and birds, which adds more arguments for supporting the close phylogenetic relationships between both groups.

Poster Session I, (Wednesday)

**RECONSTRUCTION OF PLEISTOCENE SOUTHEAST ASIAN ENVIRONMENTS THROUGH MEGAFUNA COMMUNITY ANALYSIS**

LOUYS, Julien, Liverpool John Moores University, Liverpool, United Kingdom; MEIJAARD, Erik, The Nature Conservancy, Balikpapan, Indonesia

Megafauna (large-bodied species) are the most frequently recovered mammals from Pleistocene sites in Southeast Asia. Although environmental inferences have been made in the region on the basis of individual species, the scarcity of micromammals from most sites has hampered multivariate environmental reconstructions. We reconstructed the habitat types of 30 Pleistocene sites in Southeast Asia through synecological (community) analysis. This method specifically targets large-bodied mammals, and as such can be applied widely in the region. Ecological variables were chosen such that these can be directly assessed from species lists. The method allows the reconstruction of fossil sites as closed (continuous tree cover), mixed (heterogeneous tree cover) and open (limited to no tree cover). Four Pleistocene sites can confidently be assigned to one of the three habitat types. Tam Hang, a Middle Pleistocene site from Laos, is classified as mixed. Ban Fa Suai, a Middle Pleistocene site from Thailand, is also classified as mixed. Trinil, a Middle Pleistocene site from Java, is classified as open. Lastly Hang Hum II, a Late Pleistocene site from Vietnam, is classified as open. Insufficient numbers of fauna are present in the remaining sites to allow strictly confident habitat assignment. Nevertheless, conditional habitat assignments can be achieved, and are largely congruent with other paleoenvironmental data obtained from the literature. The analyses suggest that through most of the Pleistocene, Southeast Asia was composed of mixed habitats, and that the widespread distribution of rainforests, such as found today, is a relatively rare phenomenon.

Edwin H. and Margaret M. Colbert Poster Competition (Thursday)

**SOMATIC RESEGMENTATION ERROR: A CONGENITAL PHYSICAL ANOMALY IN A SPECIMEN OF APATOSAURUS**

LOVELACE, David, University of Wisconsin - Madison, Department of Geology and Geophysics, Madison, WI, USA

Physical anomalies in the fossil record, though rare, can lend insight into developmental and evolutionary histories. A recently discovered mid-caudal vertebra of *Apatosaurus* exhibits an unusual morphology consistent with a congenital anomaly associated with errors during somatic resegmentation. The specimen exhibits two stunted neural arches fused to a single vertebral body of normal (expected) size; a single stunted haemal arch is also present and fused to the mid-ventral surface of the vertebral body. Aside from the anomalous neural and haemal arch, the vertebral body does not differ appreciably from that of the expected condition. During embryogenesis the development of the axial column proceeds through a number of steps that are not altogether understood; however, recent chimeric and molecular studies have unambiguously demonstrated that a vertebra is composed of cells from two adjacent somites (i.e. resegmentation). Cells from the leading somite contribute to the anterior portions of the neural arch, laminae, processes, and vertebral body, while the following somite contributes to the posterior portions of the same vertebra. It is hypothesized that during this stage of development the somites - that contributed to the vertebra under investigation - incompletely assimilated, leading to disordered vertebral segmentation (e.g. block vertebrae). The only reported instance of block vertebrae in the fossil record was observed in a *Tyrannosaurus* specimen. The presence of congenital physical anomalies in the axial column of *Apatosaurus*, a taxon that has greater than 80 caudal vertebrae, is not too surprising; however, physical anomalies such as this provide a unique window through which early development can be viewed.

Technical Session V, Wednesday 3:30

**THE CRANIAL ANATOMY OF A NEW TETRAPODOMORPH FISH FROM THE LOWER DEVONIAN OF CHINA**

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Previous studies have suggested that the divergence between dipnomorphs and tetrapodomorphs occurred prior to the Lochkovian, however, the history of the latter can only be definitely traced back to the late Emsian with *Kenichthys*. Here we report a new tetrapodomorph fish from the Pragian Posongchong Formation of Yunnan, southwestern China that extends the earliest record of tetrapodomorphs to at least 10 million years earlier in the geological history. The new form agrees well with *Kenichthys* and ‘osteolepiforms’ in the pattern of neurovascular openings on the lateral wall of neurocranium, and the flat parasymphysial dental plate. It bears the largest orbital notch relative to the parietal shield length and the most anteriorly positioned pineal foramen among basal tetrapodomorphs, and a large tusk on the parasymphysial dental plate. The new form resembles basal dipnomorphs (e.g. *Youngolepis* and *Powichthys*) and *Styloichthys* in a broad and elongate parasphenoid. Characters shared with *Styloichthys*, *Youngolepis*, *Kenichthys* and *Thursius wudingensis* include the infraorbital sensory canal following the premaxillary suture, and a compound cheek bone plate with three pits. The unique character combination of the new form further bridges the gap between tetrapodomorphs and dipnomorphs, and provides a novel insight into the character acquisition sequence of stem tetrapods. High-resolution CT scan data of an anterior cranial portion of the new fish have been acquired via the scanning facilities at the Australian National University, Canberra. The scanning and digital imaging offer an opportunity to depict a complete three-dimensional ethmosphenoid region from a very early tetrapodomorph, and allow for detailed comparisons between the neurocrania of basal tetrapodomorphs and other sarcopterygians.

Poster Session III, (Friday)

**VERTEBRATE FAUNA, STRATIGRAPHY AND AGE OF THE WHITAKER QUARRY (GHOST RANCH, NEW MEXICO), THE RICHEST UPPER TRIASSIC DINOSAUR QUARRY IN THE WORLD**

LUCAS, Spencer, New Mexico Museum of Natural History, Albuquerque, NM, USA; HECKERT, Andrew, Appalachian State University, Boone, NC, USA; RINEHART, Larry, New Mexico Museum of Natural History, Albuquerque, NM, USA; SPIELMANN, Justin, New Mexico Museum of Natural History, Albuquerque, NM, USA; JASINSKI, Steven, State Museum of Pennsylvania, Harrisburg, PA, USA

The Whitaker quarry at Ghost Ranch, Rio Arriba County, New Mexico, USA, is one of the most extensive Late Triassic bonebeds known, yielding hundreds of skeletons of the theropod dinosaur *Coelophysis bauri*. The quarry also yields the following tetrapod taxa: the sphenodont *Whitakersaurus*, at least two drepanosaurid taxa, the sphenosuchian *Hesperosuchus*, a rauisuchian (cf. *Postosuchus*), the archosaurs *Vancleavea* and *Shuvosaurus* (= *Effigia*) and the phytosaur *Redondasaurus*. The Whitaker quarry is an unusual Late Triassic paucispecific tetrapod assemblage representing a mass kill of dinosaurs and a limited number of specimens of other tetrapod taxa. Notable is the absence of metoposaurs and aetosaurs, common constituents of Upper Triassic tetrapod assemblages in the American Southwest. Strata that include the Whitaker quarry have been assigned by various workers to the Petrified Forest, Owl Rock or Rock Point formations of the Chinle Group or to the

Moenave Formation. Assignment to the Rock Point Formation is justified on a lithologic basis, as the Whitaker quarry is in a succession of alternating beds of fine-grained, laminar/ripple laminar sandstone and non-smectitic siltstone, closely resembling other Rock Point outcrops across the Colorado Plateau, with which it is homotaxial at the top of the Chinle Group. Indeed, the quarry was recently mapped in the Rock Point Formation by the New Mexico Bureau of Geology. Lithology also precludes assignment to the dissimilar Petrified Forest or Owl Rock formations, which are dominated by smectitic mudstone. Recent assignment of the Whitaker quarry to the Moenave Formation based on magnetostratigraphy lacks a lithostratigraphic basis, confuses chronostratigraphy with lithostratigraphy, and erroneously assigns the quarry a Jurassic age. The presence of *Redondasaurus* indicates the Whitaker quarry is of Apachean age, a correlative of the characteristic Apachean tetrapod assemblage in eastern New Mexico. Although long considered to be correlative to the Rhaetian marine stage, the Apachean is more likely slightly longer, equivalent to the latest Norian and the Rhaetian.

Technical Session XVI, Saturday 11:30

#### MODELS AND OREODONTS: TESTING METHODS FOR CODING POLYMORPHIC CONTINUOUS CHARACTERS

LUDTKE, Joshua, University of Calgary, Calgary, AB, Canada

Paleontological morphospecies are unique composites distinct from extant biological species. Whereas extant populations can only show variation over spatial ranges, morphospecies can show variation over temporal and spatial ranges. Amongst extinct mammals, these variations often occur in morphological characters related to size and can potentially show a significant amount of drift over time. These continuous character polymorphisms pose difficulties when attempting to infer the phylogenetic relationships between different morphospecies. While phylogenetic literature has discussed polymorphism within discrete characters, there appears to be much less discussion of polymorphism within continuous characters. Therefore it bears asking: what is the most accurate way to code polymorphic continuous characters? Using a dataset of measurements of dental characters in agriochoerid oreodonts, five different methods of coding were compared: a typological approach, coding the mean of all measurements taken for a morphospecies, coding the mean of random samples, coding the spread between one standard deviation above and below the mean of all data, and coding the entire range of known data. These different coding criteria were used to generate slightly different character matrices with both discrete and continuous characters, which were then analyzed with parsimony and Bayesian analyses to determine if different statistically significant topologies could be produced. In addition, character matrices testing these different methods on a generated matrix of hypothetical organisms were also analyzed. Although there is no way to verify any inferred topology of extinct organisms, the results of the analyses may point to the same types of conclusions that have been drawn from the analysis of polymorphism within discrete characters. In particular, this previous research has suggested that in phylogenetic analyses of clades with high levels of polymorphism, increasing the taxonomic sample is a more efficient method for improving phylogenetic accuracy than increasing the number of characters, a conclusion with implications for studies maximizing the number of characters.

Edwin H. and Margaret M. Colbert Poster Competition (Thursday)

#### A NEW BASAL CENTROSAURINE DINOSAUR (ORNITHISCHIA: CERATOPSIDAE) FROM THE UPPER CRETACEOUS KAIPAROWITS FORMATION, SOUTHERN UTAH

LUND, Eric, University of Utah, Utah Museum of Natural History, Salt Lake City, UT, USA

Ceratopsid dinosaurs are represented by numerous taxa that radiated throughout western North America (Laramidia) during the Late Cretaceous. Despite their abundance and diversity, the early evolution of Ceratopsidae remains enigmatic, due in part to the paucity of fossils from basal members of the clade. Recent work in the Upper Cretaceous (Campanian) Kaiparowits Formation in Grand Staircase-Escalante National Monument, Utah, has resulted in three exceptionally preserved specimens of a new genus and species of basal centrosaurine ceratopsid, including a nearly complete skull and multiple postcranial elements. The new Kaiparowits taxon exhibits several synapomorphies of Centrosaurinae, including: subtriangular rostral; semicircular and hypertrophied narial region; narial spine formed from contributions of nasal and premaxilla; expansion of ventral margin of premaxilla, forming characteristic "ventral angle"; and short, rounded parietosquamosal frill. In addition, the new Kaiparowits centrosaurine retains several symplesiomorphic features shared with basal non-ceratopsid neoceratopsians (e.g., *Magnirostris*, *Protoceratops*); the latter include: low ridge on nasal rather than true horncore; ventral displacement of maxillary alveolar margin below rostral; hypertrophied epijugals; and rostrocaudally abbreviated, dorsoventrally deep craniofacial region of skull. The new Kaiparowits centrosaurine also possesses a midline epiparietal, otherwise present only in *Avaceratops* and *Triceratops*. Finally, this new taxon possesses several cranial autapomorphies, including highly pneumatized nasals and laterally directed, rostrally curved, and torsionally twisted supraorbital horncores—absolutely the largest known within Centrosaurinae. Taken together, these data provide direct insight into the mosaic evolution of characters early in evolution of ceratopsids, and shed new light on the evolution of centrosaurine horned dinosaurs in particular.

New Perspectives on the Early Evolutionary History of the Synapsida, Saturday 12:00

#### HOMOPLASTIC EVOLUTION IN THE PRECURSOR STATES OF THE DEFINITIVE MAMMALIAN MIDDLE EAR (DMME) CHARACTERS IN THE EARLIEST MAMMALIAN TRANSITION

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Evolution of the definitive mammalian middle ear (DMME) in the transition from pre-mammalian synapsids to extant mammals is documented by numerous fossils. While an orderly and stepwise assembly of character complexes occurred in the evolution of some key mammalian apomorphies, transformations of other structures are neither orderly nor stepwise in the earliest evolution of mammals. As more taxa with disparate morphologies and unique mosaics of characters are being discovered and included in phylogenies, a result tends to be a stronger manifestation of homoplasies in morphological evolution. On the broadest scale of synapsid-mammal evolution, the evolution of the mammalian middle ear appears to be orderly and without the complication of homoplasy. However, recent discoveries of transitional taxa with unique combinations of features showed that this evolution is homoplastic on a finer scale with denser taxonomic sampling. The DMME in extant mammals has a stapedial process of the incus, and lacks a quadratojugal or ossified Meckel's cartilage connecting the mandible to the ear in adults. But their Mesozoic cynodontian and mammalian relatives showed prominent homoplasies in the precursor conditions of these apomorphies: (1) Reduction and loss of the quadratojugal help to increase the mobility of the middle ear. In transitional mammalian forms, the quadratojugal is retained in tritylodontids and brasilodontids, but lost in tritheledontids and mammaliaforms. (2) The quadrate (incus) stapedial process is a critical part of the lever system in mammalian middle ear. While this is absent in the mammaliaform *Sinoconodon* and tritheledontids, it occurs independently in tritylodontids, brasilodontids and Morganucodon. (3) Paedomorphic retention of an ossified Meckel's cartilage connecting the ear to the mandible in eutriconodonts, which are phylogenetically nested among living monotremes and therians that have otherwise lost the Meckel's cartilage and the primitive connection of the ear to the mandible as adults. The distribution of these homoplasies appeared to be random and divergent, before the mammalian evolution crossed the Rubicon of the definitive middle ear.

Technical Session VI, Thursday 2:45

#### SPECIES LEVEL RESPONSE OF BAENID TURTLES ACROSS THE CRETACEOUS/TERTIARY BOUNDARY

LYSON, Tyler, Yale University, New Haven, CT, USA; JOYCE, Walter, University of Tübingen, Tübingen, Germany

The Cretaceous/Tertiary (K/T) extinction is a well-studied global event likely caused by the impact of an extraterrestrial bolide. A few studies have previously analyzed the response of turtles to this event and most turtles reportedly survive into the Paleogene. However, like most K/T extinction studies, these studies either document changes in local diversity, thus potentially overestimating extinction by measuring local climate or facies changes, or they document changes in the presence of higher taxonomic ranks (e.g. genera, family, etc.), thus potentially underestimating true extinction at the species level. The excellent fossil record of baenid turtles, a speciose clade endemic to North America, provides an opportunity to analyze the extinction response of a particular clade at the continental level. As part of an ongoing research program, we systematically reviewed the alpha taxonomy of Baenidae and produced a comprehensive phylogeny that is resolved to the species level and that predicts a number of ghost lineages. The number of valid taxa was secondarily lowered by synonymizing shell and skull taxa that hold the same phylogenetic position and that originate from stratigraphically equivalent sediments. This analysis indicates that five out of eleven baenid lineages survived the K/T extinction event, which corresponds to a survival rate of 45%. The corresponding "background" extinction rate from the Campanian to the Maastrichtian is six out of eight baenid lineages (75% survival), which is significantly higher than the survival rate across the K/T boundary. If "species" (i.e., diagnosable taxonomic entities) were simply counted as present or absent between two time intervals, the extinction rate would have to be considered higher. Interestingly, three of the five baenid lineages that survive the K/T extinction event have a broad tritubing surface and are generally interpreted as durophagous. The results of this research are intriguing in that a group that supposedly passes through the extinction event relatively unscathed actually exhibits a 55% extinction rate.

Poster Session IV, (Saturday)

#### A NEW SPINOSAURID FROM THE CRETACEOUS ALCANTARA FORMATION (MARANHÃO), NORTHEASTERN BRAZIL

MACHADO, Elaine, Museu Nacional/UFRJ, Rio de Janeiro, Brazil; AZEVEDO, Sergio, Museu Nacional/UFRJ, Rio de Janeiro, Brazil; CARVALHO, Luciana, Museu Nacional/UFRJ, Rio de Janeiro, Brazil; HENRIQUES, Deise, Museu Nacional/UFRJ, Rio de Janeiro, Brazil; KELLNER, Alexander, Museu Nacional/UFRJ, Rio de Janeiro, Brazil

The theropod record in Brazil is extremely meager and consists of mostly isolated and incomplete specimens. Only six species were described so far: from the Triassic Santa Maria Formation (*Staurikosaurus pricei*), from the Late Cretaceous deposits of the Bauru Basin (*Pycnonemosaurus nevesi*), and four from the Albian Romualdo Formation of the Araripe Basin (*Santanaraptor placidus*, *Angaturama limai*, *Irritator challengeri*, and *Mirischia asymmetrica*). Here we provide the description of an isolated premaxilla (MN

6117-V) collected in the Cenomanian Alcântara Formation at the locality known as Laje do Coringa, Cajual Island, Maranhão State. This fossil concentration consists of hundreds of isolated elements that probably were reworked from previous deposits. The preserved part of the premaxilla is about 201mm long and 103mm high. It bears 7 alveoli on each side and is expanded laterally forming the typical terminal rosette reported in spinosaurid theropods. No tooth is complete but the preserved portions clearly lack serrations, a condition observed in the spinosaurids *Angaturama*, *Irritator*, and *Spinosaurus*, but differing from the finely serrated carinae of *Baryonyx*, *Cristatusaurus*, and *Suchomimus*. In ventral view, the rosette is more expanded than in *Angaturama* and has an almost circular shape, similar to *Spinosaurus*, but differing from the more oval shaped distal end of *Baryonyx*, *Suchomimus* and *Cristatusaurus*. In the third alveolus on each side two replacement teeth were observed, a feature that, to our knowledge, was not reported in theropods before. The new material from Maranhão further differs from *Angaturama* and *Irritator* by the lack of a sagittal crest (assumed to be present on the distal end of the latter). Up to date the new specimen represents the largest theropod recorded in the country and indicates a more diverse spinosaurid fauna in the Brazil coast during the Upper Cretaceous. The assignment of some putative spinosaurid teeth from the Bauru Basin that we have questioned before, are really unlikely to represent this distinct group of dinosaurs, limiting the spinosaurid record in Brazil to the middle part of Cretaceous.

Technical Session IV, Wednesday 4:30

#### THE EFFECTS OF EXTERNAL AND INTERNAL MORPHOLOGY ON LOAD DISSIPATION IN HOMININ CAPITATES: IMPLICATIONS FOR INTERPRETING HOMININ BEHAVIOR.

MACHO, Gabriele, University of Bradford, Bradford, United Kingdom; SPEARS, Iain, University of Teesside, Middlesbrough, United Kingdom; LEAKEY, Meave, National Museum of Kenya, Nairobi, Kenya

Bone morphology is known to be phylogenetically and ontogenetically constrained, while trabecular architecture is generally considered to be more plastic and to better reflect the habitual loads encountered by that bone. A combined analysis of internal and external bone structure thus promises to shed light on evolutionary processes as well as on the behavioral repertoire of individuals/species. This was explored for a number of extant primates with known locomotor and manipulatory behavior and compared with results derived from analyses of extinct australopithecids. Finite element models of primate capitates were created from high resolution mCT. For one set of analyses bones were given homogenous properties of bone, while for the other different properties derived from CT values were inputted into the models, thus mimicking the effects of trabeculae. Capitates were scaled to the same size and loaded at their heads. The proportion of total load directed towards the ulnar and radial aspect of the distal surface were recorded and the differences were compared. In arboreal species, trabeculae tend to re-direct the load applied towards the ulnar aspect, whereas in terrestrial species the re-direction was towards the radial aspect. The latter trend was further exacerbated in species with marked manipulatory capabilities, such as *Theropithecus oswaldi* and *Australopithecus afarensis*. Conversely, earlier hominins do not yet show this trend towards radially directed loads despite their somewhat derived external morphology. This finding suggests that a decreased dependence on arboreal behaviors and increased manipulatory capabilities only began with *A. afarensis*.

Poster Session I, (Wednesday)

#### TWO NEW EARLY DEVONIAN (LOCHKOVIAN) SPECIES OF THE ACANTHODIAN GENUS *BROCHOADMONES* FROM THE MOTH LOCALITY, NWT, CANADA, AND SIGNIFICANCE OF DENTAL VARIATION IN THE GENUS

MACKENZIE, Lindsay, University of Montana, Missoula, MT, USA; WILSON, Mark, University of Alberta, Edmonton, AB, Canada; HANKE, Gavin, Royal British Columbia Museum, Victoria, BC, Canada

The Early Devonian (Lochkovian) acanthodian *Brochoadmones milesi*, with its elaborated series of pre-pelvic spines and reduced pectoral fin and spine, was previously thought to be the only species in the family Brochoadmonidae, in the traditional but probably paraphyletic order Clamatiiformes. Two new species of *Brochoadmones* have been discovered at the extraordinarily diverse MOTH locality, Mackenzie Mountains, Northwest Territories, Canada, and presently, this is the only location where undoubted specimens of *Brochoadmones* have been recovered. There are multiple specimens for each new species, ranging from partial to nearly complete body fossils. The new species are distinguished from *B. milesi*, and from each other, by the structure of their scales, the length and ornamentation of their fin spines, and by the number and shape of their pre-pelvic paired spines. The new species, together with further study of specimens of *B. milesi*, demonstrate additional features of dentition. All three species of *Brochoadmones* possess tooth whorls lining the upper and lower jaw margins as well as pharyngo-branchial denticles. The three species differ in tooth whorl and denticle structure allowing isolated whorls to be identified to species. The common feature of their whorls and denticles reinforce the distinctions between dentitions of primitive acanthodians and that of other early eugnathostomes such as putative stem-group chondrichthyans.

Poster Session II, (Thursday)

#### THE POSTCRANIAL ANATOMY OF PROCONSUL MAJOR

MACLATCHY, Laura, University of Michigan, Ann Arbor, MI, USA; DESILVA, Jeremy, Boston University, Boston, MA, USA

Four species of the catarrhine Proconsul are known from Early Miocene sites in Kenya and Uganda. Body weight estimates are ca. 10-20 kg for both *P. heseloni* and *P. africanus*, 30-40 kg for *P. nyanzae*, and 60-90 kg for *P. major*. Previous studies of the three smallest species have found the postcrania to be similar, and compatible with above branch quadrupedalism. However, *P. major* postcrania are sparse and locomotor adaptations are poorly known. It has been argued on the basis of its large size that it may have been either more terrestrial, or more suspensory, than the smaller species. Here we report on a new distal humerus and proximal radius, and functionally interpret a distal tibia, of *P. major* from the ca. 20 Ma Napak localities, Uganda. The radial head is posterolaterally flattened, as in extant quadrupeds, and so differs from *P. africanus* and extant hominoids. The lateral lip is wide. Both these features maximize surface area contact between the radius and humerus during quadrupedal weight bearing. However, the articular facet for contact with the humeral capitulum is wide as in extant hominoids. Correspondingly, the capitulum is spherical, and the zona conoidea is deep, suggesting more stability during forearm rotation than found in typical quadrupeds. Of extant anthropoids, the elbow morphology most resembles that of *Nasalis*. Previous work on the Napak distal tibia has found that it may be a scaled-up version of smaller Proconsul tibiae. However, a resampling approach comparing the tibial morphology in extant catarrhines shows it to be distinct from other Proconsul tibiae in possessing a thick medial malleolus and a wide anterior aspect of the talar surface. These differences are functionally related to loading the ankle in positions of dorsiflexion and inversion. Kinematic studies of extant primates have found that these foot positions are important during orthograde vertical climbing bouts. These new fossils and analyses, when integrated with data from other postcranial remains, suggest that *P. major*, while still using above branch behaviors, may have had a different locomotor repertoire than the smaller Proconsul species.

Poster Session I, (Wednesday)

#### EVOLUTION OF THE NEUROCRANIUM IN CAECILIIDAE (GYMNOPHIONA)

MADDIN, Hillary, University of Calgary, Calgary, AB, Canada

The debate regarding the origin(s) of Lissamphibia remains a contentious issue in paleontology, as the results from several of the most recent phylogenetic analyses continue to yield conflicting hypotheses. Several factors pertaining to the nature of these datasets have been identified as the causes of this conflict, including the need for new sources of data, and the large amounts of missing data and uncertainty surrounding the polarity of characters for poorly known taxa. Among the most relevant groups that suffer from these weaknesses is Gymnophiona (caecilians). Historically caecilians are rare components of museum collections, often being known from only holotype material or very few specimens, thus limiting the extraction of character data to accessible anatomy in a subset of abundant taxa. The application of non-destructive imaging techniques, such as high-resolution CT (hrCT), has facilitated the investigation of previously inaccessible skeletal anatomy, thereby permitting its use in addressing this paleontological issue. As the vital first step towards gaining a more complete understanding of neurocranial evolution in Gymnophiona as a whole, a survey of the neurocranium and its associated anatomy in representative members of the most derived and taxonomically diverse caecilian clade, Caeciliidae, is conducted using hrCT. Thirteen new characters pertaining to the neurocranium are identified. These characters are analyzed within the context of caeciliid phylogeny, and the plesiomorphic state of the caeciliid neurocranium is inferred. The relevance and utility of each of the new characters is discussed as each applies to the lissamphibian origin(s) debate. Notably, it is revealed that details of the caeciliid sphenethmoid appear to more closely resemble those of microsaurians, whereas the overall pattern of cranial nerve foramina lies within the range of variation seen in frogs, salamanders, and other dissorophoids. The new information gained here provides a foundation for future study of more basal caecilian taxa, which, taken together, lead to the ultimate goal of determining the plesiomorphic condition of the neurocranium for the entire Gymnophiona.

Poster Session I, (Wednesday)

#### CARNIVORA FROM THE LATE EARLY PLEISTOCENE OF CAL GUARDIOLA (TERRASSA, VALLES-PENEDES BASIN, CATALONIA, SPAIN).

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We report the carnivoran faunal assemblage from the late Early Pleistocene site of Cal Guardiola (UTM 31T DG1702), which is situated in the western bank of the Torrent de Vallparadís, within the town of Terrassa (el Vallès Occidental, Catalonia, Spain). This locality was discovered in 1997, during the construction of a socio-sanitary building next to the Mútua de Terrassa. Paleontological excavation of 691 m<sup>2</sup> led to the discovery of abundant macro- and microvertebrate remains, as well as fossil wood and pollen, which were recovered from fossiliferous beds caused by massive mud-flow and debris-flow catastrophic events. The composition of the fauna and flora enables to infer the existence of a warm-temperate and humid riverine/rivermarsh ecosystem. The large mammal

remains recovered from Cal Guardiola include well-preserved carnivoran specimens of the following taxa: *Ursus deningeri*, *Canis mosbachensis*, *Vulpes praeglacialis*, *Pachycrocuta brevirostris*, *Homotherium latidens* and *Panthera cf. gombaszoeensis*. On the basis of magnetostratigraphic data, these sediments are clearly situated below the Brunhes-Matuyama geomagnetic boundary, so that an age older than 0.8 Ma can be inferred. This agrees with the rodent fauna recorded at the site, which includes *Mimomys savini*, *Allophaiomys chalinei* and *Allophaiomys cf. burgondiae*. As such, Cal Guardiola records the latest Epiplafanchian carnivores from the Iberian record, just before the arrival of true Galerian elements, such as *Crocuta crocuta*, *Panthera pardus* and *P. leo*. Among others, the faunal assemblage from Cal Guardiola includes one of the latest records of *Pachycrocuta* in Western Europe. It is also noteworthy that the ursid from Cal Guardiola is one of the earliest representatives of the cave-bear lineage, first recorded in the Vallonnet Cave.

Technical Session I, Wednesday 8:15

#### MAXIMUM LIKELIHOOD ESTIMATION OF BIOGEOGRAPHIC HISTORIES USING THE FOSSIL RECORD

MAGUIRE, Kaitlin Clare, UC Berkeley, Berkeley, CA, USA; MATZKE, Nicholas, UC Berkeley, Berkeley, CA, USA

A new historical biogeographic method, Likelihood Analysis of Geographic Range Evolution (LAGRANGE), addresses assumptions and problems associated with current parsimony methods used in paleontology by modeling ancestral ranges in a likelihood framework. Here we demonstrate the use of this new method by using it to examine the diversification of equids in North America during the Miocene. LAGRANGE represents a breakthrough in paleobiogeography because it uses a character evolution approach that infers the biogeographic range of an ancestral node based on the branch lengths of its daughter species. Paleontologists have traditionally used biogeographic methods that employ a cladistic framework and parsimony methods to determine repeated patterns of area relationships and/or to reconstruct ancestral ranges (e.g. Tree Recognition Analysis, Brooks Parsimony Analysis). Unlike previously used methods, LAGRANGE does not assume vicariance as the primary mode of speciation and includes dispersal and local extinction rates that can be modified *a priori* based on known historical events. This new method was originally developed to determine the ancestral ranges of extant species. Here we modify LAGRANGE to incorporate extinct species by including fossil occurrences. To do so, fossil occurrences are added to the phylogeny as terminal taxa with short branch lengths. Each fossil occurrence is added to the phylogeny based on its stratigraphic age. Including fossil occurrences in ancestral range reconstructions confines the time period and areas in which a species diversified, resulting in more accurate analyses of geographic speciation patterns. The reconstructed ancestral ranges from the LAGRANGE analysis are compared to parsimony methods. In addition, dispersal and extinction parameters are adjusted to determine how including or excluding historical events influences the results, and the analysis is run including and excluding species occurrences with uncertain identifications.

Technical Session XVII, Saturday 1:45

#### INTERNAL CRANIAL ANATOMY OF BRASILDONTIDS AS DETERMINED BY MICRO-CT

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An as yet undescribed specimen of *Brasilitherium* spec. (no. 1043) from the Late Triassic of Rio Grande do Sul (Brazil) was studied by means of Micro-CT (RaySan 200). This specimen showed relatively well preserved structures of the nasal and brain cavities, which were analyzed with the software VGStudio Max 1.1 and Amira 3.1.1-4. In the anterior nasal floor the gutter-like medial palatal process of the premaxillary indicates the presence of an elongated vomeronasal organ of the mammalian type. For the first time, delicate remnants of maxillo-, naso- and ethmoturbinals are demonstrated in a member of the stem-group of mammaliaforms. The two ethmoturbinals are housed in a paired ethmoturbinal recess slightly expanding posteriorly at the side of the olfactory bulbs. Although the epipterygoid / alisphenoid and the orbitosphenoid are fairly broad, the lateral fontanella of the braincase is still wide. A new interpretation of the pterygoid process and fossa with respect to the origins of the muscles of the soft palate is suggested. The basicranial joint between the alisphenoid and the prominent basitrabecular process shows a peculiar transversal orientation. The hypophyseal fossa is well pronounced. The posterior fossa of the braincase is anteriorly bound by very prominent, though delicately built antotic pillars; laterally these pillars show concave and rounded dorsal margins which are interpreted as relatively large trigeminal incisures leading into the wide and open epipterygoid cavities. The size of the trigeminal nerve seems to be in accordance with the well differentiated nasal and rostral, nasal and buccal systems of these animals. The reconstruction of the endocast of the petrosal labyrinth is characterized by a short and stout cochlear recess. The anterior semicircular canal frames a marked subarcuate fossa. A displaced stapes was discovered in the orbital area, and it appears to be of the primitive type of advanced cynodonts. The presented new anatomical data are a contribution to improve our understanding of the groundplan and the functional adaptations of the stem-group of mammaliaforms.

Poster Session III, (Friday)

#### JURASSIC & CRETACEOUS PALEO GEOGRAPHIC CONNECTIVITY, DINOSAUR BIOGEOGRAPHY & THE PALEO BIOGEOGRAPHIC INDEX MAIN, Derek, University of Texas at Dallas, Richardson, TX, USA; SCOTSE, Christopher, University of Texas at Arlington, Arlington, TX, USA; NOTO, Christopher, Grand Valley State University, Allendale, MI, USA

As Pangea broke apart in the Jurassic, expanding ocean basins separated terrestrial ecosystems in tropical and temperate latitudes. However, at the Polar Regions, land areas remained connected throughout most of the Jurassic and Cretaceous. In the northern hemisphere, terrestrial migration routes can be traced eastwards from Greenland to Europe and northern Asia throughout the Jurassic and Cretaceous via Barentsia. Connections between western North America and northeastern Eurasia, through Beringia, were more sporadic, but a good case can be made that Arctic Canada and Siberia were connected continuously from the Albian. In the southern hemisphere, migration pathways were more complex. South America, Africa, Madagascar, India, Antarctic and Australia were interconnected throughout the Jurassic and the Cretaceous. However, in the Albian, India and Madagascar became isolated from Gondwana. A paleobiogeographic connectivity index was developed to predict the availability of land bridge connections and the probability of terrestrial dispersal. Over time, the paleobiogeographic score decreases with increased separation of the continents. In order to investigate the effect of paleogeographic connectivity on dispersal and paleobiogeographic patterns, dinosaur distributions were plotted on 2-D rectilinear and 3-D polar projection maps of the Late Jurassic (Oxfordian, Kimmeridgian, Tithonian) and Early Cretaceous (Berriasian and Hauterivian, Albian, Cenomanian). The maps were created utilizing Arcmap 9.2, Point Tracker 4.0 and dinosaur localities from an updated Dinosauria database. In this paper we present 16 paleobiogeographic maps of dinosaurs that illustrate the polar paleobiogeographic pathways that connected the continents during the Late Jurassic and Early Cretaceous.

Technical Session XV, Saturday 11:00

#### TWO NEW COELUROSAURS FROM THE EARLY CRETACEOUS XINMINPU GROUP OF GANSU PROVINCE, CHINA.

MAKOVICKY, Peter, Field Museum of Natural History, Chicago, IL, USA; LI, Da-qing, Gansu Bureau of Geology and Mineral Resources Exploration, Lanzhou, China; GAO, Ke-Qin, Peking University, Beijing, China; NORELL, Mark, American Museum of Natural History, New York, NY, USA; ERICKSON, Gregory, Florida State University, Tallahassee, FL, USA

Joint fieldwork by Chinese and American institutions in rocks of the Aptian-Albian Xinminpu Group in the Yujingzi Basin, Gansu Province, China, has yielded several new dinosaur taxa including a tyrannosauroid and an ornithomimosaur. The new tyrannosauroid, *Xiongguanlong baimoensis* represents a phylogenetic, morphological, and temporal link between the disjunct Late Jurassic-Barremian and Campano-Maastrichtian parts of the tyrannosauroid fossil record. *Xiongguanlong* is the sister-taxon to Tyrannosauridae plus *Appalachiosaurus* and marks the earliest appearance of several tyrannosaurid traits, such as a parietal sagittal crest, a boxy basicranium, a flared quadratojugal dorsal ramus with a flexed caudal edge, premaxillary teeth with median lingual ridges, and an expanded axial neural spine with dorsolateral processes. *Xiongguanlong* has a long and narrow muzzle like those of *Alioramus* and juvenile tyrannosaurids, although its nasals are unornamented.

Three specimens of a new ornithomimosaur, *Beishanlong grandis*, were discovered. *Beishanlong* is similar to *Harpymimus*, with which it shares a phylogenetic position as more derived than *Shenzhousaurus* and as sister to a clade uniting all Late Cretaceous ornithomimosauroids. Autapomorphies of *Beishanlong* include dorsally notched anterior caudal neural spines and ventral keels on mid-caudal centra. It is one of the largest ornithomimosauroids yet described, though histology reveals that the holotype individual was still growing when it died.

The new taxa are part of a fauna also comprising therizinosaurs, hadrosauroids, neoceratopsians, and small and large deinonychosaurs. Most Cretaceous faunas of China and Mongolia comprise members of these, but very few other, dinosaur lineages. Neoceratopsian and maniraptoran dinosaurs tend to dominate xeric red-beds across Cretaceous localities of the Gobi Basin, whereas tyrannosauroids, hadrosauroids, and ornithomimosauroids are prevalent in more mesic deposits. The fauna of the Yujingzi Basin represents one of the earliest instances of both environmentally mediated faunal sorting and the very stable, but depauperate, lineage composition of Cretaceous Central Asian dinosaur faunas.

Poster Session IV, (Saturday)

#### ALLOSAURUS FRAGILIS FROM THE PORTUGUESE UPPER JURASSIC MALAFAIA, Elisabete, Laboratório de História Natural da Batalha, Batalha, Portugal; ORTEGA, Francisco, Fac. Ciencias. UNED, Madrid, Spain; ESCASO, Fernando, Fac. Ciencias. Universidad Autónoma de Madrid, Madrid, Spain; DANTAS, Pedro, Laboratório de História Natural da Batalha, Batalha, Portugal; GASULLA, José Miguel, Fac. Ciencias. Universidad Autónoma de Madrid, Madrid, Spain

The description of *Allosaurus fragilis* in the Andres quarry (Pombal, Portugal) has been used as an argument to support the hypothesis about dispersion events of continental vertebrate faunas between North America and Iberian Peninsula during the Upper Jurassic. However,

the recent description of the new species *A. europaeus* supported by a suite of cranial remains extracted from the synchronous quarry of Praia de Vale Frades (Lourinhã) is not congruent with the available information from the Andrés specimens and has important paleogeographic implications. Here a discussion about the diagnosis of *A. europaeus* based on the description of the holotype as well as in personal observations is presented. *A. europaeus* was justified by a series of primitive characters for Tetanurae that are in some cases submitted to intraspecific variations. This is the case, for example of the following characters: the anterior tip of the quadratojugal anterior to the laterotemporal fenestra, the ventral extremity of the squamosal projecting ventrally into the laterotemporal fenestra, the presence of two pneumatic foramina of different size in the nasal and the rough dorsal rim of the nasal. These two last characters are also present in some *A. fragilis* specimens and hence don't contribute for the taxon diagnosis. These characters were also recognized in nasal fragments from the Andrés quarry. The trait that would be more stout to define *A. europaeus* is the described suture between the jugal, the lacrimal and the maxilar. The morphology of this contact is expressed by means of two equivalent characters: the jugal contacts with the anteorbital fenestra and doesn't exist contact between the lacrimal and the maxilar. However, observations of the Praia de Vale Frades specimen suggest the anterodorsal outline of the jugal is similar to that of the North American *A. fragilis* specimens. Based on the argumentation presented above we consider that for the moment it doesn't exist enough features supporting the diagnosis of an endemic *Allosaurus* species in the Portuguese Upper Jurassic.

Poster Session IV, (Saturday)

#### REARING GIANTS: A BIOMECHANICAL ASSESSMENT OF SAUROPOD REARING CAPABILITIES

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The feeding heights of sauropods have seen ample debate, mostly focused on neck posture. As early as 1901, Hatcher suggested that sauropods could adopt a bipedal or tripod (with tail support) upright pose to increase their feeding range. This notion has been reiterated by both popular books and films as well as scientific publications, especially for titanosaurs. As alternative uses of an upright posture inter- and intraspecific combat and display have been suggested. So far, however, no biomechanical investigation of sauropod rearing capabilities has been undertaken, except for an investigation of pathologies potentially resulting from repeated rearing. A main factor for obtaining and sustaining an upright body posture is the position of the center of mass (COM). In sauropods, the long tail and short forelimbs along with postcranial pneumaticity shift the COM posteriorly compared to mammals. However, other factors such as limb extensor muscle mass and issues of stability in the upright pose also play an important role. No extant animal with a body weight greater than 250 kg rear habitually and regularly for feeding. However, during times of draught, elephants rear regularly to reach feeding heights beyond even those of giraffes, opening up food sources otherwise inaccessible. This behavior is energetically less effective than quadrupedal feeding, but ensures increased survival chances under extreme conditions. A comparison of extant animals to sauropods with regards to rearing must therefore include elephant rearing. Results of detailed kinetic/dynamic NASTRAN computer modeling of sauropod rearing motions and pose stability in comparison to extant elephants indicate the ability to rear for prolonged times as a means of fodder acquisition may be an ancestral trait in sauropods, was lost in some derived clades including titanosaurs, and emphasized in diplodocids. These results have implications for paleobiological and biogeographical interpretations.

Technical Session XIII, Friday 3:15

#### GENERAL INSIGHTS INTO THE ORGANISATION OF THE MEGAHERBIVORE ASSEMBLAGE FROM THE DINOSAUR PARK FORMATION (LATE CAMPANIAN) OF ALBERTA

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The late Campanian Dinosaur Park Formation of Alberta preserves an abundance of large, herbivorous hadrosaurids, ceratopsids, and ankylosaurs. At some horizons within the formation, as many as nine of these megaherbivores are simultaneously present. How so many of these animals could coexist is a question of interest because similar megaherbivore diversity is rarely seen elsewhere. We examined various aspects relating to the ecomorphology of these animals, including dental microwear, jaw mechanics, and cranial morphometrics, in order to better understand how they might have partitioned the herbivore niche through time. Dental microwear analysis demonstrates a separation among these higher-level taxa according to the relative abundance of pits and scratches. Ceratopsids have a low pit percentage (31+/-12%) compared to hadrosaurids (68+/-17%) and ankylosaurs (59+/-19%). This suggests a propensity in the former for feeding on fibrous foodstuffs, particularly in light of their shearing dental batteries. Lever modeling of the jaw apparatus, using the middle of the tooth row as the effective bite point, also shows separation among these groups. Biting is most efficient in hadrosaurids (97+/-24%), followed by ceratopsids (71+/-11%) and ankylosaurs (54+/-11%). Increased efficiency between these groups appears to be due to increased height of the coronoid process, depression of the jaw joint below the level of the tooth row, and migration of the tooth row caudal to the coronoid process. A principal component analysis of 17 cranial variables related to feeding shows further ecomorphological distinction between these taxa. Ankylosaurs separate from ceratopsids and

hadrosaurids along PC1, which accounts for differential elongation of the face in addition to changes in size. Ceratopsids and hadrosaurids separate along PC2, which describes changes in both occipital width and tooth row length. These differences likely relate to biting efficiency and feeding selectivity. The megaherbivorous dinosaur groups of the Dinosaur Park Formation thus appear to have achieved coexistence via differential ecomorphology, thereby facilitating food partitioning.

Poster Session I, (Wednesday)

#### THE SMALL VERTEBRATE ASSOCIATION FROM QUIBAS (MURCIA, SPAIN) AND THE ENVIRONMENTAL CONTEXT OF EARLY HUMAN DISPERSAL IN WESTERN EUROPE

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The early Pleistocene site of Quibas is a part of the karstic complex placed in the Sierra de Quibas, in the region of Murcia (SE Spain). The main interest of this site lies in its rich vertebrate assemblage, which is very close in age to the sites which have delivered the first evidence of human presence in Western Europe, such as Fuente Nueva 3 and Barranco León, in the Guadix-Baza Basin, and Sima del Elefante, in the Atapuerca karstic complex. The small vertebrate association includes amphibians, squamates, insectivores, bats, rodents and lagomorphs. Squamate reptiles constitute a very important part of the small-vertebrate assemblage of Quibas, especially snakes, geckos and amphisbaenians. A particular characteristic of the herpetofaunal association of Quibas is the presence of extinct taxa such as a large anguid (*Dopasia*) and agamid lizards. In the Iberian Peninsula, the last mention of genus *Dopasia* comes from the early Pleistocene localities of Barranco León and Fuente Nueva 3, whereas the last mention for agamid lizard comes from some latest Pliocene karstic sites from Barcelona (Vallirana) and Castellón (Almenara-Casablanca 1). Concerning the bat fossils, unusually high species richness is observed. At least 11 different taxa are represented in the material so far analyzed, comprising both cave and forest species. The insectivores represent a lower richness, with remains of an erinaceid and three soricids. The rodent association is dominated by a rootless microtine (*Allophaiomys* sp.), which is also present at the sites of Fuente Nueva 3 and Barranco León. It is accompanied by murids (*Apodemus* sp., *Castillomys rivasi*), gliroids (*Eliomys* aff. *quercinus*) and sciurids (*Sciurus* sp.). As a whole, such an association suggests warm and humid conditions with important rocky-dry habitats at proximity of the cave but with a larger patchy open wooded landscape, with a high amount of precipitations, therefore composing a favorable setting for the entry of hominids in the region, as evidenced by the human remains preserved in nearby localities of similar age.

Technical Session XV, Saturday 8:15

#### A FINITE ELEMENT APPROACH TO THE BIOMECHANICS OF DROMAEOSAURID DINOSAUR CLAWS

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Dromaeosaurid theropod dinosaurs possessed strongly recurved, hypertrophied and hyperextensible ungual claws on both the pes (digit II) and manus. The morphology of these unguals has been linked to the capture and dispatching of prey. The effectiveness of the enlarged pedal digit II ungual as a disemboweling implement has been challenged by recent experiments using a hydraulic reconstruction of a dromaeosaurid hind limb. However, the mechanical properties or, more importantly, the mechanical potential of these structures have not been explored. The generation of a 3D finite element (FE) stress/strain contour map of a Velociraptor manual ungual has for the first time allowed quantitative evaluation of the mechanical behavior of a dromaeosaurid terminal ungual phalanx. The role of the finite element analysis was to test the relationship of form and function, from an engineering point of view. X-ray microtomography scans have allowed the construction of an accurate 3D finite element mesh. Analogue biomaterials from an extant avian theropod, the pedal digit and claw of an eagle owl (*Bubo bubo*), were analysed to provide input data for the Velociraptor claw FE model. The resultant finite element model confirms that claws of dromaeosaurid dinosaurs were well-adapted for climbing as they would have been resistant to forces acting in a single (longitudinal) plane, in this case due to gravity. However, the strength of an ungual claw was limited with respect to forces acting tangential to the long-axis of the structure. The tip of the claw functioned as the puncturing and gripping element of the structure, while the expanded proximal portion transferred the load stress through the cortical and cancellous bone. Claw form and function varies widely among vertebrates however, claw sheath composition does not. The possession of a keratinous sheath also played an integral role in the distribution of load stress into the bone core of the claw. The proposed enhanced climbing abilities of dromaeosaurid dinosaurs, a function of pedal morphology, support a scansorial phase in the evolution of flight.

**A MULTIDISCIPLINARY APPROACH TO ELUCIDATING THE EFFECTS OF SAMPLING BIASES ON DIVERSITY: IMPLICATIONS FOR SAUROPODOMORPH DINOSAURS**

MANNION, Philip, University College London, London, United Kingdom

Deducing diversity patterns is an important element in understanding the macroevolutionary history of a group of organisms. However, there is increasing evidence suggesting observed diversity merely mirrors fluctuations in the rock record; thus, any patterns we see may purely reflect sampling biases. In order to test this, sauropodomorph dinosaurs have been used as a case study. These were an important component of Mesozoic terrestrial ecosystems and their evolutionary relationships are well understood. A taxic diversity curve has been produced for all valid sauropodomorph genera, as well as five phylogenetically corrected curves. These have been compared statistically with several sampling proxies, including a new completeness metric. Models that are perfect predictors of diversity have been created using these proxies, then subtracted from diversity to leave a residual diversity signal that cannot be explained in terms of sampling biases. Numbers of dinosaur collections show a strong correlation with Mesozoic diversity, while Cretaceous diversity is also correlated with sea-level and dinosaur-bearing formations. Additionally, individual-based rarefaction has been implemented to correct for sample size; this is the first time this has been carried out for dinosaurs. After correcting for biases, sauropodomorph diversity appears to be genuinely high in the Pliensbachian-Toarcian, Bajocian-Callovian, Kimmeridgian-Tithonian and Aptian, while low diversity levels are recorded for the Oxfordian and Berriasian-Barremian, with the J/K boundary seemingly representing a real diversity crash. Diversity in the remaining Triassic-Jurassic Stages appears to be largely controlled by sampling biases. Late Cretaceous diversity is difficult to elucidate and it is possible that this Epoch remains relatively under-sampled. Although distorted by sampling biases, much of sauropodomorph diversity is a reflection of a genuine biological signal. This study illustrates that use of a number of proxies is imperative in any attempt to tease apart genuine diversity from the biases of an uneven rock record, and it is hoped that similar methods will be applied to other taxonomic groups.

Technical Session IX, Thursday 3:45

**THE TAPHONOMY OF TWO MICROFAUNAL FOSSIL ASSEMBLAGES FROM NORTHWESTERN KENYA**

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A key question in paleontology concerns the processes through which faunal assemblages would have accumulated. Taphonomic studies have been carried out on assemblages of microfauna from two Pliocene localities in north-western Kenya, in order to understand the agent/s responsible for their accumulation and the taphonomic processes that have influenced the assemblages. Characteristics of the assemblages such as the high representation of nearly all skeletal elements suggest that the faunal assemblages accumulated by way of predation. The intention of this presentation is to highlight work in the two Kenyan sites, and to underline the importance of taphonomic studies in understanding the different process that affect faunal assemblages.

Poster Session IV, (Saturday)

**MULTIVARIATE ANALYSIS AND MORPHOLOGICAL DESCRIPTION OF THE CERVICAL COLUMN OF *MAIACETUS INUUS*: IMPLICATIONS FOR HEAD AND NECK MOVEMENT IN A PROTOCETID CETACEAN FROM PAKISTAN**

MANZ, Carly, University of Michigan, Ann Arbor, MI, USA; BEBEJ, Ryan, University of Michigan, Ann Arbor, MI, USA; GINGERICH, Philip, University of Michigan, Ann Arbor, MI, USA

Semiaquatic protocetid whales possessed skeletal morphologies intermediate between those of their terrestrial ancestors and modern, fully aquatic Cetacea. Understanding how their morphology enabled them to negotiate contrasting environments is vital for documenting this transition from land to sea. Movements of the head and neck are facilitated or restricted by the cervical column. *Maiacetus inuus*, a recently described protocetid from the Habib Rahi Formation of Pakistan, was chosen for a detailed study of the cervical column because it is one of the most complete archaeocetes known and its neck can be examined in the context of other important semiaquatic features of the body. A principal components analysis (PCA) of cervical measurements of *M. inuus* and 20 extant terrestrial to fully aquatic mammals, reduces the variation in these taxa to two main principal components. While PC1 differentiates taxa based on size, PC2 adequately orders extant species by the degree of their aquatic habits. *M. inuus* clearly fell in the semiaquatic range on PC2, plotting closer to completely aquatic taxa. It has relatively wide vertebrae that could distribute compressional forces or stabilize the head against lateral movements while it was swimming, needs that are accomplished in modern Cetacea by further widening and compression and fusion of the cervical column. While the vertebrae of *M. inuus* are relatively short compared to other semiaquatic mammals, they are long enough to have allowed independent head and neck movements while on land. *M. inuus* has eccentric vertebral body articulations and flat, oblique zygapophyses that are consistent with considerable mobility of the neck. Large spinous and transverse processes indicate connections to powerful muscles that would allow *M. inuus* to move its head and neck freely on land and in the water while hunting, but could also be used during swimming to stabilize the head. The neck of *M. inuus* is congruent with

other aspects of the skeleton in exhibiting a morphological compromise, allowing efficiency in its dual terrestrial and aquatic environments.

Poster Session II, (Thursday)

**A NEW GENUS AND SPECIES OF ADAPIDAE (MAMMALIA, PRIMATES) FROM THE MIDDLE EOCENE OF MAZATERÓN (ALMAZÁN BASIN, SORIA, SPAIN)**

MARIGÓ, Judit, Institut Català De Paleontologia, Universitat Autònoma De Barcelona, Cerdanyola Del Vallès, Spain; MINWER-BARAKAT, Raef, Institut Català De Paleontologia, Universitat Autònoma De Barcelona, Cerdanyola Del Vallès, Spain; MOYÀ-SOLÀ, Salvador, Icrea At Institut Català De Paleontologia And Bave Department, Universitat Autònoma De Barcelona, Cerdanyola Del Vallès, Spain; CUESTA, Miguel Ángel, Departamento De Geología, Facultad De Ciencias, Universidad De Salamanca, Salamanca, Spain

In this work we report the discovery of a new adapid primate from the Robiacian (middle Eocene) site of Mazaterón (Soria, Spain). For this new genus and species, assigned to the Tribe Anchomomyini, more than 60 dental pieces have been recovered, and almost all the dental elements are represented.

This new genus shows clear morphological and biometrical differences with the other Anchomomyini (*Anchomomys*, *Periconodon* and *Buxella*). In particular it shows extremely mediolaterally compressed P/3 and P/4, with the P/3 larger than the P/4, highly imbricated premolars, with overlapping crowns and continuous basal cingula. It differs from *Periconodon* in lacking a pericone, in the considerably reduced hypocone, in lacking a metaconule, in having the hypoconulid lobe more lingually placed on the M/3 and in the better-developed protocone in the upper molars. It can be also distinguished from *Buxella* in lacking a pericone, in the much more reduced hypocone, in the more buccal cristid obliqua, in the more lingual hypoconulid lobe, and in lacking a paraconid and a well-developed premetacristid.

It is more similar to *Anchomomys* sharing relative small hypocone, absence of metaconule and pericone, reduction or absence of paraconid and triangular upper molar shape. However it differs from the species of this genus in the peculiar morphology of the lower premolars described previously, in the very reduced metacone and hypocone of the upper molars, in the presence of a single root in the P2/ and in its large size.

The new primate taxon discovered in the site of Mazaterón (Soria, Spain), reinforces the endemic nature of the Western Iberian Bioprovince during the Middle Eocene and its isolated situation from the southern Pyrenees and the rest of Europe.

Poster Session IV, (Saturday)

**A CLOSER LOOK AT THREE PUBLISHED DATA MATRICES REVEALS SUPPORT FOR THE "LEPOSPONDYL HYPOTHESIS" ON THE ORIGIN OF EXTANT AMPHIBIANS**

MARJANOVIĆ, David, CNRS UMR 7207, Paris, France; LAURIN, Michel, UMR 7207, Paris, France

Despite decades of intensive research, the origin of the extant amphibians remains controversial. Of the morphological phylogenetic analyses of limbed vertebrates published in the last few years, some have found a monophyletic Lissamphibia nested in the temnospondyls (the "temnospondyl hypothesis"/TH), some have found the same nested in the lepospondyls (the "lepospondyl hypothesis"/LH), and some have found some extant amphibians to be lepospondyls and others to be temnospondyls (the "polyphyly hypothesis"/PH). We have tested the accuracy of three recently published data matrices, two of which supported the PH and one of which supported the TH, and disagree with the scoring of many cells; this includes a spectrum from differences of interpretation of how to delimit character states or whether to split or merge characters, over cases where states of ontogeny-related characters in immature or paedomorphic specimens were taken at face value instead of scored as unknown, all the way to (numerous) unambiguous mistakes that are best explained as typographic errors. We have also ordered all potentially continuous multistate characters. In one of the matrices that supported the PH, we disagree with the scoring of 35% of the cells; when these are changed, the TH results, and when the lepospondyl *Brachydectes* and the temnospondyl *Gerobatrachus* are added or *Doleserpeton* is considered morphologically immature, the LH results. The second such matrix, which accompanied the description of *Gerobatrachus*, strongly supports the LH. Preliminary work on the largest matrix that supported the TH similarly finds support for the LH to be highest. We thus confirm the previous finding that errors in data matrices have a large impact on the results of phylogenetic analyses. We further offer new interpretations of the skull roof of *Brachydectes* and the teeth and tarsus of *Gerobatrachus* and suggest, based on (in part recent) literature, that pedicellate teeth could be more widespread than usually thought. Finally, as occasionally suggested in the literature, Albanerpetontidae could be the sister-group of Lissamphibia rather than a member of it.

Poster Session I, (Wednesday)

**TWO SMALL SCOTTISH MIDDLE DEVONIAN PLACODERMS IN ESTONIA**  
MARK-KURIK, Elga, Institute of Geology at Tallinn University of Technology, Tallinn 19086, Ehitajate tee 5, Estonia

The Middle and Late Devonian basins in Scotland and the Baltic area were for a long time considered as isolated freshwater bodies, inhabited with endemic fishes. These faunas differed partly on generic and particularly on species level. Revision of psammosteid heterostracans demonstrated that some typically Baltic species, *Psammolepis undulata*, *Psammosteus megalopteryx* and *P. falcatus*, occurred also in Scotland. In 1997 an international team with an aim to contribute to the correlation of both regions studied fish collections in London and Edinburgh. The leader of the team was P. E. Ahlberg. Tarlo's identifications were verified. Very close species were recognized also among the representatives of other groups. It was known since Gross' and Westoll's time that several arthrodire and antiarch genera, *Coccosteus*, *Homostius*, *Asterolepis* and *Bothriolepis*, were identical in the Baltic area and Scotland. Later more genera, *Plourdosteus*, *Watsonosteus* and *Microbrachius*, were added. Gross identified *Coccosteus* cf. *minor*, similar to a Scottish endemic arthrodire (at present in the genus *Millerosteus* Stensiö), in NE Estonia. The Estonian specimen, a single minute plate appeared to belong to a juvenile of *Coccosteus cuspidatus*, a species, occurring both in Scotland and in Estonia. The latter has now a genuine *Millerosteus*. The most recent discovery is that of *Actinolepis* in Scotland, a genus, particularly well known from Estonia. The species of tiny antiarch *Microbrachius* are quite probably identical in both regions. It is generally recognized that in the Devonian shelf sea covered the Baltic area. Marine fish fauna could enter the Scottish basin during some periods when the sea level was high and a connection was established between the basin and the Rheic Ocean.

Edwin H. and Margaret M. Colbert Poster Competition (Thursday)

**ASPIDIN - THE EARLIEST VERTEBRATE SKELETAL TISSUE IS ACELLULAR BONE**

MARQUART, Chloe, University of Cambridge, Cambridge, United Kingdom

Aspidin, the hard tissue comprising the integument of the earliest skeletonizing vertebrates, has been the subject of vigorous debate over its biology and homology for the last 60 years; having been identified as a form of dentine, cementum and cellular or acellular bone. Previous workers had failed to reach consensus on the nature of structures present in the tissue or resolve aspidin's homologies, in part hindered by the limited technology of the day. This debate has been revisited, utilizing new techniques to elucidate the true function of these structures and use this to draw further conclusions about the placement of aspidin in the development of skeletogenesis in the vertebrates. Etched histological specimens were investigated using SEM to examine and characterize aspidin in the main groups of heterostracans, with SRXTM imaging used to create a 3D model revealing the architecture of the heterostracan dermoskeleton. From this it is concluded that the structures that typify aspidin include: a linked osteonal network, individual or woven bundles of unmineralised intrinsic fibres and extrinsic fibres of attachment. This is consistent with aspidin being a form of acellular bone.

Poster Session III, (Friday)

**A POSSIBLE EXTRA-OSSEOUS AIR SAC PRESERVED IN THE PELVIS OF A TAPEJARID PTEROSAUR FROM THE CRETACEOUS SANTANA FORMATION OF BRAZIL**

MARTILL, David, University of Portsmouth, Portsmouth, United Kingdom; HYDER, Elaine, University of Portsmouth, Portsmouth, United Kingdom

A three-dimensional pelvic girdle and synsacrum enclosed within an early diagenetic concretion from the Romualdo Member (Cretaceous, ?Albian) of the Santana Formation of north east Brazil can be tentatively assigned to the azhdarchoid pterosaur *Tapejara* sp. The specimen includes left and right ischiopubes, both ilia and at least 5 fused sacral vertebrae and a dorsal, ossified supraneural ligament extends across several neural processes. Both acetabulae are clearly defined and are imperforate. The specimen displays a cavity between the left and right ischiopubes that aspects of the sedimentology and biostratigraphy suggest should be interpreted as a relic of the soft tissue anatomy. The cavity has not developed as a consequence of diagenetic expansion of the concretion as septarian cracks are absent, and there has been no compaction or distortion of the pelvis. Instead, the cavity is interpreted as an external mould of part of the soft tissues of the animal located within the space between the ischiopubes and beneath the synsacral vertebrae. A thin veneer of late drusy calcite has developed as a cavity lining. An alimentary tract origin for the cavity is ruled out on the grounds that larger cavities of the digestive system, such as the crop and stomach, occupy a more anterior position in extant ornithodirans. Similarly, a reproductive system origin for the cavity is dismissed on the grounds that the cavity is an unpaired chamber. A void originally occupied by a muscle mass is also ruled out on location grounds. The cavity is here considered to represent part of an extra osseous air sac system that lay behind the lungs and may be analogous to the abdominal air sac of avians. CT scans of the pelvis after minimal mechanical preparation also show several enlarged cavities within the elements of the pelvis that can also be attributed to the air sac system, although pleurocoels are not readily identifiable.

Poster Session I, (Wednesday)

**SALT GLANDS IDENTIFIED IN A LATE CRETACEOUS POLYCOTYLID PLESIOSAUR**

MARTIN, James, SD School of Mines & Technology, Rapid City, SD, USA; FERNÁNDEZ, Marta, Departamento Paleontología Vertebrados, Museo de La Plata, La Plata, Argentina

In 2007, a new polycotyloid plesiosaur, *Pahasapasaurus haasi*, from western South Dakota was described. The specimen is housed in the Adams Museum, Deadwood (AMM 98.1.1), and was derived from the early late Cenomanian Orman Lake Member at the base of the Greenhorn Limestone north of the Black Hills in Butte County. The holotype is represented by a relatively complete cranium, which is broken away in antorbital area, revealing paired natural casts of lobulated structures preserved in concretionary ferruginous marl. These structures are clearly separated from the exposed infilling of the nasal capsule and must have been covered in the living marine reptile dorsally by extensions of the maxillae, the premaxillae, and probably the anterior frontals. The position and lobate structures resemble salt glands of other extant marine reptiles like the iguana *Amblyrhynchus* and do not resemble normal sedimentological structures. Reptiles that have reinvaded the marine habitat require a means to remove the excess of salt to prevent lethal osmotic dehydration. Such salt glands in plesiosaurs had been expected, but this specimen possesses the first actual evidence for these structures.

Technical Session XII, Friday 3:15

**A NEW MESOEUCROCODYLIAN TAXON WITH GONDWANAN AFFINITIES FROM THE LATE CRETACEOUS OF ROMANIA**

MARTIN, Jeremy, Université de Corse, Corté, France; ZOLTÁN, Csiki, University of Bucharest, Bucharest, Romania; RÁBI, Márton, Eötvös Loránd University, Budapest, Hungary; BURNAZ, Silvia, Muzeul Civilizatiei Dacice si Romane, Deva, Romania

Among the questions concerning the Late Cretaceous continental fauna of Europe, a recurring one is the nature of its origins: a taxonomic assemblage of mixed Laurasian and Gondwanan affinities was considered to characterize this fauna. However, the proportion of Gondwanan taxa has recently been diminished thanks to recent taxonomic reevaluations. Presently, only abelisauroid theropods, madtsoiid snakes, bothremiid turtles and maybe sebecosuchian crocodylians support its Gondwanan connections. Moreover, except for bothremiid turtles, the remains of the presumed Gondwanan taxa are either fragmentary, or their affinities are still discussed. Here, we describe a new mesoeucrocodylian taxon based on cranial remains from the Maastrichtian of Romania. It consists of maxillary remains, as well as a partial skull table, portion of the palate and a fragment of the dentary. The most remarkable feature pertains in the marked heterodonty of the maxillary dentition: anterior teeth are conical while posterior teeth are mediolaterally compressed, low crowned and pseudo-zipodont. Our phylogenetic analysis nests this new taxon with Araripesuchus, a mesoeucrocodylian of wide Gondwanan distribution. While it cannot be attributed to the genus Araripesuchus, this taxon also displays several differences in the morphology of its dentition with the possible sebecosuchian Doratodon. The Romanian taxon provides further evidence for Gondwanan influence on the composition of the Late Cretaceous European crocodylian fauna. However, it is not yet possible to constrain neither the time interval when, nor the route through which this faunal migration took place.

Poster Session II, (Thursday)

**CYRIL WALKER AND THE OTHER HALF OF AVIAN EVOLUTION**

MARTIN, Larry, University of Kansas, Lawrence, KS, USA

Cyril Walker made one of the most momentous discoveries in the history of ornithology with the description of enantiornithine birds. While the original material came from southern South America he also recognized that they occurred in North America and therefore the entire Western Hemisphere. Martin recognized the significance of this discovery and claimed that they were best thought of as an infraclass within the subclass Sauriurae. This subclass was proposed by Haeckel to contain *Archaeopteryx*, and act as a sister clade to the Ornithurae that contains all modern birds including the archaic Ichthyornithiformes and Hesperornithiformes. Martin also suggested that they were the dominant terrestrial birds during much of the Mesozoic. Discoveries in Asia, Europe, Africa and Australia show that by the Early Cretaceous they had a worldwide distribution and an ecological diversity rivaling that of modern ornithurine birds. They achieved this in part through the evolution of a flight mechanism that duplicated the backstroke evolved by ornithurines but with many different solutions including those in the shoulder girdle that had been emphasized by Walker. Additionally they had a unique caudal structure analogous to the ornithurine pygostyle that supported their characteristic elongated tail feathers and a furcular keel that resembles that of hoatzins, but otherwise has no similarity to the hypocleidium of ornithurine birds. They share a similar quadratojugal; a unique process on the ischium, and developmental pattern for the tarsometatarsus with *Archaeopteryx*. The Early Cretaceous record of China shows that Ornithurine birds had perfected a modern flight stroke at a time when enantiornithine birds were still making that transition.

**SEDIMENTOLOGY, TAPHONOMY, AND ICHNOLOGY OF LATE JURASSIC DINOSAUR TRACKS FROM THE JURA CARBONATE PLATFORM (NW SWITZERLAND): INSIGHTS INTO THE TIDAL-FLAT PALEOENVIRONMENT AND DINOSAUR DIVERSITY, LOCOMOTION, AND PALEOECOLOGY**  
MARTY, Daniel, Palaeontology A16, Section d'archéologie et paléontologie, Porrentruy, Switzerland

This study is based on dinosaur tracks from the Swiss Jura Mountains, excavated on multiple superimposed paleosurfaces located within Late Jurassic (Kimmeridgian) biolaminite intervals. The approach is first actualistic by studying processes acting during the formation and taphonomy of human footprints on tidal-flats, notably the stabilizing role of microbial mats. When compared with these recent prints, dinosaur tracks and the encasing sediment provide insight into walking dynamics, properties of the substrate, processes modifying and preserving tracks, consolidation history, and they identify true tracks, undertracks, and overtracks. These observations can be linked with the exposure index and suggest that the paleoenvironment was a supratidal flat. Trackway configuration (e.g. gauge) and patterns (degree of manus overprinting) are quantified and analyzed. Their variability is an expression of locomotion capabilities related to walking style and speed, behavior, and substrate properties. Manus-only and pes-only sauropod trackways are explained by animals exerting more pressure on manus than pes, and to overprinting of manus by pes. Sauropod trackways with similar track morphology vary from medium- to wide-gauge (not clearly related to speed and ontogeny) challenging the traditional classification of sauropod trackways. Nonetheless, wide-gauge trackways are tentatively assigned to *Brontopodus* and narrow-ones to *Parabrontopodus*. Small (i.e. < 0.2 m long) tridactyl tracks are assigned to *Carmelopodus* (extending this ichnogenus into the Late Jurassic), and larger (i.e. > 0.2 m long) ones to *Therangospodus*. Trackway orientation and alignment indicates gregarious behavior amongst sauropods, and the common presence of small bipedal dinosaurs on supratidal flats. Small tridactyl and small (i.e. < 0.3 m) sauropod tracks are abundant, but large tridactyl (up to 0.8 m) and sauropod (up to 1.2 m) tracks are also common. Size-frequency distributions suggest the establishment of *in situ*, saurischian-dominated populations on the Jura carbonate platform, which consequently was regularly connected with the neighboring massifs and could also serve as a migration corridor.

The Evolution of Birds in the Mesozoic: a Symposium in Honor of Cyril A. Walker, Thursday 11:15

**MORPHOMETRICS AS A PROXY FOR DEDUCING THE LIFE-HISTORY OF THE EARLY CRETACEOUS BIRD *CONFUCIUSORNIS SANTUS***  
MARUGÁN-LOBÓN, Jesús, Natural History Museum of Los Angeles County, Los Angeles, CA, USA; CHIAPPE, Luis, Natural History Museum of Los Angeles County, Los Angeles, CA, USA

In the last decade, hundreds of specimens of the basal pygostylian bird *Confuciusornis sanctus* have been collected from the Early Cretaceous Yixian and Jiufotang formations (~ 125-120 mya) of Liaoning Province, in northeastern China. Such a great number of specimens has resulted in detailed information regarding the anatomy of this early bird but many aspects of its ecology and life-history remained unclear and/or controversial. There have been interpretations about its feeding habits, flying abilities and foraging styles, growth rates, and life-history and reproductive behavior. Here we focus on the latter, namely, on the hypothesis that the presence of a pair of long stiff caudal feathers in some specimens indicates the existence of marked sexual dimorphism as well as lekking behavior. Morphometrics and multivariate statistics of measurements of the large sample available for this early bird allow us to evaluate this null hypothesis. Our study aims to determine whether the alleged dimorphism in plumage is also expressed by differences in the size of the males and females. Our analyses are based on the maximum lengths of five limb bones (humerus, ulna, radius, femur, and tibiotarsus) measured in 106 specimens. Our results refute the null hypothesis—while size variability within the sample is divided into two size classes, the pair of long stiff caudal feathers is distributed throughout the sample. Not surprisingly, these analyses also revealed further insights about other important life-history attributes. The most notable is the fact that the two size classes resultant from the analyses indicate that the growth in these animals was isometric. Other interesting aspects of the life-history of *Confuciusornis sanctus* are explored through an expansion of our analytical tools and a larger data set that includes more than 1000 measurements of the skull and the post-cranium.

Technical Session XVIII, Saturday 2:30

**THE SAUROPOD DINOSAUR *TURIASAUURUS RIODEVENSIS* IN THE LATE JURASSIC OF PORTUGAL**  
MATEUS, Octávio, New University of Lisbon (CICEGe-FC) & MUSEUM of Lourinhã, Lisboa, Portugal

A partial sauropod was found in Vale Pombas, north of Lourinhã, Central West of Portugal, in the Lourinhã Formation, top of Amoreira Porto Novo member dated as c. 150 M.a. (Early Tithonian, Late Jurassic) and is currently housed at Museum of Lourinhã, in Portugal. The specimen (ML368) comprises a complete tooth with root, anterior chevron and almost complete right forelimb including partial scapula, complete coracoid, humerus, ulna, radius, metacarpals I, III and V, phalanx, and ungual phalanx I. It can be ascribed to *Turiasaurus riodevensis*, which was previously described from the Villar del Arzobispo

Formation at Riodeva (Teruel, Spain). Characters shared with *T. riodevensis* holotype include: curvature and asymmetry of tooth crown, expansion of crown, outline of humerus, medial deflection of the proximal end of humerus, shape and prominence of deltopectoral crest, vertical ridge in the distal half of the ulna (considered as diagnostic of *Turiasaurus*), configuration of metacarpals, and bone proportions. It differs from *T. riodevensis* holotype by the smaller size and the more rectangular ungual phalanx in lateral view. The sediments from which the Riodeva specimen was recovered were previously thought to be Tithonian to Berriasian in age. The presence of this species in Portugal, in beds confidently dated as Early Tithonian, may allow a more precise date for the Riodeva type locality of early Tithonian in age. The humerus of the Portuguese *T. riodevensis* is 152 cm long. Although shorter than the Spanish specimen (790 mm), it represents a large individual. All adult sauropods recovered in Portugal thus far are very large individuals: *Dinheirosaurus* (estimated body length is 20-25 m), *Lusotitan* (humerus length estimated to be 205 cm), *Lourinhasaurus* (femur length: 174 cm), and *Turiasaurus* here reported. The lack of small or medium adult body-sized sauropods in the Late Jurassic of Portugal, suggests browsing niches thought to be occupied by smaller forms, could have been available for other dinosaurs, like the long necked stegosaur *Miragaia longicollum*.

Poster Session IV, (Saturday)

**THE HANKSVILLE-BURPEE QUARRY: NEW INSIGHTS INTO A SAUROPOD DOMINATED BONEBED IN THE MORRISON FORMATION OF EASTERN UTAH**  
MATHEWS, Joshua, Burpee Museum of Natural History, Rockford, IL, USA; WILLIAMS, Scott, Burpee Museum of Natural History, Rockford, IL, USA; BONNAN, Matthew, Western Illinois University, Macomb, IL, USA; HENDERSON, Michael, Burpee Museum of Natural History, Rockford, IL, USA

The late Jurassic Morrison Formation is one of the most productive and diverse dinosaur bearing formations in the world. Perhaps one of the most striking features of the formation is the abundance of sauropod dinosaur remains. Notable Morrison Formation dinosaur quarries include Dinosaur National Monument, the Cleveland-Lloyd Quarry, and the Mygatt-Moore Quarry. A newly discovered bonebed in eastern Utah preserves the remains of at least six different dinosaur taxa including *Camarasaurus*, *Diplodocus*, *Stegosaurus*, *Allosaurus* and possibly *Brachiosaurus* and *Barosaurus*. The site, designated as the Hanksville-Burpee Quarry, was discovered in the summer of 2007 by a small crew from the Burpee Museum of Natural History on federal land managed by the Bureau of Land Management. In the initial days available to explore the site, many well preserved dinosaur bones were discovered, including sauropod scapulae, limb elements, and partially articulated vertebrae. Subsequent excavations over in the summer of 2008 by Burpee Museum and Western Illinois University crews have uncovered over 150 bone from the site which measures at least 100 meters wide and 400 meters long. Sauropod dinosaur account for the majority of the remains. Of particular interest at the site is the absence of large specimens. Other interesting features of the site include numerous large petrified logs, possible mammal burrows and abundant unionid bivalves. A preliminary analysis of the geology, taphonomy and vertebrate paleontology of the site indicates that this quarry represents a series of sand bars in a braided river system, upon which dinosaur carcasses washed. Due to the size of the site, taxa present and good preservation of the site, the site has considerable long term research potential.

Poster Session III, (Friday)

**PALEOENVIRONMENT ESTIMATION OF THE CHAINGZAUK MAMMAL FAUNA (LATE NEOGENE, MYANMAR) USING STABLE ISOTOPES OF TOOTH ENAMEL**

MAUNG-THEIN, Zin-Maung, Primate Research Institute, Kyoto University, Inuyama, Japan; EGI, Naoko, Primate Research Institute, Kyoto University, Inuyama, Japan; TSUBAMOTO, Takehisa, Center for Paleobiological Research, Hayashibara Biochemical Laboratories, Inc., Okayama, Japan; UNO, Hikaru, University of Tokyo, Tokyo, Japan; WYNN, Jonathan, University of South Florida, Tampa, FL, USA

The upper Neogene Irrawaddy Sediments are widely distributed in central Myanmar and are mainly composed of fluvial sediments characterized by the abundance of the silicified fossil wood. These sediments yield a variety of mammalian fossils that have been correlated with those from the Siwalik Group of the Indian Subcontinent. In the Siwalik, the isotopic evidences from paleosols and fossil teeth have indicated that many C3 plant dominant forests were replaced by C4 grasslands around 6 Ma, corresponding to a global floral turnover. Such floral transition probably occurred in Southeast Asia due to the effect of an enhanced monsoon, but paleoenvironment in this region have not been studied in detail. Here, we present paleoenvironmental estimation for a mammal fauna from the Upper Miocene/Lower Pliocene part of the Irrawaddy sediments at Chaingzauk area in the western part of central Myanmar. We carried out the stable carbon and oxygen isotopic analyses using tooth enamel of several ungulates that are relatively abundant in the Chaingzauk Fauna. The rhinoceros (*Rhinoceros*), an elephant (*Stegodon*) and boars (*Propotamochoerus* and *Sivachoerus*) have  $\delta^{13}C$  values from -12.8‰ to -10.0‰ (n=12), indicating that they were forest dwelling browsers. In contrast, the bovids (*Tragoptax* and cf. *Selenoptax*) and hippotamid (*Hexaprotodon iravaticus* and *Hex. sivalensis*) have  $\delta^{13}C$  values ranging from -4.0‰ to 1.9‰ (n=16), supporting that they mainly consumed C4 plants in grasslands. The coexistence of browsers and grazers suggest presence of both forests/woodlands and grasslands that were large enough to support both ecological niches. Therefore, the Chaingzauk mammals have possibly inhabited mosaic environment ranging from forests

to grasslands. On the other hand, the moderate to dominant amount of C4 grass in the diet of bovids and hippopotamids suggests that an expansion of grasslands occurred in the late Neogene of Myanmar as in the Indian Subcontinent in corresponding to the development of the monsoon system.

The Scientific Legacy of Mary Anning — Recent Advances in Marine Reptile Paleobiology and Evolution, Wednesday 9:45

**A NEW UPPER JURASSIC ICHTHYOSAUR FROM NORTHERN CANADA**  
MAXWELL, Erin, University of Alberta, Edmonton, AB, Canada

Mesozoic marine reptiles from high latitude deposits are poorly known, especially in North America. Although isolated sauropterygian remains are widespread in the Arctic, few articulated specimens have been collected. Arctic ichthyosaur fossils are even less common, but play an important biogeographic role, as the Arctic provided a corridor linking the Western Interior Seaway and the Tethys during the Jurassic. Middle to Upper Jurassic marine rocks are extensively exposed in the Canadian Arctic islands, however the remoteness of the area has resulted in limited prospecting effort and most of the collected ichthyosaur material consists of isolated elements. There is one exception: a large ichthyosaur from the Upper Jurassic of Melville Island (Northwest Territories, Canada) collected in 1985. This specimen can be referred to Ophthalmosauria, a clade including most Middle Jurassic to Upper Cretaceous ichthyosaurs, and diagnosed by the presence of a facet on the distal humerus for articulation with a preaxial element. Although the specimen was first identified as a new species of the widespread genus *Ophthalmosaurus*, detailed study indicates that it exhibits morphological features incompatible with this generic assignment. These include a basioccipital with an extremely reduced extracondylar area, and a foramen for the internal carotid artery located on the posterior surface of the parabasisphenoid. Thus, although the postcranial skeleton bears a general similarity to the European species *O. icenicus*, cranial morphology suggests that the two species are not closely related. A phylogenetic analysis using parsimony supports this conclusion, recovering a sister group relationship between the Arctic specimen and the South American genus *Caypullisaurus*. The similarities to *Ophthalmosaurus* observed in the axial and appendicular skeleton are interpreted as convergence, an unsettling finding given the practice of using paddle morphology to dictate generic assignment in ophthalmosaurians. This specimen represents the most complete ichthyosaur from the Canadian Arctic, and has important implications for marine reptile diversity at high latitudes during the Jurassic.

Poster Session IV, (Saturday)

**A NEW DESCRIPTION AND PHYLOGENETIC REASSESSMENT OF IANTHASAURUS HARDESTIURUM (SYNAPSIDA:EUPELYCOSAURIA), A BASAL EDAPHOSAURID FROM THE UPPER PENNSYLVANIAN OF KANSAS**  
MAZIERSKI, David, University of Toronto Mississauga, Mississauga, ON, Canada; REISZ, Robert, University of Toronto Mississauga, Mississauga, ON, Canada

The Rock Lake Shales near Garnett, Kansas preserve the contents of an abandoned channel and have proven to be a productive source of Pennsylvanian flora and fauna, including the oldest known diapsid reptile *Petrolacosaurus kansensis* and several basal Permo-Carboniferous synapsids. The fauna of this locality includes six endemic synapsid taxa, including the basal edaphosaurid *Ianthasaurus hardestiurum*, making this the most diverse assemblage for the Pennsylvanian. A new partial skeleton of *Ianthasaurus hardestiurum*, formerly known from two fragmentary skeletons of juvenile individuals, adds valuable new information about this early edaphosaur. The complete fusion of the neural arches to the centra, the overall larger size of the vertebrae relative to those previously described, the presence of taller, more robust vertebral spines and intact, *in situ* intercentra indicate that this skeleton belonged to an adult individual. The maxilla, pterygoid, and section of mandible shed new light on its dental morphology, as teeth present in the earlier described specimens were poorly preserved. This new skeleton allows us to reevaluate the phylogeny of edaphosaurid synapsids. Our analysis supports the hypothesis that *Ianthasaurus* is the sister taxon of all other members of the clade. However, the precise phylogenetic position of the poorly known edaphosaurids *Lupeosaurus* and *Glaucosaurus* remain unresolved. Tooth morphology in the marginal dentition of *Ianthasaurus* resembles closely that seen in the well known herbivorous *Edaphosaurus*, allowing us to reassess the origin of herbivory in this clade.

Poster Session I, (Wednesday)

**AN ASSESSMENT OF INTRACOLUMNAR VARIATION IN SEVERAL SPECIES OF MODERN SNAKES AND ITS IMPLICATIONS FOR THE FOSSIL RECORD**  
MCCARTNEY, Jacob, Stony Brook University, Stony Brook, NY, USA

Snakes are problematic as fossils because they are often found only as isolated vertebrae. The phylogenetic assignment of these vertebrae is difficult because the morphology of a vertebra varies depending on the location in the column, yet intracolumnar variation is poorly documented, even among extant snakes. As a result, a single extinct species represented only by isolated vertebrae may be split into several named species, each coming from a different region of the spine. Intracolumnar variation is additionally complicated because the sources of variation are complex; phylogeny certainly plays a role, but the axial skeleton is the functional system involved in both locomotion and prey acquisition. It is therefore expected that there will be functional signals in the vertebrae that may complicate potential phylogenetic

characters. In order to particularize the variation throughout the vertebral column of snakes, I made a series of measurements along the entire column of several extant snakes. The measurements were made in all planes of the vertebra: lengths, heights and widths, including measurements of the articular surfaces and processes for muscular attachment. The snakes were chosen to maximize differences in locomotion, feeding behavior, and phylogeny. The shapes of the curves resulting from the plots of individual measurements against position in the column are compared between taxa for similarities in distribution between phylogenetic groups; any deviations may be due to functional influences. This preliminary data set consisting of measurements made on the entire column of several snakes will begin to elucidate how intracolumnar variation differs between taxa, and how these differences are related to variations in behavior and ecology. Additionally, it will serve as the basis for a much broader analysis throughout Serpentes by allowing a more directed set of measurements to be made on fewer vertebrae per specimen. Ultimately, grasping the intracolumnar variation in snake vertebral columns will aid in accurately describing fossil snakes, particularly in instances where there are faunas with many species.

Technical Session XIII, Friday 2:00

**THUMB-SPIKED DINOSAURS LARGE, SMALL, AND STRANGE: NEW INFORMATION ON BASAL IGUANODONTS FROM THE CEDAR MOUNTAIN FORMATION OF UTAH**

MCDONALD, Andrew, University of Pennsylvania, Philadelphia, PA, USA; KIRKLAND, James, Utah Geological Survey, Salt Lake City, UT, USA; BIRD, John, College of Eastern Utah Prehistoric Museum, Price, UT, USA; DEBLIEUX, Donald, Utah Geological Survey, Salt Lake City, UT, USA; MADSEN, Scott, Utah Geological Survey, Salt Lake City, UT, USA

Basal iguanodonts are one of the most abundant and diverse types of dinosaur in the Early Cretaceous, with a vast array of species and specimens from Europe and Asia. In contrast to those continents, the North American record of Early Cretaceous basal iguanodonts has long consisted mostly of the well known and aberrant *Tenontosaurus*, with *Planicoxa depressa*, "*Iguanodon*" *ottingeri*, and *Dakotadon* represented by only imperfect remains. Recent discoveries in the Cedar Mountain Formation of eastern Utah have enhanced this record, adding *Planicoxa venenica* and *Cedrorestes*, though these are also quite incomplete. We report herein additional fossils from the Cedar Mountain Formation that dramatically expand our understanding of basal iguanodont history in North America. A new genus and species is represented by a gigantic partial skull and postcranium from near the base of the Yellow Cat Member (Barremian, possibly older). This new taxon can be diagnosed by its distinctive squamosal, in which the prequadrate process is greatly elongated, and by a unique combination of features, such as a strong ventral curve to the preacetabular process of the ilium, a short pubis that tapers to a blunt point, and a cranial pubic process with little expansion of its distal end. A much smaller complete skull and partial postcranium from the upper portion of the Yellow Cat Member (upper Barremian-lowermost Aptian) signifies a second novel genus and species. This new taxon is distinguished by an unusual dentary, on which the tooth row is medially offset by a rounded lateral shelf that extends from the coronoid process to the first alveolus and slopes ventromedially to contact the labial side of the tooth row. This form also exhibits a moderately large antorbital fenestra, very pronounced curvature of the quadrate, and a short, unexpanded, caudally inclined coronoid process. In addition to the adult holotype and paratype from the Mussentuchit Member (lower Cenomanian), *Eolambia caroljonesa* is now known from two bonebeds of juvenile material in which nearly every skeletal element is represented, revealing much regarding the anatomy, variation, and ontogeny of this animal.

Technical Session I, Wednesday 10:45

**MICROTUS CALIFORNICUS TOOTH SHAPE AS A POTENTIAL PALEOCLIMATIC INDICATOR**  
MCGUIRE, Jenny, UC Berkeley, Berkeley, CA, USA

Voles (Cricetidae: Rodentia) are important biostratigraphic indicators for Quaternary localities. However, they also have the potential to provide valuable local paleoclimatic information because their teeth are abundant and are often found at sites that lack other paleoclimate indicators. I investigated the extent to which vole teeth can reveal climate information by examining correlations between *Microtus californicus* first lower molar shape (m1s) and geographic and climatic clines. I used geometric morphometrics, a method that examines detailed shape data independent of size that, when combined with geographical data, is a powerful tool to trace phenotypes across landscapes and through time. I analyzed m1s of 307 modern specimens of *M. californicus* from throughout its current range and performed a generalized Procrustes analysis (GPA) to superimpose landmark configurations and correct for non-shape variation. I then reduced the dimensionality of these shape data using a partial least squares (PLS) analysis, which maximizes the covariance between tooth shape and geographic position (latitude and longitude). I found that *M. californicus* m1s are relatively straight in the northwest, cooler, moister portion of California and more curved in the southeast, hotter, drier portion of the state. These tooth shape changes may be related to different vegetation ultimately controlled by climate, and therefore diet, within the species' range. The pattern in m1 shape persists when phylogeographic hypotheses are taken into account, indicating that the climate signal is significant independent of intraspecific groupings. This method may add an important new tool to the suite of proxies available to reconstruct past climates at fine spatiotemporal scales.

**FEEDING BEHAVIOR IN A LARGE PLIOSAUR - THE PALEOECOLOGY OF *KRONOSAURUS QUEENSLANDICUS***

MCHENRY, Colin, University of Newcastle, Newcastle, Australia

*Kronosaurus queenslandicus* is known from numerous incomplete specimens, collected from the Early Cretaceous marine sequences of the Great Artesian Basin (Australia) over the last 100 years. One specimen, on display at the Museum of Comparative Zoology in Harvard since 1959, established this species one of the largest pliosaurs known. Re-examination of the available material, however, suggests that the Harvard reconstruction is too large, and that maximum body size in *Kronosaurus* was ~10.5 meters / 11,000 kg. This size is exceeded by several pliosaurid specimens from the Upper Jurassic, although maximum body size in these has also been subject to inflated estimates. Comparative biomechanical analysis between *Kronosaurus queenslandicus* and the modern saltwater crocodile *Crocodylus porosus*, using high resolution finite element analysis, indicates that during simulations of the behaviors used by crocodiles to render large prey, the skull of *K. queenslandicus* carries higher strain. This result is interpreted as indicating smaller maximum prey size, relative to predator size, in *Kronosaurus*. The anterior rostrum in *K. queenslandicus* is relatively longer and narrower than that of *C. porosus*, a configuration expected to increase strain under given loads but which has been interpreted as increasing efficiency in catching smaller aquatic prey for extant aquatic predators.

Taphonomic indicators of diet in *K. queenslandicus* comprise preserved gut contents and bite marks on presumed prey. Three specimens indicate a broad range of reptilian prey, ranging from 1/500 to 1/5 of the size of the predator, reflecting the maximum size of prey available. Prey at the lower end of this size range were likely an important component of diet: *Kronosaurus* thus required the capacity to catch, kill, and process prey ranging from several kilograms to several tonnes in size. Several anatomical features were important in this respect, especially the dorsal median ridge of the rostrum and circum-orbital region of the skull roof: the functional consequences of the pronounced ontogenetic variation exhibited in these are significant, and also have important taxonomic and phylogenetic implications.

Poster Session IV, (Saturday)

**RAPID DIVERSIFICATION IN THE KAROO: LIFE FLOURISHING DURING THE SOUTH AFRICAN PERMO-TRIASSIC EVENT? WHAT THE THERAPSID AREN'T TELLING YOU**

MCHUGH, Julia, University of Iowa, Iowa City, IA, USA

The Beaufort Group of the Karoo Basin (South Africa) contains the only known continuous deposit of terrestrial sediments from the middle Permian (Guadalupian) to the early Middle Triassic. Temnospondyls are the second most abundant clade in the sequence and their pattern of stratigraphic occurrences through the Beaufort Group (Karoo Supergroup) is dominated by the apparent radiation of non-rhinesuchid stereospondyls (Temnospondyli: Stereospondyli) in the *Lystrosaurus* Assemblage Zone. This radiation occurs just up section of the Permo-Triassic Boundary, whose exact position is currently a matter of debate. Although stereospondyls are thought to have been semi-aquatic, the pattern of stratigraphic occurrences does not appear to track depositional environment. The Katberg Formation (Beaufort Group) is dominantly a braided stream deposit, which would afford more available habitat space for these amphibians than the underlying semi-arid, meandering stream floodplain deposits of the Balfour Formation (Beaufort Group); however, the overlying Burgersdorp Formation (Beaufort Group) is a return to the semi-arid floodplain-dominated meandering stream system and hosts more origination events than the Katberg. Thus, taphonomic conditions related to channel versus floodplain deposits are not consistent with the pattern of temnospondyl diversification in the Karoo Basin. Preliminary phylogenetic analyses also indicate that this is a real biotic event, and not an artifact of taxonomy. The inclusion of ghost lineages enhances the robustness of the originations and indicates that many lineages actually originated in the uppermost *Dicynodon* Assemblage Zone. This implies that the low fossil occurrences in the 'laminated beds' of the Palingkloof Member (Balfour Formation) are a taphonomic artifact of a slow depositional period and that these beds were not as lifeless as some have proposed.

Poster Session III, (Friday)

**HISTOLOGY AND GROWTH PATTERN OF THE CENTROSAURINE DINOSAUR PACHYRHINOSAURUS LAKUSTAI FROM THE LATE CRETACEOUS WAPITI FORMATION OF NORTHWESTERN ALBERTA, CANADA.**

MCNEIL, Paul, Grande Prairie Regional College, Grande Prairie, AB, Canada

Histological evidence is often used to provide insight into growth rates and patterns in dinosaurs. However, dinosaur species are usually known from only a handful of specimens that are often fragmentary or partially preserved. Additionally, most specimens of the same species are collected from different stratigraphic and geographic locations, and thus significant differences in time and environment may be represented in a single species. The Pipestone Creek Bonebed, located in the Late Cretaceous Wapiti Formation (Grande Prairie, Alberta, Canada) is an important site as it represents a single catastrophic event that killed a large number of individual dinosaurs (*Pachyrhinosaurus lakustai*) from a single population approximately 73 million years ago. At least 27 individuals have been excavated

to date, and drilling at the site has indicated that thousands of individuals remain buried. These specimens represent a rare example of a complete age series, juveniles through to adults, which allows an analysis of the growth patterns of this dinosaur to be linked to their long bone histology. Measurements of the collected limb bones indicate that five distinct size classes of individuals exist at the site. A representative series of humeri, selected for their tendency to document a good growth record, as well as their general robustness and resistance to crushing, were sampled at the midshaft. The smallest juveniles show extremely high rates of growth, initially with no Lines of Arrested Growth (LAGs) in highly vascularized bone. Larger juveniles have widely spaced LAGs with the additional development of a layer of denser cortical bone. Mature individuals are characterized by closely spaced LAGs with a high degree of remodeling of the interior part of the bone. This remodeling process makes absolute age determinations of mature individuals difficult to impossible. However, by looking at a complete series of size classes, it is possible to recreate the entire growth history of *P. lakustai*.

Technical Session XIV, Friday 4:15

**EXTREME HUMERAL THICKENING IN THE SABER-TOOTHED CAT, *SMILODON FATALIS*, SUGGESTS SPECIALIZATION FOR KILLING VERY LARGE PREY.**

MEACHEN-SAMUELS, Julie, University of California, Los Angeles, Los Angeles, CA, USA; VAN VALKENBURGH, Blaire, University of California, Los Angeles, Los Angeles, CA, USA

Cats (family Felidae) are well known for using both their crania and their forelimbs for killing prey. As a result, the cortical thickness of the long bones may remodel to accommodate extra loads placed on the limbs. If secondary cortical thickening occurs because of prey-capturing behavior, then the humerus should be thicker relative to length than the femur. In this study, we use radiographs to examine cortical thickness of the humerus and the femur of 18 extant felid species, as well as the extinct *Smilodon fatalis* and *Panthera atrox* from the Rancho La Brea Tar Pits in Los Angeles, California. Results from ANOVA and linear regressions reveal differences in the relative cortical thicknesses of the humerus and femur in extant cats with differing prey size preferences. Small prey cats have relatively thicker cortical areas of the femur than the humerus, while large prey cats have a relatively greater thickness of the humerus (up to 20% thicker than the femur). This suggests that the humerus may be secondarily thickened to accommodate stresses from larger, struggling prey. The saber-toothed cat, *Smilodon fatalis*, had disproportionately thick humeri, with a difference of almost 40% between the humerus and the femur, well outside the 95% confidence intervals of the regressions based on extant felids. Humeral thickening in the extinct American lion, *Panthera atrox*, was similar to but somewhat greater than that of the living lion, *P. leo*, with 30% greater humerus than femur thickness. This demonstrates the observed differences in cortical thickness cannot be attributed to size alone, as the thicker-limbed *S. fatalis* has a reduced shoulder height and weighed considerably less than *P. atrox*. The extreme cortical thickening in *S. fatalis* likely indicates that these cats experienced high stresses on their forelimbs at regular intervals, probably due to taking very large prey relative to their body size. Two living cats that also showed anomalously high values include the clouded leopard, *Neofelis nebulosa*, and the jaguar, *Panthera onca*. Perhaps these two living pantherines can give some insight into the behavior and forelimb use of the saber-toothed cat.

Poster Session IV, (Saturday)

**DISPERSAL AND EVOLUTION OF BOVIDS (RUMINANTIA: BOVIDAE) IN NORTH AMERICA**

MEAD, Jim, East Tennessee State University, Johnson City, TN, USA

Bovids are the most diverse group of ruminants today, and exist in habitats ranging from rainforests to woodlands, savannahs, deserts, mountains, and arctic environments. Bovids are some of the rarest of all large mammal fossils dating to the latest Miocene and Pliocene in North America. In contrast, during the Pleistocene, they exhibit a nearly worldwide distribution. Arrival of the earliest North American bovid, *Neotragocerus*, occurred during the late Hemphillian land mammal age and correlates to about 6.7 Ma (Hh2, C3a). Although designated a 'rupicaprine', the affiliation of this genus needs detailed scrutiny. Blancan-age bovids were lacking until recently. Specimens include the earliest member of Caprini in North America, *Sinocapra willdownsi* from the early Blancan (C3n.2n; 4.5 Ma), and an unanticipated diminutive caprine, *Pumilovis richwhitiei*, which was described from the latest Blancan (C2r.2r; ~2.47 Ma). Pleistocene records are marked by a heavy influx of musk-oxen within the caprine Ovibovini (*Bootherium*, *Euceratherium*, *Sorgelia*, and *Ovibos*) during the Irvingtonian, and the first appearance of the caprine *Oreamnos* and *Ovis* during the middle and late Irvingtonian (unfortunately chronological resolution is poor). Rancholabrean is marked by the introduction of antelope *Saiga* and the bovine *Bison*, both of which are the first members of their tribes to disperse into North America. Future investigations need to concentrate on the latest Miocene and entire Pliocene to better understand the dispersal from Asia and the evolutionary history of this unique group of ungulates.

Poster Session I, (Wednesday)

#### **TOOTH REPLACEMENT IN *MOSASAURUS HOFFMANNI***

MEIJER, Alexis, Natuurhistorisch Museum Maastricht, Maastricht, Netherlands;  
VERDING, Louis, Natuurhistorisch Museum Maastricht, Maastricht, Netherlands;  
CORNELISSEN, Dirk, Natuurhistorisch Museum Maastricht, Maastricht, Netherlands;  
SCHULP, Anne, Natuurhistorisch Museum Maastricht, Maastricht, Netherlands

New specimens and additional observations on previously collected dentary and maxillary material of the Cretaceous marine squamate *Mosasaurus hoffmanni* from the Maastrichtian type area (SE Netherlands, NE Belgium), allows improved understanding of its tooth growth and replacement patterns. Tooth development and replacement in mosasaurs has been described in detail previously, and has even been discussed as early as 1786. However, most studies were based on small samples, in part due to the often destructive nature of such analysis.

Tooth development and replacement in *M. hoffmanni* can be characterized as a continuous process optimized to leave as little time between shedding of the previous tooth and the completion of the next fully functional tooth. We recognize that the tooth replacement process actually involves two zones of resorption and redeposition of bone material. The first zone (caudolingually in the tooth socket) provides space for the initial development and growth of the crown of the replacement tooth from the apex down; the second zone (within the pulp cavity) ultimately acts as to provide a separation between the area covered by enamel (tooth crown) and the remainder of the tooth to be shed. This second zone develops as to separate the tooth crown sensu stricto from the lower dentine cone. The basal aspect of the majority of shed teeth is smooth or almost so, suggesting that the teeth are only released once the majority of bone and dentine has been resorbed in this zone, rather than just break. The pulp cavity of shed teeth becomes almost completely filled with dentine during the separation process. The exposed alveolus appears to become covered with a centripetal outgrowth of the dental collar. The apex of the replacement tooth penetrates into the pulp cavity, and moves from its caudolingual position to emerge at a more central position, to perforate from there the collar, which is resorbed during this phase. Once the tooth is in place, the tooth socket becomes partially fused to the mandibular bone.

The Evolution of Birds in the Mesozoic: a Symposium in Honor of Cyril A. Walker,  
Thursday 12:00

#### **A NEW SPECIES OF GIANT MARABOU FROM THE LATE PLEISTOCENE OF FLORES (INDONESIA)**

MEIJER, Hanneke, Nationaal Natuur Historisch Museum Naturalis, Leiden, Netherlands;  
DUE, Rokus, National Centre for Archaeology, Jakarta, Indonesia

Liang Bua, a limestone cave in western Flores (Indonesia), received worldwide fame with the finding of a new species of tiny hominins, *Homo floresiensis*. More importantly, the cave has yielded one of the largest Late Pleistocene and Holocene insular faunal assemblages in Southeast Asia, preserved in well-dated sections. New research on the 95,000 year spanning sequence of Liang Bua shows that Flores was a hotspot for insular evolution. The isolated position of Flores and the phylogenetic continuity from the Middle to Late Pleistocene resulted in a highly endemic and unbalanced insular fauna, which included pygmy proboscideans (*Stegodon*), giant rats, bats, Komodo dragons, birds, and eventually a species of dwarfed hominins. A study of fossil bird remains from Liang Bua shows that a new species of giant marabou from the genus *Leptoptilos* was present at Pleistocene Flores. This giant bird is characterized by large size and a thick cortical bone wall of the tibiotarsus, which implies a terrestrial lifestyle. An evolutionary lineage is proposed in which the Flores giant marabou evolved from a volant *Leptoptilos dubius*-like ancestor which arrived on the island in the Middle Pleistocene. The terrestrial lifestyle of the Flores giant marabou adaptations to an insular environment with abundant prey items and a lack of mammalian carnivores, and emphasize the extraordinary nature of the *Homo floresiensis* fauna.

Technical Session XIV, Friday 4:00

#### **HABITAT ADAPTATION AS PREDICTED BY HUMERUS MORPHOMETRY IN FELIDAE (FISSIPEDIA, CARNIVORA): IMPLICATIONS FOR PALEOECOLOGICAL RECONSTRUCTIONS**

MELORO, Carlo, Hull York Medical School, The University of Hull, Hull, United Kingdom; ELTON, Sarah, Hull York Medical School, The University of Hull, Hull, United Kingdom; LOUYS, Julien, Liverpool John Moores University, Liverpool, United Kingdom; DITCHFIELD, Peter, School of Archaeology, University of Oxford, Oxford, United Kingdom; BISHOP, Laura, Liverpool John Moores University, Liverpool, United Kingdom

The functional morphology of mammalian carnivores is seldom considered in paleoenvironmental reconstructions. Although several species are restricted to specific ecosystems, this group of mammals is often interpreted as being generalist in habitat preferences and hence morphological adaptations. Here we examine a taxonomically homogenous group of fissioned (terrestrial) Carnivora: the cat family. Although they are all meat eaters, modern felids vary in both size and locomotor adaptations. Morphological adaptations of the humerus were investigated in order to identify potential predictors of habitat selection in extant felids. Forty functional measurements were recorded on 88 individuals from 19 species. Each modern species was assigned to a broad habitat categorization (Open, Mixed, Closed), based on its presence or absence in terrestrial biomes.

Statistical models were performed on complete as well as nested datasets that simulated fossil preservation (proximal and distal epiphyses). Open habitat adapted species are better classified (> 85% of accuracy) than specimens assigned to Mixed and Closed categories. Proximal epiphysis dimensions were the best performing variables within the models. Our data indicate that humerus morphometry is generally a good predictor of habitat categories in extant felids. In particular, bicipital groove morphometry as well as the length of the greater tubercle suggest the relative importance of supraspinatus and biceps brachii muscles. Some simple measurements of the distal humerus (mediolateral and anteroposterior length) were also effective predictors. Finally, normal log transformed measurements performed better than functional indices and size-free variables. Application of this methodology to fossil humeri from African Plio-Pleistocene localities at Olduvai suggests that *Panthera leo* from Bed II is an Open adapted species while two other fossils of *Panthera* spp. from Bed IV and V are both categorized as Mixed.

Poster Session III, (Friday)

#### **EARLIEST PALEOCENE RECOVERY OF MARINE VERTEBRATES: EVIDENCE FROM THE BASAL KINCAID FORMATION, EASTERN TEXAS**

MENASCO-DAVIS, Lauren, Texas A&M University, College Station, TX, USA;  
STIDHAM, Thomas, Texas A&M University, College Station, TX, USA

Sediments of the Kincaid Formation (immediately above the K-T Boundary along the Brazos River) accumulated during the P0 - P1b planktonic foraminiferal zones, representing the first ~300,000 years of the Paleocene. Screen-washing has produced hundreds of teeth and bones of marine vertebrates from several horizons through the earliest Paleocene. Those specimens are from a variety of marine vertebrates, including bony fish, sharks, and rays. Triakid sharks are the most common shark clade (85% of shark specimens). Other less common shark clades include members of Scyliorhinidae, Odontidae, and Orectolobiformes. Batoids are the single most common clade among all vertebrate material collected representing 41% of all specimens. *Dasyatis puericensis* (previously only known from the early Paleocene of Montana) is the most common species of batoid (94% of batoid specimens). Bony fish are represented by teeth, skull elements, vertebrae, and fin spines, and include specimens of phylloodontid fish, percomorphs, and other currently unidentified taxa. Among the phylloodontid fish, specimens of *Parabula* are the most common (76% of specimens), but *Albula* (20%), and *Phyllodus* cf. *paulkatoi* (4%) also are present. In the earliest Paleocene of eastern Texas, there appears to be at least 18 species of marine vertebrates (11 sharks, 3 batoids, and 4 bony fish) whereas there were approximately 24 species present prior to the K-T Boundary. However, some of the genera (but none of the species) present in the early Paleocene portion of the Kincaid Formation are known from the Cretaceous. Our data indicate a near complete replacement of the Cretaceous marine vertebrate fauna locally, but at a somewhat lower diversity than present before the mass extinction. That lowered diversity appears to have been stable for much of the early Paleocene.

Poster Session III, (Friday)

#### **LATE OLIGOCENE CHANGES IN MAMMAL COMMUNITIES OF WESTERN EUROPE: WARMING AND COOLING EVENT ?**

MENNECART, Bastien, Departement of Geosciences - Earth Sciences, Fribourg, Switzerland; SCHERLER, Laureline, Departement of Geosciences - Earth Sciences, Fribourg, Switzerland; BECKER, Damien, Section d'archéologie et paléontologie, Porrentruy, Switzerland; BERGER, Jean-Pierre, Departement of Geosciences - Earth Sciences, Fribourg, Switzerland

Numerous authors describe the European Oligocene as a quiet period with a relative faunal and climatic stability. Data from the deep-sea record, however, show that during the Late Oligocene (ca. 25.5 Ma) a huge decrease of the  $\delta^{18}O$  characterizes the well-known "Late Oligocene Warming". The  $\delta^{18}O$  amplitude could correspond to an increase of 4°C of ocean water in about two million years. This climatic change seems to be linked to a precipitation increase and a woodland expansion in Western Europe that contrasts with the more open environments of the Early Oligocene. Since MP28, the low hypsodont to brachyodont rodents diversify, and digging rodents appear. They testify to more forested and wet environments. In the same way, the ruminant fauna totally changes. Primitive Oligocene taxa with incomplete rumination (*Lophiomeryx*, *Bachitherium*, *Prodremotherium*) disappear and give away to modern Pecora (e.g., *Dremotherium*, *Bedenomeryx*) that will diversify during the Early Miocene. These faunal changes seem to be related to the "Late Oligocene Warming", which is hardly supported by the regional temperature peak recorded from paleofloral data of Central Europe. After this warming event, we observe in MP29 the disappearance of the typical Oligocene *Rozontherium* (Rhinocerotidae) and *Anthracoatherium* (Anthrocotheriidae) genera and the migration of new large mammal taxa as *Diceratherium* (Rhinocerotidae). At the same time, the Swiss Molasse Basin displays a modification in its sedimentary record with the appearance of evaporate deposits, and in its paleoflora with the disappearance of palms and taxads. These local shifts seem to emphasize new environmental conditions, starting in the latest Oligocene and marked by a general trend of aridity and cooling, and leading at the global scale to the Mi-1 Glaciation of the Oligo/Miocene boundary. These results suggest that the major part of the "Late Oligocene Warming" permitted the diversification of forest-dwelling mammals, whereas the end of this event and the transition to the Mi-1 Glaciation implied an environmental damage and new mammal occurrences.

#### EVOLUTION OF JAWS AND TEETH

MEREDITH SMITH, Moya, King's College London, London, United Kingdom;  
JOHANSON, Zerina, Natural History Museum, London, United Kingdom

As early vertebrate evolutionary history largely involves fossil groups, the old dichotomy between molecules and morphology would restrict any interpretation from exciting new advances in molecular biology to only part of the lineage. This extensive region of phylogeny, including the transition between jawless and jawed fishes would remain outside the debate. Several years ago, the orthodox view that teeth arose in vertebrate history from external scales was challenged with a new suggestion that teeth evolved instead from inside and was proposed as the inside out theory. The reason was based on pattern information that could be recruited from sets of organized denticles on the gill arches (for example, among fossil jawless vertebrates such as the thelodonts). These would be using a gene network for temporal and spatial regulation that could be recruited and modified to form the essential replacement sets of teeth with regulated spacing and timing, supported by the jaws but as an independent module. Recently, two separate studies have identified common gene expression (core dental genes) and teeth and placoid scale genes that support either of these two hypotheses. The latter study found similarities in genes expressed in scales and teeth in sharks, that suggested the classic model for tooth evolution 'outside to in', while the second found similar gene expression between gill arch teeth and teeth in cichlids on both the pharyngeal and oral jaws. This supported the 'inside to out' model. These new studies not only suggest that molecules and morphology can combine to illuminate questions of character evolution in deep phylogeny, but also promote research to answer these questions more fully.

Poster Session IV, (Saturday)

#### NEW MORPHOLOGY IN EARLY AMNIOTES

MEYER, Taran, University of Calgary, Calgary, AB, Canada

Accurate interpretation of morphology is vital to phylogenetic analysis of fossils. In the case of the earliest amniotes this is particularly true as many taxa are known from only a handful of, often poorly preserved, specimens worldwide, and their resulting phylogenetic positions have a great impact on the interpretation of the origin and evolution of many modern groups. Two such amniotes are *Brouffia* and *Coelostegus* from the Late Carboniferous of the Czech Republic. Previous phylogenetic analysis has suggested that *Coelostegus* is the sister-taxon to *Eureptilia*, whereas *Brouffia* may be the sister-taxon to *Hylonomus*, the oldest known crown amniote; thus, their precise relationships are key to understanding the origins of both modern diapsids and the entire sauropsid lineage in general. Unfortunately, both taxa are incomplete, and character codings include substantial amounts of missing data. The goal of the current study was to gain new morphological information from these two important taxa, thereby clarifying previous areas of morphological ambiguity and decreasing the number of morphological uncertainties. This was achieved through a detailed re-examination of previously described fossil material. For *Brouffia*, a new interpretation of the pattern of dermal skull roof elements, such as the location of the tabular and the morphology of the supraoccipital, is presented. As well, features not previously observed, such as the presence of sclerotic plates, are reported here for the first time. A complete manus was identified in *Brouffia*, revealing the typical amniote phalangeal formula (2-3-4-5-3) was present in this basal taxon. The cranial description of *Coelostegus* is elaborated upon and the first description of a pedal digit in this taxon is presented. The current study permits the refinement of the characters chosen for phylogenetic analysis, and also enables us to expand the range of characters used for coding these taxa and reduce the number of missing data entries. These characters are discussed within the context of early amniote phylogeny and their potential to resolve the phylogenetic uncertainty that currently exists is considered.

Technical Session XI, Friday 9:30

#### DENTAL MICROWEAR AS AN INDICATOR OF RESPONSE TO CLIMATE CHANGE IN THE CONDYLARTH *ECTOCION* DURING THE PALEOCENE-EOCENE TRANSITION IN THE BIGHORN BASIN, WYOMING

MIHLBACHLER, Matthew, New York College of Osteopathic Medicine, Old Westbury, NY, USA; SOLOUNIAS, Nikos, New York College of Osteopathic Medicine, Old Westbury, NY, USA; GOUDIABY, Ibrahim, New York College of Osteopathic Medicine, Old Westbury, NY, USA; EL-NEEMANY, Diana, New York College of Osteopathic Medicine, Old Westbury, NY, USA; WOOD, Aaron, University of Michigan Museum of Paleontology, Ann Arbor, MI, USA

Carbon and oxygen isotope records indicate a marked increase in temperature and atmospheric CO<sub>2</sub> during the Paleocene-Eocene transition (PETM), starting at 55Ma and lasting ~86k.y. Coincident decreases in the body sizes of several mammalian taxa, including the condylarth ungulate, *Ectocion*, are hypothesized to have been a response to this atmospheric excursion. To test the hypothesis that this global event was sufficient to influence the dietary ecology of species, we examined microwear patterns of *Ectocion* from the Northern Bighorn Basin through the Clarkforkian and Wasatchian land mammal ages. Photomicrographs were taken at 100X under a stereomicroscope and standard microwear features (e.g. pits, scratches) were quantified. Overall, the microwear of *Ectocion* resembles that of modern small-bodied tropical rainforest concentrate selectors such as duikers and

tragulids that ingest significant quantities of fruit. Additionally, the microwear data reveal two subtle but significant patterns, including a short term increase in large coarsely textured microwear features during the earliest Eocene (WA-0) interval that is coincident with the PETM, and a progressive decrease in the frequency of coarse microwear features and fine-textured scratches in subsequent Wasatchian intervals. It has been suggested that lower nutritional quality of foliage associated with increased CO<sub>2</sub> levels during the PETM may have stimulated the decreased body size of *Ectocion* and other earliest Eocene ungulates. The microwear data suggest increasing emphasis on frugivory during this interval. A shift to a more fruit dominated diet might have been a factor leading to reduced body size, and consequently, higher mass-specific metabolism and reduced absolute metabolic demand. It is possible that decreased body size and associated dietary shifts were part of an adaptive response to the warmer climate of the earliest Eocene. Microwear trends in subsequent Wasatchian subages suggest decreasing frugivory. A decrease in fossil occurrences of *Ectocion* accompanies these later Wasatchian microwear trends, suggesting that this taxon was less successful in late Wasatchian habitats in the Bighorn Basin.

Technical Session IX, Thursday 2:15

#### COMPARING ECOLOGICAL DATA FROM DIFFERENT DEPOSITIONAL ENVIRONMENTS

MILLER, Joshua, The University of Chicago, Chicago, IL, USA

How do we compare fossil communities from different depositional settings? Comparative paleoecological analysis of vertebrate assemblages from different depositional environments requires detailed understanding of the taphonomic pathways that generate such bone accumulations. The distribution and survival of vertebrate skeletal remains across a landscape are influenced by biological factors including species distributions, habitat preferences, and prey consumption, as well as abiotic factors affecting bone decomposition and burial. Quantifying taphonomic patterns and the ecological fidelity of skeletal remains in modern settings provide more detailed understanding of how faithfully different depositional systems capture ecological data and how those data may be most appropriately sampled and compared. Using the surficial ungulate-dominated bone accumulations of Yellowstone National Park, WY, I test the habitat-controls on ecological fidelity. Death assemblage data were collected using transects in four habitats (grasslands, lake-margins, river-margins, and forests). The Minimum Number of Individuals represented by bone accumulations in each transect (then pooled by habitat) were compared to surveys of the living community to quantify habitat variability in ecological fidelity (e.g., richness, evenness, relative abundances). Death assemblages of the four habitats differentially sample richness and community structure. Lake-margins show exceptionally high fidelity in richness and community structure to the living ungulate community, and also capture the broadest vertebrate diversity. River-margins and grasslands also show strong ungulate live-dead agreement. Forested areas (environments with the lowest fossilization potential) provide data on ungulate community structure that are the least representative, but provide a rich assemblage of small-bodied fauna (heavily influenced by raptor pellets). Rarefying richness and community data from individual habitats illustrate sampling strategies for comparing ecological metrics among environments applicable in both paleobiological and modern conservation contexts.

Poster Session I, (Wednesday)

#### THE PHYLOGENY AND INTERRELATIONSHIPS OF NECTRIDIAN AMPHIBIANS

MILNER, Angela, The Natural History Museum, London, United Kingdom; RUTA, Marcello, University of Bristol, Bristol, United Kingdom

Nectrideans are a clade of tetrapods recorded in the Pennsylvanian and Permian of Europe, North America, and Africa. They are among the earliest discovered groups of Paleozoic tetrapods as well as one of the most readily recognized due to their characteristic vertebral morphology. There have been few cladistic attempts to investigate their internal relationships, and their phylogenetic position relative to other Paleozoic tetrapod groups is somewhat controversial. We constructed a data matrix consisting of eight outgroups, 11 nectridean OTUs for the best known taxa, and 173 characters (109 cranial; 64 postcranial) using a combination of characters from previously published work, supplemented by additional first hand observations on nectridean specimens. Our analysis recovered a monophyletic nectridean clade in contrast to some other recent works. Two monophyletic sister groups are represented within the clade. The first is urocordylids, with the two subfamilies, sauropleurines and urocordylines, paired as sister taxa. The second group is represented by the terrestrial *Scincosaurus* as sister taxon to the diplocaulids, which are all aquatic. Nectrideans as a group received an unexpected low bootstrap support, as did the nodes subtending urocordylids and the scincosaurid-diplocaulid clade. The low bootstrap percentage and decay index for nectrideans as a whole are also surprising, given the large number of putative shared derived characters of the group. This might result from the fact that nectridean synapomorphies are mostly confined to their postcranial skeleton; indeed, the majority of those pertain to the construction of vertebrae. Therefore, it is possible that the signal carried by those synapomorphies is swamped by the distribution of other, particularly cranial, features.

**UNIQUE MIDDLE-LATE PERMIAN ACTINOPTERYGIAN FAUNA FROM THE SOUTH URALS AND PRE-URALS**

MINIKH, Alla, Institute of Earth Sciences, Saratov State University, Saratov, Russia; MINIKH, Maxim, Institute of Earth Sciences, Saratov State University, Saratov, Russia; MUTTER, Raoul, Bernard Price Institute for Palaeontological Research, University of the Witwatersrand, Johannesburg, South Africa; BENTON, Michael, Department of Earth Sciences, University of Bristol, Bristol, United Kingdom

Diverse ichthyofaunas and assemblages have been described from the Middle-Late Permian of European Russia. Detailed comparisons with approximately coeval actinopterygian faunas and assemblages such as from the Posidonia Shales in East Greenland [1], the Kupferschiefer (Germany) and Marl-Slate (NE England) [2], the Changhsing Limestone (Chekiang Province) [3], Rangel Coal Measures (Queensland, Australia) [4], Parana Basin (Brazil) [5], the Karoo Basin [6] and equivalents in sub-Saharan Africa including Madagascar [7], reveal that the majority of 38 actinopterygian genera reported from European Russia [8] are currently unique occurrences. However, ten genera (*Acrolepis*, *Acropholis*, *Atherstonia*, *Boreolepis*, *Elonichthys*, *Euryotoides*, *Platysomus*, *Palaeoniscus*, *Reticulolepis*, and *Saurichthys*) occur also elsewhere and two more genera (*Pygopterus* and *Pteronisculus*) occur in two or more of the above-mentioned assemblages. Seven out of 16 actinopterygian families are shared with at least one other assemblage, and four families co-occur. Analyses at the genus- and family-level comparing faunal assemblages [1-8] suggest that equatorial marine waterways (i.e., southern Proto-Atlantic and eastern Tethys) were well connected during the Middle-Late Permian, allowing for east-west faunal exchange. The actinopterygian fauna from the South Urals/Pre-Urals shows closest affinities with the Kupferschiefer and coeval beds from northwestern Europe [2]. Northern vs. southern Hemisphere high latitude assemblages (i.e., northern European Platform vs. Parana and Karoo basins) are relatively more distinct in generic composition, indicative of latitudinal (climatic and paleoenvironmental) constraints, possible geodispersal events, and basin isolation. These comparative studies open the way for a deeper understanding of osteichthyan evolution through the Permian and through the end-Permian mass extinction event.

Poster Session III, (Friday)

**CYMBALOPHUS CUNICULUS FROM THE EARLY EOCENE OF ERQUELINNES (BELGIUM), AND ITS IMPLICATIONS FOR BASAL PERISSODACTYL PHYLOGENY**

MISSIAEN, Pieter, Ghent University, Ghent, Belgium; SMITH, Thierry, Royal Belgian Institute of Natural Sciences, Brussels, Belgium

The abrupt appearance of perissodactyls is one of the major biogeographic markers of the Paleocene-Eocene Boundary. The study of basal perissodactyls has been a popular research topic for over a century and has recently enjoyed a renewed interest. However, the particularly well-preserved specimens of *Cymbalophus cuniculus* from the Early Eocene of Erquelinnes have received surprisingly little recent attention, given that they arguably represent the oldest European perissodactyl. *Cymbalophus* has been regarded either as a basal equoid close to North American *Hyracotherium sandrae* or as a basal tapiriform close to North American *Systemodon*. An entire hemimandible from Erquelinnes with p3-m2 in place represents the most complete specimen from *C. cuniculus*. This specimen moreover holds the only known lower premolars of *Cymbalophus* and we present its morphology in view of the different phylogenetic interpretations. The second perissodactyl fossil from Erquelinnes is an isolated m3 that was traditionally also attributed to *C. cuniculus*. This fossil was however found in a different and potentially older level. Various morphological aspects of this specimen are somewhat atypical of *C. cuniculus* and overlap with the morphology of *H. sandrae*. These specimens therefore highlight the variability and the gradual evolution of basal perissodactyls, and contribute to the understanding of the complex evolutionary patterns of early perissodactyls in Europe.

Poster Session III, (Friday)

**EVOLUTIONARY INSIGHTS FROM PRELIMINARY STATISTICAL ANALYSIS OF TEETH OF THE VENOMOUS MICROVERTEBRATE UATCHITODON (ARCHOSAURIFORMES) FROM THE UPPER TRIASSIC (SANFORD SUB-BASIN, CUMNOCK FORMATION) OF NORTH CAROLINA, USA**

MITCHELL, Jonathan, Appalachian State University, Boone, NC, USA; HECKERT, Andrew, Appalachian State University, Boone, NC, USA; VINCE, Schneider, North Carolina Museum of Natural Sciences, Raleigh, NC, USA; PAUL, Olsen, Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY, USA

Venom is one of the most potent weapons in the animal kingdom, and evolved multiple times in a diverse array of lineages, yet only rarely in the highly successful archosauriforms. Only two named extinct venomous archosauriforms are known, both from Late Triassic teeth (*Graoulyodon hacheti* and *Uatchitodon kroehleri*). Here we report the discovery of numerous (~30) venom-conducting teeth and tooth fragments in the Upper Triassic of North Carolina (Moncure locality, Cumnock Formation, Sanford sub-basin) that are similar to broadly contemporaneous, previously described teeth from Arizona as well as *U. kroehleri*. The Moncure teeth are tall, recurved, and laterally compressed, with serrated edges possessing compound denticles and a venom canal on both the labial and lingual surfaces. We therefore assign these teeth to the genus *Uatchitodon*, although the

encapsulation of the venom canal varies from infolded but open to completely enclosed and tubular and thus may warrant a separate species designation from the open *U. kroehleri*. We measured length, width, the distance of canals with respect to carina, the surface and each other, intercarinal angle, and area of canals as visible on the basal-most exposed cross-section. All results are preliminary, owing to small ( $n = \sim 10$ ) sample sizes. Canal shape does not vary significantly with position in the jaw, as inferred from intercarinal angle ( $n/plr = 10/0.22/0.46$ ) or canal area ( $8/0.11/0.57$ ) or distance from the surface ( $8/0.96/-0.02$ ), but it does with respect to distal offset of the canals ( $12/0.03/-0.63$ ) and canal proximity to each other ( $9/0.00/0.84$ ). The variation from two median canals (*U. kroehleri* and some Moncure specimens) to enclosed tubes (other Moncure specimens and Arizona specimens) mirrors the ontogenetic stages seen in elapid and viperid fangs and leads us to suggest that these teeth may represent a similar evolutionary trajectory. Also, given the high proportion of these teeth at the site, and the variation implying that they are from several different positions in the jaw, we suggest that *Uatchitodon* had a unique arrangement of venom-conducting teeth unlike that of known analogs.

Poster Session II, (Thursday)

**A NEW APPROACH FOR THE TAXONOMIC CLASSIFICATION OF FOSSIL RABBITS (GENUS: HYPOLAGUS) USING EIGENSHAPE ANALYSIS**

MITCHELL, William, Carleton University, Ottawa, ON, Canada; RYBCZYNSKI, Natalia, Canadian Museum of Nature, Gatineau, QB, Canada; SCHRÖDER-ADAMS, Claudia, Carleton University, Ottawa, ON, Canada; SIMONS, Andrew, Carleton University, Ottawa, ON, Canada

The Beaver Pond site on Ellesmere Island (Nunavut Territory, Canada: 78° 33' N, 82° 22' W) is a 5-3 million year old fossil deposit that preserves the remains of "boreal-like" forest ecosystem, including fossil birds, mammals and plants. The mammal assemblage is particularly remarkable, in part, because most taxa show strong Eurasian affinities. One possible exception is a fossil rabbit, of the genus *Hypolagus*, which shows some characteristics that suggest it is derived from a North American lineage. Traditional classification techniques for leporids use linear and angular measurements of features on the occlusal surface of the lower third premolar. These techniques are difficult to replicate accurately and do not account for the overall shape of the tooth. Here we use standard eigenshape analysis to discriminate and compare the differences in tooth shape of fossil leporids. Fourteen teeth (lower p3) representing nine species were analyzed. The results showed the Beaver Pond site *Hypolagus* to be nested within the North American clade, however the approach did not recover the currently proposed phylogeny for the known *Hypolagus* species. This unexpected finding suggests that the current methods of fossil leporid taxonomy are not adequate and should be revisited. Eigenshape analysis may be a useful tool in the development of a new taxonomic approach and may result in a revision of our current understanding of the phylogeny of *Hypolagus*, as well as other fossil leporids.

Technical Session XV, Saturday 12:00

**A NEW PHYLOGENY OF THE TYRANNOSAUROIDEA (DINOSAURIA, THEROPODA)**

MIYASHITA, Tetsuto, University of Alberta, Edmonton, AB, Canada; CURRIE, Philip, University of Alberta, Edmonton, AB, Canada

A comprehensive phylogenetic analysis (97 cranial characters; 32 postcranial characters) of tyrannosauroids rigorously tests previous phylogenetic hypotheses. Characters were tested to determine which ones are ontogenetically or allometrically controlled. *Itemirus* is possibly the most basal tyrannosauroid. The analysis strongly supports the tyrannosauroid affinities of *Dilong* and *Guanlong*, the latter possibly more derived than the former. A coelurosaurian branch from the Late Jurassic of Utah is likely to represent the relatively derived tyrannosauroid *Stokesosaurus clevelandi*. *Appalachiosaurus* is a basal tyrannosauroid, whereas an undescribed tyrannosauroid taxon from the Kaiparowits Formation of Utah is resolved as an albertosaurine. *Alioramus* is the most basal tyrannosaurine. *Tarbosaurus* is outside the clade *Tyrannosaurus* + *Nanotyrannus*. Species of *Daspletosaurus* form a monophyletic tyrannosaurine clade, with the exclusion of one species from the Kirtland Formation of New Mexico. Postcranial characters are more important in resolving relationships between basal tyrannosauroids, whereas cranial characters account for most phylogenetic signals within tyrannosauroids. The tyrannosauroid postcranial anatomy is under strong biomechanical constraints imposed by large body size. Some characters that were previously considered as synapomorphic for the Tyrannosauridae are present in basal tyrannosauroids and were acquired gradually along the lineage. These results suggest that the Tyrannosauroidea originated in Asia during early Jurassic times, and dispersed to Europe and North America before the Late Jurassic. Tyrannosauridae evolved in western North America before the early Late Cretaceous (Santonian) and crossed into Asia in two separate dispersal events during Santonian and Campanian. The tyrannosauroids from the Late Cretaceous of eastern North America may represent an endemic fauna. The analysis also supports the view that information content of a phylogenetic character plays a greater role than proportions of missing data.

Poster Session III, (Friday)

**NEW MATERIAL OF A "SHORT-FACED" TROGOSUS (TILLODONTIA, MAMMALIA) FROM THE DELMAR FORMATION (BRIDGERIAN), SAN DIEGO COUNTY, CALIFORNIA, USA**

MIYATA, Kazunori, Fukui Prefectural Dinosaur Museum, Katsuyama, Japan; DEMERE, Thomas, Dept. of Paleontology, San Diego Natural History Museum, San Diego, CA, USA

The tilloodont, *Trogosus*, is an index taxon for the Bridgerian (Br2) North American Land Mammal Age, with six valid species described from the western interior of USA, mostly from Wyoming and Colorado. The first known Bridgerian fossils from California include *Trogosus* sp. (SDSNH 40819) and *Hyrachyus* sp. (SDSNH 55276), which were recovered from Eocene lagoonal sandstones of the Delmar Formation in coastal San Diego County. The Delmar Formation specimens are well preserved and allow correlation of the West Coast Bridgerian-age strata with provincial and international marine biochronologies. Based on superposition (overlying marine strata contain nannofossils assigned to CP12b) and paleomagnetic analysis (reversed polarity interval assigned to C21r) the Delmar Formation is approximately 48-49 Ma. SDSNH 40819 is one of the most informative known specimens of *Trogosus* and consists of a dorsoventrally compressed skull with beautifully preserved cheek teeth and basicranium, posterior portions of both dentaries with m2-3s, cervical vertebrae (atlas, the third, fourth, and fifth), and incomplete stylohyoids, all from a single individual. The Delmar *Trogosus* belongs to a moderate-sized species, differing from the larger *T. latidens*. It differs from *T. grangeri* and *T. hyracoides* by having a shallower dentary and a slender skull with shorter snout and lower sagittal crest. The shortness of the snout in SDSNH 40819 is comparable to that of a "short-faced" species, *T. hillsii*. The nasals in the Delmar *Trogosus* converge posteriorly to form a roughly V-shaped wedge between the frontals like in *T. hyracoides*. In this character SDSNH 40819 is clearly distinguished from the broader nasals with rectangular reentrant in *T. grangeri* and *T. hillsii*. The Delmar *Trogosus* also has brachydont cheek teeth, and differs from *T. gazini* in having P3 with a small but distinct parastyle, P4 with a distinct preprotocrista, and m3 with no posthypocristid like in *T. hyracoides*. However, the relationship with another "short-faced" species, *T. castoridens* (the type species), is unresolved because *T. castoridens* is only known from a fragmentary dentary with short i2-p3 diastemata.

Technical Session III, Wednesday 3:00

**COMPUTATIONAL MODELING OF THE EVOLUTIONARY CHANGES IN THE LEPIDOSAURIAN SKULL**

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Patterns of bone loss and gain in the lepidosaurian skull, particularly in relation to bars and fenestrae, have led to a variety of hypotheses relating to skull use and kinesis. Perhaps the most enduring of these hypotheses concern the absence of the lower temporal bar in squamates and the evolution of streptostyly. We performed a series of computer modeling studies on the skull of the herbivorous lizard *Uromastyx hardwickii* in order to investigate the role of the lower temporal bar in reptiles. Multibody dynamics analysis (MDA) in conjunction with finite element analysis (FEA) was implemented to predict the forces acting on the skull and the pattern of stress distribution. In the FEA, we applied the MDA result to a series of models, based on the *Uromastyx* skull, to characterize different skull configurations within past and present members of the Lepidosauria. The ancestral lepidosaur had no lower temporal bar but the quadrate was fixed by the pterygoid and squamosal. Under these conditions the quadrate can become highly stressed during hard biting; development of a lower temporal bar would have provided additional support. Streptostyly, on the other hand, can reduce the joint forces acting on the skull, but there is a concomitant reduction in skull robusticity because loss of the bony attachment between the quadrate and pterygoid increases the level of mechanical stress across the skull.

Poster Session II, (Thursday)

**A NEW AND UNUSUAL PROCOLOPHONID REPTILE FROM THE LOWER TRIASSIC OF SOUTH AFRICA**

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A small skull collected from the Lower Triassic Katberg Formation of South Africa represents a new procolophonid parareptile. The skull is characterized by the absence of a ventral temporal emargination, presence of a large posterior maxillary tooth, an edentulous pterygoid, a reduced transverse flange of the pterygoid, and other features. The presence of large maxillary teeth, their positioning ventral to well developed antorbital buttresses, and the loss of the ventral temporal emargination are suggestive of a diet of arthropods with tough exoskeletons, but this dietary inference is not consonant with the thin walls of the maxillary teeth. A cladistic analysis identifies the new procolophonid as a basal member of the procolophonid clade Leptopleuroninae. Optimization of geographic distributions onto the phylogeny indicates that the presence of the new leptopleurine in the Karoo Basin of South Africa is explained most parsimoniously as the result of migration from Laurasia.

It is the fifth procolophonoid species to be described from the Induan of the Karoo Basin, providing further support for the hypothesis that procolophonoid evolution was not greatly perturbed by the end-Permian extinction event.

Poster Session II, (Thursday)

**TESTING AN EFFICIENT LASER SCAN METHOD TO DIGITIZE SAUROPOD VERTEBRAE FOR ANATOMICAL AND KINEMATIC NECK MOVEMENT SIMULATIONS**

MOELLER, Jan-Thomas, Universitaet Flensburg, Institut fuer Biologie und Sachunterricht und ihre Didaktik, Flensburg, Germany; DZEMSKI, Gordon, Universitaet Flensburg, Institut fuer Biologie und Sachunterricht und ihre Didaktik, Flensburg, Germany; CHRISTIAN, Andreas, Universitaet Flensburg, Institut fuer Biologie und Sachunterricht und ihre Didaktik, Flensburg, Germany

In the past it was very difficult and expensive to digitize and analyse the dorsoventral and lateral flexion of neck vertebrae especially of heavy vertebrae like those in sauropod dinosaurs. For this reason a new method of object digitizing was tested. The equipment and development of the digitizing process was relatively simple, a laser line was projected on a reference plate, a webcam and the software "DAVID" were the conditions to triangulate the XYZ-datapoints of the object. This software creates a 3D-Polygon mesh. The scan software and additional software, f. ex. BLENDER and RHINO, gives the possibility to fuse all scans to a complete, high detailed polygon mesh. To compare the 3D results with the morphology and dorsoventral flexion of real vertebrae of *Giraffa camelopardalis* and *Diplodocus carnegii* it was necessary to measure the physical dimensions and the dorsoventral flexion. Then the 3D-vertebrae were articulated, using Blender. Based on results of analysing the physical conditions of the real vertebrae of Giraffe and *Camelus ferus* and the limitation of the flexion through bone structures and ligament tensions the basic knowledge was applied to the 3D-models. Comparing the results between the real vertebrae vs. the 3D-vertebrae flexion show a total difference of 3° in dorsoventral direction of the same joint for Giraffe and 9° for the Diplodocus. The greater difference for the Diplodocus could be found in the deformation during the fossilisation process. During the manual measurements of the flexion it was impossible to bring the zygapophysial joints to an anatomically correct position. These deformation problems would be easily solved by using the 3D-Polygon models. The new ability to reformat the vertebrae and the method of fast and accurately digitizing neck vertebrae is necessary for profound flexion measurements and physical simulations based on computer models. The results of these kinematic simulations are an important contribution to the understanding of the physical limitations in the neck movement of sauropod dinosaurs.

Poster Session III, (Friday)

**A NEW PHYLOGENY OF RHYNCHOSAURIA (DIAPSIDA, ARCHOSAURIFORMES)**

MONTEFELTRO, Felipe, FFCLRP-USP, Ribeirão Preto, Brazil; LANGER, Max, FFCLRP-USP, Ribeirão Preto, Brazil

Rhynchosaurs are basal archosauriforms known from Triassic rocks worldwide. All previous studies depict the group as monophyletic, but the relationships of Middle and Late Triassic forms are still controversial. For this phylogenetic revision, 41 OTUs were selected, including all valid rhynchosaur taxa proposed in the literature, as well as various undescribed South American specimens. Two OTUs were based on *Fodonyx spenceri*; one encompassing the material originally described under the specific epithet, and another based on new associated specimens. *Mesosuchus* and *Howesia* were placed in the outgroup (the former constrained as more basal), and the OTUs were scored for 77 revised and newly proposed characters. A first analysis recovered 3,200 MPTs with 176 steps, the consensus topology of which retained almost no resolution regarding the Upper Triassic forms. Five OTUs, with a minimum of 75% of missing data, were then excluded from a second analysis, and 16 MPTs with 174 steps were recovered. Their consensus shows the more derived position of *Stenaulorhynchus* in relation to *Rhynchosaurus*; the sister-group relation between the former and the "Mariante rhynchosaur"; the apical position of the holotype of *Fodonyx spenceri* in relation to the specimens described along the proposition of the generic epithet (which belongs to a new, still unnamed taxon); the basal position of *Isalorhynchus* among other Hyperodapedontinae; and the apical position of 'Scaphonyx' *sulcognathus* among taxa specimens ascribed to *Hyperodapedon*. This genus is, therefore, either paraphyletic, or more inclusive than previously thought. In addition, the resulting clades that congregate specimens usually assigned to *Hyperodapedon* do not conform their geographically distribution. Indeed, there is no strong evidence for the existence of separated Brazilian and Argentinean species of that genus, and the same could apply for the Scottish and Indian species as well.

**LATE CRETACEOUS MICROVERTEBRATE FAUNA FROM THE NORTHERN STATE OF COAHUILA, MEXICO**

MONTELLANO, Marisol, Instituto de Geología, UNAM, Mexico, Mexico; MONROY, Heidi, Facultad de Estudios Superiores, Iztacala, Mexico, Mexico; HERNÁNDEZ-RIVERA, René, Instituto de Geología, Mexico City, Mexico; TORRES, Esperanza, Posgrado Ciencias Biológicas, UNAM, Mexico City, Mexico

In Mexico, the Late Cretaceous microvertebrate faunas are poorly known. For several years field work had been carried on in the northwestern corner of the State of Coahuila, where outcrops of the Aguja Formation are present. Previous paleomagnetic studies showed a normal polarity which correlates to the chron C33. In and corresponds to the upper Campanian. Sediments had been collected and screen washed for microfossils, which are not very abundant. The recovered taxa include the chondrichthyes *Lonchidion selachos*, *Squalicorax* sp., the rays *Myledaphus bipartitus*, *Myledaphus* sp., and *Ptychotrygon* sp., the osteichthyes *Lepisosteus* sp., and an indetermined phylloodontid form. This assemblage of aquatic forms indicate brackish to freshwater environment, like an estuarine. Also the crocodiles *Goniopholis* sp., *Brachychampsia* sp., and the giant *Deinosuchus riograndensis* are present; the dinosaurs are represented by the small theropods: cf. *Troodon*, three forms of the genus *Saurornitholestes*, *S. langstoni*, *S. n. sp. A?* and *S. n. sp. C.*, remains of other theropods: a form of an indetermined tyrannosaurid and teeth of kritosaurinae hadrosaur were also identified. Unusually, *Richardoestesia* is missing, this taxa had been reported as abundant in the Campanian southern faunas. The diversity recognized until now is poor compared to that reported from the fauna of the Big Bend National Park, Texas, remains of amphibians, lizards and mammals had not yet been recovered. The remains of osteichthyes are the most abundant, follow by those of crocodile, theropods and chondrichthyes. This relative abundance of taxa is similar to that present in the southern faunas such as in the Big Bend National Park, Texas; compared to the northern faunas (p.e., Two Medicine Fm., Dinosaur Provincial Park) where the theropod material is much more abundant. So far, this fauna shares most of the genera and species of microvertebrates with the Campanian southern faunas, supporting the hypothesis of the faunal latitudinal gradient proposed by previous authors.

Technical Session IX, Thursday 2:30

**INSIGHTS INTO THE PRESERVATIONAL PATTERNS OF VERTEBRATE FOSSILS IN A FLUVIAL SYSTEM USING A TWO-DIMENSIONAL COMPUTER MODEL**

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The three-dimensional distribution of vertebrate fossils preserved in a lithological sequence can vary greatly from formation to formation. Some rock units show preferential preservation in channel lag or fill deposits, others in lacustrine or distal floodplain environments. In addition, the taphonomic characteristics of fossil assemblages (for example the size-frequency distribution of elements or the degree of modification by weathering and abrasion) can also vary greatly. An understanding of the processes controlling these variations is necessary to accurately assess the information lost from fossil assemblages, to determine when it is possible to validly compare assemblages and potentially to enable prediction of the fossiliferousness of unstudied units. To investigate the patterns of preservation in fluvial systems, I have created a two-dimensional model of an aggrading floodplain with a meandering channel, inhabited by a steady-state vertebrate community. During each time-step of the model, a proportion of the individuals in the community die, disarticulate and are transported across the floodplain. As the river migrates and the floodplain aggrades, the remains of these individuals become buried. The elements are subject to degradation based on their individual physical properties whilst in the taphonomically active zone, but are considered preserved once they are buried below this level. By altering the parameters of the model, the influence of different properties on the distribution of fossils in a rock unit can be investigated. Altering the rate, severity or style of river flooding significantly influences the distance over which elements are transported. The balance of floodplain aggradation and river erosion is one control on the distribution of skeletal elements between channel and more distal floodplain facies. Models run without any element destruction in the taphonomically active zone provide some suggestions as to the magnitude of loss of elements that must occur in even the most fossiliferous of vertebrate assemblages. The results of this model provide a “null model” against which fossil distributions in the geological record can be compared.

Technical Session X, Friday 11:30

**ASSESSING DINOSAUR ICHNO-VARIABILITY WITH GEOMETRIC MORPHOMETRICS. THE ORNITHOPOD TRACKS FROM THE CAMEROS BASIN (LOWER CRETACEOUS, SPAIN) AS A CASE STUDY**

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The Cameros Basin constitutes a sedimentary area especially well-known by its dinosaur tracksites. It represents a geographically large area (about 8000 km<sup>2</sup>) that encompasses an enormous time span, ranging from the Upper Jurassic (Tithonian) to the Lower Cretaceous (Aptian). The Cameros dinosaur ichnocoenosis is markedly dominated by theropods (about 86%), followed by ornithopods (about 11%), and lastly, by sauropods (3%), and consists

of isolated tridactyl footprints (and of both bipedal and quadrupedal trackways). However, most footprint shapes and shape variability have been treated descriptively so far, and no study has yet tried to exploit the potentials of quantitative characterizations, in particular, using geometric morphometrics (GM), which are perfectly suited for this particular. Using GM, we pursue to explore and visualize for the first time the variation of the ornithopod track record from Cameros Basin, as well as to disentangle the possible presence of two distinct ornithopod footprint morphotypes. A sample of 43 well-preserved ornithopod Cameros tracks was implemented for comparison with other specimens from the world's fossil record. The footprints were digitalized from field schemes and pictures, and thereafter a configuration of landmarks and semilandmarks were used to capture the geometry and the outline of the footprints. On the one hand, a principal components analysis allows visualizing that, 1) digit width, the relatively footprint elongation, and the location of both hypex, and 2) the relatively footprint width related to digital angulation, both account for more than 50% of the sample variability. On the other hand, multivariate regressions reveal that footprint shape is statistically correlated with size, in such a way that larger footprints tend to be broader whereas smaller tend to be more slender. This result suggests that the long-time observed morphotypes are possibly contained within an allometric continuum, and therefore, that they may have important implications in dinosaur foot morphology and/or biomechanics.

Poster Session I, (Wednesday)

**BITE FORCE IN MEGALANIA**

MORENO, Karen, UNSW, Paris, France; PINO, Andrea, PUC, Valparaiso, Chile; WROE, Steven, UNSW, Sydney, Australia; MCHENRY, Colin, U of Newcastle, Newcastle, Australia

We performed 3D finite element analyses of the skulls of *Varanus komodoensis* and *V. giganteus*, two of the largest modern varanids. The results show that their bite force is proportional to the square of the linear dimensions, despite distinct bone stress distributions and feeding behaviors (“hold-and-pull” vs. “puncture-crushing”). We find however, that the horizontal component of the bite force is greater in *V. komodoensis*. This is due to specific features in its skull architecture, which are almost certainly related to a distinct feeding behavior. Here, we use morphology and performance data obtained on *V. komodoensis* and *V. giganteus* to constrain the feeding behavior of an extinct varanid, *Megalania prisca*, for which remains are too incomplete to build an accurate model of its skull. We find that the feeding behavior of *M. prisca* seems to resemble that of *V. giganteus*. Furthermore, the bite force of *M. prisca* is estimated to have been under 200N, an extremely low value for an animal this mass. Indeed, *M. prisca* is the largest terrestrial varanid known (5 meters) and allegedly a top predator in Australian Pleistocene. As the prey of *Megalania* were potentially large, its feeding behavior is unlikely to have been based solely on bite strength.

Poster Session III, (Friday)

**A HIGH-DIVERSITY EGGSHELL LOCALITY FROM THE HAUTERIVIAN-BARREMIAN TRANSITION OF THE IBERIAN PENINSULA**

MORENO-AZANZA, Miguel, Grupo Aragosaurus. Universidad de Zaragoza, Zaragoza, Spain; GASCA, José Manuel, Grupo Aragosaurus. Universidad de Zaragoza, Zaragoza, Spain; CANUDO, José Ignacio, Grupo Aragosaurus. Universidad de Zaragoza, Zaragoza, Spain

La Cantalera site is located near the village of Josa (Iberian Range, Teruel, Spain). La Cantalera site is an outcrop of Early Cretaceous clays from the Blesa Formation. The fossiliferous beds are grey clays with abundant vegetal remains, charophytes, ostracods, gastropods and vertebrate remains. The site was formed in a restricted palustrine environment with periodic droughts. The charophyte assemblage dates the site as late Hauterivian-early Barremian in age.

The highly diverse vertebrate fossils comprise isolated teeth, disarticulated complete or fragmented bones, eggshell fragments and coprolites. Up to 29 different vertebrate taxa have provided recognizable skeletal remains. Dinosaurs are the most diverse vertebrates, with 16 taxa identified, including theropods, sauropods, thyreophorans and ornithopods. Other archosaurs are represented by four crocodylians and two pterosaurs. One turtle, two amphibians, one lacertid and three mammals make up the vertebrate assemblage. The most abundant remains are shed teeth of ornithopod dinosaurs, crocodylian teeth and theropod teeth.

Several thousand eggshell fragments have been recovered through the washing and sifting of three tons of sediment. At least eight different ootaxa have been recognized, including the oofamilies Elongoolithidae, Prismatoolithidae, Spheroolithidae?, Krokoolithidae and Testudoolithidae. Most of the eggshell fragments belong to the Elongoolithidae oofamily, and most of them can be referred to the oospecies *Macroolithus turolensis*. Prismatoolithidae eggshells include *Prismatoolithus* sp. and a new highly sculptured form in the process of being described. Krokoolithidae eggshells are provisionally identified as *Krokoolithes* sp. Noticeable is the presence of two different aff. *Testudoolithus* species, by contrast with the low number of turtle bone remains preserved. Also, the number of cf. Spheroolithidae eggshell fragments, commonly related to ornithopod dinosaurs, is unexpectedly low despite the huge number of ornithopod teeth recovered. Due to its high diversity, La Cantalera proves to be a key locality in the study of European Lower Cretaceous ootaxa.

**DINOSAUR SMILES: CORRELATING PREMAXILLA, MAXILLA, AND DENTARY FORAMINA COUNTS WITH EXTRA-ORAL STRUCTURES IN AMNIOTES AND ITS IMPLICATIONS FOR DINOSAURS**

MORHARDT, Ashley, Western Illinois University, Macomb, IL, USA; BONNAN, Matthew, Western Illinois University, Macomb, IL, USA; KEILLOR, Tyler, University of Chicago, Chicago, IL, USA

Crocodylians and birds are often used to restore dinosaurs as having beaks or exposed teeth, but both extant archosaur clades have specialized ecomorphs and diets that may not reflect the diversity of dinosaur extra-oral structures. Conversely, the fleshy cheeks and lips of mammals are also poor models because dinosaurs lacked facial muscles. However, mammals and extant archosaurs are probably extremes among a larger spectrum of amniotes possessing extra-oral structures. For example, the teeth of lizards and snakes are often covered by extra-oral tissues that form a lip-like seal when the mouth is closed. We found that nutrient foramina on the teeth-bearing jaw bones (premaxilla, maxilla, dentary) are ubiquitous among amniotes and vary among the major taxonomic groups. Using foramina counts on these elements, we tested the hypothesis that there is a significant, quantitative correlation between foramina number and the presence or absence of overlying soft tissues among extant amniotes. Non-parametric tests show a significant, inverse correlation between the number of nutrient foramina on the premaxilla, maxilla, and dentary bones and the presence or absence of extra-oral tissues in amniotes. Taxa with fewer nutrient foramina (mammals, snakes, lizards) have more pliable extra-oral tissues covering their teeth, whereas amniotes with many foramina have either bare teeth (crocodylians) or relatively immobile extra-oral structures (e.g., bird and turtle beaks). When compared to the extant sample, both saurischian and ornithischian dinosaurs fall with amniotes that have covered teeth. Our results support the hypothesis that foramina density and the presence/absence of extra-oral structures are correlated. We suggest that at least the teeth of many dinosaurs were covered in life by a pliable and somewhat mobile extra-oral tissue.

Technical Session XIV, Friday 3:00

**WHAT, IF NOT NOTHING, IS A CREODONT? PHYLOGENY AND CLASSIFICATION OF HYAENODONTIDA AND OTHER FORMER CREODONTS**

MORLO, Michael, Forschungsinstitut Senckenberg, Frankfurt am Main, Germany; GUNNELL, Gregg, Museum of Paleontology, University of Ann Arbor, Ann Arbor, MI, USA; POLLY, P. David, University of Indiana, Bloomington, IN, USA

Two groups of extinct carnivorous mammals have traditionally been placed in the order Creodonta, Oxyaenidae and Hyaenodontidae. Most authorities acknowledge that there are no synapomorphies uniting these two families and Creodonta has remained in use only by taxonomic inertia. A phylogenetic reanalysis of cranial and postcranial remains fails to sustain a monophyletic Creodonta. Instead, these two families are better distributed among three different higher level taxa.

One new higher level taxon contains the family Oxyaenidae which includes three or four subfamilies. Except for a few Eurasian specimens, oxyaenids are an exclusively North American radiation.

Within the former Hyaenodontidae two completely distinct higher level taxa can be recognized, Proviverroidea as a very specialized group within Cimolesta and Hyaenodontida, containing most of the taxa formerly placed in Hyaenodontidae.

Proviverroids retain mostly primitive characteristics such as a three-cusped molar talonid, double-rooted p1, and non-fissured terminal phalanges. The taxon includes the proviverrine *Proviverra* and allied forms and a new subfamily with more trenchant molars typified by *Eurotherium*. Proviverroids are nearly exclusively European and may have evolved from an African cimolestan ancestry.

Hyaenodontida share a single-rooted p1, a derived molar talonid structure, and fissured terminal phalanges. One family of hyaenodontans, typified by *Prototomus*, has molars of equivalent size or with m3 reduced. In addition to taxa associated with *Prototomus*, this family includes limnocyonines, machaeroidines, apterodontines, and also may include some aberrant taxa such as *Francotherium*. A second family includes *Arfia*, *Hyainailouros* and related taxa. It is characterized by molars that increase in size posteriorly with m1 mostly remaining sectorial. The last family, Hyaenodontidae, consists of *Hyaenodon* and its relatives (such as *Propterodon*). Hyaenodontida presumably originated in Asia.

Separating Creodonta into three unrelated taxa provides a solution to the seemingly intractable paleobiogeographic pattern presented by creodonts which resulted from a misunderstanding of taxonomic complexity.

**APPLYING TECHNIQUES OF DIGITALIZATION USING STRUCTURED WHITE LIGHT AND MODELLING BY SINTERING TO REPLICATE VERTEBRATE FOSSILS**

MOROS, Alfredo, Paleoymas, Zaragoza, Spain; BARCO, José, University of Zaragoza, Zaragoza, Spain; CANUDO, José Ignacio, University of Zaragoza, Zaragoza, Spain; CUENCA-BESCÓS, Gloria, University of Zaragoza, Zaragoza, Spain; SAUQUE, Victor, University of Zaragoza, Zaragoza, Spain

The discovery of a horn fragment in the Río Martín Cultural Park (Ariño, Teruel) has made it possible to recover the complete cranium of a *Bos primigenius*. The fossil remnant has been carbon-14-dated to some 45,000 years ago (Upper Pleistocene). After thorough preparation, the possibility was raised of presenting the cranium to the public as part of a temporary exhibition held in the area where it was found. However, the structural fragility of the fossil and its considerable weight, concentrated in certain parts of the item, made transporting it seem inadvisable. After analyzing the situation, it was decided to produce a replica of the fossil. For this, a technique was required that would reduce to a minimum the manipulation of the fossil remnant and that would not involve making moulds or applying products directly to the cranium. It was thus decided to apply inverse-engineering techniques, which make it possible to reproduce the fossil without touching it and also generate files that enable researchers to study the specimen without manipulating it. The process is divided into three phases, the first of which consists in the digitalization of the fossil remnant using structured white light. To this end, more than 10 million points were captured and subsequently processed to create an STL file (file type CAD). This type of file defines the shape of the fossil using small triangles (facets), which adapt to its surface. The following step was the physical reproduction of the model, for which polyamide is used, shaped by means of selective sintering by laser. This technique, which is common in the elaboration of industrial prototypes, consists of applying successive layers of 1mm-thick polyamide in accordance with the graphic model. These are heated using a laser, causing them to adhere together (sintering). The final step was the decoration of the replica with painting and dying techniques, for which – among other things – soils and iron oxides from the same source as the fossil matrix were used, thus achieving a high level of realism in the finish.

Poster Session II, (Thursday)

**OLDEST LAGOMORPH SKELETON FROM EUROPE**

MÖRS, Thomas, Swedish Museum of Natural History, Stockholm, Sweden; KALTHOFF, Daniela, Swedish Museum of Natural History, Stockholm, Sweden

The Paleogene lagomorph record in Europe is based exclusively on dental remains with the exception of an undetermined skeleton from the late Oligocene oil shale locality Rott, Germany (Paleogene Mammal Unit MP 30). A new find was excavated from the late Oligocene oil shales of Enspel in the Westerwald, Germany. These crater lake deposits are famous for the discovery of the first skeleton of a gliding eomyid rodent. The site has an 40Ar/39Ar date of between 24.79 Ma and 24.56 Ma, and is biostratigraphically correlated with MP 28, based on the occurrence of *Eomys quercii*. The new lagomorph specimen is an articulated partial skeleton with preserved skull and almost complete dentition, mandibles, trunk, and forelimbs. Based on the dentition, it can be safely attributed to the European early lagomorph *Amphilagus*, and is one of the oldest representatives of the genus. The cheek teeth are significantly larger than those of *Amphilagus antiquus*, the only species known from the Paleogene of Europe. Therefore, we assign the Enspel lagomorph to *Amphilagus* n. sp. The Enspel specimen represents a juvenile animal, since its cheek teeth are almost unworn, and some deciduous teeth are still present. Based on the development of the dentition and skeletal elements, we estimate the individual age of the animal at about five weeks. Nevertheless, it is much larger than the Rott lagomorph which also is a juvenile individual of approximately the same age. This suggests that the Rott lagomorph represents a taxon different from *Amphilagus* n.sp. from Enspel. Furthermore, *Amphilagus* n. sp. is very important for the reconstruction of lagomorph phylogeny, because the enamel microstructure in the cheek teeth differs from that known in Ochotonidae and Leporidae.

Poster Session III, (Friday)

**THE TAPHONOMY OF A RICH COLLECTION OF BASAL NEOCERATOPSIAN DINOSAURS (CERATOPSIA: ORNITHISCHIA) FROM THE APTIAN-ALBIAN OF NORTHWESTERN GANSU PROVINCE, CHINA**

MORSCHHAUSER, Eric, University of Pennsylvania, Philadelphia, PA, USA; YOU, Hai-Lu, Chinese Academy of Geological Sciences, Beijing, China; LI, Da-qing, Fossil Research and Development Center, Third Geology and Mineral Resources Exploration Academy, Gansu Provincial Bureau of Geo-Exploration and Mineral Development, Lanzhou, China; DODSON, Peter, University of Pennsylvania, Philadelphia, PA, USA

The Mazongshan area of northwestern Gansu Province, China has yielded one of the most diverse Early Cretaceous dinosaur faunas from the Trans-Altai Gobi Desert. During the summer of 2007, teams collaborating with the Fossil Research and Development Center, Third Geology and Mineral Resources Exploration Academy, Gansu Provincial Bureau of Geo-Exploration and Mineral Development collected no fewer than thirty-six individual basal neoceratopsian skeletons from the Yujingzi Basin, approximately 100 kilometers north of Jiayuguan City. Provisional taxonomic assessment considers these specimens cf. *Auroraceratops* sp., though the sample exhibits some morphological variation, which

is under investigation. Here, we present the preliminary results of a taphonomic analysis of these specimens. The specimens were found in the upper red unit of the late Early Cretaceous (Aptian-Albian) Xinminpu Group, a series of fluviolacustrine sediments that have been interpreted as having been deposited in alternating semiarid to moist climatic conditions. Thick caliche layers support the interpretation of aridity for some of the time intervals in the group. All the specimens were collected from two layers separated vertically by 3-4 meters within an area approximately one kilometer in diameter. In some cases, several skeletons occurred within a few meters of each other, while others they were separated by 50 to 100 meters. The skeletons are in a variety of states of preservation, from nearly complete and fully articulated to fragmentary associated remains. The animals also span a moderate size range, with the smallest individuals being approximately half the size of the largest. The earliest stage in ontogeny appears to be lacking. If referable to that taxon, this assemblage would make *Auroraceratops* the third well-represented ceratopsian genus outside of Ceratopsidae, after *Protoceratops* and *Psittacosaurus*.

Molecular Tools in Paleobiology: Trees, Clocks and linking Geno- with Phenotype, Friday 8:45

#### DIVERGENCE ESTIMATES, FOSSIL CALIBRATIONS, AND BAYESIAN INFERENCE: AN EXAMPLE FROM LIZARDS

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Although molecular dating is typically considered the realm of molecular biology, its inherent historical nature also places it firmly within paleontology. In the absence of a good fossil record, estimating molecular divergences is particularly useful for reconstructing evolutionary scenarios, inferring patterns of diversification, and calculating rates of evolutionary change. However, molecular clock dating relies heavily on the choice of fossil calibrations and the model of rate variation used for estimating the evolutionary split. Divergence dating has benefited greatly from the recent advent of Bayesian methods that incorporate phylogenetic uncertainty and calibration error into their estimates. Here we present the example of lacertid lizards, an Old World clade of reptiles whose phylogenetic relationships and biogeographic history are among the most poorly understood in Squamata. The lacertid fossil record is mainly restricted to Europe, whereas the current distribution covers all of Eurasia and, with a distinct monophyletic assemblage, Africa. Because available fossil dates for Lacertidae cannot be constrained with certainty, we use prior probability distributions to approach a maximum age for each of the calibrated nodes. Four different models of rate variation were implemented, and their relative performances are ranked using Bayes factors. We also performed selective deletions of fossil calibrations and compared their posterior estimates. Our results suggest that a migration from Europe into Africa occurred deep in the Paleogene, much earlier than previously reported, coinciding with similar movements in mammals. However, the African radiation may not have initially originated in Africa itself but potentially diverged from the remaining Eurasian lineages well before. A Eurasian origin for the African clade is also supported by Eocene lacertids from Europe possessing features similar to African forms. Our analysis shows that next to calibration error, different models of rate variation should be carefully accounted for in molecular divergence dating. When properly applied, however, fossils and molecules can illuminate each other successfully.

Poster Session IV, (Saturday)

#### A NEW LANTIANIINE ARTIODACTYL FROM THE MIDDLE EOCENE KHAICHIN II LOCALITY OF MONGOLIA

MUNKHBILEG, Namsrai, Institute for the Study of Mongolian Dinosaurs, Ulaanbaatar, Mongolia; BOLORTSETSEG, Minjin, Institute for the Study of Mongolian Dinosaurs, Ulaanbaatar, Mongolia; GEISLER, Jonathan, Georgia Southern University, Statesboro, GA, USA

We describe an isolated and partial upper molar of a probable artiodactyl from the Russian quarry 2 at Khaichin II, Omnogovi Province, Mongolia. The specimen comes from the Khaichin Formation, which is thought to be equivalent to the Irдинmanhan Asian Land Mammal Age (middle Eocene). Key features of the tooth include a rectangular shape with the labiolingual diameter greater than the mesiodistal diameter, a paraconule and metaconule without crista extending into the trigon basin, a postparaconule crista that joins with the metaconule, and a small pericone on a well developed lingual cingulum. Based on comparisons to known Eocene artiodactyls from Asia, the specimen probably represents a new species. To determine its phylogenetic affinities, the tooth was coded for characters in a previously published data matrix. The analysis placed it within the endemic, Asian, artiodactyl subfamily Lantianiinae, either as the sister-group to *Elachistotherium* or to *Lantianius*. Like these two taxa, the new specimen has a straight centocrista and a weak ectocingulum. Lantianiinae is known from the Irдинmanhan and Sharamurungia, thus the discovery of a new species at the Irдинmanhan Khaichin Formation is not surprising. The new species brings the known artiodactyl diversity of the Khaichin Formation to six species, indicating that although rare, artiodactyls of the middle Eocene of Mongolia are more diverse than formerly thought.

Poster Session IV, (Saturday)

#### REVISION OF THE LATE MIOCENE DELPHINID (CETACEA: DELPHINOIDEA), "STENELLA" KABATENSIS FROM HOKKAIDO, JAPAN

MURAKAMI, Mizuki, Waseda University, Tokyo, Japan; SOEDA, Yuhji, Historical Museum of Hokkaido, Sapporo, Japan; HIKIDA, Yoshinori, Nakagawa Museum of Natural History, Nakagawa, Japan; HIRANO, Hiromichi, Waseda University, Tokyo, Japan

It is thought that the oldest fossil record of the delphinidae is from the Late Miocene of California. Reliable Miocene fossil delphinids, however, are few even now, since most of fossil delphinid specimens from the Miocene, are very fragmentary preserved (e.g., one tooth, or one periotic). Even more, and their taxonomical discussions are insufficient. Horikawa described *Stenella kabatensis* (MHM 68037 housed in Historical Museum of Hokkaido), which has been yielded from the upper Miocene Mashike Formation, Hokkaido, Japan. Because this specimen consists of facial skull, right and left mandibles, isolated teeth, both right and left tympano-periotics, this is a very significant specimen, as a clue for understanding early evolutionary history of the delphinidae. In the original description, this specimen shows an abnormal feature for the delphinid; the saggittal plane of the choanae consists of both right and left paratines which separate right and left hamular process of pterygoids. However, the specimen is incompletely prepared, and the original description is insufficient to discuss taxonomical position. Therefore, we carefully prepared the specimen again, and re-examined taxonomic position of this specimen. After this preparation, following characters are identified: (1) in the palate of this specimen near the saggittal plane of the choanae consist of both right and left hamular processes of pterygoids as in other delphinids. (2) this specimen has alispenoid fossa in front of foramen ovale and caudal carotid foramen as in other delphinids (this fossa is very deep medially in phocoenids). (3) on the other hand, the wall of the rostrum is flat as in phocoenids rather than having the clear keel from the end of hamular processes of pterygoids as in most of delphinoids (4) in addition to that, on the wall of the rostrum of this specimen, maxilla fused paratine irregularly as in non-delphinid delphinoid rather than maxilla fused paratine at a contact marked by elongate sub-horizontal striations as in many other delphinids. Considering these characters, it is assumed that MHM 68037 is not assigned to genus *Stenella* but a new primitive delphinid genus.

Technical Session V, Wednesday 1:45

#### ACTINOPTERYGIANS FROM THE KAROO BASIN (SOUTH AFRICA) AND THEIR PALEOBIOGEOGRAPHIC CONTEXT

MUTTER, Raoul, Bernard Price Institute for Palaeontological Research, University of the Witwatersrand, Johannesburg, South Africa

Twelve actinopterygian families are known from the Paleozoic Witteberg, Dwyka, Ecca and Lower Beaufort Group in the Karoo Basin. Abrupt changes in faunal composition are recorded at the Witteberg-Dwyka boundary (Devonian-Carboniferous boundary) and at the Lower-Upper Beaufort Group boundary (Permian-Triassic boundary). The relatively well-known Permian Karoo faunal assemblages show a high degree of endemism, with a few taxa being reported from isolated Sub-Saharan localities. At the end of the Permian, widespread genera are present with *Atherstonia* and *Elonichthys* (and, possibly with *Palaeoniscus*), documenting well-connected waterways. With the exception of the family Elonichthyidae, the Permian actinopterygian fauna is fully replaced by new families in the *Cynognathus* Assemblage Zone (subzone B) by the end of the Early Triassic. The Karoo Basin yields members of marine and freshwater families of advanced evolutionary levels by the end of the Triassic, while the marine Early Triassic is worldwide impoverished: The actinopterygians *Meidiichthys*, *Pristisomus* and saurichthyids (possibly also *Cleithrolepidina* and *Hydropessum*) document marine Scythian origin, although the exact paleogeographic provenance of these fish groups is at present unknown. The slightly younger, well-known freshwater fish assemblages of New South Wales (in particular from Gosford and Brookvale) reveal a comparable pattern. This suggests one (unrecorded) sea-level high stand affecting Gondwana and following the well-documented worldwide regression at the Permian-Triassic boundary. The oldest record of redfieldiiform fishes is from the Late Permian of Queensland. The oldest redfieldiiforms from the Karoo Basin are early Triassic in age, and more advanced members of this family occur in the Middle Triassic of Australia and Argentina and are abundant in the Late Triassic and Early Jurassic freshwaters of North America. The distribution of the non-marine redfieldiiform fishes is most easily explained assuming freshwater connections in Madagascar, India and Antarctica during the Late Permian and/or Early Triassic and in mainland South America (and possibly Africa) during the Middle-Late Triassic.

**CARNIVORES AND THEIR PALEOECOLOGY FROM THE HOMINID SITE GALILI, SOMALI REGION, ETHIOPIA**

NAGEL, Doris, Department of Palaeontology, University Vienna, Vienna, Austria; KULLMER, Ottmar, Forschungsinstitut Senckenberg, Palaeoanthropology, Frankfurt, Germany; SANDROCK, Oliver, Hessisches Landesmuseum, Geologie-Palaeontology and Mineralogy, Darmstadt, Germany; VIOLA, Thomas, Department of Anthropology, University Vienna, Vienna, Austria; SEIDLER, Horst, Department of Anthropology, University Vienna, Vienna, Austria

The *Australopithecus*-bearing locality Galili is located in the southern Afar depression (Somali Region, Ethiopia) and has been excavated by the International Paleanthropological Research Team. The fluvial-to-lacustrine sediment succession is separated by volcanic layers. Preliminary radiometric results and biostratigraphic correlations date the fossil material to the early Pliocene (3.5 to 4.5 Ma years). The fossil assemblages from the Mount Galili Formation correlate with the Asa Issie, Kanapoi and the Apak and Kaiyumung Members at Lothagam. The carnivores were recovered from the Lasdanan, Dhindinley and Shabeley Laag Member. Although the specimens are fragmented and no associated skeletons have been found so far, tooth remains identify a wide range of carnivores, from small insectivore viverrids, like *Genetta* sp., to large hypercarnivore felids, e.g. *Dinofelis*. Most carnivores from the Galili area are small to medium-sized. The taxa, known from related sites, are classified as terrestrial and additionally one lutrine form could be identified. This data can be compared with the results retrieved from the investigation of the abundant suids, bovids and elephantids from the Galili deposits and draws a complex paleoecological picture of the faunal community in the time of early hominid evolution. The results suggest an open woodland to bush-woodland habitat with good water supply.

Poster Session IV, (Saturday)

**EXTANT ANIMALS PROVIDE NEW INSIGHTS ON HEAD AND NECK POSTURE IN SAUROPODS**

NAISH, Darren, University of Portsmouth, Portsmouth, United Kingdom; TAYLOR, Michael, University of Portsmouth, Portsmouth, United Kingdom; WEDEL, Mathew, Western University of Health Sciences, Pomona, CA, USA

The neck posture of sauropod dinosaurs has long been controversial. At one extreme, some workers have argued for vertical, mast-like necks while, at the other, some have reconstructed these animals with horizontal or even downward-sloping necks that put the head close to the ground. It has recently been argued that neck posture can be reconstructed by positioning the cervical vertebrae and skull in an 'osteological neutral pose' (ONP), the best fit arrived at by articulating the vertebrae while keeping the zygapophyses in maximum contact. When sauropod necks are reconstructed in ONP, their necks are horizontal. It has also been claimed that ONP represents the habitual life posture, and provides an indication of feeding height. Several authors have also reconstructed sauropod heads such that the long axis of the brainstem cavity is parallel with the neural canal of the atlas and axis: or, in other words, that the cranio-cervical junction is fully extended. To date, conclusions on sauropod head and neck posture have taken surprisingly little account of what is known about extant animals. A substantial literature on extant amniotes (mammals, turtles, squamates, crocodylians and birds) shows that living animals do not habitually maintain their necks in ONP. Instead, the neck is maximally extended at the cervico-dorsal junction and maximally flexed at the cranio-cervical junction, so that the mid-cervical region is near vertical. This is true even in apparently short-necked animals. We manipulated the vertebrae of modern mammals and birds and found that the life postures (as determined by X-ray observations) are more extended than ONP, and indeed more elevated than can be achieved when manipulating dry bones alone. The fact that elevated, extended necks are widespread across Amniota means that elevated necks should be assumed for sauropods in the absence of evidence to the contrary. Elevated neck postures for sauropods are indicated by the extant phylogenetic brackets at the levels of Saurischia, Archosauria, Diapsida, Reptilia and Amniota.

Edwin H. and Margaret M. Colbert Poster Competition (Thursday)

**A NEW EARLY TRIASSIC FOSSIL VERTEBRATE ASSEMBLAGE FROM NORTHEASTERN JAPAN**

NAKAJIMA, Yasuhisa, the University of Tokyo, Tokyo, Japan

The South Kitakami Terrane (SKT) is a tectonic region located in Northeastern Japan. SKT contains a Paleozoic-Mesozoic continental shallow-marine sedimentary sequence whilst most of other tectonic regions in Japan consist of deep-sea sediments accreted onto the continental shelf. Because of this, understanding the structural development of the SKT is believed to clarify the complex tectonic history of the overall Japanese archipelago. Marine invertebrate fauna from Permo-Triassic of SKT has been shown to resemble that of North China therefore it is possible to affirm that Paleo-Japan is regarded to be located near North China. However, no land vertebrate has been described till now. Here the author reports a new vertebrate fossil assemblage from the Hiraiso Formation (Lower Triassic) in the Tsuya area of the SKT. It includes an assemblage of capitosauroid temnospondyl and selachians, which differ from the vertebrate assemblage from overlying Osawa Formation consisting mainly of ichthyopterygians. The fossils occur from a pebbly sandstone bed from the lower to the middle of the Hiraiso Formation, described as a coastal sand bar system.

Nonetheless, disarticulated occurrences of vertebrate remains associated to the existence of capitosauroid suggest that, at least in part, the vertebrate fossils were transported from non-marine environment. This fossil vertebrate assemblage provided new important information on the biogeographical setting of Paleo-Japan. The occurrence of a capitosauroid, which is generally thought to be non-marine dweller, suggests that there were no barrier for land vertebrates to migrate between North China and SKT during some period from Late Permian to Early Triassic. The new vertebrate assemblage is expected to provide further information on land vertebrate fauna of Paleo-Japan in the Early Triassic, and need further detailed investigation.

Poster Session III, (Friday)

**MESOWEAR ANALYSIS FOR CHEEK TEETH OF UNGULATE FOSSILS FROM THE LATE MIOCENE MARAGHEH FORMATION, NORTHWESTERN IRAN**

NAKAYA, Hideo, Kagoshima University, Kagoshima, Japan; HASUMI, Eri, Kagoshima University, Kagoshima, Japan; MIYAZATO, Nao, Kagoshima University, Kagoshima, Japan; WATABE, Mahito, Hayashibara Museum of Natural Sciences, Okayama, Japan

The tooth mesowear method is a new approach of reconstructing ungulate diets and their paleoenvironments. We analyzed mesowear of hipparions and bovids upper and lower cheek teeth (P4 to M3) from the Late Miocene Maragheh Formation, Northwestern Iran to evaluate diet and paleoenvironments. For tooth mesowear analysis, the occlusal relief of the buccal side is scored as high or low. Cusp shape is classified as sharp, round or blunt.

The occlusal relief of hipparions were classified as "high" in all upper teeth of *H. prostylum*, 94% of upper teeth of *H. moldavicum*, and 97% of upper teeth and 98% of lower teeth of *Hipparion* sp.

The cusp shape of hipparions were classified as "round" in 89% of upper teeth of *H. prostylum*, 78% of upper teeth of *H. moldavicum*, and 69% of upper teeth and 97% of lower teeth of *Hipparion* sp., and as "sharp" in 11% of upper teeth of *H. prostylum*, 22% of upper teeth of *H. moldavicum*, and 26% of upper teeth and 2% of lower teeth of *Hipparion* sp.,

The occlusal relief of bovids were classified as "high" in 20% of upper teeth and 55% of lower teeth of bovids in small size, 58% of upper teeth and 53% of lower teeth of bovids in middle size.

The cusp shape of bovids were classified as "round" in 20% of upper teeth and 50% of lower teeth of bovids in small size, 42% of upper teeth and 70% of lower teeth of bovids in middle size, and as "sharp" in 70% of upper teeth and 7% of lower teeth of bovids in small size, 58% of upper teeth and 17% of lower teeth of bovids in middle size.

Paleodiet of ungulate fossils from the Maragheh Formation in comparison with recent ungulates are suggested the following: hipparions may be mixed feeder, bovids in small size may be browser, and bovids in middle size may be browser near mixed feeder. The following conclusions are reached: The paleoenvironment of the Maragheh Formation may have been a woodland savanna environment.

Poster Session II, (Thursday)

**PREDICTING THE SOCIAL SYSTEMS OF EXTINCT HOMINIDS USING DIGIT RATIOS (2D:4D)**

NELSON, Emma, Department of Archaeology, University of Liverpool, Liverpool, United Kingdom; ROLIAN, Campbell, Department of Cell Biology and Anatomy, University of Calgary, Calgary, Canada; CASHMORE, Lisa, Department of Archaeology, University of Southampton, Southampton, United Kingdom

Social systems are notoriously difficult to identify in the hominid fossil record. Fragmentary remains and low canine dimorphism confound predictions of sexual dimorphism. This is highlighted by the ongoing differences in opinion concerning the social system of the Pliocene hominid *Australopithecus afarensis*. Recent studies have shown that the second-to-fourth digit ratio (2D:4D), a proposed biomarker for prenatal androgen effects (PAE), co-varies with social systems in haplorhine primates; pair-bonded taxa have significantly higher 2D:4D ratios (low PAE) than non-paired, promiscuous species. Here we attempt to use digit ratios to predict the social systems of three fossil hominid taxa - *Hispanopithecus laietanus* (~9.3 mya), *Australopithecus afarensis* (~3.2 mya) and *Homo neanderthalensis* (~60 kya). We regressed soft-tissue ratios (2D:4D) against bone ratios derived from the second-to-fourth proximal phalanges (2PP:4PP) of extant hominoid species ( $r^2=0.95$ ). The regression equation obtained was used to predict soft-tissue ratios for fossil 2PP:4PP ratios. Discriminate function analysis was then used to predict the social systems for the extinct taxa using 2D:4D values for the fossils and known relationships between 2D:4D and social systems for extant species. Phylogenetic and substrate effects were controlled for in all analyses. Results: *Hi. laietanus* and the *H. neanderthalensis* were predicted to be non-pair-bonded, while *Au. afarensis* was classified as pair-bonded. Issues surrounding small fossil sample sizes and possible taphonomic effects on sampling and bone length are addressed. This evidence suggests that, as more fossil hand bones become available, digit ratios might augment current techniques for elucidating the social systems of fossil hominids.

**THE ANTIQUITY OF ARCHOSAURIA AND THE ORIGIN OF LATE TRIASSIC ARCHOSAUR ASSEMBLAGES**

NESBITT, Sterling, American Museum of Natural History, New York, NY, USA

Archosaurs have a rich history that originated in the Triassic and continues today with two extant clades, the crocodylians and the avians. Nonetheless, the initial divergence of Archosauria is poorly understood. Few archosaur fossils have been found prior to the Ladinian Stage (late Middle Triassic), even though published archosaur phylogenies predict most Triassic archosaur ghost lineages stretch into the Middle Triassic or earlier. New discoveries of archosaurs from the Middle Triassic Manda Formation of Africa, the Moenkopi Formation of North America, and the re-identification of existing material from the Early Triassic of China help fill these ghost lineages. I conducted a thorough phylogenetic analysis (80 archosauriform taxa, 412 characters) to assess the early evolution of Archosauria. The analysis recovered a well resolved, robustly supported consensus tree that includes a monophyletic Archosauria. "Rauisuchians" are found to be paraphyletic, but include a monophyletic poposauroid clade, rauisuchid clade, and crocodylomorph clade. A monophyletic clade containing *Silesaurus* and similar forms is supported as the sister-taxon to Dinosauria. Time-calibration of this phylogeny indicates that the origin and initial diversification of Archosauria occurred prior to the Middle Triassic, just after the Permian-Triassic extinction. A *Silesaurus*-like taxon from the Anisian Manda Formation indicates that the Pterosauria, Dinosauromorpha, Dinosauriformes, and Dinosauria lineages were present by the Anisian. Similarly, the "sail-backed" poposauroid *Xilousuchus* from the late Early Triassic of China indicates that Archosauria, the Ornithodira, Phytosauria, Aetosauria, Ornithosuchidae, and Paracrocodylomorpha lineages were present by the end of the Early Triassic. High rates of homoplasy, long ghost lineages, and high rates of character evolution characterize the early history of Archosauria. These data imply that much of the early history of Archosauria has not been recovered, and the typical archosaur assemblages in the Late Triassic were possibly established by the Middle Triassic.

Poster Session I, (Wednesday)

**GROWTH CHARACTERISTICS OF SOME LATE CRETACEOUS LAMNIFORMS (ELASMOBRANCHII) OF NORTH AMERICA**

NEWBREY, Michael, Royal Tyrrell Museum of Palaeontology, Drumheller, AB, Canada; COOK, Todd, University of Alberta, Edmonton, AB, Canada; WILSON, Mark, University of Alberta, Edmonton, AB, Canada; NEUMAN, Andrew, Royal Tyrrell Museum of Palaeontology, Drumheller, AB, Canada; TAKEUCHI, Gary, Natural History Museum of Los Angeles County, Los Angeles, CA, USA

Fossil lamniform sharks are relatively common from the Late Cretaceous of North America, but little has been done to study their growth biology and there have been no comparisons of size at a standardized age across taxa. We analyzed growth characteristics of *Cretoxyrhina*, *Archaeolamna*, and six taxa of anacoracids to compare size at birth, age of asymptotic growth, longevity, and size of centra and teeth at three years old. Age and growth were quantitatively estimated from 20 vertebral centra of different individuals of which 16 were sagittally sectioned. As in extant lamniforms, growth bands (i.e., periodic markers or growth increments) were interpreted as annular rings. Centrum radial distance at birth was significantly smaller in the anacoracids and *Archaeolamna* compared to *Cretoxyrhina*. Longevity in *Cretoxyrhina* was estimated as up to 36 years compared to *Archaeolamna* at 18 years and the anacoracids, which ranged from 9-22 years depending on the taxon examined. Growth was rapid in *Cretoxyrhina* until age 6 and then slowed. Growth in *Cretoxyrhina* was highly variable after age 6 and a substantial amount of growth in centrum size occurred after age 6 in some individuals. *Archaeolamna kopingensis* reached 70% of adult size by age 5. Anacoracid growth tapered off between the ages of 4 and 11 years depending on the taxon examined. Anacoracids had tightly clustered growth profiles; at age 3, centrum radial distance ranged from 7 to 14 mm and overlapped in size with that of *A. kopingensis*. Specimens of *Cretoxyrhina* had significantly larger centra at age 3 (22-28 mm centrum radial distance) compared to those of the anacoracids. Tooth base lengths of *Cretoxyrhina* were adjusted for size at age 3 and ranged from 18 to 22 mm; teeth of *Cretoxyrhina* were generally larger than those of the anacoracids (4-15 mm) and *Archaeolamna* (13 mm) at the same age. Our results show that size of centra at birth, growth profiles, size of centra and teeth at age 3, and longevities were more similar for *Archaeolamna* and the anacoracids, but specimens of *Cretoxyrhina* were larger and lived longer than those of *Archaeolamna* and the anacoracids.

Poster Session II, (Thursday)

**NEW DATA ON THE ANATOMY AND PHYLOGENETIC POSITION OF *SILESAURUS OPOLENSIS* FROM THE LATE CARNIAN OF POLAND**

NIEDZWIEDZKI, Grzegorz, Department of Paleobiology and Evolution, University of Warsaw, Warsaw, Poland; PIECHOWSKI, Rafal, Department of Paleobiology and Evolution, University of Warsaw, Warsaw, Poland; SULEJ, Tomasz, Institute of Paleobiology PAN, Warsaw, Poland

*Silesaurus opolensis* is one of the best-known early dinosauriform archosaurs, represented by several, partially articulated skeletons and hundreds of isolated bones collected from the Keuper beds (Late Triassic: late Carnian) at the Krasiejów near Opole, Upper Silesia, Poland. *Silesaurus* is peculiar in having herbivorous-like teeth as well as evidence for a beak

on the anterior end of the dentary. The phylogeny of basal dinosaurs and closely related taxa has been examined by numerous cladistic analyses. However, areas of uncertainty remain, such as the relationships of *Silesaurus*-like dinosauriforms to basal ornithischian and sauropodomorph dinosaurs. Following the initial description of this taxon in 2003, *Silesaurus* has been the subject of detailed anatomical study. We present new observations on the anatomy of the skull, dentary, limbs and pelvis, shedding new light on the phylogenetic position of this taxon. A new phylogenetic dataset was constructed to resolve relationships amongst dinosauriforms, *Silesaurus*-like dinosauriforms, basal saurischians (including basal sauropodomorphs) and basal ornithischians. This dataset includes 25 species and 125 characters (10 new); characters were compiled based upon a thorough reassessment of previous phylogenetic datasets and direct examination of relevant specimens. Character scorings were drawn from previous analyses as well as the recently published and ongoing results of taxonomic reviews of the Late Triassic dinosauriform and basal dinosaur record. Analysis of the new dataset suggests that *Silesaurus opolensis* is the basalmost known ornithischian, forming the sister taxon of other early ornithischians, including *Pisanosaurus*, *Lesothosaurus*, *Eocursor*, 'fabrosaurids' and Heterodontosauridae. The major ornithischian character of *Silesaurus* is a beak at the tip of mandible. The symphysis does not show permanent junction of dentaries and they clearly had significant mobility, although their tip was apparently armed with horny cover. *Silesaurus* was also advanced in the construction of its pelvis and sacrum relative to other early dinosauriforms.

Technical Session XV, Saturday 11:15

**A REMARKABLE LONG-SNOUDED, MULTI-HORNED TYRANNOSAURID FROM THE LATE CRETACEOUS OF MONGOLIA**

NORELL, Mark, American Museum of Natural History, New York, NY, USA; BRUSATTE, Stephen, American Museum of Natural History, New York, NY, USA; CARR, Thomas, Carthage College, Kenosha, WI, USA; BEVER, Gabe, American Museum of Natural History, New York, NY, USA; ERICKSON, Gregory, Florida State University, Tallahassee, FL, USA

Tyrannosaurus and close relatives comprise the Tyrannosauridae, a derived clade of large-bodied theropods that were the apex predators in most terminal Cretaceous ecosystems in Asia and North America. Tyrannosaurids are characterized by a generalized body plan: all well-known taxa possess short deep skulls, a robust lower jaw, and thickened teeth, features thought to enable powerful bite-forces. One enigmatic tyrannosaurid, *Alioramus* from the Late Cretaceous of Mongolia, is a long-snouted and gracile predator that deviates from this trend. However, further details of its anatomy, biology, and phylogenetic relationships are controversial, due to fragmentary holotype material. We report a peculiar new tyrannosaurid specimen from the Maastrichtian Nemegt Formation of Mongolia, which represents a new species of *Alioramus* and helps clarify the anatomy and systematics of the genus. This specimen is remarkably complete, allowing for unprecedented observation of tyrannosaurid cranial anatomy. The new species is small-bodied, with an estimated mass of 368 kg, and possesses a bizarre long-snouted and gracile skull with eight discrete horns, including one on each jugal, a novel cranial form for a Late Cretaceous tyrannosaurid. The maxillary and dentary tooth counts, 17 and 20 respectively, are greater than other tyrannosaurids. Cervical pneumaticity is extreme and includes two unusual features: an autapomorphic pocket on the transverse processes and a deep fossa on the centrodiapophyseal laminae. Histological analysis indicates that the specimen was approximately 14 years old when it died in the stationary phase of growth, and thus was approximately 1/5 the mass of a similarly-aged Tyrannosaurus. *Alioramus* retains many features of juvenile Tyrannosaurus and Albertosaurus until later in ontogeny, suggesting that heterochrony may have played a role in tyrannosaurid evolution. Phylogenetic analysis places *Alioramus* as a member of the derived Tyrannosaurinae. Thus, *Alioramus* represents a small, sleek, longirostrine tyrannosaurid, which lived alongside its hypercarnivorous relative *Tarbosaurus*.

Technical Session X, Friday 11:45

**THE EARLY ORNITHISCHIAN HETERODONTOSAURUS TUCKI: CRANIAL ANATOMY AND RELATIONSHIPS**

NORMAN, David, University of Cambridge, Cambridge, United Kingdom; CROMPTON, Alfred, Harvard University, Cambridge, MA, USA; BUTLER, Richard, Bayerische Staatssammlung, Munich, Germany; PORRO, Laura, University of Chicago, Chicago, IL, USA; CHARIG, Alan, Natural History Museum, London, United Kingdom

The early Jurassic ornithischian *Heterodontosaurus* was described on the basis of a partially prepared skull. Subsequent discoveries of similar, better-preserved, material, and the re-assessment of earlier mis-identified specimens, has added much to our knowledge of this taxon and that of closely related forms (heterodontosaurs). The postcranial skeleton of a referred specimen (that also included an articulated skull) of *H. tucki* was described in detail and provided the basis for most of our current understanding of these highly characteristic ornithischians. The cranial material, although subjected to various phases of preparation in later years, was not described in detail. Recent study has culminated in a more complete description of the craniology of *Heterodontosaurus*. The skull of *H. tucki* exhibits a number of anatomical peculiarities when compared to those of most ornithischians; the most immediately obvious features, such as the strongly heterodont dentition, the presence of fine serrations on the caniniforms and the reduced (and evidently episodic) pattern of tooth replacement, have been well-documented. However a number of additional, and generally unusual, features can now be described. The lower jaws are pinned

at the symphysis by means of a complex suture with the prementary and while the dentary is massive the postdentary bones are remarkable in that they incorporate a remarkable dentary-angular-surangular structure that facilitates intramandibular flexibility. The upper jaws exhibit components of the pneumatic sinus system seen more extensively in related archosaur groups. The basicranial and palatal elements are exceptionally narrow, deep and closely linked internally, combining with features in the skull roof that create a novel cranial architecture. *Heterodontosaurus* was clearly a remarkable early Jurassic ornithischian that exhibits an extraordinary combination of features in its anatomical make up; some reflect a basal dinosaur ancestry, others its basal ornithischian status and yet others demonstrate its unique biological attributes.

Poster Session III, (Friday)

**PECTORAL GIRDLE AND FORELIMB OF *PUIJILA DARWINI*, A FOSSIL PINNIPED FROM THE HAUGHTON CRATER FORMATION, DEVON ISLAND, NUNAVUT**

NORTHOVER, Joanna, Carleton University, Ottawa, ON, Canada; RYBCZYNSKI, Natalia, Canadian Museum of Nature, Ottawa, ON, Canada; SCHRÖDER-ADAMS, Claudia, Carleton University, Ottawa, ON, Canada

A new genus of fossil carnivore, *Puijila darwini*, was recently discovered in Haughton Crater, on Devon Island, Nunavut (75°N). Prior phylogenetic work based primarily on cranial characters, grouped *Puijila* and the early Miocene fossil *Potamothereum vallentoni* within the clade Pinnipedia. Although *Puijila* is a pinniped, its limb proportions and long tail are reminiscent of modern otters (Lutrinae), particularly *Lontra canadensis*. The forelimb of *Puijila* resembles *Lontra* in the caudal angle of its partially preserved scapula. Also, the overall shape of *Puijila's* humerus - which possesses an enlarged deltoid crest - and its distally expanded radius appear similar to *Lontra*. In spite of these similarities, the deltoid crest of *Puijila* is more developed than *Lontra*, expanding further distally, and its manus is proportionally larger - which suggests a greater degree of swimming specialization. Although *Puijila* superficially resembles a lutrine many of the traits of its pectoral girdle and forelimb support its relationship to *Potamothereum* and flippered pinnipeds. Traits that suggest this affiliation include a scapula with an expanded infraspinous fossa to accommodate the teres musculature, an enlarged greater and lesser tuberosity of the humerus and a robust, rounded radial head. Also, the ulnas of both *Puijila* and *Potamothereum* have a shallow trochlear notch, as compared to *Lontra* - although neither is as shallow as that of flippered pinnipeds. In addition, *Puijila's* ulna is remarkably similar to *Potamothereum* with a triangular transverse section on the lower shaft and a posteriorly expanded olecranon process, which is more robust than *Lontra's*. In general, *Puijila's* forelimb shows a degree of swimming specialization greater than *Lontra* but less than that of *Potamothereum*. Postcranial traits in *Puijila* (and *Potamothereum*) lend further support to the phylogenetic hypothesis that these are stem pinnipeds.

Poster Session IV, (Saturday)

**USE OF SYNCHROTRON MICROTOMOGRAPHY TO EXAMINE TOOTH REPLACEMENT PATTERNS IN A TAPINOCEPHALID DINOCEPHALIAN**

NORTON, Luke, Bernard Price Institute (Palaeontology), University of the Witwatersrand, Johannesburg, South Africa; TAFFOREAU, Paul, European Synchrotron Radiation Facility, Grenoble, France; RUBIDGE, Bruce, Bernard Price Institute (Palaeontology), University of the Witwatersrand, Johannesburg, South Africa; DE KLERK, William, Albany Museum, Grahamstown, South Africa

Tapinocephalid dinocephalians were the earliest synapsids to develop specialized crushing surfaces on their teeth; however unlike those of modern animals, these crushing surfaces were on the incisors and not on the molars. Previous studies of the dentition of titanosuchid dinocephalians have relied on destructive sampling. One of the findings of these studies was the possible intermeshing of incisors in all dinocephalians, as well as the additional intermeshing of postcanines in tapinocephalid dinocephalians. Due to poor preservation and the small number of specimens, there has been little recent work on dinocephalian dentition. The discovery of a tapinocephalid dinocephalian with well-preserved teeth *in situ* has provided an opportunity for detailed analysis of tooth replacement and occlusion in the group, using modern non-destructive techniques. State of the art three-dimensional scanning technology was used to examine the occlusal surfaces of the teeth in detail without the risk of damaging the teeth through further preparation. The specimen was scanned at the European Synchrotron Radiation Facility on the biomedical beamline with a voxel size of 90µm. 61 teeth are evident in the synchrotron scans, double that visible prior to scanning with a conventional machine, and with far better detail. Of the 61 teeth, 32 were erupted and functional teeth, while 29 were unerupted. These 'replacement' teeth can be classified into several successive 'generations,' according to their developmental stages. The positions of unerupted teeth relative to the erupted teeth and one another support findings of previous studies. Our study has also provided new information, showing a greater number of unerupted teeth present in the jaw than previously thought. There is also evidence for a change in the morphology of the postcanine teeth as an individual aged, implying that some habitat partitioning took place between individuals of different ages in Dinocephalia.

Technical Session IX, Thursday 3:30

**THE POTENTIAL UTILITY OF AUTHIGENIC MINERALS ON MODERN AND FOSSIL BONES FOR ENVIRONMENTAL AND TAPHONOMIC ANALYSIS**

NOTO, Christopher, Grand Valley State University, Allendale, MI, USA

The presence of authigenic mineral growth has been noted on modern, archeological, and fossil bone surfaces, though its potential utility has been overlooked. Fossil bone is an important environmental recorder, because it can retain information about the prevailing conditions before and during fossilization. Most studies have focused on differences in surface features or chemical composition of bones and correlating these with particular environmental contexts. Many authigenic minerals form under specific biogeochemical conditions (pH, Eh, porewater chemistry), making them suitable environmental indicators. Despite the observed relationship between environmental conditions and mineral formation on bone, little is understood regarding how bone interacts with the burial environment during decay and diagenesis. Authigenic mineral formation was observed following a year-long taphonomic experiment investigating the effect of different environmental conditions on the diagenesis of buried bone. Bone was found to interact with the surrounding sediment, buffering porewater pH changes and contributing to local anoxia. Mineral growth was observed on bones under low hydraulic conductivity, where more acidic and anoxic conditions prevailed. Examination with SEM-EDS showed these crystals to be an iron phosphate, most likely vivianite, which has been found on modern and archeological remains buried under similar conditions. Other iron minerals (e.g., pyrite) are common on fossil bones and appear closely connected to similarly acidic and/or anoxic environments seen in the experiment. The decay of soft tissue in the remains by bacteria or other preconditions may be necessary for mineral formation, with bone tissue providing an appropriate matrix for crystallization. If this is true, then certain authigenic minerals in fossil bones may provide information on the condition of the remains at the time of burial. Comprehensive examination of minerals growing on bone surfaces may therefore provide a sensitive indicator of its taphonomic history before burial and the biogeochemical conditions surrounding a bone during diagenesis.

Late Triassic Terrestrial Biotas and the Rise of Dinosaurs, Thursday 11:15

**NEW DINOSAUR REMAINS FROM THE LATE TRIASSIC OF CENTRAL INDIA**

NOVAS, Fernando, Museo Argentino de Ciencias Naturales, Buenos Aires, Argentina; CHATTERJEE, Sankar, Museum of Texas Tech University, Lubbock, USA; EZCURRA, Martin, Museo Argentino de Ciencias Naturales, Buenos Aires, Argentina; KUTTY, Tharavat, Indian Statistical Institute, Kokatta, India

Until recently the sole Triassic dinosaur fossil from India was represented by the basal saurischian *Alwalkeria*, which came from the lower part of the Upper Triassic Maleri Formation (late Carnian-early Norian) of the Pranhita-Godavari Valley. With the discovery of new dinosaur fossils from the younger horizons of the same basin, we enlarge the dinosaurian faunal list. The new fossil assemblages were recovered from the Upper Maleri (Norian) and Lower Dharmaram (Norian-Rhaetian) formations respectively, and the material is housed at the Geology Museum of the Indian Statistical Institute (ISI), Kolkata. Preliminary identifications of specimens from the Upper Maleri Formation reveal the following dinosaurs: ISI R282 resembles herrerasaurs in having a vertically oriented pubic shaft and absence of a brevis fossa; ISI R284 apparently belongs to a basal saurischian of uncertain affinities; ISI R277 resembles basal sauropodomorphs (e.g., *Guaibasaurus*, *Saturnalia*, *Panphagia*) in the presence of an iliac acetabular wall incipiently open, and postacetabular process longer than the acetabular length; ISI R273 and ISI R274 are sauropodomorphs closely related with plateosauroids due to the presence of ilium that lacks a buttress between the preacetabular process and supraacetabular crest, metatarsal I with an angled distal end, and metatarsal V proximal wide, representing more than 30 percent of its whole length. The younger Lower Dharmaram Formation has yielded remains of medium-sized sauropodomorphs (ISI R280 and 281), and a femur of a coelophysoid theropod (ISI R283), the latter represents the first definite member of this clade from India. The new material provides a more complete dinosaur faunal succession for the Upper Triassic in India, including basal saurischians, a variety of primitive sauropodomorphs, and coelophysoid theropods. This composition of the Indian Triassic dinosaur faunas is similar to that of Upper Triassic horizons of South America, South Africa, and Europe in the Pangean world.

The Evolution of Birds in the Mesozoic: a Symposium in Honor of Cyril A. Walker, Thursday 8:30

**ESTIMATING THE FLIGHT CAPABILITIES OF EXTINCT MESOZOIC BIRDS FROM THEIR PRIMARY FEATHER MORPHOLOGY**

NUDDS, Robert, University of Manchester, Manchester, United Kingdom; DYKE, Gareth, University College Dublin, Dublin, Ireland

The flight capabilities of early birds have been a source of huge controversy for more than 150 years. Archaeopteryx remains the oldest (150 mya) and phylogenetically earliest lineage of theropods (birds) with differentiated flight feathers, yet its aerodynamic abilities remain questionable. A sequence of character refinements is supposedly seen through the phylogeny of Mesozoic birds, leading to the modern avian flight apparatus and wing feathering, and the presence of feathered wings resembling those of modern birds are, of course, usually considered to be the property of a volant organism. The exact flight capabilities of early

birds, however, have entirely been inferred from other parts of their anatomy (e.g. shoulder and pectoral morphology, and wing bone proportions). Here we describe an analysis that allows extrapolation of flight capabilities from primary feather morphology. Modeling the feather shaft as a hollow cylinder and using Euler-Bernoulli beam theory we calculate the force sustainable by an individual feather before failure by buckling occurs. Buckling has previously been shown to be the cause of failure in modern bird primary feathers undergoing structural strength tests. The maximum lift force sustainable by the wing was calculated from the individual feather buckling failure limit; once an upper limit for lift production is known an animal's flight abilities may be hypothesized, because lift production is fundamental to flight performance. Using Archaeopteryx and Confuciusornis as examples, we show that whilst the feathers of extinct taxa ostensibly resemble those of living birds, they were not as structurally robust. Consequently, Confuciusornis and Archaeopteryx likely operated within much narrower flight envelopes than do most of their modern counterparts. Using this approach we are able to develop the first realistic envelopes for the flight performance of early birds that take structural biomechanical principles into account.

Edwin H. and Margaret M. Colbert Poster Competition (Thursday)

**ANCIENT TROPICAL FORESTS OR MARSHLANDS IN THE DESERT?  
RECONSTRUCTING THE ANCIENT DIET AND HABITAT OF A LATE  
PLEISTOCENE LOCAL FAUNA FROM NORTHEASTERN SONORA, MEXICO**  
NUNEZ, Elvis, University of Florida, Gainesville, FL, USA

Vertebrate faunas are exceedingly rare in the region of northern Mexico. Terapa, a unique site located in the deserts of northeastern Sonora, Mexico (29°41'N, 109°39'W and 605m) contributes to our understanding of the paleoecology and paleoclimate of the region. It represents a diverse fossil assemblage with strong tropical affinities. At least 60 taxa, including amphibians, turtles, a crocodylian, snakes, birds and many mammals (e.g. capybara, deer, horse, bison, mammoth, and ground sloths), have been recovered from an 11-m-thick sequence of fossiliferous sediments. The diversity of taxa recovered at the site suggests a more tropical climate than is evidenced by today's desert habitat, possibly a well-established marsh habitat with adjacent savanna. To test this hypothesis, bulk and serial carbon and oxygen isotope analyses of tooth enamel carbonate were performed. The results of the bulk analyses suggest a diverse habitat mosaic with variations in diet that include C4 hypergrazers, mixed feeders and some browsers. Of particular interest are the tooth enamel carbonate  $\delta^{13}C$  values of  $-6.1$  to  $-5.6$ ‰ for *Odocoileus*, which suggests a more variable diet than is evidenced by strict browsing, including possibly feeding on CAM and/or C4 plants. In order to investigate differences in diet and climate between ancient and modern Terapa, serial sampling of mammals with hypsodont dentitions (*Equus* and *Bison* for ancient; *Equus* and *Bos* for modern) were performed. If the deserts of Sonora replaced ancient tropical forests, the ancient fauna would have yielded an equable oxygen isotopic signature. Instead, the isotopic signatures indicate a climate that is only slightly less seasonal than that evidenced today. These results provide evidence that Terapa was not strict tropical forest, but instead a marshland that extended northward into Mexico by about 350 km during the late Pleistocene.

Poster Session I, (Wednesday)

**ARTICULATED LIZARD SKULLS FROM THE WAPITI FORMATION (UPPER  
CRETACEOUS) OF WEST-CENTRAL CANADA**  
NYDAM, Randall, Midwestern University, Glendale, AZ, USA; CALDWELL, Michael,  
University of Alberta, Edmonton, AB, Canada; FANTI, Federico, University of Bologna,  
Bologna, Italy

New material of borietioidean lizards (Squamata: Scincomorpha) from northern Alberta, Canada, represents the earliest and northernmost record of multiple articulated skull elements from the Cretaceous of North America. Specimens were recovered from a bentonitic paleosol of the Wapiti Formation (Campanian) exposed at Kleskun Hill Park, east of the town of Grande Prairie. This portion of the Wapiti Formation correlates with the maximum transgression of the Bearpaw Seaway (73-74 My) and provides additional important information on a time interval for which paracontemporaneous microvertebrate faunas with lizards have been recovered throughout much of the Western Interior of North America. The cranial material represents two taxa that are distinguished by several morphological characteristics and differ in size. The larger specimens are referred to *Socognathus unicuspis*, a taxon known previously from isolated jaws recovered from the Oldman Formation of southern Alberta and possibly the BCA locality (mixed Cretaceous and Paleocene) of Montana. We present a revision of this taxon and a more comprehensive comparison with other taxa. The smaller specimens from Kleskun Hill are referred to a new genus. Both *S. unicuspis* and the new genus are assigned to a newly recognized taxon that also includes the ubiquitous Late Cretaceous taxa *Chamops* and *Leptochoamops*, as well as several other morphologically similar (e.g., "*Chamops*-like") taxa from North America.

The Evolution of Birds in the Mesozoic: a Symposium in Honor of Cyril A. Walker,  
Thursday 8:15

**A COMPREHENSIVE PHYLOGENY OF MESOZOIC BIRDS**  
O'CONNOR, Jingmai, Natural History Museum of Los Angeles County, Los Angeles, CA,  
USA; CHIAPPE, Luis, Los Angeles Natural History Museum, Los Angeles, CA, USA;  
BELL, Alyssa, Los Angeles Natural History Museum, Los Angeles, CA, USA

The phylogenetic relationships of Mesozoic birds are unfolding as new taxa and groups are uncovered. Despite the continuous stream of new findings, many relationships have remained fairly constant between different analyses through time (Enantiornithes and Ornithuromorpha forming Ornithothoraces, Confuciusornis and Sapeornis as basal pygostylians, and the relationships between Archaeopteryx and other long-tailed birds) and focus has shifted to uncovering the inner-relationships of clades such as Enantiornithes and Ornithuromorpha. However, differences in the taxonomic sampling between analyses have made it difficult to compare phylogenetic hypotheses each based on a different partial picture of known variation. New morphological information continues to expand character matrices and destroy preconceived notions about 'derived avian characters.' In some recent analyses, many well-established relationships are no longer supported suggesting the need for more detailed inspection of Mesozoic birds as a whole. We present the largest cladistic analysis of Mesozoic birds performed to date. Consisting of over 50 of the most complete taxa known, the matrix samples all known groups of Mesozoic birds and includes taxa never before included in a cladistic analysis. The matrix of over 240 characters is a refined version of earlier matrices by the authors, which better expresses variation within early birds. The resultant phylogenetic hypothesis reflects what is currently known of Mesozoic birds and is expected to shift as new fossils are uncovered and more morphological information becomes available for some taxa.

Poster Session II, (Thursday)

**THE LATE CRETACEOUS (MAASTRICHTIAN) AVIFAUNA FROM THE  
MAEVARANO FORMATION, NORTHWESTERN MADAGASCAR: RECENT  
DISCOVERIES AND NEW INSIGHTS RELATED TO AVIAN ANATOMICAL  
DIVERSIFICATION**

O'CONNOR, Patrick, Ohio University, Athens, OH, USA; FORSTER, Catherine, George  
Washington University, Washington, DC, USA

Over the past 16 years field efforts conducted in the Mahajanga Basin (Maevarano Formation) of northwestern Madagascar have recovered a diverse assemblage of Late Cretaceous (Maastrichtian) terrestrial and freshwater vertebrates. Included among these are representatives of all major vertebrate groups, with an increasingly well-documented avialan fauna. Previous work has resulted in the description of two named birds, *Vorona* and *Rahonavis*, the latter of which has recently had its avialan affinities questioned, and a number of isolated elements referable to enantiornithes. At present, a minimum of six avialans are known from the formation, with the vast majority of these recovered from a single locality, MAD93-18. Field efforts since 2005 have further enhanced our knowledge of Cretaceous birds from Madagascar, with the recovery of numerous (~30) isolated specimens from locality MAD05-42. These materials include partial-to-complete isolated elements representing most portions of the postcranial skeleton. Among these are specimens (e.g., tibiotarsus, tarsometatarsus) referable to *Vorona*. Although morphologically identical to the holotype (including putative autapomorphies such as an irregular ridge along the proximomedial surface of the tibiotarsus), the specimens are only ~60-70% the size of the holotypic materials. The individual components of these composite elements are fused (assessed internally via microCT), indicating that skeletal maturity had been attained and suggesting the presence of considerable size dimorphism in this taxon. Another new specimen, a near-complete carpometacarpus, exhibits a minor metacarpal that exceeds the major metacarpal in length and is fused proximally and unfused distally, thereby further documenting the enantiornithine component of the fauna. Finally, a synsacrum referable to Ornithurae is notable in the presence of distinct, transversely-oriented lumbosacral canals (also revealed via microCT) along the inner margin of the bony neural canal. This suggests the early evolution of a secondary neurosensory system likely related to decoupling of fore- and hind limb locomotor modules, a system thus far only known in extant birds.

The Scientific Legacy of Mary Anning — Recent Advances in Marine Reptile Paleobiology and Evolution, Wednesday 11:45

**A NEW RECONSTRUCTION OF PLESIOSAUR PECTORAL MUSCULATURE:  
PHYLOGENETIC, OSTEOLOGICAL, AND FUNCTIONAL CONSTRAINTS.**

O'KEEFE, F., Marshall University, Huntington, WV, USA; WILHELM, Benjamin, Marshall  
University, Huntington, WV, USA

Reconstructing the pectoral musculature of plesiosaurs is a difficult problem due to the clade's unique shoulder morphology. Here we offer a new reconstruction of plesiosaur pectoral musculature, with inferences based on three sets of criteria. The first is phylogenetic; we dissected forelimb musculature in extant iguanas, varanids, and alligators to identify the major reptilian shoulder muscles and their attachments. We used observed commonalities to infer conservative identities and originations of major muscle groups, including subscapularis, scapulohumeralis, deltoid, supracoracoideus, coracobrachialis, latissimus dorsi, and pectoralis. The sizes and distal insertions of these muscles were then inferred using osteological and functional criteria. Osteologically, large ventral fossae on the

pectoral girdle were presumed to hold major muscle masses, while attachment scars on the humerus were presumed to be insertions of locomotor muscles. A functional model based on the locomotion of modern sea lions was used to link different muscle bellies to distal attachment sites. Sea lions are considered the best extant analogs for plesiosaur locomotion, and their pectoral limbs display three major movements when swimming: abduction-adduction, protraction-retraction, and medial and lateral rotation. We infer that protraction and retraction were effected primarily by the deltoid and coracobrachialis, and that abduction and adduction were produced by the subscapularis and pectoralis. The need for medial and lateral rotation leads us to propose a novel mechanism to achieve these motions. This mechanism involves attachment of the pectoralis on the antero-dorsal aspect of the humerus to effect medial rotation, while lateral rotation was achieved by attachment of the supracoracoideus to the postero-ventral surface of the humerus. This mechanism is vaguely reminiscent of the pectoral musculature in birds, in that contrasting locomotor motions are achieved by antagonistic ventral muscle bellies. This reconstruction produces the necessary forces for a lift-based, sea lion-like swimming style.

Poster Session I, (Wednesday)

#### **PALEOCENE ICHTHYOFAUNA AND PALEOENVIRONMENTAL SETTING, IMO FORMATION, SOUTHEASTERN NIGERIA**

ODUNZE, Shirley, Department of Geology, Anambra State University, Uli, Nigeria; STEVENS, Nancy, Department of Biomedical Sciences, 228 Irvine Hall, Ohio University, Athens, OH, USA; STEVENS, Nancy, Department of Biomedical Sciences, 228 Irvine Hall, Ohio University, Athens, OH, USA; OBI, Gordian, Faculty of Sciences, Anambra State University, Uli, Nigeria; EASTMAN, Joseph, Department of Biomedical Sciences, Athens, OH, USA

The Paleogene vertebrate fossil record of Nigeria has until recently been limited to marine deposits in the Eocene-age Ameki Formation. New work in the Imo Formation of southeastern Nigeria has revealed a diverse ichthyofauna of Paleocene age. The Imo formation overlies the Nsukka Formation, and underlies the Ameki Formation. Sedimentological evidence suggests that the Nsukka Formation documents a phase of fluvio-deltaic deposition that began close to the end of the Maastrichtian and continued into the Paleocene. The Imo-Ameki succession contains three depositional lithologically and architecturally similar cycles, each consisting of a basal fluvial and tidally-influenced fluvial facies, bone-bearing estuarine bay-fill delta/estuarine central basin mudstone facies, and progradational shoreface-foreshore facies assemblages. The uppermost bone-bearing interval of the Imo Formation is separated from the overlying Ameki bone cycle by a NW-SE trending, shoreface-tidally-influenced sandstone ridge that dominates the Ozuitem-Umuahia landscape. The marine Ameki beds outcrop to the west of the sandstone ridge, whereas the Imo outcrops to the east. Vertebrate fossils were recovered from an interval of interstratified crudely laminated clay/shale and calcareous lenses of well-sorted sandstone/siltstone which outcrops to the east of the sandstone ridge in the Bende District. This fauna is represented by at least seven taxa, including an actinopterygian, five chondrichthyans (represented by one ray and four shark species), and an enigmatic incertae sedis taxon. Four of the species in the Imo fauna appear to have survived into the Eocene, whereas the remaining three are hitherto undocumented in younger faunas in Nigeria.

Poster Session I, (Wednesday)

#### **A CROCODYLIFORM NESTING SITE FROM THE UPPER CRETACEOUS ADAMANTINA FORMATION OF BRAZIL**

OLIVEIRA, Carlos Eduardo, Fundação Educacional de Fernandópolis-FEF/Instituto de Geociências e Ciências Exatas, UNESP-Rio Claro, Fernandópolis, Brazil; SANTUCCI, Rodrigo, Departamento Nacional de Produção Mineral-DNPM, Brasília, Brazil; ANDRADE, Marco, Department of Earth Sciences, University of Bristol, Bristol, United Kingdom; BASÍLIO, José, Fundação Educacional de Fernandópolis-FEF, Fernandópolis, Brazil; BENTON, Michael, Department of Earth Sciences, University of Bristol, Bristol, United Kingdom

Studies of fossil nests and nesting sites provide information on the reproductive biology of the egg-laying taxon that, otherwise, could not be evaluated by the study of skeletal remains. However, only dinosaur and turtle nests and nesting sites have been described to date. Here we report a hitherto unknown crocodylomorph nesting site in the Upper Cretaceous Adamantina Formation at Jales, Southeastern Brazil. At least twenty egg clutches were found in four distinct stratigraphic layers within an area of  $\approx 0.15$  km<sup>2</sup>. Morphological analyses of the eggs and eggshells showed that all eggs can be assigned to the same egg type. Most of the egg clutches were collected from the same layer, whereas few were collected from three other layers, respectively 1.09 m under and 0.71 and 0.99 m above the main egg layer. The minimum distance among egg clutches in the same layer is 1.8 m. The terrestrial mesoeucrocodylian *Baurusuchus* was the only vertebrate recovered from the outcrop, with three partially articulated specimens and several scattered remains found in close association with the egg clutches. The maximum number of preserved eggs per clutch is five, and all have been found with the main axis parallel to the ground. Eggshell fragments are frequent inside the nests, randomly distributed within the egg clutches (concave up and concave down percentages of 59% and 41%, respectively). Within the most complete eggs several stacked eggshell fragments were found. These are interpreted as hatched eggs in which the opening hole made by the hatchling also cracked the eggshell, producing additional eggshell fragments that fell within the egg as the shell membrane detached from the inner surface of

the egg. These data suggest that: a) most of the egg clutches were preserved *in situ*, without any transport; b) this crocodylomorph species nested in colonies, returning to the same nesting site periodically, and; c) nest fidelity in crocodylomorphs may have been present as far back as the Late Cretaceous.

Poster Session II, (Thursday)

#### **EVOLUTION OF MEGACRICETODON TOOTH PATTERN THROUGH GEOMETRIC MORPHOMETRIC ANALYSIS**

OLIVER, Adriana, Museo Nacional de Ciencias Naturales, Madrid, Spain; LÓPEZ-GUERRERO, Paloma, Universidad Complutense de Madrid, Madrid, Spain; GARCÍA-PAREDES, Israel, Nacionaal Natuurhistorisch Museum, Naturalis, Leiden, Netherlands; ÁLVAREZ-SIERRA, María, Universidad Complutense de Madrid, Madrid, Spain; PELÁEZ-CAMPOMANES, Pablo, Museo Nacional de Ciencias Naturales-CSIC, Madrid, Spain

*Megacricetodon* (Rodentia, Cricetodontinae) is a characteristic taxon of the Early and Middle Miocene used to define most of the biochronological units and local biozones. One of the best records of this genus comes from the Calatayud-Daroca Basin (Province of Zaragoza, Spain) where more than one hundred localities in stratigraphical superposition are known. The lineage *M. primitivus*-*M. collongensis* was defined based on material from this basin, and includes the first representatives of this genus in Spain. In the Calatayud-Daroca Basin it is represented in 32 fossil associations covering 1.7 My approximately.

This lineage of primitive *Megacricetodon* shows the progressive acquisition of a cingulum in the upper first molars that connects the anterocone with the hypocone and extends lingually to the protocone. In this study, we explore the effect that the acquisition of this structure has on the relative position of the main cusps, comparing the situation of the principal cusps with regard to the outline of the tooth in occlusal view.

The present study was carried out performing a geometric morphometric analysis to explore the morphological evolution of the upper first molars of *Megacricetodon*. We used pictures of M<sup>1</sup> in occlusal view to define landmarks corresponding to the tips of the main cusps of the tooth, and sliding semilandmarks along the outline of the crown.

We discuss the variability observed within each *Megacricetodon* sample and amongst successive samples, as well as the proposed trend towards a more developed cingulum and the consequent displacement of the lingual cusps to the middle part of the tooth.

Technical Session XVII, Saturday 3:30

#### **COMPARATIVE ANALYSIS OF POSTCRANIAL OSSIFICATION SEQUENCES ACROSS EXTINCT AND EXTANT TETRAPODS**

OLORI, Jennifer, The University of Texas at Austin, Austin, TX, USA

I assessed the sequence of ossification of postcranial skeletal elements for 33 extinct and extant tetrapods including Paleozoic temnospondyls and microsaur. This is the first study of its kind to include ontogenetic data from any lepospondyl. I scored a total of 21 ossification events according to standard event pairing methods, resulting in 210 event pair characters. When missing elements were treated as uncertain, preliminary exploration of the event pairs through parsimony analysis resulted in a topology inconsistent with conventional hypotheses of crown tetrapod relationships. Notable departures included the clustering of the frog *Pipa pipa* with Paleozoic taxa in a basal position as well as the placement of the opossum *Didelphis* within an otherwise monophyletic Caudata. The remaining anurans formed a monophyletic group as did Amniota (excepting *Didelphis*), which included mammals and reptiles as sister taxa, although turtles were polyphyletic. Branchiosaurid temnospondyls were consistently placed on the stem of Caudata, but living amphibians as a whole were paraphyletic with respect to Amniota. In order to further evaluate developmental heterochronies, I subjected event pair characters to a combination of traditional character mapping and Parsimov analysis. Phylogenies reconstructed from event pairs suffer from non-independence of data and therefore characters were mapped onto three pre-existing hypotheses of tetrapod relationships rather than the one produced from event pairing. The three phylogenies represent the Lepospondyl (LH), Temnospondyl (TH), and a modified Polyphyletic-Temospondyl Hypothesis (PH-TH) of Lissamphibian origins, respectively, all of which propose a different set of relationships between extinct and extant taxa. Parsimov analysis demonstrated that the LH tree produces the fewest number of sequence heterochronies under ACCTRAN optimization, while the PH-TH tree produces the fewest number of heterochronies under DELTRAN optimization. However, a consensus of ACCTRAN and DELTRAN results suggested that the LH provides an overall, slightly better fit to the ossification sequence data.

Late Triassic Terrestrial Biotas and the Rise of Dinosaurs, Thursday 8:30

#### **IMPLICATIONS OF THE NEWARK BASIN ASTROCHRONOLOGY AND GEOMAGNETIC POLARITY TIME SCALE (NBAGPTS) FOR THE TEMPO AND MODE OF THE EARLY DIVERSIFICATION OF THE DINOSAURIA**

OLSEN, Paul, LDEO, Columbia University, Palisades, NY, USA

The NBAGPTS established a high-resolution framework for the Late Triassic and Early Jurassic. Paleomagnetic correlations to marine sections suggested that the stage- (age-) level correlations of continental sequences were off by as much as  $\sim 10$  Ma. Not kindly viewed

by many biostratigraphers, new published U-Pb ages from marine and continental sections nonetheless have shown that these marine correlations and the associated astrochronology are accurate. Published magnetic polarity stratigraphies and new radiometric dates from the Chinle Grp., Glen Canyon Grp., Fleming Fjord Fm., and Ischigualasto Fm keyed into the NBAGPTS point to the following. 1, there are no unequivocal Carnian age dinosaurs. 2, the 20-Ma-long Norian Age was characterized by a slow increase in saurischian diversity with no definitive evidence of ornithischians. 3, there was profound Late Triassic provinciality with tropical and subtropical communities apparently lacking dinosaurian herbivores with their ecological vicars being diverse crurotarsian and non-dinosaurian Dinosauriformes; in contrast, small and large herbivorous sauropodomorph dinosaurs were abundant in the high latitudes of both hemispheres. 4, a testable case can be made that the classic Chinle-, Germanic- and Los Colorados-type assemblages persisted to the time of the late Rhaetian marine extinctions. 5, that the distinct genus-level faunal transition and associated floral change traditionally correlated with the marine Carnian-Norian is in fact mid-Norian in age and within published error estimates of the age of the Manicouagan impact. 6, that the end-Triassic marine invertebrate extinctions were contemporaneous with the extinctions on land. Finally 7, compared to Triassic communities, Hettangian and Sinemurian age terrestrial communities were nearly globally homogenous and of low diversity in all meanings of the word excepting perhaps species number. A significant lesson that can be derived from the NBAGPTS is that the emerging picture of dinosaur diversification is complex and surprising and that biostratigraphically independent geochronologies need to be developed in each of the faunally important areas.

Technical Session XIV, Friday 4:45

**THE CARNIVORE FAUNA OF RANCHO LA BREA: AVERAGE OR ABERRANT?**  
ORCUTT, John, University of Oregon, Eugene, OR, USA; DAVIS, Edward, University of Oregon, Eugene, OR, USA

Rancho La Brea is among the best-known and most intensively studied Pleistocene localities in the world and is the basis for much of what is known about the paleoecology of its eponymous North American land mammal age, the Rancholabrean. It is most remarkable for representing a predator trap, preserving a diverse and abundant fauna of carnivorous mammals and birds lured to the site by prey mired in asphalt seeps. Comparable preservational environments are extremely rare, and as such Rancho La Brea represents a unique taphonomic environment within Pleistocene North America. While it has long been recognized that the number of carnivores preserved at Rancho La Brea is aberrantly high, it is also probable that the site does not preserve a carnivore fauna representative of either southern California or North America as a whole. Rather, taphonomic data suggest that predators preserved in the tar pits are likely to be those that are more prone to scavenging and that are large enough to defend carcasses from smaller competitors. We have applied a paleoecological test to this hypothesis using an updated version of the online database FAUNMAP to compare the carnivore fauna of Rancho La Brea to sites from across North America. Using site occupancy as a proxy for relative abundance, we confirm that Rancho La Brea does preferentially preserve large, scavenging taxa. This is true both between families (felids and canids are abundant in the tar pits, whereas mustelids and procyonids are more common on a regional and continental scale) and within families (*Smilodon fatalis* and *Panthera atrox* are the most common felids at Rancho La Brea, while the smaller *Puma concolor* and *Lynx rufus* predominate at other sites). While Rancho La Brea is a poor proxy for other, more incompletely preserved Pleistocene faunas, abundance or scarcity of taxa within the assemblage may prove to be a useful tool for reconstructing life histories of taxa with no modern analogs, such as the machairodontines *Smilodon* and *Homotherium*.

Molecular Tools in Paleobiology: Trees, Clocks and linking Geno- with Phenotype, Friday 8:15

**MOLECULES AND MORPHOLOGY IN EVOLUTIONARY GENOMICS: COMPATIBLE AND COMPULSORY**

ORGAN, Chris, Harvard University, Cambridge, MA, USA; JANES, Dan, Harvard University, Cambridge, MA, USA; MEADE, Andrew, University of Reading, Reading, United Kingdom; PAGEL, Mark, University of Reading, Reading, United Kingdom

Most evidence for the genomic structure of extinct organisms is absent from the fossil record. Yet, as a primary research goal, paleontologists endeavor to reconstruct the biology of extinct organisms. Current approaches for inferring unfossilized character states do not account for uncertainty (in reconstructions or trees) or make use of branch lengths or correlated evolution. We review our Bayesian method for inferring continuous characters given a tree and a dataset and present a new method for inferring binary character states. Our new approach uses correlate information within the dataset, phylogenetic position, branch lengths, and estimated rates of character change to produce a posterior probability distribution of inferred states. It accounts for the uncertainty we have in both reconstructions and trees. We discuss both approaches, as well as evidence from other fields, such as metagenomics, in the light of recent discoveries that have advanced our understanding of how genomes evolve over geologic timescales. We will specifically focus on genome contraction and gene duplication in birds, and the evolution of sex chromosomes in ichthyosaurs, mosasaurs, and sauropterygians.

Technical Session XIX, Saturday 2:30

**REVISION OF THE AFRICAN PALAEOCHOERIDS: IMPLICATIONS FOR THE RELATIONSHIPS OF HIPPOPOTAMIDAE (CETARTIODACTYLA, MAMMALIA), ORLIAC, MAEVA, ISEM - Univ. Montpellier 2, Montpellier, France; LIHOREAU, Fabrice, ISEM - Univ. Montpellier 2, Montpellier, France; BOISSERIE, Jean-Renaud, IPHEP - Univ. Poitiers, Poitiers, France; MACLATCHY, Laura, University of Michigan, Ann Arbor, MI, USA**

Until now, only one species of palaeochoerid suoids (Old World peccaries), possibly related to the Tayassuidae, has been described in Africa: *Morotochoerus ugandensis* from the early Miocene locality of Moroto (Uganda). The reexamination of the material of *Morotochoerus* reveals that this species does not display close morphological affinities with palaeochoerids and tayassuids, but rather presents dental similarities with the poorly known *Kulutherium kenyensis* from Rusinga (earliest Miocene, Kenya), so far referred to the Anthrotheriidae. The position of *Morotochoerus* with respect to hippopotamoids (anthrotheres and hippopotamuses) and suoids was investigated by mean of a phylogenetic analysis including a wide array of suoid and hippopotamoid taxa, notably European palaeochoerids, African and Eurasian anthrotheriids, and fossil hippopotamids. In the most parsimonious trees, *Morotochoerus* and *Kulutherium* are sister taxa, this clade being clearly set apart from the suoid clade. *Morotochoerus* and *Kulutherium* appear on the contrary to be closely related to Miocene hippopotamids. This result indicates that the Hippopotamidae most likely evolved from non-suoid taxa present in Africa near the Oligocene-Miocene transition. These advances emphasize the paraphyletic nature of "Suiformes"; (grouping suoids and hippopotamids), classically considered as a major artiodactyl clade. It constitutes an important step towards the understanding of high-level phylogenetic relationships within Cetartiodactyla.

Poster Session IV, (Saturday)

**TAPHONOMY OF AMPHIBIANS FROM THE NYRANY EXCEPTIONAL FAUNA (CARBONIFEROUS) IN THE CZECH REPUBLIC**

ORR, Patrick, School of Geological Sciences, University College Dublin, Dublin, Ireland; REDELSTORFF, Ragna, School of Geological Sciences, University College Dublin, Dublin, Ireland; KEARNS, Stuart, Department of Earth Sciences, University of Bristol, Bristol, United Kingdom; BENTON, Michael, Department of Earth Sciences, University of Bristol, Bristol, United Kingdom

Nyrany in the Czech Republic represents a diverse, abundant and exceptionally well preserved Carboniferous vertebrate fauna that includes both semi-aquatic and terrestrial components. A comprehensive study, focused on the amphibians, reveals these taxa to have a complex taphonomic history. Isolated skeletal elements are common, indicating extensive disarticulation of taxa during, or before, transport to the site of deposition. Critically, however, the same lithologies yield numerous partially disarticulated skeletons. Disarticulation of these originated after deposition, primarily via explosive rupture of the body following the build up of decay gases internally. This occurred at three loci: i) least surprisingly, in the abdominal cavity affecting the caudal-most ribs and part of the trunk vertebral column; ii) at the pharynx, resulting in disarticulation of skull elements; iii) in the vicinity of the anus, resulting in disarticulation of the pelvic bones, hind limbs, and tail. Five amphibian taxa (the 'snake-like' taxa *Ophiderpeton*, *Sauropelta*, *Phlegetonia*, and *Dolichosoma*, plus the more compact *Scincosaurus*) illustrate unusual preservation of their tail. In otherwise highly articulated specimens, tail vertebrae are separated from each other, consistent with stretching, and/or kinked, shunted, shifted, and/or turned, all variations generated by compression parallel to the tail axis. These features are accompanied by strong curving, even coiling, of the tail although the trunk vertebrae remain as a straight or slightly curved line. The phenomenon is attributed to a buoyant tail floating in the water column above, while the anterior of the specimen lay on the sediment-water interface. Notably, this phenomenon is not present in fossil snakes including examples preserved in aquatic settings and comparable in body plan and size to the Nyrany amphibians. Our preliminary conclusion is that there is a phylogenetic control on the physical taphonomy of different vertebrate taxa that remains to be elucidated in detail.

Poster Session III, (Friday)

**THE VERTEBRATE DIVERSITY OF THE UPPER CAMPANIAN-LOWER MAASTRICHTIAN "LO HUECO" FOSSIL-SITE (CUENCA, SPAIN)**

ORTEGA, Francisco, Fac. Ciencias, UNED, Madrid, Spain; ESCASO, Fernando, Fac. Ciencias, Universidad Autónoma de Madrid, Madrid, Spain; PÉREZ GARCÍA, Adán, Universidad Complutense Madrid, Madrid, Spain; TORICES, Angelica, Universidad Complutense Madrid, Madrid, Spain; SANZ, José Luis, Universidad Autónoma de Madrid, Madrid, Spain

The "Lo Hueco" vertebrate fossil-site includes one of the most abundant assemblage of the South-Western European upper Campanian-lower Maastrichtian continental vertebrate fauna. Lepisosteid fishes are mainly well-represented by scales and a nearly complete individual. Several postcranial bones attributed to lissamphibians as well as various cranial bones of squamates preliminarily assigned to iguanids were collected. Crocodylian and chelonian fauna at "Lo Hueco" is composed by hundred of cranial and postcranial remains. However, the represented diversity of both groups is strikingly low. In fact, the great amount of available specimens probably will allow reinterpreting several previously described genera as part of

the variability of a unique taxon. Pterosaurians are represented by several teeth. Dinosaur remains are very common, and three major groups, sauropods, theropods and ornithomorphs, are represented. The abundant teeth material provides the presence of, at least, three different taxa attributed to dromeosaurinae and velociraptorinae dromeosaurids as well as the basal tetanuran *Ricardoestesia*. Moreover, cranial and postcranial bones of a basal large theropod besides several postcranial remains of dromeosaurid theropods are recognized. The diversity of ornithischian dinosaurs is relatively poor. At present, this fauna is mainly represented by cranial and postcranial bones of the well-known European ornithomorph *Rhabdodon*. Sauropod titanosaurs are the dinosaur group better represented at "Lo Hueco". Several partial skeletons besides abundant isolated cranial and postcranial bones have been found and the sample is surprisingly diverse. The sauropod diversity is represented, at least, by three saltasaurinae titanosaurs. The presence of new taxa, the great increase of information about some poorly known taxa and the presence of species not recorded before in the Iberian domain, allows to review the phylogenetic status of some Campano-Maastrichtian European macrovertebrates, and to redefine the paleobiogeographical implications of its presence at South-western Europe

Technical Session X, Friday 8:45

#### **FEEDING RELATED CHARACTERS IN BASAL PTEROSAURS: IMPLICATIONS FOR JAW MECHANISM, DENTAL FUNCTION AND DIET**

OSI, Attila, MTA-MTM Research Group for Paleontology, Budapest, Hungary

Comparative study of various feeding related characters observed in basal pterosaurs reveal a significant change in feeding strategies during the early evolutionary history of the group. These features are related to the skull architecture (e.g. temporal cavity, quadrate morphology and orientation, jaw joint), dentition (e.g. crown morphology, wear patterns), reconstructed adductor musculature, and postcranium. The analysis indicates that the most basal forms (*Preondactylus*, dimorphodontids and anurognathids) were small bodied animals with a wing span no greater than 1.5 m, they possessed a relatively short skull composed of weakly ossified skull elements, lightly constructed, straight mandibles with a large gape, sharply pointed teeth, and well developed external adductors. The absence of tooth wear marks excludes active dental occlusion, and the jaw closure was simply orthal. These primitive forms probably represent the earliest groups of pterosaurs, and their features indicate a predominantly insectivorous diet. Among the stratigraphically oldest but more derived forms (*Eudimorphodon*, *Raeticodactylus*, *Caviramus*) complex, multicusped teeth (probably independently evolved in several lineages) allowed the consumption of a wider variety of prey via a more effective form of active food processing. This is strongly supported by heavy dental wear in all forms with multicusped teeth which indicates efficient dental occlusion. Piscivory, as the dominant feeding mode, probably did not become widespread within the Pterosauria until the Early Jurassic. Typical piscivorous forms are characterized by widely spaced, enlarged procumbent teeth forming a fish grab, and an anteriorly inclined quadrate, allowing only a smaller gape for the mandibles. In addition the skull became more elongate and body size increased. Besides the dominance of piscivory, dental morphology and the scarcity of tooth wear reflect accidental dental occlusion that could have been caused by the capturing or seasonal consumption of harder food items.

Edwin H. and Margaret M. Colbert Poster Competition (Thursday)

#### **PHYLLODONTID ALBULOID FISH (TELEOSTEI: ELOPOMORPHA) FROM THE LATE CRETACEOUS OF MADAGASCAR AND IMPLICATIONS FOR GONDWANAN BIOGEOGRAPHY**

OSTROWSKI, Summer, Michigan State University, East Lansing, MI, USA

Upper Cretaceous deposits of Madagascar collected by the Mahajanga Basin Project have produced a diverse terrestrial vertebrate fauna. The majority of this fauna accumulated within a fluvial setting in a semi-arid environment and includes a variety of mammals (multituberculates, marsupials, and gondwanatheres), crocodylians (notosuchids, peirosaurids, and trematochampsids), dinosaurs (abelisaurids, noasaurids, saltasaurids, and titanosaurs), birds, frogs, and fishes (e.g., catfish, gars, and lungfish). The albuloid fish specimens reported here represent a further addition to the fish fauna. Albuloids (or "bonefishes") include extant forms (e.g. tarpons) and are found in warm coastal marine waters around the world. The fossil record of these fishes is largely limited to toothplates, vertebrae, and a few cranial elements. The toothplates are considered diagnostic within albuloids to family and even genus level. Albuloid toothplates have an array of multiple, stacked teeth on plates within the oral cavity, and the vertebrae are simple in form and similar to shark vertebrae, with little rugosity around the margin and an uneven, undulating perimeter. The distinctive linear "stacking," hemispherical shape, and smooth surface texture of the teeth from Madagascar indicate that these specimens likely pertain to the extinct phyllodontid albuloid genus *Egertonia*. The presence of this genus on Madagascar is notable because *Egertonia* has previously been reported only from the Cenozoic of North America and Europe (albeit other taxa of fossil albuloids are known from northern Africa, Europe, and North America). These fossils thus significantly increase the geographic and temporal range of this genus to south of the equator and into the Late Cretaceous, and are consistent with earlier speculation that *Egertonia* first evolved in the Maastrichtian. The Malagasy specimens provide important new biogeographical data on Gondwanan albuloids and their distribution patterns during their Late Cretaceous diversification.

Poster Session I, (Wednesday)

#### **CENOZOIC FRESHWATER FISH OF AFRICA, FROM THE FOSSIL RECORD TO THE PAST DIVERSITY**

OTERO, Olga, iPHEP - UMR CNRS 6046, University Poitiers, Poitiers, France

In the last decade, renewed fieldwork efforts in historical outcrops and excavations in newly discovered fossiliferous areas provide a great amount of freshwater fish fossils in Africa. The systematic information they provide and the diversity they represent owe a big tribute to the use of screening sampling methods in the field. As a result, some gaps in the fossil record of African fishes are filled in both time and space. Here, we propose a critical analysis of this fossil record to offer a renewed comprehension of the fish past diversity and distribution in continental Africa throughout the Cenozoic. In that aim, we identify the factors that control the fossil record: 1) extrinsic constraints, i.e. geological and environmental processes that allow deposit, fossilization and exhumation of fossiliferous layers, and 2) intrinsic constraints, i.e. evolution (ecology, distribution, anatomy and osteology), that make a fish present or not at a given time in a given place, and also that make a fossil identified or not. The fossil record mainly concentrates in the north-equatorial half of the African Plate except the Congo basin and including the Arabian Peninsula. The diversity observed in most Neogene assemblages roughly corresponds to the diversity of modern communities screened by taphonomic processes. The modern Nilo-Sudan freshwater fish fauna has been present throughout the Neogene in its current extension area and over. It has been shaped by environmental changes such as the Saharan aridification and the Eastern Africa rifting processes. The analysis of the Paleogene assemblages is more cautious because of phylogenetic uncertainty for most taxa and weak knowledge on the paleoenvironments. The modalities of the rise of the modern ichthyofauna are thus hard to identify. However, if we assume that the evolutionary history of taxa partly conforms to that of the whole ichthyofauna, the analysis of the fossil record of fishes that cross the whole Cenozoic time period might teach us about the Paleogene African fish fauna history. Then, the case study of the fossil record of the African lungfish *Protopterus* indicates drastic changes in the Late Paleogene.

Preparators' Session, Thursday 8:15

#### **ACID PREPARATION OF FOSSILS USING SULFAMIC ACID, A WEAK ORGANIC ACID, AND ITS ADVANTAGES OVER ACETIC AND FORMIC ACID PREPARATION**

PADILLA, Carlos, Fundacion Colombiana de Geobiologia, Bogota, Colombia; PARRA, Mary, Fundacion Colombiana de Geobiologia, Bogota, Colombia

Organic acids such as formic and acetic have long been used for preparation of fossils embedded in calcareous matrices. Formic acid is considered preferable to acetic acid as, although it is more aggressive, it is less damaging for the fossil to have fewer immersions to remove matrix. However, at the Fundacion Colombiana de Geobiologia we have been experimenting with sulfamic acid in order to determine its effectiveness and to optimize its usage. Sulfamic acid (H<sub>2</sub>NSO<sub>3</sub>H) is a weak organic acid that is less toxic than acetic or formic acids. It has been used extensively in domestic and industrial cleaning products to remove limescale. Sulfamic acid's logarithmic dissociation constant (pKa) is 1.18 at 25° making it stronger than acetic (pKa 4.76) or formic (pKa 3.74) acids. Due to its greater acidity, it more effectively removes large volumes of matrix given the same number of immersion cycles. The procedure developed follows the general outline of other acid preparation techniques. By experiment, 2% weight by volume (wbv) acid concentration was found to provide a good balance between time, number of immersions and fossil integrity. The fossil goes through a preliminary cleaning cycle of 10 minutes in 2% wbv sulfamic acid followed by a one day rinsing and drying cycle prior to initial protection of the exposed bone. The specimen is washed in ethanol to displace remaining moisture, and then 5% wbv Paraloid B-72 (methacrylate resin) in ethanol is applied to the fossil as a first protective coat. Further coats of 15% wbv Paraloid are applied and this is repeated until a homogeneous, non-porous film is achieved. The specimen is completely dried before being submitted to 2% wbv sulfamic acid buffered with calcium phosphate (Ca(POH)<sub>2</sub>) to inhibit chemical action to exposed bone. The first immersion is carefully observed to see the extent of matrix removal. Results indicate sulfamic acid is effective for removal of calcareous matrix surrounding large fossils, which would otherwise have required many more cycles in acetic or formic acid. The fossil material preserves the same fine detail exposed with acetic and formic acids, but with less stress to the fossil.

Poster Session III, (Friday)

#### **THE FIRST DISCOVERY OF A EUORNITHOPOD MANDIBLE FROM THE CRETACEOUS OF KOREA**

PAIK, In Sung, Department of Environmental Geosciences, Pukyong National University, Busan, Korea, South; LIM, Jong-Deock, Natural Heritage Center of Korea, Daejeon, Korea, South; KIM, Hyun Joo, Department of Environmental Geosciences, Pukyong National University, Busan, Korea, South; KONG, Dal-Yong, Natural Heritage Center of Korea, Daejeon, Korea, South; GIM, Hyunjoon, Natural Heritage Center of Korea, Daejeon, Korea, South

Korean Cretaceous Dinosaur Coast has produced well-preserved dinosaur footprints, bird tracks, pterosaur tracks, postcranial skeletons of dinosaurs, nests of dinosaurs, crocodylian skulls, etc. In 2008, an isolated mandible with dentition was discovered from the Goseong

Formation (Late Cretaceous) of Goseong County in southern coast of Korea. The Goseong Formation is correlated with Campanian to Maastrichtian on the basis of the polarity data of the Goseong Formation and the geological age of the underlying Jindong Formation in which innumerable dinosaur tracks are preserved. The Goseong Formation is fluvial deposits with frequent intercalations of tuff and tuffaceous deposits. The tooth and bone fossils occur in light purple to greenish gray shaley sandy mudstone, which was deposited on a floodplain. The left mandible is incomplete and has seven teeth. The tooth row is curve and convex lingually. The mandible preserved dentary, coronoid, angular, and sphenial. The dentary teeth are well-enamelled on the lingual surface. Marginal denticles of each tooth are strongly developed and are confluent with ridges on the lingual surface. Primary ridges are prominent and secondary ridges are quite strong as in *Quantassaurus* and *Atlascoposaurus* from the late Early Cretaceous coastal outcrops in southeastern Australia. The number of the ridges of the dentary crowns is six to seven, which is a primitive characteristic for hypsilophodontid dinosaurs. As in *Thescelosaurus*, *Yandusaurus*, *Othnielia*, *Parksosaurus*, *Hypsilophodon*, *Zephyrosaurus*, and *Orodromeus*, the dentary crowns have a well-developed cingulum on the labial surface, which is a synapomorphy for Hypsilophodontidae. Absence of the cingulum is an ancestral character as in *Tenontosaurus*, *Dryosaurus*, *Camptosaurus*, and *Heterodontosaurus*. The apex of dentary crown is centrally placed which is ancestral for Ornithischia. In lateral view, the angular which is the caudoventral part of the mandible forms its dorsal border with the ventral boundary of the external mandibular foramen. Except in the case of isolated teeth, the left mandible with dentition is the first and most complete jaw element of dinosaur in Korean Peninsula.

Poster Session II, (Thursday)

**CRICETODONTINI (RODENTIA, MAMMALIA) FROM THE UPPER ARAGONIAN AND LOWER VALLESIAN OF THE TORIL-NOMBREVILLA SECTION (MIDDLE AND UPPER MIOCENE, CALATAYUD-DAROCA BASIN, ZARAGOZA, SPAIN)**

PALOMA, López-Guerrero, Universidad Complutense de Madrid, Madrid, Spain; ÁLVAREZ-SIERRA, María, Universidad Complutense de Madrid, Madrid, Spain; GARCÍA-PAREDES, Israel, Nationaal Natuurhistorisch Museum Naturalis, Leiden, Netherlands; LÓPEZ-ANTOÑANZAS, Raquel, Museo Nacional de Ciencias Naturales-CSIC, Madrid, Spain; OLIVER, Adriana, Museo Nacional de Ciencias Naturales-CSIC, Madrid, Spain

This work is focused on the study of 1870 fossil dental remains of two Cricetodontini genera, *Cricetodon* and *Hispanomys* from the Toril-Nombrevilla section (Calatayud-Daroca Basin). This section is situated in the northeastern part of Spain and comprises 11 micromammal sites: Toril 2, 3A & 3B, Nombrevilla 2, 3, 4, 9, 10, 14, the classical Nombrevilla (1) and Pedregueras 2A. The stratigraphical superposition of the fossiliferous levels and their richness and abundance of fossil remains make this section especially interesting for the analysis of rodent faunas evolution from the Late Aragonian to Early Vallesian. In addition, *Cricetodon* and *Hispanomys* have biochronological and biostratigraphical relevance within this interval.

One of the first results of this study is the unexpected high diversity and turnover shown by *Cricetodon* and *Hispanomys* in this basin. The taxa recorded are the following: *Cricetodon* aff. *jotae* in TOR 2, 3A and 3B; *Hispanomys aguirrei* and *H. lavocati* in NOM 2, 3 and 4; *H. nombrevillae* in NOM 9, 1 and 10; and *H. aragonensis* in NOM 14 and PED 2A. One of the most relevant conclusions of this study is that the replacement of *Cricetodon* by *Hispanomys* took place (NOM 2) long before the first appearance of *Hipparion* (NOM 1); this fact has important consequences for the local biozonation. On the other hand, in the localities NOM 2, 3 and 4 two taxa have been found for the first time in the Calatayud-Daroca Basin, *H. aguirrei* and *H. lavocati*. These species have been described before in the Duero and the Vallés-Penedès basins respectively. The presence of two different species of *Hispanomys* in the same fossiliferous level is unusual but an analogous situation has been described on the Vallés-Penedès Basin. Our preliminary results suggest that probably these three basins (Calatayud-Daroca, Duero and Vallés-Penedès) had periods of higher faunal exchanges than previously thought.

Poster Session III, (Friday)

**THE DIVERSITY OF MEGALOOOLITHID PALEOOÖPECIES IS NOT THE DIVERSITY OF DINOSAUR PALEOSPECIES.**

PANADES I BLAS, Xavier, The University of Bolton, Bristol, United Kingdom; BADDELEY, Roland, The University of Bristol, Bristol, United Kingdom

Megaloolithid eggshells are abundant in Late Cretaceous outcrops around the world, and have provided paleobiographical, systematic, and parataxonomical information of dinosaurs. However, their role as indicators of nesting paleobiodiversity has been debated, because they cannot be directly assigned taxonomically to a dinosaur paleospecies. Comparative quantifications between the eggshell structures of megaloolithid and modern reptile eggshells should corroborate the parataxonomic validity of each paleoöpecies. Detailed comparative statistical analysis of the variance of the (logarithm of) of eggshell thickness and with of unit, were run; to attempt to infer the inter- (eggs and clutches) and intra- (paleoöpecies) specific variation and variability; between eggs of modern species, and megaloolithid dinosaur eggshells from the Upper Cretaceous of Sutterranya (Upper Campanian-Early Maastrichtian, Catalunya, South-central Pyrenees), and other French and Indian contemporaneous megaloolithid paleoöpecies Reptile and megaloolithid eggs,

clutches, and oospecies, exhibited highly significant morphometric heterogeneity. The morphometric variation of the Catalan megaloolithid samples also corresponded with the inter- (eggs and clutches) and intra- specific variation (oospecies) of samples representing a modern reptile oospecies. Subsequently, the megaloolithid paleoögenera from Sutterranya are in reality eggshells from different areas of the same eggs, indicating the variability of a single megaloolithid paleoöpecies laid by the same paleospecies of dinosaurs. Hence, they are invalid indicators of the paleobiodiversity of nesting dinosaurs in the Catalan Pyrenees during the Late Cretaceous period.

Poster Session II, (Thursday)

**ANTERIOR MANDIBULAR MORPHOLOGY, MASTICATORY BIOMECHANICS AND DIETARY RECONSTRUCTIONS OF FOSSIL HOMINOID.**

PANAGIOTOPOULOU, Olga, Hull York Medical School, University of York, York, United Kingdom; COBB, Samuel, Hull York Medical School, University of Hull, Hull, United Kingdom

The anterior mandible is well represented in the hominoid fossil record and used both for taxonomic and dietary assessments of fossil taxa. The morphology of the mandibular symphysis displays considerable variation, while this has been related to a number of factors (eg. dentition, sexual dimorphism, facial orientation), most emphasis has been given to the adaptive significance of symphyseal to the mechanical loading during chewing. The current state of knowledge regarding the adaptive significance of the mandibular symphysis is based on a combination of allometric studies, *in vivo* strain gauge studies on *Macaca fascicularis* and biomechanical modeling of the mandible as a curved beam. These approaches have shown that the symphysis undergoes both lateral transverse bending (LTB) and dorsoventral shear (DVS) during unilateral biting, and have lead to the generation of hypotheses about the adaptive significance of symphyseal morphology and the dietary implications, but are hitherto untested. In this study we use a series of modified hypothetical morphologies of the *M. fascicularis* adult mandible to test the hypotheses about the adaptive significance of different symphyseal morphologies present in the hominoid fossil record (transverse tori, inclination and depth of the symphysis). FEA results confirm the mechanical hypotheses that both the superior transverse torus and an oblique symphyseal inclination serve to reduce strains associated with LTB and that an increased symphyseal depth reduces strains associated with DVS. In addition, the results indicate previously unreported findings that both an increased superior transverse torus and an oblique symphyseal inclination contribute to the reduction of strains associated with DVS.

The finding that adaptation to minimize both patterns of bending can be achieved through a number of different morphologies, contributes to our understanding both of potential sources of intraspecific variation that may obscure both taxonomic and dietary assessments of fossil taxa and the influence of evolutionary and or developmental constraints such as dental development on symphyseal form.

The Scientific Legacy of Mary Anning — Recent Advances in Marine Reptile Paleobiology and Evolution, Wednesday 10:15

**NEW MARINE REPTILES FROM THE CRETACEOUS OF CENTRAL COLOMBIA**

PÁRAMO, María, Departamento de Geociencias, Universidad Nacional de Colombia, Bogotá D.C., Colombia; ETAYO-SERNA, Fernando, Universidad Nacional de Colombia, Bogotá D.C., Colombia; GÓMEZ PÉREZ, Marcela, CASP, University of Cambridge, Cambridge, United Kingdom; PADILLA, Carlos, Fundación Colombiana de Geobiología, Bogotá D.C., Colombia; NOË, Leslie, Thinktank, the Birmingham Science Museum, Birmingham, United Kingdom

Over the last ten years, the remains of a large number of marine reptiles have been found in Lower Cretaceous rocks from the Villa de Leiva region of Central Colombia. The majority of these fossils have been collected by the Fundación Colombiana de Geobiología and are preserved in this collection. Here, for the first time, we offer an overview of this highly productive locality and present some characteristics of this new paleontological material. The well-preserved fossils of plesiosaurs, ichthyosaurs and turtles (although currently no marine crocodiles) have been found in the claystones and calcareous concretions of the Arcillolitas Abigarradas member of the Paja Formation of Barremian-Aptian age, which has been interpreted as deposited in an intertidal complex. Surface finds are usually isolated skeletal elements or bone fragments, however, deeper discoveries frequently consist of substantially complete and articulated skeletons. The majority of the specimens are preserved in three-dimensions and following chemical preparation display superb anatomical detail. The long-necked plesiosauroids and turtles are restricted to upper Aptian beds, whereas short-necked plesiosauroids and ichthyosaurs exhibit a wider stratigraphic distribution, from the lower Barremian to the upper Aptian. Both plesiosauroids and ichthyosaurs appear to be represented by several taxa, including new genera and/or species. Currently, at least three plesiosauroid taxa of different ages have been identified, and probably at least as many genera of ichthyosaurs, although full study of each specimen is required to confirm or refute this suggestion. Villa de Leiva provides excellent conditions for obtaining detailed vertebrate biostratigraphical controls and reliable taphonomic interpretations. The fossils provide valuable information about plesiosauroids, plesiosaurs, and turtles, which together with the abundant, varied and well-preserved ichthyosaurs constitute an important opportunity to improve our understanding of Cretaceous marine reptiles, whose remains are scarce across the world. Hence the Villa de Leiva fauna has great potential to revolutionize our understanding of early Cretaceous marine faunas.

Molecular Tools in Paleobiology: Trees, Clocks and linking Geno- with Phenotype, Friday 9:30

#### **A REVIEW OF TETRAPOD FOSSIL CALIBRATIONS: PROBLEMS, SOLUTIONS, AND DATABASES**

PARHAM, James, Field Museum of Natural History, Chicago, IL, USA

The temporal correlation of evolutionary events with climate change, geological evolution, and other historical patterns is essential to understanding the processes that shape biodiversity. Traditionally, fossils have provided the only evidence of lineage divergence/origination dates, but over the past few decades, molecular approaches to estimating divergence times have become increasingly common. The integration of these methods with fossil data has been inconsistent, unreliable, and sometimes not replicable. In general, the development of rigorous synthetic approaches has been hindered by the relative inaccessibility of paleontological data (its literature, sources of error, and attendant assumptions) to non-paleontologists. A review of tetrapod fossil calibrations shows that many studies of divergence dating employ flawed or unsubstantiated calibrations based on incorrect interpretations of the paleontological literature. There are widespread problems relating to the selection of fossils, the inexplicit translation of relative to absolute dates, the conflict between morphological and molecular phylogenies, and the improper construction and reporting of fossil calibrations. In general, the justification of fossil calibrations in molecular divergence dating studies is held to low standards. The renewed interest in fossil data for calibrating biotic evolution presents an opportunity for paleontologists to address the complexities and importance of their discipline. For that reason, paleontologists should take a more proactive approach to guiding how their data are being appropriated. Given that rapid access to information is one of the defining revolutions of modern science, bioinformatics approaches that utilize the power of databases and online resources like the Encyclopedia of Life, Fossil Record, and the Paleobiology Database should play a role in guiding the development of fossil calibration studies.

Late Triassic Terrestrial Biotas and the Rise of Dinosaurs, Thursday 8:15

#### **CONSTRAINING THE STRATIGRAPHIC POSITION OF THE LATE TRIASSIC (NORIAN) ADAMANIAN-REVUELTIAN FAUNAL TRANSITION IN THE CHINLE FORMATION OF PETRIFIED FOREST NATIONAL PARK, ARIZONA**

PARKER, William, University of Texas at Austin, Austin, TX, USA; MARTZ, Jeffrey, Petrified Forest National Park, Petrified Forest, AZ, USA

Since the 1980s it has been established that Upper Triassic Chinle Formation of Petrified Forest National Park in northeastern Arizona contains two distinct non-marine vertebrate faunal assemblages, separated by a narrow stratigraphic interval, which are the basis for the Adamanian and Revueltian land vertebrate faunachrons. This faunal turnover was thought to occur at the level of the Sonsela Sandstone bed, which divided the Petrified Forest Member of the Chinle Formation in northeastern Arizona into lower and upper units. Furthermore, the contact between the Sonsela Sandstone and the lower Petrified Forest Member was thought to represent a major unconformity (Tr-4), which divided the two faunal assemblages and approximated the Carnian-Norian boundary. However, recent lithostratigraphic revisions in the park correlated the Sonsela Sandstone bed to the lowest Flattops sandstone, which all previous workers had considered to lie higher in the section. This resulted in an apparent overlap between the two faunal assemblages. This current study demonstrates that much of the previous lithostratigraphic work, especially the recent revisions, incorrectly correlated the Sonsela sandstone bed. We have revised these correlations, and resurrected the hypothesis of two distinct, non-overlapping faunal assemblages. Furthermore, recent collection and detailed documentation of fossil vertebrates has constrained the stratigraphic position of this faunal turnover, which occurs in a well-developed paleosol horizon several meters above the traditional Sonsela Sandstone bed (now known as the Jasper Forest bed). The highest occurrences of the characteristic Adamanian taxa *Leptosuchus* and *Calptosuchus* occur just below this horizon, and the lowest occurrences of the characteristic Revueltian taxa *Pseudopalatus* and *Typhothorax* occur just above it. Finally, recent studies suggest that almost the entire Chinle is actually Norian in age. Thus, there is currently no strong lithological or paleontological evidence for the Tr-4 unconformity within the Chinle Formation, and the faunal turnover occurs neither where this unconformity was hypothesized, nor at the Carnian-Norian boundary.

Edwin H. and Margaret M. Colbert Poster Competition (Thursday)

#### **STICKING OUR NECKS OUT: ANATOMY OF THE FIRST CERVICAL VERTEBRA AND IMPLICATIONS FOR INFERRING LOCOMOTION AND POSTURE IN FOSSIL PRIMATES**

PARKS, Hillary, Western Illinois University, Macomb, IL, USA

One of the most challenging issues faced when working with fossil material is the determination of their paleoecological role. To some extent, inferences about paleoecology can be drawn from the observation of extant relatives. In the case of adapiform skeletal anatomy, deciphering postural and locomotor behavior of this extinct group hinges on the inferences derived from extant mammalian taxa. I compared the shape of the atlas vertebra in extant primates (prosimian and anthropoid taxa) using two-dimensional Thin-Plate Splines analysis, a Principal Components Analysis of Shape, and traditional statistical analyses. Using the framework of earlier studies of vertebrae shape in a limited taxonomic sample, the hypothesis that atlas shape, postural, and locomotor behavior are functionally

correlated was tested using a large comparative sample spanning prosimian primates (extant lemurs and lorises), Old and New World monkey taxa, and hominoids ( $N = 111$ ). The results indicate that prosimians generally have a distinct atlas shape, separate from that of other anthropoid taxa, particularly hominoid genera. Moreover, there is no support for uniform shapes associated with any locomotor or postural behavior. These data suggest that functional interpretations of fossil skeletal material should be made using datasets designed not only to explore shape variation within a large group, such as Primates, but also within smaller taxonomic groups. Additional analyses will determine whether there are distinct locomotor or postural predictions that can be made within smaller taxonomic groups, such as prosimians, New or Old World Monkeys, or within hominoids, and whether this can be applied to infer posture and locomotion in extinct clades such as adapiformes.

Poster Session III, (Friday)

#### **AN UNUSUAL NEW MAMMAL FROM THE LOWER CRETACEOUS CLOVERLY FORMATION OF CENTRAL MONTANA**

PARSONS, William, Buffalo Museum of Science, Buffalo, NY, USA; PARSONS, Kristen, Buffalo Museum of Science, Buffalo, NY, USA

The remains of at least two individuals from a new mammalian taxon were discovered within the basal portion of Unit VII of the Cloverly Formation of Montana. Preliminary phylogenetic analysis indicates that it occupies a basal position among Mammaliaformes, but further work is needed to more precisely elucidate placement of this new taxon. The material represents a mammal that is approximately 20 to 30 percent larger than the extant Short-beaked Echidna (*Tachyglossus aculeatus*). Both cranial and postcranial material has been recovered. The skull is represented by much of the roof of the braincase, maxillae, an incomplete jugal, a portion of the basicranium, and complete mandible. The teeth exhibit polyphyodont replacement, with new teeth erupting behind the older teeth in both the dentary and maxilla. There is no canine, but there appears to be a large caniniform incisor. The molariform teeth have unusual crown configuration, with vertical enamel-covered walls surrounding deep basins. These walls comprise a number of both large and small cusps. The postcranial material includes the ilia, several centra and isolated neural arches, partial humerus, proximal end of the radius, several manual elements, rib fragments, fragments of the femur, complete tibia, possible fibula, articulated calcaneum and astragalus (collected as a block), an isolated astragalus, and numerous pedal bones. The manual unguals are dorsoventrally flattened, and all the manus elements closely resemble those of the echidna, suggesting similar fossorial behavior. The manual elements are at least twice the size of the pedal elements. The transverse processes of the sacral vertebrae are not fused to the ilia, but contact them in a "ball and socket" articulation. A small block of possible gut contents containing two small teeth and bone fragments has also been recovered.

Technical Session XV, Saturday 11:45

#### **THE BRAINCASES OF ARGENTINIAN THEROPOD DINOSAURS: OSTEOLOGY AND PHYLOGENETIC IMPLICATIONS**

PAULINA CARABAJAL, Ariana, CONICET-Museo Carmen Funes, Av. Córdoba 55 (8318), Plaza Huincul, Argentina

Most cranial descriptions do not include the braincase, which is why comparatively little braincase information is used in taxonomic diagnoses and phylogenetic analyses. Argentina is, within the framework of South America, the territory with the greatest number of known theropods. Nevertheless, the number of known skeletons with preserved braincases is less than ten. Although the statistical significance of such a small sample is poor, the Argentinean taxa represent different stages of theropod evolution throughout the Mesozoic. Theropod braincases share with prosauropods a number of plesiomorphic characters that not found in sauropod braincases, which have a number of unique characters. Twenty-five differences were identified to distinguish theropod and sauropod braincases. Theropod braincases develop mostly axially (in contrast with sauropods, which develop mostly transversely), and the dorsoventral height tends to vary in correlation with the degree of dorsoventral development of the basicranium. The variability observed in theropod braincases is high, although many characters are apparently dependent on body size. In order to determine how braincase characters influence the resolution of relationships within the Theropoda, a phylogenetic analysis was done using 29 taxa. Fifty-seven of the 113 braincase characters are new for this study, and another 37 characters are modified (and the rest taken) from previous analyses. Braincase characters support well the monophyly of the clades Theropoda, Neotheropoda, Abelisauridae and Tyrannosauridae, and the resulting trees include *Herrerasaurus* within the Theropoda. The inclusion of braincase characters in previous matrices results in trees whose topology is not modified significantly, which implies that braincase characters produce trees that are congruent with trees obtained with the rest of the cranial and postcranial characters. The phylogenetic analysis shows that braincase characters have a high degree of homoplasy. This does not agree with the low level of homoplasy that would be expected if the braincase is the most conservative part of the skull, as has sometimes been stated.

**BA/CA AND SR/CA AS PROXIES FOR TROPHIC LEVEL AND SALINITY PREFERENCES OF MARINE MAMMALS**

PEEK, Stephanie, University of Wyoming, Laramie, WY, USA; CLEMENTZ, Mark, University of Wyoming, Laramie, WY, USA; FOX, David, University of Minnesota, Minneapolis, MN, USA

Trophic position is a key ecological parameter for defining an organism's niche in marine food webs. One method for estimating trophic position relies on variations in the elemental concentrations of barium, calcium, and strontium in bioapatite. The ratios of Ba/Ca and Sr/Ca decrease as trophic level increases due to *biopurification*, a process by which calcium is preferentially incorporated into skeletal material over strontium and barium. Ba/Ca and Sr/Ca are commonly used in archaeological studies but have only rarely been applied to marine foodwebs. The objective of this study was to determine if these proxies were applicable to modern marine foodwebs in the hope that they may then be applied to the reconstruction of ancient marine foodwebs. Analyses were performed on marine primary producers (3 species; n=8) and specimens from several marine mammal groups: sirenians (3 species, n=28); marine mustelids (1 species, n=4); pinnipeds (6 species, n=21); and cetaceans (14 species, n=61). Preliminary research shows a similar relationship between Ba/Ca and Sr/Ca in the marine and terrestrial environments, but with two important and useful differences. First, barium concentrations in seawater are highly variable; log(Ba/Ca) varies with salinity, depth, and productivity (-4.78 to -3.5). Thus marine species are depleted in barium relative to terrestrial species and Ba/Ca shows some separation between sirenian species dependent on freshwater (e.g. manatees) and those that are not (e.g. dugongs). Second, strontium concentrations are more stable. The log(Sr/Ca) of seawater averages -1.728 and varies only slightly across latitude and depth (-1.731 to -1.725). Sr/Ca shows effective separation of marine mammals into three diet groups: plants or invertebrates; invertebrates and vertebrates; and solely vertebrates. Together Ba/Ca and Sr/Ca record a variety of environmental factors important to the ecology of marine mammals. If this method can be applied to well-preserved fossil material it would be a relatively inexpensive method for estimating trophic position that could complement other methods of paleoecological reconstruction (e.g., stable isotopes, morphometrics, etc.).

Poster Session IV, (Saturday)

**A POSTCRANIAL RECONSTRUCTION OF THE BASAL EUPELYCOSAUR AEROSUARUS WELLESI**

PELLETIER, Valerie, Cal State San Bernardino, San Bernardino, CA, USA

The basal eupelycosaurian family Varanopidae has the longest fossil record among Paleozoic amniotes, extending from the Late Carboniferous to the Late Permian and ranging from North America to Russia and South Africa. It appears to have been a highly conservative lineage, surviving Permian climatic changes and coexisting with therapsids in both Laurasia and Gondwana while other pelycosaurian-grade families were replaced. Unfortunately, varanopids are rare fossils in lowland aquatic ecosystems, the most common of Permian sites. They appear to have been more prominent members of upland terrestrial ecosystems where they were the top predators. Only two such sites are known at this time, making our understanding of this important group being based on usually one, often poorly preserved, specimen per locality. *Aerosaurus wellsi*, from the Lower Permian Abo/Cutler Formation of New Mexico is one of the best preserved varanopids. A thorough study of *A. wellsi* improves our understanding of this long-lived, widespread group. A complete reconstruction of the postcranial skeleton has been done in both dorsal and lateral view, along with a comparison of the individual postcranial elements with those of other known members of the Varanopidae. The dorsal centra of *Aerosaurus* are similar to other varanopids. The height of the neural spines is greater than those of *Archaeovenator* or *Mycterosaurus*, but shorter than either *Watongia* or *Varanops*. *Aerosaurus* has a slight lateral excavation at the base of the neural spine that is deeper in *Varanops* and even more so in *Watongia*. The overall shape of the clavicle is more similar to *Varanops* than other varanopids, the head is more expanded than in *Watongia* or *Pyozia*, but slightly less so than in *Varanops*. The proximal head of the humerus is similar in shape to those of *Watongia* and *Varanops*, but more robust than either *Archaeovenator* or *Mycterosaurus*. Distally the humerus is less robust than *Varanops* and the angle of twist of distal upon proximal ends is greater in *Aerosaurus* than in the other varanopids. The shaft of the femur is straight unlike *Mycterosaurus* and *Archaeovenator* in which the shaft is more sigmoidal.

Poster Session II, (Thursday)

**ANALYSIS OF DIGESTION DEGREE OF FOSSIL RODENT TEETH FROM LANTIAN, SHAANXI PROVINCE, CHINA**

PELTONEN, Hannele, University of Helsinki, Helsinki, Finland

Attempts to establish predator consumption from the fossil record are often hampered by taphonomic overprinting from secondary processes, such as soil acid etching and hydraulic transport. However, the ability to deduce the primary cause of fossil accumulation is an integral part of any paleontological site assessment. A comprehensive taphonomic analysis was conducted on a collection of fossil rodent teeth derived from 13 different paleontological sites of the Late Neogene Lantian Formation of the Shaanxi Province, China. The purpose of this analysis was to identify possible traces of predator digestion on fossil micromammal remains and to test the persistence of predation signal across geological timescales. The

assessed collection (n=177) included the dental remains of the murid species *Progonomys sinensis*, the gerbillids *Myocricetodon lantianensis* and *Abudhabia baheensis*, the dipodid *Protolactaga lantianensis*, the zaptodid *Lophocricetus xianensis*, and the sciurids *Eutamias lishanensis* and *Sciurotamias pusillus*. The degree of digestion was analyzed according to a set of 12 standard criteria that took into account the presence and spatial extent of fragmentation, etching, enamel loss, fracturing, splitting, rounding, staining, and pitting of individual molar teeth. The quantitative analysis of the tooth assemblage revealed some marked taxon-specific differences in the areal spread and intensity of acid etching tracery. Gerbillid molar teeth were characterized by a high degree of breakage, slight to moderate rounding, and a small to moderate amount of enamel loss. The murid tooth crowns were quite heavily etched, showing frequent surface pitting and scouring. Staining and alterations of the enamel surface texture were the most notable features of the squirrel teeth. The degree of modification by digestion was highest in the squirrel *Eutamias lishanensis*, whereas the other rodent species showed only slight to intermediate digestion index values. Subsequent analysis will involve the comparison of the Lantian fossil rodent assemblage with modern actinotaphonomic specimens for the purpose of predator diagnosis.

Poster Session II, (Thursday)

**A SINGULAR CONCENTRATION OF BOTHREMYDID TURTLES FROM THE UPPER CRETACEOUS OF LO HUECO (CUENCA, SPAIN).**

PÉREZ GARCÍA, Adán, Universidad Complutense Madrid, Madrid, Spain; ORTEGA, Francisco, Fac. Ciencias, UNED, Madrid, Spain; MURELAGA, Xabier, Universidad del País Vasco, Leioa, Spain

Bothremydidae is one of the most abundant groups of chelonians in the Campano-Maastrichtian record of western Europe, in which are so far represented by six species: *Rosasia soutoi*, *Foxemys mechinorum*, *Polysternon provinciale*, *Polysternon atlanticum*, *Elochelys perfecta* and *Elochelys convenarum*. However, probably due to the scarceness of information about some of them, at present, there is not a robust phylogenetic hypothesis on the group, and especially about the structure of the most inclusive taxon Bothremydinae. The upper Campanian-lower Maastrichtian site of Lo Hueco (Cuenca, Spain), discovered in May 2007, have yielded hundreds of remains attributed to bothremydid turtles. The collection is composed of plates and isolated bones, but also for portions of carapaces, complete carapaces, and even almost complete skeletons retaining a high percentage of its elements, including cranial and mandibular material. Among them, it can be recognized the characters of some previously cited taxa of the Ibero-Occitan region that are still not well known. Part of the collection can be attributed to *Polysternon atlanticum*, until now just represented by isolated postcranial elements from Campano-Maastrichtian sites of southern France and northeastern Spain. Another part of the collection can be attributed to *Elochelys convenarum*, at present only known by a carapace from the upper Maastrichtian of Central French Pyrenees. However, due to the large number of individuals found in Lo Hueco, some of them articulated and fairly complete, it is possible a better fit of the intraspecific variability, ontogenetic or arising from the presence of sexual dimorphism. This analysis will allow to review the diagnosis of the involved bothremydids and the phylogenetic relationships among them.

Poster Session II, (Thursday)

**TOOTH MORPHOLOGY AND RELATIONSHIPS OF "CONDYLARTH" MAMMALS**

PERINI, Fernando, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil; SALLES, Leandro, Museu Nacional, Rio de Janeiro, Brazil

Condylarthra is a highly paraphyletic assemblage of early Tertiary mammals that are thought to have been involved on the origin of a variety of extinct and extant orders of ungulates. In the last decades, these issues became even more controversial with a series of molecular evidence indicating Ungulata as a polyphyletic group. Most condylarths are known mainly based on dental remains, and this work presents an extensive review of tooth morphology and phylogenetic contexts associated to several condylarth groups. Dental patterns of variation are scrutinized as hypotheses of primary homology for seventy-eight species representing most of the groups once considered a Condylarthra, including as well basal representatives of some "ungulate" orders. Seventy-two dental characters are elaborated. TNT software was used carried out analyses of parsimony based on tree bisection and reconnection (TBR) and New Technology algorithms applied to the built data matrix. The result was 3200 most parsimonious trees, each 573 steps long, with a consistency index of 0.167 and retention index of 0.626. Mesonychia emerges monophyletic, with some support for their association with the Triisodontidae. No special relationship of this group to Artiodactyla is corroborated. The family Periprychidae came out monophyletic, rooted as sister-taxon of a clade embracing Mioclaenidae, Hyposodontidae and Phenacodontidae, including also Artiodactyla, Perissodactyla and Meridiungulata. The monophyletic status of Mioclaenidae is supported, it is underline however that *Ellipsodon* and *Pleuraspidotherium* *Orthaspidothierium* are placed elsewhere, and no association of this family with South American ungulates is observed. Hyposodontidae came out polyphyletic, with some support for the monophyly of the Apheliscinae. The phenacodontid genera were distributed in a paraphyletic fashion, with some genera related to either Perissodactyla or Didolodontidae + Litopterna. Further developments on the evolution of the masticatory apparatus of these early "ungulates" are expected for the near future.

Poster Session IV, (Saturday)

#### **VENTILATION AND HEAT EXCHANGE IN THE RESPIRATORY SYSTEM OF SAUROPOD DINOSAURS**

PERRY, Steven, Universität Bonn, Bonn, Germany; BREUER, Thomas, Universität Bonn, Bonn, Germany; PAJOR, Nadine, Universität Bonn, Bonn, Germany; WITZEL, Ulrich, Ruhr-Universität Bochum, Bochum, Germany

Combination of a recent gigantothermic model with physiological and morphometric models for avian and reptilian lungs leads to the conclusion that an avian-like respiratory system would have satisfied the metabolic demands of the largest sauropods during rest and activity. The extremely heterogeneous lung structure would also obviate consideration of gravitational constraints, because the gas-exchange region could have been restricted vertically and the thoracic/abdominal sac-like regions (SLR) would lack pulmonary circulation. Simulation of breathing movements based on 3-D reconstruction of rib swing beginning at a resting angle determined from Sharpey's fiber traces yields such a large tidal volume that the SLR would have easily accommodated tracheal dead space air. Our preliminary calculations demonstrate the degree to which evaporative cooling in the trachea plus heat transfer to humidified air in the flow-through lungs and SLR could have contributed to solving the gigantothermy problem. The respiratory system thus did not present an obstacle to sauropod gigantism, but may have exacerbated it.

Technical Session XV, Saturday 9:45

#### **THEROPOD TAIL MUSCLE RECONSTRUCTION AND ASSESSMENT OF THE LOCOMOTIVE CONTRIBUTIONS OF THE *M. CAUDOFEMORALIS***

PERSONS, Walter, University of Alberta, Edmonton, AB, Canada

Perhaps related to a lack of teeth and claws, the tails of theropods have not been extensively studied, and the size and arrangement of theropod tail musculature is not well understood. Examination of ornithomimid and tyrannosaurid tails has revealed sequential scarring (running diagonally, anterior/ventral to posterior/dorsal) on the lateral faces of four or more haemal spines that consistently correlates with the zone of the tail just anterior to the disappearance of the vertebral transverse processes. This sequential scarring is interpreted as the tapering boundary between the insertions of the *M. caudofemoralis* and the *M. ilioischio-caudalis*. The anterior termination of this scarring is interpreted as evidence that the *M. caudofemoralis* inserted across the entire lateral face of anterior haemal spines. Dissections performed on a range of modern reptiles, including *Caiman crocodilus* (spectacled caiman) and *Tupinambis merrianae* (the Argentine black and white tegu), show that an anteriorly expansive *M. caudofemoralis* is consistent with extant analogs. Assuming that the muscle was roughly elliptical in cross-section and that its anterior girth was bound dorsoventrally by the undersurface of the transverse processes and the ventral tips of the haemal spines, it is now possible to digitally reconstruct the size and shape of the *M. caudofemoralis*. In this study, primary tail musculature is reconstructed for three theropod genera: *Gorgosaurus*, *Ornithomimus*, and *Tyrannosaurus*. The results indicate that these theropods had bulkier tails than has commonly been assumed and depicted. Most of the additional bulk was composed of the *M. caudofemoralis*, a primary retractor of the hind limb. This suggests greater locomotive potential. Muscle force, power, and possible contribution to turning performance are calculated from the digital models.

Poster Session III, (Friday)

#### **MICROBIAL FEATURES IN DINOSAUR BONES FROM UTRILLAS (TERUEL, SPAIN)**

PESQUERO, María, Fundación Conjunto Paleontológico de Teruel-Dinópolis, Teruel, Spain; LUQUE, Luis, Fundación Conjunto Paleontológico de Teruel-Dinópolis, Teruel, Spain; ALCALÁ, Luis, Fundación Conjunto Paleontológico de Teruel-Dinópolis, Teruel, Spain; ROYO-TORRES, Rafael, Fundación Conjunto Paleontológico de Teruel-Dinópolis, Teruel, Spain

Histological analyses of fossil bones can throw light on the burial environment and taphonomic history of the site. A study on dinosaur bones from the Albian tidal flood plain facies of Utrillas (Teruel) has been carried out through thin sections, SEM, XRD and EDS. Remains show a poorly preserved cortical tissue and external longitudinal fissures filled with calcite cement. Various phases of inner cementation dominantly calcitic and a fine iron oxide crust produced later have been observed. Iron crust partially fills fissures and coats the bone surface. Original bone phosphate has been replaced by calcite. Examination of polished sections of bones using SEM show a well preserved histological structure in the cortical layer. In this zone both voids and Haversian canals are filled by crystals of calcite growing around several iron microspheres. However, the cancellous bone shows a number of diagenetic cracking as a result of collapse of the internal structure probably influenced by previous bacterial attack. Iron microspheres, range between 6 and 11  $\mu\text{m}$ . They lie within the cracks and are joined to the surfaces of the bone fractures. These structures are spherical aggregates of minor microspheroids preserved in Fe whose diameter ranges between 1 and 2  $\mu\text{m}$ . Microspheres were primarily formed at the edges of bone tissues by bacteria activity; after that, some of these microspheres penetrated into the bone through voids and canals, producing the filling of the Haversian system. There is no evidence of direct bacterial attack on the bone, but the presence of these microspheres is diagnostic of bacterial action in anoxic burial environment. This taphonomic alteration reveals a sequence of different local microenvironmental conditions: an anoxic phase with low pH and bacterial degradation with

partial demineralization of the bone was followed by mechanical cracking. In this phase the formation of iron microspheres by bacteria occurs. After that, the precipitation of calcite, in a rather well oxygenated environment, took place.

Poster Session I, (Wednesday)

#### **PANAMA AS A PALEO-NURSERY AREA FOR GIANT SHARK BABIES (*C. MEGALODON*)**

PIMIENTO, Catalina, Florida Museum of Natural History/University of Florida, Gainesville, FL, USA; EHRET, Dana, Florida Museum of Natural History/University of Florida, Gainesville, FL, USA; MACFADDEN, Bruce, Florida Museum of Natural History/University of Florida, Gainesville, FL, USA

Although sharks are apex predators in the oceans, juveniles are susceptible to being preyed upon by larger individuals. Females give birth to pups in shallow environments called nursery areas that protect their offspring. Juveniles use these environments as a refuge from predators. These nursery areas are essential habitats for the success of sharks. The extinct shark (*Carcharocles megalodon*) "Megalodon", is the biggest predator that ever lived. The huge size of this shark has caused curiosity in both the scientific community and among fossil collectors. A single *C. megalodon* tooth can reach 168 mm in crown height and studies have estimated that an adult could reach more than 15 m of total length. Fossil teeth of this extinct giant are found worldwide, including the Late Miocene Gatun Formation of Panama. We have collected and measured a number of *C. megalodon* teeth from the Gatun Formation. Surprisingly, no large teeth are present (i.e., the crown heights of Gatun *C. megalodon* teeth range from 16 mm to 54 mm). Estimates of the total length based on tooth height show that *C. megalodon* from the Gatun Formation range from 2-6 m, indicating that they are juveniles. In order to test this, we have compared these specimens with different isolated teeth, associated dentitions, and composite jaws from analogous localities such as Bone Valley Formation, Florida; Cooper River, South Carolina; Lee Creek Mine, North Carolina and Calvert, Maryland. These comparisons confirm that *C. megalodon* sharks from the Gatun Formation are juveniles. During the Late Miocene the Gatun was a warm shallow water marine environment that supported a diverse fauna of sharks. We propose that Gatun was a nursery area during this period of time and that *C. megalodon* juveniles spent their juvenile stage in this shallow environment that provided them protection from larger predators. This study represents the first report of a paleo-nursery area that supported *C. megalodon* babies using quantitative and testable data from measurements, comparisons and estimates.

Poster Session IV, (Saturday)

#### **ICHOLOGICAL EVIDENCES OF GIGANTIC DINOSAURS IN THE LATE JURASSIC OF THE IBERIAN PENINSULA**

PIÑUELA, Laura, Museo del Jurásico de Asturias (MUJA), Colunga, Spain; GARCIA-RAMOS, Jose, Museo del Jurásico de Asturias (MUJA), Colunga, Spain; RUIZ-OMEÑACA, José, Museo del Jurásico de Asturias (MUJA), Colunga, Spain

Several dinosaur footprints recently discovered in the Late Jurassic of Asturias (North Spain) were made by enormous trackmakers. These new footprints come from three localities placed in the coastal cliffs of Colunga and Villaviciosa municipalities, both in the famous Asturian "Dinosaur Coast". All of them are preserved as sandstone casts belonging to Lastres Formation, deltaic in origin and Kimmeridgian in age, and are housed in the Jurassic Museum of Asturias (MUJA). A 57 cm long tridactyl stegosaur pes print, assigned to *Deltapodus* sp., from cape Lastres (Colunga) is the biggest of its kind. A theropod footprint, 82 cm in length, from Argüero (Villaviciosa) is one of the largest worldwide known, only surpassed by a 90 cm long footprint from the Upper Jurassic of the Central High Atlas of Morocco (Iouaridène Formation, Oxfordian-Kimmeridgian). Finally, a sauropod manus print from Tazones (Villaviciosa), similar in morphology to *Brontopodus*, is 95 cm long, the longest length for a sauropod manus currently known; its corresponding pes print could reach or exceed 2 m in length. It should be noted here, that the pes prints of *Gigantosauropus asturiensis*, a trackway located in La Griega beach (Colunga) from the Tereñes Formation (Kimmeridgian), are between 95 and 125 cm long and are the biggest in the Jurassic record. The Asturian tracks, together with a very big footprint cast, 70 cm in length, from the Upper Jurassic Lourinhã Formation (Kimmeridgian-Tithonian) of Portugal (Lourinhã, Lisbon district) attributed to an ornithomimid by other authors but belonging probably to a theropod for us, indicate the presence of very big stegosaurian, theropod and sauropod dinosaurs in the Late Jurassic of the Iberian Peninsula, not recognized up to the moment by skeletal evidences.

**DECREASED DORSOVENTRAL AND MEDIOLATERAL VERTEBRAL JOINT STIFFNESS IN THE TAIL, ALONG THE LINE OF DESCENT BETWEEN NON-AVIAN AND AVIAN THEROPODS**

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The tail is an important structure in the dinosaurian origin of birds because this transition is correlated with a reduction of tail length and caudal number, as well as tail function. To improve our understanding of the form, function, and evolution of maniraptoran tails, we examined factors associated with dorsoventral and mediolateral vertebral joint flexibility in 20 taxa. We expect dorsoventral and mediolateral vertebral joint stiffness to decrease on the line to birds since greater tail flexibility would help make the tail feathers easier to manipulate. Approximately 3000 vertebral measurements were taken and normalized for body size using femoral length. Each vertebral parameter was plotted against percentage tail length to identify trends in flexibility along the tail, and differences in vertebral joint flexibility in each maniraptoran clade. We also used a principal components analysis (PCA) of four length measures in ten specimens to independently identify differences in vertebral joint flexibility between different clades. In the dorsoventral plane, factors associated with vertebral joint stiffness, particularly neural spine and chevron height, indicate that stiffness decreases along the line of descent between non-avian theropods and avian theropods. *Crocodylus* has stiffer vertebral joints compared to the taxa studied although oviraptors share similarly stiff vertebral joints. The troodontids have the least dorsoventrally stiff vertebral joints. Factors associated with mediolateral vertebral joint stiffness, particularly centrum length, indicate that mediolateral stiffness decreases along the same line of descent. Avian theropods have similar mediolateral stiffnesses to crocodiles, suggesting that dorsoventral vertebral joint stiffness is responsible for their functional tail differences. These changes in tail function should have allowed the tail to become increasingly more dynamic, and better equipped to manipulate the tail feathers. This biomechanical, morphometric and phylogenetic approach would be useful in reconstructing functional change associated with major shifts in locomotory patterns in the vertebral series of other animal groups.

**SKULL ANATOMY OF A NEW BASAL EUSAUROPOD FROM THE CAÑADON ASFALTO FORMATION (MIDDLE JURASSIC) OF CENTRAL PATAGONIA**

POL, Diego, Museo Paleontológico Egidio Feruglio-CONICET, Trelew, Argentina; RAUHUT, Oliver, Bayerische Staatssammlung für Paläontologie und Geologie, München, Germany; CARBALLIDO, Jose, Museo Paleontológico Egidio Feruglio-CONICET, Trelew, Argentina

The Cañadon Asfalto Formation has provided a diverse Middle Jurassic vertebrate fauna, including two eusauropod taxa: *Patagosaurus fariasi* and *Volkheimeria chubutensis*. Recent work in this unit led to the discovery of abundant material of a new eusauropod taxon, including one of the most complete skulls and lower jaw from the Middle Jurassic of the Southern Hemisphere. The ascending process of the premaxilla is slender, posterodorsally oriented, and bears a distinct step at its anterior margin. The maxilla is low and elongated, has a rounded subnasal foramen on its lateral surface and ten neurovascular foramina that are not dorsoventrally aligned (the most posterior of which is moderately enlarged). The maxilla lacks an antorbital fossa and bears a lateral plate that partially covers its 13 spatulate teeth that are slightly procumbent and extend up to the posterior margin of the antorbital fossa. The teeth have wrinkled enamel, marginal denticles, buccal and lingual grooves, and many of them show v-shaped wear facets. The frontals are unfused and broader than long and the postorbital has a long and anteriorly curved cylindrical process for the jugal and a reduced squamosal process. The squamosal forms part of the supratemporal fossa and has an anteroposteriorly broad descending process. The quadrate bears a large, deep posterior fossa. The occipital surface is flat and the paroccipital processes project ventrolaterally, and lack a distinct expansion on their lateral ends. The basiptyergoid processes are subtriangular in cross-section, slightly more than twice as long as wide, and directed ventrolaterally. Several features of the skull suggest that this taxon is more advanced than *Shunosaurus* (e.g., unaligned maxillary neurovascular foramina, supratemporal fenestra transversely elongated, elongation of basiptyergoid process, depth of quadrate fossa, tooth count) but the presence of numerous plesiomorphic features indicates that the new taxon is basal to Neosauropoda (e.g., absence of preantorbital fenestra, cylindrical descending process of postorbital, laterally facing subnasal foramen, presence of external mandibular fenestra, teeth with marginal denticles).

**NEW SPECIMENS OF *ANGOLASAUROS BOCAGEI* AND COMMENTS ON THE EARLY RADIATIONS OF PLIOPATECARPINE MOSASAURS**

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New, well preserved material of the Turonian mosasaur *Angolasaurus bocagei* from the Tadi Beds of the Itombe Formation in northern Angola, allows detailed redescription of its morphology and reassessment of its phylogenetic relationships. *Angolasaurus* had been previously referred to the genus *Platecarpus*; however, phylogenetic analysis confirms the valid taxonomic status of *A. bocagei*, and reconstructs that taxon within a clade that also includes the genera *Selmasaurus* and *Ectenosaurus*. These forms are united by an elaborated infrastapedial process of the quadrate and a unique ridge-like descending process of the parietal forming the supraoccipital articulation, but also retain a relatively plesiomorphic configuration of the braincase. That clade is united with all other pliolatecarpines by a number of derived characters including the presence of a novel basicranial circulation pattern. In Africa, North and South America, early pliolatecarpines are known by the Middle Turonian and Angolasaurus and closely related forms appear by the Upper Turonian. *Selmasaurus* and *Ectenosaurus* are a rare faunal component of the Santonian and Campanian of North America. *Platecarpus planifrons* appears in the Coniacian of North America and represents the plesiomorphic condition of the clade containing the remaining species of *Platecarpus* and *Plioplatecarpus*, that appears in the Santonian and persist until the end of the Cretaceous, reaching global distribution. The temporal and geographic distribution of these radiations suggest influence of paleogeography and eustatic sea levels.

**A NEW TREMATOPID AMPHIBIAN FROM THE EARLY PERMIAN OF RICHARDS SPUR, OKLAHOMA**

POLLEY, Brendan, University of Toronto at Mississauga, Mississauga, ON, Canada; REISZ, Robert, University of Toronto at Mississauga, Mississauga, ON, Canada

A new trematopid amphibian from the fissure fill deposits of the Dolese Brothers limestone quarry near Richards Spur, Oklahoma is based on several excellently preserved, articulated cranial materials and scattered postcranial elements. While this prolific locality has yielded the most diverse assemblage of Paleozoic tetrapods, the majority of described taxa have all been of relatively small body size. Recently collected material has revealed the presence of larger forms, the largest represented by the uncrushed, nearly complete adult skull of the new trematopid described here. The skull measures 167 mm along its dorsal midline, with an estimated total length of about 200 mm. It most closely resembles *Acheloma cummingsi*, sharing with it the combination of a slit-like otic notch and internarial fenestra. The new taxon has several autapomorphies, including the presence of distinct lateral exposures of the palatine (L.E.P.) and ectopterygoid (L.E.E) that are completely enclosed within the suborbital elements and do not reach the orbital margin. Although the presence of L.E.P. and L.E.E. is common among dissorhophoids, these structures have always been seen to contribute to the ventral margin of the orbit. This is not an ontogenetically variable feature in this new trematopid because two juvenile partial skulls show the same distinctive pattern as seen in the adult. Both skulls are considerably smaller than the adult, but exhibit clear trematopid features along with the lateral exposures of the palatine and ectopterygoid that do not contribute to the circumorbital rim. Functionally, the L.E.P. and L.E.E. are considered to play a role in dissipating strong compressive forces acting on the skull associated with feeding, indicating that this new trematopid may be one of the top predators of the faunal assemblage.

**PLEISTOCENE MAMMAL ASSOCIATIONS: IMPLICATIONS OF ECOLOGICAL NICHE MODELLING AND A METHOD FOR RECONSTRUCTING PALEOCLIMATE**

POLLY, P. David, Indiana University, Bloomington, IN, USA; ERONEN, Jussi, Helsinki University, Helsinki, Finland

The bioclimatic envelope of a species is a multivariate space whose axes are climatic variables and whose boundaries defined by the range of values on each variable across the species' geographic range. If climate limits geographic range, then the climate envelope can be used to predict which species can be plausibly expected to occur together in paleofaunas and to reconstruct paleoclimate based on its mammalian fauna. We explored these ideas using ten living mammal species found at Quaternary sites in Britain, four cold-weather species (*Alopex lagopus*, *Lemmus lemmus*, *Ovibos moschatus* and *Rangifer tarandus*), three warm-weather ones (*Crocota crocuta*, *Panthera leo*, and *Hippopotamus amphibius*), and three generalist ones (*Arvicola terrestris*, *Cervus elaphus*, and *Sus scrofa*) for analysis. We used the WorldClim dataset of 19 climatic variables to characterize climate envelopes for these species and we used a maximum-likelihood function to estimate the most likely climate for a site given the species found in association there. Twenty-two of the possible 45 pairs of these ten species live allopatrically today and twelve pairs have climate envelopes that do not overlap. All of the species found together in British Pleistocene faunas were climatically compatible given their modern climate envelopes, except for associations between *C. crocuta* and *R. tarandus* and between *C. crocuta* and *L. lemmus*.

Additional associations between *P. leo* and *R. tarandus* were marginally incompatible. Most likely the modern geographic range of *C. crocota* does not accurately reflect the range of climate conditions in which this species flourished in the past. Climates reconstructed from their mammal faunas were mostly plausible. For example, the Joint Mitnor Cave fauna (MIS 2) was estimated to have a mean annual temperature of 2° C, annual precipitation of 633 mm, and a very high seasonality. Examples of gross misestimation appear to be due to the presence of large carnivores that today inhabit comparatively restricted environments compared to where they lived in the past.

Poster Session III, (Friday)

#### A NEW SPECIMEN OF IGUANODONTIAN DINOSAUR FROM THE CEDAR MOUNTAIN FORMATION OF UTAH

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A new iguanodontian specimen from the Yellowcat Member (Barremian) of the Cedar Mountain Formation is described. Elements excavated include an ilium, ischium, femur, astragalus, several caudal vertebrae, four of which are articulated, and two chevrons, though more material remains in the quarry. The ilium is clearly distinguished from that of the previously described iguanodontians of the Cedar Mountain Formation, *Cedrorestes crichtoni*, *Planicoxa venenica*, and *Eolambia caroljonesa*, by its transversely compressed pubic peduncle and lack of a suprailiac crest (=antitrochanter). The ischium shows the typically iguanodontian characters of a proximally placed obturator process and expanded distal boot. The shaft of the ischium is straight, a feature shared only with *Altirhinus kurzanovi*. The femur is straight in cranial view, but in lateral view it bows slightly cranially, particularly in its distal half. It has a long, rectangular fourth trochanter centered near the middle of the shaft, similar to those seen in *Mantellisaurus atherfieldensis* (= *Iguanodon atherfieldensis*) and *Iguanodon bernissartensis*, though somewhat longer and lower than in those species. It is possible this specimen could belong to either *Dakotadon lakotaensis* (= *Iguanodon lakotaensis*) or *Theiophytalia kerri*, as these taxa are known only from cranial material. As more material remains in the quarry, and it is possible that this material could yet be assigned to a known taxon, it is not named at this time.

Poster Session I, (Wednesday)

#### THE DIVERSITY AND NOMENCLATURE REVISION OF THE HOLOCEPHALIAN FISHES (CHIMAERIFORMES) FROM THE KIMMERIDGIAN (LATE JURASSIC) OF WESTERN EUROPE

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Kimmeridgian (= Kim. below) chimaeriform fishes are known only from S England (Dorset), NW France (Normandy) and SW Germany (Württemberg) (Chimaeroidei: 3 genera, 11 species prior revision). A number of museum and private collections were recently studied in the UK, France and Germany. In addition some microvertebrate bulk sampling was undertaken (Weymouth, Dorset) which allowed us to review the Kim. chimaeriform assemblage. The British material (L. Kim., cymodoce zone) consists of callorhynchids (*Brachymylus* sp. [possibly, a new species], "*Brachymylus*" minor [separate genus]), "edaphodontids" (*Ischyodus egertoni*, *Elasmodectes secans*) and rhinochimaeroid (*Harriotta* sp. [a new species]). French material (Up. Kim., mutabilis zone) consists of the same species plus Myriacanthidae indet. (new? genus) and excluded *Brachymylus* sp. German material (Nusplingener plattenkalk: Up. Kim., ulmense zone) is better preserved (associated dentitions and partial skeletons) but more restricted in diversity and number, and include only three chimaeroid taxa: Callorhynchidae indet., *Ischyodus quenstedti* (probably, junior synonym for *I. egertoni*) and *Elasmodectes avitus*. A nomenclature revision of the numerous *Ischyodus* species described from Kim. confirm the validity of one species: *Ischyodus egertoni* [= *I. beaugrandi*; *I. beaumonti*; *I. bouchardi*; *I. dufrenoyi*; *I. sauvaigi*; *I. suprajurensis*; =? *I. schuebleri*; =? *I. suevicus*; =? *I. quenstedti*]. Myriacanthid and rhinochimaerid dental taxa were recorded for the first time from the Kim. and Jurassic respectively. The Kim. chimaeriform diversity in Western Europe consists of two suborders: Myriacanthoidei (1 genus and species) and Chimaeroidei (5 genera and about 7 species). The character of the Kim. chimaeroid assemblage is similar to those from the Cretaceous, with representatives of three families (Callorhynchidae, "Edaphodontidae" and Rhinochimaeridae) but also have a relict Early Jurassic element (Myriacanthidae indet.) and are less diverse in "edaphodontid" genera.

Technical Session XII, Friday 4:30

#### FINITE ELEMENT MODELING OF ALLIGATOR MISSISSIPPIENSIS: MULTIDIMENSIONAL ANALYSIS, VALIDATION, AND IMPLICATIONS FOR FOSSIL TAXA

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The engineering technique of finite element analysis (FEA) is increasingly being used in biomechanical studies to quantitatively predict deformation, strain, and stress in complex

biological structures. Furthermore, FEA is one of the few techniques that can be used to test functional hypotheses in extinct animals. Recent advances in finite element modeling include the ability to rapidly generate models, and techniques (such as multibody dynamics analysis) that provide refined loading data. Additionally, sensitivity analyses permit researchers to quantify how estimated input parameters (e.g., material properties and constraints) affect model results. In order to understand how well FEA reflects reality, however, validation studies of living taxa are needed. Extensive validation work has been carried out on primates; however, validation of taxa that phylogenetically bracket extinct species is necessary. We present results from a high-resolution finite element model of an *Alligator* mandible, and compare these to data obtained from *in vitro* and *in vivo* strain gauge experiments. Our model incorporates soft tissues (such as sutures and periodontal ligament), heterogeneous, anisotropic material properties, and data obtained from electromyography and PCSA estimation. Results are compared to earlier, simpler finite element models of *Alligator*. The validated model will allow us to identify input parameters that significantly impact FEA results and place error bars on measures of cranial and mandibular mechanical behavior in future FE studies of extinct archosaurs. Integrating these FEA results with geometric morphometrics techniques will give us a quantitative platform on which to compare data along an ontogenetic series and between extant and extinct species.

Poster Session II, (Thursday)

#### THE SMITHSONIAN HUMAN ORIGINS INITIATIVE: RESEARCH, EXHIBITION, EDUCATION AND OUTREACH

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Surveys by public media and scientific organizations (e.g., National Academy, NSF, AAAS) alike indicate that just over 50% of the U.S. adult population understands or accepts basic findings regarding human evolution, significantly lower than in similar samples of Europeans (~70%). Data from a Smithsonian Institution study show that adult visitors to the National Museum of Natural History understand and/or accept the basic tenets of evolution (e.g., adaptation, cumulative change through time) at a rate of 85-95%, but with substantial falloff to 60% when those tenets are applied to humans. To complement our ongoing research program in human origins, and in an effort to advance public understanding of human origins, a new, permanent exhibition will open in 2010 at the Smithsonian's National Museum of Natural History. The exhibition's overall message is that the defining qualities of *Homo sapiens* evolved over millions of years as early hominins adapted to diverse and dynamic environments. Displays will present fossils and artifacts (originals, casts, reproductions) from early hominin sites in Africa, Asia, and Europe that explain the major milestones in hominin adaptation in their environmental context. Interactive displays will encourage learning about how paleoanthropological evidence relates to research interpretations and dynamic aspects of evolutionary change. The exhibit will also highlight critical contributions from genetics and primate studies. The Smithsonian will simultaneously launch a human evolution education initiative that will rely on a network of scientists, educators, and organizations. This poster enables the scholarly community to examine our scientific treatments, methods of public outreach, and challenges of presenting human evolution on the U.S. National Mall.

Poster Session III, (Friday)

#### IBERIAN LATEST MIOCENE-PLEISTOCENE FOSSIL RECORD OF CARNIVORAN: DIVERSITY AND HOME-RANGE-SIZE STRUCTURE

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The latest Miocene-Pleistocene Carnivoran fauna of Iberia has been considered in order to analyze ecological and evolutionary responses in relation to climatic events. The Iberian Peninsula (topographically and ecologically very variable) experienced the transition from a relatively warm to a generally cooler climatic condition. Influenced by the Plio-Pleistocene climatic oscillations, new carnivoran migrated into Iberia mainly from Europe across the Pyrenees but some also crossed from Africa over the Gibraltar Strait. Iberia has been attractive to a great variety of animals acting as a refugium for temperate taxa. These dispersal events would be expected to cause changes in the ecology and evolution of carnivoran guilds. We evaluated the variations in diversity and home-range-size structure to predict these changes. Trends in diversity over time were analyzed in successive unequal time intervals. Species were assigned to various ecological categories in accordance with feeding (carnivore and omnivore) and preferred habitat (forest dwellers, ubiquitous and open landscape dwellers). Body size of fossil species was estimated from dental metrics. As a proxy for home-range size of fossil species we used three different estimations based on allometric relationships implemented from data of modern species that were arranged following taxonomic, habitat preference and trophic categories. The diversity patterns show at least two rise and fall pulses (with peaks during the late Pliocene and the last Glacial) that are only roughly correlated with the general global climate signal. The major change in home-range-size structure occurred at the beginning of the Early Pleistocene, coincident with the onset of glacial cycles. Wolves and large hypercarnivorous canids progressively dispersed into Iberia and occupied new niches that became available as a consequence of

this environmental change. By increasing home-range size, they could have expanded their feeding area and eat the same diet or feed for longer periods. After this event, the modern Mediterranean niche partitioning begun to build up, but it was definitively installed during the Glacial Pleistocene.

Technical Session XII, Friday 1:45

**NEW MICROVERTEBRATE ASSEMBLAGE FROM THE CONTINENTAL UPPER TRIASSIC ROCKS OF PENINSULAR INDIA**

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In India, Continental Upper Triassic rocks are represented by the Maleri and Dharmaram formations of Pranhita-Godavari valley and Tiki Formation of South Rewa basin. Limited number of fossils consisting of fragmentary remains of xenacanthid sharks, lung fish, prosauropod dinosaurs, aetosaur and phytosaur are known from the Dharmaram Formation. As compared to this, the Maleri and Tiki formations have been a source of a diversified assemblage of large vertebrates represented by remains of lung fish, xenacanthid sharks, a possible subholostean, rhynchosaurs, phytosaurs, a coelurosaur, a prosauropod, an eosuchian, an aetosaur and traversodont cynodonts. Based on metoposaur amphibians and phytosaurs, the Maleri and Tiki formations were regarded Late Triassic (Caranian to Norian) in age. Extensive search for microvertebrate yielding horizons in the Maleri and Tiki formations employing bulk screen-washing techniques led to the discovery of two and ten fossiliferous sites in the Tiki and Maleri formations, respectively. The microvertebrate fauna recovered from these new sites has substantially improved the Late Triassic vertebrate diversity of India. The newly recovered fauna includes fish: xenacanthid (*Xenacanthus moorei*), hybodont sharks (*Lonchidion estesi*, *L. incumbens*, *Lissodus duffini*, *Parvodus tikiensis*, *Polyacrodus ?contrarius*), Palaeoniscidae (*Gyrolepis* sp.), Semionotidae indet., Dipnoi indet.; reptiles: Sphenodontia indet., Squamata indet., *?Tikisuchus romeri*, phytosaurids, Archosauromorpha indet., Saurischia indet., Ornithischia indet., and dromatheriid cynodonts (*?Tricuspes*, *Pseudotricodon*). In addition to these taxa, mammal-like teeth were also recovered from one of the sites in the Maleri Formation. Though fragmentary in nature, remains of sphenodontids, squamates and archosauromorphs of saurischian and ornithischian affinity are documented for the first time from the Late Triassic of India.

Technical Session I, Wednesday 10:15

**PRE-HUMAN CLIMATIC FORCING FOR LATE PLEISTOCENE MEGAFUNAL EXTINCTION: EVIDENCE FROM THE DARLING DOWNS, EASTERN AUSTRALIA**

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Late Pleistocene vertebrate fossil localities from the Darling Downs, eastern Australia, provide an accurate, dated paleoecological record for the region, which helps constrain anthropogenic versus climate change megafauna extinction hypotheses. Each stratigraphic unit at site QML796, Kings Creek Catchment was shown to have similar sampling potential, and the basal units contain both small-sized taxa (e.g., land snails, frogs, bandicoots, rodents) and megafauna. Ecological preferences of the vertebrate taxa strongly implies a mosaic of habitats including open and closed woodlands, vine thickets, open grasslands and riparian vegetation. However, up-section, the ecological signature of the taxa changed markedly, such that by deposition of the youngest unit, the fauna was dominated by open-adapted taxa (e.g., grazing kangaroos) and those with non-obligate habitat requirements (e.g., long-nosed bandicoots). Most browsing megafauna and smaller-sized woodland or vine thicket-adapted taxa (e.g., montane frogs) were not sampled in the youngest units. Importantly, sequential faunal horizons show stepwise decrease in taxonomic diversity with the loss of some, but not all, megafauna. Sedimentologic and taphonomic data suggest a seasonally arid paleoclimate (abundant calcrete, flashy discharge in an ephemeral fluvial setting, and drought-like kangaroo mortality patterns). There is no paleontological or archaeological evidence of megafauna-human overlap in the region. Chronologies of deposition were established using accelerator mass spectrometry (AMS) 14C, U/Th, and optical stimulation luminescence (OSL) dating methods (n ~40 dates). OSL and U/Th dating demonstrate that the faunal sequences span ~120-55 ka, thus occurring beyond the AMS 14C dating window. Most importantly, the dates suggest that local habitat change and loss of biological diversity was initiated ~75,000 years before the colonization of humans on the continent. Collectively, the data are most parsimoniously consistent with a pre-human climate change model for local habitat change and megafauna extinction, but not with a nearly simultaneous extinction of megafauna as required by the human-induced blitzkrieg extinction hypothesis.

Technical Session XIII, Friday 3:00

**A NEW CLADE OF EURASIAN LAMBEOSAURINAE (DINOSAURIA, ORNITHOPODA), WITH A NEW RECONSTRUCTION OF THE CREST OF *TSINTAOSAURUS***

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The Late Cretaceous Lambeosaurinae are characterized by posterodorsally displaced nasal passages enshrouded by hollow supraccranial nasopremaxillary crests. An exception lies in *Tsintaosaurus spinorhinus*, from the Wangshi Group of Shandong, China, which has been reconstructed with a long, narrow, hollow nasal tube projecting from the supraorbital region of the skull. Although this has been attributed to *post-mortem* deformation of the nasals, re-examination of the material supports other authors in that the nasals are correctly restored. Close examination of a partial crest from the type locality, originally attributed to an indeterminate lambeosaurine, reveals the outline of the distal end of the nasals of *T. spinorhinus* separated by arcuate, conjoined posterodorsal processes of the premaxilla. The crest is referable to *T. spinorhinus*, and demonstrates that the species possessed a more conventional lambeosaurine nasopremaxillary crest surrounding the nasal passage, rather than the blind, spike-like structure depicted in the literature. Maximum parsimony and Bayesian phylogenetic analyses of Hadrosauria incorporating this and other new anatomical data both recover a well-supported clade consisting of *Tsintaosaurus spinorhinus* and *Pararhabdodon isonensis* (Maastrichtian of northern Spain) within Lambeosaurinae. The latter species has been variously regarded as a lambeosaurine or a non-hadrosaurid. Its placement in our tree is a result of reinterpretation of key characters, and the fact that it shares an elevated maxillary jugal joint continuous with the ectopterygoid shelf and extreme medial projection of the symphyseal region of the dentary with lambeosaurine *T. spinorhinus*. The trophic synapomorphies of this clade constitute a novel source of variation within Lambeosaurinae, which were previously known to vary significantly only in crest size and shape and robustness of the postcranium. Biogeographic analysis supports an Asian origin for lambeosaurines, and attributes the European occurrence of *P. isonensis* to a single dispersal event from Asia no later than the middle-late Campanian.

Technical Session I, Wednesday 9:45

**STASIS IN LATE PLEISTOCENE BIRDS AND MAMMALS FROM LA BREA TAR PITS OVER THE LAST GLACIAL-INTERGLACIAL CYCLE**

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One of the great puzzles of evolutionary biology is how organisms remain static in the face of dramatic climatic changes, contradicting the "Galapagos finch" model of organisms that are constantly changing in response to their environment. Such stasis was documented in Pleistocene mammoths by Darwin's friend, Hugh Falconer, and is widely recognized among most Pleistocene large mammals. We examined all the common birds and mammals from the Rancho La Brea tar pits in the Page Museum in Los Angeles. The studied taxa included the extinct horse *Equus occidentalis*, *Bison antiquus*, *Camelops hesternus*, the large ground sloth *Paramylodon harlani*, the sabertooth *Smilodon fatalis*, and the Ice Age lion, *Panthera atrox*, as well as the extant golden eagle *Aquila crysaetos* and the ancestral California condor, *Gymnogyps amplus*. We measured large samples (more than 100 of each element) of several dimensions of the most common bones (typically leg or foot bones) from all the pits with good radiocarbon dates. Even though pollen, plants, snails, and isotopic studies provide evidence of dramatic climatic and vegetational change from the previous interglacial (40 ka-20 ka) to the peak glacial (20 ka-15 ka) to the glacial-interglacial transition (15 ka-10 ka) to the Holocene, none of these taxa show any statistically significant differences in size or shape of their bones from one level to the next. Such stasis among all the common mammals and birds over the late Pleistocene-Holocene, despite significant climatic changes, casts doubt on the responsiveness of birds and mammals to environmental variables, and suggests that intrinsic rather than extrinsic factors are more important in evolution.

Technical Session V, Wednesday 3:00

**GUIYU ONEIROS AND THE CHARACTERS OF BASAL SARCOPTERYGIANS**

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As the oldest articulated osteichthyan, *Guiyu oneiros* from the Ludlow (Silurian) of Yunnan, China, provides not only the near-complete restoration of a primitive fish with mosaic gnathostome characters, but also a new minimum date for the sarcopterygian – actinopterygian split (about 419 million years ago). *Guiyu* forms the sister taxon to the clade comprising *Psarolepis* and *Achoania*, and substantiates the unexpected mix of postcranial features in basal sarcopterygians, previously restored from the disarticulated remains of *Psarolepis*. The discovery of *Guiyu*, with a combination of primitive gnathostome, primitive

osteichthyan, and primitive sarcopterygian features, offers new insights into the incremental acquisition of sarcopterygian apomorphies. The median fin spine and spine-bearing pectoral girdle as in *Psarolepis*, early chondrichthyan *Doliodus*, placoderms and acanthodians denote primitive gnathostome features in basal sarcopterygians, and might provoke a novel look at the disarticulated fin spines, which were assigned to the Acanthodii or the Chondrichthyes. The absence of the first dorsal fin in the *Guiyu* clade corresponds to the development of large median dorsal plates behind the median extrascapular, and suggests a parallelism between osteichthyans and placoderms. The resemblance of the cheek and operculo-gular bone pattern between actinopterygians and stem-group sarcopterygians reveals a primitive condition for osteichthyans. The *Guiyu* clade retains its primitiveness in the sarcopterygian lineage with its polybasal pectoral fin articulation. However it is more derived than another stem sarcopterygian *Meemannia* regarding its dermal and endoskeletal intracranial joints. The striking resemblances between the *Guiyu* clade and onychodonts, especially in the neurocranial features, bridge the morphological gaps between stem-group and crown-group sarcopterygians.

Poster Session I, (Wednesday)

#### **SIMOSAURUS (NOTHOSAURIA) FOSSIL SITE: A NEW SPANISH WINDOW TO THE UPPER TRIASSIC**

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Tethys coast were extensive composed by evaporitic plains, in which were generated the Keuper facies, during the Upper Triassic. Sauropterygians, mainly represented by fragmentary remains attributed to Nothosaurinae, are relatively frequent in these facies in the Western Iberian Range record. In this context was recently discovered the singular fossil site of "El Atance" (Sigüenza, Guadalajara, Spain). The "El Atance" quarry is composed by a succession of marly, sandy-marly and sandy beds, with centimetric and decimetric thickness, deposited in a shallow marine environment. The marly beds have yielded two different eosauroptrygians Nothosauria. In both cases, centra of dorsal vertebrae exhibit the characteristic cruciform sutural facet. Some of them are platycoelous to weakly amphicoelous, not strongly compressed laterally, with less than 10 mm in diameter, and with dorsal facets exceeding the width of the centra along its entire length. These centra are attributed to members of Nothosauridae. However, the site has yielded a second type of Nothosauria represented by several nearly complete and articulated skeletons, over two meters long. These skeletons exhibit a suite of character exclusive of *Simosaurus*: slightly amphicoelous or platycoelous dorsal vertebrae with pre- and postzygapophyses, infrazygapophyses and zygosphenes and zygantrum, high neural spines with strong lateral striation, high neural canal with a rectangular contour forming a deep and wide longitudinal groove on the centrum and with dorsal articular facets that only exceed the width of the centrum in the middle region, where centra are constricted. Besides, the available cranial character combination, such as the upper temporal fossae larger than orbits, the pineal foramen displaced posteriorly or the mandibular articulation displaced to a level well behind the occipital condyle, is also shared by *Simosaurus*. The presence of these partial skeletons of *Simosaurus* in the Iberian Peninsula extends to the Southwest the geographic distribution of the genus, and extraordinarily increases its known record.

Poster Session II, (Thursday)

#### **AN UPDATE OF THE LATE CRETACEOUS CHELONIAN AND CROCODYLIAN FAUNA OF CENTRAL EUROPE**

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The study of Late Cretaceous chelonians and crocodylians in the area goes back to the second half of the 19th century and since then the research went with variable intensity. Thanks to recent fieldworks several new discoveries have been made and a summary of these including a revision of different collections is provided here. New pleurodiran turtle remains have been discovered in the continental Santonian Csehbánya Formation of Hungary. An unnamed bothremiid is known on the basis of several skulls and jaws and partial shells. It is considered to be a new species of *Foxemys* belonging to a monophyletic European group formerly only recorded from Western Europe. The other pleurodire from the same formation is only represented by isolated shell fragments and shows affinities with the Dortokidae, an ancient endemic lineage of the Mediterranean area, previously documented in Spain, France and Romania only. *Senonemys* from the marine Campanian Ugod Limestone Formation of Hungary and *Emys neumayri* from the continental Campanian Gosau Formation of Austria are considered as invalid taxa with uncertain relationships because of the undiagnostic nature of their material. New isolated cranial and mandibular remains of the ziphodont crocodile, *Doratodon*, come from the Csehbánya Formation, including a fragment of a maxilla, a partial dentary, a pterygoid and a quadrate. The preliminary study of these remains coupled with the revision of the type collection suggest the close relationships of *Doratodon* with Gondwanan sebecosuchians, exhibiting more derived characters than *Peluenchesuchus* but more primitive than *Sebecus*. Cranial and dentary remains were recently discovered in the Maastrichtian Hateg-basin of Romania which belong to an undescribed mesoeucrocodylian closely related to the Gondwanan *Araripesuchus*. An undescribed derived eusuchian from the Csehbánya Formation is represented by isolated mandibular elements and it is probably

related to primitive globodontan alligatoroids (exhibiting laterally shifted articular foramen aereum). Although fragmentary, it provides one of the earliest record of the Alligatoroidea. A very similar form can be identified from the Austrian Gosau Formation too.

Technical Session XIX, Saturday 3:45

#### **INNER EAR MORPHOLOGY OF BALAENOPTEROID MYSTICETES (CETACEA: MYSTICETI)**

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Cetacean inner ear morphology is an important source for functional and phylogenetic information. Features of the cochlea that correlate with hearing capability include the basilar membrane length and the number of turns of the cochlear spiral. High-resolution X-ray CT scans of the tympanoperiotics of fossil and extant representatives of balaenopteroid mysticetes allowed digital isolation of the inner ear labyrinths and subsequent visualization and measurement of these structures. Measurements from these data, including basilar membrane length, were used to infer frequencies potentially heard by fossil and modern mysticetes. Adult and neonate *Eschrichtius robustus* cochleae are nearly identical in shape and dimensions. The arc heights of the semicircular canals of the neonate and adult *E. robustus* are not significantly different (3-4mm), while canals of an undescribed fossil eschrichtiid have the most variable arc heights (2.6-5mm) of the three. This variability could indicate phylogenetic or locomotor differences in the species. Among odontocetes, the beluga has the largest semicircular canal arcs, similar to the balaenopteroids, and both groups possess unfused neck vertebrae and increased neck motility. Odontocetes have smaller semicircular canal arcs than mysticetes, presumably resulting from a more acrobatic lifestyle. Previously unobservable neural canals (0.5-0.7mm diameter) which converge with the vestibulocochlear nerve are present ventral to the ampullae on the vestibules of all species studied. The cochlea of the fossil eschrichtiid differs from the extant species in having a less pronounced scala vestibule at the base, and 2.25 cochlear turns, but its laminar gap measurements align closely with the other balaenopteroids implying that it heard at similar frequencies to extant species. *Balaenoptera acutorostrata* has the shortest laminar gap width measurements of the species measured, indicating that it has higher frequency hearing than eschrichtiids and a new fossil balaenopterid. Divergences in inner ear morphology signify changes in mysticete hearing through time, with conservation implications for extant species as anthropogenic noise has changed the ocean soundscape.

Poster Session IV, (Saturday)

#### **AN EVALUATION OF METHODS FOR ESTIMATING THE BODY MASS OF LARGE ANIMALS WITH REFERENCE TO APATOSAURUS EXCELSUS**

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Mechanical and physiological aspects of organisms often behave as functions of body mass. Therefore, it is necessary to derive and employ accurate mass estimates in the study of these aspects in extinct fauna. Sauropod dinosaurs present a unique challenge due to their immense size, complex body forms and the lack of adequate modern analogues. Physical models have been employed for this purpose, and a variety of mathematical and digital methods have been proposed. The accuracy of these methods appears to be dependent upon the complexity of the body being modeled, the ability of the model to faithfully reproduce these shapes, and is subject to variation in individual measurement style. This study employed three techniques to estimate the *en-vivo* mass of *Apatosaurus excelsus*, based upon the University of Wyoming specimen (UW 15556). A physical model produced an estimate of ~13,500 kg, while two mathematical models generated estimates of ~16,900 kg. Resolving this observed discrepancy is vital to future studies requiring valid mass estimates as well as other work based upon them. This can be accomplished by estimating the mass of individual large extant animals, and comparing the estimates to known mass values. Zoo-housed individuals from two extant taxa, *Loxodonta africana* (African elephant) and *Giraffa camelopardalis* (reticulated giraffe), provided the basis for such a comparison. Two individuals of *Loxodonta* and seven individuals of *Giraffa* were photographed in side profile as well as front and rear views to allow for accurate three-dimensional reconstruction, and alongside objects of known size to facilitate scaling. Lens distortion, focal length, depth of field and other factors were considered when scaling the images prior to modeling. Each animal was modeled, and its mass was estimated using a physical model and immersion into a viscous medium, as well as by two mathematical methods. This rigorous evaluation of three commonly employed mass-estimating methods provides insight into the complexity of estimating mass in large or extinct animals, and may improve the probability of producing accurate results in future studies.

#### PALEOECOLOGY OF SOUTH ASIAN PRIMATES: PALEOENVIRONMENTAL IMPLICATIONS

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With up to nine species comprising Adapiformes (Sivaladapidae) and Anthropoidea (Amphipithecidae and Eosimiidae), the late middle Eocene primate community of the Pondaung Formation is among the most diverse in the Paleogene of South Asia. To better understand how resources were shared in this community, the diet for each Pondaung species was assessed by analyzing dental microwear patterns and by measuring molar shearing crests. Our results show that most Pondaung primates were primarily frugivorous. Medium to large bodied amphipithecids (*Pondaungia*, *Myanmarpithecus*) probably ate fruit and hard objects, and as such occupied a distinct ecomorphospace from most other primates of the community [i.e., eosimids (*Bahinia*), and small sivaladapids (*Paukkaungia*, *Kyitchaungia*)]. The latter were fruit and insect eaters, thus limiting competition between families, although a large bodied sivaladapid possibly occupied a similar niche to *Pondaungia*. However, the Pondaung Formation documents only one primate community among several others during the Paleogene in South Asia. Sites from India, China, Thailand, Myanmar and Pakistan range from the early Eocene to early Oligocene. Most present similar dietary distributions (derived from shearing quotient analysis) with a prevalence of frugivores over folivores within each community, particularly small bodied frugivore-insectivores, which are numerous in early to middle Eocene localities from India (Vastan) and China. In fact, leaves seem to be reduced to a secondary role in the diet of these primates, much like some South American tropical rainforest communities today. Common characteristics between these past and modern communities suggest similar ecological conditions between the Eocene of South Asia and equatorial-tropical South America today. Similarities between cenograms (based on body mass distributions of each mammal community) indicate relatively similar paleoecological conditions – i.e., closed tropical rainforest environments – even though the studied fossiliferous localities belong to different geographic areas in South Asia suggesting the existence of a vast biogeographic province throughout most of the Paleogene.

Poster Session I, (Wednesday)

#### A SPOTTED HYENA DEN FROM THE MIDDLE PLEISTOCENE OF TERUEL (NE SPAIN)

RAMON-DEL-RIO, Diana, University of Zaragoza, Zaragoza, Spain; CUENCA-BESCÓS, Gloria, University of Zaragoza, Zaragoza, Spain; CANUDO, José Ignacio, University of Zaragoza, Zaragoza, Spain

An important bone bed was discovered at the end of the 90' in a cave thus named after these bones as *Cueva de los Huesos* by local amateurs and speleologists. It is carved in the massive Jurassic limestones of the *Macizo de las Muelas* in Obón (Teruel, Spain). The cave is shaped in three small chambers connected by passages aligned in north-south direction for nearly 100 meters. The bone bed is located in the last chamber, though during the Middle Pleistocene it was probably the main entrance of the cave. The bone-bed area consists of exokarstic deposits of 130 cm in thickness divided into seven lithostratigraphic layers. The fossils remains have been recovered from Level 2, which consists mainly of highly cemented clays. The faunal assemblage consists mainly of large mammals, though insectivores (*Erinaceus europaeus*), bats (*Rhinolophus* sp.), and rodents (*Apodemus* sp. and *Allocreictus bursae corzezensis*) are also present. We have identified five carnivores, *Crocuta crocuta*, *Canis lupus*, *Vulpes* cf. *vulpes*, *Felis silvestris*, and *Meles meles*; five herbivores, the perissodactyls *Stephanorhinus hemitoechus* and *Equus* cf. *mosbachensis*, and the artiodactyls *Bison* cf. *schoetensacki*, *Capra* sp. and *Cervus elaphus* ssp. This fossil assemblage suggests that the *Cueva de los Huesos* may be Middle Pleistocene in age. Because of the absence of stone tools and bones with cut marks, we reject that the bone accumulation was produced by hominids. By contrast, there is an important percentage of bones that exhibit puncture marks and signals produced by carnivore gnawing-pits, punctures and crenulated edges. Also abundant coprolites can be attributed to hyenas: they present an external round morphology, a pale brown to yellowish color, and some contain small fragments of partially digested prey bones. On the basis of the presence of coprolites, gnawing marks produced by carnivores together with the remains of *Crocuta crocuta* in the site, we suggest that the cave could be used as a hyena den some time during the Middle Pleistocene.

Preparators' Session, Thursday, 8:30

#### FUENTESALVO SITE (VILLAR DEL RIO, SORIA), THE FIRST ACCESSIBLE DINOSAUR TRACKSITE TO THE HANDICAPPED IN SPAIN

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The dinosaur tracksite of Fuentesalvo, which lies in the locality of Villar del Río in Soria (Spain), has a remarkable scientific record comprising more than 70 theropod ichnites grouped in 12 parallel trackways, making it possible for the first time to identify the presence of a structured pack of theropods. The record is exceptionally well-preserved, which makes it easy for the general public to appreciate, and the site, located just a few meters

from the road, is very accessible. All these factors – together with its status as part of the Ichnite Route of Soria, an open-air museographical area with 15 sites that can be visited and a visitors' centre – underlay the interest of the local authorities in converting it into a point of tourist and cultural interest that is also accessible to the physically and visually handicapped. After consulting various associations concerned with the integration of people with any sort of handicap, and in accordance with the codes and laws governing construction for handicapped people, a number of infrastructures were installed around the site, allowing it to be visited by the physically handicapped: a spacious area for parking vehicles, from which there is a wooden platform and a ramp rising at an inclination of less than 6% and more than 2 meters wide, designed to allow the passage of two wheelchairs. The site has also been adapted so it can be visited by the blind, for whom there are signs in relief with Braille inscriptions, and by the visually handicapped, for whom there is an information board with large-sized letters and illustrations. The protective handrails running around the site, which are made of wood so as not to clash with the surroundings, have been planed and polished to allow them also to be used as orientation and support for the blind, but without the inconvenience of splinters typical of rural installations. These measures have permitted the important record provided by the dinosaur ichnite site of Fuentesalvo to be accessible to all, thus making it the first paleontological site in Spain to be accessible to the handicapped.

Technical Session III, Wednesday 3:15

#### A NEW TAXON OF SPHENODONTIAN WITH UNUSUAL DENTITION FROM THE LATE JURASSIC OF SOUTHERN GERMANY

RAUHUT, Oliver, Bayerische Staatssammlung fuer Palaeontologie und Geologie, Munich, Germany; HEYNG, Alexander, GeoBioCenter, Ludwig-Maximilians-University, Munich, Germany

Although the only recent representative of the Sphenodontia, the genus *Sphenodon*, is often used as a "classic" example of a living fossil, research in the recent decades has shown that this clade was widespread and both taxonomically and ecologically diverse during the Mesozoic. All sphenodontians but the most basal forms are characterized by a special, acrodont dentition, in which a juvenile dentition is retained throughout the ontogeny, and new teeth are added posteriorly in the jaws. Recently, the partial skull and mandibles of a new taxon of sphenodontian have been discovered in the marine Tithonian Mörnsheim Formation in Bavaria, southern Germany. Although the skull roof and braincase are fragmentary, the palate and lower jaws are excellently preserved. The animal is highly apomorphic, showing, among other characters, a maxilla with a medial process posteriorly, an ectopterygoid with two lateral processes, a closed interpterygoid vacuity, and a pronounced step on the medial side of the coronoid. The most conspicuous character, however, is the very unusual dentition, which consists of large lateral tooth plates in the maxilla and dentaries. This character strongly indicates a durophagous diet in the new taxon. The tooth plates are formed by the fusion of numerous, small, pencil-like teeth, very unlike the typical tooth shape in sphenodontians, and there is no distinction between a juvenile tooth row and additional teeth. Nevertheless, phylogenetic analysis indicates that the new taxon is well nested within sphenodontians that have the typical type of dentition of this clade; thus, its tooth plates should be derived from an acrodont dentition with retention of a juvenile dentition and posterior aggregation of additional teeth. This indicates a surprisingly high evolutionary plasticity in the dentition of derived sphenodontians. A possible evolutionary origin for this dentition might be the heterochronic retention and subsequent modification of small, more conical teeth, as they are found in hatchlings of the recent *Sphenodon*.

Technical Session VIII, Thursday 2:45

#### HOW MUCH CAN WE INFER FROM FINITE ELEMENT MODELS OF EXTINCT TAXA? A VALIDATION STUDY OF STRAIN IN THE OSTRICH MANDIBLE

RAYFIELD, Emily, University of Bristol, Bristol, United Kingdom

Finite element analysis (FEA) is increasingly used to explore the functional morphology and biomechanics of extinct taxa. FE-models have been used to estimate bite forces, comparative feeding behavior, functional ecology, and hypothetical morphologies of extinct organisms. A digital model is created and assigned material properties to represent the elasticity of component members. 'Boundary conditions' are applied to mimic loads experienced during function, and the stress and strain response is then calculated. FEA is widely used in engineering, but modeling the musculoskeletal behavior of extinct animals poses particular challenges, such as determining appropriate elastic properties, reasonable loading conditions, and dealing with deformed or fragmentary fossil specimens. In order to assess how accurately FEA can represent actual bone strain, a study was conducted to compare experimentally derived strain to FE-derived strain in the mandible of extant ostriches. A peak pecking force of 42 Newtons (N) was recorded in live ostriches. Dissected ostrich mandibles were clamped at the condyles and loaded at the beak tip with 50 N force in a hydraulic testing machine. Strains were recorded using gauges at four locations: lateral surangular, medial angular, dorsal and ventral dentary. Strains were consistently highest in the ventral dentary, and lowest in the lateral surangular. Specimen-specific FE-models were created from CT data, and loaded identically. Models were isotropic and homogenous, as are most FE-models of extinct taxa. Despite this inaccuracy, similarity was achieved between experimental and FE-derived strain. FE-models were always stiffer than actual mandibles, but polarity, orientation and peak strains were consistent with experimental data. This implies that FE-models of extinct archosaurs, even with simple material properties, may

have the potential to reproduce reliable patterns of strain. These models may be informative in comparative and hypothetical studies, but with the caveat that to comment on absolute strains in extinct taxa, one must be sure of the loads experienced during function, in order that the correct strain patterns are generated.

Technical Session XIII, Friday 2:15

#### THE HERITAGE OF NOPCSA: DWARF STATUS OF HATEG ORNITHOPODS SUPPORTED BY THE HISTOLOGY OF LONG BONES

REDELSTORFF, Ragna, School of Geological Sciences, University College Dublin, Dublin, Ireland; CSIKI, Zoltan, University of Bucharest, Bucharest, Romania; GRIGORESCU, Dan, University of Bucharest, Bucharest, Romania

The Late Cretaceous dinosaurs of Hateg Basin, Romania, were frequently discussed as being dwarfed, mainly based on their small size compared to their relatives from other landmasses. However, their dwarf status has yet to be supported by independent evidence. The study of bone histology is a method proven for determining ontogenetic stage and growth strategies of fossil vertebrates. We sampled a series of long bones of the Hateg ornithopods *Zalmoxes* and *Telmatosaurus* in order to reveal whether these represent true small-sized adults (i.e. dwarfed taxa) or juveniles of normal-sized taxa. A complete ontogenetic series was available for the basal-most hadrosaurid *Telmatosaurus*, from hatchlings (femur length 38 mm) to large-sized specimens (femur length 464 mm); juvenile to adult ontogenetic stages were available for sampling of the rhabdodontid *Zalmoxes* (femur lengths 164 - 355 mm). The long bone histology of the Hateg ornithopods reveals a slow growth rate in *Zalmoxes*, and a moderate rate in *Telmatosaurus*. According to the high number of lines of arrested growth (LAGs - up to eight), an external fundamental system is present in the largest specimens of *Telmatosaurus*, indicating cessation of growth. A slow growth rate in *Zalmoxes* is supported by the narrow-spaced LAGs, which occur in an extremely high number (up to 15) indicating an adult stage for most sampled specimens. In contrast to the high number of LAGs, bone histology of *Zalmoxes* shows vascular canals open to the bone surface indicating active growth at time of death. Thus, its dwarfed status is less well supported. Femur lengths of *Zalmoxes* were compared to other rhabdodontids and basal iguanodontians, and those of *Telmatosaurus* to basal hadrosaurids and derived hadrosaurids. These comparisons suggest reduced body size in both taxa, presumably caused by a slowdown of growth rate, which was taken to the extreme in *Zalmoxes*. The combination of extremely reduced growth rate and extended growth period, observed in *Zalmoxes*, contrasts with the only other study on rhabdodontid bone histology available. These features are also unknown in any other ornithopod, and suggest a unique growth strategy in this taxon.

Edwin H. and Margaret M. Colbert Poster Competition (Thursday)

#### THE HETERODONTY OF TYRANNOSAURIDS: BIOMECHANICAL IMPLICATIONS INFERRED THROUGH 3D MODELS

REICHEL, Miriam, University of Alberta, Edmonton, AB, Canada

Most *Albertosaurus sarcophagus* teeth collected from the *Albertosaurus* bonebed in Dry Island Park (southern Alberta) are well-preserved. Seventy teeth were studied to determine how jaw position and biomechanical differences influence heterodonty in *Albertosaurus*. *Tyrannosaurus rex* teeth were included in the analyses as a control. The objective of this study was to compare how different tooth morphologies respond to the stresses generated by the bite forces of *A. sarcophagus*, and *T. rex*. The 3D models were obtained by micro CT Scans, or were sculpted through the 3D modeling software ZBrush®. Those 3D models were edited using Rhinoceros®, and Finite Element (FE) analyses were done with Strand7®. The results show significant differences between the models constructed with or without carinae. In *A. sarcophagus*, the premaxillary teeth show lower levels of tension on the model with carinae, whereas the posterior maxillary teeth have increased levels of tension when carinae are added. For *T. rex*, both premaxillary and posterior maxillary teeth have significantly lower tension levels in the models with carinae. *T. rex* dentary teeth, on the other hand, show higher tension levels when provided with carinae. The contrast between carinate and non-carinate models is more pronounced in *T. rex* than in *A. sarcophagus*. The results reflect the higher level of heterodonty observed in *T. rex*, because there are more significant differences between the stress responses of teeth in different positions in the jaws of this taxon. The more homogenous response of *A. sarcophagus* teeth is expected for jaws with simplified mechanics, in which most teeth respond similarly to stresses. Additionally, some of the *A. sarcophagus* teeth show evidence of intense *in vivo* wear with spalled-off flakes of enamel and dentine. This pattern is not commonly observed in other theropod teeth and suggests a unique behavior that will be studied by adding this information to models and applying forces in the direction of wear patterns. This study demonstrates how techniques previously applied in medicine and engineering can also help understanding the functional significance of morphological variation.

Poster Session I, (Wednesday)

#### INTRASPECIFIC VARIATION IN THE ROSY BOA (*LICHANURA TRIVIRGATA*)

REINKE, Beth, Indiana University, Bloomington, IN, USA; CASSERLY, Anna-Marie, Indiana University, Bloomington, IN, USA; ROWE, Matthew, Indiana University, Bloomington, IN, USA; LAWING, A. Michelle, Indiana University, Bloomington, IN, USA

Species are distinguished from other species based on the presence of intraspecifically fixed diagnostic morphological characters. The morphological characters used in species identification differ between extant and fossil taxa. Squamate taxonomists use scale counts and body measurements to identify species, while paleontological taxonomists use osteologic characters as species delimiters. By measuring and studying the intraspecific variation in extant taxa, we aim to identify relationships between "outer" morphology and skeletal morphology. In turn, these relationships will serve to identify variation within species, simplify species delimitation in fossil taxa, as well as contribute to paleoenvironmental reconstructions. Our research explores the relationship between "outer" morphology (e.g., scalation patterns, organ position, body metrics, and masses), functional morphology (e.g. vertebral torsion) and skeletal morphology (size and shape of vertebrae). In a preliminary analysis, we examined intraspecific variation in eleven Rosy Boas (*Lichanura trivirgata*) donated to the William R. Adams Zooarchaeology Laboratory at Indiana University. We found strong correlations between head scale patterns and structural bone measurements (supralabial scales and head volume,  $R=0.6357$ ; temporal scales and head length,  $R=0.7042$ ; intersupraocular scales and head volume,  $R=0.6789$ ) and within structural bone measurements (head width and head height,  $R=0.8114$ ). We also found strong correlations between body scale patterns and body measurements (subcaudal scales and tail length,  $R=0.6240$ ), within body measurements (total length and girth,  $R=0.8511$ ; heart position and body length,  $R=0.6195$ ), and mass and body measurements (mass and body length,  $R=0.9132$ ). Future research will include vertebrae shape and their relationship with functional morphology, skeletal morphology, and "outer" morphology. This research will allow for more predictions about scalation, body size and environmental context from individual vertebra typically found at fossil localities and will help taxonomists delimit fossil species by providing the amount of expected intraspecific variation within a species.

New Perspectives on the Early Evolutionary History of the Synapsida, Saturday 8:00

#### PHYLOGENETIC RELATIONSHIPS AND PATTERNS OF DIVERSIFICATION OF NON-THERAPSID SYNAPSID

REISZ, Robert, University of Toronto at Mississauga, Mississauga, ON, Canada

Recent studies of Late Pennsylvanian and Early and Mid-Permian synapsids have permitted a thorough revision of their phylogeny and patterns of diversification. The available evidence supports a basal split of synapsids into Caseasauria and Eupelycosauria, the former composed of two clades, Eothyrididae and Caseidae, the latter comprised of all other synapsids, including Varanopidae, Ophiacodontidae, Edaphosauridae, and Sphenacodontia. Despite its basal position, the fossil record of Caseasauria is restricted to the Early and Middle Permian of Laurasia, with caseids being present in Middle Permian sediments of Northern Russia. Since Eupelycosauria includes mammals, the fossil record of this clade extends to the present. However, the early history of this clade is characterized by an interesting pattern of diversification and dispersal before the end of the Permian. Like the herbivorous caseids, the fossil record of the faunivorous varanopids extends into the Middle Permian Northern Russia, but remains of small varanopids are also preserved in Gondwana. Ophiacodontids and edaphosaurids are restricted to the Late Pennsylvanian and the early part of the Early Permian of Laurasia. In contrast, the Sphenacodontia is a very successful clade of predators that includes not only small to medium sized hapodontines and sphenacodontids from the Late Pennsylvanian and Early Permian of Laurasia, but also includes therapsids. The latter is a very large clade that first appears in Middle Permian sediments of Laurasia and Gondwana, quickly gain a global distribution, and eventually give rise to mammals. The taxonomic position of the Early Permian synapsid *Tetraceratops*, considered to be a stem therapsid, is discussed in the context of sphenacodontian diversification.

Technical Session XVIII, Saturday 2:15

#### A NEW BASAL SAUROPOD WITH A SPIKE-BEARING TAIL FROM THE MIDDLE JURASSIC OF NIGER AND THE ORIGIN OF EUSAUROPODA

REMES, Kristian, Steinmann Institute, University of Bonn, Bonn, Germany; ORTEGA, Francisco, Departamento de Física Matemática y de Fluidos, Facultad de Ciencias, UNED, Madrid, Spain; FIERRO, Ignacio, Museo Paleontológico de Elche (MUPE), Elche, Spain; KOSMA, Ralf, Staatliches Naturhistorisches Museum, Braunschweig, Germany; JOGER, Ulrich, Staatliches Naturhistorisches Museum, Braunschweig, Germany

Mesozoic sediments of the Republic of Niger have produced two famous dinosaur faunas: that of the Early Cretaceous Elrhaz Formation containing spinosaurids, carcharodontosaurids, rebbachisaurids, and iguanodontians; and that of the upper Middle Jurassic Tiourarén Formation containing basal tetanurans and basal macronarian sauropods. Field work in the region of Agadez during the years 2006-2008 led to the discovery of two sauropod skeletons, for the first time in strata underlying the Tiourarén Formation (lithostratigraphically dated as lower to middle Middle Jurassic). Both skeletons belong to the same new species, and in combination preserve all body regions except some parts of the skull, the distal forelimb, and the feet. In phylogenetic analyses the new taxon consistently

forms the sister group to Eusauropoda (*Shunosaurus* and more derived sauropods), and is therefore the most complete basal sauropod currently known. The new taxon exhibits a mixture of plesiomorphic and derived characters, and more closely resembles contemporary East Asian sauropods than Lower and Middle Jurassic forms from other parts of Gondwana. Autapomorphic characters include laterally directed basal tubera; teeth with large, spaced denticles; and rod-like, overlapping distal chevron bones that form a ventral bracing of the tail. A peculiar feature is the presence of paired, spike-bearing osteoderms that probably were positioned distally on the tail. Given its phylogenetic position and anatomical characters, the new taxon hints to an origin of Eusauropoda in North Africa. The similarity to East Asian forms indicates that Laurasian/North African and South Gondwanan sauropod faunas were separated early in sauropod evolution, possibly due to Lower Jurassic paleoclimate and phytogeography.

Poster Session III (Friday)

#### THE PSEUDOTRIBOSPHENIC CONCEPT, A HISTORY

RICH, Thomas, Museum Victoria, Melbourne, NA, Australia; VICKERS-RICH, Patricia, Monash University, NA, Australia

The term pseudotribosphenic was invented to describe a condition in the lower molars of the Late Jurassic mammal *Shuotherium dongi* from Szechuan, China. Each of the three most posterior lower molars bears a basin anterior to the trigonid (named the pseudotalonid) that was interpreted as having occluded with a protocone-like cusp on the upper molars, at that time unknown. As this hypothetical arrangement of a pestle-like upper cusp occluding with a mortar-like lower basin was functionally analogous to the tribosphenic condition of therian mammals, in which the talonid basin lies behind the trigonid, the term pseudotribosphenic suggested itself to describe it. Corroboration of this concept occurred when an upper molar bearing a pseudoprotocone was described from the holotype locality of *S. dongi*. Similar molars were reported the same year in Europe. Dramatic confirmation of the reality of pseudotribospheny came with the description of the skull and skeleton of a second shuotheriid, *Pseudotribos robustus* from the Inner Mongolian mid-Jurassic. *P. robustus* demonstrated that the pseudoprotocone snugly fitted into the pseudotalonid. This unique pattern of occlusion provides a persuasive example of convergence on the tribosphenic dentition, a key adaptation of therian mammals. That such a complex, yet different occlusal pattern did evolve gives credence to the idea that, despite its structural complexity, the tribosphenic condition most certainly could have arisen more than once in therians. Shuotheriids have been regarded as close to the Australosphenida, a group of otherwise Gondwanan taxa that mostly possess tribosphenic molars and often retain the primitive Morganuocodon-like trough for postdentary bones. The difference in molar pattern and tooth number (*Shuotherium* has four molars, not three as commonly cited, whereas australosphenidians have three), casts doubt on the inclusion of shuotheriids with this purported clade of early tribosphenic mammals. Some docodonts are described as having a pseudotalonid, but because an occlusal arrangement with a pseudoprotocone cusp is lacking, this term incorrectly implies a pseudotribosphenic condition.

Poster Session III, (Friday)

#### “CHICKEN RUN”: A NEW UNUSUAL, HEAVILY DINOTURBATED TRACKSITE FROM THE LOWER CRETACEOUS SANDSTONES OF OBERNKIRCHEN, NORTHERN GERMANY

RICHTER, Annette, Niedersächsisches Landesmuseum Hannover, Hannover, Germany; BÖHME, Annina, Niedersächsisches Landesmuseum Hannover, Hannover, Germany; VAN DER LUBBE, Torsten, Niedersächsisches Landesmuseum Hannover, Hannover, Germany

We report a spectacular new track-bearing surface from the Obernkirchen Sandstone Quarries (Obernkirchener Sandsteinbrüche), excavated in 2008. It is composed of storm-induced, semi-terrestrial sandstones (Lowermost Cretaceous, Berriasian), showing two phenomena: First, the surface is moderately to heavily dinoturbated, exhibiting hundreds of tridactyl tracks, a condition previously unknown from Germany. Second, approximately 75 % of the tracks derive from theropods, which is very uncommon for tracksites in general and prompted the internal name “chicken yard”. Usually, the majority of tracks from the Berriasian (‘German Wealden’) can be assigned to the most common ichnogenus *Iguanodontipus*. All tracks and trackways of the “chicken yard” show a multi-directional pattern with many of them presenting brilliantly preserved impressions of claws, digital- and metatarsal pads. Preservation altogether ranges from hardly recognizable “true” undertracks through moderately well-preserved tracks to extremely well preserved ones. The largest tracks with a robust appearance can be assigned to theropods with a length of app. 8 m. However, several theropods have been described from the Latest Jurassic to Early Cretaceous of Europe, all showing similar foot-morphology, which must consequently be taken into consideration as potential track makers. In fact, differences in track morphology suggest that the tracks derive from more than one type of large theropod. Much smaller, didactyl tracks have been assigned to the *Troodontidae*. Besides some large *Iguanodontipus*, we tentatively interpret another type of tracks - obviously belonging to small bipedal herbivores - to *Stenopelix*, the only partial skeleton from Obernkirchen known to date. The “German Wealden” is characterized by few separate trackways, indicating either short times of track-recording or not much dinosaur traffic. In contrast, the “chicken yard” probably represents an extended time of lagoonal sedimentation (up to several weeks) and a lot of dinosaur traffic.

Technical Session VII, Thursday 3:45

#### OCCLUSAL WEAR MORPHOLOGY OF GIANT BEAVER (*CASTOROIDES*)

LOWER INCISORS: FUNCTIONAL AND PHYLOGENETIC IMPLICATIONS  
RINALDI, Caroline, University of Missouri-Kansas City School of Medicine, Kansas City, MO, USA; MARTIN, Larry, University of Kansas Natural History Museum and Biodiversity Research Center, Lawrence, KS, USA; COLE III, Theodore, University of Missouri-Kansas City School of Medicine, Kansas City, MO, USA; TIMM, Robert, University of Kansas Natural History Museum and Biodiversity Research Center, Lawrence, KS, USA

Evergrowing incisors are a key adaptation in the order Rodentia. While incisors are superficially similar among the various families of rodents, details of 3-D incisor morphology (e.g., helical form, pattern of wear) vary. In this study, we examine lower incisor occlusal wear patterns of giant beavers (Castoridae: *Castoroides*) and compare them to wear patterns found in other fossil and Recent members of Castoridae, as well as to those of other families of rodents. We begin with a three-dimensional outline that captures information about the occlusal end of a tooth. The outlines are collected from high-resolution digital reconstructions created with a Breuckmann optoTOP scanner. Once landmarks are collected from the digital reconstruction, we use eigenshape analysis to compare occlusal outlines, measuring the intraspecific and interspecific variation in occlusal wear pattern to clarify the relationship between pattern of occlusal wear, incisor function, and phylogeny. Helical form of giant beaver lower incisors is characterized by high pitch and orientation in the mandible that results in the medial surfaces of the occlusal ends being closely approximated as the incisors erupt in towards the midline. The symphysis is unfused, and was likely capable of movement. As a result, lower incisors show massive, flat interstitial wear, resulting in the creation of a common occlusal point. In contrast, in all Recent and most fossil beavers, movement is limited at this joint, and wear does not occur on the medial surfaces. Ridges on lower incisors of giant beavers create a serrated occlusal edge, making them more capable of cutting fibrous material. There also is distinctive wear on the lingual dentin surface, proximal to the occlusal ends. We propose this wear was created by abrasion from fibrous material (e.g., roots, tubers, horsetail stems) or possibly bark stripping. This unusual feeding behavior has not been observed in Recent rodents, but may be key to the success and distribution of giant beavers in the Pleistocene.

Poster Session I, (Wednesday)

#### FIRST RECORD OF A PLEISTOCENE VERTEBRATE ASSEMBLAGE IN THE LLANOS OF VENEZUELA

RINCÓN, Ascanio, Instituto Venezolano de Investigaciones Científicas (IVIC), Caracas, Venezuela; CHÁVEZ-APONTE, Edwin, Universidad Central de Venezuela, Caracas, Venezuela; AGUERO, Argenis, Fundación La Salle de Ciencias Naturales, San Carlos, Venezuela

The Venezuelan Llanos belongs to the Orinoco basin, and represent 280,000 km<sup>2</sup> in area, where the fossil record is poorly known. We report a new fossil bed, located in Zanja de Lira area in Los Llanos of Venezuela, Cojedes State. We discovered seven fossiliferous localities across the Igues Creek basin, called Divivide, Caño Negro, Ranchosol, Caño Jobito, Caño Urapal, Puerto Escondido, El Chorro. Taxa, such as crocodiles, turtles, fishes and cat fishes (*Doradidae* and *Pimelodidae*), and crabs suggest permanent rivers and/or lagoons in the area. The presence of *Eremotherium* suggests a forest-savanna ecotone. Cf. *Cuvieronius* sp., *Holmesina* sp., *Glyptodon* sp., *Macrauchenia* sp., and *Sigmodon* Cf. *S. alstoni* represent open savannas. We also report two leaf morphotypes, and a small Carnivore to Puerto Escondido, which have been the most fossiliferous locality in this area, but unfortunately this fossil site is from an allochthonous origin, but the faunal assemblage is agree with a Pleistocene age. The numerical representation of Proboscideans and Giant Ground Sloths, and the taxonomic makeup suggest that the fauna and flora remains probably belonged to a woodland savanna community, which is not agree with the tropical extreme desert hypothesis from Los Llanos of Venezuela during the Late Pleistocene. All these remains represent the first record to Los Llanos of Venezuela, for all the taxa mentioned before, and suggest a most complex ecosystem during the Late Pleistocene to the Northern of South America.

Poster Session IV, (Saturday)

#### LATERAL LINE GROOVE DEVELOPMENT AS AN INDICATOR OF TERRESTRIALITY IN METOPOSAURID AMPHIBIANS

RINEHART, Larry, New Mexico Museum of Natural History, Albuquerque, NM, USA; LUCAS, Spencer, New Mexico Museum of Natural History, Albuquerque, NM, USA; HECKERT, Andrew, Appalachian State University, Boone, NC, USA

Some workers have proposed that metoposaurs became increasingly aquatic throughout their ontogeny, and we have shown negative allometry (allometric constant = 0.76) in the mid-shaft femoral diameter of a growth series of *Buettneria perfecta*. Femoral diameter defines the strength of the limb bones because it controls cross-sectional area, and must increase in positive allometry (allometric constant ~ 1.5) to maintain constant stress on the bones during growth. We concluded that large, adult *Buettneria* were water-bound, while the juveniles were much more terrestrial. These hypotheses suggested ecological separation of adults and juveniles, which explains the absence of small juveniles in all major metoposaur death assemblages (Scurry County, Rotten Hill, Lamy; n > 150 individuals, all “adults”), and the near-cosmopolitan distribution of metoposaurs. Lateral line systems are arrays of water motion sensing organs, and where they overlaid dermal bone in metoposaurs, they

are housed in well-defined grooves in the bone. Adult *Buettneria* have deep, wide, lateral line grooves in their skulls while a small juvenile *Buettneria* skull shows extremely poorly developed lateral line grooves. We propose that the undeveloped nature of the grooves is additional evidence of terrestriality in juvenile *Buettneria* and that the grooves developed later as the animal grew larger and became fully aquatic. Lateral line grooves are also poorly developed on skulls of the small metoposaur *Apachesaurus*; the grooves are reduced to a barely-discernable string of slightly larger pits in the pitted skull texture. *Apachesaurus* has been considered a somewhat terrestrial metoposaur because of its elongate vertebrae that show robust rib facets. Poorly developed lateral line grooves in *Apachesaurus* substantiate this hypothesis. Thus, the extent of lateral line groove development is an additional measure of the terrestriality of these animals and supports the idea of terrestrial juvenile and aquatic adult *Buettneria*, and of terrestriality in *Apachesaurus*. The possibility exists that a heterochronic agent (progenesis) facilitated speciation of *Apachesaurus* from larger metoposaurid genera.

Technical Session I, Wednesday 9:15

### THIRTY METERS UNDER SEA LEVEL: DIETARY TRAITS AND PALEOECOLOGY OF WOOLLY MAMMOTHS, RHINOS, AND OTHER LATE PLEISTOCENE UNGULATES FISHED IN THE NORTH SEA

RIVALDS, Florent, ICREA and Institut Català de Paleocologia Humana i Evolució Social, Tarragona, Spain; MOL, Dick, CERPOLEX/Mammuthus and Natural History Museum Rotterdam, Rotterdam, Netherlands; DE VOS, John, National Museum of Natural History Naturalis, Leiden, Netherlands

The glacial/interglacial climatic cycles of the Pleistocene resulted in significant variations in sea level. During glacial periods sea levels fell dramatically. The southern North Sea became a dry-land area with both rivers and lakes. Hundreds of thousands of fossil bones of Pleistocene mammals, both terrestrial and marine, have been fished from the bottom of the North Sea between Great Britain and The Netherlands. AMS radiocarbon dates were obtained from the Brown Bank locality and range from ca. 45,000 to 34,000 BP. We examined dietary traits of the late Pleistocene ungulates with dental wear patterns (mesowear and microwear) that relate to diet abrasion. Eight species were analyzed: *Mammuthus primigenius*, *Coelodonta antiquitatis*, *Equus ferus*, *Megaloceros giganteus*, *Alces alces*, *Cervus elaphus*, *Rangifer tarandus*, *Bos primigenius*, and *Bison priscus*. Considering mesowear, all cervids fall among the ungulates with low abrasive diets. For the bovids, mesowear signals indicate dietary habits with relatively high levels of abrasion. However, *Bos* displays significantly lower abrasion in its diet than *Bison*. *Equus* is observed among the modern grazers with a very high level of abrasion. Considering microwear, dietary traits form a continuum from browsing to grazing. In the low abrasion range (grazers), we observe *Megaloceros*, *Cervus*, *Rangifer*, *Bos*, and *Coelodonta*. *Mammuthus* is found among the mixed feeders, and finally *Equus* and *Bison* among the grazers (high abrasion). All these taxa have relatively low numbers of pits. The continuum of dietary traits indicates the presence of the wide diversity in the vegetal resources available and used by the ungulates. Diet thus reflects the presence of a dominant steppe-tundra with some deciduous trees or shrubs. The fauna could reflect the transition stadial/interstadial during the Pleniglacial. *Alces*, however, has a diet significantly different from the other species and falls among the dirty browsers which might be explained by (1) the use of a different resource (resource partitioning because of high competition) or (2) a different chronology (beginning of an interstadial).

Poster Session III, (Friday)

### SYMMETRY IN THE SEMICIRCULAR CANALS OF THERIAN MAMMALS

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Past researchers have relied on a sporadically tested assumption that corresponding contralateral (opposite side) semicircular canals have mirror symmetry in therian mammals. Measured deviations from that symmetry, however, could have functional or phylogenetic implications. Researchers who work with the bony labyrinth of the inner ear understand the difficulty of making dimensional measurements upon it. That difficulty and the necessarily destructive nature of early vestibular canal arc radius of curvature (R) measurements and simultaneous orientation measurements for the ipsilaterateral (same side) and contralateral canals resulted in few studies with mostly laboratory animals, with contradictory results. By use of HRXCT scans for both dried skull and whole head specimens, I imaged the skulls of 34 therian mammal species. Digital imaging methods enabled the construction of a head-centered Reid reference plane system with which R and individual canal orientations were determined for all six semicircular canals. Deviations from symmetry found in a number of specimens point to potential function purposes in those species and warrants further research on those species. Thus the assumption of symmetry in the left and right vestibular canals may not exist for every species and locomotor style. This could point to evolutionary changes in the orientation, as well as R for given species.

Poster Session III, (Friday)

### THE PHYLOGENETIC POSITION OF THE PTEROSAUR *BRASILEODACTYLUS* (PTEROSAURIA, DSUNGARIPTEROIDEA)

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The genus *Brasileodactylus* is known by three specimens: the type species, *Brasileodactylus araripensis*, based on a mandibular symphysis from the Romualdo Formation (Aptian/Albian of Brazil); a partially prepared specimen from the same unit composed of skull, lower jaw and wing elements; and probably an incomplete rostrum from the Crato Formation (Aptian). Here we describe a new specimen from the Romualdo Formation, MN 6503-V, and tentatively refer it to *Brasileodactylus*. The skull is well-preserved but incomplete, bearing the premaxillae, maxillae, palatines and vomer. The anterior part of the rostrum is rounded in lateral view, differing from the anhanguerids. There is a distal expansion reaching its wider diameter by the fourth pair of teeth. The rostrum is apparently more elongated than in the anhanguerid *Anhanguera*, with a lower and wider skull. A remarkable feature from this specimen is the presence of a convexity dorsally in the premaxilla. This structure does not form a crest and shows that care must be taken when considering the existence of such cranial structures in crushed specimens, e.g. from the Crato Formation. The anterior portion of the mandibular symphysis is also present, and lacks a ventral dentary crest, as is also the case of *Brasileodactylus* and *Ludodactylus*. A cladistic analysis using a previously published data matrix has positioned MN 6503-V, *Brasileodactylus* (represented by the holotype and the Crato specimen) and *Ludodactylus sibirici* in a polytomy with the Anhangueridae (*Anhanguera* and *Tropeognathus*). This monophyletic entity had "*Ornithocheirus*" *compressirostris* as sister-group. This analysis indicates that some crestless, toothed forms from the Santana Group (that includes the Romualdo and Crato formations) are closely related to the Anhangueridae.

Poster Session II, (Thursday)

### *CROCIDURA KORNFELDI*: THE TINY AND VERSATILE INTRUDER THAT COLONISED EUROPE

ROFES, Juan, Universidad de Zaragoza, Zaragoza, Spain; CUENCA-BESCÓS, Gloria, Universidad de Zaragoza, Zaragoza, Spain

Here we present the first reliable record of *C. kornfeldi* on the Iberian Peninsula. This comes from the Lower Red Unit (levels TE8-14) of the site of Sima del Elefante (Sierra de Atapuerca, Burgos, Spain), which correspond to the second third of the Early Pleistocene (ca. 1.2 – 1.5 Ma). A rigorous morphological, morphometric and chronological comparison of the Sima del Elefante specimens with those of all the species of the genus *Crocidura* that have inhabited Europe from the Early Pliocene through to the present supports this assignment. We propose a differential diagnosis for the taxon. Then we undertake an extensive revision of the evolutionary and biogeographical framework in which *C. kornfeldi* and all other, subsequent crocidurines, appeared and flourished, tracing back many of their possible phylogenetic relations. Being the species which, highly probably, colonized the European continent it would be feasible to postulate that when arriving to a new and extensive territory it met a great variety of available ecological niches, fact that would endow *C. kornfeldi*, at least initially, of a high morpho-adaptive versatility whose footprint would be phenotypically expressed in the skeleton and, in our case, in the jaw of the animals, explaining this way the observed high intra-specific variability. We also focus on such poor-known aspects as the paleoecology of the group and its contribution to continental biochronology.

Poster Session IV, (Saturday)

### GIRAFFIDAE (ARTIODACTYLA, MAMMALIA) ENTERED CENTRAL EUROPE IN THE EARLIEST LATE MIOCENE

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Central Europe never was known as a habitat for giraffes. Although in Southern and Eastern Europe giraffe remains are recorded from the Early Miocene onwards, it seemed that they never entered Central Europe. However, this idea was questioned some years ago, when possible giraffe remains from the middle Late Miocene of Austria were discovered. Now, a recent finding definitively disabused the current opinion that giraffes generally failed to enter to central Europe. An inventory of large mammals from the Miocene of the Vienna Basin at the collection of the Natural History Museum in Vienna revealed a hemimandible with an almost complete tooth row from an early Late Miocene site. The jaw is comparable in size to large representatives of the palaeomerycids, extinct ruminants, but the teeth differ by higher crowns. Their morphologies basically indicate a giraffe by a transitional status between brachyodont and hypsodont tooth crowns with a plesiomorph structured lingual wall of the lower molars. But they are not in agreement with any known Miocene giraffe species with their specific combination of apomorph high and slender labial stylids in common with a plesiomorph unmolarized third premolar. Consequently, the specimen is considered to represent a previously unknown species of Miocene Giraffidae. Today, the site (Laaerberg Hill), where it was found in the 1920s, lies in Vienna (Austria) and is stratigraphically dated as early Late Miocene (early Pannonian, MN9). That appearance datum is synchronous to the appearance datum of another large herbivore ungulate, the equid *Hippotherium*

*primigenium*, what is used as the key species for the beginning of the Late Miocene. In Europe, *H. primigenium* heralded the time of horses with high crowned teeth suitable to masticate abrasive food items and interpreted to reflect climate/habitat changes from more closed/wet to more open/seasonally dry conditions. Although, giraffes never equal the ecological success of horses in central Europe, the changing ecological conditions at the beginning of the Late Miocene obviously were attractive to them, too, and caused migration from Spanish or Greco-Iranian or Eastern European bioprovinces.

Preparators' Session, Thursday 9:00

**SKETCHING IT: USING DIGITAL PHOTOS, DRAWINGS, AND ARTIST SOFTWARE TO MAP A FIELD JACKET DURING PREPARATION**  
ROTH, Dennis, Fort Hays State University, Hays, KS, USA

I prepared a field jacket from the 2008 field season, recovered by a team from the Big Horn Basin Fossil Foundation south of Douglas, Wyoming, which has the quarry information missing or unavailable at this time. Detailed mapping of fossil quarry sites is a necessity for accurate measurement and subsequent study. Often in the field, limited information is available during excavation, leaving the preparation of the fossils vital to collecting accurate data. During each day of preparation, several digital images were taken. A schematic drawing of the field jacket was also updated with new information as each fossil was uncovered and extracted. The photos were compiled using commercial artistic software (Adobe Photoshop 7.0™), and using my notes, the fossils were outlined to create an accurate composite of a portion of the quarry floor for future study.

Poster Session IV, (Saturday)

**TURIASAUR SAUROPODS IN THE TENDAGURU BEDS OF TANZANIA**  
ROYO-TORRES, Rafael, Fundación Conjunto Paleontológico de Teruel-Dinópolis, Teruel, Spain; COBOS, Alberto, Fundación Conjunto Paleontológico de Teruel-Dinópolis, Teruel, Spain

In this work we compare the sauropod recovered in the Tithonian-Berriasian in Teruel (Spain, project CGL2006-13903) with the Gondwana fauna of the Upper Jurassic. Some of the best sauropod sites to make the comparison are the Tendaguru Beds (Tithonian). These sites have produced species of six neosauropoda genera: *Brachiosaurus*, *Dicraeosaurus*, *Janenschia*, *Tendaguria*, *Torniera* and *Australodocus*. Personal observations at Museum für Naturkunde allow us to study questionable materials referred to different genus (*Janenschia*, *Brachiosaurus*) or a *incertae sedis*. From site G, the caudal vertebrae and chevrons (MB. R. 2091. 1-30) have cranial chevrons with the left and right proximal rami linked by a bridge of bone over the hemal canal like basal eusaurotops and diplodocids. The anterior caudals have their centra with flat or concave ventral surface without pleurocoels, so we include them as basal eusaurotops. They share with Turiasauria apart from the procoelus, a lateral process project cranially with *Turiasaurus* and caudal neural spines projected strongly caudally with *Losillasaurus* (unknown in *Turiasaurus*). From site Nr.5 there is a complete right manus (MB.R.2093.1-12). The primitive characters imply that it is a eusaurotop non neosauropod, e.g.: metacarpal I is shorter than II, III and IV, ungual on digit I is 50 % longer than metacarpal I and the manual digits possess at least two phalanges in digits I, and II. They have the same morphology in metacarpals I, III and V as *Turiasaurus* manus. Another material is the *astragalus* (MB. R. 2095.6) from site P, where the ascending process extends over the cranial two-thirds of the proximal surface is a primitive character. Finally the humerus (MB.R. 2910) from site I presents similar characteristics to Turiasauria genera: proximal end of humerus deflected medially and prominent humeral deltopectoral crest oriented cranially. Our understanding of Tendaguru sauropod had just indicated a high diversity and now we add some possible relationship of these specimens with Turiasauria clade. Thus, this clade would be distributed not only in Laurasia (Europe), but also in Gondwana (Africa) at least during Tithonian age.

New Perspectives on the Early Evolutionary History of the Synapsida, Saturday 9:15

**GONDWANAN MIDDLE PERMIAN SYNAPSID RADIATIONS**  
RUBIDGE, Bruce, BPI Palaeontology, University of Witwatersrand, Johannesburg, South Africa; ANGIELCZYK, Kenneth, Department of Geology, The Field Museum, Chicago, IL, USA; DE KLERK, William, Albany Museum, Grahamstown, South Africa; ABDALA, Fernando, BPI Palaeontology, University of Witwatersrand, Johannesburg, South Africa

The South African Karoo preserves the best unbroken record of continental Permian to Jurassic biotas, enabling extended studies tracking changes in the biodiversity, particularly in relation to the P-T event. Although much research has been undertaken on biostratigraphic ranges in the Middle and Upper Beaufort Group, biostratigraphic refinement of the Lower Beaufort is more difficult because of the relative paucity of tetrapod fossils, outdated taxonomy of the tetrapods represented, and the complex folded nature of the rocks in the southern Karoo. The end Guadalupian extinction event is well documented in the marine realm, but not yet understood in the terrestrial realm. As the lower Beaufort Group is one of the few fossil-bearing terrestrial depositional basins which has the possibility of recording this event, an understanding of lithostratigraphy and the biostratigraphic ranges of tetrapods in this stratigraphic interval is critical. Synapsids in the lower Beaufort are represented by varanopids, biarmosuchians, gorgonopsians, therocephalians, dinocephalians and dicynodonts. Long term stratigraphic collecting has led to the recognition of trends in

the geographic and stratigraphic distribution of synapsid genera. Along the Ecce-Beaufort contact *Eodicynodon* is restricted to the southwestern Beaufort; further northwards *Robertia* is present as far as Phillipolis. Following Walther's Law, the same stratigraphic pattern exists in the southernmost Karoo where *Eodicynodon* is restricted to the lowermost Beaufort Group, followed by *Robertia*, and finally *Diictodon*. Dateable volcanic ash layers in the lower Beaufort offer additional opportunities for correlating fossils in the lower Beaufort and providing insight on the rate of evolution of the earliest therapsids as well as faunal turnover and diversity pulses in the Middle Permian.

Technical Session II, Wednesday 9:15

**PLACODERM JAWS AND THE ORIGIN OF TEETH**  
RÜCKLIN, Martin, Department of Earth Sciences, University of Bristol, Bristol, United Kingdom; DONOGHUE, Philip, Department of Earth Sciences, University of Bristol, Bristol, United Kingdom; STAMPANONI, Marco, Swiss Light Source, Paul Scherrer Institut Villigen; Institute for Biomedical Engineering, University and ETH Zürich, Villigen; Zürich, Switzerland

Though the monophyly of placoderms is open to debate, whether they comprise a clade or a grade, placoderms are the earliest jawed vertebrates and their fossil record reveals the final stages of assembly of the gnathostome bodyplan. It has long been held that placoderms lacked teeth and, thus, that jaws evolved before teeth. More recently it has been argued that teeth are present in derived but not primitive placoderms, supporting a thesis that teeth evolved independently in a number of distinct lineages of jawed vertebrates. This view has been contested on the grounds that the 'tooth-like' structures seen in derived placoderms fail to meet the typological definitions of a gnathostome tooth. Using SRXTM we analysed the ontogenetic development of jaw structure in the basal placoderm *Bathriolepis* and the derived arthrodire *Compagopiscis*. *Bothriolepis* has organized and patterned denticles, lacking regular dentine, with large cavities under the denticle; while it has tooth-like structures performing a tooth function, these structures share only some similarities to the teeth of crown-gnathostomes. The tooth-like structures of *Compagopiscis* are composed of orthodentine, a pulp-cavity, patterned and organized development, and also functioned as teeth; they fulfill all the expectations of a gnathostome tooth. If placoderms are paraphyletic stem-gnathostomes, these data indicate that teeth evolved gradually, and the gnathostome tooth-condition was established in arthrodires long before the radiation of crown-gnathostomes, supporting the view that teeth evolved just once.

Poster Session IV, (Saturday)

**NEW INSIGHTS ABOUT THE ANATOMY OF THE HAND OF CARNOTAURUS SASTREI (THEROPODA: ABELISAUROIDAE)**  
RUIZ, Javier, Centro de Biología Molecular, CSIC-Universidad Autónoma de Madrid, Cantoblanco, Madrid, Spain; NOVAS, Fernando, Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", Buenos Aires, Argentina

The abelisaurid theropod *Carnotaurus sastrei*, from the Late Cretaceous of Argentina, is characterized for the unusual presence of frontal horns and extremely abbreviated forelimbs, among other curious features. In particular, the four digit hand of *Carnotaurus* shows highly derived features, as recognized in previous works on this animal. However, reexamination of the hands of the holotype -and only available- specimen of *Carnotaurus sastrei*, reveals interesting details that modify previous interpretations about its manual anatomy. For example, proximal phalanges of digits II and III are longer than their respective metacarpals, an unusual condition absent in other theropods, including abelisaurids (e.g., *Aucasaurus*). Bizarre features of *Carnotaurus* are mainly concentrated on metacarpal IV. This constitutes the largest bone of the hand. Moreover, metacarpal IV of *Carnotaurus* is conical-shaped, with a wide and gently concave proximal articular surface for the ulna, and an acute distal tip lacking of an articular surface for a phalanx. Notably, the aspect of metacarpal IV resembles that of an ungual phalanx. The robust condition of metacarpal IV of *Carnotaurus* is in sharp contrast with the splint-like condition present in basal theropods. Metacarpal IV is proportionally shorter in other abelisaurids (*Aucasaurus* and *Majungasaurus*) for which this bone is known. However, in both *Carnotaurus* and *Aucasaurus* metacarpal IV has a conical shape and no phalanges of digit IV are present, in contrast with *Majungasaurus* in which a phalanx fused with metacarpal IV has been reported. This information is congruent with recent information supporting closer relationships between *Carnotaurus* and *Aucasaurus* with respect to the Malagasy taxon. Differences noted above for these three genera suggest a certain degree of manual morphological diversity among abelisaurids.

Poster Session III, (Friday)

**A DACENTRURINE STEGOSAUR FROM THE LATE JURASSIC OF ASTURIAS (NORTHERN SPAIN)**

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*Omosaurus armatus* Owen, from the early Kimmeridgian of England (Wiltshire), was the first articulated stegosaur described in the world and is the type species of *Dacentrurus*. *Dacentrurus* Lucas has been subsequently cited in the Late Jurassic of France (Upper Normandy region), Portugal (Leiria and Lisboa districts) and Spain (Teruel and Valencia provinces), and also in the Early Cretaceous of Spain (Burgos province). *Miragaia longicollum*, a stegosaur closely related to *Dacentrurus* has been recently described in the late Kimmeridgian-early Tithonian of Portugal (Lisboa district). Both genera form the Dacentrurinae clade (all stegosaurs more closely related to *Dacentrurus* than to *Stegosaurus*). Here we present a new locality with dacentrurine remains from Villaviciosa (Asturias, north Spain), recovered in the Kimmeridgian Lastres Formation, deltaic in origin. The stegosaur remains were found disarticulated and mixed with remains of bony fishes, turtles, plesiosaurs and theropods. Most of the bones were broken prior to fossilization, and are unidentified fragments. The best preserved fossils are cervical vertebrae, dorsal centra and ribs; there are also fragments of the sacrum, girdles and limb-bones. The degree of fusion of the neurocentral suture in the vertebrae indicates that at least two individuals are represented in the assemblage, a juvenile one and an adult one. Two of the four unambiguous synapomorphies of Dacentrurinae can be tested in the Asturian material: cervical ribs fused to para- and diapophyses of cervical vertebrae and centra of dorsal vertebrae wider than long, so the remains are here assigned to Dacentrurinae indet. The fossils from Burgos, Teruel and Valencia, assigned to *Dacentrurus* by previous authors mainly on the basis of ribs fused to cervical vertebrae and/or dorsal centra wider than long, currently regarded as synapomorphies of Dacentrurinae, should be restudied in order to clarify its belonging to *Dacentrurus*, *Miragaia* or another unrecognized dacentrurine.

Poster Session III, (Friday)

**THE OLDEST CERATOPSID CRANIAL MATERIAL (FOREMOST FORMATION, MIDDLE CAMPANIAN) FROM NORTH AMERICA**

RYAN, Michael, Cleveland Museum of Natural History, Cleveland, OH, USA; EVANS, David, Royal Ontario Museum, Toronto, ON, Canada

In 1958 Wann Langston, Jr., collected ceratopsian cranial remains from a low-density bonebed within the Foremost Fm (lower Middle Campanian) of southern Alberta. The material includes portions of the braincase, quadrates, quadratojugals, squamosals, and numerous isolated triangular epimarginal ossifications and parietal fragments. Recent preparation of previously unopened field jackets has revealed the remains of three partial parietals from at least two adult-sized individuals. The most complete parietal preserves three epiparietals along the posterior margin of the frill adjacent to the midline; the central epiparietal forms a massive, flattened triangular spike that is flanked medially by a short, broad-based, procurving hook (with a base perpendicular to the base of the spike), and laterally by a much smaller, very low, elongate epiparietal. A parietal fenestra is present, but apparently relatively small compared to most Campanian-aged ceratopsids. The largest parietal bar preserves a fused procurving hook, but has an inflated sutural surface for the large, but unfused, triangular spike. This suggests that the order of epiparietal fusion differs from that outlined for centrosaurs, and that complete fusion did not occur until full adult size was achieved. It also calls into question the previously proposed homology of epiparietals between centrosaurs and chasmosaurs. As presently interpreted, the remainder of the parietal frill margin is made up of a series of cup-shaped depressions, similar to those seen on some specimens of *Triceratops*, that mark the fusion points of the smaller isolated epiparietals. Foremost Formation sediments date between 78-79 million years old making this material the oldest putative ceratopsid remains from North America. The preserved parietal ornamentation is unique amongst ceratopsids and indicates that the material belongs to a new ceratopsid taxon, possibly of chasmosaurine affinity.

Technical Session VI, Thursday 2:00

**THE INTERRELATIONSHIPS, PALEOBIOGEOGRAPHY AND THE P-TR EXTINCTION EVENT SURVIVAL RATE OF THE PARAREPTILE CLADE PROCOLOPHONOIDEA**

SÁILÁ, Laura, University of Bristol, Bristol, United Kingdom

The parareptilian group Procolophonoidea has been increasingly studied in recent years, and a high survival rate during the P/Tr extinction event has been estimated for the clade. Procolophonoid interrelationships, however, have remained poorly known because of many taxa have lacked adequate descriptions. Recent publications on several South African and Chinese procolophonoids, along with my redescriptions of the European procolophonoids *Anomoiodon liliesterni* and *Leptopleuron lacertinum*, and the putative Permian Russian procolophonoids enable a more in-depth phylogenetic study. Thirty-nine procolophonoid taxa were included in the study, and the results suggest novel compositions of the procolophonoid clades Leptopleuroninae and Procolophoninae; the monophyly of the genus *Kapes* is questioned; the phylogenetic position of *Suchonosaurus*, *Pintosaurus*

and *Phaanthosaurus* among the other basal procolophonids remains unresolved; and the results cast doubt on Procolophonoidea being divided into the two generally accepted clades, Owenettidae and Procolophonidae. However, when stratigraphically-calibrated, the results of the phylogenetic analysis support separate Owenettidae and Procolophonidae; biogeographically Owenettidae remains restricted to Gondwana, and Procolophonidae either originated in the Permian of Laurasia, or a migration to Laurasia took place among the basal members of Procolophonidae during the Late Permian. Furthermore, in contrast to previous survival estimates, the topology with the best stratigraphic fit indicates that only 57% of procolophonoid lineages might have survived through the P/Tr boundary. Alternatively, it is possible that up to 80% lineages crossed the boundary, but this requires a scenario that maximizes the number of ghost lineages.

Poster Session III, (Friday)

**POSTCRANIAL MORPHOLOGY AND THE LOCOMOTOR HABITS OF LIVING AND EXTINCT CARNIVORANS**

SAKAI, Stacey, University of Rhode Island, Kingston, RI, USA; SAMUELS, Joshua, University of California, Los Angeles, Los Angeles, CA, USA; MEACHEN-SAMUELS, Julie, University of California, Los Angeles, Los Angeles, CA, USA

Living carnivorans display a broad range of locomotor habits, including cursorial, scansorial, arboreal, semi-aquatic, and semi-fossorial species from multiple families. Ecomorphological analyses have been used successfully in prior studies of carnivores and rodents to accurately infer the locomotor habits of extinct species. This study uses 20 postcranial measurements that have been shown to be effective indicators of locomotor habits in rodents and incorporates an extensive sample of over 200 individuals from more than 50 living carnivore species. Statistical analyses including analysis of variance (ANOVA) and stepwise discriminant function analysis were performed using a set of functional indices (ratios). Our ANOVA results revealed consistent differences in postcranial skeletal morphology among locomotor groups. Aquatic and semi-aquatic species display relatively shortened, robust femora with large femoral epicondyles and elongate metatarsals. Semi-fossorial species display relatively short, robust limbs with enlarged muscular attachment sites and elongate claws. Both aquatic and fossorial species have relatively elongate olecranon process of the ulna. Cursorial species displayed distal elongation of the limbs and relatively narrow humeral epicondyles. Arboreal, scansorial, and unspecialized terrestrial species show intermediate values for most indices. These differences effectively discriminated locomotor groups and allowed accurate classification of the carnivorans studied. Both within and between families, species with similar locomotor habits converge towards similar postcranial morphology despite their independent evolutionary histories. The discriminant analysis worked particularly well to correctly classify members of the Canidae, Felidae, and Mustelidae, but not as well for members of the Ursidae or Herpestidae. Extinct species from several families were included in the discriminant function analysis for locomotor classification, including *Smilodon fatalis*, *Panthera atrox*, *Felis lucustris*, *Dinictis felina*, *Hoplophoneus occidentalis*, *Barbourofelis loveorum*, *Canis dirus*, *Arctodus simus*, *Agriotherium africanum*, and *Satherium piscinaria*.

Romer Prize Session, Thursday 11:30

**MYOLOGY AND FUNCTIONAL MORPHOLOGY OF BITING IN AVIAN AND NON-AVIAN DINOSAURS**

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Biting is a key adaptation in vertebrate evolution and an understanding of its functional morphology and biomechanics provides a valuable insight into the behavior and ecology of feeding in animals that direct observations are all but impossible, e.g. extinct dinosaurs. However, biomechanical models of musculoskeletal systems are affected heavily by parameters associated with muscles, conditions that are virtually unknown in extinct organisms. For such taxa, one must rely on muscle reconstructions or on muscle parameters extrapolated from extant relatives. To date, efforts in constraining errors associated with muscle parameter estimation in the jaw adductor muscles of archosaurs is limited. Here, I provide an overview of the anatomy, architecture, and cross-sectional areas (CSA) of the jaw closing muscles in extant birds and crocodylians to form a basis for reconstructing muscle parameters in extinct non-avian dinosaurs. Further, functional metrics, primarily mechanical and displacement advantages, were calculated from digitized landmarks of the origin and insertion points of muscles in extant bird specimens. Muscle scars were investigated in dinosaurs to identify presences and positions of jaw adductor muscle attachment sites, the digital coordinates of which were used to compute mechanical and displacement advantages. Muscle CSA were estimated in theropods using several extrapolation techniques. Functional metrics in most theropods are comparable with each other, with tyrannosaurs and carnosaurines dominating the upper and lower extremes in mechanical and displacement advantages respectively, confirming these two groups as above-average biters. The opposite is true of baryonychines with an extremely low mechanical advantage and extremely high displacement advantage, comparable in range to modern long-billed birds, indicating a weak-bite, fast-shutting jaw function. Preliminary CSA estimates show strong correlation with skull size, indicating a strong size influence in the estimation procedure, establishing the need for further groundwork.

**VERTEBRATE BIODIVERSITY AND LARGE-SCALE TURNOVER DURING THE DEVONIAN-MISSISSIPPIAN TRANSITION**

SALLAN, Lauren, University of Chicago, Chicago, IL, USA

Great attention has been paid to the vertebrates of the Late Devonian, such as placoderms and sarcopterygians. Studies have focused on the morphology, phylogeny, biogeography, and more recently the biomechanics of these forms. In comparison, the fish faunas of the following Mississippian period have been neglected. While other studies have recorded diversity shifts among individual groups over the mid-late Paleozoic, none have focused on quantitative changes across the vertebrate biota as a whole. This is surprising since this interval contains one of the "Big Five" mass extinctions (The Late Devonian biotic crisis), which had considerable effects on marine invertebrate faunas. Here, results from a new genus-level vertebrate occurrence dataset are presented, characterizing in detail the major turnover in the total biota from the Devonian to the Mississippian. "Placoderms" and finned sarcopterygians reached peak numbers during the Late Devonian, and latter exhibiting sustained increases throughout that time. However, the taxonomic richness of both groups falls off drastically into the Mississippian, representing the permanent loss of more than 70% of sarcopterygian generic diversity and the extinction of all placoderms. Scarce Devonian forms (chondrichthyans, limbed tetrapods, and actinopterygians) radiate during the Mississippian, with an average increase of 150% in levels of generic diversity into the middle of the period. The vertebrate faunal turnover was probably tied to the end-Devonian Hangenberg extinction event, rather than the earlier, more widely known Frasnian-Famennian extinction. Hangenberg shales and sandstones were deposited globally during a period of dramatic sea level instability and climate change. Event sediments are now known from the same localities are important late Famennian vertebrate deposits - most notably as fossil-poor layers directly above the placoderm-rich Cleveland Shale. The Hangenberg event appears to have had a major role in shaping subsequent vertebrate biodiversity.

Technical Session XIII, Friday 4:30

**TWO NEW CHASMO SAURINE CERATOPSIDS FROM LATE CRETACEOUS (CAMPANIAN) OF UTAH**

SAMPSON, Scott, University of Utah, Salt Lake City, UT, USA; LOEWEN, Mark, University of Utah, Salt Lake City, UT, USA; FARKE, Andrew, Raymond Alf Museum of Paleontology, Claremont, CA, USA; SMITH, Joshua, University of Utah, Salt Lake City, UT, USA; ROBERTS, Eric, Southern Utah University, Cedar City, UT, USA

Recent fieldwork in Grand Staircase-Escalante National Monument, southern Utah, has resulted in discovery of two new genera of chasmosaurine ceratopsid dinosaurs. Both were recovered from the late Campanian Kaiparowits Formation, occurring in sediments dating to between 76 and 75 Ma. The stratigraphic overlap of these taxa suggests that members of each taxon co-existed within the same ecosystem, a rarity within Chasmosaurinae (and, to date, not documented among centrosaurines). Taxon A, represented by eight specimens, possesses a large (~2.5 m long) skull bearing a pronounced, caudally positioned nasal horncore and an elongate, tapering parietosquamosal frill with a deep, ornamented caudomedian embayment. Taxon B, represented by four specimens, possesses a significantly smaller (~2 m long) skull with a transversely narrow nasal horncore and a transversely broad frill bearing relatively small parietal fenestrae and ten well developed, procurved epi-ossifications on the caudal margin. Although both taxa possess dorsolaterally directed supraorbital horncores, their morphology is highly distinctive and specific to each genus, being abbreviated and blunt-tipped in Taxon A and relatively elongate and pointed in Taxon B. A phylogenetic analysis of Chasmosaurinae places Taxon A in a clade with two other southern taxa, *Pentaceratops* and *Agujaceratops*, whereas Taxon B falls out in a distinct clade with the northern form *Chasmosaurus irvinensis*. Remaining members of the genus *Chasmosaurus*, *C. russelli* and *C. belli*, form a distinct clade at the base of Chasmosaurinae. Considered in unison, the phylogenetic, stratigraphic, and biogeographic evidence is most consistent with an interpretation of endemic northern and southern chasmosaurine clades in the Western Interior of North America during much of the late Campanian, followed by a pair of south-to-north dispersal events near the close of the Campanian.

Technical Session XIV, Friday 3:45

**TURBINATE SCALING AND STRUCTURE IN CARNIVORANS**

SAMUELS, Joshua, University of California, Los Angeles, Los Angeles, CA, USA; BIRD, Deborah, University of California, Los Angeles, Los Angeles, CA, USA; MEACHEN-SAMUELS, Julie, University of California, Los Angeles, Los Angeles, CA, USA; VAN VALKENBURGH, Blaire, University of California, Los Angeles, Los Angeles, CA, USA

The turbinate bones found in the nasal cavity of mammals extend from the maxillary, nasal, and ethmoid bones. These bones and the respiratory and olfactory epithelia covering them function in thermoregulation, water conservation, and olfaction. While the structure of the turbinates varies greatly among taxa, the functional significance of this variation is not well understood. We used high-resolution CT scan data to quantitatively analyze turbinate structure and scaling in a wide range of carnivorans. Measurements include the nasal cavity volume and total turbinate surface area, which were compared to an individual's skull length and average species mass. The varying thermoregulatory, locomotor, and olfactory demands among living carnivorans allow us to predict species with differing ecologies should have different turbinate scaling and structure. Species living in cold or arid

environments should have relatively greater turbinate surface area than relatives living in more mesic environments. Species with particularly high locomotor and aerobic capacities are also predicted to have relatively greater turbinate surface area. Results indicate turbinate surface area correlates well with nasal cavity volume, thus allowing for the prediction of surface area for fossil taxa. Turbinate surface area shows positively allometric scaling relative to skull length and body mass in all taxa. The cheetah, *Acinonyx jubatus*, and the arctic fox, *Alopex lagopus*, show particularly high relative turbinate surface areas, falling outside the 95% confidence intervals for all regressions. While respiratory epithelia (mucosa) can be found on all of the turbinate bones, olfactory epithelia may be restricted to the ethmoturbinates. Preliminary results suggest the relative size of the different bones is associated with ecology. For example, maxilloturbinates tend to be accentuated in taxa with greater thermoregulatory or water conservation demands like otters, arctic foxes, and cheetahs. Ethmoturbinates, which are covered in olfactory tissue, are enlarged in species with a stronger sense of smell like wolverines, skunks, and hyenas.

Poster Session II, (Thursday)

**LATE CRETACEOUS (CENOMANIAN) HESPERORNITHIFORMES FROM THE PASQUIA HILLS, SASKATCHEWAN, CANADA**

SANCHEZ, Joseph, Carleton University, Ottawa, ON, Canada; CUMBAA, Stephen, Canadian Museum of Nature, Ottawa, ON, Canada; SCHRÖDER-ADAMS, Claudia, Carleton University, Ottawa, ON, Canada

A large assemblage of fossil bird bones, collected over several field seasons from marine deposits at a locality in the Pasquia Hills, Saskatchewan, Canada, has revealed new information on the Order Hesperornithiformes. The fossils were discovered in the Belle Fourche Member of the Ashville Formation, a mid Cenomanian (~95 Ma) deposit which outcrops along the eastern margin of the Western Interior Basin. Over 250 disarticulated and non-associated fossil bird bones were discovered with fossils of sharks, bony fishes and tetrapods in a bonebed associated with the *Ostrea beloiti* layer, a regional stratigraphic marker. Two species of the hesperornithiform genus *Pasquiaornis*, previously described from a locality on the Carrot River, 100 km to the SE and of similar age, have now been identified at the Pasquia Hills locality. These two localities have produced the oldest diverse avifauna found to date in North America, including Ichthyornithiformes and Enantiornithes, as well as the oldest Hesperornithiformes known from North America. The fauna from the Pasquia Hills bonebed includes a possible new species of *Pasquiaornis* as well as a possible new hesperornithiform genus. The original description of *Pasquiaornis* included the femur, tarsometatarsus and humerus. This study adds descriptions of new elements such as the cranial and mandibular elements, teeth, vertebrae, scapula, coracoid, ulna, radius, carpometacarpus, pelvis, tibiotarsus, fibula and phalanges as well as a more complete description of previously described *Pasquiaornis* elements. The new pectoral and wing elements of *Pasquiaornis* add new information on the evolution of flightlessness in Hesperornithiformes. Comparisons are made with several other genera of Hesperornithiformes, including *Enaliornis* from the late Albian of England, the oldest known. The new discoveries of Hesperornithiformes from the Pasquia Hills locality add considerably to interpretations of the early evolution and diversification of these marine toothed birds in the Late Cretaceous Western Interior Seaway.

Technical Session V, Wednesday 3:45

**LIMB BONE HISTOLOGY ACROSS THE FISH-TETRAPOD TRANSITION**

SANCHEZ, Sophie, Uppsala University, Uppsala, Sweden; TAFFOREAU, Paul, European Synchrotron Radiation Facility, Grenoble, France; CLACK, Jennifer, University Museum of Zoology, Cambridge, United Kingdom; DAESCHLER, Edward, Academy of Natural Sciences, Philadelphia, PA, USA; AHLBERG, Per, Uppsala University, Uppsala, Sweden

Multiscale synchrotron phase contrast tomography of humeri of the tristichopterids *Eusthenopteron* and *Hyeria*, the Devonian tetrapod *Acanthostega* and several post-Devonian fossil tetrapods allow us to investigate their histology non-destructively and draw inferences about evolutionary change across the fish-tetrapod transition. In post-Devonian and modern tetrapods, continuing deposition of cortical bone causes the cortex to thicken in the diaphyseal region during ontogeny. In tristichopterids on the other hand there is no continuing cortical thickening during later growth: after the initial phase of deposition when the cortex thickens rapidly, the cortex becomes thinner again in adult individuals, suggesting that perimedullary and perivascular resorption of the inner part of the cortex proceed more quickly than appositional growth. Simultaneously with this cortical thinning, there is a reduction in the number of medullary trabeculae resulting in a more open spongy texture in the centre of the bone. The adult humerus is thus more lightly, though more completely, ossified than the subadult. Cortical organization is also different. In subadult *Eusthenopteron* the cortex is homogeneous without lines of arrested growth (LAGs); in adult *Eusthenopteron* and *Hyeria*, there is a thin external region of LAG bone with two or three LAGs, but the deeper part of the cortex is still homogeneous. This suggests that the bulk of cortical growth occurred rapidly, with a substantial slowing down in the later part of life. In post-Devonian tetrapods almost the whole cortical thickness is composed of LAG bone with numerous LAGs, showing that cortical growth continued at a fairly steady pace over a number of years. Adult *Acanthostega* shows an intermediate character mosaic. The cortical bone is of intermediate thickness, is composed entirely of LAG bone (at least four LAGs), and shows clear evidence of internal erosion. The medullary bone is denser than in the tristichopterids. Thus, despite its persistent "fish" characteristics such as gills and tail fin, *Acanthostega* shows the beginnings of a "tetrapod" humeral histology with novel growth patterns and biomechanical characteristics.

Poster Session IV, (Saturday)

**PHYLOGENETIC POSITION OF THE MUSK DEER (MAMMALIA, CETARTIODACTYLA, MOSCHIDAE): INTEGRATED FOSSIL AND MOLECULAR DATA APPROACH**

SÁNCHEZ, Israel M., Museum of Zoology, University of Cambridge, Cambridge, United Kingdom; ASHER, Robert, Museum of Zoology, University of Cambridge, Cambridge, United Kingdom; MORALES, Jorge, Museo Nacional de Ciencias Naturales-CSIC, Madrid, Spain

The Moschidae (musk deer) comprise small hornless pecorans whose only extant representatives are the Asian musk deer (*Moschus* spp.). Many Oligo-Miocene pecorans were considered moschids, but the definition of the Moschidae has been strongly unstable, depending on the characters used by the different authors to cluster 'moschid' taxa; thus, the Moschidae ranged from a monotypic group (only containing *Moschus*) to include up to fifteen genera. Despite the traditional lack of consensus among both morphological and molecular studies regarding the phylogenetic relationships of the major pecoran groups, the Moschidae were repeatedly clustered with the Cervidae or at least within the 'Cervoidea' in the vast majority of works. Only recent molecular studies have pointed to a sister-group relationship between moschids and bovids. Thus, the unstable definition and phylogenetic position of moschids are two correlated problems that have to be solved.

The fossil record of the Miocene moschids *Micromeryx* and *Hispanomeryx* has been recently updated, especially after the new *Hispanomeryx* and *Micromeryx* findings from Spain. These new fossils allowed us to describe previously unknown cranial and postcranial features of these taxa, and compare them with other pecorans, adding new data about their comparative anatomy and their phylogenetic relationships. A cladistic analysis of Maximum Parsimony (MP) was conducted through a molecular scaffold approach, using molecular data as a frame to run the MP analysis with our morphological data. This analysis allowed us to explore the phylogenetic relationships of moschids, and to define and diagnose the Moschidae. Our most parsimonious tree (MPT) recovered a monophyletic Moschidae composed by *Micromeryx*, *Hispanomeryx* and *Moschus* and a monophyletic Bovoidea formed by the Moschidae and the Bovidae, characterized by a set of derived cranial, dental and postcranial features. This is the first time that a sister-group relationship between moschids and bovids is backed up by morphological data. Thus, moschids turn up as an advanced group of Miocene hornless bovids instead of the morphologically heterogeneous 'cervoids' that were supposed to be.

Poster Session III, (Friday)

**COMPARING SKULL ONTOGENESIS: A CASE STUDY USING OTARID SKULLS (PINNIPEDIA, MAMMALIA)**

SANFELICE, Daniela, MCN/FZBRS; UCL, Porto Alegre, Brazil; DE FREITAS, Thales, UFRGS, Porto Alegre, Brazil

Our central purpose is to compare ontogenies and developmental allometries of skull shape of *Arctocephalus australis* (n=76), *Callorhinus ursinus* (n=51) and *Otaria flavescens* (n=84) to determine if they share a common postnatal ontogeny of shape and if the degree of differentiation among ontogenies decreases or increases over time. By this way, we aimed to analyze the evolutionary patterns that had act in these otarids species ontogenies and to understand the relations between development and phylogenetic history. Three ontogenetic stages were defined through the sutural closing and chronological ages were estimates by the growth layers groups of canines. Twenty landmarks were defined on the ventral view of skulls and they were superimposed follow the Procrustes approach. Partial warps were used as shape variables, relative warp analysis was carried on Procrustes residuals and interspecific comparisons were performed separately for each sex. To determine whether a single linear vector can characterize the ontogeny of shape we used a combination of ordination and statistical methods and the allometric coefficients were calculated by multivariate regression of shape on size. We also tested for channeling and for changes confined to early or to late morphogenesis. We found that the ontogenies cannot be summarized by a single linear vector in any of the analyzed groups because the rates change with time. So, it would be problematic to perform a heterochronic analysis, but allometric repatterning could be observed. Shape changes in the otarids studied are more correlated with size than with age and none species share a common growth allometry or a common ontogenetic trajectory/pattern. Similarly, shapes at onset or offset or the lengths of the ontogenetic trajectories are not the same in any case. Whether ontogenetic trajectories are linear or curve could be a function of developmental timing or, more specifically, it could depend on the age at which allometries stabilize in post-natal ontogenies. We conclude that the changes in otarids skull ontogenies occurred in spatial and temporal terms and that the general pattern is in agreement with the phylogeny.

Technical Session II, Wednesday 8:45

**THE ORDOVICIAN RADIATION OF FISH**

SANSOM, Ivan, Earth Sciences, University of Birmingham, Birmingham, United Kingdom

Ordovician fish are rare. Despite this, recent years have seen a comparatively rapid discovery of new taxa and new localities, which, together with a reconsideration of long established forms and reinvestigation of some of the 'classic' sites, permits a revised look at the paleobiogeographic dispersal of early vertebrates, their phylogenetic relationships and

paleoecology. The Laurentian record is dominated by the astraspid-eriptychiid fauna that is widely dispersed through North America in early Sandbian times, with microsquamous forms such as thelodonts and chondrichthyan-like taxa occurring within specific ecological niches. A similar pattern is also evident from detailed studies of Gondwana sites, with the widespread and almost ubiquitous appearance of arandaspids in peri-Gondwanan localities in Australia, Argentina, Bolivia and Oman, and a stratigraphic range from the Floian through to the Sandbian. There is also evidence that rare microsquamous taxa show a similar ecological segregation from the heavily armored ostracoderms to that seen within Laurentia, and that all Ordovician fish inhabited shallow water paleoenvironments. The available evidence indicates that the Middle Ordovician was the time of a major (and probably the first) diversification event of fish with biomineralized dermal skeleton, and their narrow paleoecological range may be used as a prospecting tool to search for other Ordovician vertebrate-bearing horizons and thus enhance the available dataset.

Technical Session II, Wednesday 8:30

**EXPERIMENTAL DECAY OF LAMPREYS AND HAGFISH PROVIDES TAPHONOMIC CONSTRAINTS ON VERTEBRATE ORIGINS**

SANSOM, Robert, University of Leicester, Leicester, United Kingdom; GABBOTT, Sarah, University of Leicester, Leicester, United Kingdom; PURNELL, Mark, University of Leicester, Leicester, United Kingdom

The origin and early evolution of the vertebrates occurred prior to the evolution of mineralized hard tissues. Consequently, our knowledge of these crucial stages in evolution is limited to the narrow windows provided by exceptional preservation of soft-tissues. Often rare, collapsed and partially-decomposed, soft-bodied fossils are difficult to interpret unequivocally, principally because the sequence of loss and transformation of key anatomical characters during decay is poorly understood. In order to provide rigorous taphonomic constraints upon the interpretation of putative soft-bodied vertebrate fossils, we undertook laboratory experiments to investigate the decay of vertebrate characters using extant proxies. Comparison of results for different taxa reveals some general patterns (e.g. relative recalcitrance of the notochord, hepatic and keratinous tissues), but the rate and sequence of loss of anatomical characters are profoundly different in the hagfish (*Myxine*) and both adult and larval lampreys (*Lampetra*). This is especially true of phylogenetically important cartilagenous tissues, such as the skull and branchial apparatus. This cross-taxon variability in decay creates serious difficulties for comparative interpretations that do not take taphonomic data fully into account, and suggests that current hypotheses regarding the anatomy of controversial, soft-bodied purported early vertebrates (e.g. myllokungingids and *Jamoytitus*) require revision. Our results also allow true phylogenetic absence to be more clearly distinguished from taphonomic character loss in fossils, which in turn allows more robust placement of these taxa, and clearer distinction of stem-group placements that carry evolutionary meaning from those that reflect non-preservation. In the broader context of early vertebrate evolution, it is clear that experimental investigation of decay of vertebrate characters will enable much better assessments of the unacknowledged taphonomic biases that currently skew macroevolutionary scenarios of vertebrate origins.

Poster Session IV, (Saturday)

**THE PHYLOGENETIC RELATIONSHIPS OF A NEW AEOLOSAURINI TITANOSAUR FROM THE ADAMANTINA FORMATION, BAURU GROUP, UPPER CRETACEOUS OF BRAZIL**

SANTUCCI, Rodrigo, Departamento Nacional de Produção Mineral-DNPM, Brasília, Brazil; ARRUDA-CAMPOS, Antonio, Museu de Paleontologia de Monte Alto, Monte Alto, Brazil

During the last years several cladistic studies on titanosaurs have been proposed. Although these studies achieved a minimum consensus about the position of Titanosauria within Sauropoda, the relationships of most titanosaurs within this clade remain controversial, which in part can be explained by differences in number of taxa and characters used in these analyses. Here we present a phylogenetic study of a new Aeolosaurini titanosaur (catalogue number MPMA) from the Adamantina Formation of the City of Monte Alto, São Paulo State, Brazil. The material consists of a partially articulated skeleton, comprising incomplete axial remains and appendicular elements. In order to establish its phylogenetic relationships we performed three cladistic analyses based on data matrices available in the literature. Two of them refer to broad cladistic studies on sauropods and one comprises a study on titanosaurs. In order to standardise the analyses we added taxa usually regarded to Aeolosaurini or taxa considered to be closely related to this clade (e.g. *Aeolosaurus rionegrinus*, *A. colhuehuapensis*, *Gondwanatitan*, *Rinconosaurus*, and *Muyelensaurus*) whenever necessary. We also added in the analyses the synapomorphies suggested for Aeolosaurini and *Aeolosaurus*. In all analyses a clade comprising *A. rionegrinus*, *A. colhuehuapensis*, *Gondwanatitan*, and MPMA was recovered, corresponding to the definition of Aeolosaurini. This clade is diagnosed by the presence of neural spines directed forward on middle-anterior and middle caudal vertebrae and haemal arches with double articular facets. The relationships within this clade, however, remain unclear. *Rinconosaurus* has been resolved as being more related to *Muyelensaurus*, *Malawisaurus*, or Aeolosaurini, respectively. These results suggest that Aeolosaurini comprises the two *Aeolosaurus* species formally described to date, *Gondwanatitan*, and the new titanosaur from Monte Alto and is diagnosed by at least two synapomorphies. *Rinconosaurus* and *Muyelensaurus*, however, cannot be unequivocally placed within Aeolosaurini.

**AND THEN THERE WAS ONE: SYNONYMY CONSEQUENCES OF *TRICERATOPS* CRANIAL ONTOGENY**

SCANNELLA, John, Museum of the Rockies, Montana State University, Bozeman, MT, USA

Two years after the initial description of the famous ceratopsid dinosaur *Triceratops*, O.C. Marsh named and described the first specimen of *Torosaurus latus* (Ceratopsidae: Chasmosaurinae) from the same geological formation and roughly the same area of Wyoming, USA. Since then, only a handful of specimens of *T. latus* have been recovered whereas *Triceratops* remains abundant and represented by several different ontogenetic stages. These genera are distinguished solely on the basis of their parietal-squamosal frill morphology. *Triceratops* has been considered an unusual chasmosaurine for possessing a short, broad unfenestrated cranial frill, whereas *Torosaurus* has an expanded, fenestrated frill. A study of comparative cranial morphology reveals that the major changes which occur throughout *Triceratops* ontogeny continue beyond what was previously considered the adult growth stage and result in the parietal-squamosal frill morphologies which diagnose *T. latus*. *Torosaurus* actually represents the mature adult morphology of *Triceratops*. Osteohistological examination of a *Triceratops* postorbital horn core growth series confirms that large *Triceratops* which have yet to develop the expanded frill morphology previously considered characteristic of *Torosaurus* are not fully mature. *Torosaurus* horn core osteohistology reveals multigenerational Haversian tissue, which is indicative of mature bone. The unexpected degree of plasticity found in ceratopsid and other dinosaur skulls throughout growth entails that an understanding of ontogeny is critical to our comprehension of dinosaur paleobiology and systematics.

Poster Session III, (Friday)

**PELVIC AND HINDLIMB MYOLOGY OF THE BASAL ARCHOSAUR *POPOSAURUS GRACILIS* (ARCHOSAURIA: SUCHIA)**

SCHACHNER, Emma, University of Pennsylvania, Philadelphia, PA, USA; DODSON, Peter, University of Pennsylvania, Philadelphia, PA, USA

The pelvic myology of extinct archosaurs has been a common subject of research for over a century, with particular attention focused on the caudofemoral musculature of bipedal dinosaurs and the evolution of the avian condition. The discovery of a largely complete and extremely well preserved specimen of *Poposaurus gracilis* (YPM 57100) has provided the opportunity to generate the first phylogenetically based reconstruction of pelvic and hindlimb musculature of an extinct non-dinosaurian archosaur. Like dinosaurs, multiple groups of basal archosaurs evolved parasagittally erect limbs; however, in contrast to the ornithomimid 'buttress-erect' hip posture, *P. gracilis* and other 'rauisuchian' archosaurs developed a 'pillar-erect' hip morphology in which the acetabulum opens ventrally as opposed to laterally. Reconstruction of the musculotendinous system in a bipedal pseudosuchian archosaur demonstrates how myological changes associated with the evolution of bipedalism in basal archosaurs differed from the musculoskeletal evolution of bipedal dinosaurs. This reconstruction was based primarily on the direct examination of the osteology and myology of extant archosaurs, lepidosaurs and turtles in conjunction with osteological correlates from the skeleton of *P. gracilis*. Placed into a phylogenetic context, these observations were used to generate and constrain a series of inferences regarding the pelvic and hindlimb musculature (presence/absence of a muscle, number of components, and origin/insertion) of *P. gracilis*. This data set provides a foundation for subsequent examination of variation in myological function and orientation, based on pelvic and hindlimb morphology, across the basal archosaur lineage leading to extant crocodylians.

The Scientific Legacy of Mary Anning — Recent Advances in Marine Reptile Paleobiology and Evolution, Wednesday 10:30

**FOSSILIZED ONTOGENIES: OSTEOLOGICAL AND BONE MICROSTRUCTURAL CASE STUDIES OF FOSSIL MARINE REPTILES FROM THE UNESCO WORLD HERITAGE SITE OF MONTE SAN GIORGIO, TICINO, SWITZERLAND**

SCHEYER, Torsten, Paläontologisches Institut und Museum, Karl Schmid-Strasse 4, Universität Zürich, CH-8006 Zürich, Switzerland; HUGI, Jasmina, Paläontologisches Institut und Museum, Karl Schmid-Strasse 4, Universität Zürich, CH-8006 Zürich, Switzerland; DELFINO, Massimo, Paläontologisches Institut und Museum, Karl Schmid-Strasse 4, Universität Zürich, CH-8006 Zürich, Switzerland; SÁNCHEZ-VILLAGRA, Marcelo, Paläontologisches Institut und Museum, Karl Schmid-Strasse 4, Universität Zürich, CH-8006 Zürich, Switzerland

A fossil specimen represents only a snapshot of the ontogenesis spanning the time between fertilization to death of an individual, but it is important to gather as much ontogenetic data as possible for a fossil species if we wish to understand the evolution of extinct life histories. This is generally accomplished by studying growth series, and lately there is an increasing trend to incorporate ontogenetic aspects in paleobiological studies, and for evolutionary developmental biologists to consider fossils. These studies have been largely restricted to basal groups among Vertebrata (e.g., tetrapodomorphs, temnospondyl amphibians), basically because of exceptionally preserved fossils in these groups. Concurrently, major advances in the study and phylogenetic analyses of skeletal developmental events were achieved over the past two decades. Triassic marine reptiles are well suited to increase the scope of these

studies within Amniota. However, even in the UNESCO site of Monte San Giorgio, the most important fossil lagerstätte of marine reptiles from the Middle Triassic, the discovery of fossils of different age stages (embryos, juveniles, and adults) is still a rare circumstance. The most common fossil reptile groups, i.e., pachypleurosaurs and ichthyosaurs, yielded the best growth series so far. Furthermore, less comprehensive growth series are available for placodont reptiles, nothosaurs, and the early archosauromorph genera *Tanystropheus* and *Macrocnemus*. Limb development is studied in the four genera of pachypleurosaurs (three species of *Neusticosaurus* and one species of *Serpianosaurus* for the first time, and it is compared to other sauropterygian taxa, as well as with modern marine and non-marine reptiles, i.e., turtles and squamates. Long bone histology is used to access data on growth and paleoecology. It is inferred that it took ten to fifteen years for a specimen of *Mixosaurus* to reach an overall body length of approximately 100 cm. *Paraplocodus* long bone histology is similar to that of *Placodus*, i.e., pachyostotic in a broad sense, with the bones appearing more dense (osteosclerotic) than in the latter.

Poster Session III, (Friday)

**PERIPHERAL ELEMENTS AND 3D RECONSTRUCTION OF THE CRANIAL DOME OF '*PRENOCEPHALE*' *BREVIS* (ORNITHISCHIA: PACHYCEPHALOSAURIDAE) AND ITS SYSTEMATIC POSITION**

SCHOTT, Ryan, University of Toronto, Toronto, ON, Canada; EVANS, David, Royal Ontario Museum, Toronto, ON, Canada; BELL, Phil, University of Alberta, Edmonton, AB, Canada

The squamosal is one of the most diagnostic bones in pachycephalosaurids, with most species identifiable solely on the basis of its morphology and associated ornamentation. Several of the most contentious pachycephalosaurid taxa from the Campanian of North America have been erected on the basis of isolated frontoparietals while diagnostic peripheral bones remain unknown. For nearly a century the taxon '*Prenocephale*' *brevis* (originally *Stegoceras brevis*), from the Belly River Group of Alberta, has been known only from isolated frontoparietals. Due largely to a lack of a complete parietosquamosal bar, this taxon has been highly problematic. It has been widely synonymized with *Stegoceras validum*, but also recognized as a distinct taxon in two different genera, originally *Stegoceras* and more recently *Prenocephale*. Currently no consensus has been reached on its taxonomic or systematic placement. New peripheral skull bones, including two postorbitals and a well-preserved squamosal are identified here as pertaining to '*P.*' *brevis* based on the shape of their contact with the dome and the pitted surface texture that is characteristic of the taxon. Detailed laser surface scans of these peripheral bones and a complete frontoparietal were used to assemble a 3D reconstruction of the posterior peripheral margin of the skull dome that provides the most complete picture of this taxon to date. The parietosquamosal bar includes a primary row of 6 nodes on its posterior border. The posterior region of the squamosal is devoid of the minute nodes found in *S. validum*, but does have a prominent lateroventral corner node, as in *Prenocephale*. In posterior view, the squamosal is distinctly sloped ventrolaterally, as in *Sphaerotholus* and *Prenocephale*, but it maintains the same depth throughout its width. Preliminary phylogenetic analyses using this new morphological data definitively rejects the notion that '*P.*' *brevis* is closely related to *S. validum*, and indicates that it is a distinct taxon more closely related to *Sphaerotholus*. These results are an important step towards an increased understanding of pachycephalosaurid evolution and diversity during the Late Cretaceous.

Poster Session I, (Wednesday)

***CRETALAMNA APPENDICULATA* (LAMNIFORMES: CRETOXYRHINIDAE) TEETH FROM THE PARI AIKE FORMATION (MAASTRICHTIAN) OF SANTA CRUZ PROVINCE, ARGENTINA**

SCHROETER, Elena, Drexel University, Philadelphia, PA, USA; LACOVARA, Kenneth, Drexel University, Philadelphia, PA, USA

Recent work in the Pari Aike formation (Maastrichtian) of Santa Cruz Province, Argentina, has yielded numerous shark teeth, including two nearly complete specimens. One is assigned as an anterior tooth of *Cretalamna appendiculata* on the basis of the following characters: an erect, smooth cusp with a flat labial face and a strongly convex lingual face; a weakly sigmoid, non-serrated cutting edge; a crown taller than it is wide; one pair of triangular cusplets; a pronounced lingual protuberance that is medially restricted and lacks a nutrient groove; a bilobate root with root lobes approximately equal in length; a deeply indented, U-shaped basal concavity. A second specimen displaying a broader basal concavity and a less pronounced lingual protuberance is tentatively assigned as an intermediate tooth of *C. appendiculata*; a missing root lobe obscures definitive placement within the jaw. Though characterized as a cosmopolitan species by various authors, the majority of material described as *C. appendiculata* comes from the northern hemisphere. Only a scant number of occurrences are documented in the southern hemisphere, and previously published localities are limited to the African (Morocco, Angola, Madagascar) and Australian continents. This is first documentation of *Cretalamna appendiculata* from southernmost Patagonia, thus extending the known geographical distribution of the species and lending further support to its characterization as global.

Poster Session III, (Friday)

**PLIONARCTOS (URSIDAE; TREMARCTINAE) FROM THE GRAY FOSSIL SITE WITH A REEVALUATION OF THE GENUS**

SCHUBERT, Blaine, East Tennessee State University, Johnson City, TN, USA; WALLACE, Steven, East Tennessee State University, Johnson City, TN, USA; SOIBELZON, Leopoldo, Museo de La Plata, La Plata, Argentina

The Gray Fossil Site (GFS) of northeastern Tennessee, USA is the only Mio-Pliocene fossil locality in the Appalachian Highlands and is producing a unique and diverse fauna from a forested environment. This ecological setting is well established based on plant fossils, isotopic analyses, and the recovered fauna. New species only known from the GFS include an ailurine panda (*Pristinailurus bristoli*) and Eurasian woodland badger (*Arctomeles dimolodontus*); both of which have forest affinities. In sum, the GFS is a sinkhole pond deposit dated to late Hemphillian using mammalian biochronology: the extinction of the rhinoceros *Teloceras* ~ 4.5 Ma and appearance of tremarctine bears ~ 7 Ma. Other recovered mammals are consistent with this age assignment. Bears are represented at GFS by mandibular and dental remains of the small tremarctine, *Plionarctos*. Two species are described in the literature, *P. edensis* and *P. harroldorum*; both from western North America. Previous researchers considered these taxa to represent an anagenetic lineage, with the late Hemphillian – early Blancan *P. edensis* as the precursor of *P. harroldorum* (only recorded from the early Blancan). While *Plionarctos* specimens are known from central and eastern North America, most are isolated teeth, and none are assigned to species level. Specimens from the GFS include one dentary with teeth, one edentulous dentary, and isolated lower teeth. The described morphological features that separate *P. edensis* and *P. harroldorum* are primarily located on the M1 and M2. However, proportional differences in size and shape of m1 and m2 are also noted in the diagnoses. Based on these dimensions the GFS *Plionarctos* diverges more from both *P. edensis* and *P. harroldorum* than they do to each other. Whether or not this indicates a third species of *Plionarctos* or regional variation is not yet clear. Because living ursid species exhibit morphological plasticity in dental dimensions we proceed cautiously with the specific diagnosis of the GFS *Plionarctos* specimens.

Poster Session II, (Thursday)

**FUNCTIONAL ANALYSIS OF PRETRIBOSPHEMIC MAMMALIAN TEETH**

SCHULTZ, Julia, Steinmann-Institut fuer Geologie, Mineralogie und Palaeontologie, Bonn, Germany; MARTIN, Thomas, Steinmann-Institut fuer Geologie, Mineralogie und Palaeontologie, Bonn, Germany

The therian tribosphenic molar originated in the basal Cretaceous and gave rise to a great functional and morphological dental diversity. During the Jurassic in various mammalian lineages molar patterns evolved which were functionally close or even equivalent to the tribosphenic pattern. By evolving a combined cutting and crushing function new food resources became accessible which is probably related to the upcoming angiosperms. For the understanding of the evolution of the tribosphenic functional pattern an analysis of the pretribosphenic dentition is crucial. High resolution microtomography of Jurassic dryolestid molars was applied to obtain 3D models of the occlusal surface, and occlusal relationships and movements during mastication were analysed by virtual simulation. Dryolestid molars exhibit three characteristic wear facets which are formed during phase I of the chewing cycle. The first contact occurs between the shearing edges of the paracrista of the upper molar and the metacristid of the lower molar where cutting is performed. When the edges glide past each other the pair of shearing facets 1 is formed. During the formation of facet pair 1, the metacrista of the upper molar meets the paracristid of the adjacent lower molar and facet pair 2 is formed which also has cutting function. The formation of facet pair 1 ends when the paracone shears down the labially open guiding groove of the talonid. Subsequently shearing facet 3 is formed covering the concave surface of the groove. Centric occlusion is achieved when the movement along facet 3 ends. Striations indicate a diagonal lifting of the lower jaw at about 45°. From attrition tracks on two additional wear facets a short phase II of the power stroke can be clearly identified. Our results show that in stem therians of the pretribosphenic stage a considerable lateral jaw movement occurred with a two phase chewing cycle with emphasis on phase I where the main shearing surfaces are formed.

Poster Session IV, (Saturday)

**BODY SIZE EVOLUTION IN LEPTOMERYX AND RHINOCEROTINAE (SUBHYRACODON AND TRIGONIAS) ACROSS THE EOCENE - OLIGOCENE (CHADRONIAN - ORELLAN) BOUNDARY**

SCHULTZ, Wendy, University of Colorado at Boulder, Boulder, CO, USA; EBERLE, Jaelyn, University of Colorado at Boulder, Boulder, CO, USA

Research has shown that there was dramatic climate change, specifically a significant drop in temperature, across the Eocene – Oligocene (Chadronian – Orellan) boundary. However, few studies have looked at the effects of this climatic deterioration on the terrestrial vertebrate fauna. This study focuses on changes in mammalian body size across the Chadronian – Orellan transition, in particular within the small-bodied artiodactyl *Leptomeryx* and the large rhinocerotine perissodactyls, based upon fossils from the White River Group in the Northern Plains (Colorado, Wyoming, Nebraska, and South Dakota). Specifically, we tested whether Bergmann's Rule (which suggest that in a given taxon, the colder climate populations will

be larger than the warmer climate populations) correlates with climatic cooling across the Chadronian-Orellan boundary. With regard to the rhinocerotines, we used *Trigonias*, *Subhyracodon*, and specimens identified as Rhinocerotinae gen. indet. On the latter, these specimens are missing their anterior dentition (which is what differentiates teeth of *Trigonias* from *Subhyracodon*) and consequently were simply identified only as Rhinocerotinae genus indet. Length and width measurements of upper and lower molars were used as a proxy for body size of both Chadronian and Orellan representatives of two lineages of *Leptomeryx*, (*L. speciosus* – *L. evansi* lineage and *L. yoderi* – *L. mammifer* – *L. exilis* lineage). The Rhinocerotinae show a significant decrease in tooth size across the Chadronian-Orellan transition (N=184, p<0.02). With regard to the two lineages of *Leptomeryx* (N=441), although others have noted that only one survived the Eocene-Oligocene transition, this research suggest that both lineages survived this boundary and saw a significant decrease in tooth size in the Orellan (p<0.03). Quite unexpectedly, these results are the opposite of what is expected by Bergmann's Rule as well as Cope's Rule, the idea that lineages grow larger over time. Our data suggests that other factors, besides climatic cooling, also need to be considered in mammalian body size evolution across the Eocene-Oligocene boundary.

Technical Session VII, Thursday 3:00

**THREE-DIMENSIONAL MICROTTEXTURE ANALYSIS - A NEW APPROACH FOR DIETARY RECONSTRUCTION**

SCHULZ, Ellen, Biocenter Grindel and Zoological Museum, Hamburg, Germany; CALANDRA, Ivan, Biocenter Grindel and Zoological Museum, Hamburg, Germany; KAISER, Thomas, Biocenter Grindel and Zoological Museum, Hamburg, Germany

A diverse set of two dimensional analytic tools has been so far successfully applied to analyze tooth enamel wear facets and infer dietary traits of extant and fossil herbivorous mammals at different levels of resolution. The chewing process in mammals is functionally complex and not yet understood in detail. Taking into account that chewing function always involves surface interaction dominated by wear, established technical standards in quantifying wear are proposed to allow inference on both dental function at the level of an individual wear facet and diet at the level of an individual animal. For the first time, we therefore establish a system of dental wear evaluation strictly based on industrial engineering standards and parameters set by the International Standardization Organization (ISO). 2D and 3D-ISO roughness parameters are computed using metrology software as is the standard in technical protocols. We link these parameters with dental wear using 3D-topographic models of tooth enamel wear surfaces acquired with a high resolution confocal surface measuring system. As a fully quantitative approach to dental wear evaluation, we find ISO-roughness parameters particular robust as no intra- nor inter- observer errors are involved. Extant ungulates representing different well known dietary traits are analyzed for intra-facet, intra-tooth and inter-species tooth enamel surface variations. Sixteen well defined tooth enamel facets of upper and lower premolars and molars are tested for each species and new functional indices are identified.

Poster Session IV, (Saturday)

**EPAXIAL TRUNK MUSCULATURE AND LIGAMENTS IN DIPODOCIDS AND DICRAEOSAURIDS (DINOSAURIA: SAUROPODA) AND THEIR POSTURAL FUNCTION DURING LOCOMOTION**

SCHWARZ-WINGS, Daniela, Museum für Naturkunde, Berlin, Germany

Trunk ligaments and thoracic epaxial muscles of diplocid and dicraeosaurid sauropods were reconstructed using the Extant Phylogenetic Bracket approach. Osteological correlates permit reconstruction of ligamentum elasticum interspinale and ligamentum supraspinosum, muscle fibers and the tendons of m. transversospinalis, m. longissimus dorsi and m. iliocostalis (Level I inference), and of a deep layer of m. transversospinalis (Level I inference). Based on these reconstructions, m. transversospinalis was the largest of the dorsal epaxial trunk muscles in these sauropods and comprised at least two crosswise running tendons homologous to those of crocodylians and avians. During synchronous contraction, this tendon lattice would, through its direct connection to various neural spines, have braced the neural spines against each other, and would have been further supported in Dicraeosauridae by the enlarged mm. interspinales. Because of its vertical orientation, lateral to the vertebral bodies and along the height of the rib cage, and its extension from the preacetabular process of the ilium over the dorsal rib cage, unilateral contraction of a large m. iliocostalis would bend the dorsal vertebral column to the contracted side, whereas bilateral contraction of m. iliocostalis would stiffen the trunk against such lateral bending. However, lateral bending of the vertebral column was strongly reduced by a bony articulation between the neural arches (hyposphen-hypantrum articulation), and epaxial muscles of diplococids and dicraeosaurids most probably had a more important role in hindering unwanted flexions of the vertebral column during locomotion. This is consistent with the conditions in extant birds and mammals, in which the epaxial muscles are activated in a bilateral pattern associated with the support phases of the hindlimbs to provide postural support during locomotion. The large epaxial trunk muscles of diplococids and dicraeosaurids therefore were important in maintaining the stability of the dorsal vertebral column during various kinds of locomotion.

Poster Session I, (Wednesday)

**A NEW CLADE OF OSTEOSTRACANS FROM THE MACKENZIE MOUNTAINS, NWT, CANADA AND EVIDENCE FOR A DISPERSAL OF OSTEOSTRACANS FROM EUROPE INTO NORTHERN CANADA**

SCOTT, Bradley, University of Alberta, Edmonton, AB, Canada; WILSON, Mark, University of Alberta, Edmonton, AB, Canada

Located in the Mackenzie Mountains, NWT, Canada, the MOTH locality has yielded Lower Devonian vertebrate specimens of spectacular diversity and preservation. A major constituent of the diversity represented at this locality is the Osteostraci, a group of jawless early vertebrates considered by many to be the sister group to the gnathostomes. Previous descriptions of material from MOTH have yielded new species in three genera, including the monotypic *Superciliaspis*. Previously undescribed specimens are here recognized as new two species. Based on recently published characters and trees, a revised phylogenetic analysis places the new species within the Zenaspida and within a new clade that includes *Superciliaspis*. This clade is unique to MOTH and represents significant increase in zenaspidan diversity. The new species are included within the Zenaspida based on their expanded hypophysial division and united with *Superciliaspis* within the Zenaspida based on the interorbital distance being equal to the orbital breadth, and the lack of a superficial layer of the dermal skeleton. Zenaspida are primarily a Lower Devonian order with most of the members known from Europe. The zenaspidans *Diademaspis*, *Parameteoraspis*, and *Machairaspis* have previously been described from localities in northern Canada. Given the Lower Devonian age of MOTH and the new clade proposed here, along with previously documented relationships between European and Canadian taxa, there is evidence for at least one dispersal event of osteostracans from Europe into northern Canada preceding the Devonian period.

Poster Session III, (Friday)

**MOLECULAR DETERMINANTS OF MARSUPIAL MODULARITY AND CONSTRAINT**

SEARS, Karen, University of Illinois, Urbana, IL, USA

What are the factors responsible for generating mammalian biodiversity? To begin to answer this question, my lab is studying how development has influenced the evolution of one of the two major groups of living mammals, the marsupials (kangaroos, possums and their kin). Despite arising at the same time, marsupials have never achieved the taxonomic or morphologic diversity of eutherians (humans, bats, whales, etc.). Previous research demonstrated that this is due to marsupials being evolutionarily constrained by their reproductive mode, specifically by their newborn's forelimb-driven crawl to the teat. The marsupial hind limb plays no role in the crawl, and is less developed at birth. We are currently examining possible mechanisms for this constraint. Our research suggests that differential selective pressures imposed by the crawl on the fore- and hind limbs of marsupials decoupled their developmental networks. We studied the expression levels and patterns of genes (e.g., Bmp's, Wnt3, Shh, Fgf's, etc.) involved in the formation and maintenance of the two primary signaling centers of the developing limb bud (the AER and ZPA), and confirmed that the molecular basis of development of the marsupial fore- and hind limb is more dissimilar than in any studied amniote. We hypothesized that this decoupling resulted in a reduction in the phenotypic integration of marsupial fore- and hind limbs. To test this, we performed a phylogenetic and morphometric analysis of integration of the fore- and hind limbs of marsupials (n=6), eutherians (n=5), and monotremes (n=2). These analyses confirm that the marsupial fore- and hind limb are less integrated than in eutherians or monotremes, and support the hypothesis that the lower level of marsupial limb integration was the result of a reduction in integration on the marsupial lineage. With reduced limb integration, marsupial forelimbs would have been freed up to specialize for the crawl. With this specialization would have come the reduced developmental evolvability we have already demonstrated, and resultant evolutionary constraint. Eutherians, who develop internally and do not make a crawl, would not be constrained.

Edwin H. and Margaret M. Colbert Poster Competition (Thursday)

**RE-EVALUATION OF CHUANJIESAURUS ANAENSIS: OSTEOLOGY, PHYLOGENY AND BIOGEOGRAPHY OF SAUROPODS IN ASIA**  
SEKIYA, Toru, Jilin University, Changchun, China

*Chuanjiesaurus anaensis* was originally erected based on a postcranial skeleton (Lfch1001; *in situ*) from the Chuanjie Formation (Middle Jurassic) in Lufeng County, Yunnan Province, Southwest China. Although the holotype specimen is almost completely preserved, the osteological description and the classification were only briefly reported, and it was regarded as "Sauropoda *incertae sedis*." The holotype and referred specimen are described in detail, and the diagnosis is emended (For example, additional ridge besides the fibular condyle of the femur), result of cladistic analysis, and Principle Component Analysis (PCA) of femur of titanosaurid and Chinese sauropods. Although the phylogenetic position of *Chuanjiesaurus* is a sister taxon of *Mamenchisaurus* (Eusauropoda), the result of PCA shows close relationship of *Chuanjiesaurus* and Asian Titanosauriformes. Additionally, several autapomorphies of Titanosauriformes present in *Chuanjiesaurus* as follows: spongy bone structure in the presacral vertebrae, acute caudal margin of the dorsal pleurocoels, presence of the prespinal lamina on the dorsal spine, procoelous caudal centra, relatively proximal position of the neural arch of the caudal vertebrae, perpendicular pubic peduncle

of ilium against the sacral axis, undivided distal condyle of the metacarpal I. Furthermore, based on sauropod distribution and geographical isolation of Asia during the Middle Jurassic to Early Cretaceous, *Chuanjiesaurus anaensis* could be regarded as an ancestor of Chinese Titanosauriformes.

Poster Session IV, (Saturday)

**WHAT DOES MESOWEAR ANALYSIS OF NORTH AMERICAN CHALICOTHERIIDAE (MAMMALIA, PERISSODACTYLA) REVEAL ABOUT DIFFERENCES IN FEEDING BEHAVIOR AMONG CHALICOTHERES FROM TWO CONTINENTS?**

SEMPREBON, Gina, Bay Path College, Longmeadow, MA, USA; FAHLKE, Julia, Steinmann-Institut für Geologie, Mineralogie und Paläontologie, Universität Bonn, Bonn, Germany; COOMBS, Margery, University of Massachusetts, Amherst, MA, USA

To supplement current studies of chalicotherid diet by low magnification stereoscopic microwear, we explored molar tooth surfaces of selected Miocene North American chalicotheres (*Tylocephalonyx skinneri*, *Moropus elatus*, *Moropus merriami*) using macroscopic facet development (mesowear analysis). This technique measures the relative abrasion surface attrition imposed on molar teeth cumulatively during the lifetime of an individual animal. We then compared our results to published mesowear results on European chalicotheres as well as to other paleodietary information available for chalicotheres. While chalicotheres have often been reconstructed as browsing folivores, the mesowear signatures of both North American and European taxa are clearly not similar to those of typical extant leaf browsers. Instead, with one exception, they clearly indicate the consumption of some more abrasive plant material in addition to leaves. We also find distinctive differences between the North American taxa we studied and certain European taxa. In particular, the North American schizotheriine chalicotheres (*Tylocephalonyx* and *Moropus*) have less abrasive mesowear signatures overall than the two European chalicotherines (*Anisodon* and *Chalicotherium*.) At the same time, the two North American schizotheriines showed similar mesowear patterns to the European schizotheriine *Metaschizotherium*. Of the North American taxa studied, *Tylocephalonyx* has a more abrasive mesowear signature than *Moropus*. *M. elatus* from similarly aged latest Arikarean faunas of the Agate Quarries and Morava Ranch Quarry seem to have eaten similar diets. *M. merriami* apparently had the least abrasive diet of all chalicotheriid taxa analyzed so far, being the only one with a browser's signature. The mesowear results complement microscopic enamel scar patterns (as measured by microwear analysis), and it is apparent that both North American and European chalicotheres were unusual browsers. Our analyses suggest that these unusual clawed herbivores may have supplemented a leaf diet in some cases by stripping off bark and in others by gaining access to tough fruits and/or seeds.

Poster Session IV, (Saturday)

**A NEW, MIDDLE TRIASSIC TEMNOSPONDYL FROM INDIA**

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The Middle Triassic Denwa Formation of the Satpura Gondwana basin of India has yielded an almost complete skull and mandibles of a new temnospondyl amphibian. The specimen is similar to *Hadrokkosaurus bradyi*, a brachyopid known from the Moenkopi Formation of Western United States. The skull of *Hadrokkosaurus* is parabolic with large orbits and unusual quadratojugal emargination. The type specimen of *Hadrokkosaurus* was an isolated right mandible. The mandible was later connected to the skull that was not articulated with the mandible. The mandible of *Hadrokkosaurus* has labyrinthine teeth and an external mandibular fenestra like the archosaurs. Recently, the skull and mandible of *Hadrokkosaurus* have been taxonomically separated. The skull has been designated as *Vigilius welllesi* and the mandible as "Brachyopoida *incertae sedis*". In this backdrop, the new temnospondyl that was collected from central India becomes important. The skull and the mandibles of the new taxon are very similar to those of "*Hadrokkosaurus*". Thus, the new taxon from India, with skull and associated mandibles, reaffirm the validity of *Hadrokkosaurus bradyi*. The new taxon has a vaulted palate, large orbits and unusually long retroarticular processes of the mandibles. It also has an external mandibular fenestra and large openings at its cheeks. The combination of the above characters is not noted in any other temnospondyl genera apart from *Hadrokkosaurus* (*Vigilius*) and *Vanastega*, another Middle Triassic genus from South Africa. So far, both the taxa are included within the Brachyopoida. However, the discovery of the new temnospondyl indicates the presence of a distinct group during the Middle Triassic that may include *Vigilius*, *Vanastega* and the new taxon. On the other hand, the mandibles of the new taxon show similarity with the mandibles of *Plagiosuchus pustuliferus*, a plagiosaurid, from Middle Triassic of Germany. Hence the group shares few characters with the coeval plagiosaurids.

**THE UNUSUAL SOUTH AMERICAN PELOMEDUSOID TURTLE, ARARIPEMYS, DISCOVERED IN AFRICA**

SERENO, Paul, University of Chicago, Chicago, IL, USA; ELSHAFIE, Sara, University of Chicago, Chicago, IL, USA

An articulated, well preserved skull and postcranial skeleton of a turtle was discovered in the Lower Cretaceous (Aptian-Albian) ElRhaz Formation in Niger. Many features link this new species with the pelomedusoid pleurodire *Araripemys barretoii* from similar age sediments in northeast Brazil, including the very flat carapace with the first costal forming much of the anterior margin, anteriorly prominent epiplastra, and median plastral vacuities. The carapace and plastra, as well as the maxilla, exhibit a distinctive scrawled, pitted texture. Several features further develop those in the type species that are already unusual among turtles. The epiplastra are more pointed and project farther past the anterior margin of the carapace. The skull is proportionately larger than that of the type species, measuring approximately one-fourth, rather than one-fifth, the length of the carapace. The skull of this new species is proportionately very low with greatest depth anteriorly, where the orbital margin is gently telescoped. Other cranial features include a deep cheek emargination with a posterior prong formed by the maxilla, and a slender, ventrally curved dentary ramus with terminal squared chin. The elongate cervicals have centra four times longer than anterior centrum diameter, and the limbs appear to be reduced in size relative to *A. barretoii*. The presence of closely related species of the derived freshwater pelomedusoid *Araripemys* in Brazil and Niger at approximately 110 Ma provides additional evidence of faunal exchange between South America and Africa prior to the opening of the Atlantic Ocean.

Technical Session XII, Friday 3:30

**MORPHOLOGY AND SYSTEMATICS OF THE NOTOSUCHIAN CROCODYLIFORM SIMOSUCHUS CLARKI FROM THE LATE CRETACEOUS OF MADAGASCAR**

SERTICH, Joseph, Stony Brook University, Stony Brook, NY, USA; KLEY, Nathan, Stony Brook University, Stony Brook, NY, USA; TURNER, Alan, Stony Brook University, Stony Brook, NY, USA; GEORGI, Justin, Midwestern University, Glendale, AZ, USA; KRAUSE, David, Stony Brook University, Stony Brook, NY, USA

The initial discovery over a decade ago of a remarkably complete articulated anterior skeleton of *Simosuchus clarki* from the Maastrichtian Maevarano Formation of northwestern Madagascar revealed a bizarre, pug-nosed notosuchian crocodyliform with numerous derived cranial features. Subsequent discoveries of three additional partial and nearly complete skeletons and numerous isolated elements referable to *S. clarki* fill key gaps in the skeleton permitting a detailed and comprehensive description and analysis of nearly the entire cranial and postcranial skeleton. Among the most notable features of the tall foreshortened skull are its transversely oriented premaxillae, enlarged laterally directed orbits, ventrally positioned quadrate condyles, broad and complex secondary palate, and multicuspined foliiform teeth. The jaw and tooth morphologies indicate cropping and shearing functions consistent with an herbivorous diet. Though typically crocodyliform in overall morphology, the postcranial skeleton preserves several derived features indicative of a primarily terrestrial habitus, including a short tail and robust appendicular elements. The postcranial axial skeleton includes 8 cervical vertebrae, at least 15 dorsal vertebrae, 2 sacral vertebrae, and at least 15 caudal vertebrae with morphology indicative of a relatively mobile neck but relatively immobile trunk. The postcranial appendicular skeleton is notable for its relative robustness including well developed proximal limb elements with hypertrophied proximal muscle attachments. Features of the appendicular skeleton are consistent with a non-cursorial crocodyliform capable of semi-erect posture with hypertrophy of pectoral and pelvic musculature related to a relatively inflexible trunk. A cladistic analysis of 302 morphological characters distributed among 90 crocodyliform taxa was conducted to assess the relationship of *Simosuchus* within Mesoeucrocodylia. In all most parsimonious trees, *Simosuchus* occupies a basal position within a derived clade of notosuchians, a topology supporting a widespread Gondwanan distribution of notosuchians by the "middle" Cretaceous.

Poster Session I, (Wednesday)

**THE LATE JURASSIC FISH ASSEMBLAGE FROM THE CANADON CALCAREO FORMATION OF PATAGONIA**

SFERCO, Emilia, Bayerische Staatsammlung fuer Palaeontologie und Geologie, Munich, Germany; RAUHUT, Oliver, Bayerische Staatsammlung fuer Palaeontologie und Geologie, Munich, Germany; LÓPEZ-ARBARELLO, Adriana, Bayerische Staatsammlung fuer Palaeontologie und Geologie, Munich, Germany

The Cañadón Calcáreo Formation, Argentina, bears one the few Late Jurassic freshwater fish faunas known so far. Only two other important freshwater fish assemblages of Late Jurassic age are known, the Talbragar beds in Australia and the Morrison Formation in USA. The main fish-bearing stratum of the Cañadón Calcáreo Formation is found in at least six widely spread localities, up to 30 km apart from each other, all of which have a remarkably uniform fish composition. This suggests that a single large lake, or a series of smaller interconnected lakes were present. The absence of fossil plants and tetrapods support the hypothesis of a single large lake. Although a total of up to 60 m of lacustrine sediments are present at the base of the formation, abundant fishes only occur in a single layer of some 80 cm near the

top of the sequence in the majority of known localities. Only in the most distant locality of Sierra de la Manea, several fish layers and desiccation cracks can be recognized, indicating closer proximity to the coast of the lake. This stratigraphically isolated occurrence of fish remains in the basal lacustrine part of the formation indicates that these layers represent mass mortality events, possibly associated with volcanic activity. Every studied locality shows the same association of teleosts with basal chondrosteans, with a marked dominance of teleosts. Together with the occurrence of chondrosteans specimens with teleost remains in their digestive system, this suggests a predator-prey relationship among these taxa. Interestingly, recent fieldwork resulted in the discovery of a second fish-bearing level within the formation, some 50 m above the layer in the basal part. This second layer is less than 50 cm thick and intercalated between fluvial sandstones, but also seems to be dominated by teleosts. The fish association of the Cañadón Calcáreo Formation thus seems to be remarkably similar to that of the roughly contemporaneous Talbragar Beds. The latter also contain abundant teleosts and rarer chondrosteans (together with a few other taxa) that occur in a mass-mortality layer due to volcanic activity within a fresh water environment.

Edwin H. and Margaret M. Colbert Poster Competition (Thursday)

**WHERE ARE YOU, ERNANODON? MORPHOLOGICAL AND BIOMECHANICAL MORPHOMETRIC ANALYSES OF ERNANODON ANTELIOS TO XENARTHRA AND OTHER MAMMALS**

SHAW, Barbara, Portland State University, Portland, OR, USA

*Ernanodon antelios* was found in the Paleocene strata from Guangdong, China. When described, it was placed with Superorder Xenarthra (Orders Pilosa including anteaters, tree and ground sloths, and Cingulata including armadillos, glyptodonts, and pampatheres) although the biogeography did not support this inclusion. Xenarthrans are hypothesized to have originated from Gondwanan ancestors and were isolated on South America for ~90 million years. They retained a host of plesiomorphic characters while amassing unique derived traits that together robustly support this group as a monophyly. Since *Ernanodon* is a single specimen, most statistical test assumptions are violated. Therefore two different approaches were used to support the exclusion of *Ernanodon antelios* from Xenarthra. The first approach was a morphological investigation to evaluate the position of *Ernanodon* with 42 extinct and extant xenarthrans, *Orycteropus afer*, two Pholidota species (*Manis gigantea*, *Manis pentadactyla*), and as the outgroup, *Didelphis virginiana* by scoring 167 morphological characters, and analyzing those data with PAUP and Mr. Bayes. The convergent pholidotans are grouped with the Pilosa, and some work remains to separate them. *Ernanodon* is sister taxon to the outgroup, *O. afer* is sister taxon to *Ernanodon*, and Cingulata and Pilosa are sister taxa to *O. afer*, supporting the hypothesis that *Ernanodon* does not belong to the Superorder Xenarthra. The second approach was a biomechanical morphometric investigation to examine variability of mobility among and within genera. In the first study, 44 measurements from 21 extant and 51 extinct xenarthran species together with *Ernanodon*, and in the second study, 23 measurements from 38 xenarthran, 19 eutherian, 1 metatherian and 1 prototherian species and *Ernanodon* were used, analyzing those data with Principal Component Analysis. The results group all Xenarthra together within the 95% confidence ellipsoid and with a significantly different slope than all other mammals, including *Ernanodon*. It is therefore recommended that *Ernanodon antelios* be excluded from Superorder Xenarthra.

Poster Session I, (Wednesday)

**A REMARKABLE CASE OF A SHARK-BITTEN ELASMO SAURID PLESIOSAUR FROM THE UPPER CRETACEOUS OF JAPAN**

SHIMADA, Kenshu, DePaul Univ., Chicago, IL, USA; TSUIHIIJI, Takanobu, National Museum of Nature and Science, Tokyo, Japan; SATO, Tamaki, Tokyo Gakuji University, Tokyo, Japan; HASEGAWA, Yoshikazu, Gunma Museum of Natural History, Tomimoka, Japan

*Cretalamna* (= *Cretalamna appendiculata* (Agassiz)) is a medium-sized lamniform shark known from Early Cretaceous-Paleocene marine deposits nearly worldwide. It is thought to be an ecological generalist with small to medium-sized bony fishes as its previously inferred primary diet. Here, we report 87 teeth of *C. appendiculata* that co-occurred with a partial skeleton (holotype) of a large (estimated range of 6.4-9.2 m) elasmosaurid plesiosaur, *Futabasaurus suzukii* Sato, Hasegawa, and Manabe, from the Upper Cretaceous of Japan. Five of them are tooth tips pierced in four separate bones of the plesiosaur. Deposited at a nearshore environment likely below the fair-weather wave-base, the association of these fossils is interpreted as a case of feeding on the plesiosaur by multiple individuals of *C. appendiculata*. Although the cause of the death of the plesiosaur cannot be ascertained, our study suggests that at least six or seven shark individuals possibly ranging as much as 1.5-4.2 m in total length scavenged the plesiosaur carcass. Combined with the fact that the skeleton of *F. suzukii* is largely articulated and lacks evidence for the bloat-and-float scenario, the plesiosaur carcass was likely buried in less than a few months after its death. The present fossil record is significant because it constitutes the first direct evidence suggesting that the diet of *C. appendiculata* included plesiosaurs. In addition, the fact that the teeth consist of different sizes indicates that small (young) and large (old) individuals of *C. appendiculata* inhabited the same water. This fossil record represents one of the most remarkable cases of shark feeding in the fossil record.

Technical Session II, Wednesday 11:15

#### FEEDING MECHANISM OF LARGE MESOZOIC FOSSIL CHIMAERIDS (CHONDRICHTHYES, HOLOCEPHAL): HOW LARGE A SHELL COULD THEY CRUSH?

SHIN, Ji-Yeon, University of California, Davis, Davis, CA, USA; MOTANI, Ryoosuke, University of California, Davis, Davis, CA, USA

Holocephalans are well adapted to durophagy, feeding upon hard prey, with their massive toothplates equipped with hypermineralized pads providing a molariform-crushing surface called tritons. Some fossil chimaeroids possessed the largest toothplates (up to 20cm long) known in holocephalans, suggesting they could have consumed larger and stronger prey than their living relatives. *Edaphodon* commonly co-occurs in the Cretaceous with inoceramids, which could reach more than 1m in length and up to 1cm in shell thickness. So it is important to test if the genus could crush some of these large bivalves. I estimated the maximum theoretical bite force in two fossil chimaeroid genera, *Ischyodus* and *Edaphodon*, to determine their feeding performance. Bite force was calculated using lever mechanics and estimated cross-sectional areas of adductor mandibulae muscles. A preliminary theoretical bite force analysis suggested a range of 210-866N from anteriorly to posteriorly in the jaw of *Edaphodon* (estimated total length of 305cm) and 232-939N for *Ischyodus* (333cm). Published data on the extant chimaeroid, *Hydrolagus colliei* (body size range of 21-44cm) show that bite force ranges from 11-191N including both anterior and posterior values. I also measured shell strength of the extant bivalve *Tapes philippinarum* and the gastropod *Tegula funebris* to compare the values with the calculated theoretical bite forces. During the shell strength analysis, metal casts of *Edaphodon* toothplates were attached to a stress analyzer to investigate the crushing performance of the tritons. The crushing test showed that tritons not only provided crushing surface but also held and stabilized the prey effectively. The measured shell strength ranged from 52-253N for bivalves with shell lengths 3.2-5.3cm and 107-908N for gastropods with shell lengths 1.1-2.7cm. Bite force estimates and extrapolations from the shell strength measurements suggest that *Ischyodus* and *Edaphodon* were capable of generating sufficient bite force to consume bivalves within gape size limitations while crushing rigid gastropod shells were mechanically challenging.

Technical Session XVI, Saturday 9:15

#### PHYLOGENETIC ANALYSIS OF RELATIONSHIPS AMONG TRADITIONAL FAMILIES OF NOTUNGULATA USING POSTCRANIAL CHARACTERS

SHOCKEY, Bruce, Manhattan College and AMNH, New York, NY, USA; FLYNN, John, American Museum of Natural History, New York, NY, USA; CROFT, Darin, Case Western Reserve University, Cleveland, OH, USA; WYSS, André, University of California, Santa Barbara, Santa Barbara, CA, USA; NEINAST, Alexandra, New York University, New York, NY, USA

Proposed hypotheses for intraordinal relationships of Notoungulata consistently have shown two post-Eocene clades, Typotheria and Toxodontia, as well as some early Cenozoic basal groups (e.g., Henricosborniidae, Notostylopidae). Although recent phylogenetic analyses have rigorously examined within-family relationships, little has been published on inter-familial relationships. Most have concentrated on cranium-dental morphology, leaving the postcranial skeleton largely unexplored. The present phylogenetic work, a component of a larger multi-system investigation of notoungulate phylogeny, thus focuses on the postcranial skeleton. This analysis fails to provide support for the traditional Typotheria-Toxodontia dichotomy. The “advanced Toxodontia” (including leontiniids, notohippids, and toxodontids) can be recognized by postcranial synapomorphies, including neckless astragalus, down-curved olecranon process, and lack of a medial epicondylar foramen of the humerus. The “advanced Toxodontia” further share an enlarged, subquadrate fibular facet of the calcaneum and a nearly vertical ectal articulation between the calcaneum and astragalus with *Eurygenium pacegnum* (previously considered a notohippid) and intertheriine intertheriids, a group traditionally placed in the Typotheria (postcranial skeleton of basal intertheriids remains unknown). In conflict with previous hypotheses, no postcranial characters unite the Isotemniidae with other taxa typically placed in the Toxodontia. Typotheria, as generally recognized, appear to be paraphyletic relative to “advanced toxodonts”. Of the typotheria taxa for which postcranial material are known, the Mesotheriidae possess a robust form of an otherwise plesiomorphic notoungulate skeleton: pentadactyl hands and feet, short, uncompact metapodia, upwardly curved olecranon process, astragalus with elongated neck and with separation of tibial trochlea from the digital flexor groove. Mesotheriine mesotheres, however, are characterized by a distinctive pelvis having extra fused sacral vertebrae (up to 9) and ischium-sacrum fusion. Hegetotheres show fusion of the tibia and fibula, which is extensive (rabbit-like) in the pachyrhines.

New Perspectives on the Early Evolutionary History of the Synapsida, Saturday 11:45

#### NEW INFORMATION ABOUT CYNODONTS FROM THE MIDDLE TRIASSIC MANDA BEDS (RUHUHU BASIN) OF TANZANIA

SIDOR, Christian, University of Washington, Seattle, WA, USA; KENNETH, Angielczyk, The Field Museum, Chicago, IL, USA; HOPSON, James, University of Chicago, Chicago, IL, USA; KAMMERER, Christian, University of Chicago, Chicago, IL, USA; SMITH, Roger, South African Museum, Cape Town, South Africa

The Ruhuhu Basin of southern Tanzania is one of several rift basins in East Africa containing nonmarine rocks broadly contemporaneous with those of the South African

Karoo. Expeditions to the Ruhuhu in the 1930s and 1960s recognized the presence of several fossiliferous horizons containing Permian and Triassic tetrapods. In 2007 and 2008, our team returned to the Ruhuhu to make the first paleontological collections in over 40 years. The most abundant therapsid fossils collected in the Lifua Member of the Manda Beds were the remains of cynodonts, including *Aleodon*, *Cricodon*, *Scalenodon angustifrons*, and ‘*Scalenodon hirschsoni*. Historical collections of these taxa are typically limited to a few, mostly fragmentary, specimens. Our fieldwork has produced extensive well-preserved cranial and postcranial materials, many representing the first known postcranial elements for their respective taxa. The probainognathian *Aleodon brachyrhamphus* numerically dominates the new collection, with partial skulls, isolated jaws, and postcranial elements. The new collection also includes multiple complete skulls of the traversodontid *Scalenodon angustifrons* and cranial and postcranial materials of the trirachodontid *Cricodon metabolus*. In addition to the completeness and fine preservation of the new fossils, this collection is remarkable for including growth series for *S. angustifrons* and *Aleodon*. The Manda cynodont fauna is comparable to the Anisian faunas of the *Cynognathus* C Zone in South Africa, the upper Omingonde Formation in Namibia, and upper N’taware Formation in Zambia. However, the Tanzanian fauna is more diverse taxonomically, with seven nominal species (those noted above plus *Luangwa*, ‘*Scalenodon attridgei*, and ‘*S. charigi*). Moreover, none of the other African cynodont faunas co-occur with abundant archosauriforms, suggesting that the Manda preserves a distinct habitat. Ongoing preparation and analysis of the new cynodont material will shed light on character polarities within Eucynodontia and Traversodontidae, as well as on the phylogenetic position of taxa such as *Aleodon*.

Romer Prize Session, Thursday 9:45

#### THE FIRST COMPLETE SKELETAL DESCRIPTION OF THE PUTATIVE STEM LISSAMPHIBIAN *DOLESERPETON* (TEMNOSPONDYL: DISSORPHOIDEA) SHEDS NEW LIGHT ON THE ORIGIN OF MODERN AMPHIBIANS

SIGURDSEN, Trond, McGill University, Montreal, QB, Canada

The Permian amphibamid *Doleserpeton* has often been suggested as a close relative of modern amphibians (Lissamphibia), but the skeletal morphology of this important form has never been described in full. An overview of its anatomy reveals numerous features that shed light on the origin of lissamphibians. As in other amphibamids, the interpterygoid vacuities of *Doleserpeton* are bordered by the pterygoid, parasphenoid, vomer, and palatine elements, but the palate lacks the ectopterygoid bone. These traits are shared with anurans, caudates (although the palatine is absent in salamanders), and the primitive Jurassic caecilian *Eocaecilia*. These taxa also share the presence of a transverse tooth row on the vomer with *Doleserpeton*. Such features are usually absent in lepospondyls and primitive tetrapods. The otic region and hearing system resemble those of anurans, as has been pointed out by several authors. The postcranial skeleton of *Doleserpeton* is in some regards typical for temnospondyls. However, it has a combination of primitive and derived traits that are consistent with lissamphibian affinities. Since it was first noted that *Doleserpeton* had pedicellate bicuspid teeth, a number of other fossil forms have been described as having tooth morphologies similar to those of modern amphibians. A review of these descriptions reveals that *Doleserpeton* remains the Paleozoic taxon with the most lissamphibian-like tooth morphology, including an elongated cylindrical base (pedicel) easily separated from a bicuspid crown. Phylogenetic analyses of amphibamids using both Bayesian inference and maximum parsimony reveal problems with previous phylogenies. The amphibamid morphology is closer to the primitive temnospondyl condition than previously published character matrices indicate, and the interrelationships of individual amphibamid taxa are still poorly resolved. However, the derived features seen in such dissorophoid taxa as *Apateton*, *Gerobatrachus*, and *Doleserpeton* support the theory of lissamphibian origins within a paraphyletic Dissorophoidea.

Technical Session XIII, Friday 4:15

#### NEW INFORMATION ON THE MORPHOLOGY OF EMBRYONIC PROTOCERATOPSIAN AND HATCHLING ANKYLOSAUR DINOSAURS FROM BAYAN MANDAHU (INNER MONGOLIA, CHINA), USING MICRO-CT.

SISSONS, Robin, University of Alberta, Edmonton, AB, Canada

Excellent embryonic and hatchling dinosaur specimens were collected in 1988 and 1990 during the Sino-Canadian dinosaur expeditions in the Campanian redbeds of the Bayan Mandahu Formation (Inner Mongolian, China). Cranial and post-cranial material of two protoceratopsians and one ankylosaur, studied with the help of micro-CT data, represent the most complete neonate specimens described from the Gate and North Canyon areas of Bayan Mandahu. An embryonic protoceratopsian, cf. *Bagaceratops* (IVPP V16281), includes most of the skull and mandibles. A second embryonic specimen of cf. *Bagaceratops* (IVPP V16282) preserves a pair of mandibles and much of the postcranium. A partial cranium and postcranial skeleton of a hatchling ankylosaurian, cf. *Pinacosaurus*, was also collected. The protoceratopsian skull is truncated posteriorly, with several elements partially disarticulated and taphonomically shifted. Two structures on the tip of the rostral may have had a function similar to that of an egg tooth, the first such report in ornithischian dinosaurs. Despite being comparable to *Bagaceratops*, the nasals do not have a distinct horn core, although it is a very small structure in other juveniles of this taxon, and may not yet have been present in such a small individual. The predentary, even in an embryonic individual, is fully fused as one midline element, with no evidence of a bilateral origin as suggested by some researchers. Of

note also is the striking overall similarity between the teeth of protoceratopsians and some ankylosaurs. Small osteoderms are associated with the hatchling ankylosaur, perhaps the beginnings of half rings, which are present in juvenile individuals. The specimens provide an important window into ontogenetic stages that are rarely preserved, especially in the case of ankylosaurs, for which young individuals are rare.

Poster Session I, (Wednesday)

**NEW INFORMATION ON *KOKARTUS HONORARIUS* (LISSAMPHIBIA, CAUDATA) FROM THE MIDDLE JURASSIC OF KYRGYZSTAN**

SKUTSCHAS, Pavel, Saint Petersburg State University, Saint Petersburg, Russia

The Middle Jurassic Balabansai Svita in Kyrgyzstan has yielded one of the oldest and most primitive stem salamanders, *Kokartus honorarius*. *Kokartus* was briefly described on the base of fragmentary specimens. Nesov and others presented a skull reconstruction for *Kokartus* but did not provide any illustrations and descriptions of this material. They found that *Kokartus* is a paedomorphic animal having a quadratojugal (absent in crown group salamanders), abbreviated maxillae, and retaining a tooth bearing coronoid in the mandible. Averianov and others first noted the presence of a complex strap-like glenoid and supraglenoid foramen in scapulocoracoid in *Kokartus* and confirmed the most basal phylogenetic position of *Kokartus* within the Caudata. Study of all available materials additionally shows that *Kokartus* has an incisure between premaxillae, a character present in some branchyosaurid temnospondyls, only non-pedicellate monocuspid teeth, the spinal cord supports in vertebrae (synapomorphy of the Caudata). *Kokartus* has no the fontanelle between frontals and the pineal pit on the frontals. Presence of the abbreviated maxillae and tooth bearing coronoid in *Kokartus* is not obvious and the suggestion about paedomorphic nature of this animal needs further clarification. The outlines of some bones (premaxilla, parietal, frontal, squamosal, and pterygoid) clearly differ from that on previous reconstructions. The presence of the non-pedicellate teeth in *Kokartus* suggests that the pedicellate teeth might have evolved in parallel in the Salientia, non-lissamphibian temnospondyls, and Caudata.

Poster Session III, (Friday)

**A LATE TRIASSIC DINOSAUFORM ASSEMBLAGE FROM THE EAGLE BASIN (CHINLE FORMATION), COLORADO, U.S.A.**

SMALL, Bryan, Denver Museum of Nature and Science, Denver, CO, USA

Recent discoveries in the Upper Triassic Chinle Formation of New Mexico and Arizona, and the Dockum Group of Texas demonstrated non-dinosaurian dinosauriforms and non-dinosaurian dinosauriforms co-existed with basal saurischian and theropod dinosaurs. Here I report the discovery of dinosauriform elements from various localities in the Chinle Formation of the Eagle Basin, northwestern Colorado. All fossil discoveries occur in the upper unit (informal red siltstone member) of the Eagle Basin Chinle Formation. Basal dinosauriform material includes: a *Dromomeron romeri* femur with the distinctive hook-shaped femoral head, lateral emargination ventral to the femoral head, and lack of fourth trochanter; *Silesaurus*-like elements represented by teeth, femora, and pelvic material (including a well-preserved ilium with the distinctive horizontal, saddle-like blade); coelophysoid dinosaurs represented by femora, pelvic material, pes material, and possible cranial bones. Basal saurischian dinosaurs known from other sites in the Chinle Formation and Dockum Group seem to be absent in the Eagle Basin. The age of the Eagle Basin Chinle sediments remains difficult to determine because 1) there are no absolute dates and 2) it can't be correlated with Chinle deposits to the south because of the Eagle Basin's isolation due to the Uncompahgre highlands and ancestral Rocky Mountains. There are some possible biostratigraphically useful vertebrate taxa that give a Norian age (Revueletian). Some of the taxa suggesting a Revueletian age are: a leptoleurine procolophonid, possibly *Libognathus*; *Rioarribasuchus*-like aetosaurs; and by far the most common Eagle Basin taxon *Aetosaurs*. The Eagle Basin dinosauriform discoveries, along with previously reported Chinle Formation and Dockum Group occurrences of non-dinosaurian dinosauriforms further demonstrates their widespread distribution and abundance in the Late Triassic of the western U.S.A.

The Scientific Legacy of Mary Anning — Recent Advances in Marine Reptile Paleobiology and Evolution, Wednesday 8:30

**DIVERSITY OF HETTANGIAN (LOWER JURASSIC) PLIOSAUROIDS FROM SOUTHERN ENGLAND**

SMITH, Adam, National Museum of Ireland, Dublin, Ireland

The Hettangian stage Lower Lias deposits of southern England have provided some of the earliest discoveries and stratigraphically oldest representatives of plesiosaurs. Four pliosauroid plesiosaur taxa are currently recognized from these strata: *Thalassiodracon hawkinsi*, *Macropalata tenuiceps*, *Rhomaleosaurus megacephalus* and *Eurycleidus arcuatus*. A clarification of their holotype specimens is performed as a prerequisite for assessing the true taxonomic diversity of the pliosaurs. *T. hawkinsi* and *M. tenuiceps* are considered valid taxa supported by several autapomorphies. The holotype of *E. arcuatus* is a disarticulated but substantially complete skeleton that lacks a cranium and may be insufficient for modern diagnostic purposes. The holotype of '*Plesiosaurus*' *megacephalus* was destroyed during an air raid on Bristol city during the Second World War. A replacement neotype was proposed

and '*P. megacephalus*' was assigned to the genus *Rhomaleosaurus*. However, plaster casts of the holotype are satisfactory and remain valid. Several recent phylogenetic analyses have recognized that the genus *Rhomaleosaurus sensu stricto* is restricted to species from younger Toarcian rocks. *Rhomaleosaurus megacephalus* therefore requires a new genus name. Several additional plesiosaur specimens from the Hettangian can be referred to this new genus and at least one novel species is present. This new species has a longer mandibular symphysis and narrower skull than '*R. megacephalus*' and is represented by an almost complete skeleton from the Hettangian of Wilmcote, Warwickshire. The specimen is housed in the Warwickshire Museum, Warwick, UK, and is important as the only complete Hettangian rhomaleosaurid exposed in ventral view, preserving the limb girdles in association with the cranium and mandible. A thorough understanding of these earliest plesiosaurs is vital for determining the origins of plesiosaurs and their relationship to basal sauropterygians.

Technical Session V, Wednesday 2:45

**BIOGEOGRAPHY AND PALEONTOLOGY OF WESTERN NORTH AMERICAN FRESHWATER FISHES**

SMITH, Gerald, University of Michigan, Ann Arbor, MI, USA

Since the Cretaceous, freshwater fishes of North America have been divided into two contrasting faunas. The depauperate western assemblage originated on a narrow, tectonically active arc between the Pacific and the epicontinental sea. The rich eastern fauna developed with the Mississippi River drainage on the large, stable craton. Pacific drainage faunas are especially species-poor because the Continental Divide remained close to the Pacific Ocean in the Paleogene, which created short drainages originating in high mountains, forcing high extinction rates. Isolated western habitats did not improve with the Laramide Orogeny and the extension of the Basin and Range Province, although the numerous grabens collected a rich fossil record of the several lineages. The Green River Eocene fauna was eastern and rich because of its association with the developing Mississippi drainage and large rivers at low elevations. After the cold, dry Oligocene, the Sacramento drainage and its primary tributary, the upper Snake River, provided diverse habitats, especially the large, deep rift lake on the western Snake River Plain in Idaho and Oregon. The rich fossil record of the rift lake indicates that speciation rates exceeded extinction rates in these habitats through the Late Miocene and Pliocene. Headwater transfers between the Snake River and Green River colonized fishes into the developing Colorado River drainage in the Late Miocene or Pliocene. In the Pleistocene, extinction again dominated in the west. Numerous western pluvial lakes were transient in a generally dry climate, supporting only small, relict faunas. By contrast, the north-south orientation and long-term stability of the large Mississippi drainage and its many tributaries facilitated consistently low extinction rates, allowing slow evolution of a freshwater fauna with three times the number of fish families and 10 times more species than in the west.

Technical Session IV, Wednesday 2:15

**FEMALE MASTODONS AT THE BOTHWELL SITE: SIMULTANEOUS OR SUCCESSIVE MORTALITY EVENTS?**

SMITH, Kathlyn, University of Michigan, Ann Arbor, MI, USA; FISHER, Daniel, University of Michigan, Ann Arbor, MI, USA

The Bothwell site, discovered in northwestern Indiana in 2005, yielded a late Pleistocene mammalian assemblage. Over 300 skeletal elements, including at least 13 American mastodon (*Mammot americanum*) tusks, were recovered from silty, organic-rich sediment. Morphological analysis of complete to nearly complete tusks (n=9) indicates they all belong to females. A site with exclusively female mastodons is rare, and this study seeks to investigate this death assemblage by answering questions pertaining to: number of individuals, age distribution, possible life associations among individuals, and season, simultaneity, and cause(s) of death. To answer these questions, tusk morphology has been evaluated, as well as dentin growth histories (on annual and fortnightly scales) and isotopic compositions. Ages, based on the number of annual increments in tusks or by morphological comparison with tusks of known age, range from approximately 20 to 40 years, but most tusks appear to represent mastodons between approximately 20 and 30 years of age. The lack of juveniles suggests that the site does not represent a complete matriarchal family unit, but this does not eliminate the possibility of social relationships among individuals. Fortnightly growth rate profiles of the final years of life for four tusks show that individuals died in different seasons, indicating that the assemblage represents multiple mortality events. Serial analysis of carbonate  $\delta^{18}O$  corroborates growth-increment season of death for one tusk, and is being used to evaluate season of death for the other tusks. Cause of death has not been determined, but because there is no apparent decrease in growth rate at the end of life, and three deaths occurred when nutrients should have been readily available (spring and summer), death by nutritional stress is unlikely. Beyond answering the above questions, the methods employed in this study can be used to explore the life histories of mastodons at this site, with implications for recognition of reproductive events in tusk records.

**A LIKELIHOOD APPROACH TO THE SECONDARY ASSOCIATION OF ISOLATED VERTEBRATE REMAINS**

SMITH, Krister, Senckenberg Museum, Frankfurt am Main, Germany

The vast majority of the vertebrate fossil record consists of isolated elements. Frequently, these elements are concentrated in small sedimentary packages that were deposited over a relatively short interval of time, and the fossils can be assumed to represent a set of penecontemporaneous populations. To make full use of the vertebrate record in addressing ecological and evolutionary questions, it would be desirable to associate secondarily all preserved elements of a species in a locality so as to form a better picture of its overall morphology and phylogenetic relations. I develop a maximum likelihood model for secondary association. The model presumes that one has identified distinct morphotypes of each skeletal element. It is not necessary that these elements be globally diagnostic; an element morphotype need only be distinct from those of other species in the same locality. Data from a variety of sources, especially size and relative abundance but also including more direct data bearing on association, are then used to estimate parameters including species richness and the most likely set of element associations. The model is tested by application to a moderately diverse Recent and a fossil assemblage. Varying intra- and interspecific scaling relationships, which are *a priori* unknowns, as well as other sources of data and potential error not incorporated into the model may influence one's confidence in any particular association. Thus, the model does not provide necessarily the best set of specimen associations but rather an objective and quantitative basis for discussing confidence.

Technical Session X, Friday 10:45

**PATTERNS IN EARLY DINOSAUR BIOGEOGRAPHY REVEALED BY QUANTITATIVE METHODS OF ANCESTRAL GEOGRAPHIC RANGE RECONSTRUCTION**

SMITH, Nathan, Field Museum of Natural History, Chicago, IL, USA; TURNER, Alan, Stony Brook University, Stony Brook, NY, USA; IRMIS, Randall, Utah Museum of Natural History, Salt Lake City, UT, USA; NESBITT, Sterling, American Museum of Natural History, New York, NY, USA

The Hayden Quarry (Late Triassic, Norian) at Ghost Ranch, New Mexico has yielded a diverse assemblage of theropod dinosaurs, including a new taxon that is the sister-group to Neotheropoda. A phylogenetic analysis of basal dinosaurs reveals that the Hayden theropods are not monophyletic, suggesting they do not represent an endemic radiation in the Norian of the American Southwest. We performed several biogeographic analyses on a Late Triassic time-sliced subset of Dinosauriformes to explicitly test this and previous hypotheses of early dinosaur biogeography. Initial analyses utilized Dispersal Vicariance Analysis (DIVA), a parsimony-based method of ancestral range reconstruction that does not include temporal information. Additional analyses explicitly incorporated temporal data using a likelihood method, the dispersal-extinction-cladogenesis (DEC) model. Temporal information was added by including minimum estimates of missing branch lengths implied by phylogeny, and by a method of "smoothing" the temporal spacing of cladogenetic events between internal calibrations. All analyses reject scenarios of an endemic North American theropod radiation. Analyses differ slightly in support for range reconstructions at individual nodes, but are consistent in providing high relative support for inferring South America as the ancestral range through the spine of the basal dinosaur tree. DEC analyses that do/do not incorporate temporal data allow us to assess the contributions of topology and time to this pattern, and find that both the phylogenetic relationships and the age of South American taxa supports these reconstructions. This is the first application of the DEC model to a fossil dataset, and highlights areas of quantitative biogeography in need of development: 1) better incorporation of temporal uncertainty, while accounting for relative stratigraphic relationships; 2) methods to include geographic data from poorly phylogenetically constrained fossils; 3) assessing biases introduced by temporal calibration; and 4) integrating paleoclimatic/paleogeographic data to propose and test more explicit hypotheses of geographic range evolution.

New Perspectives on the Early Evolutionary History of the Synapsida, Saturday 11:00

**BURROWING AS A SURVIVAL STRATEGY IN THE EARLIEST TRIASSIC KAROO BASIN, SOUTH AFRICA**

SMITH, Roger, Iziko South African Museum, Cape Town, South Africa; BOTHA-BRINK, Jennifer, National Museum, Bloemfontein, South Africa

The southern half of the main Karoo Basin in South Africa contains an almost continuous stratigraphic record of terrestrial sedimentation through the Permo-Triassic boundary (PTB). Systematic biostratigraphic collecting of multiple sections has defined an extinction event among the tetrapods, and shown it to coincide with a distinctive change in fluvial style interpreted as the result of rapid aridification. From facies interpretation and taphonomic data it is proposed that pronounced climatic warming and storminess at the onset of an unreliable, monsoonal rainfall regime contributed to a mass extinction in southern Gondwana, 252 Mya. Field data from 450 *in situ*, identifiable vertebrate fossils demonstrates a 54% mass extinction within the uppermost 40m of strata below the PTB which we estimate to represent some 300Ky, followed by a lesser extinction event approximately 160Ky later, involving four "survivor" taxa that crossed the PTB. The Early Triassic "recovery" fauna appears 5m above the PTB and becomes fully-developed by 90m. Ghost lineages of these new taxa

predict a higher survival rate, but as yet no fossils have been found to corroborate this. Large (30cm diameter) sandstone burrow casts, some containing scattered skeletons of *Lystrosaurus*, appear +/-10m below the PTB coincident with the first red mudrocks. Around 60m above the PTB, a smaller type of burrow cast (15cm diameter) with a more irregular architecture becomes common and these contain one or more articulated skeletons of adult and juvenile cynodonts (*Thrinaxodon* and *Galesaurus*) and one instance of shelter-sharing between unrelated taxa (*Galesaurus* and *Owenetta*). It is proposed that underground burrows were opportunistically excavated by drought-stricken cynodonts, cynodonts and therocephalians into the Early Triassic floodplains of the Karoo to conserve moisture and shelter from the heat of the day. Under these conditions physiological adaptations to low oxygen conditions underground, diaphragm breathing, nocturnal foraging and insectivory may have been the selective advantages that ensured the successful radiation of small insectivores in the earliest Triassic.

Technical Session XVI, Saturday 9:45

**ADAPISORICULID MAMMALS FROM THE PALEOCENE OF HAININ (BELGIUM) SHED LIGHT ON THE PHYLOGENETIC AFFINITIES OF THE ENIGMATIC ARBOREAL CRETACEOUS DECCANOlestes FROM THE DECCAN TRAPS OF INDIA**

SMITH, Thierry, Royal Belgian Institute of Natural Sciences, Brussels, Belgium; DE BAST, Eric, Catholic University of Louvain, Louvain-la-Neuve, Belgium; SIGÉ, Bernard, Université Claude Bernard - Lyon 1, Villeurbanne Cedex, France

The controversial family Adapisoriculidae, a group of shrew-sized Paleocene mammals, has been related to insectivores, marsupials and more recently to plasiadapiforms. Adapisoriculid remains are abundant in the early Paleocene locality of Hainin in Belgium, and allow us to test these various phylogenetical hypotheses. Here we identify the first tarsal bones of adapisoriculid mammals. These bones are highly specialized and indicate an arboreal mode of life. Moreover, the tarsal bones are nearly identical to those of the genus *Deccanolestes* from the Deccan intertrappean beds of India. Both tarsal and dental morphology of the Hainin material suggest adapisoriculid affinities for the previously enigmatic archontan *Deccanolestes*. This hypothesis also has unexpected paleobiogeographic implications. Because of the apparent absence of adapisoriculids in Asia, their dispersals between India and Europe during Maastrichtian-early Paleocene times seems to have occurred either via East Africa or across the Tethys area.

Technical Session V, Wednesday 4:45

**BRIDGING ROMER'S GAP: NEW TETRAPODS FROM THE BASAL CARBONIFEROUS OF THE SCOTTISH BORDERS.**

SMITHSON, Tim, Learning and Skills Council, Gloucester, United Kingdom; WOOD, Stan, Mr Wood's Fossils, Selkirk, United Kingdom

Romer's Gap is a period of some 20my at the base of the Carboniferous characterized by a world wide break in the fossil record of early tetrapods. Hitherto, material has only been found at two localities: Horton Bluff, Nova Scotia, Canada and Auchenreoch Glen, Dumbarton, Scotland. Here we report the discovery of five new horizons yielding tetrapod remains at two localities in the Tweed Basin, one in the bank of the River Tweed at Coldstream and four among coastal exposures at Burnmouth. All form part of a sequence of the Cementstone Group in the Courceyan stage of the Tournaisian, that is contemporary to the exposures at Auchenreoch Glen. They were deposited on a coastal plain, crossed by meandering rivers, that was subject to brief marine incursions. Two of the horizons at Burnmouth are calcareous sandstones; the remaining three are organic-rich mudstones. At least three different tetrapod taxa have been identified so far. The disarticulated cranial bones, axial elements and limb bones found at Coldstream and the sandstone horizons at Burnmouth are similar in size to *Pederpes* from Dumbarton and the disarticulated bones from Horton Bluff. The material from the two other horizons is much smaller and may be the first evidence that the radiation of tetrapods was preceded by a period of small size. A partial mandible with an estimated maximum length of 40 mm has been recovered from one mudstone at Burnmouth and a partial skull including a mandible just 30 mm long has been found in the other. The associated vertebrate fauna in all five beds includes the acanthodian *Gyracanthus*, lungfish, rhizodonts and actinopterygians, whilst the mudstone horizons also include an invertebrate fauna including ostracods, scorpions and myriapods. Other horizons containing fish and arthropods have recently been found within the Cementstone Group of the Tweed Basin which may yield further evidence of the radiation of early tetrapods during the time of Romer's Gap.

Poster Session IV, (Saturday)

### THREE-DIMENSIONAL GEOMETRIC MORPHOMETRICS AND KINEMATICS OF THEROPOD HIP-JOINT FUNCTION

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There has been longstanding interest in the terrestrial locomotor apparatus of theropod dinosaurs, yet a dearth of quantitative research on hindlimb joint geometry contributes to the difficulty of reconstructing the limb movements in fossil species. To address this problem we combined whole-body 3D walking kinematics data from two extant bird species with a 3D geometric morphometrics analysis of their articular facets. This integrative approach allows quantification of the morpho-functional link between joint geometry and limb segment motions. Contrary to the common parasagittal depiction of theropod limb function, our data reinforce that femoral motions in 3D are considerable, including important medio-lateral hindlimb movements. We propose a model to explain how this medio-lateral motion is constrained by articular geometry, particularly the antitrochanter of the avian hip joint. Validation by cineradiographic motion analysis shows that, through a gait cycle, the trajectory of the femur is indeed very close to rotation around a single oblique axis. This generates a combination of femoral pro-/retraction, abd-/adduction and long-axis rotation that guides distal segments of the limb and passively helps to maintain trunk balance. We then applied these morphometric techniques to fossil theropod hip joints (*Ornitholestes hermanni*, *Bambiraptor feinbergi*), tracing the evolution of the geometry of the antitrochanter and related structures to reveal how gradually hip form and function evolved. We thus provide a novel step in reconstructing the evolution of 3D hip joint function from early theropods to birds.

Poster Session III, (Friday)

### WANTED! INFORMATION LEADING TO THE DISCOVERY OF OUTLAWS, QUARRIES, AND FOSSIL REMAINS OF THE "DEVIL'S-TAILED" BEAST FROM THE ROBBER'S ROOST QUARRY, COMO BLUFF WYOMING, USA: A REAL "WILD WEST SHOW" OF DINOSAUR PALEONTOLOGY

SOUTHWELL, Elizabeth, Geological Museum, University of Wyoming, Laramie, WY, USA; MATTHEWS, Neffra, Geological Museum, University of Wyoming, Laramie, WY, USA; BREITHAUP, Brent, Geological Museum, University of Wyoming, Laramie, WY, USA

In 1887, Buffalo Bill Cody's Wild West Show brought spectacular tales of the Rocky Mountain West to Bristol, England. Englishman Arthur Lakes and railroad worker William Reed also portrayed the mythic West with stories and sketches of fossil collectors working in the newly explored frontier of Wyoming Territory. Tales of strange petrifications, "devil fish," and the remains of gigantic beasts attracted notable scientists to stop at Como, a remote railroad station located in the midst of a breached anticline. The nose of this fold contains an area of complex geology, cut by small canyons. One of the canyons was named Robber's Roost, as a gang of outlaws hid there prior to a failed train robbery. In the area of their camp at the western end of Como Bluff, Robber's Roost Quarry (Quarry 12) was found in December 1879 by men employed for O.C. Marsh. Work continued through the winter months and a narrow east-west trending trench, 24 m long, 7.5 m deep was created. Although a difficult site to work because of the steep inclination of the Morrison Formation and extreme weather conditions, the quarry produced remains of *Camarasaurus*, *Diplodocus*, *Allosaurus*, *Coelurus*, *Dryosaurus*, *Goniopholis* and cf. *Glyptops*, as well as a partial skeleton of the type specimen of *Stegosaurus unguilatus* and the first remains of "devils' tails" (tail spikes) to be found. Because of the importance of these fossils and the increasing presence of rival collectors, Marsh instructed his workers to collect throughout the frigid winter months. Crews battled the elements, with bitter cold temperatures and blinding blizzard conditions made worse by frequent collapses of the steep quarry walls and inundation of the pit by underground springs. Although some western stories are fantasy, the reports of dinosaur collecting in the late 1800s, personified the true "West of the Imagination." As the result of Lakes and Reed's excellent field notes, letters, and sketches, sites like Quarry 12 have been geographically relocated. Providing a historical geospatial context for historic sites allows them to be used for biostratigraphy and paleoecological interpretations, and for better management of these resources.

Technical Session XIV, Friday 4:30

### A NEW VIVERRAVIDAE (MAMMALIA: CARNIVORMORPHA) FROM THE EARLY EOCENE OF WYOMING

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Viverravidae is a diverse clade of early carnivoramorphans, comprised of several genera of generally small-bodied forms (but with some large species) ranging from the Early Paleocene to Late Eocene. Yet little is known of the skeleton of this group, especially compared with basal Carnivoraformes (non-viverravid Carnivoramorpha). There are only two previously published accounts of viverravid specimens with a significant number of postcranial elements assuredly associated with cranio-dental material. The postcranial skeleton is a rich source of characters, useful for both building phylogenetic trees and

diagnosing clades based on non-cranial information. As the Viverravidae are the earliest diverging clade of Carnivoramorpha, data about their postcranial skeleton is essential for polarizing characters to better understand relationships of fossil carnivoramorphan stem-taxa deeper within the Carnivoramorpha.

Here we present a new viverravid species known from associated dental, basicranial, and postcranial material. The only known specimen was collected from the Lost Cabin Member of the Wind River Formation of latest Wasatchian age. While it was preliminarily identified as *Oödictes* (a basal carnivoraform) further examination has revealed that it clearly is a member of the Viverravidae, closely resembling species of the genus *Viverravus*. This specimen is similar in size to the smallest known *Viverravus* species. As the only other described postcranial material of *Viverravus* is from the earliest Wasatchian, this specimen offers an excellent opportunity to examine character evolution and body size diversity in the postcranial skeleton of the genus. We present comparisons with previously described Viverravidae and basal Carnivoraformes, placing the specimen in a phylogenetic context using a matrix comprised of previously utilized dental, cranial, and postcranial characters as well as additional dental characters. This is the first step in re-evaluating relationships among the Viverravidae (the genus *Viverravus* in particular) and offering apomorphy-based diagnoses, as many existing species are defined only by provenance and size rather than discrete characters.

Technical Session XII, Friday 4:00

### MODEL-BASED APPROACHES TO PHYLOGENY RECONSTRUCTION WITH MORPHOLOGICAL DATA: CROCODYLIA AS A TEST CASE FOR BAYESIAN INFERENCE

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Model-based methods (e.g. maximum likelihood, Bayesian inference) are widely used with nucleotide and amino acid sequence data, where they might be more desirable than maximum parsimony and there are computer programs to evaluate the data matrix to approximate the most appropriate model of evolution. Recently, there has been an increase in the application of model-based approaches to phylogeny reconstruction, particularly Bayesian inference, utilizing morphological (mainly fossil) data; however, the input parameters (prior probabilities) for the models are unclear, particularly when concerned with unobserved character states. Here, I evaluated the validity of Bayesian inference on a comprehensive morphological data set for Crocodylia based on 104 extinct and extant taxa and 169 characters. The Bayesian topology was, as expected, far more resolved than the parsimony strict consensus tree; however, the overall clade membership was not dramatically different. The major discrepancy between both trees was the unresolved relationships in the parsimony tree compared with the full resolution of the Bayesian tree. Posterior probabilities for the Bayesian tree were universally higher in support of the resolved clades than were the bootstrap proportions for the parsimony tree. However, as there is no sufficient model of morphological evolution that can be used to construct a Bayesian topology, and thus, no accurate way to establish prior probabilities that are essential to determining the posterior probabilities that provide such robust support in the recovered topology in this analysis, the increase in resolving power may not be meaningful. One cannot use parsimony optimization to map character evolution on a tree based on an explicit model of evolution (unless the model approximates maximum parsimony). Until there is an adequate model of morphological evolution, perhaps through the advancement of evolutionary developmental biology, we need to err on the side of caution when reconstructing phylogenies based on morphological data where maximum parsimony is still the preferred method.

Poster Session II, (Thursday)

### PLIOCENE CERCOPITHECOID SUCCESSION AT THE MOUNT GALILI FORMATION, EASTERN ETHIOPIA

STADLMAYR, Andrea, Department of Anthropology, University of Vienna, Austria, Vienna, Austria; VIOLA, Thomas, Department of Anthropology, University of Vienna, Austria, Vienna, Austria; KULLMER, Ottmar, Palaeoanthropologie, Forschungsinstitut Senckenberg, Germany, Frankfurt/Main, Germany; SANDROCK, Oliver, Hessisches Landesmuseum, Darmstadt, Germany, Darmstadt, Germany; SEIDLER, Horst, Department of Anthropology, University of Vienna, Austria, Vienna, Austria

The fossil monkey remains of the Mount Galili Formation, southern Afar depression (Somali Region), Ethiopia, offer a rare opportunity to study the taxonomic shift in Early Pliocene cercopithecoids at a single site. Based on biostratigraphic correlation of suids and elephantoids as well as radiometric results, the fossiliferous sediments at Galili are estimated to cover the time span between about 4.5 and 3.5 million years ago. More than 350 cercopithecoid specimens (about 16 percent of the total faunal remains) representing conceivably seven different taxa were collected from different stratigraphic horizons. Though in total colobines make up less than one fourth of the primate assemblage at Galili, they account for almost fifty percent in sediments of the lower Mount Galili Formation. However, the colobines from these sediments do not measure up in quantity to those from the contemporaneous site of Aramis, Middle Awash - indicating a less closed woodland habitat at Galili. This is consistent with the comparatively higher percentage of Reduncini at the latter site. While in the oldest sediments at Galili fossils of colobine monkeys and *Pliopapio* predominate, the younger sediments accommodate few colobine fossils, but primarily fossils of *?Parapapio* and early forms of *Theropithecus*.

Poster Session II, (Thursday)

**BONE HISTOLOGY AND SKELETAL PATHOLOGY OF TWO RECENTLY-EXTINCT FLIGHTLESS PIGEONS: *RAPHUS CUCULLATUS* AND *PEZOPHAPS SOLITARIUS***

STEEL, Lorna, Natural History Museum, London, United Kingdom

The bones of two extinct flightless birds of the Mascarene Islands (western Indian Ocean) are currently being studied in histological thin section for the first time. In the well-known dodo of Mauritius, *Raphus cucullatus*, the femur and tibia are composed of rapidly-growing fibrolamellar bone, as is typical of most extant birds. The hindlimb bones of the dodo do not contain lines of arrested growth, or any growth marks. However, all regions of the cortex are heavily reworked by secondary osteons. In the less-famous solitaire of Rodrigues, *Pezophaps solitarius*, the hindlimb bones are composed of fibrolamellar bone, but lack secondary osteons and contain growth marks. Histological differences between the histology of the robust hindlimbs and the small wing bones are predicted for both taxa. Unlike *Raphus*, *Pezophaps* exhibits striking sexual dimorphism, making it easy to distinguish males and female bones. Histological differences between the sexes may indicate different life histories. Although the wings of the solitaire were not used for flight, contemporary accounts state that they were used in fights and aggressive displays, and healed fractures of the forelimb and pectoral girdle are not uncommon. The taphonomic setting of the specimens affects the histological preservation. Most of the dodo material is from a marsh site near the south-east coast of Mauritius. Although a peat bog, the ground water is buffered by the presence of alkaline sand layers. Bones of the extinct fauna are well-preserved and abundant in two bone beds. The solitaire bones are from cave sites on a limestone plain forming the south-western corner of Rodrigues. Most of these caves are dry, and well-preserved bones are usually found on or close to the sediment surface. However, a very damp cave was discovered in November 2008 and solitaire bones were recovered from deep within the sediment. The preservation of bone histology is usually better in dry limestone caves than in damp caves and marshes.

Poster Session II, (Thursday)

**THE LONG BONE HISTOLOGY OF THE STEM-SAUROPODOMORPH *SATURNALIA TUPINIQUIM*, IMPLICATIONS FOR THE EARLY EVOLUTION OF DINOSAUR BONE MICROSTRUCTURE**

STEIN, Koen, Steinmann Institut für Geologie, Mineralogie und Paläontologie, Bonn, Germany; LANGER, Max, Departamento de Biologia, FFCLRP-USP, São Paulo, Brazil

In the evolution from basal sauropodomorphs to later sauropods, a growth rate acceleration took place, along with the evolution of laminar fibrolamellar bone. However, basal dinosaur bone histology remains virtually unstudied, and it is unclear how fibrolamellar bone evolved throughout Sauropodomorpha. *Saturnalia tupiniquim* is one of the oldest and most basal members of the sauropodomorph lineage. It is known based on three partial skeletons, collected from the Carnian beds of the Santa Maria Formation in South Brazil. We took histological samples from the paratypes of *S. tupiniquim*: a femur of MCPV 3846 and ribs of MCPV 3845. The transverse section of the ribs shows a fibrolamellar cortex with longitudinal vascular canals. Sharpey's fibres are present, and a number of cyclical growth marks extends through the rib bone cortex. The meaning of these marks is ambiguous, as they are not typical lines of arrested growth. A thin lining of endosteal bone is also visible at the cortex-medullary cavity transition. The transverse section of the femur displays a bone cortex with a fibrolamellar matrix and a reticular vascularization pattern, interrupted by two annuli that each contain one principal, and up to three additional lines of arrested growth. The fibrolamellar bone matrix indicates high growth rates relative to the lamellar zonal bone seen in e.g. crocodiles, and is associated with high resting metabolic rates like in mammals and birds. The precise meaning of the annuli remains unclear, but they most likely represent intercalating, perhaps seasonal, periods of slower growth. This type of bone tissue can be compared with that seen in the more derived prosauropods. A fibrolamellar bone matrix and its associated high growth rates were a prerequisite for the transition towards the typical continuously fast growing laminar fibrolamellar long bone microstructure seen in sauropods. The presence of fibrolamellar bone in an early dinosaur suggests that this kind of tissue evolved as a common trait to all members of the group, and not as a convergent feature in more derived taxa.

Poster Session III, (Friday)

**LONG BONE HISTOLOGY AND GROWTH PATTERNS IN ANKYLOSAURS**

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Over the last decade, long bone histology of most major dinosaur groups has been studied to determine growth strategies, life history, and physiology. Although some research exists on the histology of ankylosaur osteoderms, their long bone histology has remained virtually unknown. This study provides the first in-depth description of ankylosaur long bone histology. Several long bones (humeri, a femur, radii, ulnae, and a fibula) and a few ribs of ankylosaurid and nodosaurid specimens, predominantly excavated from the Dinosaur Park Formation in Alberta, Canada, were sampled. The sampling was performed by using the core-drilling-method at a standard location in the midshaft region of the different bones. The cores were ground into thin sections and examined with a transmitted light microscope in normal and polarized light. The bone cortex shows the fibrolamellar tissue typical of most

dinosaurs with primary osteons. The tissue is relatively poorly vascularized, suggesting a slower growth rate and/or a lower metabolic rate in ankylosaurs compared to other dinosaur groups. Varying amounts of secondary osteons and Haversian bone are very abundant, and even young specimens show extensive remodelling zones. Possibly, this feature results from the repair of microcracks in the cortex due to strong loading of the long bones by the ankylosaur body armor.

Technical Session X, Friday 11:00

**NON-PARASAGITTAL YET EFFICIENT: THE ROLE OF THE PECTORAL GIRDLES AND TRUNK IN THE WALK OF *TRICERATOPS* AND *APATOSAURUS***  
STEVENS, Kent, University of Oregon, Eugene, OR, USA; WILLS, Eric, University of Oregon, Eugene, OR, USA

The robust forelimbs of *Triceratops* and *Apatosaurus* represent postural extremes of semi-sprawling versus nearly columnar, respectively. Reconstructions of their gaits remain controversial regarding forelimb, pectoral girdle, and trunk motions. Limbs are redundant kinematic systems with more degrees of freedom (DOF) than required for locomotion, resulting in an infinite space of possible walks, and requiring further constraint (e.g., from ground reaction forces or muscle moments). We introduce a purely kinematic constraint deriving from the phase in a walk cycle when both left and right hindlimbs (or forelimbs) are bearing weight (dual support). During dual support, the left and right kinematic chains (from ground to body) are constrained to propel the body on the same path. The kinematic analysis begins with a digital skeletal model, and for each joint involved in locomotion, the axis and range of motion are estimated for each DOF (e.g., flexion/extension). Next, a configuration space is created by computing the set of all combinations of deflections sampled at uniform intervals within each DOF. The dual support constraint then selects those poses consistent with dual support. For quadrupeds, further constraint is provided by coupling the fore and hind limbs through limited trunk flexion. Using a genetic search algorithm, walk cycles are then sought that maximize smoothness of body trajectory. An efficient gait is thus found without prior assumptions regarding osteological neutral pose, or the angular extremes of joint DOFs, or whether or not the limb's movement is parasagittal. The method successfully replicates the sprawling gait of a reptile and the parasagittal gait of a cursorial mammal. In *Triceratops*, to achieve efficient locomotion, the semi-sprawling forelimb motion required compensation, e.g., by a combination of pronation/supination, pectoral girdle mobility and back flexion. For *Apatosaurus*, the forelimb movements, while not strictly parasagittal, were readily compensated for by moderate girdle and back mobility. This method allows exploration of the effect of pronation/supination, pectoral girdle, and trunk mobility in combination and in isolation.

Poster Session III, (Friday)

**VERTEBRATES FROM NEWLY DISCOVERED LACUSTRINE LOCALITIES IN THE LATE OLIGOCENE NSUNGWE FORMATION, RUKWA RIFT BASIN, TANZANIA**

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Field and laboratory studies of Red Sandstone Group strata in the Rukwa Rift Basin of southwestern Tanzania document a complex basin history with at least two time-distinct tectonic and depositional events, represented by alluvial fans transitioning into fluvial and lacustrine depositional environments during the late Paleogene. Fluvial localities in the Songwe Member of the Nsungwe Formation predominantly preserve microfauna including rodents, macroscelideans, hyracoids, and primates (both strepsirrhine and anthropoid), along with crocodylian, lizard, and snake remains, and articulated anurans and invertebrates. These facies are dated at ~25 MYA using both radiometric dating of intercalated tuffs and detrital zircon geochronology. Underlying the fluvial deposits is a recently identified lacustrine sequence that has yielded an increasingly diverse array of micromammals and anurans also common to fluvial facies, in addition to much larger elements including crocodylian osteoderms and cranial remains, articulated turtle material, an incomplete avian ulna (> 12 cm in length), a large mammalian cervical vertebra and partial ilium, as well as ostracods and numerous coprolites. Importantly, new discoveries also include the following fish groups: Dipnoi, Polypteriformes, at least two taxa representing Siluriformes, cf. Characiformes, and Acanthomorpha. These discoveries offer a glimpse at the evolutionary history of late Oligocene freshwater habitats in East Africa, providing new data on the complex tectono-sedimentary history of the Rukwa Rift Basin. Continued exploration of these shallow lakeshore facies offers a new perspective on the Paleogene-Neogene transition, with expanded opportunities for recognizing paleobiological diversity by sampling different habitats with alternative taphonomic modes of preservation.

The Evolution of Birds in the Mesozoic: a Symposium in Honor of Cyril A. Walker,  
Thursday 9:30

#### LATEST CRETACEOUS PRESBYORNITHIDS (ANSERIFORMES) FROM NORTH AMERICA

STIDHAM, Thomas, Texas A&M University, College Station, TX, USA

Presbyornithids are the long-legged waterfowl common in early Paleogene deposits around the world. Molecular clock data and the Cretaceous *Vegavis* (sister to Anatidae) point to a Cretaceous diversification within the crown group of Anseriformes. Based on those data, at least the base of the presbyornithid lineage should have been present in the late Cretaceous. Fossils from the late Maastrichtian Hell Creek and Lance Formations of Montana and Wyoming have produced skeletal elements that are attributable to new presbyornithid taxa. Those formations also have produced enantiornithines, hesperornithiforms, and other neornithine taxa. While none of the material has been found in articulation, their morphology, size, and ability for different skeletal elements to be placed in articulation (such as the sternal rostrum, coracoid, and scapula) suggests that the individual bones once belonged to similar or the same species. In addition, the skeletal elements also display anseriform or presbyornithid characters. For example, the Cretaceous coracoids have a unique apomorphy that is present only in *Presbyornis*, among all other neornithines. Other characters, such as the presence of a bridge over a tendon of the interosseus muscle on the distal end of the carpometacarpus (while present in presbyornithids) is also present in at least some individuals of galliforms, anatids, coraciiforms, and parrots (although on distinctly different carpometacarpus). The new fossil material appears to represent two presbyornithid species. There are subadult scapulae (indicated by their smaller size and the absence of a smooth bone surface) that appear to be a growth series for one of the presbyornithid species. The presence of juvenile material indicates that these waterfowl bred in this region of North America before the end of the Cretaceous. The presence of presbyornithids in the latest Cretaceous and Paleogene clearly indicates that the clade survived the mass extinction at the end of the Cretaceous. However, the pattern of survival of that clade (and any extinction at the species level) is unclear given the much poorer record of birds in the earliest Paleocene.

Poster Session II, (Thursday)

#### PHALANGES, LIMBS, AND LOCOMOTOR BEHAVIOR IN MAMMALS AND THEROPODS: IMPLICATIONS FOR AVIAN ORIGINS

STIEGLER, Josef, Montana State University, Bozeman, MT, USA; VARRICCHIO, David, Montana State University, Bozeman, MT, USA; HAMRICK, Mark, Medical College of Georgia, Augusta, GA, USA

Terrestrial vertebrates have consistently invaded the arboreal realm, achieving selective advantages in foraging, safety, and reproduction, among others. A long-standing debate over the potential tree climbing abilities of theropod dinosaurs has in part been fueled by recent discoveries of new small-bodied taxa. In this study, we assess the potential scansorial ability of theropods through 1) manual phalangeal and 2) limb proportions. Only paravians are hypothesized to be potential climbers, though sampling ranged from basal theropods through the most derived coelurosaurs. (1) Ternary plots of element length as a percentage of central digital ray length were created for the manus of 412 skeletal specimens representing 154 mammalian taxa. Relative reduction of the metacarpal was the most robust indicator of arboreal habit for mammalian hands. Most of the arboreal mammals sampled possessed relatively elongate proximal manual phalanges, while dermopterans and xenarthrans had elongate penultimate phalanges. Scansorial mammals shared significant portions of morphospace with both terrestrial and arboreal taxa. The hands of many non-avian theropods sampled do not co-occupy morphospace with mammals, but some paravian taxa share convergent intradigital phalangeal patterning with dermopterans, consistent with climbing behavior. (2) Intermembral index  $((\text{Humeral} + \text{Radial Length}) / (\text{Femoral} + \text{Tibial Length}))$  was calculated for taxa belonging to mammalian clades containing taxa with variable locomotor modes. Mammalian limb proportions are indicative of substrate use in some cases. Only 4 of 185 arboreal animals sampled have a forelimb less than seventy percent of hindlimb length. Terrestrial bipeds exhibit reduced forelimbs whereas their close arboreal relatives show relative lengthening of the forelimb, indicating facultative quadrupedality as a necessity for climbing behavior. Within the theropods examined, only paravians have intermembral indices above seventy percent. Among non-avian theropods, shifts in manual phalangeal and limb proportions like those associated with arboreal mammals occur in the taxa most closely related to birds.

Technical Session XII, Friday 2:00

#### AN APOMORPHIC ASSESSMENT OF THE VERTEBRATE DIVERSITY AT THE BASE OF THE LATE TRIASSIC SEQUENCE OF TEXAS

STOCKER, Michelle, The University of Texas at Austin, Austin, TX, USA

Understanding the details of stratigraphically low and chronologically old fossil assemblages in the Late Triassic has a renewed importance because of the recent implementation of the "long Norian." The Otis Chalk Quarries preserve an exceptional assemblage of traditional Late Triassic vertebrates (e.g., *Trilophosaurus*, phytosaurs, aetosaurs, and metoposaurs), and their precise stratigraphic placement is uncertain. However, no absolute dates exist for the lower portions of either the Chinle Formation or Dockum Group sections, and both the fauna and stratigraphic position suggest the quarries lie at the base of the Dockum Group sequence. These quarries are either equivalent to the base of the Chinle Formation or are

older, recording a fossiliferous record in the Dockum Group that is poorly represented or absent in the Chinle Formation. Preparation of previously-collected Otis Chalk material reveals that many of the specimens are partially articulated or associated, indicating little transport. Furthermore, the fossils are likely deposited in one bedding plane, indicating a single depositional event. Microvertebrates also are present in the event bed and are a previously unsampled portion of the assemblage that is recovered through screen washing. Using an apomorphy-based identification of specimens collected from Quarry 3 and Quarry 3A, I recognize new occurrences of a drepanosaur, *Doswellia*, a dinosauromorph similar to *Dromomeron romeri*, a *Silesaurus*-like taxon, and a basal dinosaur. These new occurrences form part of an assemblage that comprises endemic taxa (e.g., *Trilophosaurus buettneri*) and taxa found in other stratigraphically low localities (e.g., *Paleorhinus*, *Angistorhinus*). This new apomorphic understanding of the taxonomic content of the faunas of Quarry 3 and Quarry 3A provides an enhanced ability to accurately compare Late Triassic faunas on a broader scale, recognizing that the Otis Chalk quarries represent a possible Carnian locality in North America where a pseudosuchian fauna and a dinosauromorph fauna coexisted.

Poster Session I, (Wednesday)

#### PRELIMINARY OBSERVATIONS ON A GIANT SARCOPTERYGIAN (RHIZODONTIDA) FROM THE UPPER MISSISSIPPIAN (CHESTERIAN) OF KENTUCKY, USA

STORRS, Glenn, Cincinnati Museum Center, Cincinnati, OH, USA; HOLLAND, Timothy, Monash University School of Geosciences, Clayton, Australia

A remarkable specimen of rhizodontid sarcopterygian recovered from the Chesterian Hancock Site of Kentucky preserves matrix-free, three-dimensional elements from the major part of the skeleton. On the eastern margin of the Illinois (Eastern Interior) Basin, the Hancock Site comprises exposures of the Buffalo Wallow Formation, within which, carbonaceous shales appear to correlate with the upper Palestine Sandstone of the deeper basin. These shales are interpreted as fluvial to upper estuarine in nature, potentially an abandoned channel or oxbow facies, and contain a diverse vertebrate fauna including tetrapods, dipnoans and acanthodians. The assemblage is similar, although not identical, to other Mississippian (Lower Carboniferous) fresh and brackish water faunas, strengthening the presumption of a cosmopolitan Mississippian tetrapod province. The rhizodontid was perhaps 6-7 m long in life and may be the most complete example known of such a large individual. Preserved are skull table and temporal bones, opercular and gular plates, premaxillae, maxillae, vomers, the complete right mandible with partial palatoquadrate complex, clavicles, cleithra, pelvic bones, various fin elements and numerous scales. Excepting the mandible, this material is disarticulated although associated. The premaxillae are unique amongst rhizodontid specimens in allowing observation of both internal and external aspects. The 10 cm long, curved premaxillary tusks possess a narrow cutting edge as in *Rhizodus*. The maxillae are anteriorly deep and taper posteriorly, as in *Rhizodus* and *Strepsodus*, but in contrast to those of *Barameda* and *Gooloogongia*. The anterior flange bordering the posterior margin of the choana is positioned more posteriorly than that of other known rhizodontids. As in *Rhizodus*, the flange extends well beyond the dorsal margin of the primary maxillary ramus, as distinct from that of *Strepsodus* and *Strebiodon*. The maxillary teeth are significantly smaller than those of both *Rhizodus* and *Strepsodus*. The ventral lamina of the cleithrum is relatively narrow compared to that of all known rhizodontid taxa. While seemingly closest in appearance to *Rhizodus*, preliminary analysis suggests that the Kentucky animal potentially represents a new rhizodontid taxon.

Poster Session II, (Thursday)

#### SKELETAL MORPHOLOGY AND SYSTEMATICS OF LATE PLIOCENE ALLIGATOR FROM FLORIDA

STOUT, Jeremy, East Tennessee State University, Johnson City, TN, USA

The American alligator (*Alligator mississippiensis*) is one of two species of alligator in the modern world. It is only distantly related to the other extant species (*A. sinensis*), with much closer relatives to *A. mississippiensis* known from the geologic past of North America. A disparity exists, though, in the fossil record between *A. mississippiensis* and its closest relative, the late Miocene – early Pliocene *A. mefferdi*. While *A. mississippiensis* is well known from the early Pleistocene and later, no *Alligator* was known from the middle and late Pliocene until the discovery of Haile 7C and 7G, new late Pliocene (~ 2 Ma) sites from Alachua County, Florida. These specimens were analyzed using an established diagnostic character matrix along with systematic analyses of the results. The research shows that these Haile alligators exhibit a suite of characters from both *A. mississippiensis* and *A. mefferdi*, illustrating an evolutionary transition in time. This research upholds *A. mefferdi* as a valid taxon, though the utility of the species in fossil identification is questioned. The Haile material cannot easily be placed within either of the aforementioned taxa, but a lack of apomorphic characters prevents its own species designation. These specimens represent a chronospecies between *A. mefferdi* and *A. mississippiensis* at a point in geologic history in which fossil *Alligator* was previously unknown.

**MORE THAN JUST A PRETTY FACET: QUANTIFYING MORPHOLOGICAL VARIATION IN 3D SURFACE DATA**

STRAIT, Suzanne, Marshall University, Huntington, WV, USA; SMITH, Nick, Marshall University, Huntington, WV, USA

There has been a technological revolution in 3D data collection which has extended to paleontology. Unfortunately the ability to analyze 3D data has lagged behind these technological developments. With the exception of GIS, there has been little exploration of industrial software by paleontologists. Digital shape sampling and processing (DSSP) is becoming more and more prevalent in industry, and analytical software is also being developed (e.g., Geomagic Qualify and Rapidform Inspect Works). These programs are specifically designed for parts inspection (e.g., examination of prototype vs. production model) or measuring wear (e.g., on gear surfaces). Given that many paleontological hypotheses are concerned with specimen comparison and changes in dental wear are studied for dietary reconstruction, these programs may have application outside industry. To compare wear and function, we selected two wild-caught *Propithecus edwardsi*, including one individual with moderately worn and one with very worn teeth. Molds for these individuals were collected for 3 consecutive years. Fully 3D surface data of m2s were acquired using a LDI RPS 120 high-resolution laser scanner and rendered in Geomagic Studio. Once aligned, pair-wise comparisons of surface deviation were assessed using the "3D Compare" function in Geomagic Qualify. This analysis generated a color spectrum model highlighting gradients of positive and negative deviation with corresponding linear values. In the younger individual, the distal surfaces of the hypoconid and protoconid exhibited the most wear (0.298 mm and 0.246 mm). In the older individual, the entoconid and facet 9 in the talonid exhibited the most wear (0.132 mm and 0.100 mm). Three-dimensional data also lends itself extremely useful to phylogenetic analyses. Using a dental collection of Eocene marsupials, we assessed the utility of Qualify for generating an "average" model of multiple specimens, therefore permitting visual and quantitative assessment of variation within samples. In sum, this study supports the potential to exploit these programs for paleontological studies of function, and systematics.

Technical Session III, Wednesday 2:00

**A NEW PARTIAL SKELETON OF THE CRYPTOCLEIDOID PLESIOSAUR *TATENECTES LARAMIENSIS* AND AN INTERPRETATION OF THE NOVEL BODY SHAPE OF A SHALLOW MARINE DWELLING PLESIOSAUR**

STREET, Hallie, Marshall University, Huntington, WV, USA; O'KEEFE, Frank, Marshall University, Huntington, WV, USA

An incomplete, articulated skeleton of a cryptocleidoid plesiosaur was excavated from the Jurassic Sundance formation of Wyoming, during the summer of 2006. The specimen is referable to the taxon *Tatenectes laramiensis*, the smaller of two known cryptocleidoid plesiosaurs from that formation. The skeleton comprises an articulated dorsal vertebral series, ribs, gastralria, and complete hips. This new specimen adds greatly to our knowledge of this taxon and displays several autapomorphic features. In *Tatenectes*, the neural spines of the vertebrae angle anteriorly, whereas in all other known cryptocleidoid plesiosaurs, the neural spines angle posteriorly. The dorsal vertebral series has little arch dorso-ventrally, unlike other plesiosaurs. The orientation of the rib-head articulation facets on the transverse processes of the vertebrae indicates that the ribs lay at an extreme posterior slant. The gastralria do not display much curvature, making the ventrum of *Tatenectes* relatively flat. The illia articulate with the ischia at a very shallow angle. Together these traits suggest an extremely dorso-ventrally compressed overall thorax shape. Possibly the most novel of all the characteristics of this specimen are the gastralria. In comparison to the ribs and the size of the animal, the gastralria are quite pachyostotic. The ribs are of expected proportions for a specimen of this size, but the gastralria are disproportionately robust. Based on cross-sections of the ribs and gastralria, it appears that the pachyostosis of the gastralria was not coupled with osteosclerosis. The highly oblate, dorso-ventrally compressed thorax coupled with pachyostosis confined to gastralria only is a completely novel body shape among plesiosaurs. We hypothesize that this body shape contributed to stability along the pitch and roll axes, and that this may be an adaptation to life in shallow lagoonal environments.

Technical Session XI, Friday 10:30

**ALPHA SPECIES DIVERSITY IN EARLY-MIDDLE EOCENE MAMMALIAN COMMUNITIES (WA5-BR2) OF THE BIGHORN, BRIDGER AND WIND RIVER BASINS, WYOMING: HIGH SPECIES DIVERSITY CORRELATES WITH GLOBAL WARMING DURING THE EARLY EOCENE CLIMATIC OPTIMUM**

STUCKY, Richard, Denver Museum of Nature & Science, Denver, CO, USA; CHEW, Amy, Western University of Health Sciences, Pomona, CA, USA; HAILU, Meseret, University of Denver, Denver, CO, Uganda

The Early Eocene Climatic Optimum (EECO) was an interval of the highest temperatures during the Cenozoic. Global temperatures from approximately 53-50 million years ago rose to reach peak levels of warming in midcontinental North America of approximately 23 degrees Centigrade, when tropical/paratropical forest ecosystems dominated midcontinental regions. After peak warming, temperatures declined gradually. We recognize two phases of the EECO: EECO-W (Wa6-Wa7 or Br1a), when temperatures were increasing, and EECO-C (Br1a-Br3), when temperatures were declining. We investigate the alpha diversity of local

communities during these two phases in the Bighorn, Bridger, and Wind River basins of Wyoming and beta diversity and trophic structure among Eocene mammalian communities. More than 100 fossiliferous horizons (restricted fossil beds) were investigated using rarefaction analysis. Rarefaction estimates of alpha species diversity at a sample size of 100 specimens are: Wa5, 19.7 (n=12), Wa6 19.6 (n=62); Wa7, 27.1 (n=5); Br1a, 28.0 (n=4); and Br2, 18.6 (n=18). High alpha diversity appears to correlate with peak temperature during Wa7 and Br1a during the transition from the EECO-W to the EECO-C after which species diversity declines coincident with cooling. Beta diversity is also significantly higher during the EECO-W phase and local mammalian communities appear to have more even abundance curves. Increased alpha diversity appears to have involved increased redundancy in trophic guild membership (more species in each guild) rather than the appearance of new guild structure.

New Perspectives on the Early Evolutionary History of the Synapsida, Saturday 11:30

**REMARKABLE NEW MATERIAL OF *BOREOGOMPHODON* (CYNODONTIA: GOMPHODONTIA) FROM THE UPPER TRIASSIC PEKIN FORMATION OF NORTH CAROLINA**

SUES, Hans-Dieter, National Museum of Natural History, Washington, DC, USA; SCHNEIDER, Vincent, North Carolina Museum of Natural Sciences, Raleigh, NC, USA; LIU, Jun, Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China

We report on the discovery of remarkably well preserved new material of the traversodont cynodont *Boreogomphodon* from the Pekin Formation (Newark Supergroup) in Chatham County, North Carolina. The fossils occur in large siltstone boulders that were removed as overburden in an active brick-clay quarry. Based on lithological comparison with extensive cores from other localities in this formation, the fossiliferous siltstone can be placed in the upper half of the Pekin Formation, but well below the contact with the Cummock Formation. To date, 10 complete or partial skulls and four partial skeletons of a small traversodont cynodont have been recovered. The material is clearly referable to *Boreogomphodon* and differs from the type species *B. jeffersoni* from the Carnian-age Vinita Formation of the Richmond basin in Virginia in the presence of two rather than three anterior cusps on the lower molariform teeth, the absence of a posterior cingulum on the upper molariform teeth, and less pronounced sculpturing on the bones of the snout. The largest individuals have only five upper molariform postcanines. The material from the Pekin Formation documents, for the first time, most of the postcranial skeleton of *Boreogomphodon*. Distinctive postcranial features include the presence of four sacral ribs, simple thoracolumbar ribs lacking costal plates, extension of the scapular neck below the acromion process, presence of a short scapular facet on the procoracoid, strongly concave anterior margin of the procoracoid, and presence of a fifth distal carpal.

Late Triassic Terrestrial Biotas and the Rise of Dinosaurs, Thursday 10:45

**EARLY DINOSAURS WITHIN THE VERTEBRATE ASSEMBLAGES OF THE GERMANIC BASIN, AND THE PALEOECOLOGY OF THE LATE TRIASSIC ECOSYSTEMS OF POLAND**

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Recently, several new and unique Triassic vertebrate assemblages have been discovered in the Keuper deposits of southern Poland. Dicynodont remains occur in two localities, Woniki and Lisowice, where Carnian/Norian and Rhaetian strata respectively are exposed. At Woniki dicynodonts co-exist with a typical Germanic Basin tetrapod fauna represented by cyclostosaurs and phytosaurs. At least three different terrestrial ecosystems appear to have been present in the Late Triassic of the Germanic Basin: a diverse assemblage containing phytosaurs, aetosaurs and rauisuchians (Carnian-Norian), an assemblage containing dicynodonts known from a more inland environmental setting (Carnian-Rhaetian), and an assemblage containing basal sauropodomorphs known only from Germany (Norian-Rhaetian). The faunal differences between these assemblages were probably connected with environmental conditions reflecting the relative degree of coastal or terrestrial climatic influence. Various dinosauriforms and/or early dinosaurs are known from all of these assemblages. In the Carnian (Late Triassic) of the Germanic Basin early dinosauriforms are rare and phylogenetically problematic, and include *Silesaurus* (?Ornithischia) from Krasiejów (Poland) and *Saltopus* from the Lossiemouth Sandstone Formation of Scotland. Only an aquatic or semiaquatic herpetofauna is known from the Carnian of Germany. Theropods (*Liliensternus*, *Procompsognathus*), indeterminate theropod material ("*Dolichosuchus*", "*Halticosaurus*", "*Pterospodylus*"), and a basal sauropodomorph (*Ejfrasia* [= *Sellosaurus*]) occur in the Norian of Germany. Rhaetian taxa include the theropod *Liliensternus*, two new theropod taxa from Lisowice, "*Zanclodon*" (Theropoda indet.), and the basal sauropodomorph *Plateosaurus*. The herbivorous dinosauriforms/dinosaurs (*Silesaurus*, *Plateosaurus*) apparently lived in relatively humid environments, and lacked obvious competitors. By contrast, the herbivorous dicynodonts inhabited more inland regions with a more continental climate.

**THE ASYMMETRIC CARPUS OF ADVANCED NON-AVIAN THEROPODS AND ITS ROLE IN THE EVOLUTION OF THE FLIGHT STROKE**

SULLIVAN, Corwin, Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China; HONE, David, Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China; XU, Xing, Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China; ZHANG, Fucheng, Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China

The avian wrist joint involves two proximal carpals and a convex trochlea formed by the carpometacarpus. It is well known that the proximal part of the avian carpometacarpus is at least partially homologous to the semilunate carpal (SLC) of advanced non-avian theropods, and that the convexity of the SLC permitted great mobility in the radio-ulnar plane. A less widely discussed aspect of theropod carpal function is that the wrist is asymmetric in birds and their close relatives: the capacity for ulnar deflection is much greater than that for radial deflection. For this study we re-evaluated the wrist structure of a wide range of theropods in order to investigate the anatomical basis and evolutionary origin of this carpal asymmetry. Where asymmetry exists, it is imposed by a specialized condition of the radiale, in which the articular surface for the SLC is angled towards the ulnar side of the manus. Even in theropods as derived as *Allosaurus*, the radiale is relatively symmetric and the proximal convexity of the SLC is poorly developed, implying that there was no strong bias towards ulnar deflection. However, in deinonychosaurs, oviraptorosaurs and therizinosaurs the radiale is wedge-shaped, the SLC is strongly convex, and the manus is highly mobile in the ulnar direction but not the radial one. Clear evidence of asymmetry is limited to these advanced maniraptorans, although it cannot be ruled out in clades such as Tyrannosauroidae and Compsognathidae for which little information is available. Despite such uncertainties, the appearance of strong carpal asymmetry in theropod phylogeny roughly coincides with that of elongate forelimb plumage, as exemplified by *Caudipteryx*. Accordingly, the main advantage of a carpus with a large range of ulnar deflection may have been that it facilitated a rudimentary folding of the forelimb to protect the feathers. Such folding would have helped prevent wear or damage to what were undoubtedly biologically important structures, despite uncertainty as to their specific function(s). In birds, asymmetric mobility of the carpus was subsequently exapted to allow partial folding of the wing during the upstroke in powered flight.

## Poster Session III, (Friday)

**THE FIRST "LAMBEOSAURIN" (DINOSAURIA, HADROSAURIDAE, LAMBEOSAURINAE) FROM THE UPPER CRETACEOUS OJO ALAMO FORMATION (NAASHOIBITO MEMBER), SAN JUAN BASIN, NEW MEXICO: FURTHER IMPLICATIONS FOR THE AGE OF THE ALAMO WASH LOCAL FAUNA**

SULLIVAN, Robert, State Museum of Pennsylvania, Harrisburg, PA, USA; JASINSKI, Steven, State Museum of Pennsylvania, Harrisburg, PA, USA; LUCAS, Spencer, New Mexico Museum of Natural History and Science, Albuquerque, NM, USA; SPIELMANN, Justin, New Mexico Museum of Natural History and Science, Albuquerque, NM, USA

A nearly complete robust left humerus (SMP VP-2263) and right jugal (SMP VP-1534) belonging to a "lambeosaurin" lambeosaurine (= *Lambeosaurus* + (*Corythosaurus* + *Hypacrosaurus*)) dinosaur have been recovered from the Naashoibito Member (Ojo Alamo Formation), San Juan Basin, New Mexico. Measurements of the humerus are: length-550 mm; deltopectoral crest length-260 mm; deltopectoral width-135 mm. The robust morphology and measurements of the humerus confirm it pertains to a member of the "lambeosaurin" clade. The jugal has a maximum anteroposterior length of 25.5 cm and a shape that is inconsistent with the jugals of all species of *Parasaurolophus*. These specimens, which are very similar to the humerus and jugal of *Corythosaurus* and *Hypacrosaurus*, constitute the first record of lambeosaurines from the Naashoibito Member, despite previous erroneous reports of the occurrence of *Parasaurolophus tubicen* from this horizon. Recent field studies have demonstrated that *P. tubicen* is restricted to the underlying De-na-zin Member (Kirtland Formation). Lambeosaurines have been recently reported from Nemeghtian (early Maastrichtian) units of Russia (*Amurosaurus riabinini* [Udurchukan Formation]) and northeastern China (*Charonosaurus jiyinensis* [Yuliangze Formation]) and they remain unknown from late Maastrichtian age units of North America. Although a putative lambeosaurine has been reported from the Hell Creek Formation, lambeosaurines are not known from either the Lance or upper part of the Hell Creek formations (late Maastrichtian/Lancian) of the Western Interior. Moreover, lambeosaurine dinosaurs are not considered a faunal component of the Lancian LVA, which is 65.8 - 67.61 Ma (late Maastrichtian). The youngest known North American "lambeosaurin," *Hypacrosaurus altispinus*, is from the Horseshoe Canyon Formation of Alberta, and it comes from the upper part of the formation (unit 4), which is dated at 69-68 Ma. Unit 4 of the Horseshoe Canyon Formation correlates with the Naashoibito Member--both are 69 Ma. Recovery of a lambeosaurine in the Naashoibito interval lends further support to a pre-Lancian age for this stratum and for the Alamo Wash local fauna.

**NEW INFORMATION ON THE BASAL PELYCOSAURIAN-GRADE SYNAPSID OEDALEOPS**

SUMIDA, Stuart, California State University San Bernardino, San Bernardino, CA, USA; PELLETIER, Valerie, California State University San Bernardino, San Bernardino, CA, USA; BERMAN, David, Carnegie Museum of Natural History, Pittsburgh, PA, USA; ENGLISH, Lauren, California State University San Bernardino, San Bernardino, CA, USA

*Oedaleops*, together with *Eothyris*, comprises the basal-most family of pelycosaurian-grade synapsids, the Eothyrididae. The original description of *Oedaleops* suggests that some postcranial elements might be referable to the genus. However, virtually all subsequent references to it have stated that the genus is known exclusively from a single partial skull and referred dentigerous elements. Careful re-examination of a series of associated blocks from the Lower Permian Cutler Formation of Rio Arriba County, New Mexico reveals that in addition to the dominant presence of the varanopid *Aerosaurus*, two other pelycosaurian taxa are present: a large sphenacodontid and materials most parsimoniously assigned to *Oedaleops*. Given its position so close to the base of Synapsida and Amniota, any new information on the structure of *Oedaleops* is important. Remains of two right and two left dentaries have spaces for 15-16 teeth. Both maxillary and dentary teeth are bluntly peg-like. A slightly developed ventral keel is seen on scattered vertebrae. The neural arch does not appear to be expanded as previously reported. Neural spines angle caudally to a greater degree than in the larger *Aerosaurus* vertebrae on the same block. Five different scapulocoracoids have been recovered and show a slight embayment at the junction of the anterior and posterior coracoids. The clavicle has a relatively small head and a thin, splint-like dorsal process. An interclavicle initially attributed to *Aerosaurus* may belong to *Oedaleops*. The ectepicondyle of the humerus is distinct but not large. The ulna is curved slightly with a well-developed olecranon process. The iliac process is directed strongly caudally and the acetabular margin is embayed caudally. Despite its small size, the femur has a well-developed adductor ridge, internal trochanter, and fourth trochanter. The tibia is curved slightly and has a ridge running to its distal terminus on its presumed ventral surface. Unguals possess highly recurved claws. Overall, processes of appendicular elements are well defined and differentiated, but not as large relatively as those of other basal pelycosaurs.

## Poster Session I, (Wednesday)

**EARLIEST HYPISISOMATIC NEOPTERYGIANS (PISCES, ACTINOPTERYGII) FROM THE MIDDLE TRIASSIC (ANISIAN) OF YUNNAN PROVINCE, SOUTH CHINA**

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Although hypsisomatic (deep-bodied) fish, adapted to bottom environment where they usually graze on benthic organism, are frequently present in actinopterygians, currently there are no records of deep-bodied neopterygian before the Late Triassic (Norian). We herein present a hypsisomatic fish from a newly discovered marine ichthyofauna, the Luoping Fauna of Yunnan, South China. It certainly represents a neopterygian in the presence of interopercle, a narrow subvertical preopercle, free posterior end of maxilla, lower jaw with high coronoid process. Associated conodont *Nicoraella kockeli* gives a Pelsonian (Middle Anisian, Middle Triassic) age, being so far the earliest recorded hypsisomatic neopterygian. It shows also some characters usually seen in semionotids, such as the tube-like rostral and nasals and the presence of several suborbitals posterior and ventral to the infraorbitals. Its body is very deep, even if the maximum height is only 60% of the SL, owing to a very elongate caudal region. Its dorsal outline is characterized by a striking pointed dorsal bump showing a very steep, slightly concave, anterior edge and a more gently sloping posterior margin. In the anterior region the scales are heavy ornamented and they are somewhat deeper than longer. Of the known fusiform semionotid genera, the new taxon closely resembles *Sangiorgioichthys* in the general skull pattern (similar mosaic of suborbitals, three or more postcleithrums, a very elongate anteriormost supraorbital, etc.). The new taxon distinctively differs from other hypsisomatic representatives of basal neopterygians, in its asymmetrical shape with the anterior region much shorter than the posterior one, a rather short insertion of the dorsal fin, with its origin far from the hump top, the hypurals close to the abdominal region and the heavy scale ornamentation. Thus, we provisionally propose this new taxon as a neopterygian incertae sedis, probably close to semionotids. The overall interest of the new taxon is related to the very early appearance of this specialized neopterygians, thus emphasizing once more the crucial importance of the Luoping Fauna in the marine vertebrate recovering after the Permo-Triassic crisis.

Poster Session II, (Thursday)

**LAGOMORPHS FROM THE EARLY CHADRONIAN MCCARTY'S MOUNTAIN FAUNA OF SOUTHWESTERN MONTANA**

TABRUM, Alan, Carnegie Museum of Natural History, Pittsburgh, PA, USA; FOSTOWICZ-FRELIK, Lucja, Carnegie Museum of Natural History, Pittsburgh, PA, USA

The McCarty's Mountain fauna is derived from a thick sequence (c. 250+ meters) of early Chadronian sediments exposed over an area of about one-quarter square mile south of McCarty's (now McCartney) Mountain in southwestern Madison County, Montana. Although the McCarty's Mountain fauna is justly renowned for producing several important type specimens, as well as a variety of well-preserved skulls, much of the fauna (including the lagomorphs) has never been formally described. Sufficiently precise locality data are retained with enough specimens that it should eventually prove possible to biostratigraphically zone the McCarty's Mountain section. The lagomorphs from McCarty's Mountain include at least three partially contemporaneous leporid species: *Mytonolagus* sp., *Chadrolagus* sp., and *Palaolagus* sp. cf. *P. temnodon*. *Chadrolagus* sp. is the rarest of the McCarty's Mountain leporids and is represented by only a few isolated teeth, while *Mytonolagus* sp. and *Palaolagus* sp. cf. *P. temnodon* are relatively common and about equal in abundance. *Mytonolagus* and *Chadrolagus* occur in both the lower and upper parts of the McCarty's Mountain sequence, whereas *Palaolagus* appears to be restricted to the upper part of the section. The McCarty's Mountain *Mytonolagus* is morphologically intermediate between early Duchesnean *M. wyomingensis* from the Badwater localities of central Wyoming and the late Duchesnean species of *Mytonolagus* reported from the Diamond O Ranch localities of Montana. The McCarty's Mountain species exhibits an advanced condition of P3 in which the anteroloph coalesces with the anterolingual part of the central lobe isolating the crescentic valley but leaving a distinct anterobuccal notch between the anteroloph and central lobe. Upper cheek teeth of this species are strongly curved and have well-developed buccal roots that bend markedly buccally. The hypostriae of P3 and P4 are shallow and transitory.

Poster Session I, (Wednesday)

**EVOLUTION OF ENAMEL MICROSTRUCTURE IN HYRACOIDEA (MAMMALIA, AFROTHERIA)**

TABUCE, Rodolphe, CNRS-ISEM, Montpellier, France

The mammalian tooth enamel is a biological tissue unique among vertebrates in its prismatic microstructure. Various levels of enamel investigations represent a powerful source of characters and information for phylogenetic reconstructions and biomechanical approaches. In ungulate evolution, the modifications of the enamel microstructure are commonly associated with adaptation to herbivory. This work surveys the evolution of the enamel microstructure of the order Hyracoidea. We investigate here some living and Neogene Procaviidae and several Pliohyracidae from various Eocene and Oligocene localities from North Africa. In all studied taxa (e.g. *Microhyrax*, *Sagatherium*, *Bunohyrax*) the prisms cross-sections are generally keyhole-shaped. The Schmelzmuster appears to be constituted only of radial enamel, except in *Titanohyrax mongereui* where bundles of prisms appeared. This structure evokes the 3D enamel which is observed in most proboscideans and also in the putative primitive embriothopod *Phenacolophus*. This character could represent thus an interesting parallel evolution within Tethytheria. In some taxa (e.g. *Seggeurius* and *Bunohyrax*) moreover, the outer enamel zone presents a peculiar organization in which the prisms are parallel each other but not rectilinear, they present undulations of great amplitudes but without evidence of "Hunter-Schreger-bands" (HSB). As a positive correlation between HSB occurrence and body size is generally observed in mammals, the absence of HSB in all large hyracoidea is intriguing. The presence of HSB being usually associated with chewing ability, the absence of HSB in large-sized and specialized folivore (e.g. *Pliohyrax graecus*) or omnivorous (e.g. *Megalohyrax eoacenus*) hyracoidea could reflect a peculiar pattern of enamel evolution or chewing ability within Hyracoidea.

Poster Session IV, (Saturday)

**NOVEL INTERPRETATION OF THE EVOLUTION AND FUNCTION OF CRANIAL SINUSES IN NON-AVIAN THEROPODS**

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Cranial pneumaticity of modern archosaurs is derived from extensivenasal and tympanic sinuses. Comparative anatomy between extant and extinct archosaurs has revealed the presence of similar pneumatic anatomy in Aves and many non-avian theropods. Descriptions of this anatomy along the avian stem lineage has been restricted to Coelophysoidea, Abelisauroida, Torvosauroida, Allosauroida, Tyrannosauroida, Oviraptorosauria, Troodontidae, and Dromaeosauridae and details of the evolution of this complex anatomy have remained elusive. We reassess the evolution of cranial sinuses in non-avian theropods and Aves and include a full description of *Ornithomimus*. This study establishes the presence of an avian-like antorbital sinus at Neotetanurae and an avian-like tympanic sinus at Coelurosauria. This phylogenetic pattern suggests a correlation with inferred physiological functions of this complex anatomy. The timing of the origin of an avian-like elaborated nasal sinus at Neotetanurae may be associated with the large body size and presumed thermoregulatory requirements of this clade. Elaboration of the tympanic sinuses at Coelurosauria may be associated with increased thermoregulatory requirements of the

enlarged brain size diagnostic of this clade. The evolutionary origin of the avian-like cranial sinuses of non-avian theropods is hypothesized to correlate with functions involved with the evolution of physiological thermoregulation and may offer novel insights into the evolution of theropod physiology.

Poster Session II, (Thursday)

**FIRST DISCOVERY OF CERCOPITHECID MONKEYS FROM THE PLIOCENE OF CENTRAL MYANMAR**

TAKAI, Masanaru, Primate Research Institute, Kyoto Univ., Inuyama, Japan; HTIKE, Thuang, Primate Research Institute, Kyoto Univ., Inuyama, Japan; MAUNG-THEIN, Zin-Maung, Primate Research Institute, Kyoto Univ., Inuyama, Japan

Here we report the newly discovered fossil specimens of two cercopithecoid monkeys (= Old World monkeys) from the late Miocene to Pliocene sediments of central Myanmar. The oldest fossil record of Old World monkeys in Eastern Eurasia is *Mesopithecus pentelicus*, a primitive colobine monkey, from the late Miocene of Maraghe (Iran) and Molayan (Afghanistan). The more derived forms, "*Sennopithecus*" *sivalensis* and "*Presbytis*" *palaioindicus* have been discovered from the late Miocene of Hasnot (Pakistan) and from the late Pliocene of Siwalik (India/Pakistan), respectively. However, the Pliocene fossil record of cercopithecids in Southeast Asia is very few, despite the high diversification of the living species in this area. This is the oldest fossil record of cercopithecoid monkeys in Southeast Asia. The new specimens are isolated teeth and fragmentary mandible of colobines and macaques collected in the two different localities: the late Miocene/early Pliocene Myokhinthal locality (Chaingzauk area) and the later Pliocene Gwebin locality, central Myanmar. According to the preliminary analysis of these two fauna, the Gwebin mammal fauna is certainly younger than the Chaingzauk mammal fauna. The colobine fossils consist of left mandible preserving M1-3, isolated upper molar, and isolated lower molar, probably belonging to the same species. They are apparently different from *Mesopithecus* in molar morphology, and are much larger than "*S.*" *sivalensis* and "*P.*" *palaioindicus*. They are likely the oldest fossil record of colobine monkeys in Southeast Asia. On the other hand, the macaque specimens are of isolated right P4 and isolated upper molar. The upper molar is as large as that of *M. nemestrina*, and may be the oldest fossil record of *Macaca* not only in Southeast Asia but also in South Asia.

Poster Session II, (Thursday)

**TRACKING THE EVOLUTION OF MUS SPECIES IN PENINSULAR INDIA USING PLEISTOCENE DEPOSITS**

TAMMA, Krishnapriya, National Centre for Biological Sciences, Bangalore, India; RAMAKRISHNAN, Uma, National Centre for Biological Sciences, Bangalore, India

Understanding species' response to past climatic events is critically important for predicting future responses to current anthropogenic climate change. The fossil record allows us to reconstruct past communities and their evolution. The Indian subcontinent is an especially important region to investigate species response to climatic change, given that almost nothing is known about peninsular Indian fauna and past climates. We seek to investigate the evolution of small mammals in the Indian peninsula during the late Pleistocene, a period that includes significant climatic transitions and resulting changes in ecological habitats. One approach to answer this question is to contrast relative abundance of different genera through a paleontological deposit. Alternatively, we can investigate changes in species abundance within a speciose genus. The Indian subcontinent includes 11 species of *Mus*, many with overlapping distributions and similar ecologies. In fact, the evolution of this genus is paleontologically documented from the sub-Himalayan region. We conducted an excavation of karstic deposits in Southern India as such deposits provide an opportunity to investigate the evolution of this genus as it colonized novel, warmer. In my research, I specifically focus on fossil and sub-fossil remains of the *Mus* genus in the paleontological record that we have recovered in peninsular India. Identification to species level based on dentition patterns is very difficult due to similar morphology and poor characterization of extant species. I used MATLAB to measure morphological characteristics of 100 *Mus* specimens in our deposit. Further, I used cluster analysis to better characterize dentition patterns in both paleo and extant *Mus* species. Our analyses reveal the presence of four different morphotypes of *Mus* in Pleistocene peninsular India. Including our paleo data and measurements with those from the Siwaliks will allow us to better investigate the evolution of this genus in the Indian subcontinent.

Technical Session XIII, Friday 3:45

**MANDIBULAR MECHANICS IN BASAL CERATOPSIA (ORNITHISCHIA, DINOSAURIA)**

TANOUE, Kyo, Canadian Museum of Nature, Ottawa, ON, Canada; GRANDSTAFF, Barbara, University of Pennsylvania, Philadelphia, PA, USA; YOU, Hai-Lu, Chinese Academy of Geological Sciences, Beijing, China; DODSON, Peter, University of Pennsylvania, Philadelphia, PA, USA

Ceratopsia was one of the dominant herbivorous dinosaur clades in Cretaceous terrestrial ecosystems of Asia and western North America. Understanding the effectiveness of the masticatory apparatus should help to explain how Ceratopsia achieved ecological success. Recent discoveries of numerous new basal taxa with superbly preserved skulls make it

possible to document the early evolution of the ceratopsian masticatory system. Mandibular mechanics of basal ceratopsians was examined using both two- and three-dimensional models to understand the variability in jaw shape of early ceratopsians, and the early evolution of the masticatory system in Ceratopsia. Bite forces calculated using two-dimensional analysis increase caudally. Input force remains constant because only working-side muscles are considered, and bite force varies only with distance from the condyle. Three-dimensional analysis, never before done on Ceratopsia, uses input from both working- and balancing-side adductors. It allows more realistic bite force reconstruction. Input force varies along the jaw because the contribution by balancing side muscles is not constant. The largest bite force in basal ceratopsians was not exerted at the caudal end of the tooth row, as suggested by two-dimensional analysis, but near the caudal end of the zone with maximum input force. Three-dimensional analysis shows that medially positioned teeth generate more leverage than laterally positioned teeth. In all basal ceratopsians analyzed the largest bite force is smaller than maximum input force, a limit imposed by the morphology of basal ceratopsian jaws. Caudal extension of the tooth row in ceratopsids allowed much larger bite forces, even exceeding maximum input force. Moreover, mandibular adductor muscles were much larger in ceratopsids than in basal ceratopsians, producing a much larger input force. This study shows that improvement in the masticatory system, reflected in stronger bite forces, began early in the evolution of Ceratopsia.

The Scientific Legacy of Mary Anning — Recent Advances in Marine Reptile Paleobiology and Evolution, Wednesday 8:00

**MARY ANNING, THE BRISTOL INSTITUTION, AND THE MARINE REPTILES**  
TAYLOR, Michael, National Museums Scotland, Edinburgh, United Kingdom

Mary Anning the younger (1799-1847) and her family discovered the first complete plesiosaur skeleton at Lyme Regis in 1823, the same year that the Bristol Institution for the Advancement of Science, Literature and the Arts opened. The Institution's geological collection, combined with private collections in the area and elsewhere, assisted the classic research of William D. Conybeare (1787-1857) and Henry De la Beche (1796-1855), and it was here that Conybeare first presented his research on the complete Anning plesiosaur. The science practiced in such elite private institutions was radically different from today's in content and practice. An anti-Lamarckian ideology, based on natural theology and the Great Chain of Being, was espoused by gentleman amateurs supplied by professional collectors such as Mary Anning (the younger) of Lyme Regis in Dorset, and a working class substratum of now unnameable quarrymen, the latter also in areas such as Street in Somerset. Lyme and Street were two key localities in Bristol's paleontological hinterland. The Institution's first two paid curators were, in succession, J. S. Miller (1779-1830) of crinoid fame, and Samuel Stutchbury (1798-1859), co-describer of the then oldest known reptiles, *Thecodontosaurus* and *Palaosaurus*, from the local Triassic Dolomitic Conglomerate. The institution accumulated one of the finest collections of Jurassic marine reptiles outside London, used by Richard Owen in his classic *Report on British Fossil Reptiles* of 1840-42. However, changing social trends and fashions brought the Institution nearly to its knees, and it was saved only by being taken over by the municipal council in 1894. The collection's nadir came with the Museum's destruction in a 1941 air raid, with the loss of many specimens. However, during the last few decades of the 20th century, the City Museum saw the revival of active acquisition, following the resurgence of amateur and professional marine reptile collecting at Lyme and elsewhere, and the development of vertebrate paleontology at the University. Bristol thereby reprised its former role as a major regional centre for marine reptiles.

Molecular Tools in Paleobiology: Trees, Clocks and linking Geno- with Phenotype, Friday 10:30

**A MOLECULAR AND MORPHOLOGICAL PERSPECTIVE ON THE EVOLUTION OF ECHOLOCAATION IN BATS**

TEELING, Emma, UCD School of Biology and Environmental Science, Dublin, Ireland

Traditionally bats were classified into two superordinal groups: Megachiroptera (Old World fruit bats) and Microchiroptera based on morphological and paleontological data. Megachiroptera was considered basal and contained all bats that did not use sophisticated laryngeal echolocation. Microchiroptera contained all species of bat that could use laryngeal echolocation. As all microbats are capable of sophisticated laryngeal echolocation whereas megabats are not, it was believed that laryngeal echolocation had a single origin in the lineage leading to microbats. Currently, overwhelming molecular evidence has led to the rejection of the old suborders of Microchiroptera and Megachiroptera in favor of two new suborders: Yinpterochiroptera which contains all non-echolocating Old World fruit bats (Pteropodidae) and four families of echolocating insectivorous bats; and, Yangochiroptera which contains all other families of echolocating bats. This topology implies that laryngeal echolocation either had a single origin in the ancestor of bats but was lost in the lineages leading to the pteropodids, or that laryngeal echolocation was gained multiple times in bats.

The oldest bat fossils, *Icaronycteris* index and *Onychonycteris finneyi* are both found in the late Eocene formation of the Green River formation in Wyoming (~52 Mya) and show postcranial evidence that they can fly however, *Icaronycteris* contains evidence of echolocation capabilities and *Onychonycteris* show no evidence for this. This suggests that the evolution of echolocation occurred more recently in the bat tree than previously believed, however does not resolve the question of gain or loss of echolocation.

Recent molecular studies aimed at addressing this question amplified 'echolocation' genes in bats and have suggested that laryngeal echolocation had multiple origins in bats, however further analyses of these data sets support both the 'independent gain' and 'secondary loss' of echolocation in bats. Thus, despite congruent and resolved molecular phylogenies, new fossil discoveries, and novel gene findings, the evolutionary history of echolocation still remains ambiguous.

Technical Session VIII, Thursday 2:00

**ARE LANTHANIDE ELEMENT RATIOS IN FOSSIL BONES PALEOCLIMATE INDICATORS IN TERRESTRIAL ENVIRONMENTS?**

TERRY, Dennis, Temple University, Philadelphia, PA, USA; GRANDSTAFF, David, Temple University, Philadelphia, PA, USA

Distinct rare earth (REE) and trace (TE) element signatures are preserved in fossil bones from the Eocene and Oligocene White River Group (WRG) near Toadstool Geologic Park (TGP) in western Nebraska. The WRG is a succession of non-marine strata deposited during the climatic shift from late Eocene Greenhouse to early Oligocene Icehouse conditions. The late Eocene and early Oligocene in this region are characterized by a substantial decrease in paleotemperatures and a progressive change to increasingly drier conditions. Fluctuations in temperature and precipitation also became progressively greater during this transition. The trace element content of the fossils may provide a previously unrecognized archive of this change. REE and other TE are introduced into bones during the fossilization process. REE signatures in fossils are highly variable within individual units, ranging from heavy REE-enriched to middle REE-depleted. However, REE signatures become increasingly light REE- and middle-REE enriched toward the top of the studied section as the paleoenvironment became cooler and drier, suggesting that REE signatures may be climate proxies. Variability in REE signatures also increased up section, possibly reflecting increased climate variability. Spectral analysis of the NdN/YbN, GdN/YbN and LaN/YbN ratios indicates significant periodicities at ca. 1050, 800, 570, 440, and 225 ka. These periods are similar to modulations of Milankovitch-band astronomical, climate fluctuation, and stratigraphic periodicities suggesting that REE ratios may be paleoclimate proxies. Carbon and oxygen isotopes in bone carbonate have been analyzed in a limited number (N=27) of the fossils. There is a statistically significant positive correlation ( $p < 0.01$ ) between NdN/YbN ratios and  $\delta^{13}C$  values. However, there is no significant correlation with  $\delta^{18}O$ . The  $\delta^{13}C$  values in bone carbonate are thought to represent a proxy of relative aridity. In terrestrial environments, REE ratios may be influenced by relative availability of water, with LREE-enriched signatures produced under conditions of limited water availability. Therefore, REE may be paleo-aridity proxies.

Technical Session I, Wednesday 11:30

**SPATIOTEMPORAL DYNAMICS AND THE STRUCTURING OF HOLOCENE SMALL MAMMAL COMMUNITIES IN THE AMERICAN WEST**

TERRY, Rebecca, Stanford University, Stanford, CA, USA; BLOIS, Jessica, Stanford University, Stanford, CA, USA; HADLY, Elizabeth, Stanford University, Stanford, CA, USA

Natural accumulations of skeletal remains represent valuable but often underutilized archives of biodiversity information. By tapping into this wealth of data, paleontology has much to contribute to the discussion surrounding the future fates of species and ecosystems in the face of environmental perturbation. Here we investigate how small mammal communities (rodents, insectivores, and lagomorphs) of the western United States have responded to environmental change over multiple spatiotemporal scales through the Holocene. To do so, we use radiocarbon-calibrated time-series data from taphonomically similar caves at comparable latitude in distinct but historically related biomes (e.g., Samwel Cave in the Sierra Nevada, Two Ledges Chamber and Homestead Cave in the Great Basin, Lamar Cave in the northern Rockies, and others). We find similar sample-standardized species richness through time between the Sierra Nevada and Great Basin, but significantly lower richness at the site in the Rockies. Within-site richness exhibits no trend and is characterized by low variance through time. Community evenness is high at Two Ledges Chamber and Lamar Cave, and appears to decrease marginally through the Holocene at these sites, as well as at Homestead Cave. This decrease in evenness appears to accelerate at Homestead Cave in the late Holocene. Relative to Two Ledges Chamber and Lamar Cave, evenness is consistently low at Samwel Cave and Homestead Cave. Furthermore, community richness and evenness appear coupled within all sites but not across sites. This suggests that competitive processes likely play an important role in structuring communities through time at a local scale. At larger spatial scales, however, the relationship between richness and evenness appears to be more similar between sites in different biomes than within a biome. In light of these results, we will discuss the relative importance of climatic and anthropogenic drivers of small mammal community change, and how these factors can be disentangled in the fossil record.

Technical Session XVI, Saturday 11:00

**EAR MORPHOLOGY OF *HOMACODON VAGANS*: ADDITIONAL DATA FROM CT SCAN ANALYSIS**

THEODOR, Jessica, University of Calgary, Calgary, AB, Canada

Basicranial data for basal artiodactyls have been scarce, but are critical to resolving relationships among basal artiodactyls and whales within Cetartiodactyla. The base of the

skull of *Homacodon vagans* is well-known, based on AMNH 12695, which preserves the auditory region. This specimen shows the morphology of the ventral surface of the braincase and the petrosal, and bears a fossa bordered by the squamosal, alisphenoid and the tegmen tympani that suggests an ectotympanic bulla was present. CT scan analyses of AMNH 12695 reveal the medial (endocranial) surface of the braincase, although it has not been possible to satisfactorily resolve the ear ossicles or the semicircular canals. *Homacodon* shows a deep, anteromedially facing subarcuate fossa dorsal to the internal auditory meatus on the medial surface of the periotic. A deep subarcuate fossa is also known in *Bunomeryx*, camelids, cainotheriids, oreodonts and hypertragulids, and inferred from endocasts for xiphodontids, dichobunids and anoplotheres. The subarcuate fossa is shallow and faces medially in *Leptotragulus*, protoceratids and ruminants. The petrosal canal in *Homacodon* appears to run between the periotic, basioccipital and the auditory bulla, similar to the condition among ruminants. AMNH 12695 appears to show a sinus venosus temporalis, situated between the squamosal and the periotic, also known in camelids, oreodonts and protoceratids. The medial surface of the periotic shows a blunt change in angle dorsally between the cerebral and cerebellar surfaces. This is somewhat intermediate between the condition in camelids and cainotheriids, in which there is no clear separation of these surfaces, and the ruminant condition, where a sharp crest on the periotic divides the cranial cavity into cerebral and cerebellar surfaces.

As expected, *Homacodon* shows periotic features that appear to be basal among artiodactyls: a deep, well-developed subarcuate fossa and the presence of a sinus venosus temporalis. The position of the petrosal canal, similar to ruminants, seems to suggest that the ruminant condition of this canal may be basal.

Poster Session IV, (Saturday)

#### **A FOSSIL BRAIN CAST OF A SPERM WHALE (CETACEA, PHYSETERIDAE) FROM THE MONTEREY FORMATION, LOS OLIVOS, CALIFORNIA**

THOMAS, Howell, Natural History Museum of Los Angeles County, Los Angeles, CA, USA; BARNES, Lawrence, Natural History Museum of Los Angeles County, Los Angeles, CA, USA; TAKEUCHI, Gary, Natural History Museum of Los Angeles County, Los Angeles, CA, USA; MACGILLIVRAY, Robert, Drymax, Templeton, CA, USA

Quartz crystal-filled cavities are commonly encountered in fossil bones and skulls of vertebrates from the Monterey Formation. We here report a fossilized brain cast, formed entirely of quartz, belonging to a Middle to Late Miocene age, circa 10-12 Ma, sperm whale, probably originating from the Monterey Formation. The brain cast was associated with a portion of sperm whale skull, in which the right premaxilla overlaps the left premaxilla, both of which are expanded in a vertical plane, and the nasal passages that are greatly dissimilar in size. This brain cast provides much more detail than a cranial endocast and clearly shows the left cerebral hemisphere, with the orbital and temporal lobes, and the paleocortex region, as well as the right hemisphere, with orbital and occipital lobes. The left hemisphere displays the fissures cruciate, lateralis, and a short section of the praesylvia. Visible in the paleocortex region of the left hemisphere are the temporopolar gyrus, insula-parahippocampal sulcus, parahippocampal sulcus, parahippocampus gyrus, posterior rhinal sulcus, ambient gyrus, semilunar sulcus, semilunar gyrus, and the circular sulcus of the insular. The right hemisphere displays the fissures praesylvia, cruciate, endolateralis, coronalis and a short section of the suprasplenialis. The corpus callosum is visible on the medial surface of both hemispheres, as is the gyrus fornicatus. These two features are divided by the fissure corpus callosi in both hemispheres. All of these features are in the same locations and configurations as seen in Recent sperm whale brains. The orbital lobe is broken off of the left hemisphere, revealing the interior to be a quartz crystal internal geode. It is possible that very soon after the death of the animal very fine sediments rapidly filled the space between the brain and the braincase, hardening sufficiently that as the brain deteriorated the sediments did not collapse within the braincase. Quartz crystals subsequently formed on the inside of this natural mold. How the sediment entered the braincase is a matter for conjecture.

Technical Session XI, Friday 9:00

#### **CHRONOSTRATIGRAPHIC CONSTRAINED ASIAN EARLY PALEOGENE STRATA AND MAMMALIAN FAUNAL TURNOVER EVENTS**

TING, Suyin, LSU Museum of Natural Science, Louisiana State University, Baton Rouge, LA, USA; CLYDE, William, University of New Hampshire, Durham, NH, USA; WANG, Yuan-Qing, Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China; KOCH, Paul, University of California, Santa Cruz, Santa Cruz, CA, USA; THE, China Early Paleogene Working Group, Cooperative, New York, West Lafayette, Beijing, USA

Biostratigraphic, chemostratigraphic, and magnetostratigraphic studies of Paleocene and early Eocene sediments in Nanxiong, Chijiang, Qianshan, Hengyang, and Erlian basins, China, provide a well-resolved geochronological framework for Asian early Paleogene biostratigraphic units: Shanghuan, Nongshanian, Gashatan, and Bumbanian Asian Land Mammal Ages (ALMA). Paleomagnetic and isotope results indicate that (1) the base of Shanghuan lies within Chron C29r, (2) Shanghuan-Nongshanian ALMA boundary lies between the upper part of Chron C27r and the lower part of C26r, close to the Chron C27n-C26r reversal, (3) Shanghuan-Nongshanian ALMA boundary may correlate to Torrejonian-Tiffanian North American Land Mammal Age (NALMA) boundary, (4) typical Gashatan faunas range from Chron C25r (or possibly C26n) through C24r, (5) Nongshanian-Gashatan ALMA boundary may correlate within the Tiffanian NALMA, (6) the transient carbon isotope excursion marking the Paleocene-Eocene boundary has been identified in

the Hengyang basin and indicates that the Bumbanian Lingcha fauna may correlate with the Wasatchian-0 faunal zone of North America to within ~104 yr and with the Thanetian/Ypresian stage boundary. A cluster analysis based on shared genera shows that early Paleogene faunal assemblages from India, Pakistan, Kazakhstan, and Kyrgyzstan are quite different from those of China and Mongolia at the generic level. The major clusters of east Asian faunas are Shanghuan, Nongshanian and Gashatan, and Bumbanian. Both Shanghuan and Nongshanian faunas are composed of Asian endemic taxa. A species of modern order Rodentia appearing in the Gashatan marks initiation of a transition from Paleocene "archaic" taxa to faunas dominated by "modern" taxonomic groups. Modern mammalian orders, Primate, Perissodactyla, Artiodactyla, Cetacea, synchronously appeared at the beginning of Bumbanian as in North American and Europe, indicating a major mammalian exchange between Asia and other continents. Several of these faunal turnovers are closely related to early Paleogene global climate changes best documented in deep sea records.

Edwin H. and Margaret M. Colbert Poster Competition (Thursday)

#### **RECONSTRUCTION OF FOSSIL SHARK VENTILATION SYSTEMS BASED ON GILL ARCH MORPHOLOGY AND EVOLUTIONARY IMPLICATIONS.**

TOMITA, Taketeru, The University of Tokyo, Tokyo, Japan

Extant sharks exhibit enormous diversity in habitats, movement, and feeding. These ecological diversities are strongly correlated with their respiratory types. Based on their respiratory systems, extant sharks are divided into two types, passive ventilation and active ventilation. Measurements in this study of gill arches of 25 species of extant sharks clearly indicate that gill arch proportions are different in the two types, and for the first time, gill arch proportions are used to reconstruct the type of ventilation in fossil sharks. Actively swimming extant sharks depend mainly on a passive ventilation system—water passes through the mouth and over the gills while swimming. On the other hand, demersal sharks such as dogfish, *Scyliorhinus* spp., have active ventilation systems—they actively pump water through their gills. Because of this active ventilation system, they can breathe while staying still on the seafloor. The morphological differences in gill arches can be interpreted to mean that active-ventilation type sharks have strong water pumping capabilities. Gill-arch morphologies are also correlated with aspect ratios of caudal fins, which are indicators of swimming capability. This correlation indicates that passive-ventilation type sharks tend to have fast and continuous swimming capabilities whereas active-ventilation type sharks tend to have discontinuous swimming capabilities, or slow and continuous swimming capabilities. Applying the morphological differences in gill arches to ventilation types in fossil sharks, cladodont sharks were reconstructed to be the passive-ventilation type, and hybodont sharks were reconstructed to be the active-ventilation type. By combining aspect ratios of caudal fins with the gill-arch morphologies, three species of cladodont sharks (*Cladoseleche fylleri*, *Akmonistion zangerli* and *Cobelodus aculeatus*) were reconstructed to be fast swimmers with passive ventilation systems and two species of hybodont sharks (*Hybodus* spp. and *Hamiltonichthys mapesi*) were reconstructed to be either slow swimmers or demersal sharks with active ventilation systems.

Technical Session I, Wednesday 8:45

#### **BODY MASS AS A CORRELATE OF EXTINCTION RISK IN MAMMALS: A PHYLOGENETIC COMPARATIVE APPROACH TO THE FOSSIL RECORD**

TOMIYA, Susumu, University of California Museum of Paleontology, Berkeley, CA, USA

The search for biological correlates of extinction risk is essential for setting priorities in biological conservation programs. Body mass in particular has received much attention as a potentially useful predictor of species' vulnerability to environmental pressures and detrimental stochastic events. With regard to mammals, recent studies have reported both statistically significant and non-significant correlations between body mass and measures of extinction risk in extant and extinct mammals. The results of these studies are difficult to interpret holistically because of the differences in the measure of extinction risk and the taxonomic as well as spatiotemporal coverage of the analyses. Also importantly, studies based on modern mammals suffer from the limited record of actual extinctions, and the ones focusing on extinct mammals in the fossil record typically lack a unified phylogenetic framework, possibly leading to spurious detection of correlations. Thus, using (1) a published molecular phylogeny of extant mammals with estimated lineage divergence dates, (2) stratigraphic ranges of extinct genera reported in the literature, (3) body mass estimates of the extinct genera based on published linear regression equations, and (4) Felsenstein's phylogenetically-independent contrast method, I tested for correlation between estimated body mass and taxonomic durations within cohorts of Miocene land mammals from North America and Pakistan, with each cohort consisting of genera associated in time and space. In all cohorts, the body mass data exhibited significant phylogenetic signal, justifying the phylogenetic approach. The results of non-parametric tests show that within-cohort correlation of body mass and durations is frequently non-significant even for taxonomically diverse cohorts with wide ranges of body mass, suggesting that the predictive value and perhaps the biological significance of body mass as an extinction-risk correlate may vary critically across time and space. A fruitful avenue of future research will be the investigation of environmental conditions in which body mass is a reliable predictor of extinction risk.

**AN EXCEPTIONALLY WELL-PRESERVED SHORT-SNOUDED BANDICOOT (MARSUPIALIA; PERAMELEMORPHIA) FROM RIVERSLEIGH'S OLIGO-MIOCENE DEPOSITS, NORTHWESTERN QUEENSLAND, AUSTRALIA**

TRAVOUILLO, Kenny, University of New South Wales, Sydney, Australia; MUIRHEAD, Jeanette, University of New South Wales, Sydney, Australia; BECK, Robin, University of New South Wales, Sydney, Australia; GUROVICH, Yamilia, University of New South Wales, Sydney, Australia

This short-snouted bandicoot is the second species of peramelemorphian (*Yarala burchfieldi* being the first) described from Early Miocene deposits of Riversleigh, World Heritage Property, northwestern Queensland. It is much larger than *Y. burchfieldi*, similar in size to extant bandicoots. This short-snouted bandicoot shares a number of synapomorphies with extant peramelemorphians such as the preparacrista of M1 posteriorly orientated, the buccal position of the centrocrista, the buccal termination of the cristid obliqua and the hypoconulid being posterior to the entoconid. Both the short-snouted bandicoot and *Y. burchfieldi* share a number of plesiomorphies such as alisphenoid-parietal contact and having a complete centrocrista. Our study contains the first morphological phylogeny of peramelemorphians, demonstrating that *Y. burchfieldi* and the short-snouted bandicoot are structural links between extant peramelemorphians and dasyuromorphians, forming a paraphyletic group outside of the extant peramelemorphian clade. The morphology of the skull of the short-snouted bandicoot characterized by having a short and broad snout suggests that it filled a different ecological niche to extant peramelemorphians. Its morphology resembles the morphology of dasyurids such as *Murexia longicaudata* from the rainforest of New Guinea. The short-snouted bandicoot may have filled a similar niche in the early Miocene rainforests of Riversleigh as dasyurids; were relatively rare at that time.

Poster Session IV, (Saturday)

**INTERMEDIATE IN LENGTH FOSSIL NECKS IN GIRAFFIDAE**

TRISTER, Renata, New York College of Osteopathic Medicine, Old Westbury, NY, USA; SOLOUNIAS, Nikos, New York College of Osteopathic Medicine, Old Westbury, NY, USA

It has been reported many times that there are no known fossil intermediate in length necks between the short neck of *Okapia* and the remarkably long and specialized neck of *Giraffa*. We provide the first evidence of intermediate in length necks in the Plaeotraginae of the Giraffidae. They are the first with a clear cervical elongation and an interrupted arcus anterioris and shorter spinous processes. *Palaeotragus rouenii* and *Samotherium boissieri* have intermediate in length necks. *Schansitherium decipiens* has the longest cervical length within Palaeotraginae. Using the neck and various cranial features, Plaeotraginae are the sister subfamily of *Bohlinia* and *Giraffa* which are the only taxa with long necks. *Bohlinia* is the sister taxon of *Giraffa*. The C2 of *Bohlinia* is more robust than that of *Giraffa*; a more plesiomorphic morphology. The C7 of *Bohlinia* has no specializations and is truly primitive. In *Giraffa* elongation, slendering of articular facets and reduction of various processes enhance flexibility of the neck. In addition, the T1 and C7 of *Giraffa* are specialized and their morphology is suggestive of transposition. *Bohlinia* shows that the elongation of the neck preceded other specializations observed in *Giraffa*. The morphology and elongation of C3 is representative of an entire giraffid neck. Thus evaluation of the length of a neck can be made by using the morphology and length of the C3. Other giraffid species have shorter necks. This is the case for most archaic giraffids. *Okapia* has a truly plesiomorphic and short neck. *Giraffokeryx* has a slightly longer neck but it still retains a plesiomorphic morphology. *Sivatherium* has a very short neck but this is interpreted as a secondary adaptation. These taxa possess an uninterrupted arcus anterioris and longer spinous processes.

Poster Session III, (Friday)

**THE FIRST UPPER DENTITION OF THE SABERTOOTHED BARBOUROFELIS WHITFORDI (NIMRAVIDAE, CARNIVORA)**

TSENG, Zhijie Jack, University of Southern California, Los Angeles, CA, USA; TAKEUCHI, Gary, Natural History Museum of LA County, Los Angeles, CA, USA; WANG, Xiaoming, Natural History Museum of LA County, Los Angeles, CA, USA

Sabertoothed predators are an outstanding example of evolutionary specialization and convergent evolution. Among the clades that evolved species with elongated canines, the family Nimravidae is a group of carnivorans that bears close resemblance to true cats, felids. The last records of nimravids are represented by species of the North American genus *Barbourofelis*. Fossils of *Barbourofelis* described over the past century in Clarendonian North American Land Mammal Age deposits of California represent the western-most occurrences of the genus. Here we describe new material of *Barbourofelis whitfordi* from the late Miocene Dove Spring Formation (12.5-8 Ma) of the northwestern Mojave Desert, southern California, including the first known saber and confirmed upper cheek dentition of the species. Consistent with the delayed canine eruption observed in other *Barbourofelis* species, the newly discovered permanent cheek teeth are associated with deciduous upper canines. The upper and lower third premolars of *B. whitfordi* are larger in size relative to the carnassials, and less reduced in cusp morphology than other *Barbourofelis* species. In this regard, p3 morphology and size in *B. whitfordi* resemble that of the Eurasian *Sansanosmilus* more so than its congeneric species, supporting the interpretation of an Old World origin of *Barbourofelis*. The known stratigraphic range of *B. whitfordi* within the Dove Spring

Formation spans a two-million year period from 10.5 to 8.4 Ma. Based on a newly identified humerus fragment from the locality area, the record of *Barbourofelis* in the Dove Spring Formation now extends to the Clarendonian1-Clarendonian2 boundary at ~12 Ma.

Poster Session III, (Friday)

**NEW LATE EOCENE AMPHICYONID (MAMMALIA: CARNIVORA) FROM MONGOLIA WITH COMMENTS ON "CYNODICTIS" AND EOCENE AMPHICYONIDS FROM ASIA**

TSUBAMOTO, Takehisa, Center for Paleobiological Research, Hayashibara Biochemical Laboratories, Inc., Okayama, Japan; EGI, Naoko, Primate Research Institute, Kyoto University, Inuyama, Japan; TSOGTBAATAR, Khishigjav, Mongolian Paleontological Center, Mongolian Academy of Sciences, Ulaanbaatar, Mongolia

We report a new small amphicyonid (Mammalia: Carnivora) discovered in the upper Eocene Ergilin Dzo Formation of southeastern Mongolia. The specimen is an isolated upper second molar (M2), whose lingual cingulum is partly broken. It is similar to M2 of *Cynodictis*, which is a late Eocene to early Oligocene European amphicyonid, in overall size, relative size of the trigon cusps, and smooth lingual cingulum. But, it differs from M2 of *Cynodictis* and other amphicyonids in the extremely thick lingual cingulum that bulges distolingually and in the parastyle that positions mesial to the paracone, indicating that it belongs to a new genus of the family. Our reappraisal of Asian "*Cynodictis*" implies that none of them likely belongs to the genus *Cynodictis* and also to the Amphicyonidae. Therefore, the existence of *Cynodictis* is restricted in Europe. In the Eocene of Asia, amphicyonids are recorded from the three deposits: the present amphicyonid from the late Eocene of Mongolia, *Guanxicyon* from the late Eocene Naduo Formation of southern China, and cf. *Guanxicyon* and an indeterminate amphicyonid from the late middle Eocene Pondaung Formation of Myanmar. The present specimen confirms an existence of a late Eocene amphicyonid in the northern part of East Asia and of more than one type of the amphicyonids in East Asia during the late Eocene. Also, it opens questions on the previously reported presence and migration of "*Cynodictis*" as well as amphicyonids in Asia.

Poster Session IV, (Saturday)

**NEW INFORMATION ON THE PECTORAL GIRDLE, STERNUM, AND FORELIMB OF AVIMIMUS (DINOSAURIA: THEROPODA) FROM THE GOBI DESERT OF MONGOLIA**

TSUIHIIJI, Takanobu, National Museum of Nature and Science, Tokyo, Japan; WATABE, Mahito, Center for Paleobiological Research, Hayashibara Biochemical Laboratories, Inc., Okayama, Japan; GISHLICK, Alan, Gustavus Adolphus College, Saint Peter, MN, USA; BARSBOLD, Rinchen, Mongolian Paleontological Center, Ulaanbaatar, Mongolia; TSOGTBAATAR, Khishigjav, Mongolian Paleontological Center, Ulaanbaatar, Mongolia

The pectoral girdle and forelimb of the oviraptorosaurian theropod *Avimimus* were previously described based on incomplete material, to which many avian characteristics were ascribed. We report on additional material of these skeletal parts, including hitherto unknown elements, found in Upper Cretaceous localities in the Gobi Desert of Mongolia, which provides new anatomical information on this theropod. The fused scapula and coracoid retain the theropod plesiomorphy of a posteroventrally-facing glenoid fossa. Contrary to the original description, the coracoid is trapezoidal in shape, not elongated dorsoventrally. The previously unknown sternum consists of a single median element formed by fusion of the left and right plates. This fused element bears a pair of coracoid grooves on its anterior aspect, followed posteriorly by at least two notches for articulation with sternal ribs, and lacks a median keel. Unlike paravians, the newly-found radius has a round distal end lacking an expanded flange. Two proximal carpals, a proximally-concave radiale and a blocky second element (intermedium?), were found in articulation with forearm elements and a "carpometacarpus." The new material preserves the first known, complete "carpometacarpus," distinct features of *Avimimus* not observed in other non-avian theropods, showing that the length of the first metacarpal is approximately one third that of the second or third metacarpal. While all three metacarpals have distal articular surfaces for phalanges, only the first metacarpal bears separate medial and lateral condyles. The distal articular condyle of the second metacarpal is rotated ninety degrees medially, an apomorphy of *Avimimus*. Associated with one "carpometacarpus" is a partial phalanx, putatively representing II-2. The slender shaft of this phalanx suggests that the manus of *Avimimus* likely would have been fairly gracile. Overall, the morphology of these pectoral and forelimb elements is not as avian-like as was previously reconstructed. The conditions of these elements are generally consistent with the hypothesized phylogenetic position of *Avimimus* as a non-avian theropod.

Technical Session VI, Thursday 1:45

**DELTAJAVATA VJATKENSIS AND THE ANATOMY OF PAREIASAURIA**

TSUJI, Linda, Museum für Naturkunde, Berlin, Germany; MÜLLER, Johannes, Museum für Naturkunde, Berlin, Germany

The large, herbivorous pareiasaurs are easily recognizable members of Middle and Late Permian biotas. Pareiasaurs were recently at the center of the debate about turtle origins, but despite this seeming ubiquity there exists a paucity of detailed anatomical information, which in part is due to a lack of well-preserved specimens available for study. This lack of

knowledge makes it impossible to fully resolve the phylogeny and thus to understand the evolutionary trends within the group. *Deltavjatia vjatkensis* is the only pareiasaur found in the localities along the Vjatka River in central Russia. Since then new specimens have been excavated and a number of complete skeletons have recently been prepared. As such this is one of the few pareiasaurs that have multiple well-preserved specimens available for study, including, significantly, specimens of varying growth stages. Here, a detailed anatomical investigation of *Deltavjatia vjatkensis* is presented, which also serves as the most comprehensive morphological study for pareiasaurs in general. Cranially, a definitive stapes has been found for the first time in pareiasaurs, which differs significantly from the questionable ones previously described for the clade. In fact, it resembles more closely in form and proportion that of other ankyramorphian parareptiles, its small size suggesting it served a hearing function. Postcranially, a significant observation is the difference in the form and positioning of the osteoderms between the smallest and largest specimens. The smallest specimens have osteoderms that are closely attached to each other and to the vertebrae, whereas the larger specimens have more widely spaced osteoderms that are not as closely associated with the vertebrae. Considering the new anatomical data now available, *Deltavjatia* was recoded and included in a phylogenetic analysis of pareiasaurian and closely related parareptilian taxa. The taxon falls towards the middle of the clade, possessing characteristics that seem to bridge the morphological gap between the more basal and more derived taxa of the group.

Molecular Tools in Paleobiology: Trees, Clocks and linking Geno- with Phenotype, Friday 11:15

#### **EVO-DEVO OF THE MIDDLE EAR: FINDING HOMOLOGIES BY LINKING MORPHOLOGY WITH GENE EXPRESSION**

TUCKER, Abigail, King's College London, London, United Kingdom

During the course of evolution a remarkable morphological transformation gave rise to the ossicles of the mammalian middle ear. The primary jaw articulation of non-mammalian vertebrates was replaced in mammals by a secondary articulation formed by the squamosal and dentary bones. Comparative anatomy, embryology and paleontology suggest that the primary articulation, was subsequently incorporated into the mammalian middle ear such that the articular and quadrate are homologous to the malleus and incus, while the supporting angular and prearticular are homologous to the tympanic ring and gonial. To confirm these findings molecular biology has recently allowed us to compare gene expression patterns in extant vertebrates (mouse, chick, snake, zebrafish) as the middle ear and jaw articulation form during development. The conservation of gene expression patterns across species is very high, allowing for homologies to be made based on expression of key homeobox genes, examples including *Bapx1*, *Gsc*, *Emx2*, *Hoxa2*, and *Msx1*. Such analysis of gene expression, working with the data derived from anatomical studies, allows for a detailed mapping of homologous structures between mammalian and non-mammalian middle ears and jaws. Molecules and morphology can thus work hand in hand to address problems of homology, without conflict or compromise.

Poster Session III, (Friday)

#### **GEOLOGY AND PALEONTOLOGY OF THE UPPER JURASSIC MORRISON AND LOWER CRETACEOUS CLOVERLY FORMATIONS ALONG THE EASTERN FLANK OF THE BIGHORN MOUNTAINS, NORTHEASTERN WYOMING**

TUCKER, Ryan, South Dakota School of Mines & Technology, Rapid City, SD, USA

Several dinosaurian multitaxic assemblages have been found along the eastern flank of the Bighorn Mountains, south of Buffalo, Wyoming, over the past 18 years from the upper Jurassic Morrison Formation. The overlying lower Cretaceous Cloverly Formation has produced isolated and partial bone fragments yet to be identified. Both formations have fluvial origins, but the contact lacks detailed description locally. Stratigraphic descriptions will allow for a clearer and more concise picture of the Morrison and Cloverly formations within the study area. Two quarries containing partially articulated to completely disarticulated and unassociated dinosaurian fossils are of special interest taphonomically. Originally published under the locality name of Poison Creek by the Science Museum of Minnesota, Sheridan College has more recently opened Quarries 1 and 2 which are classified as bonebeds. The multitaxic assemblage has been preliminarily described as either an isolated channel flood or an oxbow failure. Biogenic and extrinsic origins are unlikely due to the absence of a microfaunal assemblage. Nor is there any evidence for feeding, such as toothmarks or scratches upon any macrovertebrate specimens collected thus far. A third locality, known as the Allosaur Quarry, contained one partial skeleton nicknamed "Caesar" (SCGM0177) exhibiting little or no distortion. Much of the skull is present, lacking only the right lacrimal, right squamosal, left jugal, and quadratojugal. The lower jaw is missing the angular, articulars, and surangulars. Post-cranially, the specimen includes elements from all major regions of the skeleton. This specimen is one of the more complete *Allosaur* skeletons from the North American continent, and collectively, these localities provide important insight to the poorly defined Jurassic-Cretaceous boundary along the eastern flank of the Bighorn Mountains, Wyoming.

Romer Prize Session, Thursday 8:00

#### **EXPERIMENTAL TAPHONOMY: IMPLICATIONS FOR THE FOSSIL RECORD AND PALEOENVIRONMENTAL INTERPRETATION**

TULU, Yasemin, Michigan State University, East Lansing, MI, USA

Late Cretaceous selachian teeth from two sites in the Judith River Formation (JRF) of Montana (the Woodhawk and Power Plant Ferry bonebeds) show variable states of preservation. The two sites are approximately 3 kilometers apart and consist of the same shoreface deposits and stratigraphic horizon, with nearly identical faunal diversity including shark and ray teeth, dermal denticles and centra, teleost teeth, and archosaur remains. Both sites include ca. 14 identifiable species of lamniform and rajiform selachians, differing only in 2-3 species. Subtle differences between the sites are expressed in details of faunal abundances and styles of preservation. The Woodhawk site has a greater abundance and a wider array of preservation, whereas the Power Plant Ferry site shows less abundance with more uniform preservation. This suggests localized areas of variable energy, with the Woodhawk site representing a higher energy environment bringing in specimens from farther offshore and mixing them with local material, and abrading the specimens to a higher degree than those preserved at Power Plant Ferry, where the material reflects a more autochthonous origin. This creates a mixture of marine and estuarine fossils, which in turn produces mixed interpretations of the geology and paleontology of the JRF. These observations prompted a series of taphonomic experiments on modern selachian teeth intended to serve as a proxy for simulating the post-shedding fate (wear and abrasion) of the teeth. The experiments consisted of tumbling modern shark teeth in a mixture of saltwater and JRF sediment. Visual changes in the teeth were quantifiable, with statistically significant (using t-tests) changes in height, width, and mass. The experiments show that when selachian teeth are tumbled for up to 1000 hours, the cusps, cusplets, and roots are progressively lost in a predictable manner. The pattern seen in the tumbled modern shark teeth allows for interpreting the taphonomic state of comparable teeth in the fossil record. This study reveals intrinsic links between paleodiversity, taphonomy, and the paleoenvironment and is likely applicable to other sites with discrete lag deposits.

Poster Session II, (Thursday)

#### **AVIAN AND DINOSAURIAN PATHOLOGIES PROVIDE INSIGHT INTO UNUSUAL DINOSAURIAN BONE TISSUES**

TUMARKIN-DERATZIAN, Allison, Temple University, Philadelphia, PA, USA;  
CHINSAMY-TURAN, Anusuya, University of Cape Town, Cape Town, South Africa

In recent years two novel bone tissues have been reported in dinosaurs: radial fibrolamellar bone (RFB) and medullary bone (MB). RFB is characterized by a large number of radial channels oriented perpendicular to the circumference of the bone wall, and by a localized and discontinuous distribution within individual bones. MB in dinosaurs is considered to be an endosteally-derived tissue that is homologous to avian MB, a tissue deposited by reproductive female birds. We describe associated periosteal and endosteal pathologies in long bones of a modern turkey vulture and a Late Cretaceous Transylvanian dinosaur. In both specimens, radially oriented bony spicules project from the periosteal margin of the compact bone wall, and are associated with highly cancellous endosteally-derived tissue within the medullary cavity. We propose that RFB described in subadult and adult dinosaurs may have had a pathological origin. Among modern birds, radial spicules of periosteal reactive bone result from pathologies such as hypertrophic osteopathy or osteopetrosis. In the former, reactive growth is restricted to the periosteal surface (endosteal deposits are absent), and may be followed by lamellar bone deposition to form a more compacted tissue. These features are similar to the reported appearance and distribution of RFB in dinosaurs. In avian osteopetrosis periosteal deposits are accompanied by endosteal reactions, or the latter may occur alone without periosteal abnormalities. An *Allosaurus* long bone with endosteal deposits described by previous authors as MB also shows evidence of a periosteal pathology, similar in morphology to that observed in both the turkey vulture and the Transylvanian dinosaur, raising the question that, at least in this specimen, the unusual endosteal tissues may be pathological. Although this does not negate the possibility of avian-style MB in dinosaurs, the fact that avian osteopetrosis can also cause endosteal reactive growth with virtually no associated periosteal deposits cautions the interpretation of all unusual endosteally-derived bone tissue as homologous to avian MB.

Technical Session VIII, Thursday 3:30

#### **ION PROBE INTRA-BONE OXYGEN ISOTOPE ANALYSIS - IMPLICATIONS FOR ARCHOSAUR GROWTH AND BIOMINERALIZATION**

TÜTKEN, Thomas, Steinmann Institute for Geology, Mineralogy and Paleontology, Bonn, Germany; ROLLION-BARD, Claire, Centre de Recherches Pétrographiques et Géochimiques, Vandœuvre-lès-Nancy, France; SANDER, Martin, Steinmann Institute for Geology, Mineralogy and Paleontology, Bonn, Germany

Lines of arrested growth (LAGs) are histological growth marks which are common in bone tissues of many extant and extinct vertebrates. The annual formation of LAGs is the basic assumption for skeletochronology and growth rate determinations of extinct vertebrates. To test this annual formation of LAGs and to infer the environmental and climatic influence on vertebrate growth, the intra-bone oxygen isotope ( $\delta^{18}O$ ) variability of extant and extinct vertebrates was analyzed by ion probe. The  $\delta^{18}O$  value of the skeletal apatite is determined by the  $\delta^{18}O$  value of the blood, which is related to that of the ingested water and the body

temperature during bone or tooth mineralization. Accretionarily growing, non-remodelled skeletal tissues of bones and teeth thus should provide a record of seasonal  $\delta 18\text{O}$  variability of the ingested meteoric water. Long bones with LAGs of extant vertebrates (*Equus caballus*, *Alligator mississippiensis*) and extinct vertebrates (*Camarasaurus*, *Europasaurus*, *Plateosaurus*, *Mamenchisaurus*, *Neusticosaurus*) were analyzed to infer systematic relations between LAGs and the  $\delta 18\text{O}$  values. *In situ* bulk oxygen isotope analyses were performed with high spatial resolution (30  $\mu\text{m}$  spot-size) on polished, gold-coated thin sections of the bone cortex using a CAMECA IMS 1270 ion probe (SIMS) with a Cs+ source.  $\delta 18\text{OSIMS}$  intra-bone variability on the sub-mm scale is high (up to 9‰) for both extant vertebrates as well as dinosaurs. The preservation of such high intra-bone  $\delta 18\text{O}$  variability in fossil bones is surprising and indicates that no homogenization of the  $\delta 18\text{O}$  values occurred during the diagenetic alteration. Although not all bone specimens display a clear relationship between LAGs and  $\delta 18\text{O}$  intra-bone variability,  $\delta 18\text{O}$  values are often several per mil lower in LAG zones than in non-LAG zones. This seems independent of the habitat and occurs in aquatic and terrestrial vertebrates and very pronounced even in the marine reptile *Neusticosaurus*. Implications for skeletochronology, growth rate, and biomineralization processes of archosaurs will be discussed.

Poster Session I, (Wednesday)

**CHONDRICHTHYANS FROM A CANADIAN CENOMANIAN BONEBED; IMPLICATIONS FOR FAUNAL PROVINCIALITY OF THE WESTERN INTERIOR SEAWAY.**

UNDERWOOD, Charlie, Birkbeck, London, United Kingdom; CUMBAA, Stephen, Canadian Museum of Nature, Ottawa, ON, Canada

Vertebrate concentration horizons are present within several outcrops of the Belle Fouché Member (Cenomanian) of Saskatchewan and Manitoba, Canada. The richest of these vertebrate concentrations occurs in the Bainbridge River, Saskatchewan, where vertebrate remains can make up nearly 50% of the rock within the bone bed. Fossils here are dominated by shark teeth and the slender teeth of predatory teleosts, but remains of a range of other teleosts, hesperomithid birds and plesiosaurs are all common. Shark teeth are abundant and typically very well preserved. These are dominated by eight species of lamniforms, four of which are very common, along with frequent specimens of "*Hybodus*" and three species of *Ptychodus*. Other selachian remains are very rare, with the only sign of neobenthic taxa being occasional remains of chimaeroids, *Orectoloboides* and a rhinobatid ray. The fauna is therefore indicative of high nutrient surface waters and a hostile seafloor. The different chondrichthyan taxa present show a range of different distribution patterns. Some species, such as *Cretoxyrhina* ex. gr. *mantelli*, have a global distribution, but the majority has far more restricted ranges. The majority of the species present appear to be endemic to the Western Interior Seaway, with many species, including most of the common forms, present only in the northern or northern and central parts of the WIS. In contrast, only two taxa are present throughout the seaway from Canada to Texas, with faunas from Texas having more species in common with elsewhere in Tethys than with the northern WIS. One species, *Archaeolamna* ex. gr. *kopingensis*, is common in the northern WIS and absent further south, but is also known from boreal and Antarctic sites elsewhere. The lack of other species in common with northern Europe suggests no direct link between the northern WIS and Proto Atlantic.

Technical Session X, Friday 9:00

**BRIDGING A MAJOR EVOLUTIONARY GAP: A LONG-TAILED PTEROSAUR WITH A PTERODACTYLOID SKULL**

UNWIN, David, University of Leicester, Leicester, United Kingdom; LÜ, Junchang, Institute of Geology, Chinese Academy of Geological Sciences, Beijing, China

All known pterosaurs can be assigned to two basic morphotypes: long-tailed "rhamphorhynchoids", a paraphyletic clade of basal forms, and the more derived short-tailed pterodactyloids. These morphotypes are separated by a large evolutionary gap, first recognized more than 150 years ago and that, despite recent improvements in the pterosaur fossil, still persists to this day. A new pterosaur from the Middle Jurassic of northeast China, represented by multiple individuals, some complete and well-preserved, provides the first evidence of events within this gap. The skull, with a confluent nasoantorbital fenestra, inclined quadrate and simple, well-spaced, peg-like teeth is generally similar to that of basal pterodactyloids such as *Pterodactylus* and "*Germanodactylus*" *rhamphastinus*. The cervicals are also similar, in some respects, to those of pterodactyloids, but the remainder of the skeleton, including a long tail with filiform extensions of the pre- and postzygapophyses, short metacarpus and fifth toe with two elongate phalanges, corresponds to the "rhamphorhynchoid" morphotype. Phylogenetic analysis (58 taxa, 120 characters) locates the new pterosaur as the sister taxon to Pterodactyloidea and character state distributions are consistent with the idea that it lay close to, or possibly even directly upon, the evolutionary line to this clade. These distributions also hint at two distinct phases of evolution in the lineage leading to pterodactyloids. The first involved changes to the skull and neck. In the second, modifications to the tail and limbs culminated in the pterodactyloid morphotype. Significantly, it would seem that it was events in the second phase that underpinned the basal radiation of pterodactyloids. Key among these were a sharp reduction in tail length, elongation of the metacarpus and reduction of the cruropatagium, part of a complex of changes to the locomotory apparatus that, critically, led to greater agility on the ground, enabling pterodactyloids to invade a variety of terrestrial habitats at roughly the same time as birds took to the air.

Technical Session XVIII, Saturday 1:45

**THE SAUROPODOMORPH SUPERMATRIX: TOWARDS A GLOBAL PHYLOGENY OF THE LARGEST TERRESTRIAL ANIMALS**

UPCHURCH, Paul, University College London, London, United Kingdom

A cladistic data set comprising 750 (420 binary, 330 continuous) characters for 12 outgroups and 113 sauropodomorph ingroup taxa has been constructed via synthesis of previous studies and addition of 30 new characters. The ingroup taxa range from the most basal sauropodomorphs (e.g. *Saturnalia*) to derived titanosaurs, enabling the first comprehensive overview of sauropodomorph evolution from their origin to their extinction. Analysis using TNT yields 68 most parsimonious trees. This topological resolution is achieved because the use of continuous variables means that the probability that two trees will have exactly the same length is very low. This result supports studies, based on both real and simulated data, which show that inclusion of continuous variables tends to increase tree resolution. The shortest trees support many familiar aspects of sauropodomorph phylogeny, including the monophyly of Eusauropoda, Neosauropoda, Diplodocoidea and Titanosauriformes. Basal Sauropodomorpha includes a monophyletic Plateosauria, contradicting recent studies that have placed prosauropod taxa in a completely paraphyletic array with respect to Sauropoda. However, *Yunnanosaurus* is confirmed to be a basal sauropod. One surprising result is that the monophyly of Macronaria is not supported; instead, diplodocoids and titanosauriforms are sister-taxa, to the exclusion of *Camarasaurus*. This occurs because seven of the nine putative macronarian synapomorphies are based on quantitative characters that have been affected by their reorganization as continuous variables. Character states previously considered to be convergences in diplodocoids and titanosauriforms (e.g. high-angled apical wear facets on tooth crowns) may be synapomorphies. Supposedly macronarian features (e.g. an enlarged external nostril and elongation of the metacarpals) actually characterize Neosauropoda or a more inclusive clade, and have been lost via reversal or character state overprinting in the diplodocoids. These changes might reflect the invasion of low-browsing niches by diplodocoids, which resulted in forelimb shortening and modifications to the skull and dental systems.

New Perspectives on the Early Evolutionary History of the Synapsida, Saturday 11:15

**SOUTHERN AFRICAN BAURIIDAE (THERIODONTA, EUTHERAPSIDA): IMPLICATIONS FOR EARLY-MIDDLE TRIASSIC BIOSTRATIGRAPHY**

VAN DEN HEEVER, Juri, Department of Botany and Zoology, University of Stellenbosch, Stellenbosch, South Africa; ABDALA, Fernando, Bernard Price Institute for Palaeontological Research, University of the Witwatersrand, Johannesburg, South Africa; RUBIDGE, Bruce, Bernard Price Institute for Palaeontological Research, University of the Witwatersrand, Johannesburg, South Africa

Bauriids are the youngest 'therocephalian' representatives in southern Africa, being known from the late Early to the early Middle Triassic deposits of the Karoo Basin in South Africa and of the upper Omingonde Formation in Namibia. In this contribution we present a new bauriid specimen from the *Cynognathus* Assemblage Zone of the Karoo Basin, the best preserved of all the representatives of this group. The new material is an almost complete skull with lower jaw, five cervical vertebrae with ribs and a right manus. Unexpected features of this specimen, such as the participation of the vomer in the posterior margin of the secondary osseous palate and the presence of a dorsoventrally high parasphenoidal keel in the anterior portion of the basicranium, provide fresh morphological information about this group. Our taxonomic review of the southern African Bauriidae, based on first hand examination of most of the known specimens of this group, indicates that only two morphotypes are represented. The small-sized *Microgomphodon oligocynus* (including *Sesamodon browni*, *Melinodon sinus*, *Watsoniella breviceps* and *Herpetogale marsupialis*) which, in addition to the features previously mentioned, has a complete postorbital bar and pineal foramen. The second morphotype, *Bauria cynops*, is larger and lacks the above mentioned features of *M. oligocynus*. Analysis of the geographic distribution of Bauriidae in southern Africa, indicate that both species occur in Subzone B of the *Cynognathus* Assemblage Zone in the southwestern portion of the Karoo Basin. In addition, *M. oligocynus* is also known from the older Subzone A of the *Cynognathus* Assemblage Zone in the northern portion of the Karoo Basin, as well as from the higher stratigraphic horizons of the upper Omingonde Formation of Namibia.

Poster Session IV, (Saturday)

**VELOCIRAPTOR'S SISTERS: FIRST REPORT OF TROODONTID TRACKS FROM THE LOWER CRETACEOUS OF NORTHERN GERMANY**

VAN DER LUBBE, Torsten, Niedersächsisches Landesmuseum Hannover, Hannover, Germany; RICHTER, Annette, Niedersächsisches Landesmuseum Hannover, Hannover, Germany; BÖHME, Annina, Niedersächsisches Landesmuseum Hannover, Hannover, Germany

Within a spectacular new dinotracked tracksite from the Lower Cretaceous (Berriasian, "German Wealden"), didactyl footprints have been discovered in summer 2008. The occurrence of these app. 20 cm long tracks on a surface from the Obernkirchen Sandstone Quarries (Obernkirchener Sandsteinbrüche) is a novum for Europe. Hundreds of tridactyl theropod tracks led to the popular name "chicken yard", an area covering more than 400 m<sup>2</sup>. The didactyl tracks can clearly be assigned to the Troodontidae due to morphological and morphometrical characters: the angle between digits III and IV is always greater than

20°, and digit IV is noticeably shorter than III (n = 60). Thus, these tracks represent the first record of footprints attributable to that clade of theropods worldwide. Many of the 60 individual footprints, arranged in 11 trackways, are preserved excellently, showing well defined impressions of the claws, digital- and metatarsal pads. The unexpected discovery of an extremely narrow “standing position track” (left and right foot directly aside) offers interesting insight into troodontid posture. No trace of the specialized claw of digit II is detectable in any of the tracks (n = 60). Two groups of trackways show a parallel orientation. One is composed of three trackways (W' direction), the other of four (SW' direction). In the latter group, two trackways exhibit the same type of preservation and show equal pace- and stride-lengths. These characteristics strongly suggest a simultaneous movement of at least these two individuals and thus some degree of social behavior. In contrast, one trackway within the first, westerly directed group displays clear preservational differences from the others, which means that this animal crossed the Cretaceous lagoon at another time. This particular trackway consists of 12 consecutive footprints, representing the longest didactyl trackway on the “chicken yard” surface. The neighboring quarry area is still covered by app. 7 m of sandstone, so that the ongoing quarry work will offer the opportunity to continuously add data within the next years.

Poster Session I, (Wednesday)

#### THE LARGE MAMMALS OF THE NEW PLIOCENE FOSSIL LOCALITY OF CAMP DELS NINOTS (SPAIN)

VAN DER MADE, Jan, Museo Nacional de Ciencias Naturales, Madrid, Spain; GÓMEZ DE SOLER, Bruno, Institut Català de Paleocologia Humana i Evolució Social, Àrea de Prehistòria, Universitat Rovira i Virgili, Tarragona, Spain; CAMPENY VALL-LLOSERA, Gerard, Institut Català de Paleocologia Humana i Evolució Social, Àrea de Prehistòria, Universitat Rovira i Virgili, Tarragona, Spain; OMS, Oriol, Departament de Geologia, Universitat Autònoma de Barcelona, Barcelona, Spain; BLAIN, Hugues-Alexandre, Institut Català de Paleocologia Humana i Evolució Social, Àrea de Prehistòria, Universitat Rovira i Virgili., Tarragona, Spain

The new fossiliferous locality of Camp dels Ninots (“field of the puppets” after the opal concretions found there) is in a maar in the town of Caldes de Malavella (Catalonia, Spain). Up to now five articulated skeletons of large mammals were excavated, as well as articulated skeletons of chelonians, amphibians and fishes, and abundant plant remains. A skeleton of a large rhinoceros is assigned to cf. *Stephanorhinus jeanvireti* and a particularly well preserved skeleton belongs to *Tapirus arvernensis*, the last European tapir, which is probably closely related to *Tapirus indicus*. Three skeletons belong to a bovid of the type *Parabos* - *Alephis*. The specimens from Camp dels Ninots resemble in particular the type material of *Alephis tigneresti*. The known temporal distributions of *Tapirus arvernensis* (MN13-17), *Stephanorhinus jeanvireti* (MN16) and *Parabos-Alephis* (MN13-15) situate the locality of Camp dels Ninots near the MN15-16 transition or around 3.5 Ma.

*Parabos* and the slightly later and more evolved *Alephis* are known from some 30 European localities, with ages between roughly 6 and 3 Ma, most of which yielded rather poor material. Two generic names and seven specific names were proposed for such bovids, but the group needs revision. These bovids are considered to be close to the origin of the Bovini and are much more primitive than typical Bovini like *Leptobos*, *Bos*, *Bubalus* and *Bison*. The evolution and environmental context of the early Bovini will be briefly discussed.

The Evolution of Birds in the Mesozoic: a Symposium in Honor of Cyril A. Walker, Thursday 10:45

**MESOZOIC PATERNITY SUIT: PARENTAL CARE IN AVIAN ANCESTORS**  
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The reproductive biology of living birds differs dramatically from that of other extant vertebrates. Distinctive features common to most bird species include a single functional ovary and oviduct, production of one egg at daily or greater intervals, incubation by brooding, and the extensive participation of males in the care of eggs and young. How this avian style of reproduction evolved has been the subject of much discourse over the last twenty years. In particular, controversy has arisen concerning the origins and subsequent transitions in parental care among birds and their ancestors. Cretaceous troodontid and oviraptorid dinosaurs share a close ancestry with birds together with a number of reproductive attributes, including multi-layered eggshell, asymmetric eggs and monoautochronic ovulation. Additionally, adult Troodon formosus, Oviraptor philoceratops, and Citipati osmolskae have been discovered on top of egg clutches with some retaining avian-like brooding postures. We assessed the parental care system of these dinosaurs using clutch volume and the bone histology of clutch-associated adults. We generated regression models describing the clutch volume-body mass relationships of 485 extant egg-laying vertebrates divided into six taxon/care groups: reptiles-no care, lepidosaur-maternal, crocodile-maternal, and bird-maternal, biparental, and paternal. Of the six models, the dinosaur ratios most closely match the lepidosaur-maternal and bird-paternal cases. The close phylogenetic relationship, shared reproductive attributes with extant birds, and absence of maternal histologic features in these dinosaurs favors the latter model. The nature of parental care within more basal theropods and dinosaurs in general remains ambiguous. Paternal care in troodontids and oviraptors supports previous hypotheses that

this reproductive system was primitive for Aves. Within extant birds, the three parental care strategies correspond to statistically distinct clutch volume to adult body mass relationships, with paternal care associated with the largest clutches. Clutch volume in lepidosaurs exhibiting maternal care scales as that of birds with paternal care.

Technical Session I, Wednesday 8:00

#### NEW METHODS OF NETWORK PALEOBIOGEOGRAPHY WITH AN EMPIRICAL EXAMPLE FROM MIOCENE MAMMALS

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Paleobiogeographical methods span a wide array of methodologies, however most of these methods share an underlying assumption of dichotomous relationships. While this has certain advantages, it places a fundamental assumption on the data that they can be best represented by dichotomous trees. Network analyses can allow us to relax these assumptions placed on biogeographic analyses; they allow for direct connections between localities, as well as multiple connections between multiple localities. Here we demonstrate the usefulness of these methods in visualizing patterns of biogeography, and present some preliminary methods on creating quantifiably testable subgroupings within the network. The general order of analysis involves creating a pairwise distance matrix for all the localities, and using this to find the Minimum Spanning Networks (MSN) and Minimum Spanning Trees (MST) which define the networks. While differing similarity indices used can give differing values, a robust network will be little effected by the change in values. Once these networks are calculated, they are overlain on a Non-Metric Multidimensional Scaling (NMDS) ordination or geographic plot of the localities to best visualize the data. Additionally, for pre-defined groupings we can use the network to test the internal cohesiveness, by calculating the proportion of within group connections out of the minimum number of theoretically possible connections. These results are bootstrapped to provide a separate level of confidence, as well as a test of significance against a null result. Groups which show high proportions of within group cohesiveness are interpreted to be more “natural” groupings, where they share more species with each other than with those localities outside the group. As a testing dataset we have used the MIOMAP (Miocene Mammal) database, extracting those records for the Early Barstovian only. Our results show mixed support for the traditionally recognized provinces, with some groupings showing high levels of cohesiveness while others show virtually no internal connections. Provinces appear to cluster in two distinct groups, corresponding to the plains and mountain localities.

New Perspectives on the Early Evolutionary History of the Synapsida, Saturday 10:30

#### DICYNODONTS OF SOUTH AMERICA: AN OVERVIEW OF MORPHOLOGY AND CLADISTIC RELATIONSHIPS

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Dicynodontia is a synapsid group that ranged from the Middle Permian to the Late Triassic, with a potential occurrence in the Lower Cretaceous of Australia. South America preserves numerous dicynodonts, particularly large taxa, as well as tusked and tuskless forms. In South America, dicynodonts are found in Permian and Triassic sediments of Brazil, and in Triassic sediments of Argentina. *Endothiodon* was the only Upper Permian taxon, described from Paraná State, Southern Brazil. In the Lower Triassic, the cosmopolitan genus *Lystrosaurus* occurs in Brazil, and *Kannemeyeria* and *Vinceria* occur in Argentina. During the Middle Triassic, tusked forms such as *Dinodontosaurus* (Argentina and Brazil) and *Rechnisaurus* (Argentina) occur, in addition to the tuskless dicynodont *Stahleckeria* in Brazil. *Ischigualastia* is also present in the Middle Triassic of Brazil, although cranial sutures are poorly preserved. During the Upper Triassic, the dicynodonts were greatly reduced in diversity, represented by three South American tuskless species: *Jachaleria candeleriensis* (Brazil), *Jachaleria colorata* (Argentina), and *Ischigualastia* (Argentina). Comparisons between both *Jachaleria* forms confirmed the validity of the genus, even though the species distinction is less certain. Recent phylogenetic studies, considering cranial and also postcranial characters, has showed that such postcranial characters are important for distinguishing some dicynodont genera. An analysis with 12 Triassic dicynodont taxa showed two distinct groups. One group is composed of a *Shansiodon* + *Tetragonias* clade and a *Parakannemeyeria* + *Sinokannemeyeria* clade, with *Kannemeyeria* and *Wadiazaurus* as successive outgroups. The second group is completely resolved: *Dinodontosaurus* is followed by *Placerias*, *Angonisauros*, *Stahleckeria*, *Ischigualastia* and *Jachaleria*. The result of the analysis indicates a tendency towards the disappearance of tusked in Triassic dicynodonts, probably related to changes in their diet caused by climatic and floristic alterations.

Poster Session I, (Wednesday)

#### TAPHONOMIC PATTERNS IN THE MARINE VERTEBRATE RECORD OVER THE PHANEROZOIC: A DATABASE APPROACH

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A literature search indicates papers on marine vertebrate taphonomy are underrepresented relative to those on the taphonomy of either terrestrial vertebrates or marine invertebrates, suggesting marine vertebrate taphonomy is understudied. Moreover, actualistic studies

of marine vertebrates are rare, and actualistic investigations of terrestrial vertebrates and marine invertebrates may generally not be applicable to marine vertebrate taphonomy. As a first step toward a better understanding of the marine vertebrate record, we are compiling a comprehensive database of published fossil marine vertebrate occurrences with detailed taphonomic information. The goal is to use our database in conjunction with the Paleobiology Database [PBDB] (<http://paleodb.org>) to examine patterns in marine vertebrate taphonomy over the Phanerozoic that could reveal patterns or processes unique to marine vertebrates. Occurrences will be placed in tectonic, paleoclimatic, and paleoceanographic context and compared with terrestrial vertebrates and marine invertebrate records. An initial analysis of 778 specimens (Actinopterygia, Ichthyosauria, Mosasauridae, Plesiosauria, and marine mammals) representing 242 distinct localities and ranging in age from Devonian to Neogene reveals some interesting trends. For example, articulated specimens are reported in nearly equal proportions from nearshore, offshore, and carbonate deposits. This is somewhat unexpected given the likely variations in taphonomic processes across these depositional settings. Taphonomic trends related to body size were also examined, and our initial survey indicates that larger taxa tend to be more commonly represented by dissociated elements. Our data so far suggest that the degree of articulation may not be informative for distinguishing taphonomic processes unique to specific marine depositional environments, and that preservational biases related to body size may be present in marine systems as is commonly the case in terrestrial deposits.

Poster Session IV, (Saturday)

#### LATE CRETACEOUS SAUROPOD DIVERSITY IN SOUTHERN EUROPE

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The Late Cretaceous sauropod record in Europe is composed of three lithostrotian titanosaur genera (*Magyarosaurus dacus*, *Ampelosaurus atacis* and *Lirainosaurus astibiae*) and other isolated remains assigned to indeterminate "titanosaurs". Traditionally, in Southern Europe (France and Spain) it is widely assumed that Late Cretaceous sauropods are exclusively represented by lithostrotian titanosaur. A revision of the sauropod material recovered from the localities of Bellevue, Fox-Amphoux (Southern France) and Serraduy (Northeastern Spain) and the description of new material from Molí del Baró, Presa de Trepmp, and Peguera-1 sites (Northeastern Spain) allow us to review the biodiversity and succession of sauropod taxa at the end of the Cretaceous in southwestern Europe. The study of postcranial material (15 femora) ranging from the Late Campanian to the Late Maastrichtian indicates that lithostrotian titanosaur were not the only group of Late Cretaceous Titanosauriformes. We have recognized at least five different taxa: two small to medium-sized lithostrotians like gracile *Lirainosaurus* and robust *Ampelosaurus*; a small and a giant indeterminate titanosaur and an indeterminate Titanosauriformes which is not a Lithostrotian. Most studied localities show a monotaxic record although at least one of them includes up to three different sauropods. The temporal association of the localities in the latest Cretaceous reveals faunal similarities along the French and Iberian basins. The review of the Late Campanian-Early Maastrichtian localities confirms the cosmopolitan presence of a small-sized lithostrotian form (*Lirainosaurus*) and establishes the occurrence of up to three different sauropod taxa. A similar pattern has been recognized in the Late Maastrichtian, including the presence of giant titanosaur. Therefore, the sauropod diversity is higher than previously thought in the latest Cretaceous of Southern Europe.

Poster Session I, (Wednesday)

#### NEW INSIGHTS ON THE BRAIN, TOOTH DEVELOPMENT, AND FEEDING SPECIALIZATIONS OF THE SIRENIAN *MIOSIREN KOCKI* (TRICHECHIDAE, SIRENIA) AS REVEALED BY CT

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*Potamosiren* from Columbia, all trichechines appear to have had the horizontal tooth replacement like that found in modern manatees. Two anomalous taxa of sirenians, *Anomotherium* and *Miosiren*, from the late Oligocene of Germany and early Miocene of Belgium respectively, form the subfamily Miosireninae. The Miosireninae are considered the sister group to the Trichechinae based on two cranial features, the presence of the lamina orbitalis of the frontal, and the size of the nasals. Here we report new evidence from CT scans of the skull of the holotype of *Miosiren kocki* revealing new characters of the brain endocast and tooth structure. These characters help in clarifying the relationships of the Miosireninae with the other Trichechidae and Dugongidae. In addition, this analysis allows for a more precise understanding of tooth development in these early trichechids and highlights details of the structure of the palate, which has been suggested to indicate that *Miosiren* was durophagous.

Poster Session II, (Thursday)

#### LAGERSTÄTTE MADYGEN - OUTSTANDING WINDOW TO A CONTINENTAL TRIASSIC ECOSYSTEM

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Fieldwork at the Madygen Lagerstätte (Middle to Upper Triassic, Kyrgyzstan, Central Asia) has been resumed recently in order to carry out an integrative study of the depositional environment and evolutionary history of the Madygen basin and the paleoecology of its biota. According to the preliminary results of this survey, the Madygen Formation comprises an up to 560 m thick succession of complexly interbedded conglomerates, sand-, silt-, and claystones which can be interpreted as alluvial fan, alluvial plain, and lake deposits. Deposition took place in a tectonically active basin under cool-temperate climatic conditions with year-round rainfall. Abundant fossil remains including one of the most diverse Mesozoic floras of Eurasia, various aquatic invertebrates (e.g., microconchids, molluscs, crustaceans), more than 20,000 insects representing almost all contemporary groups, freshwater sharks, palaeoniscids, lungfish, amphibians, chroniosuchians, therapsids, and diapsids are indicative of favorable ancient living conditions. As one of the world's richest Triassic fossil localities the Madygen Formation has an outstanding role for the reconstruction of the evolution of Mesozoic terrestrial ecosystems. This is exemplified by the following aspects: (1) The fossil assemblage is characterized by the co-occurrence of groups appearing in the Early Mesozoic with those which had their summit in the Late Paleozoic. (2) The Madygen deposits provide the earliest occurrence of a well-developed lacustrine invertebrate fauna; (3) In terms of abundance and diversity of first consumers, the Madygen lake was similar to modern lacustrine freshwater ecosystems of middle to high northern latitudes. The peculiarity of the Madygen paleoecosystem might be the consequence of its intra-cratonic high-northern latitudinal paleogeographic position. Situated at the intersection point of the Euramerian, Siberian, and Cathaysian faunal and floral provinces, the Triassic Madygen basin offers a unique taphonomic window with occasional soft-tissue preservation lacking any equivalent in the Early Mesozoic fossil record.

Poster Session I, (Wednesday)

#### NEW ASPECTS ON INNERSPECIFIC VARIATION IN THE GENUS *HALITHERIUM* (MAMMALIA: SIRENIA)

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Sea cows were abundant and widespread in the Miocene and Oligocene and are well-known from Africa, North America and Europe. The German Mainz Basin is one of the most famous localities for Sirenia in Central Europe. It is the type locality of the early Oligocene *Halitherium schinzii*. This taxon forms together with *H. taulannense* (late Eocene of France) and *H. christolii* (late Oligocene of Austria) the species-complex of the paraphyletic genus *Halitherium* currently regarded as valid within the European Paleogene. Intraspecific morphological variation is indicated for *H. schinzii* and *H. christolii* since the beginning of the 20th Century resulting in the description of numerous new taxa, which are now considered to be synonymous. However, the intraspecific variation in Sirenia in general is minimal according to morphometric data and morphological studies of the extant *Dugong dugon*, the three extant species of *Trichechus*, and of the extinct *Methaxytherium floridanum* (middle Miocene from Florida, US). Several sirenian finds from the Rupelian (lower Oligocene) of the Mainz Basin and Rhine Valley (Western Germany), the localities being extensively sampled for *Halitherium*, were revised or described for the first time. Several specimens differ significantly from *H. schinzii* in having a supraoccipital missing an external occipital protuberance. The area in question in the median plane of the dorsal margin of the supraoccipital is in these specimens concave anteriorly reflecting a completely opposite structure as is in *H. schinzii*. *Halitherium bronni* displays this character, but is not considered valid. According to personnel observations intraspecific variations affect the course of the temporal crests, for example, but the basic skeletal structures do not change in ontogeny and between males as in females. Consequently, ontogenetic stages and sexual dimorphism can be excluded as explanation for differences present in the Oligocene German material. This supports the presence of two distinguished morphospecies in the Oligocene of Germany and shows *H. bronni* to be a valid taxon.

Technical Session X, Friday 9:30

#### THE FIRST TAPEJARID PTEROSAUR FROM EUROPE

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Tapejaridae are a peculiar group of toothless and crested pterosaurs which are mainly known from the late Early Cretaceous (Aptian-Albian) of Brazil and China. The definition of this pterodactyloid family and its monophyly are controversial and still debated. Here we report on a tapejarid skull from the upper Barremian of the renowned Las Hoyas Lagerstätte (La Huérguina Formation, Cuenca, Spain). The fossiliferous laminated limestones of Las Hoyas

have been deposited in a continental wetland area and have yielded a rich vertebrate fauna. However, pterosaurs are very rare in this locality, where only a few isolated pterodactyloid teeth have been found so far. The tapejarid specimen from Las Hoyas (MCCM LH 9413) may represent a new taxon. The skull, preserved on slab and counter-slab, is rather incomplete and is ~24 cm in preserved length. All bones are crushed due to the lateral compression of the fossil. The dorsal part and the beak are missing. The premaxillary shows a very thin cortical bone and a typical trabecular structure, the upper and lower jaws are edentulous, and the nasoorbital fenestra is proportionally very large and has a rounded anterior edge. This latter character is diagnostic and would indicate that the Las Hoyas taxon is more closely related to *Tapejara*, *Tupandactylus*, *Sinopterus*, and the “*Huaxiapterus*” species (taxa either included into the clade Tapejarinae or considered as the only members of the Tapejaridae) than to *Thalassodromeus* and *Tupuxuara* (taxa either included into the tapejarid subfamily Thalassodrominae or considered as non-tapejarid azhdarchoids and placed in their own family, i.e. “thalassodromids” or “tupuxuarids”). Indeed, the latter two genera have a nasoorbital fenestra which is angular anteriorly. Paleobiogeographic implications of the Spanish finding are noteworthy: the Las Hoyas taxon represents the first occurrence of this group in Europe, and one of the oldest known tapejarid (a tapejarid specimen has been recently reported from the Yixian Formation, also Barremian in age). This is congruent with a Eurasian origin of these pterosaurs, as previously suggested by the Chinese discoveries.

Poster Session I, (Wednesday)

#### NEW MAMMALIAN FOSSIL RECORDS REFINING A VIEW ON EARLY/LATE PLIOCENE FAUNAL TURNOVER IN CENTRAL EUROPE

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A short period of the Early/Late Pliocene boundary (mammalian biozones MN15b-16a) presents one of the most dramatic turning points of the Late Cenozoic faunal history. The extensive rearrangements both in taxonomic content and community structure coincide with onset of aridisation/cooling that disrupted relatively humid climate characteristic for most time of the Ruscinian stage. Unfortunately, in transalpine Europe a reliable faunal record of that period is limited just to few classical assemblages: Weze (Poland), Csarnota, Osztramos 7 (Hungary), Gundersheim, Wolfersheim (Germany), Ivanovce, and Hajnacka (Slovakia). Each of them comes, however, from different stratigraphical, geographical, and paleoenvironmental contexts what complicates a comprehension to general features of that period and strongly calls for further data. Fortunately, we found several new localities responding just that claim: Vitosov, Menany 3 (Czech Republic), Hostovce 2 (Slovakia), and Crnotice II (Slovenia). These localities cover a short time span near the MN 15b/16a boundary (according to the evolutionary niveau of arviculids, especially *Mimomys gracilis-stehlini* lineage) and allow us to supplement our knowledge about this faunal transition in essential way. Based on the faunal assemblages from Vitosov and Hostovce 2, we can document the presence of typical Ruscinian fauna after Csarnota-Wolfersheim niveau. This fauna is characteristic by dominance of murids (*Apodemus atavus* clade) and glirids among rodents and highly diversified insectivores (soricids and talpids) and bats. Except of well known taxa like *Desmanella*, *Beremendia*, *Blarinoides*, or *Blarinella*, the fauna of Vitosov yielded a fragment of unknown, perhaps endemic, form of soricid showing similarities to *Zelcenia*. In the Menany 3 fauna, a little younger than the others but older than Hajnacka, a clear predominance of arviculids over murids and decline in diversity of insectivores can be observed (but cf. Osztramos 7), both the phenomena quite characteristic for the later development.

The Evolution of Birds in the Mesozoic: a Symposium in Honor of Cyril A. Walker, Thursday 10:30

#### HALCYORNIS TOLIAPICUS (LOWER EOCENE, ENGLAND) INDICATES ADVANCED NEUROMORPHOLOGY IN MESOZOIC NEORNITHES

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Current state-of-the-art micro-CT imaging has provided important information about neurological development in early neornithine clades. Our recent investigations of *Prophaethon shrubsolei* and *Odontopteryx toliapica* from the Lower Eocene of the London Clay Formation of England have revealed that the avian brain was essentially modern in form by 55 Ma, but that an important vision-related synapomorphy of living birds, the eminentia saggitalis of the telencephalon, was poorly developed. Here we describe the endocranium of *Halcyornis toliapicus*, also from the London Clay Formation. The affinities of *Halcyornis* have been hotly debated, with the taxon referred to the Charadriiformes (Laridae), Coraciiformes (Alcedinidae), and its own family Halcyornithidae erected by Harrison and Walker) and most recently as a possible senior synonym of the Pseudasturidae (Pan-Psittaciformes). Unlike *Prophaethon* and *Odontopteryx*, the eminentia saggitalis of *Halcyornis* is strongly developed and comparable to that of living species. Like those London Clay taxa, the eminentia saggitalis occupies a rostral position on the telencephalon. The optic nerves were especially well developed, which together with the strong development of the eminentia saggitalis indicates a high degree of visual specialization

in *Halcyornis*. The advanced development of the eminentia saggitalis further supports a Mesozoic age for the appearance of this structure and associated neural architectural complexity found in extant Aves. The eminentia saggitalis of living Psittaciformes is situated caudally on the telencephalon, making a Pan-Psittaciformes relationship unlikely for *Halcyornis*.

Poster Session III, (Friday)

#### A LONG-TAILED PTEROSAUR FROM THE EARLY CRETACEOUS JEHOLO GROUP, CHINA

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Here we report a new Cretaceous long-tailed pterosaur from the Jiufutang Formation (120Ma) at Mutoudengzi, Hebei Province, near Jianchang of west Liaoning, China. It is an almost complete skeleton representing an individual with an estimated wing span of 73 cm. The specimen is a non-pterodactyloid pterosaur diagnosed by features such as first two pairs of premaxillary protruding teeth relative dentary, at least 16 peg-like teeth on each side of the upper jaw, cervical vertebrae more elongated than in any known non-pterodactyloid, length of wing metacarpal about half the length of the first wing phalanx (convergent with Pterodactyloidea), very curved last pedal phalanx of the fifth toe. A phylogenetic analysis including most non-pterodactyloid pterosaurs shows that the new taxon lies outside the Novalioidea, being cladistically more primitive than the Rhamphorhynchidae and *Campylognathoides*. This analysis differs from previous studies and indicates that more work is needed before a stable picture of non-pterodactyloid pterosaur relationships is achieved. The last phalanx of pedal digit V of the new specimen is strongly curved. It can be short, straight, slightly curved in non-pterodactyloid pterosaurs. The variation of morphology and size of the phalanx of pedal digit V might indicate a variation in the shape of the uropatagium in non-pterodactyloid pterosaurs. From the non-pterodactyloid pterosaurs associated to the Jehol Biota, the only one that bears an elongated tail is *Pterorhynchus welnhoferi*. This material comes from the Daohugou Bed, whose age is controversial (Middle Jurassic, Late Jurassic- Early Cretaceous and Early Cretaceous). In any case, the Daohugou bed is older than the overlying Yixian and Jiufutang formations. The new specimen is the youngest long-tailed non-pterodactyloid known to date, showing that those primitive pterosaurs survived well into the late Early Cretaceous and were more diverse as previously thought. It further highlights the importance of the Jehol Biota that is starting to shape our understanding of the evolutionary history of flying reptiles.

Poster Session III, (Friday)

#### FURTHER BIOSTRATIGRAPHIC SUBDIVISION AND AGE CONSTRAINT OF THE LOWER PALEOGENE IN EASTERN ERLIAN BASIN, INNER MONGOLIA, CHINA

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Lack of age constraint of Asian Paleogene Land Mammal Ages has hampered not only the intercontinental biostratigraphic correlations, but also the understanding of evolutionary history of some major mammalian groups. Recent investigations in the eastern Erlian Basin, Inner Mongolia, China, provides some new information refining this issue. The lower Paleogene in the eastern Erlian Basin comprises three formations: the Nomogen Fm., the Ashanto Fm., and the Irdin Manha Fm. in ascending order. They are well represented by the composite section of strata from Nuhetingboerhe and Huheboerhe (in the Camp Margetts area of the AMNH's Central Asiatic Expeditions). Careful field work and fossil collecting clarify some of the existing problems and encourage further biostratigraphic subdivision of these rock units. Four mammal-bearing levels are confirmed for the Nomogen Fm. The lower two levels (N1, N2) produce typical Gashatan mammals, including *Lambdopsalis bulla*, *Prionessus lucifer*, *Tribosphenomys minutus*, *Bayanulanius tenuis*, *Pastoralodon lacustris*, *Prodinoceras xinjiangensis*, and *Palaeostylops iturus*. The upper two levels (N3, N4) may correlate with the Bumbanian of Mongolia, indicated by the presence of *Gomphos elkema*, and some ctenodactyloid rodents. N3 also yields *Baataromomys ulaanus*, *Anatolostylops zhaii*, two undescribed perissodactyls, a lagomorph, and *Dissacus*. Four mammal-bearing levels (A1–A4) have been recognized in the Arshanto Fm. The lowest one (A1) is characterized by the presence of *Litolophus gobiensis*, *Gobiotherium mirificum*, *Dawsonolagus antiquus*, *Archetypomys erlianensis*, *Hyrachyus*, *Schlosseria*, *Tamquammys*, *Advenimus*, and *Metacoryphodon*. The Irdin Manha Fm. can be subdivided into two levels (H1, H2). *Lophialetes expeditus* is one of the diagnostic taxa for both levels. Paleomagnetic result suggests that the composite Paleogene section can be correlated to the chron C21r-C26r of Geomagnetic Polarity Timescale. The Nomogen Fm., containing both Gashatan and Bumbanian mammals, spans from the late Paleocene to very early Eocene in age. The Arshanto Fm. spans from late Early Eocene to early Middle Eocene. The Irdin Manha Fm. is entirely within the Middle Eocene.

#### ARE BRACHYOPIDS TUPILAKOSAURS?

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Two taxa of Temnospondyli, the Brachyopidae and Tupilakosauridae are often seen as distantly related despite having skulls that are remarkably similar. The Tupilakosauridae are a taxon of rare Permian temnospondyls, found in Europe, North America, and Gondwana. In North America, *Kourerpeton* and *Eobrachyops*, initially thought to be brachyopid relatives, have been shown to be tupilakosaurids. In phylogenetic analyses the Tupilakosauridae are usually separated from the Brachyopidae as part of the otherwise Laurasian Dvinosauria, a largely Permian taxon, with the almost exclusively Gondwanan Brachyopidae forming part of the predominantly Mesozoic Stereospondyli. Triassic Tupilakosaurids are unique among temnospondyls in having diplospondylous centra, with diplospondyli originating within the taxon as evidenced by the earliest tupilakosaur, the Early Permian *Staugenhopia*, which had rhabditomous centra. In contrast, brachyopids are said to be rhabditomous, although no articulated brachyopid centra have been found. A new site east of Hobart, Tasmania, has yielded a fauna of Early Triassic age. Some fifteen skulls and mandibles of a temnospondyl have been identified as *Bothriceps australis*, an undoubted though plesiomorphic member of the Brachyopidae. This is the largest known accumulation of brachyopid skulls, and the only deposit with multiple associated mandibles and postcranial material. An articulated series of twenty six vertebral centra are diplospondylous spools, with adjacent ribs and two neural arches, all clearly identifiable as from tupilakosaurids. The combined evidence of skulls and vertebrae suggests that either brachyopids are derived tupilakosaurids or that diplospondylous centra arose twice within the Temnospondyli.

Poster Session IV, (Saturday)

#### GROWTH MARKS IN SAUROPOD RIBS FROM THE UPPER JURASSIC MORRISON FORMATION, TENDAGURU AND LOWER CRETACEOUS OF NIGER

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In most cases growth marks are not preserved in sauropod long bones like tibia, fibula, radius and ulna. Therefore several ribs of different sauropod taxa were sampled by cross sectioning and core drilling for paleohistological study. The samples are from three different localities. Most of them are basal macronarian *Camarasaurus* ribs from one almost complete individual, named E.T., found in the Howe Stephens Quarry (Morrison Formation). Three of the right side ribs of *Camarasaurus* E.T. were sampled in 6-9 different parts (from proximal to distal). A few LAGs are preserved in nearly all of these samples. In all cases the upper proximal end near the head of the rib is the part where most of the growth record is preserved. Some of the samples show up to 80% of growth record which means 30-40 LAGs. This longevity is approximately consistent with what has been suggested by previous growth curve analyses. Additional sampled taxa from this locality are *Brachiosaurus*, *Apatosaurus* and one other unidentified diplodocoid, which are currently being studied. Also a few undetermined rib fragments with a clearly preserved growth record from Niger were sampled. Because of their size and shape, they were considered to belong to a new sauropod taxon. While all samples from the Morrison Formation and Niger are cross sections, the ribs from the third locality, Tendaguru, were sampled by core drilling. Some of these samples, (two *Brachiosaurus*-, two diplodocoid-, and one *Dicraeosaurus* rib) especially those from *Brachiosaurus* show growth marks too. All these results demonstrate that it is possible to find evidence of growth in sauropod ribs. This could be the starting point for more histological research in other parts of the skeleton.

Poster Session I, (Wednesday)

#### PALEOECOLOGY OF LONCHIDION SELACHOS FROM THE LATEST CRETACEOUS HELL CREEK FORMATION, NORTH DAKOTA

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*Lonchidion selachos*, an abundant hybodont elasmobranch in Late Cretaceous deposits of North America, went extinct at the K/P boundary, however remarkably little is known about its paleoecology. We investigate this based on hundreds of specimens collected by screening microvertebrate sites in the Hell Creek Formation of southwestern North Dakota. Teeth of *L. selachos* have a low central cusp, a distinctive labial protuberance, a transverse ridge, and range in size from 3 to 5 mm. The root extends the full length of the tooth, and is 1/3 to 1/2 the height of the crown. Compared to modern elasmobranchs with similar tooth morphology and with known diets, the diet of *L. selachos* was probably primarily composed of benthic, shelled invertebrates. *L. selachos* was small, based on size of the teeth. It was probably similar in size to *L. babulskii* (20 to 35 cm in total length), based on remarkably similar teeth. *L. selachos* has been assumed to be a freshwater. However, its abundance along with other elasmobranchs and other fish (79% of 1432 specimens) suggest a more coastal setting. Because *L. selachos* was such a common fish in the latest Cretaceous, but is absent from the Paleocene, understanding its role in the Late Cretaceous paleoecosystem is important in determining the details of the K/P extinctions.

Poster Session IV, (Saturday)

#### PHYLOGENETIC RELATIONSHIPS OF EURASIAN HIPPARIONINES (EQUIDAE, PERISSODACTYLA, MAMMALIA) IN THE LATE MIOCENE

WATABE, Mahito, Hayashibara Center for Paleobiological Researches, Okayama, Japan; NAKAYA, Hideo, Kagoshima University, Kagoshima, Japan; ATAABADI, Majid, University of Helsinki, Helsinki, Finland; KRAKHMALNAYA, Tatiana, State Museum of Natural History Ukraine, Kiev, Ukraine

Hipparionine horses are widely distributed in Eurasia and Africa (Old World) in late Miocene. They have diverse facial morphology (cranial) and postcranial proportions and sizes. In the Turolian, the forms with similar facial morphology and limb proportions are recognized in mammalian faunas in the Greco-Iranian region, Northern Black Sea region, Inner Asia, and Northern China. The groups of those forms are considered as monophyletic groups. Forms with wide geographical distribution including above regions are: a form with reduced preorbital fossa (POF) (*Hipparion urmiense*, and *H. hippidioides*); that with deep and triangular POF close to the orbit (*H. mediterraneum*, *H. moldavicum*, *H. proboscideum*, *H. elegans*, and *H. forstenae*). A small form named as *H. matthewi* also belongs to this group. Those forms have slender limb proportions. There are large-sized hipparion (*H. giganteum*, *H. dermatorhinum* and *H. weihoense*) with primitive and derived condition of facial characters in those regions. They do not form a monophyletic group. There are other hipparionine forms with characteristic facial morphology (deep POF situated far from the orbit and high on face) endemic to Northern China. They are phylogenetically related to the North American Clarendonian and Hemphillian hipparionines.

The hipparionine horses that are recognized in both eastern and western parts of Eurasia can be used for long distance biostratigraphic correlation of continental beds with rich mammalian fossils. Wide distribution of the members of the monophyletic groups (*H. moldavicum* and *H. urmiense* groups typically recognized in fauna from Maragheh, NW Iran) suggests active dispersal events inside of Eurasia during the Turolian period. Endemism of speciation of primitive hipparionine horses (*Hipparion* = *Hippotherium primigenium*) in each provinces of the continent also occurred from Vallesian to Turolian.

Poster Session IV, (Saturday)

#### THE FORELIMB OF A NEW TYRANNOSAURIDAE (DINOSAURIA: THEROPODA) FROM MONGOLIA AND ITS IMPLICATIONS FOR FORELIMB EVOLUTION IN TYRANNOSAURIDS

WATANABE, Akinobu, University of Chicago, Chicago, IL, USA; SERENO, Paul, Department of Organismal Biology, Chicago, IL, USA

Study was done on the forelimb of a new theropod dinosaur (Tyrannosauridae) to further understand the evolution of forelimb morphology within tyrannosaurids. Both humeri, a left radius, a left ulna, metacarpal I, and several phalanges were examined. Despite similarities in size to those of basal tyrannosauroid *Gualong*, they exhibit several derived features, including the bulbous humeral head that covers much of the proximal surface and a flattened distal articular surface of the ulna. The length of the ulna is 57% of the length of the humerus, which is only slightly lower than that of most tyrannosaurids, but much higher than the 80% attained in *Guanlong*. When compared to the forelimb of *Tyrannosaurus* preserved in full articulation, the humerus is more gracile with a slight medial curvature near the distal end. In *Tyrannosaurus* the radius is longer and larger than the ulna, but their width is similar in the new tyrannosauroid. Several phalanges from digits I and II are slender and equipped with well-formed proximal and distal articular surfaces, which allow considerable extension at these joints. No bones associated with digit III were collected, but is assumed to have been vestigial, resulting in a functionally didactyl manus. Recently, the difference in the length of the forelimb and hind limb in tyrannosaurids has been shown to be maintained at a consistent proportion, suggesting a common function for the reduced forelimb. In the new tyrannosauroid, however, the reduction in body size has significantly increased the prominence of the forelimb, which requires reassessment of forelimb evolution in tyrannosaurids.

Poster Session II, (Thursday)

#### THE EOCENE GREEN RIVER AVIFAUNA AND ITS BIOGEOGRAPHICAL RELATIONS

WEIDIG, Ilka, Senckenberg Research Institute, Frankfurt, Germany

The Lower Eocene Green River Formation (USA) yields a high number of articulated, but often crushed, bird skeletons. So far, nearly 30 species belonging to 20 higher bird taxa have been identified, including many stem-group representatives of modern bird orders. Palaeognathous bird are represented by the volant Lithornithidae, the remaining taxa belong to the neognathous birds, including Pelecaniformes, "Ciconiiformes", Phoenicopteriformes, Anseriformes, Galliformes, "Gruiformes", Psittaciformes, Cuculiformes, "Caprimulgiformes", Apodiformes, Coliiformes, Trogoniformes, Coraciiformes s.l., and Piciformes. Passeriformes are not present in the North American Eocene except for the Zygodactylidae, a possible sister-group to Passeriformes. The Green River avifauna shows strong affinities to the contemporaneous European avifauna. The similarities between North America and Europe in the early Tertiary in both birds and mammals are well described and are due to the intermittent presence of land connections during that time. However, the Green River avifauna also exhibits relationships to Central and South America: Presbyornithidae

(Anseriformes) are found in Argentina as well as in the Green River Formation, and the only fossil representative of the modern sunbittern (Eurypygidae) is found in the Green River formation. Additionally, the North American Eocene comprises a number of stem-group representatives of taxa that are nowadays restricted to the Southern hemisphere, but occurred in the European Tertiary as well. This occurrence of the stem-group representatives in the early Tertiary of the Northern hemisphere conflicts with hypotheses of Cretaceous origins of these taxa, which were based on the distribution of modern basal crown-group representatives.

Poster Session III, (Friday)

**LOWER JAW OF ALVUGENA (EARLY PALEOCENE: EUTHERIA), STRATIGRAPHIC DEBT, AND THE ORIGIN OF THE TAENIODONTA**  
WEINSTEIN, Deborah, Ohio State University, Columbus, OH, USA

Taeniodonta, an enigmatic group of eutherian mammals from the Paleogene of North America, have had their origins and relationships questioned for well over a hundred years. Recent discoveries have provided conflicting evidence on taeniodont origins, either supporting an origin in the early Paleocene from didelphodont insectivores (palaecoryctoids) or an origin in the Late Cretaceous from some unknown eutherian group. *Alvugena*, a possible palaecoryctoid-taeniodont intermediate of Puercan (Pu2) age from the Hanna Basin, Wyoming, has been known from a single upper dentition. A well-preserved lower dentition that we refer to *Alvugena* of Pu1 age from the Williston Basin of North Dakota, adds to our knowledge of this taxon. Because the oldest, most basal taeniodont occurs in the Late Cretaceous, the interpretation of Paleocene *Alvugena* itself as ancestral to the taeniodonts is problematic. The temporal range of *Alvugena* now extends into the early Puercan (Pu1), and so the actual time separating these two taxa is not great. Stratocladistic analysis of 37 morphological characters and a stratigraphic character using StratAphy supports the results of the analysis of morphological characters alone: monophyly of Taeniodonta, placement of *Schowalteria* as the most basal taeniodont, and *Alvugena* as a sister-taxon to the entire in-group. Furthermore, there are no known autapomorphies that would preclude *Alvugena* from being the ancestor to the taeniodonts including *Schowalteria*. The order of appearance *Schowalteria*-*Alvugena*-other taeniodonts does not precisely match the branching order of the phylogeny, implying that an *Alvugena* ghost lineage may extend into the latest Cretaceous. The temporal gap between *Alvugena* and *Schowalteria* is small, much less than the average duration of a mammalian species in either the Cenozoic (~2.5 my) or Cretaceous (~4 my), minimizing the assumed duration of the hypothetical ghost lineage. There is mismatch here between branching order and appearance of fossils even though the phylogeny exhibits great congruence overall. This suggests that more can be learned about the origin and early evolution of taeniodonts by sampling in the uppermost Cretaceous.

Poster Session II, (Thursday)

**FLIGHT MORPHOLOGY AND LAUNCH DYNAMICS OF BASAL BIRDS, AND THE POTENTIAL FOR COMPETITION WITH PTEROSAURS**  
WEISHAMPEL, David, Johns Hopkins University, Baltimore, MD, USA; HABIB, Michael, Johns Hopkins University, Baltimore, MD, USA

Birds inherited a bipedal gait and feathered airfoils from their theropod ancestry. These features produce specific tradeoffs with regards to launch, maximum size, lift coefficient, and limb disparity. There are subtle effects related to the use of feathered wings, such as the ability to utilize separated wingtip slots and extensive span reduction, which have also influenced avian flight evolution. Combining information from structural mechanics, aerodynamics, and phylogeny, we conclude that the basal state for avian takeoff was a leaping launch, not a running launch. We find that several morphological features of early birds, inherited from theropod ancestry, predisposed them to radiation in inland habitats. We find that *Archaeopteryx* could sustain substantial loads on both its forelimbs and hindlimbs, but structural ratios between the forelimb and hindlimb of *Archaeopteryx* are indicative of limited volancy. Limb strength in *Confuciusornis* was modest, suggesting an emphasis on cruising flight and limited launch power. We find little evidence to support extensive competition between birds and pterosaurs in the Mesozoic. Prior literature has suggested that pterosaurs competed with early birds for resources and may have helped shape the early evolution of birds. There is some evidence of partitioning between pterosaurs and birds in ecological space. Evidence from the Jehol fauna suggests that pterosaurs dominated near coastlines during the Early Cretaceous, while birds were more important inland. However, flight is a complex character. Flight mechanics vary considerably across volant animals. Some flyers experience only limited competition for resources with other flying species, and might compete most intensely with non-flying taxa. As a baseline for understanding the interactions between Cretaceous birds and pterosaurs, the flight dynamics of the two groups need to be compared in a quantifiable framework. Birds and pterosaurs inherited different morphologies, and this impacted their flight regimes. Comparing the two systems provides a basis for hypotheses related to competition in the Cretaceous, and the influences on early avian evolution.

Technical Session VI, Thursday 2:30

**EMBRYOLOGICAL EVIDENCE FOR A BASAL POSITION OF TURTLES WITHIN AMNIOTA**

WERNEBURG, Ingmar, Paläontologisches Institut und Museum der Universität Zürich, Zürich, Switzerland; HUGI, Jasmina, Paläontologisches Institut und Museum der Universität Zürich, Zürich, Switzerland; MITGUTSCH, Christian, Paläontologisches Institut und Museum der Universität Zürich, Zürich, Switzerland; MÜLLER, Johannes, Museum für Naturkunde, Berlin, Germany; SÁNCHEZ-VILLAGRA, Marcelo, Paläontologisches Institut und Museum der Universität Zürich, Zürich, Switzerland

Comparative data on cranial anatomy and several paleontological studies suggest a phylogenetic position of turtles within "anapsids". In contrast, several recent neontological, paleontological, osteological and molecular studies support a grouping of turtles within Diapsida. We conducted analyses of new and published embryological data to detect shifts in developmental timing during embryogenesis of 15 turtle species and eight tetrapod outgroups. We used the event-pairing and the Parsimov methods for detecting temporal shifts in a phylogenetic framework and tested eight disputed hypotheses for the position of turtles within amniotes, combined to three alternative hypotheses on cryptodire turtle relationships. We developed a new standardized approach to study vertebrate embryos and used it as a basis to describe 104 developmental events that can be easily identified in amniotes, including events occurring during limb, eye, eyelid, carapace, maxillary and mandibular process, pharyngeal arch, and somite development. The Parsimov analyses of the resulting data, under several different assumptions of character definition and ordering, conclusively support the Testudines + Sauria hypothesis out of the alternative amniote phylogenies. Marine turtles are assumed to be basal within cryptodires. Amongst others, the here obtained arrangement is characterized by an early onset of sense-related characters as compared to mammals. However, based on our developmental data we cannot test if turtles evolved within one of the fossil "Anapsida"-clades or on the branch leading to Sauria within diapsids. Ongoing histological studies of head development, as well as the first detailed investigations on the ontogeny of pleurodire turtles such as *Emydura subglobosa* are likely to produce further insights into this issue.

Poster Session IV, (Saturday)

**IS THE REPRODUCTION STRATEGY OF DINOSAURS ONE FACTOR WHY SOME DINOSAURS COULD REACH SUCH EXTREME BODY SIZES IN COMPARISON TO TERRESTRIAL MAMMALS**

WERNER, Jan, Johannes Gutenberg-University, Mainz, Germany; GRIEBELER, Eva-Maria, Johannes Gutenberg-University, Mainz, Germany

Reproductive parameters often correlate with body size. Kurtén already pointed out that body size limits of any taxon are not only related to mechanical or physiological constraints, but are also related to the scaling of its reproductive parameters. Janis and Carrano stated that terrestrial non-passerine birds show no significant decline in number of offspring per clutch and total annual number of offspring with increasing body mass in contrast to terrestrial mammals. Using terrestrial non-passerine birds as dinosaur analogs Janis and Carrano concluded that this difference in reproductive strategies, may have resulted in a different ability of dinosaurs and mammals to evolve and sustain large-bodied species over evolutionary time. Large dinosaurs had a higher potential reproductive output than similar sized mammals and therefore a decreased risk of extinction under environmental disturbances. We tested the hypothesis of Janis and Carrano for a larger dataset of terrestrial herbivorous birds (N = 116) and mammals (N = 376). We additionally controlled for phylogenetic effects and fitted sauropod (herbivorous dinosaurs, largest known terrestrial animals) clutch sizes in our avian and mammalian datasets. Our results supported the hypothesis of Janis and Carrano. Birds have a higher potential reproductive output than similar sized mammals, independent of the analysis method used, and we found that sauropod clutch sizes did not fit to litter sizes of mammals but fit well to those of birds.

Technical Session VIII, Thursday 2:15

**THE INTERPLAY OF LIFE HISTORY AND PHYLOGENY IN THE LONG BONE HISTOLOGY OF LARGE FLIGHTLESS BIRDS**

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Bone growth rate and osteohistology are influenced by both evolutionary history and life history. Extant ratites (Palaeognathae: Struthioniformes) share a similar generalized bone histology reflecting a slower growth rate and extended growth duration, compared to most neognath birds. This includes a more laminar/circumferential orientation of vascular canals and low levels of remodeling in all ratites, lines of arrested growth (LAGs) in *Dinornis* and other moas, and in some cases, an external fundamental system. Historically it has been suggested that this illustrates a fundamental difference in growth physiology between palaeognaths and neognaths. However, this phylogenetic hypothesis has never been tested against neognath birds that share a similar ecology and life history (i.e., large size, flightlessness, and cursoriality) to see how these factors correlate with this osteohistological signature. I examined the mid-diaphyseal osteohistology of the major long bone elements of the extinct large cursorial neognaths *Diatryma/Gastornis* (Gastornithidae), *Dromornis*, *Ibandornis*, and an indeterminate robust dromornithid (Anseriformes: Dromornithidae). I compared these to the bone histology of extant ratites, extant large neognaths, and extinct palaeognaths. The osteohistology of the femur and tibiotarsus in *Diatryma/Gastornis* and

the dromornithids resembles that of extant and extinct ratites, with circumferential vascular canal orientation dominant and some moderate remodeling of the innermost cortex. LAGs are present in *Diatryma/Gastornis*, and annuli may be present in dromornithids. The histological microstructure and the presence of annuli indicate a similar growth strategy independent of phylogeny for all large cursorial birds, consisting of slowed growth rates (relative to most neognaths) and extended growth duration. This convergence suggests that life history may influence the histological signature of ratites more than evolutionary history.

Poster Session III, (Friday)

#### **TAPHONOMY OF HADROSAURID SKELETAL ELEMENTS IN THE AGUJA FORMATION OF WEST TEXAS**

WESTERFIELD, Marissa, Texas Tech University, Lubbock, TX, USA

Isolated hadrosaur skeletal elements are the most common large vertebrate remains found in the Aguja Formation of West Texas. Published itemized specimen data and material recently collected (252 specimens total) provide the basis for a taphonomic assessment of relative preservation and transport potential of hadrosaur skeletal elements. There is a predictable preservational bias favoring larger hind limb bones. These large elements (femora, tibiae, metatarsals) also tend to have relatively greater volume of compact bone tissue compared to spongiosa than many of the less well-represented elements. Although vertebrae (particularly mid-caudal and dorsal centra) have a high volume of spongiosa, and are well represented (about 40% of specimens), their abundance likely reflects the large number possessed by each individual and not their great durability. Observed bone macro assemblages probably reflect distinct hydraulic dispersal categories, or 'Voorhies Groups.' Group I assemblages are those readily removed by low-velocity currents, and include bones with high spongiosa to compact bone ratio (S/C ratio), high surface area to volume ratio (SA/V ratio), and low nominal diameter (Dn). Vertebrae, skull material and other highly cancellous and rare elements comprise Group I (e.g., dorsal vertebrae with S/C ratio >10, SA/V ratio >1, Dn < 6 cm). Group II elements comprise those transported by moderate currents and have intermediate S/C and SA/V ratios and Dn values. Group III elements comprise 'lag' assemblages moved only by high-velocity currents and have low S/C and SA/V ratios, and high Dn values (e.g., femora with S/C <1, SA/V <1, and Dn > 20 cm). As with sedimentary particles, the skeletal elements with higher Dn require higher critical shear velocity for transport, so some small elements (e.g., metacarpals) with Dn values < 10 are found in Group I or Group II although both S/C and SA/V may be <1. In the Aguja Formation the most commonly preserved hadrosaur skeletal elements (excluding vertebrae) represent Groups II and III.

Technical Session XIX, Saturday 2:15

#### **CHEEK-TOOTH SIZE AND INSULAR DWARFISM: NEW DATA FROM EXTINCT DWARF HIPPOS FROM MADAGASCAR**

WESTON, Eleanor, Natural History Museum, London, United Kingdom

Dwarf mammals that evolved on islands have been reported to have relatively larger cheek-teeth than those of their mainland ancestors. The same trend has been noted in females of sexually dimorphic mammals, female molars being relatively large compared to those of their male conspecifics. It has been suggested that this phenomenon could be a by-product of developmental size adjustment, rather than a direct consequence of evolutionary adaptation. However, the prevalence of this trend in mammals reputed to be 'insular dwarfs' has been much debated due to the absence of reliable data. Biometric data from adult crania with associated molars were obtained from two extinct species of dwarfed hippopotamus from Madagascar, *Hippopotamus lemerlei* and *H. madagascariensis*, and from two extant hippopotamus taxa, the large-bodied *H. amphibius* and the pygmy hippo *Choeropsis liberiensis*, to estimate the ratio of molar size to skull volume. The ontogenetic relation between skull size and body mass within and between the extant species was also determined. The third molar only is found to be proportionately larger in both dwarf taxa compared to the relative size of *H. amphibius* third molars, whereas the molars of *Choeropsis liberiensis* are not found to be relatively larger. This condition is more pronounced in *H. lemerlei*, the dwarfed species with a smaller estimated body mass (355 kg), than in *H. madagascariensis*, estimated to have mean body mass of 482 kg. Notably, third molar width is reduced more rapidly than length. The same finding, but even more pronounced, characterizes sexual dimorphism in *H. amphibius*, with females possessing proportionately larger third molars. Whether these findings are of evolutionary adaptive significance or, rather, a developmental correlate or constraint of rapid body size adjustment, is unresolved. However, this evidence strongly suggests that factors controlling aspects of molar size are independent of those affecting overall body size and postnatal growth. These data also provide new insights into the mechanistic process of rapid evolutionary dwarfism of mammals on islands.

Poster Session II, (Thursday)

#### **WHOSE TOOTH DO WE USE? EXPLORING THE UTILITY OF MODERN COMPARATIVE SAMPLES IN THE INTERPRETATION OF FOSSIL ADAPIFORM ECOLOGICAL DIVERSIFICATION**

WHITE, Jess, Department of Sociology and Anthropology, Functional Morphology and Evolutionary Anatomy Working Group, Western Illinois University, Macomb, IL, USA

In the reconstruction of the paleoecological role, dietary patterns, and functional dental morphology of extinct primates, comparison with modern mammalian outgroups is critical. Given the dietary breadth of modern prosimian primates (lemurs, lorises, and tarsiers), building a picture of the ecological diversification of the adapiforms, a fossil prosimian group, is not only dependent on understanding morphological variation in the living prosimians, but also comprehending functional patterns in other mammalian groups. Building upon previous work utilizing a sample (N=115) of extant prosimian primates and a proposed sister-group (tree-shrews; *Tupaia*), a two-dimensional geometric morphometric comparison of molar shape was conducted using a sample (N=155) of six New World marsupial genera (*Caluromys*, *Chironectes*, *Didelphis*, *Monodelphis*, *Metachirus*, *Phlander*). Using the primary landmarks of the lower first molar (protoconid, metaconid, hypoconid, entoconid, and the intersection point of the cristid obliqua with the base of the protoconid [CO-PRLPHD]), variation in molar shape was investigated in a group that demonstrates a similar breadth of dietary patterns (insectivory/carnivory, omnivory, frugivory) to those observed in extant prosimians. Although commonly described as morphological "generalists," New World marsupials do exhibit significant shape differences between dietary and taxonomic groups, as well as some similarities in the shape trends with the aforementioned prosimian sample. Differences in relative landmark locations do exist, however, between the prosimian and marsupial sample, as well as with *Tupaia*, offering insight into the interpretation of mammalian diet based on molar shape. In particular, the three samples differ in allometric patterns of shape change. Additionally, while there are similarities in the molar shape of some dietary groups that are represented in both the prosimian and marsupial samples (frugivorous taxa, for example), there are key differences to be explored. A broad understanding of functional patterns in the dentition of several mammalian groups should provide a framework in which to interpret the diversification of adapiforms.

Technical Session X, Friday 8:00

#### **FAUNAL SUCCESSION OF THE LATE TRIASSIC-EARLY JURASSIC TERRESTRIAL TETRAPOD ASSEMBLAGES FROM THE FISSURE DEPOSITS OF SOUTH WESTERN BRITAIN**

WHITESIDE, David, University of Bristol and University College London, Bristol, United Kingdom; MARSHALL, John, University of Southampton, Southampton, United Kingdom

Internationally important terrestrial tetrapod faunas occur in fissure deposits of Late Triassic–Jurassic age near Bristol in South Western Britain. The difficulties with assigning a succession for these faunas at the Triassic Jurassic boundary, and therefore their contribution to the mass extinction event debate, is discussed. Recent research has extended the range of several reptile groups found in the fissures and supports the notion that the T-J extinctions are not progressive.

It has been generally reported that there are two major faunal associations in the fissure deposits, one comprised almost entirely of reptiles such as *Clevoosaurus* and the other, assumed to be younger, which includes mammaliaforms such as *Morganucodon*. Although the faunas are well described, their age and palaeoenvironment are not fully understood. One of the reptile-dominated assemblages, that includes *Thecodontosaurus* the 'Bristol dinosaur', at Tytherington has been shown by us to be of early Rhaetian age and inhabited a small limestone island. Evidence from contemporaneous palynomorphs demonstrated that a range of environments were present on the island where the reptiles lived. Although long known to contain palynomorphs, the younger mammaliaform-bearing fissures of South Wales have not been the subject of recent palynological study. New sampling of those fissures has produced a remarkably monotonous assemblage of *Classopolis* indicative of very uniform conifer-dominated vegetation. Further scrutiny of the palynomorphs revealed a lack of marine taxa and helps in assigning a more specific age to the mammaliaforms and associated tetrapods.

Technical Session XVIII, Saturday 3:15

#### **SYSTEMATICS AND PALEOBIOLOGY OF THE DIPLODOCID SAUROPODS**

WHITLOCK, John, University of Michigan, Ann Arbor, MI, USA

The unusual skulls of *Diplodocus* and its relatives, with their protracted, blunt snouts and anteriorly restricted dentition have spawned a number of theories but no consensus regarding the method by which these megaherbivores gathered food. Recent work has shown a considerable variation in snout shape throughout the group, ranging from the square-snouted *Nigersaurus* to the more gently rounded *Dicraeosaurus*. These differences in snout shape are coupled with variations in dental microwear, suggesting that snout shape is related to diet. A broad snout shape and microwear patterns consistent with high dietary grit indicate that diplodocoids like *Diplodocus* and *Nigersaurus* were low-level browsers. Others, like *Dicraeosaurus*, were more likely to have been selective low- to mid-height browsers, based on their comparatively pointed snout and low-grit content diet. Jaw elements referred to *Tornieria* indicate that it was also a selective browser. In order to study the evolution

of herbivory of diplodocoids, a new phylogenetic analysis of the group was conducted. This analysis attempts to resolve the interrelationships of the group by creating a new character-taxon matrix generated by first hand observation of specimens. Most interesting are the relationships of the highly specialized rebbachisaurids, the most derived members of which can be divided into two clades: a South American clade including *Limaysaurus* and *Cathartesaura*; and a more widely distributed clade including the South American *Zapalasaurus* as sister taxon to the African *Nigersaurus* and an unnamed rebbachisaurid from Europe. Of additional interest is the recovery of *Suuwassea* as a basal dicraeosaurid, making it the only Laurasian representative of that group. Mapping dietary information onto the best-fit cladogram indicates that feeding behavior was independent of phylogeny. Instead, it appears that herbivorous adaptations were more directly tied to regional ecology. The phenotypic plasticity expressed between taxa is on par with the variation in snout shape recognized during the ontogeny of *Diplodocus*, and suggests that feeding specializations may have been easier to evolve than previously recognized.

Poster Session IV, (Saturday)

#### **TAPHONOMY OF A SUBADULT TYRANNOSAUR FROM THE UPPER CAMPANIAN KAIPAROWITS FORMATION OF UTAH**

WIERSMA, Jelle, Vrije Universiteit Amsterdam, Amsterdam, Netherlands; LOEWEN, Mark, Department of Geology and Geophysics and Utah Museum of Natural History, University of Utah, Salt Lake City, Utah 84112, Salt Lake City, UT, USA; GETTY, Mike, Department of Geology and Geophysics and Utah Museum of Natural History, University of Utah, Salt Lake City, Utah 84112, Salt Lake City, UT, USA

Recent excavation of the Upper Campanian Kaiparowits Formation of Utah has produced an associated skeleton, approximately 65% complete, of a subadult tyrannosaur. The caudal portion of the skull; including frontals, parietals, right squamosal, quadrate, quadratojugal, and a complete braincase; is articulated and partially broken. The rest of the skull; lacking only premaxillae, nasals, splenials, palatines, and vomers; is disarticulated but closely associated. Disarticulated axial elements include the atlas, seven cervical vertebrae and ribs, eight dorsal vertebrae and 14 dorsal ribs, two sacral vertebrae, 34 caudal vertebrae, and 19 chevrons. The appendicular skeleton is represented by the entire pelvis, right femur, tibia, fibula, a single pedal phalanx and an ungual. The quarry also preserves two carbonized logs; leaves, abundant gastropods; a quadrate, humerus, fibula and vertebrae of a single hatching hadrosaur; and a dentary from a subadult hadrosaur. Sedimentologic indicators, including scoured siltstone below the bone layer, laterally equivalent tabular sandstone, and burial in fine-grained silty claystone, suggest that the site represents a lacustrine floodplain environment. We interpret this as shallow standing water in a floodplain depression following an overbank flood. All of the elements lack any indication of surface weathering, insect modification, scavenging, or predation. The skull, vertebrae, and pelvis exhibit breakage penecontemporaneous with burial. The maxilla and dentary are completely crushed parallel to the bedding plane. Some of the vertebrae and limb elements have been postdepositionally deformed. We suggest a taphonomic history of death and burial of the animal in standing water following an overbank flood event. This resulted in burial and disarticulation of the skeleton in fine grained sediments followed by partial trampling of the skull and vertebral column in shallow standing water or water-logged sediment. This interpretation contrasts with interpretations of most other vertebrate localities in fine-grained sediments within the Kaiparowits Formation, which exhibit multiple examples of predation and insect modification.

Technical Session XII, Friday 2:30

#### **A NEW METRIORHYNCHID (CROCODYLIFORMES) FROM THE MIDDLE JURASSIC OF OREGON AND ITS IMPLICATIONS FOR CROCODYLIFORM PHYLOGENY AND HISTORICAL BIOGEOGRAPHY**

WILBERG, Eric, University of Iowa, Iowa City, IA, USA

Until recently the North American fossil record of marine crocodyliforms was restricted to Mexico, Cuba, and a single fragmentary teleosaurid from Oregon. In this study I describe new fossil material – a partial skull with associated postcranial material – of a marine crocodyliform from the Snowshoe Formation of east-central Oregon (Late Aalenian). It represents both the earliest known metriorhynchid and the first recovered from the northern East Pacific. The skull possesses large quadrilateral-shaped supratemporal fenestrae and enlarged prefrontals which overhang the laterally directed orbits. The postorbital bar is broader than in other metriorhynchids and is not distinctly inset. The lateral margin of the postorbital does not overhang the jugal as in other metriorhynchids and is more similar to the morphology seen in *Teleidosaurus*. Preserved forelimb elements do not show the extreme reduction present in more derived metriorhynchids. The humerus is longer and more slender than in other metriorhynchids. The ulna is slightly reduced and resembles the teleosaurid condition rather than the flattened plate-like ulna of *Metriorhynchus*. A phylogenetic analysis was performed to determine the relationship of the Snowshoe croc to other thalattosuchians as well as the position of Thalattosuchia within Crocodyliformes. The Snowshoe croc is recovered as sister to the Metriorhynchidae. Additionally, Thalattosuchia is recovered near the base of the mesoeucrocodylian tree, sister to all mesoeucrocodylians exclusive of *Hsisosuchus*. This result suggests that thalattosuchians may in fact belong near the base of the mesoeucrocodylian tree, not as sister to the other long snouted groups (pholidosaurs and dyrosaurs) as suggested in several recent analyses.

Poster Session I, (Wednesday)

#### **A NEW PARTIAL SKELETON OF PANTOSAURUS STRIATUS, A CRYPTOCLEIDOID PLESIOSAUR FROM THE UPPER JURASSIC SUNDANCE FORMATION OF WYOMING**

WILHELM, Benjamin, Marshall University, Huntington, WV, USA; O'KEEFE, F., Marshall University, Huntington, WV, USA

Plesiosaurs from the Middle and Upper Jurassic are well known from the Oxford Clay of the United Kingdom. The plesiosaurs of the coeval Sundance Formation of North America are more poorly known, but are thought to include three plesiosaur taxa. Here we present two specimens recently recovered from the Bighorn Basin of Wyoming, which we refer to the cryptocleidoid plesiosaur *Pantosaurus striatus*. The first specimen is a partial articulated skeleton comprising a complete pelvic girdle, dorsal, sacral, and caudal vertebrae, and numerous ribs and gastralia. This is the first adult material known for *Pantosaurus* and is the first material from the pelvic girdle as well as the first posterior axial column described. The second specimen, comprising three articulated cervical vertebrae, ties this material to the holotype of *Pantosaurus* and demonstrates that it was a long-necked cryptocleidoid plesiosaur. *Pantosaurus* shares several synapomorphies with the Oxford Clay taxon *Muraenosaurus leedsi*, another long-necked taxon whose relationships have proved contentious. *Pantosaurus* shares the following traits with *Muraenosaurus*: similar dimensions of the cervical vertebrae, strong striations of the antero-ventral and postero-ventral edges of the centra, and cervical rib facets with a dorsal excursion for a tubercle of the cervical rib. It differs from *Muraenosaurus* in having a curved ilium with a distal constriction, and posteriorly angled cervical neural spines. In addition, the partial skeleton displays pathologies of the gastralia and caudal vertebrae, resulting in a laterally bent tail. The morphology of both long-necked taxa supports the notion that *Pantosaurus* and *Muraenosaurus* are cryptocleidoid plesiosaurs, not elasmosaurs. The material described here is the first substantive data on a long-necked cryptocleidoid from outside the Oxford Clay.

Poster Session III, (Friday)

#### **HADROSAURID JAW MECHANICS FROM A DIFFERENT ANGLE: A QUANTITATIVE MICROWEAR ANALYSIS APPROACH**

WILLIAMS, Vincent, The University of Leicester, Leicester, United Kingdom; BARRETT, Paul, The Natural History Museum, London, United Kingdom; PURNELL, Mark, The University of Leicester, Leicester, United Kingdom

Among herbivorous dinosaurs, feeding of hadrosaurids has attracted particular attention. They were the dominant herbivorous vertebrates in many Late Cretaceous ecosystems, in terms of both species-richness and abundance, and achieved a near-global distribution. This success is frequently attributed to the complex jaw mechanisms possessed by these taxa, which would have given them a level of masticatory prowess equal to that of many extant mammals. These complex jaw mechanics involve robust occluding dentition and a transverse chewing stroke facilitated by a set of intracranial movements known as pleurokinesis which may have enabled hadrosaurids to process tougher more abrasive foods than herbivores with less specialized feeding apparatus. Various methods, including biomechanical analysis and 3D computer modeling, have been employed to generate detailed functional hypotheses of feeding mechanisms in hadrosaurids. Some of these have cast doubt on cranial kinesis, but in the absence of either direct observations of dinosaur feeding behavior or close living functional analogues, testing these hypotheses is problematic. Microwear (microscopic scratches that form on teeth *in vivo* during feeding) is known to record the relative motion of the tooth rows to each other during feeding and to capture evidence of tooth-food interactions. Here we present the results of analysis of tooth microwear orientation in a range of basal to derived hadrosaurid ornithomorphs. Statistical testing demonstrates that in most taxa multiple sets of scratches in different orientations are preserved, providing direct evidence for the directions and relative importance of different jaw motions during feeding. *Edmontosaurus* teeth, for example, exhibit four distinct sets of scratch orientations; their straightness and parallelism indicate tightly controlled occlusion. Significant variation between species indicates differences in feeding mechanisms and our results provide strong support for the presence of a pleurokinetic hinge in derived hadrosaurids.

Poster Session III, (Friday)

#### **PUTATIVE YOUNG PACHYCEPHALOSAUR SQUAMOSALS ARE FROM A LIZARD**

WILLIAMSON, Thomas, New Mexico Museum of Natural History and Science, Albuquerque, NM, USA; SMITH, Krister, Abt. Messelforschung und Paläoanthropologie Museum, Frankfurt, Germany; WILLIAMS, Scott, Burpee Museum of Natural History, Rockford, IL, USA; BENNETT, III, George, Shenandoah Valley Discovery Museum, Winchester, VA, USA; TREMAINE, Katie, Burpee Museum of Natural History, Rockford, IL, USA

Two isolated squamosals from the Hell Creek Formation of eastern Montana were recently described and suggested to represent a very early ontogenetic stage of Pachycephalosaurinae. They were tentatively referred to *Pachycephalosaurus* or a closely related taxon. Both squamosals are relatively small and possess a distinctive nodose surface ornamentation similar to that seen in early ontogenetic stages of the pachycephalosaur *Stegoceras*. However, a new specimen from the Hell Creek Formation of Garfield County, Montana, (SVDM VP-1877), consisting of a squamosal nearly identical to those alluded to above

and an associated zygous parietal, reveals conclusively that the specimens in question are referable to a squamate and not a pachycephalosaurine dinosaur. The ornamentation of the parietal resembles that of the parietal previously referred to "*Exostinus*" *lancensis*. The squamosals of this taxon have not previously been described. These and other specimens call into question the attribution of the parietal of "*E.*" *lancensis* and imply the presence of a hitherto unrecognized anguimorph lineage in the Late Cretaceous of North America. The nodose sculpture of this lineage is reminiscent of the enigmatic Eocene taxon *Ornatocephalus metzleri* from Messel, Germany, suggesting a potential relationship between the two.

Technical Session III, Wednesday 4:00

**A SNAKE-DINOSAUR ASSOCIATION FROM THE CRETACEOUS OF INDIA**  
WILSON, Jeffrey, University of Michigan, Ann Arbor, MI, USA; MOHABEY, Dhananjay, Geological Society of India, Nagpur, India; PETERS, Shanan, University of Wisconsin, Madison, WI, USA; HEAD, Jason, University of Toronto, Mississauga, Mississauga, Canada

Derived large-mouthed snakes (macrostomatans) possess numerous specializations in their skull and lower jaws that allow them to consume large vertebrate prey. In contrast, basal snakes lack these adaptations and feed primarily on small prey items. The sequence of osteological and behavioral modifications involved in the evolution of the macrostomatan condition has remained an open question, due to disagreement about the origin and interrelationships of snakes, the paucity of well-preserved early snake fossils on many continental landmasses, and the lack of information of about the feeding ecology of early snakes.

We report on a partial skeleton of a new 3.5 m long snake recovered from Upper Cretaceous rocks of western India. The snake was fossilized within a sauropod dinosaur nest, coiled around an egg and adjacent to the remains of a ca. 0.5 m long hatchling. Multiple snake-egg associations at the site strongly suggest that the snake frequented nesting grounds and preyed on hatchling sauropods. We interpret this pattern as "ethofossil" preservation of feeding behavior. The new snake lacks specializations of modern egg-eaters and of macrostomatans, and skull and vertebral synapomorphies place it in an intermediate position in snake phylogeny. The Indian snake is sister-taxon to the large-bodied "madtsoiid" *Yurlunggur camfieldensis* and *Wonambi naracoortensis* from the Neogene of Australia, consistent with a Gondwanan origin of the group. "Madtsoiid" snakes show specializations for intraoral prey transport but lack the adaptations for wide gape that characterize living macrostomatan snakes. The new Indian fossils provide direct evidence of feeding ecology in a Mesozoic snake and demonstrate predation risks for hatchling sauropod dinosaurs. Large body size and jaw mobility afforded some non-macrostomatan snakes a greater diversity of prey items than previously suspected based on extant basal snakes.

Poster Session II, (Thursday)

**A HIGH-LATITUDE HESPERORNITHIFORM (AVES) FROM DEVON ISLAND: PALEOBIOGEOGRAPHY AND SIZE DISTRIBUTION OF NORTH AMERICAN HESPERORNITHIFORMS**

WILSON, Laura, University of Colorado, Boulder, Boulder, CO, USA; CHIN, Karen, University of Colorado, Boulder, Boulder, CO, USA; DYKE, Gareth, University College Dublin, Dublin, Ireland; CUMBAA, Stephen, Canadian Museum of Nature, Ottawa, ON, Canada

A new hesperornithiform specimen from Devon Island in the Canadian High Arctic, is represented by two articulated and one partially articulated vertebrae collected together. These are identified as the last cervical vertebrae (16) and the first two dorsal vertebrae (17 and 18) based on comparisons with specimens of *Hesperornis regalis*. Partially articulated and disarticulated rib fragments were preserved with them as well. This specimen is assigned to *Canadaga arctica*, which was described based on vertebrae 15-17 from Bylot Island, also in the Canadian High Arctic. Shared characteristics of the *C. arctica* type specimen and the new Devon Island specimen, but lacking in *H. regalis*, include a large, deep concavus lateralis and a fovea between the costal fossa and centrum with a deep cavity below the transverse process. The new specimen from Devon Island is only the second occurrence of *C. arctica*, and corresponds in size and morphology to the type specimen.

A review of the distribution of hesperornithiforms in North America allows comparisons of various aspects of the morphology of these birds along a latitudinal gradient. Using *H. regalis* as a datum for comparison, most of the Campanian hesperornithiforms from lower latitudes (*H. bairdi*, *H. mengeli*, *H. macdonaldi*, *H. gracilis*, *H. altus*) are smaller than *H. regalis* and have more restricted geographic ranges (often coming from single localities). On the other hand, *C. arctica* is larger than *H. regalis*, and is only found in high latitudes. Thus, with the exception of *H. crassipes* and *H. chowi*, size trends within hesperornithiforms with restricted geographic ranges seem to follow Bergmann's Rule: populations found at high latitudes are larger than those found at mid latitudes. By comparison, *H. regalis* has a more extensive geographic distribution ranging from Kansas to the Arctic Circle with variability, but no clear trends in size distribution through its range. Interestingly, it has been hypothesized that *H. regalis* was migratory, based on biogeographic distribution and the abundance of juveniles in high latitudes; extant migratory birds are generally less likely to follow Bergmann's Rule.

Poster Session II, (Thursday)

**DIVERSITY TRENDS AND THEIR ONTOGENETIC BASIS: AN EXPLORATION OF ALLOMETRIC DISPARITY IN RODENTS**

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The multivariate ordination of taxa based on their allometric trajectories provides a space in which to assess allometric disparity among species, and between clades. At a large scale, allometric disparity may be considered a proxy for developmental dynamics; the exploration of allometric space occupation, and its relation with phylogenetic and ecological trends, provides an opportunity to enhance our understanding of factors influencing ontogenetic pathways. Rodents represent almost one half of all mammalian species and thus inherently capture a phenomenal amount of taxonomic diversity. In particular, when compared with other members of Rodentia, the hystricognath rodents (e.g. capybaras, chinchillas) display many atypical attributes, such as the production of few, precocial young after a long period of gestation, and extensive anatomical and ecological diversity. Here we compare cranial allometry and disparity patterns among hystricognaths with those displayed by muroid rodents: a taxonomically diverse group exhibiting a contrasting life strategy and level of anatomical diversity. Following the multivariate generalization of allometry, we used the first principal component from an analysis of 20 cranial measurements, to examine patterns of ontogeny for 20 species of hystricognath rodents and 11 species of muroid rodents. Disparity was quantified using arc cosines between species and clades, and also in comparison to isometry, thereby incorporating positional information for each trajectory. Bivariate allometry was used to assess the role of directional change, lateral shifts, and scaling in the modification of allometric trajectories. We found hystricognath and muroid rodents occupied partially overlapping portions of allometric space, with species location exhibiting correlation with age to sexual maturity, adult body mass, and habit (e.g. cursorial). Members of the microtine clade exhibited the smallest inter specific allometric angles whilst allometric trends appeared the most disparate among species of hystricognaths belonging to the echymid group.

Technical Session VI, Thursday 3:00

**AN EXCEPTIONALLY LARGE JURASSIC TURTLE TAPHOCOENOSIS FROM XINJIANG AUTONOMOUS PROVINCE, CHINA**

WINGS, Oliver, Museum für Naturkunde, Berlin, Germany; JOYCE, Walter, University of Tübingen, Tübingen, Germany

Fieldwork conducted by the Sino-German Paleontological Cooperation Project in Middle to Late Jurassic fluvial and lacustrine sediments near the city of Shanshan (Turpan Basin, Xinjiang Autonomous Province, NW China) has revealed several diverse vertebrate assemblages, that include remains of hybodont sharks, semionotid fish, rhynchocephalians, crocodylians, theropods, sauropods, basal ornithomorph and thyreophoran dinosaurs, as well as amphitheriid and docodont mammals. One of the most spectacular fossil sites identified to date is a 10 to 20 cm thick mudstone layer in the early Late Jurassic Qigu Formation, which contains an immense accumulation of fossil turtle material. The stratum dips with approximately 60° to the north and is exposed both on the west and east sides of a mesa that is capped by Pleistocene alluvial deposits. The presence of well-developed anterior and posterior plastral buttresses, a ligamentous bridge, upturned anterior peripherals, and a knee-shaped femoral/anal sulcus that crosses the xiphiplastral suture allow confident referral of all material to Xinjiangchelyidae. At least two taxa are present, currently assigned to *Annemys cf. latiens* and *Xinjiangchelys cf. chowi*. All skeletal elements are present, including complete shells, skulls, and delicate postcranial remains such as necks and articulated hands and feet, but juvenile specimens are notably absent. The deposit is estimated to have once covered an area of 500 m<sup>2</sup> and turtles range in density from 2 to 20 per m<sup>2</sup>. The total number of individuals once buried is calculated at about 2500. The deposit thus likely represents the world's largest fossil turtle taphocoenosis (death assemblage). While surrounding sediments indicate a fluvial environment, the partially articulated preservation of the turtles points to a parautochthonous deposition. It is likely, that these aquatic turtles gathered and finally perished in a retreating water hole during a severe drought, much as some aquatic turtles will do today. The extremely large number of individuals will help clarify morphological variations within xinjiangchelyid turtles and is expected to help resolve the alpha taxonomy of this group.

Poster Session II, (Thursday)

**FORELIMB ANATOMY OF SERENGETILAGUS PRAECAPENSIS (MAMMALIA: LAGOMORPHA) FROM LAETOLI, TANZANIA: TAXONOMIC AND FUNCTIONAL IMPLICATIONS**

WINKLER, Alisa, Southern Methodist University, Dallas, TX, USA; HARRISON, Terry, New York University, New York, NY, USA

Fossiliferous early Pliocene (>4.3–2.6 Ma) deposits at Laetoli, Tanzania, have yielded the most extensive collection of lagomorph remains from Africa. Specimens have been recovered from three major stratigraphic units (from oldest to youngest): the Lower and Upper Laetoli Beds, and Upper Ndolanya Beds. Although all lagomorph remains from Laetoli had traditionally been assigned to *S. praecapensis*, preliminary studies suggested that those from the Upper Ndolanya Beds might be taxonomically distinct from those from

the Laetoli Beds. It was also suggested that *S. praecipensis* was a burrower, functionally comparable (based on the forelimb) to the European rabbit, *Oryctolagus*. However, quantitative comparisons were not made between *S. praecipensis* from the Upper Ndolanya and Laetoli Beds, nor with extant taxa. For the present study, detailed measurements were taken and comparisons were made between specimens from the Upper Ndolanya and Laetoli Beds, and between *S. praecipensis* and the extant genera *Oryctolagus*, *Poelagus*, and *Lepus*. Although measurements of the forelimb of *S. praecipensis* from the Upper Ndolanya Beds are on average comparable to those from the Laetoli Beds, there are some measurements (e.g., on the scapula, humerus, and radius) on individual specimens from the Upper Ndolanya Beds that are outside the mean seen on those from the Laetoli Beds. Disparity in measurements may be greater or smaller, suggesting that overall difference in size alone do not distinguish these samples. Compared to extant leporids, the forelimb of *S. praecipensis* has more similarities to that of *Oryctolagus* than to *Lepus* (e.g., in the distance between the coracoid process and the glenoid fossa), suggesting more functional similarities with *Oryctolagus*. Quantitative and comparative comparisons of the forelimb of *S. praecipensis* suggest: 1) that some individuals from the Upper Ndolanya Beds may be (sub) specifically distinct from those from the Laetoli Beds, and 2) that *S. praecipensis* may have been as capable a burrower as *Oryctolagus*. These conclusions need to be supported by mensural studies of the cranium and hind limb from this exceptional sample of lagomorph remains.

Poster Session IV, (Saturday)

**DERMAL BONE SCULPTURE AND INTEGUMENT IN BASAL TETRAPODS**  
WITZMANN, Florian, Museum für Naturkunde, Berlin, Germany; SCHOLZ, Henning, Museum für Naturkunde, Berlin, Germany; MÜLLER, Johannes, Museum für Naturkunde, Berlin, Germany; KARDJILOV, Nikolay, Helmholtz-Zentrum Berlin für Materialien und Energie, Berlin, Germany

Dermal bones of the skull and pectoral girdle of most basal tetrapods (i.e. Paleozoic and Mesozoic stem-tetrapods, temnospondyls, stem-amniotes and basal amniotes) are conspicuously sculptured by tubercles, pits, ridges and furrows. Only those parts of the superficial bone surface that were directly overlain by the integument are sculptured, whereas the deep surface of the bones or sites of attachment for ligaments and muscles are unsculptured. In all basal tetrapods, the sculptural pattern of dermal bones is closely associated with their vascularization. Ontogenetic data suggest that the vessels that coursed to the superficial bone surface induced the formation of sculptural ridges and tubercles around their openings. Thus, the course of the blood vessels has determined the morphology and arrangement of the dermal sculpture: vessels that opened roughly vertical to the surface resulted in formation of a more or less polygonal sculpture, whereas canals that opened obliquely to the periphery of the bone caused radially aligned ridges and furrows. Imprints show that the vessels continued on the bone surface and coursed within furrows or pits, where they might have been protected by the sculpture from mechanical damage. Strong, mineralized Sharpey's fibers in the sculptural ridges and tubercles, and the presence of metaplastic tissue in several taxa indicate a consolidation of the integument in basal tetrapods. Because of the tight integration of bone and dermis, the vessels were not able to spread over the sculptural elements but had to pass interosseously. The diverse sculptural morphologies that are exhibited by basal tetrapods depend on variation in height and width of the 'nodal points' and their connecting sculptural ridges, and in size and shape of the enclosed cells and furrows. A principal component analysis (PCA) and discriminant function analysis (DFA) of 47 basal tetrapod taxa with 12 discrete characters shows that dermal sculpture can be used to distinguish among some main basal tetrapod lineages. Taxa that are interpreted as largely aquatic generally have a more regular sculptural pattern of cells and furrows than presumably terrestrial ones.

Poster Session IV, (Saturday)

**SYSTEMATICS AND PALEOECOLOGY OF HIPPARIONINE AND MODERN HORSES FROM THE PLEISTOCENE MAKUYUNI LOCALITY, TANZANIA**  
WOLF, Dominik, Howard University, Washington, DC, USA; BERNOR, Raymond, Howard University, Washington, DC, USA; KAISER, Thomas, Biocentre Grindel Zoological Institute and Museum, Hamburg, Germany; NELSON, Sherry, University of New Mexico, Albuquerque, NM, USA; SEMPREBON, Gina, Bay Path College, Longmeadow, MA, USA

Described in the early 20th century but extensively investigated in recent years, the Pleistocene sediments of the Lake Manyara area, Tanzania, are known for their abundant bone and tooth fragments of various mammals including rare fossil hominid remains as well as their Lower Paleolithic stone artifacts collected at the locality of Makuyuni. The fossil mammalian material found here between 1993 and 1995 features a diverse fauna of both late hipparionine and modern horses. Based on our studies on mandibular and maxillary teeth, we presently distinguish two species of *Eurygnathohippus* alongside two species of *Equus* within the sample. We assess the paleoecological context of these horses by utilizing various methods for paleodietary reconstruction. Macroscopic facet development (mesowear) cluster analyses suggest that all Makuyuni horse taxa were characterized by a paleodietary behavior comparable to that of typical extant grazers. The state of preservation of the teeth hampered the collection of data using low magnification stereoscopic microwear analysis, but low scratch numbers in all examined teeth indicate that the diet of at least both species of *Equus* and one species of *Eurygnathohippus* also had a browsing component. Microwear also reveals evidence for a high content of grit in the diet of these horse taxa. Consequently, some

of the tooth abrasion observed using mesowear analysis may not be due to the consumption of grass alone. We therefore reconstruct the paleodiet of the horses as most likely mixed feeders with grit encroachment on their food items. We are currently conducting additional studies on the tooth sample to further clarify the paleodietary preferences and gain insight into various other paleoecological aspects of the Makuyuni horses. Analysis of carbon isotopes reveals the relation of C4 plants (consumed during grazing) vs. C3 plants (eaten during browsing) in the diet. Oxygen isotopes are analyzed to assess paleoclimate, serial sampling of tooth enamel thereby permitting estimates of seasonality. Both carbon and oxygen isotopes are used to draw conclusions on the nature of the paleohabitat and its degree of tree coverage.

Poster Session IV, (Saturday)

**NEW SPECIES OF CACOPS FROM THE EARLY PERMIAN OF OKLAHOMA**  
WONG KEN, Nicola, University of Toronto Mississauga, Mississauga, ON, Canada; REISZ, Robert, University of Toronto Mississauga, Mississauga, ON, Canada

Dissorophid temnospondyls were a successful group of fully terrestrial, often spectacularly armored Paleozoic predators, part of a clade of amphibians that were apparently able to coexist with amniotes when the latter started to dominate terrestrial ecosystems. *Cacops* is one of the most distinctive Paleozoic dissorophids, with a relatively huge head, short trunk that carries armor on top of the vertebral column, and also has relatively elongate limbs. Details of the cranial anatomy of the genotype *Cacops aspidephorus*, known from the classic Early Permian *Cacops* bonebed are poorly known. Excellent new skulls and skeletons of this genus from the Early Permian of Oklahoma can be distinguished from the genotype on the basis of both cranial and postcranial features. The new species, *Cacops morrissi*, provides detailed anatomical and ontogenetic information about this iconic dissorophid. For example, the large, posteriorly closed tympanic notch of the adult is open in juvenile individuals. In addition, the surface of the embayment has fine striations on an otherwise smooth surface, documenting the oldest known clear evidence for the presence of a tympanic membrane in the fossil record. Postcranially, the relatively modest armor does not extend beyond the edges of the respective vertebra, and ontogenetically varies from small elements that are loosely attached to their respective neural spines in juveniles to laterally expanded, curved dermal ossifications that are fused to the top of the expanded neural spines.

The skull of *C. morrissi* also has several features associated with predatory behavior, indicating that this dissorophid may have been one of the top terrestrial predators of its time.

Technical Session XVI, Saturday 8:15

**CORRELATION VERSUS CAUSALITY IN THE FOSSIL RECORD: A GLOBAL REEXAMINATION OF THE EXTINCTION OF THE MULTITUBERCULATA**  
WOOD, D. Joseph, Ohio State University, Columbus, OH, USA

Past work based primarily in North America has implicated competition with rodents as a major factor in the extinction of multituberculates. The aim of my study was to widen the scope of investigation to include Europe and Asia in order to better describe the pattern of replacement. The incumbent replacement model of Rosenzweig and McCord predicts a positive relationship between the origination rate of the replacing clade and the extinction rate of the declining clade. To test whether this model is applicable to multituberculates, I calculated per-taxon rates of origination and extinction for the Multituberculata, Rodentia, Plesiadapiformes (another putative competitor), and Carnivora and Creodonta (control groups) to test hypotheses of competition between these groups. The results are consistent with a competition scenario for North America and Europe. In North America, the extinction rate of multituberculates is highly correlated with the origination rate of rodents. The amount of change in these rates between time slices was also highly correlated between these two groups. I found no significant relationship between the extinction rate of North American multituberculates and the origination rate of plesiadapiformes, nor did I find significant correlation between origination rate of rodents and extinction rate of early carnivores. This demonstrates that the observed correlation between the taxonomic rates of evolution of multituberculates and rodents is not merely an artifact. In North America and Europe, Multituberculates exhibit a tri-fold increase in mean extinction rate after rodents appeared. This study yielded no conclusive evidence for competition in Asia, which appears to have been an opportunistic replacement. This may be related to the fact that rodents first appeared in Asia and the multituberculates there were not diverse in the Paleocene. Body size estimates (an indicator of niche overlap) of North American and European multituberculates and rodents show significant overlap, which is not true of the Asian forms. The results of this study show that the extinction of the Multituberculata was a complex and geographically heterogeneous process.

**FIRST NEARLY COMPLETE CROCODYLIAN SKELETON (CROCODYLIA: TOMISTOMINAE) FROM TAIWAN, CHINA**

WU, Xiao-chun, Canadian Museum of Nature, Ottawa, ON, Canada; SHAN, Hsi-yin, National Museum of Natural Science, Taichung, China; CHENG, Yan-nien, National Museum of Natural Science, Taichung, China; SATO, Tamaki, Tokyo Gakugei University, Tokyo, Japan

An associated articulated long-snout crocodylian skeleton was recently collected from the Upper Miocene of Penghu Island, Taiwan, China. It is the oldest and most complete vertebrate fossil from Taiwan. The new crocodylian is referable to Tomistominae and distinguished from other tomistomines mainly in features of the orbit, skull table, suborbital fenestra, and internal choana. The most diagnostic characters for the taxon are: the prefrontal and anterior process of the jugal extend as anteriorly as the lacrimal does; the 7th maxillary tooth is the largest; the choana is sharply triangular in outline, and the nasal canal in the pterygoid and choana's borders bulge downward off the ventral surface of the palate. A phylogenetic analysis indicates that the new form is closely related to two other Asian fossil tomistomines, i.e., *Tomistoma petrolica* from southeastern southern China and *Toyotamaphimeia machikanensis* from Japan and supports the hypothesis that the extant species, *Tomistoma schlegelii*, may have originated from Mediterranean region rather than Asia. The discovery of the new tomistomine certainly enriches our knowledge of the early history of the Tomistominae and provides further information for establishing the phylogenetic relationships amongst tomistomines.

Technical Session V, Wednesday 2:00

**A NEW SCANILEPIFORM FROM THE LOWER TRIASSIC OF NORTHERN GANSU PROVINCE, CHINA, AND PHYLOGENETIC RELATIONSHIPS OF LOWER ACTINOPTERYGIANS**

XU, Guang-Hui, Institute of Vertebrate Paleontology and Paleoanthropology, CAS, Beijing, China; GAO, Ke-Qin, Peking University, Beijing, China

The Scanilepiformes were an extinct group of lower actinopterygians with a confined geological range in the Triassic. The group was mainly adapted in freshwater ecosystems of northern continents except a Late Triassic form (*Scanilepis*) from marine deposits in Sweden. In recent study of a fish assemblage from the Lower Triassic (Olenekian) deposits exposed in Beishan area, northern Gansu Province, China, a new genus and species of the Scanilepiformes is recognized from this assemblage based on well-preserved material. The new discovery documents the oldest known record of this group in China but slightly younger than *Evenkia* from the Lowest Triassic of Tunguska River Basin, Central Siberia. Although the fossil-bearing deposits of dark mudstones and siltstones in northern Gansu Province were previously interpreted as Late Permian in age, the new discovery supports the reinterpretation of an Early Triassic age and freshwater environment based on other vertebrate fossils (especially on a trirachodontid eucynodont) from the same locality and horizon. The study of the new scanilepiform generated a phylogenetic analysis to resolve the relationships of the Scanilepiformes as a significant but poorly known group of early actinopterygians. The data matrix used for the cladistic analysis included 72 characters coded across 21 taxa of actinopterygians, with the sarcopterygian *Eusthenopteron* designated as the outgroup. Contrary to previous views, the Scanilepiformes could not be placed near the origin of the Amiidae or in the Perleidiformes; instead, the phylogenetic results showed that the Scanilepiformes formed a stem-group clade of the Neopterygii, more basal than the Perleidiformes. With a characteristic long-based dorsal fin, the scanilepiforms represented a morphological diversification of stem Neopterygii that diverged from the Chondrostei no later than Early Triassic time.

Technical Session X, Friday 8:15

**AN EXCEPTIONALLY WELL PRESERVED JURASSIC TERRESTRIAL FAUNA IN NORTHEASTERN CHINA**

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The Early Cretaceous Jehol Group of northeastern China is famous for its spectacular fossil remains of terrestrial vertebrates with well preserved soft tissues. Recently, two Chinese Jurassic lacustrine deposits, the Tiaojiashan Formation of Jianchang, Liaoning and the Daohugou Formation of Ningcheng, Inner Mongolia, have also produced a number of exceptionally well preserved vertebrate specimens retaining soft tissue including feathers and fur. The Tiaojiashan Formation has traditionally been regarded as Middle Jurassic but isotopic dates range from 168 to 151 Ma; the Daohugou Formation has been suggested by some isotopic studies to represent deposits of between 164 and 158 Ma. Comparison of the Tiaojiashan and Daohugou fossils suggests that they probably belong to the same fauna, which represents an important terrestrial fauna near the Middle-Late Jurassic boundary. To date, dinosaur fossils probably representing five taxa have been recovered from these formations and all have feather or feather-like integumentary structures. Among them, the basal troodontid *Anchiornis huxleyi* provides significant information on the origin of birds and the early evolution of paravians. As a pre-*Archaeopteryx* troodontid, *Anchiornis huxleyi* refutes the 'temporal paradox' argument that is made against the theropod hypothesis of avian origins and provides significant information on the temporal framework of theropod divergence. Furthermore, the extensive plumage of this animal, particularly the profusely

feathered feet, sheds new light on the early evolution of feathers. An analysis of the distribution of skeletal and integumentary features across the phylogeny of maniraptoran theropods indicates a complex pattern close to the transition to birds. As one of the few exceptionally well preserved Jurassic terrestrial faunas, and particularly as the only known fauna with feathered dinosaurs predating *Archaeopteryx*, this new assemblage promises to provide significant new insights into Middle-Late Jurassic dinosaur evolution and particularly the origin of birds.

Late Triassic Terrestrial Biotas and the Rise of Dinosaurs, Thursday 11:30

**THE EARLY EVOLUTION OF POSTCRANIAL PNEUMATICITY IN SAROPODOMORPH DINOSAURS: NEW EVIDENCE FROM SOUTH AFRICA**

YATES, Adam, University of the Witwatersrand, Johannesburg, South Africa; WEDEL, Mathew, Western University of Health Sciences, Pomona, CA, USA; BONNAN, Matthew, Western Illinois University, Macomb, IL, USA

Postcranial skeletal pneumaticity (PSP) is present in four sauropodomorph taxa from the Elliot Formation (Late Triassic – Early Jurassic) of South Africa. These taxa, *Eucnemesaurus fortis*, an unnamed basal anchisaur (near-sauropod), *Antetonitrus ingenipes* and an unnamed basal sauropod, occupy a range of phylogenetic positions spanning the basal sauropodomorph – sauropod transition. The PSP consists of subfossae that excavate the vertices of the posterior infradiapophyseal fossae of the posterior dorsal vertebrae. These subfossae range from simple shallow depressions (*Eucnemesaurus*) to deep, steep-sided, internally subdivided and asymmetrically developed chambers (*Antetonitrus*). The middle and anterior dorsal vertebrae of these taxa lack PSP demonstrating that abdominal air sacs were the source of the invasive diverticula. Thus it appears that the evolution of PSP in sauropodomorphs proceeded in a fundamentally different pattern from that displayed by theropods where PSP started from the cervical air sacs. The site of initial PSP invasion in these sauropodomorphs suggests that the infradiapophyseal fossae were receptacles that housed pneumatic diverticula to begin with. It is probable that the identical infradiapophyseal fossae of other saurischians and basal dinosauriforms also housed pneumatic diverticula and that rigid non-compliant lungs ventilated by compliant posterior airsacs evolved prior to the origination of Dinosauria.

Technical Session III, Wednesday 2:45

**EVOLUTION OF THE LOWER TEMPORAL FENESTRA IN THE CHORISTODERA (REPTILIA: DIAPSIDA)**

YI, Hong-yu, Peking University, Beijing, China; GAO, Ke-Qin, Peking University, Beijing, China

Choristoderes are a diverse group of Laurasian freshwater reptiles ranging from possibly the Late Triassic to early Miocene. They are always considered members of the Diapsida that are characterized by having both the upper and lower temporal fenestrae in the skull. However, the lower temporal fenestra is closed in several choristoderan subclades, including Monjurosuchidae from the Early Cretaceous of China, "*Monjurosuchus* sp." from the Early Cretaceous of Japan, and *Lazarussuchus* from Oligocene to Miocene of Europe. An extensive survey of choristoderes collections in multiple research institutions in China has shed new lights on the evolution of the temporal fenestrae in choristoderes. The lower temporal fenestra in *Hyphalosaurus* was previously regarded as closed, but is actually open, as clearly shown in a new specimen of *H. baitaigouensis* from the Lower Cretaceous beds in Liaoning, China. Moreover, careful comparisons of the skull elements surrounding the lower temporal fenestra revealed two major closing patterns. The first pattern, shared by *Monjurosuchus splendens* and *Philydrosaurus proseilus*, involves a jugal with a poorly-developed postorbital process separating the postfrontal and postorbital, and a median squamosal process that closes the posttemporal fenestra. The second pattern, demonstrated by *Lazarussuchus* and "*Monjurosuchus* sp.", shows an elongate postorbital process of the jugal and a fused postorbitofrontal. In view of the evidence, it is proposed that the enclosure of the lower temporal fenestra should be treated as a compound multistate character involving different arrangement patterns of the surrounding bones (postorbital, postfrontal, jugal, squamosal and quadratojugal), rather than a simple present/absent character. Cladistic analysis of a revised taxon-character data matrix with recoded characters regarding the temporal fenestrae has consistently shown that the enclosure of the lower fenestra is independently acquired in several short-snouted basal forms, but not in those derived crocodile-like neochoristoderes; this distribution pattern indicates divergence of jaw mechanisms in different ecomorphic types of choristoderes.

Poster Session I, (Wednesday)

**A HIGH-DENSITY SNAKE BONE ACCUMULATION FROM THE LATE PLEISTOCENE OF TEXAS: EVIDENCE OF A MULTISPECIES SNAKE HIBERNACULUM?**

YOUNG, Ker Shun, Texas A&M University, College Station, TX, USA; STIDHAM, Thomas, Texas A&M University, College Station, TX, USA

A new fossil vertebrate fauna consisting of fish, snake, turtle, and small mammalian remains was discovered in a fissure filling in Austin, Texas. Identification and analysis of the species in the cave deposit reveals paleoclimatic and paleoenvironmental changes between the late Pleistocene and the present. Snake taxa identified from the site are racers

(*Coluber constrictor*) or whip snakes (*Masticophis* sp.), garter snakes (*Thamnophis* sp.) or water snakes (*Nerodia* sp.), and Baird's rat snake (*Elaphe bairdi*). Mammalian species in the site are harvest mice (*Reithrodontomys* sp.), voles (*Microtus* sp.), southern bog lemmings (*Synaptomys cooperi*), pocket gophers (*Geomys* sp.), black-tailed jackrabbit (*Lepus californicus*), shrews (*Blarina* and *Sorex* sp.), and a bat. All of the snake taxa are present in the area today, but some of the mammals no longer occur in Texas. This site is unique in the very large number of snake fossils (84% of specimens) compared to the mammalian fossils (16%, MNI 14) collected. Snake elements are consistently the dominant type of fossil throughout the deposit, while the mammalian remains are clustered (likely from the dissociation of a single individuals). All of the snake species found in the site form hibernacula today. Given the very high percentage and high density of snake elements relative to mammals across the site, the presence of hibernaculum-forming snake taxa (of 3+ spp.), and the presence of articulated snake material, it seems likely that this cave site is a strong candidate to be the world's first fossil multispecies snake hibernaculum ever discovered. Today, those types of hibernacula occur much further to the north, and the data from this site appear to support the idea of a behavioral response by snakes to warming since the end of the Pleistocene.

Technical Session XVIII, Saturday 3:45

#### TESTING HYPOTHESES OF FEEDING BEHAVIOR IN *DIPLODOCUS LONGUS* USING THE FINITE-ELEMENT METHOD

YOUNG, Mark, University of Bristol, Bristol, United Kingdom; RAYFIELD, Emily, University of Bristol, Bristol, United Kingdom; HOLLIDAY, Casey, University of Missouri, Columbia, MO, USA; BARRETT, Paul, Natural History Museum, London, United Kingdom; WITMER, Lawrence, Ohio University, Athens, OH, USA

Sauropod dinosaurs include some of the most bizarre animals ever to have existed. Determining how they fueled their multi-tonne bodies on a nutrient-poor diet of fibrous plants challenges our understanding of both extinct and extant biological systems. Among sauropods, *Diplodocus* has one of the most unusual craniodental morphologies (elongate rostrum, dentition restricted to anterior margin of jaws, and fragile 'peg-like'; teeth with oblique labial wear facets). Previous studies focusing on craniodental morphology have postulated different feeding behaviors for *Diplodocus*, including precision biting, branch-stripping and bark-stripping. Based on CT scan data of a *Diplodocus longus* skull (CM 11161), these feeding hypotheses were evaluated quantitatively using finite element analysis (FEA). Adductor muscle loads were applied to the FE-models, based upon detailed reconstructions from osteological correlates. Models were constrained at the jaw joint and the tooth row. Simulations of the various feeding hypotheses resulted in similar patterns and magnitudes in Von Mises stresses for the precision biting and branch-stripping models. The primary departure is that during branch-stripping, there is a localized peak of high stress in the dentigerous region of the upper jaw adjacent to the loaded teeth. In all simulations, regions of peak stress are situated on the: 1) caudomedial face of the quadrates; 2) ventromedial face of the pterygoids; 3) pterygoid midline; 4) rostral-edge of the palatines; and 5) rostral-region of the postorbital-squamosal contact. During bark-stripping, stress in the dentigerous region of the upper jaw is exceptionally high and widespread, with the teeth subjected to levels of stress that would have shattered them in vivo. Additionally, widespread low-level stress occurs across the snout, with moderately high stress along the ventral margin of the maxillae and quadratojugals. Quantitative modelling using FEA supports the hypothesis that *Diplodocus* could both strip leaves from branches and perform adductor-driven biting behavior, and allows us to conclusively discard bark-stripping as a viable feeding hypothesis.

Poster Session II, (Thursday)

#### A NEARLY COMPLETE SKELETON OF *SPHENISCUS URBINAI* STUCCHI (AVES SPHENISCIFORMES) IN THE BAHIA INGLESA FORMATION (MIOCENE-PLIOCENE) ATACAMA DESERT, CHILE.

YURY-YAÑEZ, Roberto, Universidad de Chile, Santiago, Chile; SOTO-ACUÑA, Sergio, Universidad de Chile, Santiago, Chile; GUTSTEIN, Carolina, Universidad de Chile, Santiago, Chile; RUBILAR-ROGERS, David, Museo Nacional de Historia Natural de Chile, Santiago, Chile

The avian fossil record in the Bahía Inglesa Formation, Atacama Desert, is composed by different seabirds such as prions, albatrosses, cormorants, shearwaters, boobies, pseudodontorns and penguins. Among these birds, the Sphenisciformes (penguins) are the most studied and best represented group. To date, the majority of the fossils studied come from a phosphatic "bonebed" (not younger than Tortonian based in Sr/Sr data from an upper level) described as a reworked layer from older strata and characterized by disarticulated and mostly fragmentary remain, but abundant in number. The penguin remains from the "bonebed" are characterized by the strong presence of the crown group Spheniscidae, particularly the extinct species from the Pisco Formation (Peru) *S. megaramphus* and *S. urbinai*, both species known from isolated cranial and appendicular remains. Here we present the first record of a semi-articulated skeleton of *S. urbinai* from a new locality, older than the "bonebed", known as "El Morro". The fossil (MPC 12002) preserves the neurocranium and rostrum, humeri, coracoids, femora and tibiotarsi, sternum, synsacrum, ilia and ischia. As the holotype, the specimen is 25% bigger than the actual species of the genus and with a proportionally bigger and dorsoventrally curved rostrum. This fossil represents the first articulated remains of a bird from the Bahía Inglesa Formation, and the

most complete bird record from Chile. This finding extends the stratigraphic record of the species in the Bahía Inglesa Formation and *S. urbinai* becomes the best represented species in the Miocene of the Southeast Pacific. In Peru *S. urbinai* has been described from strata older (Messinian) than Montemar level that is Tortonian in age, all the remains of its sister species *S. megaramphus* come from the last one. Previous records of *S. urbinai* have been suggested as a confirmation of the Tortonian age of the "bonebed" level where both species are found, due to the taphonomical reworked nature of this layer. The presence of both species makes impossible to confirm more precise ages for the "bonebed" and the level from where the articulated *S. urbinai* remains comes.

Technical Session III, Wednesday 1:45

#### POSTCRANIAL MORPHOLOGY OF THE AUSTRALIAN CRETACEOUS ICTHYOSAUR *PLATYPTERYGIUS LONGMANI*

ZAMMIT, Maria, University of Adelaide, Adelaide, Australia

The swimming styles of highly derived post-Triassic ichthyosaurs have been inferred from various modern analogues including cetaceans, fast-swimming fish (tuna), and sharks. These comparisons were based mainly on Jurassic specimens that preserved spectacular carbonized body outlines indicating a thunniform bauplan. Under this model the flipper-like limbs are assumed to have served primarily as stabilizers during axial propulsion. In contrast, evidence of body shape and swimming modes in Cretaceous ichthyosaurs is virtually unknown largely because the recovered specimens are typically fragmentary. The recent discovery of prolific amounts of exceptionally preserved remains in the Early Cretaceous (upper-most Albian) ichthyosaur *Platypterygius longmani* from Australia have thus, for the first time, permitted a detailed appraisal of body form and functional morphology in one of the stratigraphically youngest known ichthyosaur taxa. Axial and particularly appendicular elements of *P. longmani* were compared with a selection of extant marine tetrapods to assess swimming style - dugongs and cetaceans (caudal propulsion), otariid seals, penguins, and sea turtles (forelimb propulsion), and phocid seals (hind limb propulsion). Principal component analysis (PCA) was used to distinguish functional morphs. The limb elements of *P. longmani* were found to have greatest similarity with those of cetaceans, especially in the structure of the propodials and hyperphalangy. This suggests that the fore and hind limbs were probably capable of maneuvering, stabilization, and propulsion at low speeds. In addition, the very large surface area of the fore limb may have played a role in improving acceleration as observed in some fish today.

Poster Session IV, (Saturday)

#### A NEW TROODONTID (THEROPODA: PARAVES) SPECIMEN FROM THE UPPER CAMPANIAN KAIPAROWITS FORMATION, SOUTHERN UTAH: ESTIMATING THE TAXONOMIC DIVERSITY OF NORTH AMERICAN TROODONTIDAE

ZANNO, Lindsay, The Field Museum, Chicago, IL, USA; VARRICCHIO, David, Montana State University, Bozeman, MT, USA; TITUS, Alan, Bureau of Land Management, Kanab, UT, USA; WILKINS, Natalia, Lake Forest College, Lake Forest, IL, USA; KNELL, Michael, Montana State University, Bozeman, MT, USA

Despite widespread recognition across much of Laurasia, troodontid theropods are among the rarest dinosaur remains. To date, the taxonomic diversity of the clade is almost exclusively confined to Asia, where exceptional preservation permits the documentation of at least 10 species. In contrast, the diversity of Cretaceous North American (NA) troodontids is currently restricted to a single recognized species—*Troodon formosus*. Materials referred to *T. formosus* have been recovered from the Ferris, Lance, Edmonton, Judith River, Dinosaur Park, Belly River, Hell Creek, Two Medicine, and Prince Creek formations of western NA. Thus, *T. formosus* has been reported from sediments extending over 4000 kilometers and encompassing a temporal range of 20 million years, suggesting the taxonomic diversity of Cretaceous troodontids in NA is presently underestimated. Here we report discovery of a new troodontid specimen from the Upper Cretaceous Kaiparowits Formation, Grand Staircase-Escalante National Monument, southern Utah, USA, just below a horizon radiometrically dated at 75 mya. The specimen represents a single individual and includes fragmentary portions of the dorsal, sacral, and caudal axial column, left ulna and additional forelimb fragments, a partial pelvis, and partial left and right hind limbs, rendering it the most complete maniraptoran specimen recovered from the formation to date. Additional troodontid materials from the Kaiparowits Fm. that may be referable to this taxon include an isolated distal caudal vertebra, numerous isolated teeth, a previously reported isolated left frontal (UMNH VP 16303), and a partial skeleton collected by the University of California Museum of Paleontology (UCMP 143270). The following features suggest this specimen is distinguishable from *Troodon formosus*: ischiadic shaft straight, lacking proximodistal tubercle; astragalus lacking distal groove; medial distal condyle of pedal phalanx II-2 markedly asymmetrical, dorsal aspect flattened; and ventral margin of pedal phalanx II-2 straight in lateral view. However, additional study is needed to determine if these differences reflect ontogenetic and/or individual variation or represent an expansion of the known taxonomic diversity of NA troodontids.

Poster Session II, (Thursday)

#### THE ULTRASTRUCTURE OF SKIN AND FEATHERS OF CRETACEOUS BIRDS AND DINOSAURS

ZHANG, Fucheng, IVPP, Beijing, China; KEARNS, Stuart, University of Bristol, Bristol, United Kingdom; ORR, Patrick, UCD, Dublin, Ireland; BENTON, Michael, University of Bristol, Bristol, United Kingdom; ZHOU, Zhonghe, IVPP, Beijing, China

The fossil-rich Lower Cretaceous Jehol Group of North East China has yielded countless specimens of birds and many dinosaurs. Here, we report the detailed ultrastructure of integumentary elements, specifically skin and feathers. During the preparation of specimens of articulated fossils, preparators inevitably remove much material to reveal the skeletal and/or integumentary structure that lies beneath the surface. This material consists of, superficially, random rock chips with little useful detail. However on close examination – both optically and with the SEM, many fine detailed structures from the fossil integument have been observed.

Skin fragments exist as small (200-500µm) patches in the rock matrix. These represent discarded keratinized epidermal skin flakes, readily incorporated into the feather mass. This tissue is preserved as calcium phosphate – claw sheaths are also phosphatized. Focused Ion Beam analysis demonstrates preservation of original layering within the epidermis on a sub-micron scale. Such detail has been observed in *Confuciusornis* and in the maniraptoran theropods *Beipiaosaurus* and *Sinornithosaurus*.

In contrast, feather material, also keratin *in vivo*, is only very rarely phosphatized and in those cases it is only the feather rachis that is so preserved. More typically, feathers are preserved as a carbonaceous film, frequently showing detail of vanes, barbs and barbules, most clearly in the wing, tail and outer contour feathers. Downy feathers, close to the body carcass are preserved as a rather oily-looking dark carbonaceous mass. Numerous examples of isolated feathers from unknown birds may also show further diagenetic alteration, including iron and manganese oxidation that can enhance some details. Key ultrastructure features are observed and shared in the controversial filamentous integument of the compsognathid *Sinosauropteryx*, the maniraptorans *Sinornithosaurus* and *Yixianosaurus*, and the feathers of *Confuciusornis*. The new work confirms aspects of the apparent preservation of color banding in the feathers, and that the disputed filamentous structures of some of the theropod dinosaurs at least are feathers and not collagen fibers.

Poster Session I, (Wednesday)

#### A LATE CRETACEOUS OSTEOGLOSSOMORPH FISH FROM NORTHEAST CHINA

ZHANG, Jiangyong, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China

A recently found fossil from the Nenjiang Formation in Songliao Basin of northeastern China represents the first Late Cretaceous osteoglossomorph in China. The new fish differs from other known early osteoglossomorphs in having a relatively long premaxilla, lower dentary, short anal fin rays and a deep forked caudal fin.

Osteoglossomorphs are freshwater fishes except the Eocene brackish *Brychaetus*. They bear important paleobiogeographic implications due to their Recent transoceanic distribution. The Late Cretaceous deposits in Songliao Basin were traditionally thought to be completely continental, but two phases of transgression (one recorded in Nenjiang Formation) have been proposed in recent years by both geologists and paleontologists with the discoveries of the brackish fossil assemblages of foraminifera, dinoflagellates, calcareous nanofossils, serpulidae burrows, algal stromatolith and fishes. The new specimen probably represents the second brackish osteoglossomorph fish ever found and may indicate the marine dispersal of this teleost group had occurred more common than expected.

Poster Session II, (Thursday)

#### NEW PHYLOGENETIC ANALYSIS REVEALS IMPORTANT RELATIONSHIPS AMONG PARACIMEXOMYS GROUP, "CIMOLODON", ANCONODON, NEOPLAGIAULACIDAE, AND CIMOLOMYDAE

ZHANG, Yue, San Diego State University, San Diego, CA, USA

A new phylogenetic analysis on species of *Paracimexomys* group, *Cimolodon*, cimolomyids, *Mesodma*, *Ectypodus*, *Neoplagiaulax*, and *Anconodon* was conducted using both traditional parsimonious methods (PAUP\*) and relatively new likelihood-based methods (MrBayes). Results were generally consistent between the two methods, suggesting applying different methods is useful in helping to resolve relationships. Because of the highly incomplete multituberculate fossil record, only posterior premolar and molar characters, including both quantitative and qualitative characters, were used. The use of intermediate stages of character states using ordering or binary coding methods afforded greater resolution compared to giving all the changes among multiple character states an equal possibility as is often done. The analysis demonstrated that *Anconodon* is a neoplagiaulacid rather than a cimolodontid, possibly referable to *Neoplagiaulax*. The paraphyly of *Cimolodon* species, as proposed by others, is more strongly supported. The results suggested species of "*Cimolodon*" do not represent basal members of Ptilodontoidea and should be excluded from the superfamily.

Poster Session III, (Friday)

#### A STUDY ON ONTOGENETIC CHANGES IN PSITTACOSAURUS USING GEOMETRIC MORPHOMETRICS METHOD

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*Psittacosaurus* is a basal ceratopsian taxon, the fossil record of which is restricted to Lower Cretaceous sediments of Asia. Although it is among the few non-avian dinosaurian taxa that are represented by numerous, well preserved specimens, its species-level taxonomy and inter-specific relationships are highly debated. The exceptional preservation of psittacosaurid specimens in the Yixian Formation has recently improved our understanding of various aspects of this taxon and numerous specimens of different ontogenetic stages collected from the Yixian Formation at Lujiatun Locality, Liaoning Province, China make it possible to perform morphometric analyses on this taxon. Here we used geometric morphometric methods to analyze 7 specimens of *Psittacosaurus lujiatunensis*, in order to understand how its skeletal morphology changed through ontogeny. The 3D coordinates of the 17 landmarks were digitized using a Microscribe. Specimens were aged using skeletal histology and growth stage determination was performed using the Developmental Mass Extrapolation technique. The analysis recovered evidence for relatively slow growth of the rostral and frontal bones, fast development of the nasals, and a consistent position of the jugal horn relative to the neighboring elements. These data are not only important for our understanding of the ontogenetic development of this taxon, but are also useful in identifying phylogenetically significant features.

Poster Session IV, (Saturday)

#### HORIZONTAL AND INCLINED NECKS IN EXTINCT GIRAFFIDAE

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The orientation of the neck is an important character in the reconstruction of an extinct taxon as it relates to the overall posture and to intraspecific combat behaviors. Soft anatomy helps in establishing and understanding osteological correlates. The position of the soft palate, larynx and pharynx in ruminants appears to relate to the orientation of the neck. However, this anatomical feature appears to be unrelated to the type of feeding. Dissections and X rays of cervids, bovids and giraffids reveal differences in neck orientation which can explain differences of the position of the soft palate, the pharynx and the larynx. The position of C1 and C2 cervical vertebrae differs from relatively horizontal (*Bos taurus*) to inclined (*Odocoileus virginianus* and *Okapia johnstoni*) and in extreme cases vertical (*Giraffa*). In *Giraffa* the space between C1 and the ascending ramus of the mandible is very narrow and as a result the pharynx-larynx and the soft palate are positioned forward. The neck swings as a pendulum and the head locks together with the neck during that motion. The most plausible explanation of these specializations is that the head-neck complex is being used as a weapon in combating males. The position of the soft palate is known in several fossil skulls. The median palatine indentation of extinct Giraffidae is of three morphological states: Posterior to the M3, at the level of M3 and at the level of M2. The soft palate is the most forward in the latter. Using the previously described morphologies we hypothesize that the extinct: *Samotherium boissieri*, *Schansitherium*, *Palaeotragus* spp, *Honanotherium schlosseri* and *Bohlinia attica* had an inclined neck like that of *Okapia* and *Odocoileus*. The archaic giraffid *Giraffokeryx* had a more horizontal neck like that of *Bos taurus*. It is plausible that the earliest giraffids were similar to *Giraffokeryx*. *Bohlinia* (the sister taxon of *Giraffa*) has a very long neck but it was inclined as *Okapia*; it was not vertical as in *Giraffa*. Thus, the elongation of the neck preceded the extreme verticality of the *Giraffa* neck.

Poster Session III, (Friday)

#### A NON-PTERODACTYLOID PTEROSAUR FROM THE MIDDLE JURASSIC OF WESTERN LIAONING, CHINA

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As primitive pterosaurs, rhamphorhynchoids characteristically possess a short metacarpus, long and stiff tail, and a well-developed pedal digit V. Although these animals are mostly known from the Triassic and Jurassic of Europe, four rhamphorhynchoid taxa have been reported from the Middle Jurassic and Early Cretaceous of China: *Angustinaripterus longicephalus*, *Jeholopterus ningchengensis*, and *Pterorhynchus wellnhoferi* broaden the geographical distribution of rhamphorhynchoids to East Asia in the Middle Jurassic, while an isolated taxon, *Dendrorhynchoides curvidentatus*, extends the temporal distribution of rhamphorhynchoids to the Early Cretaceous in the region. This paper describes a new rhamphorhynchoid from the Middle Jurassic Tiaojishan Formation of Linglongta, Jiancheng, western Liaoning, as evidenced by features of the postcranial skeleton, including: slightly elongate cervical vertebrae, absence of mid-cervical ribs, a triangular posterior edge of the sternal plate, a small process at the base of the deltopectoral crest, a foramen on the dorsal surface of the humeral shaft, difference of metacarpals I-III in length, nubbin-like pedal phalanges III-2, IV-2, and IV-3, and a curved pedal phalanx V-2 in its proximal third with an angle of about 120 degrees. A preliminary phylogenetic analysis shows that the new pterosaur is included among primitive rhamphorhynchoids in a polytomy with *Sordes*,

*Preondactylus*, *Scaphognathus*, *Dorygnathus*, *Dimorphodon*, and the *Peteinosaurus*-*Eudimorphodon* clade. This discovery not only adds a new taxon to the Chinese rhamphorhynchoid diversity in the Middle Jurassic, but also further supports a terrestrial radiation of the rhamphorhynchoids from the Europe to East Asia was occurred no later than the Middle Jurassic.

The Evolution of Birds in the Mesozoic: a Symposium in Honor of Cyril A. Walker, Thursday 9:15

#### A NEW BASAL ORNITHURINE BIRD FROM THE LOWER CRETACEOUS OF CHINA

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A new genus and species of a basal ornithurine bird is reported from the Lower Cretaceous Jiufotang Formation of Liaoning, China. It is represented by a completely articulated skeleton. It is distinguishable from other known ornithurines by possessing a combination of features including at least 16 small and conical teeth on the dentary, scapula strongly curved, a long alular digit extending past the distal carpometacarpus, and length ratio of humerus+ulna+carpometacarpus to femur+tibiotarsus+tarsometatarsus is about 1.2. No uncinat process is observed with the seven articulated thoracic vertebrae. Gastralia are present. The synsacrum appears to comprise at least 9 sacra and fused with the ilia that extends anteriorly to the last thoracic vertebra. The pygostyle is small. The carpometacarpus is well fused at both proximal and distal ends. Both the sternum and keel are elongated, with a prominent external rostral spine. The scapula is strongly curved and shorter than the humerus, with a dorso-laterally directed glenoid facet. The coracoid possesses a well developed procoracoid process, a typical ornithurine "ball-pit" articulation with the scapula, and concave medial and lateral margins. The furcula is "U"-shaped. The humerus has a strape-like head, a large deltoic crest with a convex dorsal margin. All three manual digits retain the unguis. The first phalanx of the major digit is robust but not posteriorly curved. The pubes are slender and symphyseal distally, but not expanded. The fibula is about half the length of the tibiotarsus. The tarsometatarsus is completely fused from proximal to distal end, with the trochlea for Metatarsal III greater than that of II and IV. The associated fish fragments may indicate a piscivorous diet consistent with the dentation of the new bird.

Technical Session V, Wednesday 3:15

#### A NEW DEVONIAN TETRAPODOMORPH FISH AND ITS BEARING ON THE FISH-TETRAPOD TRANSITION

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A new articulated tetrapodomorph fish from the Famennian Zhongning Formation of Ningxia, North-West China, demonstrates a unique morphology that expands our understanding of morphological diversity in the tetrapod stem group. It shares possible synapomorphies with both elpistostegids and rhizodonts in a way that may challenge the currently accepted wide phylogenetic separation of these two groups. The new animal is a large fish, probably about 2 meters in length when complete, represented by a skull lacking the snout, a well-preserved gill region and shoulder girdle, and a very robust anterior vertebral column. The skull appears to have been broad and blunt-snouted in life, with a flat ventral surface. Characters shared with rhizodonts include extratemporal-supratemporal contact (in this case enclosing the spiracle as a fenestra within the skull roof), a large clavicular spine, and a plate-like scapulocoracoid without foramina. However, in complete contrast to known rhizodonts, the ventral portion of the cleithrum is not expanded but strongly reduced, leaving the scapulocoracoid broadly exposed ventral to the cleithrum and posterior to the clavicle. This resembles the elpistostegid condition, as does the short hyomandibula, which ends at the opercular facet as in *Panderichthys*. Autapomorphies include an extremely flat lower jaw with a large rectangular retroarticular process. The cleithrum lacks an overlap surface for an anocleithrum and the first vertebra is a morphologically distinct atlas articulating with a pair of distinct facets on the occipital arch; these features suggest enhanced mobility of the head relative to the shoulder region, convergent with tetrapods and the tristichopterid *Mandageria*. The new form shows that the diversity and disparity of tetrapodomorph fishes, until now largely documented by fossils from Euramerica and to a lesser extent eastern Gondwana, has been underestimated. Other undescribed tetrapodomorphs from the Late Devonian of Ningxia show different but equally novel character combinations and are likely to impact tetrapodomorph phylogeny in unpredictable ways.

Poster Session II, (Thursday)

#### NOTES ON HINDLIMB MYOLOGY AND SYNDESMOLOGY OF HESPERORNIS REGALIS (AVES: HESPERORNITHIFORMES)

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Partial reconstruction of hindlimb myology and syndesmyology of *Hesperornis regalis* based on the extensive fossil and extant comparative anatomical and functional data shows that this toothed cretaceous bird chose its own way to master foot-propelled diving. Possessing a combination of morphological features characteristic for modern loons and grebes and being in an overall hindlimb anatomy somewhat closer to loons, *Hesperornis regalis* shows maximal known degree of specialization to foot-propelled diving. The acetabular foramen, which is much smaller than in any extant birds, shows that femoral head of *Hesperornis* had much less excursion in comparison to modern Aves. The development of femoral retractors, such as *m. iliofemoralis* and *m. caudofemoralis*, exceeds that in modern foot-propelled diving birds, showing greater protractive forces, applied to the femur during the propulsive stroke. Insertion of these muscles on femur is marked by the prominent tuberosity. The propulsive stroke in *Hesperornis* has been carried out by *mm. gastrocnemii*. The origin of intermedial portion of this muscle reached its maximum extending proximally beyond trochanter major. Ligaments of the knee joint, which show typical avian morphology, allowed a high degree of inward-outward rotation of the tibiotarsus, which has been held close to the body and more likely was enclosed by the thickly feathered skin of the body wall. Flexion-extension movements in the knee-joint were highly reduced, partially by well-developed *mm. flexores cruris*, *m. iliofibularis* and postacetabular portion of *m. iliotibialis lateralis*, and partially by *m. femorotibialis medialis*, which inserted onto almost entire posterior surface of enlarged patella. The intertarsal joint of *Hesperornis* possessed a high degree of rotational freedom. In this way it resembled that of loons, showing loon-like manner of tarsometatarsal movements. This loon-like manner, however, was combined with grebe-like movements of toes, which undoubtedly had asymmetrical lobes.

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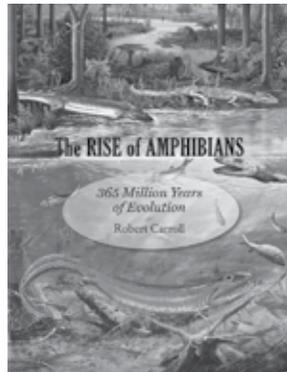
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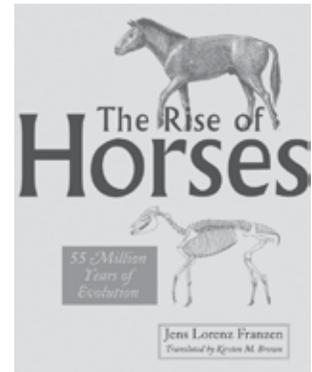
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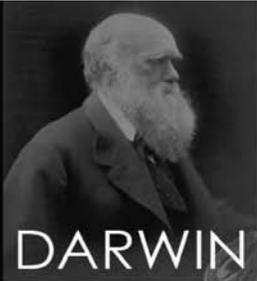
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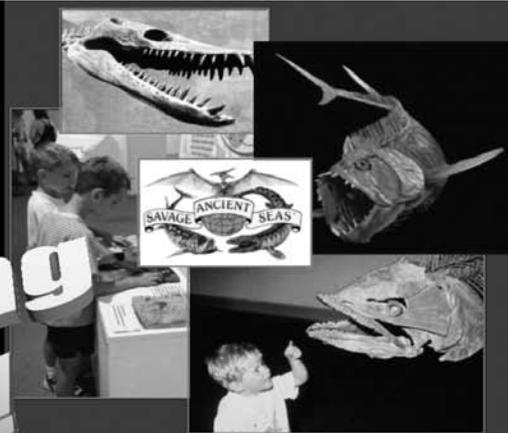


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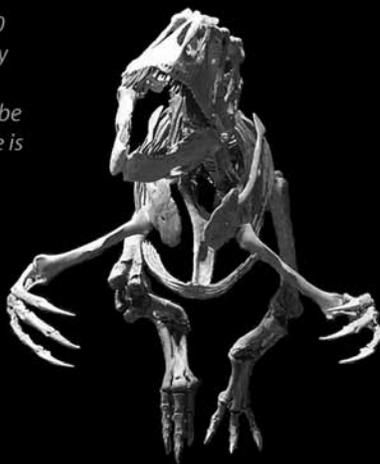
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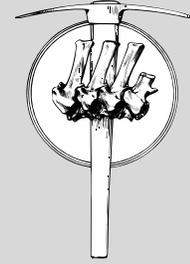
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