Technical Session IV (Wednesday, November 5, 2014, 3:15 PM)

COULD THE GIANT KANGAROO HOP?

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It is thought that the process of saltation, or hopping, was an evolutionary breakthrough in terrestrial locomotion through its ability to confer energy efficiency at relatively high speeds. While some studies have suggested an upper body mass limit to effective hopping, larger extant species such as *Macropus rufus*, whose body mass exceeds the cited limit for effective hopping, can achieve higher speeds than smaller species. However, whether the largest fossil kangaroo, the Pleistocene giant *Procoptodon goliah* (~250 kg), had the ability to hop has been questioned by some. Other studies have argued that *P. goliah* was a very specialized hopper. More recent studies have focused on muscle and tendon elasticity to evaluate limitations on saltation and have argued that *P. goliah* could not withstand the amount of stress generated during hopping. Here, we apply novel biomechanical analyses based on data from 19 extant macropodoids and *P. goliah* to predict and compare peak forces in the femur during saltation and other types of locomotion. Our findings suggest that larger marcropods are able to withstand relatively higher forces than smaller species due to allometric increase in bone size. We predict that *P. goliah* could hop.

Poster Session IV (Saturday, November 8, 2014, 4:15 - 6:15 PM)

THE SIGNIFICANCE OF THE OLIGOCENE–MIOCENE TRANSITION IN THE DIVERSIFICATION AND SPREAD OF THE CHALICOTHERIIDAE (MAMMALIA, PERISSODACTYLA)

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Like the Equidae and Rhinocerotidae, Chalicotheriidae reached their acme of diversity during the Miocene Epoch. The basal chalicotheriid genus *Schizotherium*, restricted to Eurasia, dominated the Oligocene. By the beginning of the Miocene the two chalicotheriid subfamilies, Chalicotheriinae and Schizotheriinae, had become clearly delineated. Members of the Chalicotheriinae existed in Asia (in the early Miocene of Pakistan and China), and by ~20 million years ago the chalicotheriine *Butleria rusingensis* was present in East Africa. Among the Schizotheriinae, the genera *Borissiakia*, *Phyllotillon*, and *Moropus* were all in evidence at the beginning of the Miocene. *Moropus* had joined the rhinocerotid *Menoceras* and the carnivores *Ysengrinia*, *Cynelos*, and *Cephalogale* as immigrants to North America, where it is found in faunas of late Arikareean age in the John Day Basin of Oregon, the Great Plains of western Nebraska and eastern Wyoming, and the Gulf Coast region of Texas and Florida.

Despite the centrality of Eurasia to chalicotheriid evolution at this time, our understanding of what happened on this vast supercontinent remains flawed, though promising progress has been made over the past two decades. For example, we know that the schizotheriine lineage that fuses the proximal and middle phalanges of digit II of the manus to form a duplex bone had appeared by the earliest Miocene. Fossil material of early Miocene Eurasian members of this clade (which includes *Moropus*, *Phyllotillon*, *Metaschizotherium*, *Tylocephalonyx*, and *Ancylotherium*) has been fragmentary, but this situation is changing. In Europe, good schizotheriine material from a MN3 fauna in the Chomutov Basin of the Czech Republic is aiding understanding of less complete specimens, aged MN2–MN4, from Spain, Portugal, France, and Germany that have variously been referred to *Moropus*, *Phyllotillon*, or *Metaschizotherium*. In Asia, careful stratigraphic work on chalicothere-bearing strata in the Bugti region (Pakistan), the Betpakdala Steppe (Kazakhstan), and fossiliferous basins of Gansu Province (China) is also yielding insights into schizotheriine evolution during the Oligocene–Miocene transition.

Poster Session II (Thursday, November 6, 2014, 4:15 - 6:15 PM)

A GEOMETRIC MORPHOMETRIC ANALYSIS OF ARCHOSAUR CLAW SHAPE AND ITS IMPLICATIONS FOR KERATINOUS SHEATH MORPHOLOGY IN EXTINCT TAXA

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There is a large amount of literature on the topic of pedal ungual morphology in archosaurs and its relation to niche occupation; however, the relationship between the bony unguals and keratinous sheaths of claws remains poorly understood. It is especially critical to understand this relationship since extant avian datasets of keratinous sheath shape have been applied to the bony unguals of fossils to determine likely niches for extinct animals. The vast majority of previous studies examining claw shape have focused on angle measurements on either the inner, outer, or central aspects of the claw. These analyses failed to remove either size or phylogeny from their datasets, which is critical to do before attempting to understand shape. This study is the first to quantify the shape of the keratinous sheath as it relates to the bony ungual using two-dimensional geometric morphometrics. Geometric morphometrics is an ideal technique to use in the analysis of shape because it removes differences between specimens that are the result of rotation, translation, and size, leaving only shape data. A preliminary dataset of pedal digit three claws of 503 avian and crocodilian specimens were x-rayed in lateral view. By x-raying the specimens, it was possible to visualize both the shape of the keratinous sheath and bony ungual simultaneously. Additionally, 45 fossil avian and non-avian theropod digit three claws were photographed in lateral view in order to reconstruct the missing keratinous component of the claws using bony ungual shape and to test hypotheses about niche occupation among these taxa. Landmarks and semilandmarks were applied to the images in order to capture shape digitally. An exploratory principal components analysis has shown shape partitioning between both the unguals and keratinous sheaths of claws based on locomotory mode, demonstrating the potential for using this dataset to understand niche partitioning in extant species. Future analyses will explore the extent to which phylogeny is driving the shape change in the dataset and the degree of modularization within the ungual and keratinous sheath.

Technical Session II (Wednesday, November 5, 2014, 11:00 AM)

TESTING DEVELOPMENTAL BIOLOGY PREDICTIONS WITH FOSSILS: DENTAL COMPLEXITY AND EVOLUTIONARY RATES OF THE MULTITUBERCULATA

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The increase in maximum complexity of tooth morphology through evolutionary history, both within individual clades and across most vertebrates, especially mammals, is marked. However, recent genetic and developmental studies suggest increases in morphological complexity are developmentally constrained and more difficult to achieve than reductions. Thus, over evolutionary time scales, we might expect increases in morphological complexity to occur less frequently than decreases. To address this hypothesis we studied patterns of change of tooth complexity and other parameters in the extinct mammalian order Multituberculata. Multituberculates were both the most successful Mesozoic mammal clade and the longest-existing mammalian order known. Recent work suggests an increase in multituberculate species richness, disparity, abundance, and ecological and dietary niche range occurred ca. 20 million years before the K-Pg boundary, continuing until shortly into the Cenozoic, and possibly linked with the diversification of angiosperm plants and the evolution of multituberculate herbivory.

Here, we used diversification rate, phylogenetic comparative, and evolutionary rate analyses, allied with a comprehensive multituberculate phylogeny and dataset recording functional parameters including toothrow dental complexity, tooth cusp number, and estimated body mass, to determine patterns and rates of morphological evolution and change in complexity for these animals. Dental complexity was quantified and analysed using 3D digital tooth models produced from laser-/CT-scanning lower toothrows and a recently developed measure of morphological complexity, orientation patch count (OPC). Results show significantly more increases in dental complexity than decreases across Multituberculata, suggesting selection for higher complexity outweighed developmental constraints. However, within the only clade to acquire sufficient dental complexity to become predominantly herbivorous (containing Taeniolabidoidea, Djadochtatherioidea, and other groups), equal decreases and increases in complexity occurred. It appears that once selection pressures for further complexity increases were relaxed, reassertion of developmental constraints balanced selection. Results from this fossil clade can be used to test developmental results and predictions regarding rates and direction of change of morphological complexity and offer hope for bridging the gap between micro- and macro-evolutionary studies.

Technical Session I (Wednesday, November 5, 2014, 11:15 AM)

THE ECOMORPHOLOGY OF NEW ZEALAND KEKENODONTIDS AND IMPLICATIONS FOR NICHE PARTITIONING WITH EARLY NEOCETI

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Late Oligocene kekenodontid cetaceans from New Zealand represent a clade of late-surviving Archaeoceti. Previously, archaeocetes were thought to have become extinct around the Eocene/Oligocene boundary, concurrent with the appearance of the Neoceti (Odontoceti and Mysticeti). The kekenodontid source horizon (the Kokoamu Greensand, ~28–26 Ma) has produced archaic mysticetes (baleen whales) and odontocetes (toothed whales and dolphins). The coexistence of late-surviving archaeocetes with crown-group cetaceans raises questions on niche partitioning; how did structurally archaic kekenodontids cohabit with odontocetes and mysticetes that employed more specialized feeding strategies (echolocation and filter-feeding, respectively)? Some characteristics of the kekenodontid skull and dentition are sufficiently like those of smaller basilosaurids (e.g., *Dorudon*, *Zyghoriza*) to suggest macrophagous raptorial predation, as inferred for basilosaurids. Additionally, a multivariate principal component analysis of cranial and mandibular measurements from extinct and extant cetaceans with varying feeding methods grouped kekenodontids with basilosaurids. However, details of kekenodontid skull and dental morphology suggest differences from basilosaurid raptorial predation. The relatively flattened skull of kekenodontids has a low-lying and shallow supraoccipital, with a poorly developed sagittal crest that suggest a different lever action and muscle power compared to basilosaurids. Furthermore, the slender rostrum and gracile mandible indicate a possible forceps-like action to capture prey. The posteriormost teeth in kekenodontids lie anterior to the orbit, rather than on a maxillary tubercle ventral to the orbit, implying less-powerful molar occlusion. Large diastemata between the posterior cheek teeth are similar to those in some stem odontocetes and toothed mysticetes. The resulting alternation of upper and lower teeth in occlusion possibly formed a sieve suited to consume multiple smaller prey items rather than single, larger prey. Micro-wear analysis of the anterior and posterior dentition should elucidate feeding habits. The survival of archaeocetes into the late Oligocene could reflect a shift in predation on organisms from lower trophic levels, while still using a similar method of raptorial feeding shared with basilosaurids.

Poster Session IV (Saturday, November 8, 2014, 4:15 - 6:15 PM)

NEW RODENTS OF THE FAMILY ANOMALURIDAE (MAMMLIA, RODENTIA) FROM THE PALEOGENE OF CENTRAL LIBYA

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Anomaluroid rodents are represented by three living genera that are endemic to western and central equatorial Africa. The Paleogene fossil record of this clade is sparse. The oldest African anomaluroids acknowledged so far come from the late middle Eocene of Bir El Ater in Algeria (*Nementchamys*) and the earliest late Eocene Birket Qarun Locality 2 in the Fayum Depression of Egypt (*Kabirmys* and *Shazurus*). Anomaluroids have also been reported from the Oligocene of Oman but these fossils have not yet been published. Younger anomaluroids are known from Miocene localities in East Africa. The

only known occurrence of an anomaluroid outside of Afro-Arabia is the late middle Eocene *Pondaungimys* from Myanmar.

Paleontological expeditions conducted in later Paleogene deposits exposed in the Sirt Basin of central Libya have yielded two new anomaluroid taxa, which are the first members of this clade to be described from Libya. The new taxon from the late middle Eocene Dur At-Talah escarpment constitutes one of the oldest representatives of this clade known from Africa. It appears most similar in dental morphology to the roughly contemporaneous taxa *Pondaungimys* and *Nementchamys*. It also shares many dental characters with *Kabirmys*, although the latter genus is more derived.

A second new anomaluroid taxon has been recovered from the early Oligocene Libyan site of Zallah 7. Diagnostic jaws and teeth of anomaluroids have never been reported from the well-sampled early Oligocene faunas of Fayum, where they are thought to have gone extinct near the end of the Eocene as a response to the cooler, drier climate of the early Oligocene. The discovery of anomaluroids in the Zallah 7 fauna shows that anomaluroids persisted across the Eocene–Oligocene boundary in Libya, indicating either that the Fayum record remains incompletely sampled or that marked regional provincialism characterized faunas of this age across North Africa.

Anomaluroid rodents are among the few mammal clades known from both Southeast Asia and North Africa during the later Paleogene. The new taxa from Libya yield a fuller picture of this clade's biogeographic history and phylogenetic relationships, while highlighting their usefulness in biostratigraphic correlation and paleoenvironmental reconstruction. Funding provided by NSF BCS-1441585

Technical Session I (Wednesday, November 5, 2014, 9:30 AM)

LARGE SCALE MICRO-CT BASED RECONSTRUCTIONS OF THE INNER EARS OF LIVING AND FOSSIL RUMINANTS GIVE NEW INSIGHTS INTO PECORA PHYLOGENY

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Modern pecoran ruminants find their origins in the diversified Late Oligocene-Early Miocene hornless taxa. Most of the latter look so primitive and convergent that they never really could be confidently classified, even as stem taxa of the living groups. This lack of agreement has led to problems in understanding the relative phylogenetic positions of the extant families. A still-remaining major issue is the unresolved affinity of the musk-deer family, Moschidae. While morphological data tend to favour close ties with cervids, genomic data rather plead for *Moschus* to be closely related to bovids. The mammalian petrosal bone is known to yield relevant characters for both phylogenetic and functional purposes, but the inner ear embedded within it remains poorly investigated in studies dealing with the evolutionary history of Ruminantia. The inner ear is the organ of hearing and balance. Besides these ecological functions, this structure has been recently shown to bear significant morphological information for phylogeny. The inner ear is virtually unknown in living and fossil ruminants because of its difficult accessibility. Recent advances in non-destructive high-resolution x-ray computer tomography have rendered this organ more accessible. Here, we reconstruct the inner ear of all 21 living ruminant families and tribes together with that of many fossil taxa either attributed to stem groups of the living families or sampled within the late Oligocene-early Miocene pecoran radiation. We show that non-pecoran Tragulina have a different inner ear than that of Pecora in having a dorsally branched posterior limb of the lateral semi-circular canal. We trace back the morphology of the moschid inner ear down to the Middle Miocene crown moschid *Micromeryx*. This is particularly relevant to the debate on moschid affinities. Fossil stem and crown deers and bovids like *Dicrocerus*, *Heteroprox*, or *Eotragus* help us understand the evolution of the structure in Pecora. First, morphological observations do not clearly support a relationship of *Palaeomeryx* with Giraffidae. The stem Pecora *Prodremotherium*, *Dremotherium*, and *Amphitragulus* share a junction of the lateral and posterior semi-circular canals. It is distinct from the basal condition of a secondary common crus seen in early artiodactyls. This feature interestingly also occurs in the living deers Cervini and Muntiacini. This study is the first large-scale investigation of the ruminant inner ear including all the living taxa at the tribe to family level and a large set of fossil taxa.

Technical Session VI (Thursday, November 6, 2014, 11:00 AM)

***LIMNOPITHECUS EVANSI* IS NOT *LOMORUPITHECUS HARRISONI*: IMPLICATIONS FOR ENDEMISM IN THE FOSSIL CATARRHINE COMMUNITIES OF EAST AFRICA**

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Multiple early Miocene fossil localities in East Africa richly document the evolution of stem catarrhine primates and the early divergence of cercopithecoid and hominoid clades. *Limnopithecus* is widespread throughout early Miocene sites in East Africa, but it is anatomically poorly known. Two species have been described—*L. legetet* (type species) and *L. evansi*. It has recently been suggested that *L. evansi* be transferred to *Lomorupithecus*, another stem catarrhine known only from a worn palate and a juvenile mandible discovered at Napak, Uganda (~20 Ma). Morphological comparisons of these taxa have been hampered by the limited upper dentition of *L. evansi* available to compare with the type specimen of *Lomorupithecus.*

Here, we describe two maxillae of *Limnopithecus evansi* (KNM SO-22259 and KNM SO-22736) discovered in the 1990s at the type locality of Songhor in Western Kenya (~19.5 Ma). Together, these specimens preserve both the anterior and posterior dentition from I2 to M3. The teeth are well-preserved and only lightly worn, adding greatly to our knowledge of the dental morphology of *L. evansi* and permitting more detailed comparisons with *Lomorupithecus*. We find that *Lomorupithecus* can be distinguished from *L. evansi* by several features of the upper premolars including: a reduced buccal cingulum, a less voluminous protocone, and most importantly the overall proportions of the teeth, which are buccolingually elongated. Furthermore, the genus *Limnopithecus* appears to be united by a shared I2 morphology that is distinct from all other early Miocene catarrhine taxa.

We conclude that *L. evansi* and *Lomorupithecus* do indeed represent separate taxa. This further supports the distinctiveness of the fossil catarrhine communities at Napak and Songhor, despite their apparent contemporaneity. In general, the distribution of stem catarrhines, cercopithecoids, and hominoids at localities throughout East Africa during the early Miocene suggests endemism, as many taxa are restricted to one or a handful of localities. This pattern is likely rooted in habitat differences between localities, and may further indicate that fossil localities are geographically isolated and not connected by blocks of suitable primate habitat. This work is a contribution to the REACHE Project, and is supported by the National Science Foundation (BCS #1241807). Additional support came from the Fulbright Scholar Research Grant Program, Leakey Foundation, Boise Fund, Kenya Museum Society, and Bill Bishop Trust.

Poster Session III (Friday, November 7, 2014, 4:15 - 6:15 PM)

PLEISTOCENE TROPHIC SYSTEMS IN THE PAMPEAN REGION (BUENOS AIRES PROVINCE, ARGENTINA): INSIGHTS FROM C AND O STABLE ISOTOPES.

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The Pleistocene of South America presents a unique fauna of mammals composed of endemic taxa as well as species that invaded the continent from North America since the Pliocene. There have been multiple studies on the palaeoecology of these mammal faunas, but the position of carnivorous mammals within the ecosystems and their position within the food webs is still not fully understood. Here we measured the carbon and oxygen isotopic signatures in tooth enamel of carnivores as well as their possible prey species. The rich fossil assemblages of the Pampean region (Buenos Aires Province, Argentina) have yielded specimens of early Pleistocene (Ensenadan) and Late Pleistocene (Lujanan) age that allow a comparison of ecosystems in the region through time. To give a more comprehensive view of the food webs and ecosystems, we try to reconstruct the habitat and diet of the animals as well as the broader climatic conditions. We found that some predatory taxa seem to prefer some specific environments, like *Smilodon* who was more restrained to prey from wet areas with pure C3 environments such as early Pleistocene equids or toxodontids. Large canids, like *Theriodictis* on the other hand, seemed to prefer prey like camelids from mixed C3-C4 environments that were more arid. Other herbivorous taxa show a spread in different environments such as Late Pleistocene toxodontids and proboscids. The short faced-bear *Arctotherium* presents isotopic values similar to those of *Smilodon*, at least during the early Pleistocene, therefore suggesting dietary competition between both taxa.

Technical Session IV (Wednesday, November 5, 2014, 3:00 PM)

EXAMINING THE DEVELOPMENTAL ORIGINS OF EVOLUTIONARY REVERSAL IN THE MOLAR TEETH OF MACROPODOIDS (DIPROTODONTIA: MARSUPIALIA)

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The loss and re-emergence of traits is an unusual pattern of evolutionary change. Mammalian dentitions can offer excellent insights into how trait loss and reversal occur because we can integrate macroevolutionary insights from a well-sampled fossil record with information about dietary ecology and tooth development. Macropodoids (kangaroos, wallabies, and rat-kangaroos) are interesting in this regard because previous work suggests instances of dental trait reversal. The lower teeth of basal fungivorous macropodoids, such as potoroos and musky rat-kangaroos, possess a distinctive U-shaped posterolingual depression (PD) which helps crush food against the metaconule (= placental hypocone). The PD is subsequently lost in more derived Miocene macropodids, before the origin of lagostrophine, sthenurine and macropodine kangaroos. However some derived macropodine kangaroos in the genus *Macropus* (e.g., *M. robustus, M. pearsoni*) and sthenurines (giant extinct short-faced kangaroos) in the genus *Procoptodon* (*P. goliah, P. rapha*) possess a V-shaped PD on their lower molars reminiscent of that in basal macropodoids. We examined if PD-like features in derived macropodids were developmentally and morphologically homologous to that of basal macropodoids and how tooth development might facilitate PD reversal. MicroCT scans of 17 fossil and modern macropodoid species reveal that the PD in basal macropodoids and PD-like features in *Macropus* and *Procoptodon* have a similar enamel-dentine junction morphology reflecting establishment early in tooth morphogenesis. Combined with similar spatial and topographic relationships to major occlusal features, this suggests they are developmentally and morphologically homologous and supports two instances of evolutionary reversal. Using dental measurements from 34 macropodoid species we test an inhibitory cascade model of tooth development and find that species which re-evolve the PD have smaller than predicted posterior molars suggesting early arrest of posterior molar development. In *Procoptodon* and early Pleistocene *Macropus* sp., lingual offset of the PD relative to the hypoconid and emergence of a neomorphic dentine protuberance at the posthypocristid-hypolophid crest junction suggest changes in spatial patterning accompanied heterochronic shifts. We propose that reversal occurs primarily because early arrest of molar development prevents complete integration of crests bounding the PD into the posterior molar margin leading to retention of earlier stage architecture in mature teeth.

Poster Session I (Wednesday, November 5, 2014, 4:15 - 6:15 PM)

FAUNAL ASSESSMENT AND PALEOECOLOGY OF THE ELIZABETHTOWN LOCALITY: A LATE CRETACEOUS (CAMPANIAN) MICROVERTEBRATE SITE IN SOUTHEASTERN NORTH CAROLINA.

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