their anteroposterior length to mediolateral width, the manual phalangeal formula of 2-3-3-3-2, the femur about the same length as the tibia, shell-like ventral armors present, and pes approximately twice as long as manus. Additional significant features of Liaoningosaurus paradoxus include the plesiomorphic presence of premaxillary teeth and of the antorbital fenestra and the apomorphic presence of the elongated prezygapophyses and postzygapophyses of the posterior caudals interlocking the vertebrae to form a rigid tail club handle. Our phylogenetic analysis on a dataset comprising 59 taxa and 191 characters places Liaoningosaurus paradoxus as the most basal ankylosaur. We discuss the evolution of major ankylosaurid characteristics of the skull and tail within the new phylogenetic framework, and suggest that mosaic evolution characterizes the early ankylosaurs, and in particular, the tail became specialized phylogenetically earlier than the skull in ankylosaurid evolution.

Grant Information:
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Technical Session X (Friday, October 11, 2019, 8:00 AM)

EARLY OSTEICHTHYAN EVOLUTION: INSIGHTS FROM NEW DATA OF THE SILURIAN MEGAMASTAX

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Megamastax amblyodus from the Kuantu Formation (Late Ludlow, about 423 million years ago) of Yunnan, China, is by far the largest pre-Devonian vertebrate yet discovered, with an estimated length of about one meter. It was identified as a sarcopterygian because its external dermal bones are covered in cosmine with numerous embedded pores. However, reconstructing its phylogenetic position has been impeded by the limited data (two isolated mandible and one maxilla). During recent years, more specimens of Megamastax amblyodus, including an articulated one with part of trunk and nearly complete head and cheek bones, have been found from the type locality and horizon. After almost two years' mechanical preparation, the articulated specimen has been CT scanned to reveal details of the neurocranium, palatoquadrate, dermal skull roof and cheeks, and dentition. The braincase lacks an intracranial joint and has chondrichthyan-like enclosed aortic canals. The dermal cheek bones resemble those of primitive osteichthyans as such as Pterolophus and basal actinopterygians, but the skull roof pattern differs dramatically from known osteichthyans and instead resembles the 'maxillate' placoderms. Structures previously described as "benthal conoid teeth" are actually the attachment bases for tooth cushions like those in the modern jawed vertebrates or crown-group gnathostomes and instead resembles the 'maxillate' placoderms. The squamation is composed of very small and thin rhomboid scales, and lacks large median shell-like plates. The comb-like combination of elongated prezygapophyses and postzygapophyses of the posterior caudals interlocking the vertebrae to form a rigid tail club handle. Our phylogenetic analysis on a dataset comprising 59 taxa and 191 characters places Liaoningosaurus paradoxus as the most basal ankylosaur. We discuss the evolution of major ankylosaurid characteristics of the skull and tail within the new phylogenetic framework, and suggest that mosaic evolution characterizes the early ankylosaurs, and in particular, the tail became specialized phylogenetically earlier than the skull in ankylosaurid evolution.

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

PALEOENVIRONMENTAL ANALYSIS OF AN UNUSUAL FOSSIL LOCALITY FROM THE LATE MIOCENE IN NORTHERN FLORIDA

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‘Montbrook’ is an extremely fossiliferous late Miocene to early Pliocene deposit located on the Ocala Platform in Levy County, Florida. The site has been excavated by the Florida Museum of Natural History since its discovery in 2015, producing over 40,000 catalogued fossils. Taxa such as Teleoceros, Hexemurus, Rhynchotherium, and Borophagus hilli constrain the age of the deposit, making it the only late Hemphillian locality in Florida with a predominantly terrestrial fauna. However, the fossil assemblage is mixed, spanning from terrestrial vertebrates to freshwater and marine fossils. Our initial site formation analysis was conducted to reconstruct the paleoenvironmental narrative utilizing a multiprox approach. Paleomagnetic samples were analyzed to evaluate the biostratigraphic ages assigned to Montbrook. In order to place the site in a regional geologic context, three ~13-metar sediments cores were drilled and correlated with known local deposits. Chondrichthyan taxa such as Brachycarcharias and Carcarchoros chubatensis indicate reworked Eocene and early Miocene contributions, respectively. Given that Montbrook likely represents a fluvial environment extending through earlier strata, rare earth element (REE) analysis of in situ fossils is being conducted to determine if other marine fossils were reworked or contemporaneous with terrestrial and freshwater material. High diagenetic alteration and low intensity paleomagnetic results prevented our ability to constrain the age further. Sediment cores revealed the vertical boundary of underlying bedrock is Eocene age Avon Park and Ocala Limestone formations, as well as associated karstic features. Smear slides of the cores place Montbrook within the Hawthorn Group, although they constitute a unique environmental lithofacies not yet described. Montbrook is a complex marginal environment, representing fluvial to estuarine deposition, with intermittent marine tidal influence, offering some of the first direct insights into transitional terrestrial ecosystems from 5.3-5.0 Ma in the southeastern U.S.A.

Grant Information:
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Regular Poster Session I (Wednesday, October 9, 2019, 4:15 - 6:15 PM)

AN ASSOCIATED SPECIMEN OF THE LAMNIFORM SHARK CARCARCHORIDES ANGUSTRIDENS FROM VICTORIA, AUSTRALIA, AND EVIDENCE OF POST-MORTEM FAUNAL SUCCESION

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Isolated teeth dominate the Australian fossil record of Cenozoic sharks and rays (Chondrichthyes). Associated chondrichthyan remains preserve extremely rarely in the fossil record, due to the group’s weakly articulated and mostly cartilaginous skeletons. Until now, an undescended partial lamniform dentition from the lower Miocene Batesford Limestone comprised the only report of an associated shark fossil in the Australian Cenozoic. Many fossil taxa erected from isolated shark teeth worldwide are of dubious value, confounded by morphological differences due to tooth position, ontogenetic variation, and intraspecific variability. Associated specimens are also productive sources of biostratigraphic and taphonomic context, and can inform paleoecological interpretations of depositional environment.

We report on the discovery of a partial associated specimen of the lamniform shark *Carcharocles angustidens* (NMV P253894) in the upper Oligocene (25.23 Ma) Jan Juc Marl in Victoria, Australia. This third known example worldwide represents a notable expansion of the heretofore sparse and variable assemblage of associated chondrichthyan remains preserved from this rich fossiliferous coastal outcrop. The specimen, representing an individual of total length ≥7.7m, comprised 16 functional erupted and 17 incompletely developed unerupted teeth, including representative examples of anterior, intermediate, lateral and posterior files, and one associated fragmentary vertebra. This assemblage was further augmented by the discovery of 12 fossil hexanchid shark teeth (NMV P253894) associated with the *C. angustidens* remains. All are erupted and well-preserved, showing no evidence of digestion, but several display mechanical damage to tooth crowns.

We suggest this specimen preserves a shallow-water “shark-fall” faunal succession, with initial exploitation of the *C. angustidens* carcass by hexanchid sharks within days to months of its arrival at the sea floor. Fossilised invertebrate epifauna preserved on the vertebra surface indicate the subsequent development of invertebrate faunal communities, including sulphophlicic direct scavengers and suspension feeders exploiting hard substrates. Most such communities, fossil and modern, have been observed on whale-fall carcasses, but few whales globally reached or exceeded the size of large lamniform sharks from the Oligocene to late Miocene. This discovery illustrates the likely significance of shark-fall events in providing organic content to nutrient-poor seafloor environments during the mid-Cenozoic.

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

**CRANIOFACIAL ONTOGENY IN TYLOSAURUS PRORIGER**

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*Tylosaurus proriger* was a large mosasaur that lived in the Western Interior Seaway during the Late Cretaceous. Its fossils are found in the Niobrara Chalk of Western Kansas, but despite a multitude of specimens of varying maturity, the precise sequence of growth changes that occurred in its cranial skeleton is unclear. The goals of this project were to use quantitative cladistic analysis to (1) recover the growth series of *T. proriger*; (2) evaluate whether skull length is an appropriate proxy for relative maturity in this species; (3) test for sexual dimorphism; and (4) test the hypotheses that *T. kansasensis* represent juveniles of *Tylosaurus nepaeolicus* and that *T. proriger* is a paedomorph of *T. nepaeolicus*. Nine growth stages were identified: Stage 1: predental rostrum less than 5% total skull length (TSL), broadly defined quadrate infrastapedial process; Stage 2: predental rostrum longer than 5% TSL, acutely defined quadrate infrastapedial process; Stage 3: deep dentary, quadrate height 14-15% TSL; Stage 4: length between the first and sixth maxillary teeth greater than 25% TSL; Stage 5: length between the first and sixth dentary teeth less than or equal to 25% TSL; Stage 6: length between the first and sixth dentary teeth less than or equal to 25% dentary length; Stage 7: reversal to length between the first and sixth dentary teeth less than 25% TSL; Stage 8: TSL greater than 1 m; Stage 9: reversal to slender dentary. A Spearman rank-order correlation test found no correlation between TSL and growth stage ($r_{s譬}, 16 = 0.626, p = 0.053; size rank data are normally distributed, Shapiro-Wilk $p = 0.892$), suggesting that TSL is not a reliable proxy for maturity in *T. proriger*. The ontogram does not split into two groups of specimens, and so did not show evidence for sexual dimorphism. Finally, to test the hypotheses that *T. kansasensis* is an immature form of *T. nepaeolicus* and that *T. proriger* is a paedomorph of the latter, representative specimens of each were separately analyzed in the *T. proriger* matrix; the resulting topologies were consistent with the first hypothesis, but not the second.

**Technical Session XI (Friday, October 11, 2019, 8:15 AM)**

**TAPHONOMY OF VERTEBRATE FOSSILS FROM LANG TRANG CAVE: CHARACTERISTICS OF A PORCUPINE-GENERATED FAUNAL ASSEMBLAGE**

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The origin of Pleistocene cave-hosted vertebrate accumulations has been the subject of numerous studies. Bone-accumulating agencies include physical vectors (e.g., gravity and flash floods), anthropological vectors (hominin hunter-gatherers) and zoological vectors (e.g., hyaenas, leopards, porcupines). Pleistocene fossils in Lang Trang Cave (Ba Thuoc District, Thanh Hoa Province, Vietnam) are interpreted to be the result of porcupine bone collecting and gnawing. Although the literature describes numerous examples of porcupine-influenced cave assemblages, few of these illustrate evidence of porcupine activity and the diagnostic attributes of porcupine-modified assemblages have yet to be summarized.

Lang Trang Cave is characterized by an abundant (~25,000 specimens) and diverse assemblage of fossil mammal remains representing at least 25 mammalian genera. Postcranial elements, skulls and mandibles are rare (~1% of material) whereas isolated teeth are abundant (~99% of material). Most teeth exhibit clear evidence of porcupine modification in the form of gnawing trace fossil Machichnus and in the dominance of root-wedging on the teeth.

Porcupine-generated Machichnus are characterized by wide, approximately flat-bottomed gouges, commonly 1 or more internal striae oriented parallel to the lateral gouge margins. The gouges are consistent in width with *Hystrix brachyura* incisors collected from the cave. The internal striae are consistent with imperfections (pits, spurs and gouges) characteristic of the tips of the *H. brachyura* incisors.

Many of the teeth exhibit a phenomenon informally referred to herein as root-wedging. Root-wedged teeth retain a minor, pyramid-shaped wedge of dentin beneath the enamel crown. Short Machichus may be visible on the surfaces of the wedge however they are not always apparent. Wedging was rare on the teeth of the smallest mammalian taxa collected (e.g., *Macaca*, *P. pygmaea*), omnipresent on the teeth of medium-scale mammals (e.g., *Ailuropoda*, *Ursus*, *Sus*) and occasionally present on the teeth of large mammals (e.g., *Bos*, *Elephas*, *Stegodon*).

The paucity of fossils belonging to very small and very large mammals in the collection likely reflects the gnawing preferences of the primary Lang Trang bone-collecting agent: porcupines. The degree to which Lang Trang vertebrate fossils exhibit evidence of porcupine gnawing (~95% of fossils collected) exceeds that of any other cave accumulation reported to date.

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