Technical Session XI (Friday, October 16, 2015, 8:00 AM)

ISOTOPIC ANALYSES OF MODERN AND FOSSIL HOMINOIDS

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Early Miocene Ugandan fossil localities at Moroto and Napak have yielded multiple catarrhine specimens including some of the oldest known hominoids. Isotopic analyses of the enamel of associated herbivore guilds at these sites have indicated water stressed conditions consistent with broken canopy or woodland habitats. To characterize the dietary niches of hominoids within this paleoecological interpretation, we analyzed the isotopic signature of seven fossil catarrhine teeth, including those attributed to *Morotopithecus bishopi*, *Proconsul major*, and cf. *Rangwapithecus*. To further contextualize these data, we also sampled and isotopically analysed 230 modern hominoid teeth from museum collections, including the M_1, M_2, and M_3 of individuals from variable populations of *Pan troglodytes, Pan paniscus, Gorilla gorilla, Gorilla berengei, Pongo pygmaeus, Pongo abelii, Hylobates lar,* and *Symphalangus syndactylus*. In addition, other relevant datasets of hominoid isotopic enamel values were compiled and used for comparative interpretation. There was significant isotopic variation among the molars sampled from individuals. In general, successive molars in modern taxa exhibit increasing isotopic enrichment (up to 4‰) over developmental time, emphasizing the need to control for tooth type in comparing enamel isotopic signatures from variable contexts and taxa. Relative to modern hominoids, $\delta^{13}C_{enamel}$ values of the fossil catarrhines (corrected for changes in atmospheric $\delta^{13}C$) were generally enriched with normalized values ranging from ca. -11 to -13‰, suggesting more water stressed C_3 dietary resources, consistent with the enamel values from some of the associated fossil herbivores. Of all the modern hominoids sampled, the range of values for the fossil catarrhines are closest to those of modern mountain gorillas. The values for the fossil catarrhines overlapped with some values for modern *Papio* populations published in the literature. Of the fossil hominoids, *Morotopithecus* had the most enriched carbon and oxygen values, potentially indicating that this taxon was foraging in more peripheral parts of the canopy where water stress, evapotranspiration, and irradiance were higher. Overall, the fossil isotopic data suggest catarrhine dietary niches with no clear modern analogs, and furthermore, that these Early Miocene taxa were foraging in more arid conditions, with more discontinuous canopy cover or more variable habitats than extant hominoids.

Symposium 3 (Saturday, October 17, 2015, 8:00 AM)

AUTOMATED ASSESSMENT AND IDENTIFICATION OF VERTEBRATE MORPHOLOGY FROM IMAGES AND 3D MODELS: MAKING THE JUMP FROM GEOMETRIC MORPHOMETRICS TO COMPUTER VISION, ARTIFICIAL INTELLIGENCE, AND DEEP LEARNING

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Geometric morphometrics (GM) was developed as an explicit attempt to use geometry as a means of unifying the disparate approaches employed by systematists to quantify and compare patterns of morphological variation. That the number of research reports involving some aspect of GM as a core research tool has undergone a monotonic increase year-on-year since the early 1990s stands as a testament to this toolkit's success. However, GM also suffers from various atavistic holdovers from previous stages of morphometric technique development, notably the need to decide a priori what aspect(s) of form are important for representing the structure of morphological variation, a labor-intensive approach to data collection, and a focus on the issue of ordination rather than identification. As a result, GM represents only a partial solution to the general problem of morphological analysis.

Recent developments in computer vision (CV), artificial intelligence (AI), and multifunction, non-linear approaches to neural network design (= deep learning, DL) have proven impressively successful in creating discrimination systems capable of accurately, objectively, and rapidly identifying large sets (100s to 1,000s) of objects from images and 3D models, even when trained using small sets of reference data. This technology represents step change from the rather limited success GM procedures have had in meeting the challenges of automated identification of organic morphologies to date and can be employed over an extremely wide range of object classes.

Simple datasets of vertebrate bones and teeth can be used to demonstrate the principles, advantages, disadvantages, and expected levels of performance for morphological characterization and identification under GM (landmarks); extended eigenshape, eigensurface, eigenimage (linear); eigenimage (non-linear); and DL protocols operating under both exploratory or confirmatory experimental designs and employing either supervised or unsupervised learning strategies. Results indicate that use of cascades of non-linear transformations delivers superior results in almost every case. Geometric morphometrics will remain a core tool of the quantitative morphologist for a variety of specialist applications (e.g., phylogenetic analysis, comparative method analysis). However, for those problems that require the rapid sorting of complex and highly variable morphologies into either a priori or a posteriori-defined group categories, use of CV, AI, and DL approaches will usually prove to be better choices.

Technical Sesion XV (Saturday, October 17, 2015, 8:00 AM)

NEW DATA BEARING ON THE EVOLUTION OF THE ENDOCRANIAL CAVITY OF NOTOUNGULATA (MAMMALIA), AND A PHYLOGENETIC ANALYSIS BASED ON CRANIODENTAL CHARACTERS

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The endocranium of notoungulates, a largely endemic group of extinct South American herbivorous mammals, has been studied through artificial and natural cranial endocasts, and more recently via digital endocasts. Although previous works provide descriptive anatomical and volume data on notoungulate endocasts that permit comparative studies on relative brain size, until now such data have not been analyzed within a phylogenetic framework, nor have anatomical differences been examined for their potential phylogenetic utility.

Our study combines data from previously published anatomical descriptions, natural endocasts, previously extracted plaster endocasts-all by other authors-and new data from high-resolution X-ray computed tomographic imaging to provide a broad comparative study of notoungulate cranial endocasts and to enhance understanding of the phylogenetic interrelationships of Notoungulata. A total of 22 characters of the endocranium, 11 of them new, were scored for 20 notoungulate taxa and five outgroups, based on studied specimens and the literature. These data were integrated into a larger character matrix including 99 characters from the dentition (3 of which are new), 72 from the exterior of the skull, 25 from the inner ear, and 41 from the postcranium for a total of 259 characters examined across 64 taxa (56 notoungulates and 8 outgroups). Parsimony analyses were conducted using TNT, applying new technology algorithms to search for the shortest trees and also conducting standard tree bisection and reconnection searches. All characters were considered unordered and no weighting algorithms were used. We obtained 984 most parsimonious trees measuring 922 steps of length each. Branch support was provided by a bootstrap analysis with 1000 replicates.

Using parsimony ancestral state reconstruction in Mesquite, endocranial characters were mapped onto the topology of the strict consensus tree to examine the evolution of the endocranium (brain) of notoungulates. Divergence of olfactory bulbs near their posterior junction with the rest of the cerebrum (just anterior to circular fissure) is identified as a synapomorphy for Toxodontia. Olfactory bulbs that are wider than deep is a synapomorphy for Toxodontidae. Cone-shaped parafloccular lobes of the cerebellum represent an equivocal synapomorphy for hegetotheriids in our analysis, a feature convergent in some interatheriids.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

SCALING AND FUNCTIONAL MORPHOLOGY OF STRIGIFORM HIND LIMBS

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The Strigiformes are an order of raptorial birds consisting exclusively of owls: the Tytonidae (barn owls) and the Strigidae (true owls), united by a suite of unique adaptations that aid a keen predatory lifestyle. Among these are robust hind limb elements modified for grip strength that contribute to predatory success, and may account for the ubiquitous presence of owls in diverse habitats and latitudes throughout the world. This study analyzed subfossil and modern owl specimens housed in collections at the Page Museum at the La Brea Tar Pits in Los Angeles and the Natural History Museum at Tring, Hertfordshire, respectively. Unbroken adult specimens of the three major hind limb elements: femur, tibiotarsus, and tarsometatarsus, were measured with digital calipers. Maximum length, and the maximum width and depth of the proximal end, distal end, and midshaft were obtained. In order to assess scaling patterns, the robusticity index (RI) of each element was determined (ratio of midshaft width to midshaft length) and plotted against body mass for each species, and then a simple linear regression analysis was performed. While there is no significant difference in hind limb element dimensions or robusticity between the two families of owls, results show allometric scaling of hind limb width and length with body mass. Furthermore, the tarsometatarsus RI scales allometrically to mass 0.28, whilst a weak to non-existent relationship is seen in the femur (mass 0.05) and the tibiotarsi (mass 0.07). We conclude that tarsometatarsi play a more substantial functional role in predation than the tibiotarsi and femora. Larger owls with relatively higher tarsometatarsus RIs can capture and dispatch larger prey items relative to their own body mass such as rabbits and fish, while smaller owls with lower tarsometatarsus RIs predate upon smaller, more manageable prey such as rodents and insects. Given the scaling relationship between tarsometatarsi robusticity and body mass, it may be possible to infer the body mass of prehistoric owl species by analyzing the tarsometatarsus, the element most commonly preserved in the fossil record of owls.

Technical Session XIX (Saturday, October 17, 2015, 1:45 PM)

REEVALUATION OF THE HOMOLOGY OF THE BONES OF THE TETRAPOD CRANIAL VAULT

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Bones of the cranial vault appear to be highly conserved among tetrapod vertebrates, and homologous bones are generally thought to share a common developmental origin. However, recent developmental studies reveal key differences in the embryonic origin of cranial vault bones considered to be homologous on other grounds (e.g., topology) between representatives of two amniote lineages, mammals and birds, thereby challenging this view. In mice, the frontal is derived from cranial neural crest (CNC) and the parietal is derived from mesoderm, placing the CNC–mesoderm boundary at the suture between these bones. In chickens, this boundary is located within the frontal. This difference violates the developmental criterion of homology and renders the assessment of the homology of the avian frontal via this criterion incongruent with that of mammals.

To elucidate this apparent conflict we fate-mapped CNC and mesoderm in the salamander *Ambystoma mexicanum* (axolotl) to reveal the contributions of these two embryonic cell populations to the cranial vault in a non-amniote tetrapod. The CNC–mesoderm boundary in axolotls is located between the frontal and parietal bones, as in mice but unlike chickens. If, however, the avian frontal is regarded as a fused frontal and parietal (i.e., frontoparietal) and the parietal is regarded as a postparietal, then the congruence of the avian cranial vault is improved topologically, as indicated by the inferred position of the frontal-parietal suture, and developmentally with those of salamanders and mammals. This alternative hypothesis is also supported phylogenetically where data from the fossil record reveal separate frontal, parietal, and postparietal bones