New data on the notoungulate (Mammalia) endocranial cavity and a phylogenetic analysis based on craniodental and postcranial 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 (CT) 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 endocranial characters, 11 new, were scored for 20 notoungulate and five outgroup taxa based on firsthand observations of specimens (N = 15) and published literature (N = 10). All but one taxon (*Notostylops*) were represented by a single specimen; natural endocasts are rare, molding the endocranium is often destructive (and generally no longer done), and producing digital endocasts from CT data is expensive and time consuming. 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 & 8 outgroups). Parsimony analyses were conducted using TNT, applying new technology algorithms to search for the shortest trees and also conducting standard TBR 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.