Paleocene and Eocene bird assemblage from the Southern North Sea Basin

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and clasts within a cave breccia matrix to interpret taphonomic characteristics and infer the complex taphonomic history of incorporated faunal assemblages. These data could strengthen our understanding of the ancient rainforest migrations and occupation by hominids and associated paleofauna.

Technical Session I (Wednesday, October 9, 2019, 9:15 AM)

ENDOCRANIAL MORPHOLOGY AND ENCEPHALIZATION IN THE PROTOCETID CETACEAN *GEORGIACETUS VOGTLENSIS*

SMITH, Kathlyn, Georgia Southern University, Statesboro, GA, United States of America; GEISLER, Jonathan, NYIT College of Osteopathic Medicine, Old Westbury, NY, United States of America; PATEL, Darshini, NYIT College of Osteopathic Medicine, Old Westbury, NY, United States of America

Endocranial morphology provides insight into the biology and behavior of extinct vertebrates. Previous studies have documented drastic changes to the endocranial region of cetaceans, including an increase in encephalization and a reduction or loss of the olfactory tract. Here we investigate this region in the protocetid archaeocete *Georgiacetus vogtlensis* (Mammalia: Cetacea) to provide insight into the evolution of archaeocetes.
A digital endocast of the *Georgiacetus* holotype (GSM 350) was created using computed tomography. The endocast does not preserve subtleties of its external surface, but its overall shape reflects the shape of adnexia, including a posterior rete mirabile. The presence of a rete mirabile is suggested by the fact that the posterior cranial fossa is much wider and dorsoventrally taller than the middle cranial fossa, whereas in extant mammals the cerebellum is either smaller or subequal to the cerebral hemispheres. There is no trace of a falx cerebri; instead, a comparable position is marked by a narrow and tall cast of the dorsal sagittal sinus. Posterior to this sinus is a triangular depression for a median tentorial projection, the only clear demarcation between the middle and posterior cranial fossae. Posterior to this depression the cast of the rete mirabile forms the highest point of the endocast, as in basilosaurids but unlike in *Indocetus* and *Remingtonocetus*. A cross section through the anterior of the endocast is trefoil in shape, with a median dorsal portion corresponding to the olfactory tract and bilateral ventral portions to neurovascular structures. This portion of the endocast is quite large and tubular, as in basilosaurids but unlike the narrow morphology seen in *Remingtonocetus*.
The encephalization quotient (EQ) of *Georgiacetus* was calculated using the equation EQ = brain mass/0.12*body mass$^{0.67}$, a brain mass of 451 g (endocranial volume less retial volume, converted to mass) and a body mass of 672 kg (calculated using a regression equation from a previous study that predicts body mass based on skeletal length for modern cetaceans). The resulting EQ of 0.47 is subject to some uncertainty, but is higher than reported for *Dalanistes*, slightly lower than reported for most basilosaurid archaeocetes, and substantially lower than reported for nearly all modern cetaceans. This supports previous studies that show increased encephalization, a common characteristic of modern cetaceans, did not evolve in archaeocetes.

Technical Session V (Wednesday, October 9, 2019, 3:45 PM)

PHYLOGENETIC RELATIONSHIPS OF SULIDAE (AVES: SULIFORMES) INFERRED FROM EXTERNAL MORPHOLOGICAL CHARACTERS AND CONGRUENCE BETWEEN MORPHOLOGICAL AND MOLECULAR DATASETS

SMITH, Nathan, Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America; WATKINS, Jalesa, Howard University, Washington, DC, United States of America; JAY, Judith, Howard University, Washington, DC, United States of America

Sulidae are a group of seabirds comprised of ten species of gannets and boobies. They were historically classified within the polyphyletic avian order Pelecaniformes, a group notable for long-standing conflicts between molecular and morphological estimates of relationships. Diverse phylogenetic datasets focused on sulid relationships exist for DNA, osteological, and behavioral characters. However, no external morphological (e.g., plumage traits) dataset exists, and no attempt has been made to analyze the varying levels of congruence of these disparate datasets. We present a new dataset of 24 external morphological characters collected for Sulidae and outgroups. The dataset was analyzed using maximum parsimony to infer evolutionary relationships within Sulidae. Our results exhibit some congruence with previous analyses (e.g., monophyly of Sulidae, *Morus*, and a *Sula neubouxii* + *Sula variegata* clade), but differ primarily in: 1) failing to recover *Sula* monophyly; and 2) the position of *Papasula*. The latter result confirms that independent forms of character data (nuclear genes, mitochondrial genes, osteology, external morphology) all differ in the placement of this enigmatic species. Trees inferred from osteological, behavioral, and external morphological datasets show variable congruence and conflict with the molecular topology, cautioning against simplistic arguments regarding "molecules vs. morphology" debates in phylogenetics. Additionally, statistical tests reveal that osteological, behavioral, and external morphological datasets all possess significant phylogenetic signal on the molecular tree, and also do not differ significantly from each other in measures of homoplasy or retained synapomorphy. These results lay the groundwork for more rigorous total evidence analyses of sulid phylogeny incorporating disparate data, and also suggest that the relationships of extinct sulids can be robustly resolved within such a framework. Future work requires a two-fold approach of rigorously assessing hypotheses of primary homology in avian morphological characters, and testing hypotheses of convergence using modern phylogenetic comparative methods.

Grant Information:
NSF OPP-1341475 (NDS); NSF DEB-0808250 (NDS)

Technical Session VI (Thursday, October 10, 2019, 11:00 AM)

WEEKLY-SCALE OXYGEN ISOTOPE MEASUREMENTS IN PRIMATE TEETH REVEAL ANCIENT ENVIRONMENTAL VARIATION

SMITH, Tanya M., Griffith University, Nathan, Australia; GREEN, Daniel R., Forsyth Institute, Cambridge, MA, United States of America; WILLIAMS, Ian S., The Australian National University, Canberra, Australia

Oxygen isotopes in tooth enamel vary with temperature, precipitation, and evaporation cycles during an organism's development, aiding reconstructions of past environments. Enamel is typically sampled by micro-drilling to recover oxygen inputs from food and water consumed during tooth formation. This method has poor spatial resolution, yielding samples that integrate long formation times of unknown chronological age, and therefore limiting the recovery of seasonal environmental patterns from teeth.
To address this dilemma we employ a Sensitive High Resolution Ion Microprobe (SHRIMP SI) to measure oxygen isotope compositions ($\delta^{18}O$) from tooth enamel on a spatial scale of 15 µm, which can be related to daily increments and birth lines to determine formation times and calendar ages. $\delta^{18}O$ values of sheep enamel measured by SHRIMP SI are nearly identical to those from silver phosphate microprecipitation, confirming the fidelity of this approach for enamel bioapatite oxygen recovery. Here we analyze teeth from wild orangutans (*Pongo* sp.) collected over a century ago, and two fossil orangutan teeth from Lida Ajer, Sumatra – the site that yielded the oldest insular Southeast Asian human remains; 63-73 ka. Molars were sectioned and sampled sequentially along the enamel-dentine junction on a spatial scale corresponding to a near-weekly timeframe using secondary-ion mass spectrometry. Standardized $\delta^{18}O$ values were related to temporal records of formation over 3-4 years per tooth.
Oxygen isotope values in wild-shot Bornean and Sumatran orangutan first molars ranged from 11.3 to 19.9 ‰, and 13.4 to 20.4 ‰, respectively. Concurrently forming left and right molars from the same fossil orangutan ranged from 15.4 to 20.1 ‰ and 15.1 to 19.9 ‰, supporting the biogenic fidelity of this paleoclimate record. All teeth showed isotopic variation on a circannual basis, particularly after the animals ceased feeding exclusively on mother's milk.
Enamel is the most chemically resilient tissue in the body, and the recovery of similar $\delta^{18}O$ values from these unburied and fossilized orangutan molars confirms the usefulness of teeth for probing ancient climates. We have demonstrated here and in other studies that isotope variation in fossilised mammalian tooth enamel formed over multiple years is substantial, even in equatorial regions. Future research on slow-growing primate teeth may help to establish conclusively whether environmental variation was a significant force in the evolution and dispersal of the human genus (*Homo*) and our own species 300,000 years ago.

Grant Information:
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Regular Poster Session II (Thursday, October 10, 2019, 4:15 - 6:15 PM)

PALEOCENE AND EARLY EOCENE BIRD ASSEMBLAGES FROM THE SOUTHERN NORTH SEA BASIN

SMITH, Thierry, Institut Royal des Science Naturelles de Belgique, Brussels, Belgium; MAYR, Gerald, Forschungsinstitut Senckenberg, Frankfurt am Main, Germany

Numerous bird bones from the Paleocene and early Eocene of the Belgian and Paris basins have been collected by amateur paleontologists. Four bones from the early-middle Selandian of Maret, Belgium are among the earliest

Cenozoic avian remains from Europe and include the oldest temporally well constrained records of the Gastornithidae, as well as tentative records of the paleognathous Lithornithidae and the Ralloidea. Another assemblage from the middle Thanetian of Templeuve, France contains multiple bones of the Lithornithidae as well as a record of the Pelagornithidae. Specimens from the latest Thanetian of Rivecourt-Petit Pâtis, France are tentatively assigned to the Ralloidea and Leptosomiformes. An assemblage of 54 bones from the middle Ypresian of Egem, Belgium represents at least 20 species in more than 11 higher-level taxa. Well-identifiable specimens are assigned to the Odontopterygiformes, Galliformes, Messelornithidae, Apodiformes, Halcyornithidae, Leptosomiformes, and Coraciiformes. Further specimens are tentatively referred to the phaethontiform Prophaethontidae and to the Accipitridae, Masillaraptoridae, and Alcediniformes.
These three-dimensionally preserved fossils provide new data on the osteology of taxa that are otherwise mainly known from compression fossils with crushed bones. They also further knowledge of the composition of early Paleogene avifaunas of the North Sea Basin. Paleocene avifaunas of Europe and North America appear to have had different compositions and only a few taxa, such as the paleognathous Lithornithidae, are known from both continents. This suggests that the very similar early Eocene avifaunas of Europe and North America are the result of early Cenozoic dispersal events. The well-represented small galliform species from Egem most closely resembles *Argillipes aurorum*, an ignored galliform species from the London Clay. The tentatively identified fossils of Accipitridae and Alcediniformes would represent the earliest fossil records of these clades. The birds from Egem include few seabirds (Odontopterygiformes, cf. Prophaethontidae) and is dominated by terrestrial species (Galliformes, Messelornithidae). Arboreal birds (Halcyornithidae, Leptosomiformes, cf. Alcediniformes, Coraciiformes) are less abundant and aerial insectivores (Apodiformes) very scarce, which either indicates a taphonomic bias in the composition of the avifauna or particular paleoenvironmental characteristics of the nearshore habitats in that area of the southern North Sea Basin.

Grant Information:
Funded by Belgian Science Policy Office (project BR/121/A3/PalEurAfrica).

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

SMALL CARNIVORE COPROLITES FROM THE LATE TRIASSIC OF SOUTHERN BRAZIL: PALEOBIOLOGICAL IMPLICATIONS

SOARES, Marina B., Museu Nacional - Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil; SCHULTZ, Cesar L., Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil; MARTINELLI, Agustín G., CONICET, Buenos Aires, Argentina; FONSECA, Pedro M., Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil; PAES NETO, Voltaire D., Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil

A remarkable fauna is recorded in early Norian beds (ca. 225.42±0.37Ma) from the municipality of Faxinal do Soturno, State of Rio Grande do Sul, Brazil. This is mainly composed by small-sized vertebrates (maximum body length around 200-250 mm), such as probainognathian cynodonts, rhynchocephalians, non-rhynchocephalian lepidosauromorphs and procolophonians. The only relatively large animal found there is the saurischian *Guaibasaurus* (ca. 2m). The fossils occur in massive sandy lenses interpreted as a fluvial/deltaic system. In this same level, more than 80 elliptical coprolites, resembling rodentian feces, were found. They exhibit a whitish color and range from 7 to 10mm long and 3 to 5mm in diameter. Eight isolated coprolites were analyzed chemically and by microscopy. The x-ray diffractometry indicated quartz, plagioclase, smectite and apatite with major pick, consistent with carnivore coprolitic materials. Thin section analyses showed a massive coprofabric bearing sand (quartz) grains and bone remains. Micro-CT images were obtained from a sandy block with seven "in situ" coprolites. Inside each one, a dense amount of millimetric bone elements was revealed compound about 40-70% of the total volume. All bones are disarticulated. Some are complete, but the most part fragmented. Few signs of chemical corrosion (pits) are present. Among the identifiable elements are indeterminate long bones, ribs, phalanx, and parts of neural arches of the rhynchocephalian *Clevosaurus brasiliensis.* Although it is difficult to assign these coprolites unequivocally to a specific producer, their measurements are in accordance with the sizes of the aforementioned small tetrapods. The evidences point out to a strict carnivore producer with some ability of chewing bone and with fast digestion, which refers to a more mammalian physiology than a reptilian one. The sand inside the coprolites is suggestive of soil ingestion during feeding to obtain nutrients, as commonly practiced by current fossorial animals, or just accidental ingestion. Therefore, we defend the probainognathian cynodonts may be the potential candidates. This is corroborated by their sectorial postcanine teeth with a more effective occlusion, enabling chewing movements, and features suggestive of fossoriality, like a robust humerus and hypertrophied rodent-like lower incisors (e.g., Irajatherium, Riograndia). This unprecedented Triassic record constitutes a rich ichnologic data source that contributes for a better understanding of the initial steps of the mammalian paleobiology.

Grant Information:
CNPq - 312387/2016-4 (MBS)

Technical Session XIII (Friday, October 11, 2019, 1:45 PM)

A SMALL DIAPSID FROM THE LOWER KEUPER OF GERMANY AND THE ORIGIN OF AQUATIC REPTILES

SOBRAL, Gabriela, Staatliches Museum für Naturkunde Stuttgart, Stuttgart, Germany; SCHOCH, Rainer, Staatliches Museum für Naturkunde Stuttgart, Stuttgart, Germany

The Middle Triassic was a time of major changes in terrestrial tetrapod faunas, but the fossil record of this interval is largely obscure. This is unfortunate, since many modern groups originated or diversified during this time. However, recent excavations in the upper Middle Triassic of Germany have revealed several new taxa, most of which are much smaller than those found in other tetrapod-bearing basins of similar age. Here, we report a new taxon from the Vellberg limestone quarry comprised of skull bones distinct from other diapsids from this locality. It is diagnosed by a long maxilla with a far posteriorly reaching tooth row; a long and stout ventral process of the postfrontal; exclusion of the postorbital from the lower temporal fenestra due to a contact between the anteroventral process of the squamosal and the dorsal process of the jugal; and a tall quadrate + quadratojugal complex. Some anatomical aspects of the new taxon are similar to stem diapsids such as *Elachistosuchus huenei* from similar deposits of Northern Germany and of uncertain phylogenetic affinity. A phylogenetic analysis retrieved both taxa in an "ichthyosauromorph" clade, included in an almost exclusively aquatic group. The new taxon, *Hupehsuchus*, and *Elachistosuchus* appear as successive sister-taxa to Ichthyopterygia. It is interesting to note that many of the autapomorphic characters of the new taxon pertain to elements related to the lower temporal fenestra. In particular, the contact between the jugal and squamosal is unusual, but is also found in sauropterygians, saurosphargids, *Hupehsuchus*, and *Wumengosaurus*, as well as in rhynchocephalians. Derived ichthyosaurs show the typical jugal-quadratojugal contact, but via an unusual dorsal contact between the two. The jugal–squamosal contact may thus represent a transitional state to the anatomy observed in later ichthyosaurs, reinforcing the interpretation of the 'ventral cheek embayment' of basal 'euryapsids' as a ventrally open lower temporal fenestra. Thus, the new taxon has implications for the origin of secondarily aquatic groups, and therefore also paleobiogeographic significance. The appearance of placodontians has been traced to central Europe, but ichthyopterygians are believed to have originated in the Eastern Tethys. The new taxon indicates that the earliest evolutionary history of these groups may have occurred in the Western Tethys, associated with the Germanic Basin. This new material emphasizes the importance of sampling small-bodied taxa in the understanding of reptile evolution.

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

UNUSUAL TOOTH REPLACEMENT IN A NEW CENOMANIAN IGUANODONTIAN FROM THE MUSSENTUCHIT MEMBER OF THE CEDAR MOUNTAIN FORMATION

SOKOLSKYI, Tymofii, Duke University, Durham, NC, United States of America; ZANNO, Lindsay, North Carolina Museum of Natural Sciences, Raleigh, NC, United States of America; KOSCH, Jens C., North Carolina Museum of Natural Sciences, Raleigh, NC, United States of America

A partial skeleton including both dentaries and multiple isolated teeth of an early diverging iguanodontian (NCSM 29373) was excavated from the Cenomanian-aged Mussentuchit Member of the Cedar Mountain Formation in Emery County, Utah during the 2014-2016 field seasons. Due to the presence of jaw sections with unerupted teeth, we were able to calculate tooth replacement rates of NCSM 29373 by counting incremental von Ebner lines – dentine growth lines homologous to the lines in extant amniote teeth that represent daily dentine deposition. To avoid damaging the intact dentary, we made thin sections of a complete isolated tooth and using light microscopy calculated the mean width of von Ebner lines across several increments where they were preserved – 17 µm (n=11, range = 13.4-23.2 µm). A reconstructed crown height of 6719 µm, yields an estimated tooth formation time of 395 days. Enamel thickness was determined to be greatest at the central ridge on the labial side of the tooth – 159 µm compared to 88 µm in between the ridges.