

mental models to accurately capture differential cusp plasticity. Using the methods described above, the phylogeny expected from molecular studies was obtained. This new technique of phylogenetic reconstruction would also be applicable to fossil taxa.

Poster Session II, (Monday)

#### **THE DEVELOPMENT OF CRUSHING PREMOLARS IN THE STAGODONTID, *DIDELPHODON***

CASE, Judd, Eastern Washington University, Cheney, WA, USA

The dentition of the stagodontid marsupial, *Didelphodon*, is distinguished by inflated and bulbous premolars. The premolars have a massive central cusp which is a highly derived condition compared to the more typical gracile and trenchant premolars of most other Late Cretaceous marsupials. The Judithian-aged stagodontid, *Eodelphis*, has the more typical marsupial premolar morphology compared to its highly Lancian-aged relative, *Didelphodon*. The transition between these two morphologies is not well documented. Stagodontid specimens from Red Owl Quarry in South Dakota exhibit intermediate premolar morphologies between *Eodelphis* and *Didelphodon*. The transitional states in premolar morphology culminating in the highly derived, crushing premolars in *Didelphodon*, may be explained through a morphodynamic model of tooth development.

Technical Session XV, Wednesday 11:15

#### **ASCENT WITH MODIFICATION: FOSSIL FISHES WITNESSED THEIR OWN GROUP'S ADAPTATION TO THE UPLIFT OF THE TIBETAN PLATEAU DURING THE LATE CENOZOIC**

CHANG, Mee-mann, Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China; MIAO, Desui, University of Kansas, Lawrence, KS, USA; WANG, Ning, Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China

The rapid uplift of the Tibetan Plateau during the late Cenozoic changed it into a habitat island isolated from an increasing complexity of less elevated environments. This makes it a laboratory similar to the Galápagos Islands for studying evolution in action. Inspired by studies on the spatial distribution of Recent schizothoracine fishes on the Tibetan Plateau, we report on evolution of Cenozoic fossil schizothoracines and habitat fragmentation against the backdrop of tectonic uplift. Our results show that the earlier fossil schizothoracines have more rows of pharyngeal teeth and lived at lower altitudes than their relatives from younger deposits. They belong to the primitive grade whose living representatives now live in the peripheral area of the Tibetan Plateau at relatively low altitude. These earlier fossil schizothoracines have been uplifted to the present elevation, and some are in the central area of the Plateau, where extant schizothoracines could not presently survive. Thus, the temporal distribution pattern of the fossil schizothoracines approximately mirrors the spatial distribution pattern of their living counterparts, which reflects the biological responses to the step-wise uplift of the Tibetan Plateau. The consistency in independent lines of evidence between extant and extinct fishes illustrates the beauty of Darwinism. Through ascent with modification, the fossil schizothoracine fishes demonstrate how their own group has adapted to the ever-changing environment caused by geological, biological, and climatic interplays.

Technical Session II, Sunday 11:30

#### **NEW STUDY OF THE CRETACEOUS MAMMAL *AKIDOLESTES* WITH ITS IMPLICATIONS FOR EARLY THERIAN MAMMAL POSTCRANIAL EVOLUTION**

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Recent study of the postcranial skeleton of the spalacotheriid *Akidolestes cifellii*, a basal taxon of the trechnotherian clade from the Lower Cretaceous of China, sheds new light on the diversity of locomotory adaptations of basal therian mammals. The postcranial skeleton of *Akidolestes* shows both scansorial and terrestrial locomotory features. The astragalus and the calcaneus lack the specialized features for a wide range of inversion and eversion at the mid-tarsal joint that is typical of scansorial didelphid marsupials. This seems to suggest a terrestrial habitat preference. By contrast, other features would favor a hypothesis that *Akidolestes* had a scansorial locomotory function. These include the triangular shape of the scapula, a relatively higher phalangeal index, a more elongate intermediate phalanx to the proximal phalanx, the profile of terminal phalanx of the manus, and an asymmetrical knee joint, as indicated by the larger lateral distal condyle than the medial distal condyle of the femur. In these features *Akidolestes* is significantly different from the closely related zhangheotheriids (*Zhangheotherium* and *Maootherium*) that were interpreted as generalized terrestrial mammals by the characteristics of the scapula, the manual phalangeal proportion, and by a more symmetric knee joint. Additionally, *Akidolestes* is different in having lumbar ribs and a hypertrophied parafibular process of fibula, which are absent in zhangheotheriids, although the differences in function by these divergent features remain to be understood. As *Akidolestes* and zhangheotheriids both belong to the spalacotheroids, the differences in their scapula, knee, and phalangeal proportion suggest that the known spalacotheroid species are more diverse in locomotory functions than previously thought, and that some degree of ecomorphological diversification occurred within the spalacotheroid clade. Spalacotheroids (including both *Akidolestes* and zhangheotheriids) are basal in the trechnotherian mammal lineage that includes modern marsupials and placentals. Our new data provide a new understanding that the ecomorphological diversification occurred at the generic or even species level within basal clades leading to therian mammals.

Poster Session III, (Tuesday)

#### **LATE PALEOCENE MICROMOMYID PLESIADAPIFORMS (MAMMALIA, EUARCHONTA) FROM BIG MULTI QUARRY, WASHAKIE BASIN, WYOMING**

CHESTER, Stephen, Yale University, New Haven, CT, USA; BEARD, K. Christopher, Carnegie Museum of Natural History, Pittsburgh, PA, USA

Big Multi Quarry in the upper Fort Union Formation of the Washakie Basin, southwestern Wyoming, preserves a diverse terrestrial fauna and associated flora from the late Paleocene (Clarkforkian Land Mammal Age; Cf1 or Cf2). Forty-one species of mammals have been documented at Big Multi Quarry, including 11 species of plesiadapiforms. Previously undescribed specimens of micromomyid plesiadapiforms extend the range of morphological variation known for the genera *Tinimomys* (n=36) and *Dryomomys* (n=12), and may represent new species.

*Tinimomys* sp. is similar to *T. graybulliensis* in possessing a continuous lingual cingulum on its upper molars, supporting an attribution to the genus. However, *Tinimomys* sp. is slightly smaller than *T. graybulliensis* in most tooth dimensions, and is more similar to *Chalicomomys antelucanus* in lacking a metacone and having a small protocone lobe on P3/. *Tinimomys* sp. further differs from *T. graybulliensis*, and is similar to *C. antelucanus* and *Micromomys fremdi*, in possessing a more exodaenodont parastyle on P4/ that is positioned lower relative to the paracone, resulting in a longer preparacrista slope when viewed buccally. Similarities to the most plesiomorphic species of micromomyid, *M. fremdi*, in both the relatively small protocone lobe of P3/ and long preparacrista on P4/, suggest that *Tinimomys* sp. is more primitive than *T. graybulliensis*.

The presence of *Dryomomys* at Big Multi Quarry extends the range of this genus temporally and geographically. Previously *Dryomomys* was only known from the late Clarkforkian (Cf3) of the Clarks Fork Basin, Wyoming, and only represented by the holotype of *D. szalayi*. *Dryomomys* sp. is similar in size to *D. szalayi*, but differs in possessing a significantly wider P3/, a distinct paraconid on M/1, a smaller P3/ with a less pronounced protocone and smaller protocone lobe, and a slightly longer, yet less lingually expansive P4/. Comparisons to other micromomyids suggest that these features may represent plesiomorphic retentions. These new specimens of *Tinimomys* and *Dryomomys* may serve to document evolutionary transitions among known taxa of micromomyids, helping to clarify relationships within the family.

Advances in Paleocology: Geochemistry, Microwear and Beyond, Sunday 11:45

#### **APPROACHING TRUE DIVERSITY IN FOSSIL COMMUNITIES USING A COMBINATION OF RAREFACTION METHODS AND THE PIE EVENNESS INDEX**

CHEW, Amy, Western University of Health Sciences, Pomona, CA, USA

Ecological diversity consists of two inter-related components: richness (number of species) and evenness (species abundances). Richness is usually interpolated by rarefaction, which plots cumulative species richness as a function of number of individuals (*individual-based*) or average number of individuals per sample (*sample-based*). Evenness may be quantified by the Probability of Interspecific Encounter index (PIE). Richness tracks evenness: sample richness is higher in communities with high evenness and vice versa. I use both methods of rarefaction and PIE to test the long-term relationship between climate and the diversity of the early Eocene mammal fauna of the central Bighorn Basin, WY. Individual-based rarefaction provides a null richness hypothesis given a random distribution of species. Sample-based rarefaction richness estimates reflect non-randomness in species distributions. PIE indicates whether changes in richness are related to changes in community structure. More than 33,000 specimens from 161 species were grouped into 17 ~100Kyr intervals. Six of the intervals were during a cool period and the remaining intervals were during a subsequent warm period (5-8°C warmer mean annual temperature) divided into early (6 intervals) and late (5 intervals). Individual-based rarefaction interpolated significantly higher richness during the early warm period (80 s, where s=#species/3500 specimens) than during the cool or late warm periods (65 s), whereas there were no significant changes in sample-based rarefaction estimates (64, 66, and 59 s for cool, early warm and late warm, respectively). The difference between the estimates for the early warm period appears to be related to an underestimation bias in sample-based rarefaction with the increasing size of individual samples. PIE indicates that the late warm period had low evenness compared with the cool and early warm periods. However, this shift was only reflected in the sample-based rarefaction curves. These results suggest that 1) individual-based rarefaction is a better richness estimator in most situations; 2) sample-based rarefaction and PIE add important information to the interpretation of diversity.

Poster Session IV, (Wednesday)

#### **THE EARLY MIOCENE RODENT FAUNA OF PAMPA CASTILLO, CHILE**

CHICK, Jennifer, Case Western Reserve University, Cleveland, OH, USA; CROFT, Darin, Case Western Reserve University, Cleveland, OH, USA; DODSON, Holly, Sierra College, Rocklin, CA, USA; FLYNN, John, American Museum of Natural History, New York, NY, USA; WYSS, Andre, University of California at Santa Barbara, Santa Barbara, CA, USA

The early Miocene (Santacrucian) fauna of Pampa Castillo, Chile is a rich assemblage of 35 mammal species. Of these, the most abundant is a dasyproctid rodent, *Neoreomys australis*, which accounts for more than half of identified specimens. This rodent's hypsodont cheek teeth make identification challenging, since tooth dimensions and occlusal morphology

change drastically with wear. This large sample of *N. australis* permitted a detailed wear study, the goal of which was to describe morphological differences in occlusal structures that occur due to wear. We used both intact cheek teeth as well as transverse tooth sections. Up to seven wear stages were identified per tooth position, although some incongruence was evident between sectioned and intact teeth of the same position. This may be due to limitations of tooth sectioning in mimicking natural wear patterns, or individual variation. Regardless, this study clarified expectations of how morphology changes with wear in this species and better defined the range of variation for *N. australis*.

A second objective of this study was to refine previously published descriptions of the other rodents of the fauna. Two species of *Perimys* are abundant; also present is *Prolagostomus*, two genera of eocardiids (*Eocardia* and *Luantus*), *Eosteiomys* (Erethizontidae), the echimyids *Stichomys*, *Spaniomys*, and *Acarechimys*, and the octodontid *Sciomy*s. Three species known previously only from the Pinturas Fm. of Argentina also were identified: *Luantus propheticus*, *Sceleromys quadrangulatus*, and *Prostichomys boweni*. The presence of these species only in the lower and middle sequences ("Pinturas association") of the Pinturas Fm. suggests that Pampa Castillo may better correlate with these levels than typical Santacrucian faunas; however, like typical Santacrucian faunas, *N. australis* and chinchillids are abundant at Pampa Castillo. Additional study is needed to clarify the relative roles of habitat, geography, and time in determining these patterns of species distributions and abundances.

Technical Session I, Sunday 10:15

#### THE BONE MICROSTRUCTURE OF THE POLAR HADROSAURS FROM THE NORTH SLOPE OF ALASKA

CHINSAMY-TURAN, Anusuya, University of Cape Town, Cape Town, South Africa; TUMARKIN-DERATZIAN, Allison, Temple University, Philadelphia, PA, USA; THOMAS, Daniel, University of Cape Town, Cape Town, South Africa; FIORILLO, Anthony, Dallas Museum of Natural History, Dallas, TX, USA

The polar regions of the world today experience dramatic annual changes in temperature and light. Thus, one of the most pertinent questions with regard to dinosaurs recovered from high latitudinal deposits is how they survived in the polar regions of the Mesozoic. One of the richest high latitudinal dinosaur-bearing deposits is that of the Upper Cretaceous Prince Creek Formation of the North Slope of Alaska. Palaeoenvironmental analyses suggest that the environment at the time was dominated by a coniferous forest and the mean temperature is estimated to range from 2° to 4° Celsius for the coldest monthly mean to 10° to 12° Celsius for the warmest monthly mean. The Prince Creek Formation localities in the North Slope of Alaska has yielded skeletal and track assemblages of a wide array of nonavian dinosaurs, including large- and small-bodied theropods, ceratopsians, pachycephalosaurs, hypsilophodontids, and hadrosaurs. The most abundant of these faunal remains are hadrosaurs of the genus cf. *Edmontosaurus*, which are represented by thousands of specimens.

Size dimensions of various long bones (e.g. femora, humeri, tibiae, fibulae) of the Alaskan specimens cf. *Edmontosaurus* suggests different growth stages among the individuals recovered, with the majority representative of juveniles. Different sized long bones were sampled for histological analysis. The bone microstructure revealed a well preserved bone tissue. The compacta of the bone wall is inundated with a large number of channels that suggest that the bone was well "vascularised" and was formed relatively quickly. Several of the young individuals show evidence of cycles of growth, and one large individual records eight cycles of growth. These growth cycles are unique in that the bone tissue within the alternating cycles both suggest rapid rates of bone deposition i.e. the tissues in both "cycles" are of the fibro-lamellar type, and differ only in terms of channel orientation. Details of the unusual bone microstructure of these high latitudinal hadrosaurs will be presented, and their possible lifestyle adaptations to living in the high latitudinal environment of the Alaskan North Slope will be discussed.

Technical Session XVII, Wednesday 3:15

#### ANALYSIS OF HOMOLOGY IN SERIALLY REPETITIVE MORPHOLOGICAL STRUCTURES: THE THEROPOD DIGIT PROBLEM

CHOINIERE, Jonah, George Washington University, Washington, DC, USA; DIMITROV, Dimitar, University of Copenhagen, Copenhagen, Denmark; ANTON-FERNANDEZ, Clara, Virginia Tech, Blacksburg, VA, USA; XING, Xu, Key Laboratory of Evolutionary Systematics of Vertebrates, Beijing, China; CLARK, James, George Washington University, Washington, DC, USA

The homology of repetitive structures is a longstanding problem in morphology, and the homology of the manual digits of theropods and extant birds has been particularly well-studied. Developmental studies indicate that the digits of birds are in the 2-3-4 position, while morphological comparisons of theropod digits indicate the 5<sup>th</sup> and then 4<sup>th</sup> digits were lost. The "frameshift hypothesis" sought to resolve this conflict by positing that the digits of tetanuran theropods underwent a homeotic change whereby morphology of the medial three digits of the ancestral theropod five-fingered manus were shifted laterally onto the positions of the second, third, and fourth digits in more derived theropods. The recent discovery of the Jurassic ceratopsian *Limusaurus*, with a vestigial digit I and enlarged digit II, prompted new debate on the "frameshift hypothesis". Analyzing different scenarios for a shift in digital identity requires the evaluation of alternative sets of primary homology hypotheses for digital correspondences across theropod taxa. These sets of primary homology hypotheses are analogous to different alignments produced from comparisons of homologous molecular sequences. Unfortunately, current alignment software is not designed to evaluate morphological cor-

respondences. We devised new R scripts and coding strategies to utilize the phylogenetic software POY for analysis of morphological correspondences, and use this approach to test the position of the shift in digital position on the theropod tree. The results demonstrate input parameters such as gap costs and transformation costs have a large effect on the most parsimonious position for the shift in digital correspondence. Additionally, the inclusion of developmental data from extant theropods (i.e. *Gallus*) influences the position of the shift.

Technical Session VI, Monday 2:45

#### CONVERGENT MICROWEAR PATTERNS IN EXTANT METATHERIAN AND EUTHERIAN HERBIVORES: A PROXY FOR THE ANALYSIS OF MAMMALIAN DIET IN THE LATEST CRETACEOUS AND EARLY PALEOCENE

CHRISTENSEN, Hilary, The University of Chicago, Chicago, IL, USA

As a prerequisite to direct comparison of the metatherian and eutherian mammals that cohabited during the time period encompassing the K/T boundary, the degree to which compatibility of tooth wear in extant Australian marsupial and worldwide placental herbivores has been assessed. The aim of this study was to determine whether the microwear patterns recorded on their molars are indeed the same among animals of the same dietary niche, or whether the large difference in jaw architecture and chewing strokes between modern metatherians and eutherians has an effect on the signal—whether function or phylogeny determines microwear patterns.

Low-magnification microwear analysis has so far been shown to be effective in differentiating between grazers, browsers, and hard-object herbivores in extant ungulates, lemurs, notoungulates, xenarthrans, sciurids, and macropod marsupials. The present study includes members of the above with the addition of selected rodents and members of the Australidelphia superorder (in addition to the Macropodidae). Because the aim of the study was to examine the degree to which members of the same feeding guild have similar microwear patterns, species were chosen based on their being relatively specialized feeders belonging to grazing, browsing, and hard-object feeding niches; mixed feeders were excluded. No statistical difference between marsupial and placental mammals occupying the same feeding niche was found, providing strong evidence for functional convergence in these two groups. These results support the use of microwear as a dietary proxy across the metatherian and eutherian mammals in the fossil record.

Poster Session II, (Monday)

#### PRELIMINARY RESULTS OF A COMPREHENSIVE MORPHOLOGICAL PHYLOGENY OF THE PINNIPEDIA (MAMMALIA: CARNIVORA)

CHURCHILL, Morgan, University of Wyoming, Laramie, WY, USA; BOESSENECKER, Robert, Montana State University, Bozeman, MT, USA; CLEMENTZ, Mark, University of Wyoming, Laramie, WY, USA

Pinnipeds (seals, sea lions, and walruses) are the second most diverse clade of marine mammals alive today (~36 species). Although knowledge of pinniped evolution has grown in recent decades, uncertainty still exists in the relationships of the three extant (Phocidae, Otariidae, and Odobenidae) and two extinct families (paraphyletic, early diverging "enaliarctidae", Miocene Desmatophocidae) to one another, as well as relationships within Otariidae. Molecular phylogenies support a sister group relationship between Odobenidae and Otariidae, and paraphyly of the sea lions (Otariinae). Morphology based studies in contrast have supported walruses as being either close to Phocidae, or to Otariidae, as well as monophyly of sea lions. However, many of these studies relied on small character sets, limited taxon sampling, and non-cladistic methodology. A further, more comprehensive examination of Pinnipedia is thus needed, in order to reconcile morphological and molecular analyses, as well as allow more accurate interpretation of changes in pinniped ecology through time.

We here report the preliminary results of a morphological study employing 51 taxa and 278 characters focused on examining the internal relationships within the Pinnipedia, which represents the largest study to date. Results so far find strong support for monophyly of Otariidae, Phocidae, and Odobenidae, as well as a *Pteronarctos* + Pinnipedia clade. A clade including *Pinnarctidion*, Desmatophocidae, Odobenidae, and Phocidae is recovered without strong support, and relationships within the clade are poorly resolved. A monophyletic Otariinae was recovered, with low support, however the fur seal genus *Arctocepalus* was found to be non-monophyletic. Further work will focus on continued revision of characters, addition of taxa and characters, and incorporation of molecular data to produce a total evidence phylogeny of the Pinnipedia.

Preparators' Session, Monday 11:45

#### RACING AGAINST DISASTER: THE DEMOLITION, REHABILITATION AND RECONSTRUCTION OF THE QUARRY VISITOR CENTER, CARNEGIE QUARRY, DINOSAUR NATIONAL MONUMENT

CHURE, Daniel, Dinosaur National Monument, Jensen, UT, USA

In August 1909, Earl Douglass, of the Carnegie Museum, discovered eight *Apatosaurus* caudal vertebrae in a sandstone layer of the Morrison Formation near Jensen, UT. This site, known as the Carnegie Quarry (CQ), proved to be one of the largest Jurassic dinosaur quarries ever found. Many taxa exhibited in the Carnegie Jurassic Hall are from the CQ (*Apatosaurus*, *Diplodocus*, *Camarasaurus*, *Stegosaurus*, *Dryosaurus*, *Camptosaurus*, *Marsosaurus*, *Hoplosuchus*, *Glyptops*). Between 1909 and 1924, excavations by the Carnegie