near contemporaneous deposits suggests that *C. carcharias* and *C. hubbelli* may have been sister species rather than chronospecies as discussed in previous literature. This material is amongst the earliest confirmed records of *C. carcharias* known worldwide.

Poster Session I (Wednesday, October 30, 2013, 4:15 - 6:15 PM)

NEW FOSSIL LUNGFISHES (DIPNOI, LEPIDOSIRENIDAE) FROM THE PALEOGENE OF NORTHERN SOUTH AMERICA AND NEW METHODS FOR TOOTHPLATE IDENTIFICATION

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South American lungfish (Lepidosirenidae) are known from a single extant species, *Lepidosiren paradoxa*, that lives in swamps and slow-moving waters primarily in subtropical climates of the Amazon, Paraguay, and lower Paraná River basins. While the fossil record of lepidosirenids documents a more widespread past distribution in Africa and South America, their history in the New World Tropics is largely unknown. Here we report new lungfish fossils from the Paleocene Cerrejón and Eocene Bogotá Formations in Colombia. Two relatively large (maximum jaw length: 73 mm) lungfish species (a lepidosirenid and a ceratodontid) were recovered from the middle Paleocene Cerrejón Formation of northeastern Colombia from the same localities that have yielded a diversity of reptiles including pleurodire turtles, dyrosaurid crocodyliforms, and the giant snake *Titanoboa*. The depositional environment of the Cerrejón Formation from where the fossils were recovered has been reconstructed as a freshwater portion of a deltaic coastal plain. Three additional lepidosirenid fossils of much smaller size (maximum jaw length: 22 mm) have been recovered from two levels in the early Eocene fluvial deposits of the Bogotá Formation in central Colombia. The shift from the Cerrejón to the Bogotá formations represents a transitional facies change from a low-energy, coastal plain to a higher-energy fluvial system, higher up within the drainage network. A younger Miocene lungfish discovered in the Acre state of Brazil, *Lepidosiren megalos*, is slightly larger than the Cerrejón forms (jaw length: 76 mm), when this area was a similar, low-energy freshwater environment.

The Paleogene fossils from Colombia have a snout shape (length: width ratio of the prearticular = 1.0-1.5) that is intermediate between that of extant *Lepidosiren* (> 1.5) and the extant African lungfish, *Protopterus* (< 1.0). In contrast, Miocene *L. megalos* has a snout shape (ratio of 1.47) closest to that of extant *Lepidosiren*. Based on this and other characters related to the angle at which the tooth ridges diverge, we have identified two new genera including three or four new species of fossil lungfishes from Colombia. Discovery of new fossils will help test correlation of body size with the evolution of Amazonia and tooth ridge evolution within Lepidosirenidae.

Poster Session II (Thursday, October 31, 2013, 4:15 - 6:15 PM)

EVOLUTION OF THE PEDAL FUNCTION IN NON-AVIAN THEROPODS

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Most theropods have four pedal digits, and their grasping function is relevant to arboreality and/or hunting ability. Although an opposable digit I (hallux) in birds clearly indicates their grasping ability, functional diversity of the pes in non-avian theropods possessing a non-reversed hallux has not been fully explored.

To clarify pedal functions in non-avian theropods, principal component analyses were conducted based on four datasets based on linear measurements on all non-ungual pedal phalanges of extant birds and several non-avian theropods.

In one of these analyses, functional categories observed in extant birds were successfully differentiated with plots of non-avian theropods lying close to plots of ground foraging birds.

Additionally, detailed morphological observations suggest that the axis of movement of the hallucal metatarso-phalangeal joint in non-avian theropods was more restricted to vertical motion than in extant ground-foraging birds. This might indicate the mechanical function of hallux, such as prey holding. In three specimens of *Velociraptor* (Dromaeosauridae), the attachment site of metatarsal (MT) I on MT II varied from the medial to the plantar sides, with the distal articular facet of MT I and associated phalanges correspondingly varying from lateral and posterior directions. A similar variation in the articulation of MT I was observed in several troodontid specimens. Moreover, the proximal articular facet of MT I in both dromaeosaurid and troodontid specimens was convex as in extant birds, rather than concave as in more basal non-avian theropods. These characters indicates that the mobility of the intermetatarsal joint between MT I and II was increased so that the range of hallucal movement was extended in Paraves, presumably leading to acquisition of the perching function in basal birds.

In conclusion, although non-ungual pedal phalanges of non-avian theropods in general show adaptation for ground foraging, the hallux of derived non-avian theropods shows development of the primitive grasping function, which would have presumably been exalted to subsequent acquisition of the arboreality in more derived theropods.

Symposium 2 (Thursday, October 31, 2013, 3:30 PM)

INSIGHTS FROM DENTAL MICROWEAR TEXTURE ANALYSIS INTO THE SURVIVAL OF COUGARS (*PUMA CONCOLOR*) THROUGH THE LATE PLEISTOCENE EXTINCTION

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Cougars (*Puma concolor*) are one of only two large cats in North America to have survived the Late Pleistocene Extinction (LPE). Currently, cougars maintain the largest latitudinal range of any extant terrestrial mammal in the Western Hemisphere, yet the keys to their relative success remain unknown. Here we compare dental microwear textures of cougars (n=12) and sympatric felids, *Smilodon fatalis* (n=15) and *Panthera atrox* (n=15), from the La Brea tar pits to clarify potential dietary factors that led to the cougar's survival. We further assess if the dental textures of their teeth have changed in response to different prey items between Pleistocene cougars and those residing in southern California today (n=17). Using dental microwear texture analysis (DMTA), which quantifies surface features in 3-D, we find that, consistent with modern cougars, La Brea cougars showed no significant differences in any DMTA attribute when compared to modern lions, suggesting moderate durophagy. However, Pleistocene cougars differ from their extant counterparts in southern California by having higher textural fill volume (*Tfv*, which correlates to abrasive particle size; p=0.034). In comparison to sympatric felids, Pleistocene cougars from La Brea have significantly greater *Asfc* and *Tfv* than *P. atrox* (p=0.011 and p=0.002, respectively), but do not differ significantly from *S. fatalis*. The lower complexity in *P. atrox* suggests that it might have been feeding on only the softest parts of prey item (e.g. viscera and/or muscle from megaherbivores that were also victims of the LPE), in contrast to cougars who may have eaten whole smaller, and potentially more abundant, prey. As there are only significant differences in *Tfv* between modern and Pleistocene cougars from southern California, their diets were likely similar through time and may have been a key to their survival through the LPE. However, greater *Tfv* values during the Pleistocene, suggests that La Brea cougars may have consumed slightly harder objects and/or more fully consumed prey than today, perhaps due to increased competition with larger carnivores. Ultimately the generalist diet of cougars may have been key to their survival through the LPE. Further, DMTA here sheds light on the survival potential of large cats through time, which has important implications for conservation of large carnivores in the face of habitat destruction and changing climates.

Poster Session IV (Saturday, November 2, 2013, 4:15 - 6:15 PM)

RECONSTRUCTING QUATERNARY PALEOENVIRONMENTS IN THE GREAT PLAINS USING GEOGRAPHIC RANGES OF EXTANT SPECIES

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Geographic distributions of extant terrestrial mammals are determined in part by the climatic conditions tolerated by constituent populations, which is a measure of the ecological niche of the species. Assuming niche conservatism, past populations of a species should have had the same climate tolerances as extant populations, thus past biogeographic distributions for extant species might be used to estimate paleoclimate quantitatively. The Quaternary fossil record of small mammals in the Great Plains is a good test case for this approach as many extant species have multiple occurrences over the last million years. We have developed a GIS based method that uses modern species ranges and environmental parameters that relate quantitatively to extant species distributions in North America (e.g., mean annual temperature or MAT and mean annual precipitation or MAP). Geographic ranges for 92 extant species of rodents, lagomorphs, and soricomorphs were used to determine climatic conditions where species ranges overlap. Forty-two fossil collections in the Great Plains contain at least three of the 56 extant species in the region with fossil occurrences, potentially allowing us to constrain paleoclimate for those collections. We assessed reliability of this method by varying the number of extant species for a given location used to determine range overlap and the distribution of climate variables in the area of overlap, then compared estimated and known values. For locations spanning the region, we rarefied complete extant species lists to sample sizes of 20, 15, 10, 5, and 3 species and at each sample size estimated climate variables from range overlaps for 100 randomly sampled replicates, yielding 500 total replicates at each location. Accuracy of climate estimates increased with sample size up to 10 species, but more than 10 species did not improve accuracy substantially. On average, using 10 species underestimated modern MAT by 0.3°C and overestimated MAP by 142 mm. Fossil localities were binned into four time intervals: 1.0-0.75 Ma, 0.55-0.4 Ma, 0.3-0.2 Ma, and <0.068 Ma. Based on modern tolerances of co-occurring extant species, MAT increased from 9.5±3.1°C to 10±4.7°, cooled to 7.9±5.3°, and finally increased to 13.4±5.3°C, which is close to the MAT in western Kansas today. Estimated MAP increased from 506±122 mm to 703±251 mm, then decreased to 577±233 mm, and then increased to 735±383 mm, which is similar to eastern Kansas today. This method shows promise and fossil collections with at least 10 species should yield reliable climate estimates.

Technical Session V (Wednesday, October 30, 2013, 2:00 PM)

CRANIAL OSTEOLOGY, BODY SIZE, SYSTEMATICS, AND ECOLOGY OF THE GIANT PALEOCENE SNAKE *TITANOBOA CERREJONENSIS*

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Titanoboa cerrejonensis from the Cerrejón Formation (middle to late Paleocene; 58-60 My) of Colombia, is the largest known snake. The taxon was originally diagnosed, assigned to the clade Boinae, and estimated to be approximately 12.8 m (±2.18 m) in total body length on the basis of precloacal vertebral morphology and size, but the absence of cranial remains prohibited a more precise size estimate and robust phylogenetic hypothesis. Recent fieldwork in the type locality has resulted in the recovery of several new specimens of *Titanoboa* including parts of the cranium and mandible (maxillae, palatine, pterygoid, quadrate, dentary, and compound elements) associated with partial

axial skeletons. We estimate skull length from cranial elements to be 40 cm, corresponding to a total body length of 14.3 m (±1.28 m) based on the scaling relationship of head length to body length in the extant boine *Eunectes*. Phylogenetic analyses of *Titanoboa* and extant macrostomatan snakes using cranial and postcranial osteology, and including analyses incorporating a molecular scaffold for extant taxa, supports boine affinities of *Titanoboa*, based on the extreme reduction of the palatine choanal and posteromedial processes as well as vertebral anatomy. Within Boinae, *Titanoboa* shares a close relationship with Pacific Island-Madagascan taxa. These results are the first historical evidence linking Neotropical and Old World boines, and constrain divergence timing of the clades to no younger than 58 My. Cranial elements of *Titanoboa* possess unique features relative to other boids, including high palatal and marginal tooth position counts, low-angled quadrate orientation, and reduced palatine-pterygoid and pterygoid-quadrate articulations. These characters, combined with weakly ankylosed teeth in *Titanoboa*, are characteristic of piscivorous feeding ecology in extant caenophidian snakes. Preservation in the large-scale fluvial depositional environments of the Cerrejón Formation, combined with the recovery of associated fossils of large dipnoan and osteoglossomorph fishes, also suggests a dominantly piscivorous feeding ecology for *Titanoboa*, which is unique among living and fossil boids.

Poster Session II (Thursday, October 31, 2013, 4:15 - 6:15 PM)

EVALUATING DEFORMATION IN *SPHEROOLITHUS* DINOSAUR EGGS FROM ZHEJIANG, CHINA

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A lack of stratigraphic context for dinosaur eggs inhibits understanding of dinosaur reproductive biology and the taphonomic processes of egg preservation. Past taphonomic work suggests two features, compression ridges (sharp edge of broken eggshell around the egg circumference) and deformation asymmetry (proportion of crushed to rounded sides of the egg), as geopetal structures. We examined these features across a large sample of both isolated *Spheroolithus* eggs and *Spheroolithus* egg clusters housed in the Zhejiang Museum of Natural History from the Cretaceous of Zhejiang, China to test their utility. On 103 isolated eggs, we determined asymmetry ratios by dividing the crushed side egg height by the rounded side height. The strike and dip of compression ridges on eggs within egg clusters were measured for comparative use across egg clusters. An average asymmetry ratio of 0.71 was measured for the isolated eggs. Additional observations of in situ eggs demonstrate the stratigraphic-down side as more rounded and less fractured, the stratigraphic-up side as flatter with heavier fracturing, and compression ridges as parallel to original bedding plane. We propose fractures associated with the burial process on the upper side of the egg allowed sediment to partially fill the egg, subsequently supporting the bottom portion before the top of the egg collapsed. Examining compression ridges and deformation asymmetry within 16 egg clusters allowed differentiation of biotic versus taphonomically altered arrangements. Three common cluster arrangements were observed: planar (minimal egg overlap), offset (extreme overlap), and agglomerate (randomly arranged, closely packed). Qualitative observations of fracture levels, degree of deformation, and analysis of egg strike and dip across egg clusters reveals planar and offset arrangements as partial clutches, and agglomerate arrangements as the result of intense post burial displacement.

Poster Session II (Thursday, October 31, 2013, 4:15 - 6:15 PM)

THE POWER OF TOOTH MORPHOLOGY IN THE INTERPRETATION OF CERVID EVOLUTION (RUMINANTIA, ARTIODACTYLA, MAMMALIA)

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Tooth morphology has been a strong and well-tried tool for identification, taxonomic classification and dietary indication in palaeontology. However, it has not been used for a comprehensive classification of extant cervids so far. Systematics in fossil cervids is primarily based on antler morphology and other cranial or postcranial features, whereas the same questions in extant cervids are primarily approached by analysing molecular data (DNA sequences).

In this study, a detailed comparative analysis of the occlusal surface of the upper and lower postcanine dentition of almost all extant and about 30 fossil species of cervids has been compiled for the first time. It allows for the identification of indicative characters for each genus, which can be used in approaches dealing with evolutionary history of cervids (e.g. phylogeny, palaeobiogeography, palaeoecology). The compiled overview of the diversity in tooth morphology ranging from the Miocene until today documents trends in character evolution for Cervidae in general and lower hierarchical taxa specifically. For example, the progressive molarisation of the p4 can be detected as a trend throughout the geological time scale, where all Miocene cervids show an unmolarised condition; development of the molarisation can already be observed in some Pliocene species. Among extant taxa, *Muntiacus*, for example, shows a rather unmolarised condition of the p4, whereas *Cervus* or *Dama* have strongly a molarised p4. A presumably even more specialised condition can be found in *Rangifer* and *Alces*, which transformed lingual and labial crown elements to diagonally oriented parallel crests on the p4. These results enable linking of fossil taxa with extant representatives and show the importance of tooth morphology in palaeontology and neontology to provide a more conclusive picture of cervid phylogeny and evolution.

Poster Session II (Thursday, October 31, 2013, 4:15 - 6:15 PM)

THE AETOSAUR (ARCHOSAURIA: SUCHIA) FAUNA OF THE UPPER TRIASSIC PEKIN FORMATION (NEWARK SUPERGROUP), DEEP RIVER BASIN, NORTH CAROLINA, USA, AND ITS IMPLICATIONS FOR THE PHYLOGENY AND BIOSTRATIGRAPHY OF AETOSAURS

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Aetosaur fossils, principally osteoderms, from the Upper Triassic Pekin Formation in the Deep River Basin of North Carolina represent at least three aetosaur genera: *Lucasuchus*, *Coahomasuchus*, and a new taxon based on an associated incomplete anterior carapace (North Carolina Museum of Natural Sciences specimen NCSM 21723). An important feature of the new taxon is an articulated fifth row of cervical osteoderms that almost encloses the neck, with prominent spines on both the dorsal and lateral osteoderms; a novel configuration among aetosaurs. Otherwise it preserves a mosaic of character states found in the desmatosuchine aetosaurs, while simultaneously preserving several more primitive character states, such as cervical osteoderms that are wider than long. A new specimen of *Coahomasuchus* (NCSM 23168) preserves more of the skull and dentition than does the holotype of *C. kahleorum*. Our reevaluation of other Pekin Formation specimens that various authors have assigned to *Desmatosuchus*, *Longosuchus*, or *Lucasuchus* confirms that some possess characteristics of *Lucasuchus*, whereas others are not generically determinate.

We updated existing phylogenetic hypotheses by incorporating changes dictated by recent taxonomic work on *Longosuchus* and *Lucasuchus* and updating character scorings based on NCSM 23168. These analyses, conducted using the software package TNT, resulted in a reshuffling of basal aetosaur relationships, including recovering the recently named taxon *Aetobarbakinoides* basal to *Revueltosaurus* and therefore outside of Aetosauria. We then added the new taxon represented by NCSM 21723 to the analyses, where it was consistently recovered as a basal desmatosuchine, but also collapsed typothoracines to a polytomy comprised of *Typothorax*, *Redondasuchus*, and Paratypothoracinae. This topology is conserved even when we removed *Aetobarbakinoides* from the analysis because it is necessarily ambiguous in its relationships to the many aetosaurs known solely from osteoderms, which have not been coded in *Aetobarbakinoides*. Support for many of the recovered relationships are low, and the topologies remain labile.

Previous authors have consistently assigned the Pekin Formation a Carnian age, even after the advent of the "long Norian," based on a variety of constraints, principally palynomorphs and cycle stratigraphy. The shared presence of the aetosaurs *Lucasuchus* and *Coahomasuchus* in the Pekin Formation and the Colorado City Formation of West Texas implies a similar, Carnian age, for the latter unit, including the type Otischalkian land-vertebrate faunachron.

Technical Session III (Wednesday, October 30, 2013, 3:30 PM)

LUJIATUN PSITTACOSAURIDS: UNDERSTANDING INDIVIDUAL AND TAPHONOMIC VARIATION USING 3D GEOMETRIC MORPHOMETRICS

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Psittacosaurus is one of the most abundant and speciose genera in the Dinosauria, with fifteen named species. The genus is geographically and temporally widespread with large sample sizes of several of the nominal species allowing detailed analysis of intra- and interspecific variation. We present a reanalysis of three separate, coeval taxa within the Psittacosauridae, *P. lujiatunensis*, *P. major*, and *Hongshanosaurus houi* from the Lujiatun beds of the Yixian Formation, northeastern China, using three-dimensional geometric morphometrics on a sample set of thirty skulls in combination with a reevaluation of the proposed character states for each species. Using these complementary methods, we show that individual and taphonomic variation are the joint causes of a large range of variation among the skulls when they are plotted in a morphospace. Our results demonstrate that there is only one species of *Psittacosaurus* within the Lujiatun beds and that the three nominal species represent different taphomorphotypes of *P. lujiatunensis*. The wide range of geometric morphometric variation in a single species of *Psittacosaurus* implies that the range of variation found in other dinosaurian groups may also reflect taphonomic distortion rather than interspecific variation. As the morphospace is driven primarily by variation resulting from taphonomic distortion, this study demonstrates that the geometric morphometric approach must be used with great caution to delineate interspecific variation in *Psittacosaurus* and likely other dinosaur groups without a complementary evaluation of character states.

We have additionally added a number of other psittacosaur species as well as basal ceratopsian genera to the analysis in order to determine when interspecific and intergeneric variation dominates taphonomic variation. Certain retrodeformational techniques create a greater degree of bilateral symmetry of distorted objects, but fail to restore the original form. New retrodeformational methods are necessary before small-scale shape changes, such as those between species, can be delineated by 3D geometric morphometrics alone without character evaluation. This study presents the first application of 3D geometric morphometrics to a dinosaurian morphospace and the first attempt to quantify taphonomic variation in dinosaur skulls.