Technical Session XI (Friday, October 11, 2019, 10:15 AM)

GEOGRAPHIC PATCHINESS AND ITS EFFECT ON MACROEVOLUTIONARY INFERENCE

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The fossil record is biased in space and time. Time intervals are unevenly sampled, and for any given interval, only a small portion of the Earth's surface is preserved, biased towards depositional and taphonomically advantageous environments. Compounding this, taxon distributions are independently structured, functions of environmental tolerance and ancestral range. Evolutionary inferences must be made in the context of this incomplete and structurally biased fossil record, and while such effects are often considered in the context of richness, other aspects of paleobiology might be influenced by geographic biases.

Diversification in an unsampled region cannot be observed directly and may present problems for inference of phylogeny, divergence dates, and rates of evolution. A slowly evolving clade that appears simultaneously in the fossil record as a result of changing geographic distribution has the same pattern of first appearance dates as one adaptively radiating faster than the frame rate of the fossil record. Here, we investigate the effect that these geographic biases have on reconstructions of evolutionary history.

Using a recently-developed agent-based evolutionary model, TREvoSim, we simultaneously simulated the evolution of two communities of constant and equal size. Each community comprised individuals represented by binary character genomes. In each iteration, mutations were introduced during reproduction, and individual fitness was assessed against changing environmental masks, determining the likelihood of reproducing. Dispersal between communities was permitted at a symmetric low-level probability. We tested the impact of several scenarios, including extreme environmental perturbations and increases in dispersal probability.

The resultant matrices were degraded to reflect character and taxon incompleteness and spatial biases in preservation. Topology and divergence dates were inferred from each degraded matrix with MrBayes, and compared with the true tree.

Character and taxon completeness had little effect on tree accuracy or precision except where character completeness was very low. Increased dispersal probability had little effect on tree accuracy, but resulted in lower precision, and more extinction following perturbations. Notably, for taxa that dispersed en masse, inferred divergence dates were consistently too young. These results have important implications for understanding the interactions between the geological and biological processes that underlie paleobiological data.

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

MUSCULAR RECONSTRUCTION AND COMPUTATIONAL MODELLING OF THE PECTORAL GIRDLE IN LAMBEOSAURUS (DINOSAURIA, HADROSAURIDAE).

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An animal's posture and gait are fundamental to its ecology and behaviour. Ancestral dinosaurs were likely bipedal, but a number of groups secondarily reverted to quadrupedality. Hadrosaurid ornithischians are often regarded as an example of a secondarily quadrupedal lineage, but their posture has proved contentious, as some researchers have interpreted them as habitual or at least facultative bipeds. Continuing uncertainty on this point complicates attempts to reconstruct the evolution of posture in dinosaurs overall, and hinders investigations of hadrosaurid behavior and ecology.

The functional morphology of the forelimb may hold the key to determining whether hadrosaurs were predominantly bidepal or quadrupedal. The remarkably preserved pectoral girdle and forelimbs of a partial lambeosaurine (crested) hadrosaur skeleton that was recently recovered from the Upper Cretaceous Oldman Formation of southern Alberta, Canada provide suitable material for a thorough description of the pectoral appendicular skeleton, and an analysis of its musculature and osteological range of motion. Manipulation of a digital model of the shoulder joint in Autodesk Maya indicates a maximum of 75º of protraction of the humerus, from an initial vertical orientation, and a maximum retraction of 113º. Abduction and adduction were limited to 40º and 76º respectively. Muscular reconstructions show correspondingly large muscle attachment sites associated with support of the shoulder as well as extension and retraction of the upper arm. For example, most of the blade of scapula is occupied by a very large area of origin for the deltoideus scapularis, which is thought to be involved specifically with retraction of the humerus. In contrast, areas of scarring for muscles associated with abduction and retraction are comparatively small, suggesting that these muscles were less powerful movements and possibly had smaller joint moment arms.

These findings lend support to the hypothesis that hadrosaurs were predominantly quadrupedal animals, as powerful retraction movements of the forelimb would be particularly advantageous in quadrupedal walking. Hadrosaurs likely represent a transitionary stage between bipedalism and quadrupedalism, making these animals a model organism for studying the mechanical evolution of bipedality. Creating thorough biomechanical models of the movements of these animals is therefore a crucial step to understanding how and why this major adaptive event occurred so often in the dinosaur lineage.

Grant Information:
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Technical Session VIII (Thursday, October 10, 2019, 3:30 PM)

THE EVOLUTION OF PECULIAR CRANIAL MORPHOLOGY IN NASAL-EMITTING TRIDENT BATS (CHIROPTERA: RHINONYCTERIDAE) FROM THE AUSTRALIAN MIOCENE

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In the fossil deposits of the Riversleigh World Heritage Area of northern Australia, trident bats (Rhinonycteridae) and Old World leaf-nosed bats (Hipposideridae) are among the most speciose and abundant mammal taxa. Some 20 species of these bats have been identified in Riversleigh's late Oligocene to middle Miocene karst deposits, and many are represented by hundreds of well-preserved skulls each. These kinds of bats emit pure-tone echolocation calls through the nostrils that allow detection of fluttering prey around vegetation, and have expanded nasal chambers and cochleae which are associated with energy transmission and reception. We used 3D geometric morphometrics to examine cranial traits in one of the most distinctive of these lineages, the *Xenorhinos* group. These extinct bats are characterised by a broad, deep rostrum, voluminous nasal cavities, incomplete nasal septum, broad interorbital region, extremely short palate, splint-like sphenoidal bridge, and conspicuous rostral rotation. A 3D GMM approach enabled recognition of two new species referrable to this group, reappraisal of the lineage's probable phylogenetic relationships, assessment of their likely echolocation call attributes and ecology, and a possible developmental pathway for their unique skull form. Members of the *Xenorhinos* group represent ecomorphs that have been completely lost since the middle Miocene, probably as a result of changing paleoenvironments in northern Australia, but at least some of their striking cranial features persist in the extant trident bats of Africa and Madagascar.

Grant Information:
Australian Research Council Discovery Program DP170101420

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

A REVIEW OF THE MIOCENE RHINOCEROSES FROM JAPAN, AND PALEOBIOGEOGRAPHIC IMPLICATIONS

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In Japan, the Miocene rhinocerotid remains have been well reported. Recently, the taxonomy of rhinocerotids from Eurasia has been revised. In contrast, taxonomic revisions of Japanese remains have not been undertaken since their initial descriptions except for a few teeth and mandibular remains. Numerous rhinocerotid footprints have also been reported from the Miocene strata. The Japanese rhinocerotid fossil records give new information on the paleobiogeography of rhinocerotid in far East Asia during the Miocene. However, a comprehensive discussion of Japanese Miocene rhinocerotids has not yet been carried out. Here I review the fossil records of the Japanese rhinocerotids from the Miocene and discuss their taxonomic status and distribution with the paleogeographic change of Japan island through the Miocene Period.

Brachypotherium? *pugnator*, *Plesiaceratherium* sp. and possibly a member of the Teleoceratini have been found from the Early Miocene localities (20-16 Ma). Several fragmentary remains of the Early Miocene which were identified as *Chilotherium* are re-identified as an indeterminate taxon. All rhinocerotid footprints have been found from the early Miocene strata. A lower incisor which is of a member within the Aceratheriinae is only the Middle Miocene record (around 14 Ma). I recognize two Late Miocene (9-6 Ma) remains as members within the Aceratheriini. An isolated lower molar from the early Late Miocene locality is identified as an indeterminate taxon.
In the Early Miocene, proto-Japan was a part of the eastern margin of the Asian Continent. Various species of *Plesiaceratherium* and *Brachypotherium* have been found from the Early Miocene localities in Eurasia. Therefore, Japanese ones imply that these two taxa distributed into the eastern margin of Eurasia in that time. The humid forest dominated environment in Eurasia during the Early Miocene would have affected the wide distribution of these taxa. Proto-Japan was separated from the continent with the opening of the Japan Sea and had become archipelago by the earliest Middle Miocene (around 16 Ma). The latest Early to Middle Miocene rhinocerotid records in Japan suggest that rhinocerotids presented in small islands of proto-Japan. Proto-Japan re-connected Asian continent in the early Late Miocene. Rhinocerotids presented in Japan islands during the Late Miocene. However, it is unclear that whether Japanese Late Miocene taxa are descendants of the Early to Middle Miocene taxa or new immigrants from the continent in the early Late Miocene due to incompleteness fossil records.

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

A NEW BASAL EUSUCHIAN FROM THE GRIMAN CREEK FORMATION AT LIGHTNING RIDGE, NEW SOUTH WALES, AUSTRALIA.

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The Australian Mesozoic crocodyliform record is sparse in comparison to other Gondwanan land masses. A single formally-named taxon is known from this interval: *Isisfordia duncani* (upper Albian of the Winton Formation, Queensland). A second taxon, *'Crocodylus (Bottosaurus) selaslophensis'* (Griman Creek Formation, Cenomanian, New South Wales), described in 1917 based on a jaw fragment, is enigmatic, and its taxonomic affinities have never been fully resolved.
We present evidence of a new species of *Isisfordia* from the same location and stratigraphic interval as *'Crocodylus (Bottosaurus) selaslophensis'*. This new species, based on a partial braincase, presents at least one unambiguous autapomorphy of *Isisfordia* and several unique characteristics that differentiate it from *I. duncani*.
The former holotype of '*Crocodylus (Bottosaurus) selaslophensis'* is also referred to this new species. Central to this argument is the re-identification of the jaw fragment as part of the maxilla—rather than the dentary as was previously supposed—combined with the presence of an alveolar groove. Despite the shared presence of an alveolar groove with *I. duncani*, the two differ in the shape of the alveoli and tooth crown bases, suggesting differentiation at the species level. Furthermore, additional cranial and postcranial remains from the Griman Creek Formation, including a series of associated vertebrae, also show features consistent with *Isisfordia* and are potentially assignable to the new taxon.
The identification of a second, roughly contemporaneous species of *Isisfordia* demonstrates that the genus was well-established in eastern Australia during the mid-Cretaceous. *Isisfordia* is the first Australian Mesozoic archosaur with multiple distinct species, further underscoring the paucity of Australia's Mesozoic terrestrial vertebrate fossil record. These discoveries are also significant as they extend the geographical and temporal range of *Isisfordia*, which has traditionally been considered the most basal taxon within Eusuchia.

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

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

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Estimates of extinct animal volume, center of gravity, and extrapolations from that data (e.g., physiological modeling, reconstructing stance and gait) depend on accurately constraining volumes of individual body segments. This is particularly true of the torso, which is the largest body segment in nearly all tetrapods. Limb girdles and bony ribs provide the potential for accurate torso shape and volume estimates, but competing estimates of rib orientation relative to the axial column significantly alter results. This is true whether estimates are made from multi-view anatomical diagrams or from three-dimensional LIDAR scans.
Inspection of articulated non-avian dinosaur rib cages and undistorted isolated elements confirms previous reports that for anterior thoracic ribs, full seating of tuberculi and capituli against against respective diapophyses and parapophyses results in rib shafts oriented posteroventrally in non-avian dinosaur taxa sampled. This result is consistent with X-ray data and dissections of extant crocodilians and avian-dinosaurs. As these taxa form an extant phylogenetic bracket, posteroventrally oriented anterior thoracic ribs in non-avian dinosaurs are a Level I inference.
Diapophyses and parapophyses on the anterior vertebrae of dinosaurs are frequently offset from one another vertically and horizontally. As a result more posteriorly swept ribs also produce a narrower torso. The location of the pectoral girdle of non-avian dinosaurs is dependent on the shape and anterior extent of the rib cage. Anterior thoracic ribs mounted or reconstructed in a vertical orientation requires the pectoral girdle to be moved anteriorly, functionally elongating the torso and shortening the neck. Calculating mass from competing inferences of rib orientation via double graphic integration shows a variance in whole-animal volumetric estimates of 8-10%. I suggest either adopting the well-supported Level I inference for non-avian dinosaur rib orientation, or for future authors to include these larger error bars into calculations that build upon shape or volume estimates.

Technical Session III (Wednesday, October 9, 2019, 3:00 PM)

THE SOUND OF RANCHO LA BREA

HARTSTONE-ROSE, Adam, North Carolina State University, Raleigh, NC, United States of America; ELMINOWSKI, Erin, North Carolina State University, Raleigh, NC, United States of America; FLORES, Deanna, North Carolina State University, Raleigh, NC, United States of America; ELDRIDGE, Emma, North Carolina State University, Raleigh, NC, United States of America

Withdrawn

Fossils of *Smilodon fatalis* and *Canis dirus* [illegible] Rancho La Brea (RLB) tar pits in [illegible] that [illegible] middle ear bones (the [illegible]) [illegible] have [illegible] of sound from the [illegible] to the [illegible] comparing the ossicles of *S. fatalis* [illegible] to [illegible] living relatives, we aimed to determine the range of [illegible] heard by these prehistoric predators. Due to the phylogenetic relationship, we hypothesize that the extinct species will have frequency ranges similar to their living relatives. To test this, we photographed 56 *S. fatalis* and 51 *C. dirus* auditory ossicles from RLB and digitally measured them and the ossicles of their living relatives (and some other RLB species) and found that the auditory ossicles of *S. fatalis* and *C. dirus* have similar shape and size characteristics of their modern relatives. While *S. fatalis* and *C. dirus* might have had similar hearing to their living relatives, we were also able to examine the auditory ossicles of the large extinct American lion (*Panthera atrox*) and found that its ear bones were substantially larger than those of any living cat species suggesting that it might have had very different – perhaps lower frequency – hearing. Other RLB taxa had ossicles that were so morphologically distinctive to be difficult to acoustically analyze. For instance, the giant ground sloths (*Paramylodon*, *Megalonyx* and *Nothrotheriops*) have no modern analogue remotely similar in shape and scale, and their well-preserved ossicles will require different technical approaches to assess their sound transmission properties.

Symposium: From Molecules to Macroevolution (Wednesday, October 9, 2019, 10:45 AM)

CALCIUM ISOTOPES AND DINOSAUR RESOURCE PARTITIONING

HASSLER, Auguste, Laboratory of geology of Lyon: Earth, Planets and Environments, Lyon, France; MARTIN, Jeremy E., Laboratory of geology of Lyon: Earth, Planets and Environments, Lyon, France; AMIOT, Romain, Laboratory of geology of Lyon: Earth, Planets and Environments, Lyon, France; TACAIL, Théo, Bristol Isotope Group, School of Earth Sciences, University of Bristol, Clifton, United Kingdom; ARNAUD-GODET, Florent, Laboratory of geology of Lyon: Earth, Planets and Environments, Lyon, France; ALLAIN, Ronan, Sorbonne Universités—CR2P—MNHN, Paris, France; BALTER, Vincent, Laboratory of geology of Lyon: Earth, Planets and Environments, Lyon, France