a unique set of late Neanderthals and Upper Paleolithic modern humans from northern Italy.

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Anatomical & Developmental Explorations of the Mammalian Skull

USING CT SCAN DATA TO DESCRIBE THE WELL-PRESERVED TURBINALS OF THE ADAPIFORM PRIMATE *LEPTADAPIS LEENHARDTI*

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Turbinals, small scrolls of bone housed in the nasal fossa, exhibit high degrees of morphological variability among extant primate lineages. Derived increases in ethmoturbinal and frontoturbinal numbers among extant strepsirrhines make it difficult to determine the primitive number of turbinals in crown primates. Furthermore, turbinals rarely fossilize, making establishing the primitive condition by examining fossil data difficult. As such, there is debate over whether four or five ethmoturbinals and one or two frontoturbinals is the primitive condition for primates. To date, fossil primate turbinals have only been reported and described in omomyoid euprimates and stem platyrrhines. Here, I report the first known preservation of turbinates in an adapiform euprimate, *Leptadapis leenhardti* (YPM-011481) from the Eocene Quercy phosphorites of southwestern France. In each nasal fossa, this specimen preserves a nasoturbinal and four well-developed ethmoturbinals with a small fifth ethmoturbinal posteriorly located in the olfactory recess. Sequestered posterolaterally in the frontal recess are two frontoturbinals. The primitive turbinal configuration for crown primates has been argued to be four or five ethmoturbinals and only one frontoturbinal. The configuration of turbinals in *Leptadapis* is then significant first because of the presence of a fifth ethmoturbinal, a condition seen in dermopterans and some extant strepsirrhines but has never before been seen in a fossil primate. Secondly, two frontoturbinals are commonly present amongst extant rodents and non-primate euarchontans but are only present in a few species of extant strepsirrhine primates. The anatomy in *Leptadapis* then corroborates the hypothesis that five ethmoturbinals and two frontoturbinals is the primitive condition in crown primates and was independently lost along multiple primate lineages.

Romer Prize

EVOLUTIONARY RATE ANALYSIS REVEALS DYNAMIC AND VARIABLE PATTERNING OF FORELIMB EVOLUTION ACROSS THE DEEP HISTORY OF SYNAPSIDA

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Mammals are noteworthy for their striking ecomorphological diversity in comparison to their non-mammalian synapsid ancestors. However, the lack of a large phenotypic sample coupled with a phylogeny has hindered examination of this characteristic's acquisition. Did this diversity accumulate at a constant pace, or did evolutionary rate vary between clades and elements? Here I present an analysis of phenotypic evolutionary rate for synapsid forelimbs using 2D geometric morphometric data of 1279 fossil elements, and a time-calibrated composite tree of 160 genera. Rate comparisons were made for five radiations ('pelycosaurs', non-cynodont therapsids, non-mammalian cynodonts, Mammaliaformes, Mammalia), and three functional subunits of the forelimb (proximal humerus, distal humerus, ulna). Mammaliaforms were characterized by the highest evolutionary rates for all functional units, followed by therapsids. Both of these groups underwent major ecomorphological diversifications, and the highest rates are found in taxa characterized by specialized forelimb ecologies, such as fossorial dicynodonts (Therapsida) or the semi-aquatic *Haldanodon* (Mammaliaformes).

In all groups the proximal humerus displayed higher rates than the distal humerus, with the highest found in mammaliaforms and therapsids. These groups underwent dramatic morphological change, especially in the gleno-humeral joint. Critically though, the ulna displays the highest evolutionary rates across all groups, highlighting the underappreciated role the ulna played in the morphological and functional transformations of the synapsid forelimb. The simplification of the structure likely increased the possibility for expansion into new morphologies and played a key role in facilitating ecomorphological diversification. Overall, therapsids and mammaliaforms can both be characterized by important functional changes to the forelimb that likely played a role in this dynamic.

Phylogenetic signal also varied across the sample, with Pelycosaurs and non-mammalian cynodonts displaying the lowest levels. This in turn reflects these groups' conservative forelimb morphologies, especially compared with other synapsid clades. Together, these results demonstrate that synapsid forelimb evolution should be characterized as a dynamic and complex accumulation of 'mammalian' morphologies. Evolutionary rates varied across taxa and elements as clades adapted their forelimbs

in particular ways to accommodate novel ecologies and functions.

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Biomechanics & Functional Morphology

MANDIBULAR ADAPTATIONS IN THE DIETARY DIVERSIFICATION OF THEROPOD DINOSAURS

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The diets of vertebrate animals are known to have changed multiple times across their evolution. Among these, theropod dinosaurs underwent some of the most remarkable dietary shifts in vertebrate evolutionary history. They shifted from ancestral carnivory to more specialized carnivory and to omnivore and herbivory, and even reversed back to omnivory and carnivory in some cases. The mandible serves an important role in food acquisition and likely reflects adaptations to respective feeding modes. However, the functional adaptations of the mandible that accompany theropod dietary shifts remain unclear. Here, we conducted the first comprehensive study on the feeding mechanics of 46 non-avialan coelurosaurian theropods using 2D finite element analysis.
We find that carnivorous theropods like dromaeosaurids and tyrannosauroids are less adapted to biting at the anterior tip of the mandible compared to herbivorous theropods like ornithomimosaurians, therizinosaurians, and oviraptorosaurians, as reflected by their less stress-resistant and less bite-efficient mandibles. An overall reduction in feeding-induced stress is identified along all theropod lineages, suggesting a common tendency for structural strengthening of the mandible regardless of diet. Although carnivorous and herbivorous theropod lineages demonstrate post-dentary expansion of the mandible for stress dissipation, different evolutionary pathways are identified in the dentary. Convergent evolution of a more downturned dentary to enhance mandibular stability is observed in derived herbivorous taxa. This is not observed in carnivores, which instead evolved a more speed-efficient mandible with a wavy occlusal margin for predation. Deformation simulations of mandibles from lineages of known herbivorous theropods show that the mandibles of earlier-diverging forms generate ‘more downturned mandibles’ resembling the mandibles of later-diverging forms in these lineages. This is possibly because the simulated deformed mandibles tend to be more stress-resistant than the original mandibles.
Our study uncovers the pattern of mandibular adaptions accompanying large-scale dietary shifts in non-avialan theropods, which represents a powerful case study for understanding the dietary evolution in other vertebrates.

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Holocene & Pleistocene Mammalian Macroecology & Faunal Studies

TOOTH MORPHOMETRIC ANALYSIS CONFIRMS STASIS IN LATE PLEISTOCENE HORSES FROM RANCHO LA BREA

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The Rancho La Brea tar pits are a well-studied late Pleistocene site with a large abundance of well-preserved fossils, including a great number of horse specimens. The site contains a single equid species, *Equus occidentalis* (sensu Merriam). As each pit corresponds to a distinct time period spanning the different climatic fluctuations of the last glacial-interglacial cycle, several studies have aimed to understand the morphometric responses of different mammals to this climatic change. The felid *Smilodon fatalis* showed static limb bone size, but had different jaw sizes in different pits. The dire wolf *Canis dirus* also had variation in jaw sizes, which correlated with levels of primary productivity. Prior work with limb bones of the *Equus* from La Brea revealed no variation in size among the pits, although a few cases showed significant changes which the authors attributed to a 'random walk' pattern. Within horse evolution, tooth morphology and complexity appear to be related to different feeding strategies, so if there were variation in the teeth of the La Brean *Equus,* it could indicate changes in diet. This work, then, aims to investigate whether the teeth of Rancho La Brea horses remained unchanged like the limb bones or varied among the pits. In addition, this work analyzes a larger number of pits than the prior limb bone analyses which, apart from the analysis of patellae, only included five pits. The current analysis takes into consideration all molars and premolars except third molars and second premolars. It includes 193 lower and 188 upper teeth from 15 and 11 pits, respectively. The analyses consisted of Multivariate Analysis of Variance (MANOVA), Discriminant Function Analysis (DFA) and Cluster Analysis (CA). Results from MANOVA of both upper and lower teeth showed no significant differences among pits. DFA of upper teeth can only correctly identify the pit of 26% of the total horses analyzed, while DFA of lower teeth yields only 21%. CA