Supporting Information (SI Appendix)

Oldest known euarchontan tarsals and affinities of Paleocene *Purgatorius* to Primates

Stephen G. B. Chester[a,b]*, Jonathan I. Bloch[c], Doug M. Boyer[d], William A. Clemens[e]

[a]Department of Anthropology and Archaeology, Brooklyn College, City University of New York, 2900 Bedford Avenue, Brooklyn, NY, 11210.
[b]New York Consortium in Evolutionary Primatology, New York, NY, 10024.
[c]Florida Museum of Natural History, University of Florida, 1659 Museum Road, Gainesville, FL, 32611-7800.
[d]Department of Evolutionary Anthropology, Duke University, 104 Biological Sciences Building, Durham, NC, 27708-0383.
[e]University of California Museum of Paleontology, 1101 Valley Life Sciences Building, Berkeley, CA, 94720-4780.

Correspondence to: Stephen G. B. Chester. Email: stephenchester@brooklyn.cuny.edu
Department of Anthropology and Archaeology, Brooklyn College, City University of New York, Brooklyn, 2900 Bedford Avenue, NY, 11210. Telephone: 718-951-5000 x2685.

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SI Materials and Methods

Institutional Abbreviations

AMNH, American Museum of Natural History, New York, New York, U.S.A.; BAA, Biological Anthropology and Anatomy Collection at Duke University, Durham, North Carolina, U.S.A.; DPC, Duke Primate Center, Durham, North Carolina, U.S.A.; FMNH, Field Museum of Natural History, Chicago, Illinois, U.S.A.; HTB, Cleveland Museum of Natural History, Hamann-Todd Non-Human Primate Osteological Collection, Cleveland, Ohio, U.S.A.; LACM, Los Angeles County Museum of Natural History, Los Angeles, CA, U.S.A.; MNHN, Muséum Nationale d'Histoire Naturelle, Paris, France; NMB, Naturhistorisches Museum, Basel, Switzerland; SBU, Stony Brook University, Stony Brook, New York, U.S.A.; UALVP, University of Alberta Laboratory for Vertebrate Paleontology, Edmonton, Alberta, Canada; UCM, University of Colorado Museum, Boulder, Colorado, U.S.A.; UCMP, University of California Museum of Paleontology, Berkeley, California, U.S.A.; UF Mammalogy collection, Florida Museum of Natural History, University of Florida, Gainesville, FL, U.S.A.; UM, University of Michigan Museum of Paleontology, Ann Arbor, Michigan, U.S.A.; UNSM, University of Nebraska State Museum, Lincoln, Nebraska, U.S.A.; USNM, National Museum of Natural History, Smithsonian Institution, Washington D.C., U.S.A.; VPL/JU/NKIM, Vertebrate Paleontology Laboratory, University of Jammu, India, Naskal Intertrappean Mammal Catalogue Numbers; YPM, Yale Peabody Museum, New Haven, Connecticut, U.S.A.

Allocation of Isolated Tarsal Bones

Thousands of vertebrate fossils from the Garbani Channel fauna localities, northwestern Montana, were examined at the UCMP. Several astragali and calcanei (Table S1) were identified in unsorted miscellaneous bone boxes housed at the UCMP and are attributed to *Purgatorius* here. These specimens were originally collected at four different UCMP fossil localities (Table S1) where dental specimens of *Purgatorius* were previously collected and identified (Fig. S1). Specimens are confidently allocated to *Purgatorius* based on size (see regression analysis below), diagnostic euarchontan and plesiadapiform tarsal features (see descriptions and comparisons below), and the lack of dental remains of other euarchontans known from the Garbani Channel fauna.

Regression Analysis

Regression analysis was used to evaluate the scaling relationship between the size of teeth and tarsals for euarchontan mammals, and to assess whether the tarsals attributed to *Purgatorius* are an appropriate size given the size of *Purgatorius* teeth known from the Garbani Channel fauna. Skeletal elements from a sample of 60 dentally-associated skeletons of euarchontans including extant euprimates, treeshrews, and colugos, and fossil plesiadapiforms, were microCT scanned at 4-36 microns using ScancoMedical scanners (uCT-40 and vivaCT-75 models) (see Table S2). All *Purgatorius* dental specimens were collected at UCMP locality V73080, a sublocality of the Garbani Quarry in the Garbani Channel fauna localities. Given that isolated first and second lower molars of *Purgatorius* can be difficult to differentiate, all *Purgatorius* specimens included in this study are lower jaw fragments with teeth so that tooth positions could be assessed with confidence (Table S3). Three-dimensional digital reconstructions of skeletal elements were created and measured using Avizo 6 software (http://www.vsg3d.com/avizo). Measurements include lower second molar (m2) maximum mesiodistal length (tL) and maximum buccolingual width (tW); astragalar lateral tibial facet width (aW); and calcaneal cuboid facet dorsoplantar depth (cD) and mediolateral width (cW). See Table S2 for a specimen list and corresponding tooth and tarsal measurements.

We used the method of least squares to regress natural log of m2 area (tL*tW) on natural log of astragalar lateral tibial facet width (aW), as well as natural log of m2 area (tL*tW) on natural log of calcaneocuboid facet area (cW*cD). Regressions were run on individuals, rather than species means. Such practice can create statistical problems if certain species are overrepresented compared to others. This is also true at the level of species means if certain clades are overrepresented and ultimately stems from interdependence of phylogenetically related data points (1). Of the 30 species in our sample, half are represented by a single specimen, whereas the species represented by the most specimens is represented by n=6. The taxa represented by the highest sample sizes are close to mean x-values of the regression, so they have less leverage to change the regression parameters than if they were on the extreme high or low end of the data range. We chose to use data on individuals (with dental and postcranial data from the same specimen) in order to incorporate information on scatter in the relationship between the two variables at the species level. Given our data structure, taking mean values would mainly serve to make the relationship appear cleaner than it is and lead to greater potential for type I error (the null hypothesis we tested is that the tarsals and dentition are from the same taxon).

Regressions were run in Microsoft Excel. 95% confidence limits on the prediction interval of tooth size from postcranial element dimensions were generated using equation 17.29 of (2). Prediction intervals that take into account the PSE of the data (the 'scatter') around the regression line are more appropriate than a confidence interval based on standard error in the regression parameters. Prediction intervals intuitively, are broad enough to incorporate most of the data points used to construct the regression, whereas confidence intervals based on error in regression parameters typically exclude many more data points used to create the regression. Dimensions from isolated tarsals and teeth of *Purgatorius* from the Garbani Channel fauna localities (Table S3) were then plotted on the resulting regression equations. This served as a test of our attribution of tarsals to *Purgatorius* based on morphology alone. Our hypothesis of attribution would be refuted if *Purgatorius* tooth dimensions fell outside the 95% prediction intervals of other euarchontan tooth dimensions predicted by their respective tarsal dimensions. However, the teeth and corresponding measurements of tarsals attributed to *Purgatorius* fall comfortably within the 95% prediction intervals, suggesting that they have a scaling relationship that would be expected for a euarchontan mammal (Fig. S2).

<u>Principal Component Analysis</u>

In order to evaluate our qualitative observations that the tarsals attributed to *Purgatorius* are generally similar to those of euarchontan mammals and specifically similar to those of plesiadapiforms, we ran Principal Component Analysis on a correlation matrix of linear and angular measurements. Additionally, we ran a cluster analysis also using the correlation matrix as our similar metric and using Paired Group Method for linking cases. Although the results of these two methods will not be independent, each method provides a slightly different perspective on the same phenetic dataset. All linear measurements were size-standardized using the geometric mean, and angular measurements are reported in degrees, but were analyzed in radians. Eighteen linear and five angular measurements of (3) were recorded for the astragalus (Fig. S3a) and 19 linear and six angular measurements of (4) were recorded for the calcaneus (Fig. S3b). The astragalus dataset of (3) was expanded to 48 individuals representing 34 species (Table S4). The calcaneus dataset of (4) was expanded to 54 individuals representing 33 species

(Table S5). The expanded taxonomic sample includes *Purgatorius*, other plesiadapiforms, other Puercan mammals (arctocyonid condylarth *Protungulatum* and cimolestid *Procerberus*), the Cretaceous adapisoriculid *Deccanolestes*, fossil and extant euprimates, extant treeshrews (*Ptilocercus* and *Tupaia*), and the extant dermopteran *Cynocephalus* (Tables S4, S5). Two of the seven astragali attributed to *Purgatorius* (UCMP 197507, 197509) are complete enough to record all 23 measurements. One of the nine calcanei attributed to *Purgatorius* (UCMP 197517) is complete enough to record all 25 measurements. As for the regression analysis above, all tarsals were microCT scanned and digital reconstructions were created and measured using Avizo 6 software.

Principal component analysis and cluster analysis were run using PAST v. 2.16 (5). Eigenvalue, percentage variance, and variable component loadings were recorded for each principal component (Tables S6, S7). If *Purgatorius* is not a primate, or the tarsals were incorrectly attributed to *Purgatorius*, then *Purgatorius* should not plot within primate (plesiadapiform or euprimate) morphospace. Furthermore, cluster analysis should support primates as the nearest morphological neighbors of *Purgatorius*. It should be noted that the minimum spanning tree of these datasets is also displayed, but this is not equivalent to the cluster analysis result as the algorithm for linking data points based on multivariate distances is different and can leave specimens widely disconnected from clusters to which they are actually fairly similar.

Results of principal component analysis include astragali attributed to *Purgatorius* plotting within plesiadapiform morphospace, which is distinctly separated from Puercan mammals *Protungulatum* and *Procerberus*, euprimates, treeshrews, and colugos (Fig. 4). Two species of the Cretaceous adapisoriculid *Deccanolestes* plot close to each other and near plesiadapiform morphospace. *Deccanolestes* is not supported in Euarchonta by the phylogenetic analysis in this study (Fig. 2, S4a). Principal component 1 (PC1) represents 26.2% of the variance. It is most strongly correlated with variables 12 (flexor fibularis groove width), 20 (angle between fibular facet and lateral tibial facet), and 1 (maximum proximodistal length). Generally, an astragalus with a high PC1 score has a narrow flexor fibularis groove, a smaller angle between the fibular facet and lateral tibial facet, and a longer proximodistal length. Low PC1 scores generally represent the opposite conditions. PC2 represents 13.7% of the variance. It is most strongly correlated with variables 7 (lateral tibial facet maximum mediolateral width), 3 (head and neck proximodistal length), and 22 (angle between ectal facet and fibular facet). Generally, an astragalus with a high PC2 score has a relatively narrow lateral tibial facet, a longer head and neck, and a smaller angle between the ectal facet and fibular facet. Low PC2 scores generally represent the opposite conditions.

Cluster analysis shows the two astragali attributed to *Purgatorius* (UCMP 197507, 197509) to be nearest neighbors, and micromomyid plesiadapiforms *Dryomomys* (UM 41870) and *Tinimomys* (USNM 461201) are the successive nearest neighbors to this group. Results support *Purgatorius* as a plesiadapiform, and may reflect the primitive nature of this Puercan mammal, which, like *Procerberus* and *Deccanolestes*, has tarsal features such as a wide groove for the tendon of flexor fibularis on the astragalus.

Results of principal component analysis include calcanei attributed to *Purgatorius* plotting within plesiadapiform morphospace, which is distinct from that of other mammals. Puercan mammals *Protungulatum* and *Procerberus*, and Cretaceous adapisoriculid *Deccanolestes* plot close to plesiadapiform morphospace (Fig. 4). PC1 represents 36% of the variance. It is most strongly correlated with variables 15 (proximodistal length from peroneal tubercle lateral apex to distal end of calcaneus), 19 (distance from proximal margin of peroneal tubercle to distal end of calcaneus), 11 (proximodistal length from sustentaculum medial apex to distal end of calcaneus), and 3 (distal calcaneal length). Generally, a calcaneus with a high PC1 score is elongated distally with a peroneal tuberosity and sustentaculum tali are situated fairly proximally. Low PC1 scores generally represent the opposite conditions. PC2 represents 12.1% of the variance. It is most strongly correlated with variables 6 (proximal end of tuber mediolateral width), 7 (ectal facet proximodistal length), and 8 (length of arc of ectal facet). Generally, a calcaneus with a high PC2 score has a tuber with a narrow proximal end and a longer ectal facet. Low PC2 scores generally represent the opposite conditions. Cluster analysis shows the paromomyid plesiadapiform *Ignacius* (USNM 442240) to be the nearest neighbor of the calcaneus attributed to *Purgatorius* (UCMP 197517). Results support *Purgatorius* as a plesiadapiform, and may reflect the primitive nature of this Puercan mammal, which, like *Procerberus* and *Deccanolestes*, has tarsal features such as a large peroneal tubercle on the calcaneus.

Phylogenetic Analysis

The first character matrix analyzed was modified from that of (6), which was derived from previous analyses (7, 8). Previous results of all three of these analyses did not support *Purgatorius* as a primate or even as a placental mammal (6-8). The character matrix of (6) consists of 415 characters and 80 taxa. Five euarchontan taxa were added to this matrix including micromomyid plesiadapiforms *Foxomomys fremdi*, *Dryomomys szalayi*, and *Tinimomys graybulliensis*; a carpolestid plesiadapiform, *Carpolestes simpsoni*; and an extant dermopteran, *Cynocephalus volans*. Previous codings of euarchontans and other mammals were modified based on new observations or recently published findings, with all new codings in bold (Table S8). Specimens used for coding characters in all phylogenetic analyses presented in this study are listed below. References used for coding characters in all phylogenetic analyses presented in this study are cited following each respective taxon below.

New Taxa:

Foxomomys fremdi (9, 10) UALVP 21010, 21011, 21012, 21013, 21014, 21015 (dentition)

Dryomomys szalayi (10, 11) UM 41870 (dentition, crania, postcrania)

Tinimomys graybulliensis (10, 12) USNM 461201(dentition, postcrania), 461202 (dentition, crania, postcrania)

Carpolestes simpsoni (13-15) UM 82670 (dentition, crania); UM 82688 (dentition, crania); UM 85177 (dentition, crania); UM 86273 (dentition, crania); UM 101923 (dentition, crania); UM 101963 (dentition, crania, postcrania); USNM 482354 (dentition, crania)

Cynocephalus volans—FMNH 56442 (dentition, crania, postcrania); UF 3290 (dentition, crania)

Additions or Modifications to Taxa:

Purgatorius (16-18) LACM 28128; UCMP 107406; 129266 (dentition); see Table S1 for new tarsal specimen numbers (postcrania)

Plesiadapis (19)

Notharctus—AMNH[FM] 11473 (dentition, crania, postcrania); AMNH[FM] 11474 (dentition, crania, postcrania); AMNH[FM] 11721 (postcrania); AMNH[FM] 13024 (postcrania); AMNH[FM] 127167 (dentition, crania, postcrania)

Ptilocercus lowii (20)

Protungulatum (16, 21, anterior dentition was previously coded based on a reconstruction in 22)

UCMP 105007, 112111 (cast: dentition)

Oxyprimus—YPM-PU 16704, 16866 (dentition)

Parsimony analysis was conducted using TNT (v1.1), software subsidized by the Willi Hennig Society (23), with all multistate characters treated as unordered. *Nanolestes* was designated as the outgroup, which results in the same topology as following the methods of (6) where the "Force" command was used to make four taxa (*Nanolestes, Peramus, Vincelestes,* and *Kielantherium*) consecutive outgroups. New Technology Search was used to obtain the stabilized consensus five times [135 Most Parsimonious Trees (MPTs) with a length of 2,662 steps]. Resulting MPTs were then used as starting trees and a Traditional Heuristic Search was carried out using TBR (3560 MPTs found). All resulting MPTs were used to obtain a strict consensus, and like initial results of (6), the resulting strict consensus tree was poorly resolved. The Pruned Trees function was then used to identify the least stable taxa (*Kharmerungulatum*, *Montanalestes*, and *Lainodon*), which were also the least stable taxa in the previous analysis of (6). Once removed using the Prune Taxa function, fifteen nodes were gained, leading to a considerably more resolved strict consensus tree (CI = 0.229, RI = 0.557)(Fig. S4a). The Tree Filter function was used to delete longer trees and duplicate MPTs, resulting in 1,120 MPTs retained with a length of 2,651 steps.

Bremer decay analysis was then conducted in TNT to assess branch support for the resulting strict consensus cladogram. Generally following the methods of (6), Bremer branch supports were calculated using the Traditional Search option (10 replicates per run with TBR enforced) from 50,000 suboptimal trees up to 10 steps longer than the most parsimonious tree.

Suboptimal trees were found by increasing the suboptimal option by one step for each heuristic search of 5,000 trees to avoid overestimated support values (23). Absolute Bremer support values were calculated once 50,000 suboptimal trees were found (see Fig. S4a). Also following the methods of (6), the three least stable taxa (*Kharmerungulatum*, *Montanalestes*, and *Lainodon*) were removed before branch support was calculated.

The second character matrix analyzed was modified from a matrix that was designed to evaluate relationships within Euarchonta (11). The original matrix of (11) was run in TNT following the same methods described above (except characters 55, 62, 71, and 74 are ordered) and the same resulting tree topology of (11) was obtained. The modified matrix of 173 characters and 20 taxa incorporates new *Purgatorius* tarsal data, with new codings in bold (Table S9). New Technology Search was used to obtain the stabilized consensus five times (2 MPTs with a length of 472 steps) and subsequent traditional heuristic search found one most parsimonious cladogram with the same tree topology as the original analysis conducted in PAUP (11) (CI = 0.477, RI = 0.598). Bremer decay analysis was then conducted in TNT following the same methods described above (see Fig. S4b).

The third character matrix analyzed was modified from a matrix that includes many taxa within Euarchontoglires (24). The original matrix of (24) was run in TNT following the same methods described above and the same resulting strict consensus tree topology of (24) was obtained. The modified matrix of 240 characters and 34 taxa incorporates 15 new codings of *Purgatorius* tarsal characters, with new codings in bold (Table S10). New Technology Search was used to obtain the stabilized consensus five times (3 MPTs with a length of 1,091 steps) and subsequent traditional heuristic search found two most parsimonious cladograms (CI = 0.296, RI = 0.522). Again, the strict consensus of two trees resulted in the same tree topology as the original analysis (24). Bremer decay analysis was then conducted in TNT following the same methods described above (see Fig. S4c).

The three independent phylogenetic analyses conducted in this study support Sundatheria (Dermoptera + Scandentia) as the sister group to Primates, which includes *Purgatorius* and other plesiadapiforms (Fig. S4). These results differ from those of a recent cladistic analysis designed to evaluate the phylogenetic position of Eocene euprimate *Archicebus achilles* among euprimates and other euarchontan mammals (25). This character data matrix was updated from previous matrices that either included *Purgatorius* as an outgroup taxon (26) or supported *Purgatorius* as the sole member of stem Sundatheria (27). Results of (25) support *Purgatorius* and other plesiadapiforms as members of stem Primatomorpha. More specifically, these results support a stem primatomorph clade including *Purgatorius* and representatives of additional families of plesiadapiforms (Palaechthonidae, Microsyopidae, Micromomyidae, Paromomyidae, Plesiadapidae, Saxonellidae, Carpolestidae) with *Mixodectes* (Mixodectidae) as the basal-most member of this group (25). Results of this analysis also support Euprimates as the sister group to a clade consisting of extant dermopterans, additional members of Microsyopidae and Mixodectidae (suggesting these two groups are polyphyletic), as well as Plagiomenidae (which likely is not at all closely related to Dermoptera; 28). As was the case for *Purgatorius*, postcrania have not been described for palaechthonids, microsyopids, and plagiomenids, and the discovery and analysis of such fossils should continue to improve our understanding of primate origins and supraordinal relationships.

Geological setting and age of the Garbani Channel

Geological setting

The Garbani Channel is part of the Tullock Formation in Garfield County, northeastern Montana (Fig. S1a, b). In many recent paleontological and geological studies of this area the Tullock is recognized as a formation, but currently the United States Geological Survey classifies the Tullock as a member of the Fort Union Formation. The difference is largely nomenclatorial.

The main Garbani Quarry is in deposits filling the Garbani Channel exposed on the ridge that separates the valleys of an unnamed tributary to the headwaters of Hell Creek and the next tributary to the east, Cottonwood Creek (Fig. S1b) (29). The fossil tarsals described and analyzed in Figures 1 and 3 (UCMP 197509 and 197517) were found in one of the sub-localities of the main Garbani Quarry, UCMP locality V99438. Additional astragali and calcanei attributed to *Purgatorius* were found in UCMP locality V72128, another sub-locality within the main Garbani Quarry, and UCMP localities V74122 and V75194 (see Table S1). The latter two localities are in fillings of the Garbani Channel exposed in Cottonwood Creek approximately 1.5 miles (ca. 2.4 km) southeast of the main Garbani Quarry. All the localities are in T 20 N, R 36-37 E (29). Precise locality information is available to qualified researchers from the University of California Museum of Paleontology. The fossiliferous sediments from these localities were hand-quarried and then processed by underwater screening. The resulting concentrates were sorted with microscopes providing approximately ten times magnification.

Age

Geological and paleontological research in the valleys of Hell Creek and Snow Creek began in 1902 and continued intermittently, particularly from the 1960s to the present and is ongoing (30). The Tullock Formation is distinguished from the underlying Hell Creek Formation by lithostratigraphic zones characterized by the presence of numerous beds of lignites grading into carbon-rich siltstones. Collier and Knechtel (1939) established a pattern of alphabetical designation for these lignite-rich zones, which they named Coals (Fig. S1d) (31). They clearly noted that these Coals were not regionally continuous beds but lithostratigraphic zones characterized by deposition of lenticular beds of lignite. Subsequent research (e.g., 29, 32) has fully supported this interpretation.

In the early 1960s it was recognized that many of the lignites contained tephras, sanidine-bearing silicic volcanic ashes suitable for radioisotopic age determinations (e.g., 33). Later Swisher et al. (1993) published the results of their radioisotopic age determinations and the magnetostratigraphy of a composite section based on outcrops in the headwaters of Snow, Hell, and Cottonwood creeks (34). Building on the research of Renne et al. (2013) (35), Sprain et al. (2014) (32) reported more, higher resolution radioisotopic age determinations and incorporated previous magnetostratigraphic analyses of the composite section (34, 36, 37). Figure S1d documents the results of some this research in Snow, Hell, and Cottonwood creeks, part of Sprain et al.'s (2014) "Western Area" of research (32).

In this area, the Garbani Channel was cut through the X Coal to, but apparently not through, the underlying Y Coal (Fig. S1d). Sediments forming the Garbani Channel filling, which are at least 80 feet (24.4 m) thick, are overlain by approximately 23 feet (ca. 7 m) of mudstones, siltstones and sandstones that, in turn, are capped by the W Coal (29, p. 28, Section S13). Sprain et al. (2014) report age determinations of 65.667 Ma and 65.741 Ma from tephra in two lignites within the Y Coal complex exposed in the immediate vicinity of the Garbani Quarry (Fig. S1d, Western Area) (32). The younger age determination sets a maximum age of the

Garbani Channel filling at approximately 400 Ka after the Cretaceous-Paleogene (K-Pg) boundary. An age determination from a tephra within the W Coal is 65.118 Ma, or approximately 925 Ka after the K-Pg boundary. Sprain et al. (2014) found a sediment accumulation rate of 5 to 10 cm/Ka above the HFZ in the composite section (32). Applying this rate, the ca. 7 m of sediment separating the top of the Garbani Channel filling from the base of the W Coal represents approximately 70 to 140 Ka. Using an approximate mid-value of 100 Ka the age of the top of the Garbani Channel would be on the order of 65.2 Ma or approximately 840 Ka after the K-Pg. Unfortunately a tephra suitable for radiometric age determination has yet to be found in the X Coal in the composite section. The reported age determination of a tephra in an X Coal is from a tephra found in a coal in exposed in the valley of McGuire Creek some 60 km to the east (32, Fig. 2, Eastern Area). Stressing the approximations in these calculations; the assumption that the Garbani Channel filling represents a single episode of cutting and filling, not a multistoried event; and time averaging of the vertebrate fossils was not significant, a working hypothesis that the fossils representing the Garbani Channel local faunas document vertebrates that lived between approximately 400 and 840 Ka after the K-Pg is warranted. The Garbani Channel cuts the local X Coal and reaches the younger Y Coal, which suggests the time of its cutting and filling was closer to the higher, more recent, end of this range.

Currently the Puercan North American Land Mammal Age (NALMA) is subdivided into three interval zones. Local faunas, including the Hells Hollow local fauna (Fig. S1d), preserved in sediments of the Tullock Formation deposited during magnetostratigraphic Chron C29r have been referred to the oldest interval zone of the Puercan (Pu1) (29, 38). The localities yielding these local faunas are stratigraphically below the HFZ Coal, which was also deposited during

Chron C29r. Vertebrate fossils from the interval between the HFZ and Y Coals have yet to be discovered and described.

The interval zones Puercan 2 (Pu2) and Puercan 3 (Pu3) are typified on local faunas from the San Juan Basin, New Mexico, found in deposits formed during Chron C29n. The Garbani Channel filling was deposited during Chron C29n. Lofgren et al. (2004) accurately noted that the taxonomic composition of the Garbani Channel local faunas had yet to be fully analyzed (38). They tentatively suggested its biostratigraphic correlation with Pu3 faunas of the San Juan Basin and the Hanna Basin, Wyoming, primarily on the co-occurrence of species of the genus *Taeniolabis*. In the latter two areas *Taeniolabis* is represented by *T. taoensis.* In her study of records of *Taeniolabis* from the Garbani Channel, based on a sample of seven isolated teeth, Simmons (1987) recognized two other species *Taeniolabis*, *T. lamberti* and *T.* sp. Teeth of *T.* sp. differ from those of *T. taoensis* in morphological details (39). The biostratigraphic significance of the occurrence of two species of *Taeniolabis* (*T. lamberti* and *T.* sp.) in the Garbani Channel local fauna in refined correlations remains to be determined. Subsequent analyses of other members of the Garbani Channel local fauna (e.g., 40, 41 and references therein), add support to the proposed temporal correlation with Pu3 local faunas of the San Juan Basin.

In summary, the tarsal elements attributed to *Purgatorius* that are described and analyzed here were derived from individuals that lived between approximately 400 ka and 800 ka after the K-Pg boundary. They were members of the Garbani Channel local fauna that probably is referable to the Pu3 interval zone. Analyses of the taxonomic composition of this local fauna indicate it differs somewhat from Pu3 local faunas in the Hanna and San Juan Basins. A working hypothesis that these differences primarily reflect biogeographic differentiation and not significant difference in age is favored but requires further investigation.

Description and comparison of tarsals attributed to *Purgatorius*

Description of astragali attributed to *Purgatorius*

Seven astragali are attributed to *Purgatorius* (Table S1), and there is a considerable amount of morphological variability present in this sample. This variation includes the degree of robusticity of the astragalar body and the length of the astragalar neck, as illustrated by the two most complete specimens (UCMP 197507, 197509; Fig. S2a). Despite such variability, there are no distinctive qualitative or quantitative differences in one or more specimens with respect to the remainder, leading to the conservative working hypothesis that all of these bones represent a single species. The description of astragali attributed to *Purgatorius* below is based on UCMP 197507 and UCMP 197509 unless otherwise noted. These two specimens are good representative end-members of the observed range of variation documented in this sample.

The astragali attributed to *Purgatorius* have a body that is fairly broad relative to its proximodistal length, a neck that is short, and a head that is mediolaterally broad and oval in distal view (Fig. 1). The dorsal surface of the astragalar trochlea (lateral tibial facet) is shallowly grooved and has lateral and medial trochlear crests that are low, yet clearly defined. The lateral trochlear crest is sharper and slightly taller than the medial trochlear crest. This relates to the considerably greater dorsoventral depth of the fibular facet compared to that of the medial tibial facet. The mediolateral width of the lateral tibial facet is fairly consistent from the proximal to distal margins of this facet. The defined crests of the trochlea (especially the lateral trochlear crest that delimits the lateral tibial facet from the fibular facet) would constrain the upper ankle joint to a fairly hinge-like movement. These limitations would reduce the amount of inversion that could occur at the upper ankle joint of *Purgatorius*.

In dorsal view, from the proximal side of the astragalus, the lateral tibial facet curves slightly distolaterally and then distomedially before extending slightly onto the dorsal surface of the astragalar neck. The lateral arc of the trochlear crests suggests conjunct pedal abduction during dorsiflexion, and adduction during plantarflexion. In taxa such as modern lemuriforms, such morphology has been associated with the use of small diameter supports and or vertical supports (42). The extension of the lateral tibial facet onto the neck (squatting facet) is a reflection of a habitually, strongly dorsiflexed foot that is also typical of taxa that cling to vertical supports (43). The astragalar neck and head are angled approximately 30 degrees distomedially relative to the plane of the lateral tibial facet. The lateral tibial facet extends proximally to the medial aspect of the groove for the tendon of M. flexor fibularis. This groove is large and wide mediolaterally, extending far laterally from the medial margin of the bone. No superior astragalar foramen is present in the more complete specimens attributed to *Purgatorius*, although a small foramen is present in a few specimens (e.g., UCMP 197486), suggesting that this feature is variably either small or absent. Therefore, tissues from the superior astragalar foramen probably would not have limited movement of the tibia proximally (i.e. as in extreme plantarflexion). Nevertheless, extreme plantarflexion was probably infrequent since the lateral tibial facet mainly extends medially on the posterior end of the body.

Astragali attributed to *Purgatorius* have a fibular facet that is convex and slopes slightly laterally, creating a somewhat obtuse angle between the fibular facet and lateral tibial facet. A depression is located posterior and plantar to the fibular facet for attachment of the astragalofibular ligament. The medial tibial facet is vertical dorsoventrally for approximately half of its depth before sloping medioplantarly on the proximal end. The medial tibial facet is clearly separated from the lateral tibial facet by a well-defined medial trochlear crest.

On the plantar surface, the considerably wide groove for the tendon of M. flexor fibularis is bound medially by the plantar margin of the medial tibial facet and laterally by the proximal margin of the ectal facet. The ectal facet approximates in size or is slightly larger than the groove for the tendon of M. flexor fibularis. The ectal facet is saddle-shaped, wider than long, and obliquely oriented relative to the long axis of the astragalus. It is shorter than the corresponding ectal facet on the calcanei, which would allow the astragalus to rotate on the calcaneus at the lower ankle joint. The astragalar ectal facet is bound laterally by the plantar margin of the fibular facet. An inferior astragalar foramen is present at the midline of the base of a well-marked interosseous sulcus for the attachment of the ligament between the astragalus and calcaneus. This sulcus separates the ectal and sustentacular facets. Laterally, there is no obvious ribbon-like extension of the sustentacular facet proximally towards the groove of the M. flexor fibularis. Instead, this area appears non-articular. The sustentacular facet is slightly convex and becomes mediolaterally wider as it continues mediodistally before connecting to the navicular facet distally and spring ligament posteromedially. Despite continuity of articular surfaces for calcaneal sustentaculum, navicular and spring ligament, there is a slight groove marking the distal margin of the sustentacular facet.

In distal view, the astragalar head is oval shaped, being about twice as wide mediolaterally as deep dorsoventrally. The medial and lateral sides of the head are similar in height and extend slightly dorsally and proximally creating a reniform appearance of the head in distal view. On the pronounced medial side of the head, the navicular facet is rounded, reflecting a good range for inversion and eversion at the transverse tarsal joint. The fairly large contact between the navicular and astragalus may have also allowed greater capability for dorsiflexion and adduction of an inverted pes (43).

Comparison of astragali attributed to *Purgatorius* and *Protungulatum*

Partially following characteristics outlined by (44), the astragali of *Purgatorius*, like those of the more recent and derived plesiadapiform *Plesiadapis*, differ from those attributed to *Protungulatum* (as well as the tarsals of other described Puercan mammal astragali) in several ways (Fig. S5). *Protungulatum* is considerably larger than *Purgatorius*. The lateral tibial facet of *Purgatorius* is similar to that of other plesiadapiforms in being relatively longer proximodistally than that of *Protungulatum*. More specifically, the lateral tibial facet of *Purgatorius* represents approximately two-thirds of the entire astragalar length, whereas this facet represents closer to one half of the astragalar length of *Protungulatum*. This would have allowed a greater degree of dorsi- and plantarflexion in the upper ankle joint of *Purgatorius*. In distal view it is apparent that the astragalar body of *Purgatorius* is relatively higher dorsoventrally than that of *Protungulatum*. This is especially true on the lateral side, in which the lateral trochlear crest is positioned higher dorsally than the medial trochlear crest, creating a more medially sloping lateral tibial facet in *Purgatorius*. The superior astragalar foramen is commonly absent or small when present in *Purgatorius*, whereas a large foramen is present in *Protungulatum*.

On the plantar surface of the astragalus, *Purgatorius* has considerable continuity between the sustentacular and navicular facets. This continuity is also characteristic of other euarchontan mammals but is generally lacking in *Protungulatum*, which has distinctly separated facets. This continuity allows a great deal of mobility between the astragalus and calcaneus of *Purgatorius* and helps facilitate inversion of the foot, whereas *Protungulatum* had a more restricted lower ankle joint. Most apparent in distal view, the medial side of the astragalar head of *Purgatorius* is just as prominent as the lateral side, whereas the medial side of the astragalar head of *Protungulatum* is not nearly as developed as the lateral side (44). This suggests that the medial side of the head was stressed more frequently for greater degrees of inversion than that of *Protungulatum*, which was probably a terrestrial plantigrade quadruped better suited for level oriented foot positions and for eversion on a fairly flat substrate (44). The astragalar head is oriented distomedially in *Purgatorius* whereas it is oriented more distolaterally in *Protungulatum*.

Comparison of astragali of euarchontan mammals

The astragali of euarchontan mammals are generally more similar to those attributed to *Purgatorius* than to those of terrestrial taxa such as *Protungulatum* (Fig. S5). Similarities include a lateral tibial facet that is long and extends at least slightly onto the neck, sustentacular and navicular facets that are confluent, and an astragalar head with a more pronounced medial side. Overall, the astragali attributed to *Purgatorius* are most similar to those of other plesiadapiforms in having features such as a lateral tibial facet that is medially sloping, a neck that is short, and a head that is ovoid. Euarchontan comparisons outside Primates are currently limited to extant treeshrews and colugos given the paucity of fossils representing these clades. These extant taxa exhibit autapomorphies in their tarsus, which is not surprising given estimates of more than ~60-70 million years of independent evolution since diverging from other euarchontan mammals (e.g., 45).

The medially sloping lateral tibial facet found in many plesiadapiforms, such as paromomyids and plesiadapids, relates to having a relatively taller fibular facet than medial tibial facet. This pronounced condition is unique to plesiadapiforms among euarchontans, although it should be noted that the lateral side of the lateral tibial facet is slightly taller than the medial side of the astragalus of treeshrews such as *Ptilocercus*. The pronounced medially sloping trochlea of plesiadapiforms may have reduced the potential for lateral sheer of the tibia on the astragalus when using inverted foot postures during locomotion on large-diameter supports (46). Among plesiadapiforms, the medial slope of the trochlea is less pronounced in micromomyid astragali and those attributed to *Purgatorius*, partly due to the presence of a relatively taller and more distinct medial trochlear crest. A possibly related feature in *Purgatorius* and micromomyids is a slightly deeper astragalar trochlea compared to that of most other plesiadapiforms, *Ptilocercus*, and colugos. The more pronounced medial trochlear crest in *Purgatorius* and micromomyids delineates the medial and lateral tibial facets posteriorly in these taxa (47), which would reduce the capacity for inversion at the upper ankle joint. The higher medial trochlear crest also probably served to decrease the degree of static inversion present during neutral, or closest packed-configurations of the bones. In contrast for example, taxa with a more globular astragalar body, such as *Carpolestes simpsoni*, likely had a greater capacity for mobility beyond plantar- and dorsiflexion at the upper ankle joint compared to other plesiadapiforms (48). Relatively less static inversion at the upper ankle joint in *Purgatorius* and micromomyids may relate in part to body size. These taxa are small among plesiadapiforms for which postcrania are known, and unlike larger plesiadapiforms, their hind limbs would span a smaller arc when climbing a tree trunk of a given diameter.

Astragalar medial trochlear ridge height and trochlear depth are not as pronounced in *Purgatorius* and micromomyids as in euprimates such as the fossil adapoid *Notharctus*. However, these features are more pronounced in *Purgatorius* and micromomyids than in less basal plesiadapiforms, suggesting that the more extreme medial slope of some plesiadapids and paromomyids is derived. These more extreme astragalar features among more derived plesiadapiforms, such as *Plesiadapis*, have been previously cited as characteristics that differentiate plesiadapiforms from euprimates (49). *Purgatorius* and micromomyids are more similar to euprimates than treeshrews and colugos in having a lateral tibial facet that is approximately the same mediolateral width from its proximal to distal margins (47), whereas the lateral tibial facet of other plesiadapiforms, such as paromomyids and plesiadapids, is wider distally.

The fibular facet of *Purgatorius* and micromomyids slopes slightly laterally, whereas other plesiadapiforms have a more dorsoventrally vertical fibular facet that forms an approximate right angle with the lateral tibial facet. The more obtuse angle between the fibular facet and lateral tibial facet in *Purgatorius* is somewhat similar to strepsirrhine euprimates, although *Purgatorius* has a convex fibular facet and this facet is concave dorsoplantarly in fossil strepsirrhines (50).

The plantar aspect of the astragalus of *Purgatorius* is generally similar to that of other plesiadapiforms. *Purgatorius* is most like micromomyids in having a groove for flexor fibularis that is large and very mediolaterally wide. This condition is likely primitive, as plesiadapiforms generally have a wider groove for flexor fibularis than euprimates, and *Purgatorius* and micromomyids have an equal or wider groove than more derived plesiadapiforms. This wide astragalar groove for the tendon of flexor fibularis is likely associated with correspondingly large areas for origination of M. flexor tibialis and M. flexor fibularis on the tibia and fibula, respectively, as documented in micromomyids (48). *Purgatorius* and other primates further differ from tupaiids in lacking the ventral projection of the proximomedial aspect of the astragalar body associated with this groove, and further differ from dermopterans in lacking a medially buttressed sulcus astragali that closely approaches this groove.

The head of astragali attributed to *Purgatorius* is much like that of other plesiadapiforms in being about twice as wide as deep, and in having a central depression on the dorsal surface, which makes the head appear reniform in distal view. It is also fairly similar to *Ptilocercus* in these ways, whereas dermopterans and euprimates generally have a more spherical astragalar head. Overall, the astragali of *Purgatorius* are most like those of micromomyid plesiadapiforms, which is in accord with the fact that these taxa have very similar dentitions (9, 10, 51), and are supported as among the most basal primates (Fig. S4b, c).

Description of calcanei attributed to *Purgatorius*

Nine isolated calcanei were attributed to *Purgatorius* (Table S1). One of these specimens is virtually complete (UCMP 197517)(Fig. 1), another is missing the proximal portion of the tuber (UCMP 197515)(Fig. S2b), and the remaining specimens are missing at least the peroneal tubercle (although the position and approximate size of this structure can usually be assessed based on the break on the lateral side of the bone). These calcanei articulate well with the astragali attributed to *Purgatorius* above.

Approximately two-thirds of the calcaneal length consists of the calcaneal tuber and ectal facet, so the calcaneus is rather short distal to the ectal facet (Fig. 1). The short neck of astragali attributed to *Purgatorius* also suggests that the tarsus of *Purgatorius* was not elongate. The calcaneal tuber is fairly deep dorsoventrally. In proximal view, the proximal end of the tuber is ovoid in shape and slightly deeper than mediolaterally wide, although two specimens have tubers with proximal ends more circular in outline (UCMP 197517, 153027). The tuber is wider at the proximal end than directly distal to it. The ectal facet is knuckle-shaped, oriented about 25-30 degrees distolaterally relative to the long axis of the calcaneus, and longer than the corresponding facet on the astragalus. A fibular facet is not present on the lateral side of the ectal facet, which suggests some mobility at the upper ankle joint since the calcaneus does not contact the fibula. The ectal and sustentacular facets are disconnected by an interosseous sulcus. The proximal sustentacular facet is located on a sustentaculum that is fairly large, medially projecting, and positioned mediodistal to the ectal facet. The proximal sustentacular facet is continuous distally, creating a confluent articular surface on the mediodistal side of the bone that ends near the dorsomedial margin of the cuboid facet. Orientations of the proximal and distal sustentacular facets create a concave helical surface for articulation with the corresponding convex astragalar sustentacular facet. This continuity indicates that movements would have occurred between the astragalus and calcaneus at the distal end of the lower ankle joint as well.

The cuboid facet of calcanei attributed to *Purgatorius* is concave and circular in outline and seems well suited for rotation of the cuboid (UCMP 197517 is somewhat abraded and appears to have a square cuboid facet with rounded corners in distal view; Fig. S5). The cuboid facet is oriented approximately 15-20 degrees medially relative to the long axis of the calcaneus. A slight depression is present on the plantar side of the cuboid facet. The anterior plantar tubercle is pronounced, oriented medially, and positioned slightly proximal to the plantar depression of the cuboid facet and just medial to the long axis of the calcaneus. The presence of a groove for the tendon of M. flexor fibularis on the plantar aspect of the sustentaculum is variably present in *Purgatorius*, but this groove is never deep. The peroneal tubercle is damaged or missing in most specimens, but it is clearly large and projects laterally when preserved. It arises just proximal to the distal-most aspect of the ectal facet, and ends proximal to the margin of the cuboid facet. This large tubercle is also fairly deep dorsoventrally, especially on its lateral-most aspect as it projects somewhat dorsally. The peroneal tubercle also has a shallow groove on its lateral side for placement of the tendon of M. peroneus longus, which likely created a more lateral force on the foot for eversion (49). This large tubercle for attachment of peroneal tendons further stresses the importance of eversion and inversion movements of the foot in *Purgatorius*.

Comparison of calcanei attributed to *Purgatorius* and *Protungulatum*

The calcanei attributed to *Purgatorius* and *Protungulatum* differ in many ways beyond the considerably larger size of *Protungulatum* (Fig. S5). The lack of contact between the fibula and the calcaneus in *Purgatorius* reduces some of the restrictions of the upper ankle joint that are imposed by such an articulation. The presence of a fibular facet in *Protungulatum* indicates that the fibula would act to oppose forces occurring at the lower ankle joint (44), whereas the reduction of the articulation between the fibula and calcaneus in *Purgatorius* would allow a greater range of movements, including those contributing to the capacity for hind foot reversal for head-first descent (52).

The ectal facet of *Purgatorius* is more proximodistally aligned than that of *Protungulatum*. *Purgatorius* also differs in having a sustentacular facet that extends broadly onto the distal body of the calcaneus. The helical sustentacular facets of the calcaneus and astragalus would enable inversion at the lower ankle joint of *Purgatorius*, whereas this degree of inversion would not have been frequent, if even possible, in *Protungulatum* partly due to its lack of a significant distal continuity of the sustentacular facet. Inversion and eversion of the foot of *Purgatorius* is further facilitated by the simple gliding articulation of the calcaneocuboid facet that is concave and quite circular in outline, whereas *Protungulatum* has a calcaneocuboid facet that is ovoid, less concave, and less symmetrical with a more expanded lateral side. The cuboid facet of *Purgatorius* is also less obliquely oriented relative to the long axis of the calcaneus compared to that of *Protungulatum*. The peroneal tubercle of the calcaneus is located slightly proximal to the lateral edge of the cuboid facet in *Purgatorius*, whereas it is more distal and level with the cuboid facet in *Protungulatum*.

Comparison of calcanei of euarchontan mammals

The calcanei of euarchontan mammals are generally similar to those attributed to *Purgatorius* in the ways that it differs from more terrestrial taxa such as *Protungulatum* (Fig. S5). Similarities include having an ectal facet that is more in line with the long axis of the calcaneus, a sustentacular facet that is distally continuous onto the body, and a cuboid facet that is concave and quite circular in outline. Like the astragali described above, the calcanei attributed to *Purgatorius* are most like those of other plesiadapiforms among euarchontans. One similarity that is especially apparent is the large size of the peroneal tubercle.

The peroneal tubercle of plesiadapiform calcanei and those attributed to *Purgatorius* is considerably larger and more laterally extended than that of euprimates, treeshrews, and colugos. The large size of the peroneal tubercle may be a plesiomorphic retention that was present in the ancestral euarchontan, given that this condition is also present in calcanei of other Puercan eutherians. Euprimates have a peroneal tubercle that is smaller and more proximally placed than that of *Purgatorius*. This change in size and position may relate to the elongation of the euprimate tarsus (53, 54) and or a functional shift in M. peroneus longus contributing more as a hallucal adductor than an evertor of the foot as in plesiadapiforms (49, 50). It has also been suggested that M. peroneus longus acts more as a plantar-flexor in euprimates (55). Results from a telemetered electromyography study demonstrated that peroneus longus played a greater role in eversion than in hallucal adduction during grasping in two species of lemurid euprimates (56).

Calcanei of micromomyids and those attributed to *Purgatorius* lack a deep groove for the tendon of M. flexor fibularis, which has been documented on the plantar side of the sustentaculum in other plesiadapiforms and euprimates. It should also be noted that micromomyids have large origination areas on the tibia and fibula that indicate large flexor muscles (48), and like the astragali attributed to *Purgatorius*, have a broad astragalar flexor fibularis groove. M. flexor fibularis contributes to digital flexion and plantarflexion of the foot and has been considered to be important for pedal grasping (43). The lack of a deep groove for flexor fibularis on the calcaneus may suggest the lack of powerful grasping in *Purgatorius* and micromomyids. Treeshrews and colugos also lack the deep groove on the calcaneus for the tendon of M. flexor fibularis, which suggests that this condition is primitive for Euarchonta.

Specimens attributed to *Purgatorius* appear to lack a distinct posterior facet of the sustentaculum tali for articulation with the sustentacular facet on the plantar aspect of the medial astragalar pillar. This may also be true for micromomyids, which also have a somewhat flat posterior surface of the sustentaculum tali, yet this facet may simply not be distinct due to the small body size of these taxa. This articulation has been suggested to occur during maximum inversion to increase stability and has been documented on the calcaneus of plesiadapiforms, colugos, and treeshrews, but is much less common in extant and fossil euprimates (47). The calcaneocuboid facet of *Purgatorius* is most like that of non-carpolestid plesiadapiforms, dermopterans, and euprimates in having a plantar pit on the facet (47, 48). Scandentians lack a pit and have an evenly concave facet. Like most other plesiadapiform calcanei, specimens attributed to *Purgatorius* differ from euprimates and large plesiadapids, which have a central and deeper plantar pit on the calcaneocuboid facet that creates a specialized axis of rotation with the proximally projecting process of the cuboid at the transverse tarsal joint (47). The condition of the calcaneocuboid pit of dermopterans may inhibit rotation due to its irregular funnel shape, as well as the flat navicular facet on the calcaneum (57). Overall, tarsals attributed to *Purgatorius* indicate a mobile ankle similar to that of arboreal euarchontan mammals generally, and plesiadapiforms specifically, and further support the hypothesis that arboreality was present in the ancestors of Euarchonta and Primates (11, 21, 43, 44, 48, 58, 59).

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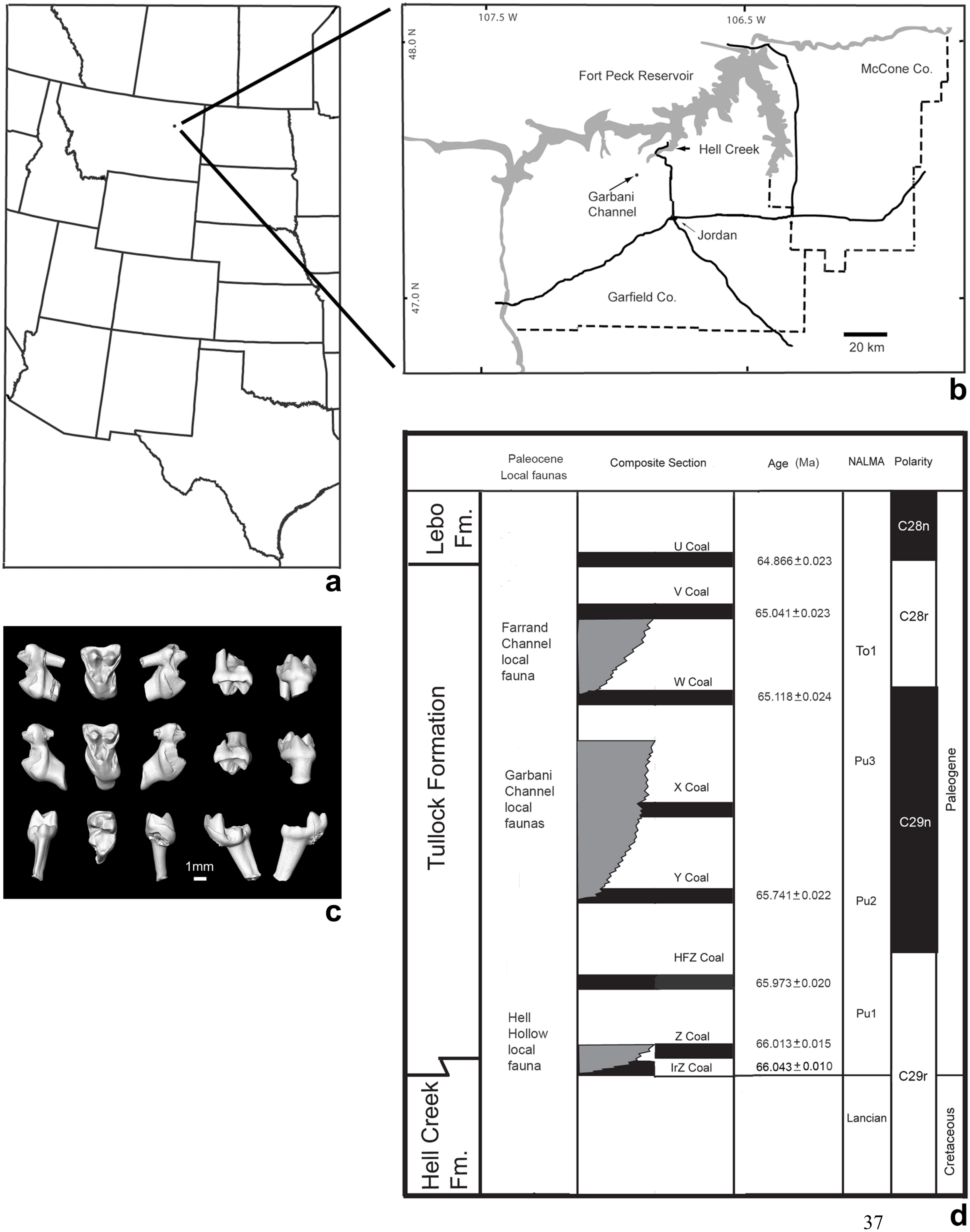
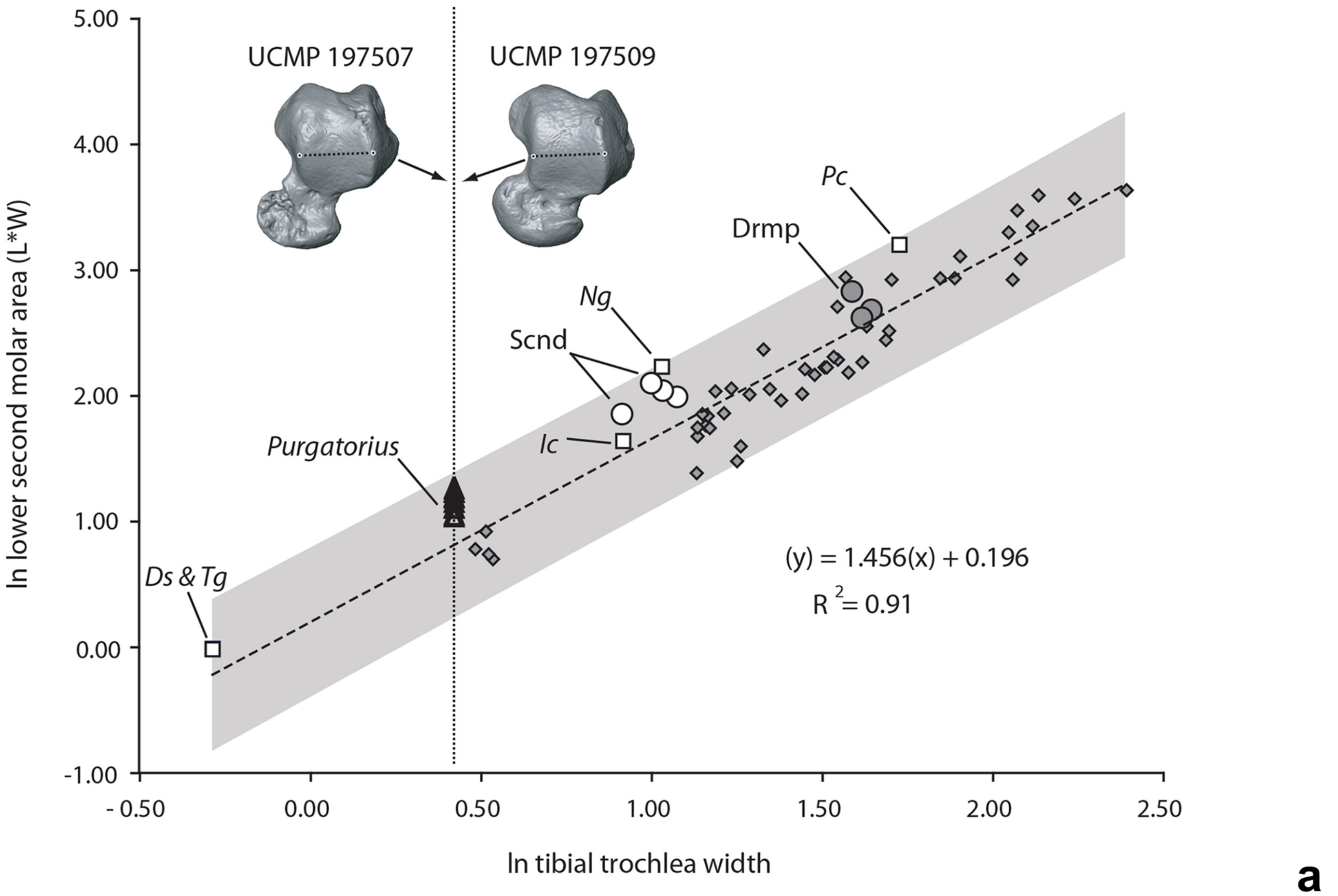
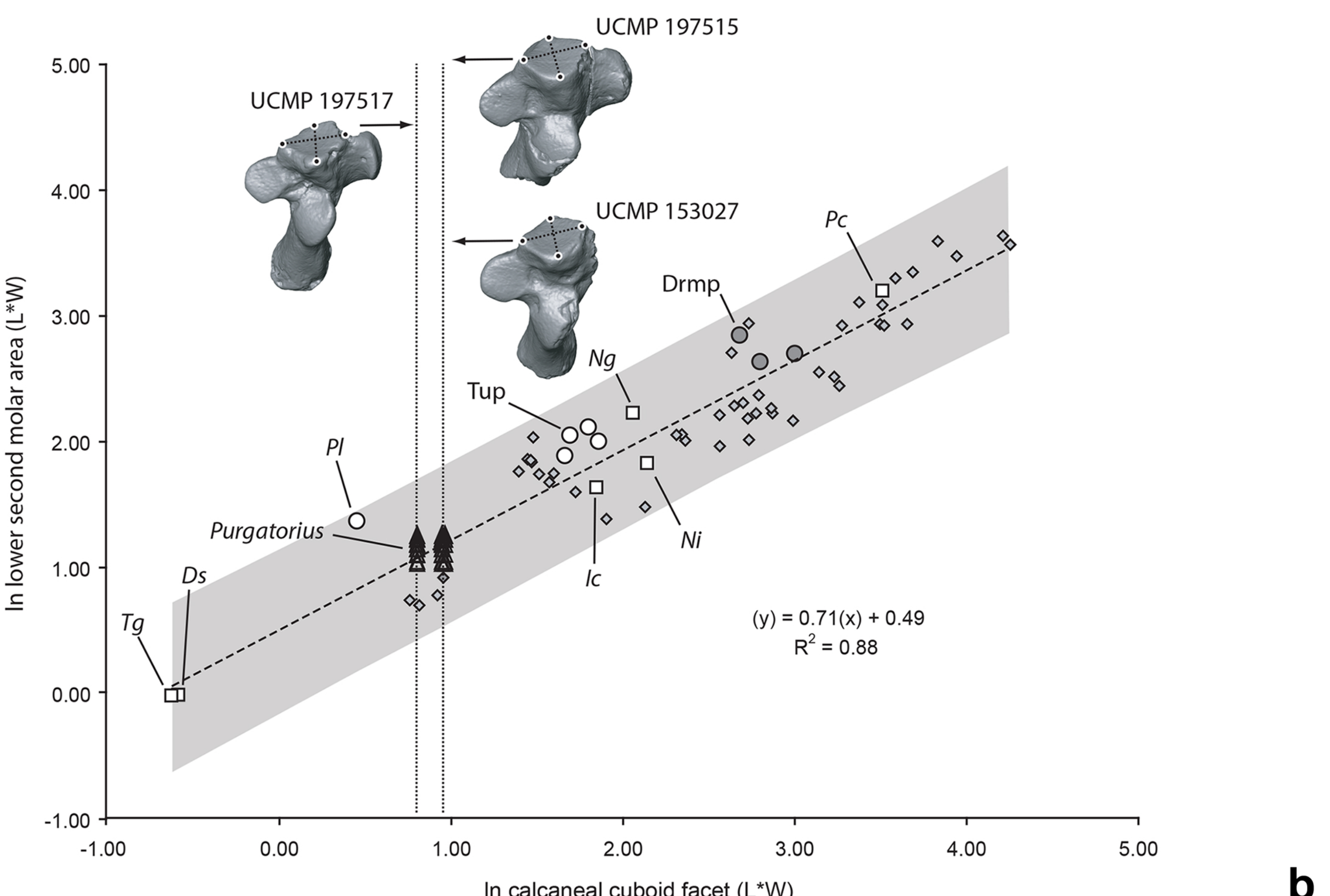

107.5 W
106.5 W
48.0 N
47.0 N
Fort Peck Reservoir
McCone Co.
Hell Creek
Garbani
Channel
Jordan
Garfield Co.
20 km
a
b
c
1mm
d
Paleocene
Local faunas
Composite Section
Age (Ma)
NALMA
Polarity
Lebo
Fm.
Tullock Formation
Hell Creek
Fm.
Farrand
Channel
local
fauna
Garbani
Channel
local
faunas
Hell
Hollow
local
fauna
U Coal
V Coal
W Coal
X Coal
Y Coal
HFZ Coal
Z Coal
IrZ Coal
64.866±0.023
65.041±0.023
65.118±0.024
65.741±0.022
65.973±0.020
66.013±0.015
66.043±0.010
To1
Pu3
Pu2
Pu1
Lancian
C28n
C28r
C29n
C29r
Paleogene
Cretaceous

Fig. S1. Locality maps, stratigraphic column, and *Purgatorius* dental fossils from study area. (**a**) Location of Garfield County in northeastern Montana. (**b**) Location of the outcrops of the Garbani Channel in Garfield County north of the town of Jordan, MT. (**c**) Micro-CT scan images of *Purgatorius* teeth from the late Puercan (Pu3; ~65 MYA) Garbani Channel fauna locality UCMP V99038. UCMP 197540, left first upper molar (top row); UCMP 197546, left second upper molar (middle row); UCMP 197553, left third lower molar (bottom row) in distal, occlusal, mesial, buccal and lingual views, respectively (from left to right). Scale bar, 1mm. (**d**) Generalized stratigraphic section of the Tullock Formation in the valley of Hell Creek and adjacent areas. Sources of the radiometric age and magnetic polarity determinations are discussed in the text.

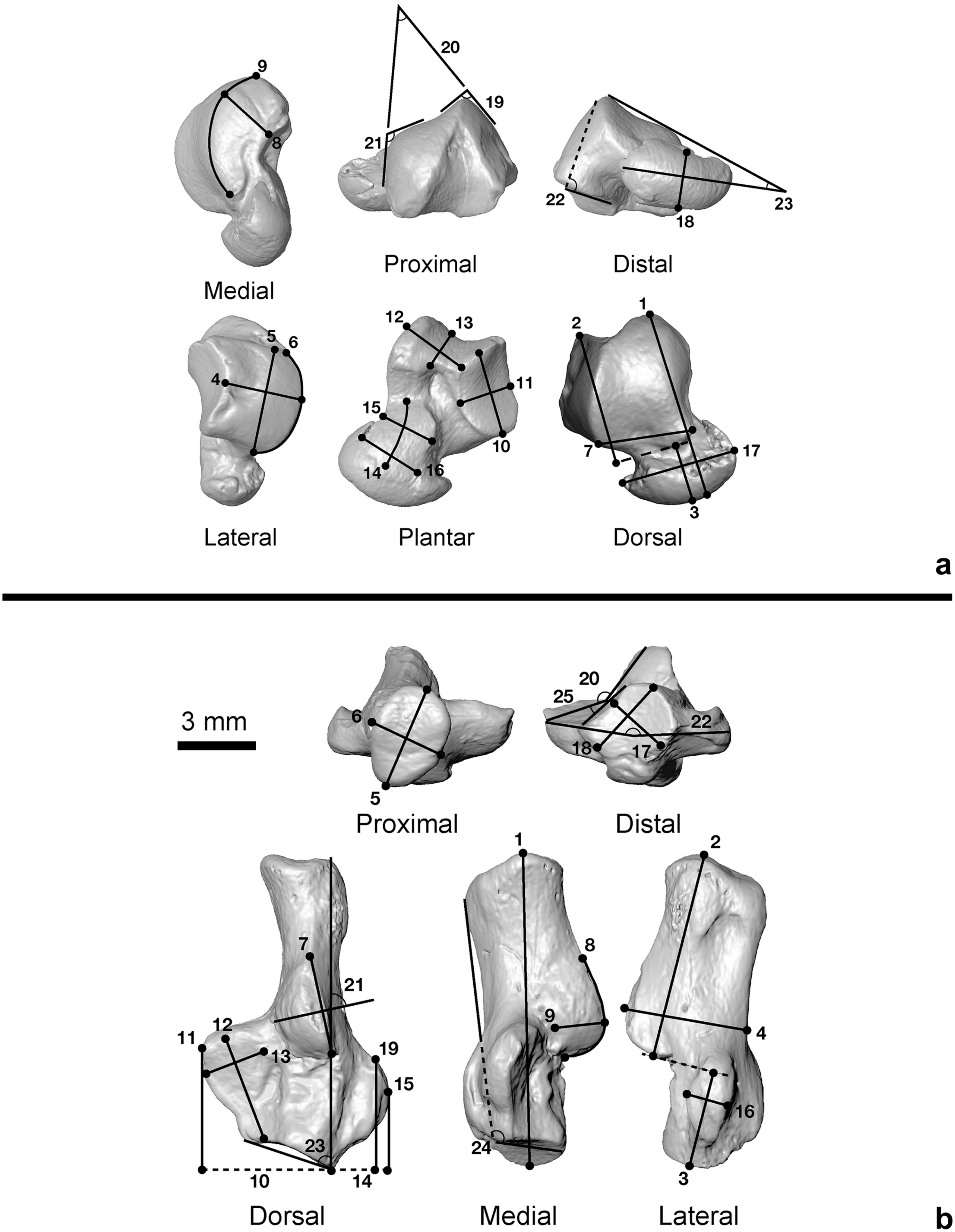


UCMP 197507
UCMP 197509
Pc
Drmp
Ng
Scnd
Ic
Purgatorius
Ds & Tg
(y) = 1.456(x) + 0.196
R 2 = 0.91
ln lower second molar area (L*W)
ln tibial trochlea width
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
- 0.50
0.00
0.50
1.00
1.50
2.00
2.50
a



UCMP 197515
UCMP 197517
UCMP 153027
Pc
Drmp
Ng
Tup
Pl
Purgatorius
Ic
Ni
Tg
Ds
(y) = 0.71(x) + 0.49
R2 = 0.88
ln lower second molar area (L*W)
ln calcaneal cuboid facet (L*W)
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
b

Fig. S2. Least squares plots to evaluate the scaling relationship between aspects of the dentition and tarsals in euarchontan mammals. **(a)** Least squares plot to evaluate the scaling relationship between the natural log of second lower molar area (maximum length * maximum width) and the natural log of astragalar lateral tibial facet width in euarchontan mammals. **(b)** Least squares plot to evaluate the scaling relationship between the natural log of second lower molar area (maximum length * maximum width) and the natural log of calcaneocuboid facet area (maximum depth * maximum width) in euarchontan mammals. See S-Table 2 for taxonomic sample and tarsal measurements. *Purgatorius* dental specimens were collected at Garbani Channel fauna locality UCMP V73080 (see S-Table 3 for *Purgatorius* dental and tarsal measurements). 95% confidence limits on the prediction interval of molar values from tarsal values are shaded in gray. Small gray diamonds represent euprimates, white circles represent Scandentia (Scnd, Scandentia; Tup, Tupaiidae; *Pl*, *Ptilocercus lowii*), gray circles represent Dermoptera (Drmp), white squares represent plesiadapiforms (*Ds*, *Dryomomys szalayi*; *Tg*, *Tinimomys graybulliensis*; *Ic*, *Ignacius clarkforkensis*; *Ng*, *Nannodectes gidleyi*; *Ni*, *Nannodectes intermedius*; Pc, *Plesiadapis cookei*), and black triangles represent the range (all possible combinations) of new isolated tarsals and lower second molars of *Purgatorius* from the Garbani Channel fauna localities.



9
8
Medial
20
19
21
Proximal
22
18
23
Distal
5
6
4
Lateral
12
13
11
15
10
14
16
Plantar
2
1
7
17
3
Dorsal
a
3 mm
6
5
Proximal
20
25
22
18
17
Distal
7
21
11
12
13
19
15
23
10
14
Dorsal
1
8
9
24
Medial
2
4
16
3
Lateral
b

Fig. S3. Tarsal measurements. **(a)** Astragalar measurements following (3). See S-Table 4 for measurement data used in principle component analysis. 1, Maximum proximodistal length; 2, Body proximodistal length; 3, Head and neck proximodistal length; 4, Fibular facet maximum dorsoplantar depth; 5, Fibular facet proximodistal length; 6, Lateral tibial facet maximum proximodistal length (along lateral margin); 7, Lateral tibial facet maximum mediolateral width; 8, Medial tibial facet maximum dorsoplantar depth; 9, Medial tibial facet maximum proximodistal length (along medial margin); 10, Ectal facet proximodistal length; 11, Ectal facet mediolateral width; 12, Flexor fibularis groove mediolateral width; 13, Flexor fibularis groove proximodistal length; 14, Sustentacular facet proximodistal length; 15, Sustentacular facet mediolateral width; 16, Sustentacular facet width of articulation with navicular facet; 17, Head maximum mediolateral width; 18, Head maximum dorsoplantar depth; 19, Angle between fibular facet and lateral tibial facet; 20, Angle between fibular facet and medial tibial facet; 21, Angle between medial and lateral tibial facets; 22, Angle between ectal and fibular facets; 23 Angle between major axis of head and plane of lateral tibial facet. **(b)** Calcaneal measurements following (4). See S-Table 5 for measurement data used in principle component analysis. 1, Maximum proximodistal length; 2, Tuber proximodistal length; 3, Distal calcaneus length; 4, Tuber maximum dorsoplantar depth; 5, Tuber proximal end dorsoplantar depth; 6, Tuber proximal end mediolateral width; 7, Ectal facet proximodistal length; 8, Ectal facet maximum length (along arc); 9, Ectal facet mediolateral width; 10, Medial projection of sustentaculum from ectal facet lateral margin; 11, Sustentaculum medial apex from distal end of calcaneus, proximodistal length; 12, Sustentacular facet proximodistal length; 13, Sustentacular facet mediolateral width; 14, Lateral projection of peroneal tubercle from ectal facet lateral margin; 15, Peroneal tubercle lateral apex from distal end of calcaneus, proximodistal length; 16, Peroneal tubercle dorsoplantar depth; 17, Diameter of calcaneocuboid facet perpendicular to sustentacular facet; 18, Diameter of calcaneocuboid facet parallel to sustentacular facet; 19, Peroneal tubercle proximal margin from distal end of calcaneus, proximodistal length; 20, Angle between ectal facet surface (parallel to its axis) and proximal part of sustentacular facet surface (parallel to its axis); 21, Angle between ectal facet axis and tuber; 22, Angle between peroneal tubercle and sustentaculum; 23, Mediolateral angle between calcaneocuboid facet and tuber axis; 24, Dorsoplantar angle between calcaneocuboid facet and tuber axis; 25, Angle between surface of proximal part of sustentacular facet (parallel to its axis) and distal part of sustentacular facet (parallel to its axis).

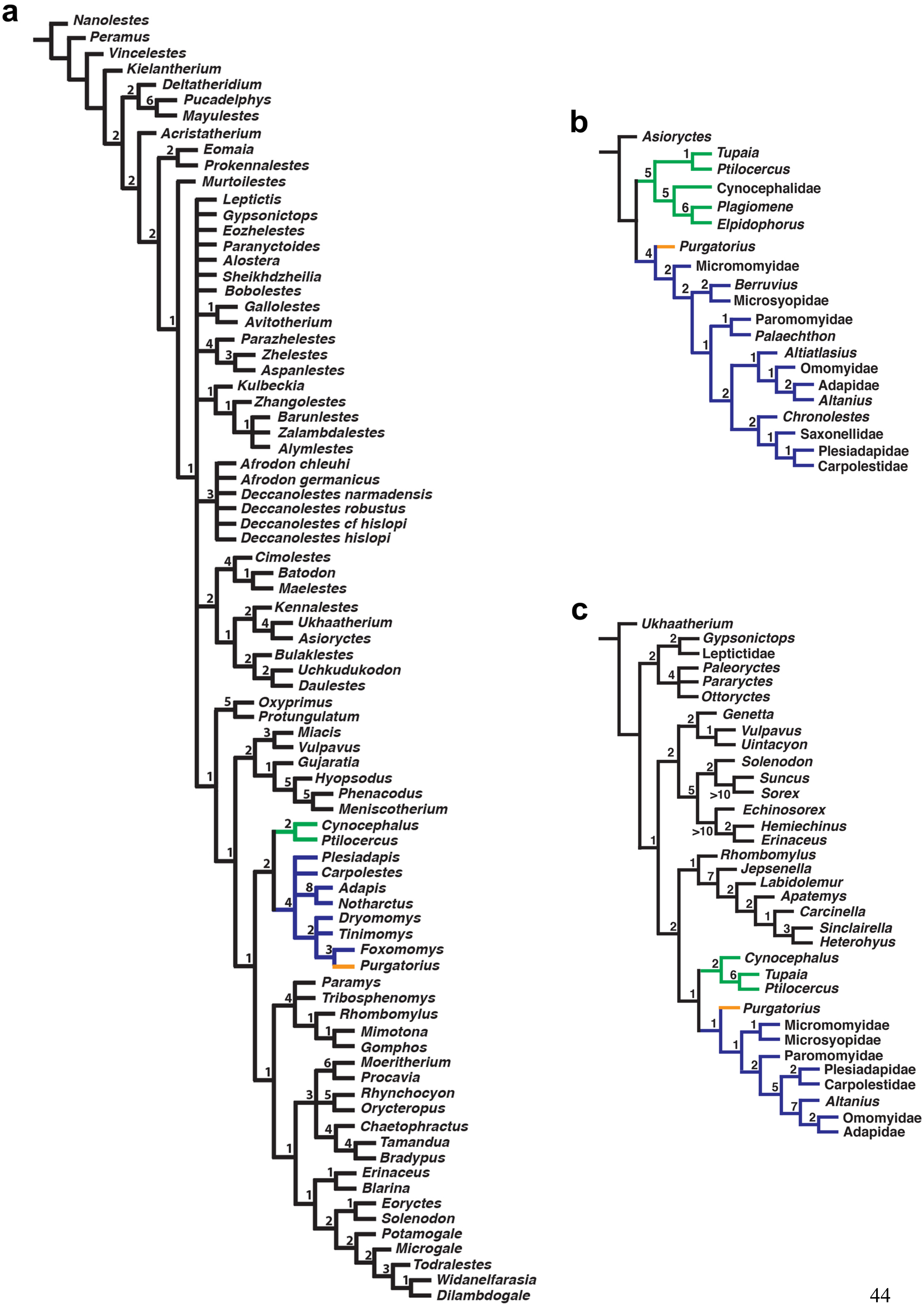
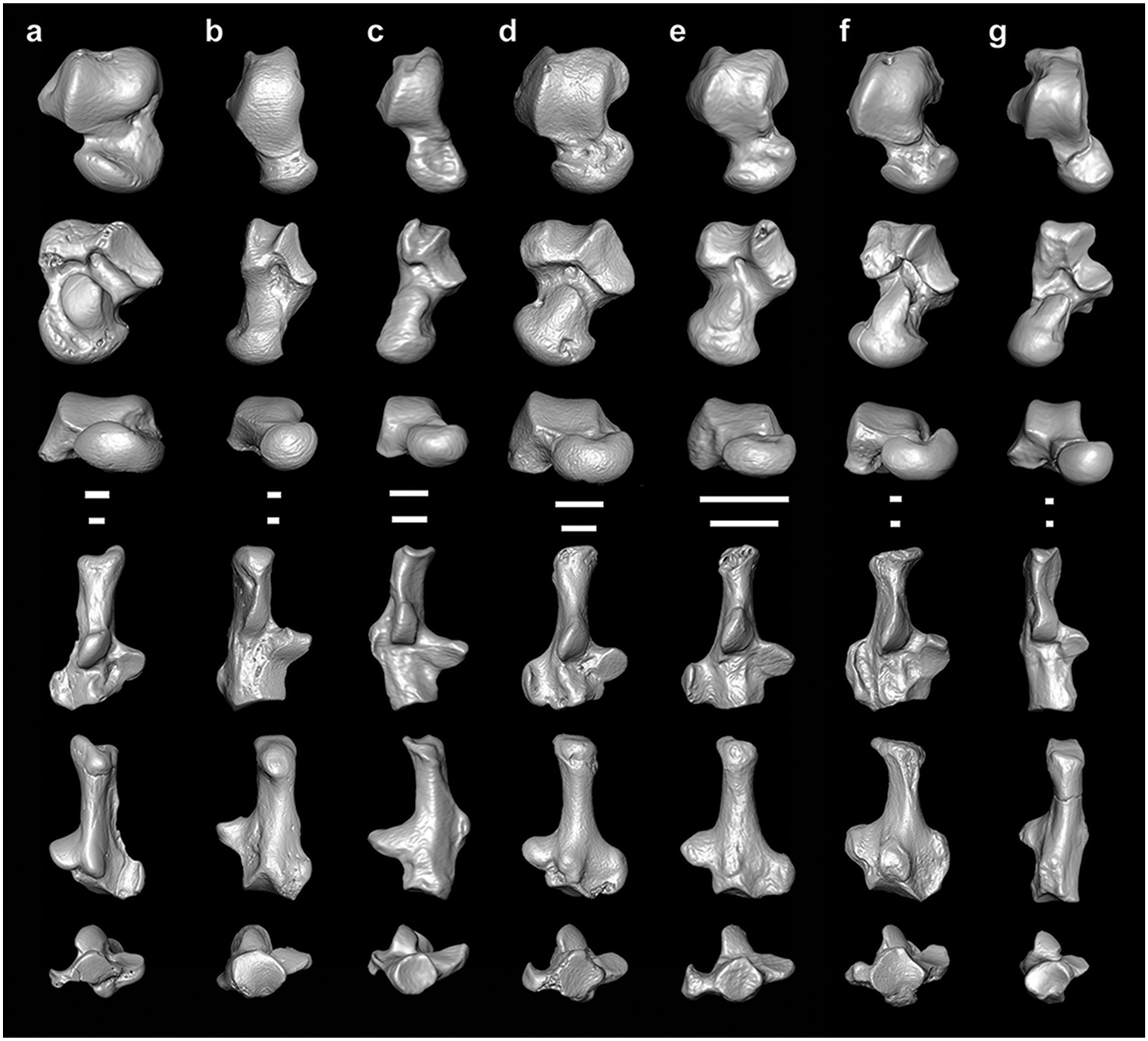

a
Nanolestes
Peramus
Vincelestes
Kielantherium
Deltatheridium
Pucadelphys
Mayulestes
Acristatherium
Eomaia
Prokennalestes
Murtoilestes
Leptictis
Gypsonictops
Eozhelestes
Paranyctoides
Alostera
Sheikhdzheilia
Bobolestes
Gallolestes
Avitotherium
Parazhelestes
Zhelestes
Aspanlestes
Kulbeckia
Zhangolestes
Barunlestes
Zalambdalestes
Alymlestes
Afrodon chleuhi
Afrodon germanicus
Deccanolestes narmadensis
Deccanolestes robustus
Deccanolestes cf hislopi
Deccanolestes hislopi
Cimolestes
Batodon
Maelestes
Kennalestes
Ukhaatherium
Asioryctes
Bulaklestes
Uchkudukodon
Daulestes
Oxyprimus
Protungulatum
Miacis
Vulpavus
Gujaratia
Hyopsodus
Phenacodus
Meniscotherium
Cynocephalus
Ptilocercus
Plesiadapis
Carpolestes
Adapis
Notharctus
Dryomomys
Tinimomys
Foxomomys
Purgatorius
Paramys
Tribosphenomys
Rhombomylus
Mimotona
Gomphos
Moeritherium
Procavia
Rhynchocyon
Orycteropus
Chaetophractus
Tamandua
Bradypus
Erinaceus
Blarina
Eoryctes
Solenodon
Potamogale
Microgale
Todralestes
Widanelfarasia
Dilambdogale
b
Asioryctes
Tupaia
Ptilocercus
Cynocephalidae
Plagiomene
Elpidophorus
Purgatorius
Micromomyidae
Berruvius
Microsyopidae
Paromomyidae
Palaechthon
Altiatlasius
Omomyidae
Adapidae
Altanius
Chronolestes
Saxonellidae
Plesiadapidae
Carpolestidae
c
Ukhaatherium
Gypsonictops
Leptictidae
Paleoryctes
Pararyctes
Ottoryctes
Genetta
Vulpavus
Uintacyon
Solenodon
Suncus
Sorex
Echinosorex
Hemiechinus
Erinaceus
Rhombomylus
Jepsenella
Labidolemur
Apatemys
Carcinella
Sinclairella
Heterohyus
Cynocephalus
Tupaia
Ptilocercus
Purgatorius
Micromomyidae
Microsyopidae
Paromomyidae
Plesiadapidae
Carpolestidae
Altanius
Omomyidae
Adapidae

Fig. S4. Hypotheses of evolutionary relationships of *Purgatorius* and other eutherian mammals. **(a)** Resulting strict consensus cladogram modified from character matrix of (6) (see S-Table 8) with addition of *Purgatorius* tarsal data and five euarchontan taxa (colugo *Cynocephalus*, micromomyid plesiadapiforms *Foxomomys*, *Dryomomys*, *Tinimomys*, and carpolestid plesiadapiform *Carpolestes*). **(b)** Resulting single-most-parsimonious cladogram modified from character matrix of (11) (see S-Table 9) with addition of *Purgatorius* tarsal data. **(c)** Resulting strict consensus cladogram modified from character matrix of (24) (see S-Table 10) with addition of *Purgatorius* tarsal data. In all cladograms Sundatheria is supported and indicated in green, Primates is supported and indicated in violet, and *Purgatorius* is supported as a primate and indicated in orange. Bremer support indices calculated in TNT are located above branches.


a
b
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g

Fig. S5. Comparison of micro-CT scan images of tarsal bones. Columns illustrate tarsals of condylarth *Protungulatum* (**a**), colugo *Cynocephalus* (**b**), treeshrew *Ptilocercus* (**c**), *Purgatorius* (**d**), micromomyid plesiadapiform *Dryomomys* (**e**), plesiadapid plesiadapiform *Plesiadapis* (**f**), and adapoid euprimate *Notharctus* (**g**). Right astragali (top three rows) and calcanei (bottom three rows) illustrated in dorsal (top), plantar (middle), and distal (bottom) views, respectively. Some elements are reversed for clarity. Scale bars for respective astragali (top) and calcanei (bottom), all 1mm. Specimen numbers for astragali and calcanei, respectively, or for both, are as follows: *Protungulatum* (AMNH 118260, 118060); *Cynocephalus* (UNSM 15502, AMNH 207001); *Ptilocercus* (USNM 488072); *Purgatorius* (UCMP 197509, 197517); *Dryomomys* (UM 41870); *Plesiadapis* (UM 87990); *Notharctus* (AMNH 11474).

Supplementary Tables

Table S1. Tarsal specimens attributed to *Purgatorius* from the Garbani Channel Fauna

Order	Taxon	Catalogue Number	Locality	Element
Primates	*Purgatorius*	UCMP 153013	UCMP V75194	calcaneus
Primates	*Purgatorius*	UCMP 153027	UCMP V74122	calcaneus
Primates	*Purgatorius*	UCMP 177255	UCMP V72128	calcaneus
Primates	*Purgatorius*	UCMP 197482	UCMP V72128	calcaneus
Primates	*Purgatorius*	UCMP 197485	UCMP V74122	astragalus
Primates	*Purgatorius*	UCMP 197486	UCMP V74122	astragalus
Primates	*Purgatorius*	UCMP 197487	UCMP V74122	calcaneus
Primates	*Purgatorius*	UCMP 197489	UCMP V74122	astragalus
Primates	*Purgatorius*	UCMP 197507	UCMP V99438	astragalus
Primates	*Purgatorius*	UCMP 197508	UCMP V99438	calcaneus
Primates	*Purgatorius*	UCMP 197509	UCMP V99438	astragalus
Primates	*Purgatorius*	UCMP 197511	UCMP V99438	astragalus
Primates	*Purgatorius*	UCMP 197513	UCMP V99438	astragalus
Primates	*Purgatorius*	UCMP 197515	UCMP V99438	calcaneus
Primates	*Purgatorius*	UCMP 197516	UCMP V99438	calcaneus
Primates	*Purgatorius*	UCMP 197517	UCMP V99438	calcaneus

Table S2. Data for regression of tooth dimensions on tarsal dimensions

Order	Taxon	Catalogue Number	aW	cW	cD	tL	tW
Dermoptera	*Galeopterus variegatus*	UNSM ZM 15502	4.93	4.14	3.55	4.46	3.81
Dermoptera	*Galeopterus variegatus*	BAA NN	5.08	4.53	3.66	3.91	3.49
Dermoptera	*Cynocephalus volans*	FMNH 61032	5.20	5.30	3.85	3.99	3.67
Primates	*Avahi laniger laniger*	AMNH 170461	5.10	5.29	4.37	4.27	3.01
Primates	*Daubentonia madagascariensis*	AMNH 185643	6.61	7.74	4.99	4.85	3.88
Primates	*Eulemur fulvus fulvus*	AMNH 31254	6.71	6.43	4.54	6.06	3.70
Primates	*Eulemur mongoz*	AMNH 17403	5.49	5.70	4.64	5.36	3.47
Primates	*Euoticus elegantulus*	AMNH 269914	3.49	3.27	2.57	2.43	1.81
Primates	*Galago crassicaudatus*	AMNH 216239	5.45	5.93	4.26	3.79	3.27
Primates	*Galago crassicaudatus*	AMNH 216244	5.40	5.90	4.41	3.78	3.05
Primates	*Galago senegalensis*	AMNH 119521	3.10	2.60	2.58	2.21	1.81
Primates	*Galago senegalensis*	AMNH 244100	3.53	2.80	2.00	2.38	2.08
Primates	*Hapalemur griseus*	AMNH 170689	4.80	4.53	3.39	4.91	3.86
Primates	*Hapalemur griseus griseus*	AMNH 61589	4.68	4.86	2.86	4.52	3.32
Primates	*Indri indri*	AMNH 100504	9.38	9.15	7.69	6.84	5.18
Primates	*Lemur catta*	AMNH 22912	6.33	7.30	4.52	5.12	3.68
Primates	*Lemur catta*	AMNH 170739	7.83	7.58	4.46	5.16	3.61
Primates	*Lepilemur mustelinus leucopus*	AMNH 170569	4.22	4.73	3.25	3.46	2.17
Primates	*Lepilemur mustelinus leucopus*	AMNH 170568	4.84	4.70	3.25	3.56	2.50
Primates	*Lepilemur mustelinus leucopus*	AMNH 170556	4.51	4.53	3.54	3.78	2.45
Primates	*Lepilemur mustelinus leucopus*	AMNH 170559	4.26	4.53	2.86	3.87	2.36
Primates	*Lepilemur mustelinus leucopus*	AMNH 170560	4.69	4.51	3.13	3.86	2.55
Primates	*Lepilemur mustelinus leucopus*	AMNH 170565	3.84	3.60	2.80	3.32	2.35
Primates	*Microcebus griseorufus*	AMNH 174430	1.62	1.51	1.66	1.57	1.39
Primates	*Microcebus griseorufus*	AMNH 174415	1.71	1.71	1.32	1.55	1.30
Primates	*Microcebus griseorufus*	AMNH 174472	1.68	1.57	1.36	1.60	1.31
Primates	*Microcebus griseorufus*	AMNH 174383	1.67	1.73	1.50	1.86	1.35
Primates	*Nycticebus coucang*	AMNH 90381	3.62	3.96	2.68	3.06	2.44
Primates	*Nycticebus coucang javanicus*	AMNH 102027	3.97	5.03	2.58	3.10	2.30
Primates	*Nycticebus coucang menagensis*	AMNH 16591	3.43	2.71	3.84	2.80	2.80
Primates	*Perodicticus potto*	AMNH 184597	4.54	4.75	3.71	3.62	2.56
Primates	*Perodicticus potto*	AMNH 269851	4.63	4.50	3.30	3.60	2.80
Primates	*Perodicticus potto*	AMNH 269907	5.04	5.03	3.48	3.55	2.72
Primates	*Perodicticus potto*	AMNH 52698	4.38	5.29	3.76	3.21	2.72
Primates	*Perodicticus potto*	AMNH 86898	3.77	4.40	3.70	3.59	2.98
Primates	*Propithecus diadema edwardsi*	AMNH 100633	10.93	9.00	7.50	7.30	5.20
Primates	*Propithecus verrauxi coquereli*	AMNH 208991	8.30	7.00	5.70	6.39	4.46
Primates	*Propithecus verreauxi verreauxi*	AMNH 170491	8.02	6.62	5.05	5.76	3.81
Primates	*Propithecus verreauxi verreauxi*	AMNH 170474	7.74	6.95	5.19	6.36	4.26
Primates	*Tarsius bancanus bancanus*	AMNH 106754	3.36	2.38	1.78	2.67	2.41
Primates	*Tarsius bancanus bancanus*	AMNH 106649	3.18	2.34	1.72	2.40	2.43
Primates	*Tarsius bancanus borneanus*	AMNH 106010	3.27	2.27	1.93	2.91	2.63
Primates	*Tarsius spectrum*	AMNH 109367	3.11	2.52	1.91	2.35	2.28
Primates	*Tarsius spectrum*	AMNH 109369	3.11	2.42	2.04	2.30	2.50
Primates	*Tarsius spectrum*	AMNH 109368	3.22	2.45	1.85	2.41	2.37
Primates	*Tarsius syrichta*	AMNH 203296	3.20	2.38	1.83	2.64	2.38
Primates	*Tarsius syrichta*	AMNH 203297	3.15	2.26	1.91	2.66	2.40
Primates	*Varecia variegata*	AMNH 201384	7.93	9.23	5.58	6.80	4.75
Primates	*Varecia variegata variegata*	AMNH 100512	8.44	8.56	5.39	7.19	5.06
Primates	***Dryomomys szalayi***	UM 41870	0.75	0.75	0.74	1.04	0.95
Primates	***Ignacius clarkforkensis***	UM 82606; 108210	2.50	2.53	2.50	2.35	2.19
Primates	***Nannodectes gidleyi***	AMNH 17379	2.80	2.95	2.65	3.00	3.10
Primates	***Nannodectes intermedius***	USNM 309902; 442229	na	3.10	2.74	2.40	2.60
Primates	***Plesiadapis cookei***	UM 87990	5.62	6.61	5.06	5.31	4.63
Primates	***Tinimomys graybulliensis***	USNM 461201	0.75	0.82	0.65	1.08	0.91
Scandentia	*Ptilocercus lowii*	YPM MAM 010179	na	1.44	1.09	2.42	1.59
Scandentia	*Tupaia sp.*	YPM MAM 010169	2.74	2.50	2.43	3.37	2.41
Scandentia	*Tupaia sp.*	YPM MAM 010518	2.93	2.59	2.48	3.27	2.23
Scandentia	*Tupaia sp.*	YPM MAM 010601	2.51	2.32	2.30	3.06	2.09
Scandentia	*Tupaia sp.*	YPM MAM 010602	2.83	2.28	2.40	3.28	2.33

aW = astragalar lateral tibial facet width; cW = calcaneal cuboid facet mediolateral width; cD = calcaneal cuboid facet dorsoplantar depth; tL = lower second molar maximum mesiodistal length; tW = lower second molar maximum buccolingual width. Fossil taxa in bold.

Table S3. Tooth and tarsal dimensions of *Purgatorius* from the Garbani Channel Fauna

Order	Taxon	Catalogue Number	Element	aW	cW	cD	tL	tW
Primates	*Purgatorius*	UCMP 107406	m2	na	na	na	2.11	1.67
Primates	*Purgatorius*	UCMP 111585	m2	na	na	na	1.99	1.66
Primates	*Purgatorius*	UCMP 111606	m2	na	na	na	2.00	1.71
Primates	*Purgatorius*	UCMP 129267	m2	na	na	na	1.94	1.49
Primates	*Purgatorius*	UCMP 129268	m2	na	na	na	2.04	1.68
Primates	*Purgatorius*	UCMP 130605	m2	na	na	na	1.84	1.54
Primates	*Purgatorius*	UCMP 157979	m2	na	na	na	1.97	1.68
Primates	*Purgatorius*	UCMP 189590	m2	na	na	na	1.84	1.66
Primates	*Purgatorius*	UCMP 223152	m2	na	na	na	1.96	1.61
Primates	*Purgatorius*	UCMP 223154	m2	na	na	na	1.98	1.66
Primates	*Purgatorius*	UCMP 223156	m2	na	na	na	2.18	1.58
Primates	*Purgatorius*	UCMP 197507	astragalus	1.53	na	na	na	na
Primates	*Purgatorius*	UCMP 197509	astragalus	1.52	na	na	na	na
Primates	*Purgatorius*	UCMP 153027	calcaneus	na	1.62	1.62	na	na
Primates	*Purgatorius*	UCMP 197515	calcaneus	na	1.64	1.57	na	na
Primates	*Purgatorius*	UCMP 197517	calcaneus	na	1.58	1.41	na	na

Table S4. Measurement data for principle component analysis of astragalus

Higher taxon	Taxon	Catalogue Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	GM	19	20	21	22	23
Adapisoriculidae	***Deccanolestes hislopi***	VPL/JU/NKIM/52	1.73	1.04	0.67	0.83	0.80	1.07	0.74	0.61	1.31	0.66	0.45	0.77	0.61	0.73	0.41	0.50	0.80	0.41	0.73	97	45	97	91	5
Adapisoriculidae	***Deccanolestes robustus***	VPL/JU/NKIM/51	2.52	1.34	0.89	1.10	1.20	1.51	0.94	1.02	1.95	0.98	0.64	1.28	0.93	1.00	0.59	0.58	1.20	0.81	1.10	118	58	102	93	-9
Cimolestidae	***Procerberus formicarum***	AMNH 117454	6.78	3.39	3.33	2.60	3.74	5.17	3.72	2.57	4.32	3.39	1.78	2.31	1.91	2.04	2.04	0.92	3.67	2.26	2.98	84	27	103	125	-10
Condylarthra	***Protungulatum donnae***	AMNH 118260	6.72	4.02	2.68	2.66	3.59	4.01	3.52	2.42	4.78	3.05	1.78	3.15	2.23	2.64	1.85	0.99	4.28	2.33	3.06	96	38	107	108	-5
Condylarthra	***Protungulatum donnae***	AMNH 11878	6.83	4.53	2.21	2.58	3.43	3.91	3.64	2.66	4.99	3.87	1.86	2.81	2.00	2.81	2.20	1.43	4.14	2.60	3.15	98	40	92	111	-11
Dermoptera	*Cynocephalus volans*	USNM 144662	10.51	7.35	2.48	3.98	5.66	6.80	4.70	4.33	10.48	4.79	2.09	4.25	4.27	3.65	2.14	2.45	4.59	3.64	4.58	103	18	95	105	8
Dermoptera	*Cynocephalus volans*	USNM 578084	10.84	9.18	1.67	3.78	6.24	7.19	5.52	4.39	10.74	5.12	2.02	3.65	3.96	3.88	2.64	2.94	5.38	3.89	4.77	108	13	92	112	7
Dermoptera	*Cynocephalus volans*	USNM 317118	11.07	8.63	2.55	4.23	5.73	7.00	5.67	3.70	10.08	4.56	2.19	2.87	3.77	3.65	2.22	2.40	4.78	4.00	4.52	99	14	97	113	12
Omomyoidea	***Hemiacodon gracilis***	AMNH 12613A	8.21	4.32	3.89	2.71	3.73	6.38	3.66	3.77	6.59	3.06	1.65	1.68	1.72	3.95	1.75	2.73	3.47	2.82	3.25	81	7	72	106	-8
Omomyoidea	***Omomys carteri***	UM 98648	6.66	3.17	3.44	2.39	3.35	4.03	2.61	2.66	4.26	2.72	1.45	1.07	1.43	2.74	1.32	1.48	2.91	2.27	2.50	74	6	68	99	2
Omomyoidea	***Omomys carteri***	UM 38321	6.91	3.50	3.39	2.36	3.26	4.46	2.69	2.41	4.00	2.87	1.45	1.11	1.35	2.77	1.01	1.85	2.66	2.17	2.43	72	6	74	102	-9
Haplorhini	*Cebuella pygmaea*	SBU-C01	4.97	2.91	2.01	1.53	2.50	3.48	2.25	1.64	3.21	2.14	1.00	1.05	1.14	1.90	1.16	1.59	2.27	1.65	1.91	70	13	87	112	-5
Haplorhini	*Cebus apella*	SBU-NCb04	18.47	11.82	6.66	6.51	10.94	14.61	7.68	6.72	14.72	8.46	4.24	4.46	3.21	7.77	4.03	6.53	7.95	6.12	7.42	78	8	85	117	-16
Haplorhini	*Saguinus oedipus*	SBU-NSg06	8.84	5.17	3.53	2.84	4.81	7.11	3.77	2.50	6.56	3.79	1.93	2.01	2.12	4.03	2.12	2.64	3.69	2.75	3.50	70	17	85	115	-10
Haplorhini	*Saimiri sciureus*	SBU-Nsm06	11.19	6.46	4.52	3.33	5.87	6.88	5.38	3.81	7.91	5.06	2.57	2.36	1.82	5.59	2.09	2.53	4.04	3.14	4.17	77	11	72	114	-11
Haplorhini	*Tarsius syrichta carbonarius*	AMNH 203296	6.38	3.76	2.65	1.68	3.01	3.74	3.22	2.29	5.12	3.07	1.09	1.46	0.66	2.29	1.93	1.92	2.80	1.85	2.34	83	16	61	110	6
Plesiadapiform	***Carpolestes simpsoni***	UM 101963	4.70	2.97	1.86	1.95	2.44	2.83	2.14	1.25	3.09	2.17	1.13	1.30	1.27	2.31	1.30	1.58	2.64	1.57	1.97	82	34	80	86	27
Plesiadapiform	***Dryomomys szalayi***	UM 41870	1.79	1.16	0.74	0.76	1.10	1.10	0.73	0.63	1.40	0.87	0.44	0.66	0.38	0.62	0.35	0.39	0.98	0.43	0.73	105	56	112	86	15
Plesiadapiform	***Ignacius graybullianus***	USNM 442235	4.57	2.88	1.71	1.80	2.54	2.85	2.20	1.46	2.78	1.94	1.21	1.28	0.94	1.91	0.98	1.32	2.64	1.43	1.86	80	38	88	89	22
Plesiadapiform	***Nannodectes gidleyi***	AMNH 17379	6.84	5.02	2.37	2.43	3.33	3.66	2.92	1.99	4.63	3.25	1.57	2.11	1.53	2.43	1.95	2.46	3.86	2.03	2.72	78	27	112	93	17
Plesiadapiform	***Plesiadapis cookei***	UM 87990	13.02	8.14	4.64	4.90	6.80	7.25	5.62	3.40	8.40	5.47	2.92	4.96	4.47	5.72	2.90	3.50	6.94	3.68	5.31	84	22	115	93	14
Plesiadapiform	***Plesiadapis rex***	UM 94816	7.94	5.51	2.46	3.39	4.10	5.43	3.86	3.01	6.32	3.49	2.71	2.97	2.44	2.98	2.39	2.99	4.79	2.27	3.61	92	43	116	93	18
Plesiadapiform	***Plesiadapis tricuspidens***	MNHN BR 14537	11.05	7.24	4.16	4.54	6.52	7.35	5.51	3.17	8.42	5.48	3.08	3.48	3.08	4.21	2.78	2.91	6.45	3.54	4.81	81	40	119	87	16
Plesiadapiform	***Plesiadapis tricuspidens***	MNHN nn	9.97	7.47	3.00	4.07	5.82	6.75	4.89	4.24	7.75	4.95	2.92	3.20	3.06	3.91	2.81	2.46	5.35	3.58	4.56	89	35	116	91	21
Plesiadapiform	***Plesiadapis tricuspidens***	MNHN R 5347	10.88	7.58	3.45	5.22	6.54	7.07	5.56	3.80	8.68	5.22	3.42	4.01	3.97	4.55	3.23	3.72	6.25	3.45	5.12	87	53	132	93	11
Plesiadapiform	***Plesiadapis tricuspidens***	MNHN R 610	10.96	7.80	3.22	4.69	6.61	8.01	5.65	4.00	9.33	5.44	3.23	3.86	3.32	3.87	3.45	4.47	6.34	3.50	5.08	77	37	131	92	20
Plesiadapiform	***Purgatorius***	UCMP 197509	3.34	2.31	1.25	1.46	1.75	2.25	1.53	1.13	2.57	1.65	1.03	1.32	0.86	1.27	0.96	1.12	1.93	0.95	1.48	99	49	114	88	14
Plesiadapiform	***Purgatorius***	UCMP 197507	3.41	2.27	1.33	1.46	1.72	2.30	1.52	1.21	2.62	1.58	0.86	1.19	0.78	1.59	0.74	1.14	1.74	0.88	1.43	93	46	107	88	17
Plesiadapiform	***Tinimomys graybulliensis***	USNM 461201	2.42	1.29	1.16	0.92	1.40	1.55	0.93	0.78	1.80	1.14	0.61	0.87	0.48	0.69	0.50	0.54	1.10	0.53	0.94	118	50	113	85	18
Scandentia	*Ptilocercus lowii*	USNM 488067	4.28	1.96	2.17	1.31	2.03	2.71	1.49	1.32	3.34	1.58	0.96	0.72	1.08	1.61	0.99	1.08	1.65	1.14	1.55	95	36	123	90	7
Scandentia	*Ptilocercus lowii*	USNM 488072	4.23	1.95	2.14	1.32	2.03	2.80	1.43	1.34	3.42	1.56	0.98	0.71	1.08	1.64	1.03	1.12	1.63	1.17	1.56	100	39	121	91	11
Scandentia	*Ptilocercus lowii*	USNM 488069	4.36	2.07	2.17	1.39	2.11	2.81	1.44	1.36	3.55	1.47	0.92	0.78	0.87	1.60	1.00	1.17	1.74	1.17	1.55	101	32	126	93	5
Scandentia	*Tupaia belangeri*	AMNH 113135	6.05	3.27	2.68	1.72	2.84	4.68	2.85	1.67	3.90	2.64	1.72	1.30	1.31	2.43	1.18	1.64	2.67	1.79	2.30	94	-1	56	105	-15
Scandentia	*Tupaia glis*	SBU coll.	6.06	3.69	2.20	1.67	2.59	4.02	3.09	1.70	3.59	2.47	1.67	0.99	1.48	2.47	1.02	1.69	2.79	1.69	2.21	72	6	87	105	-9
Scandentia	*Urogale everetti*	AMNH 203293	6.83	3.66	3.18	2.28	2.28	4.66	3.22	1.76	4.02	2.91	1.93	1.44	1.55	2.27	1.44	1.29	3.30	2.12	2.52	95	-5	62	104	2
Adapoidea	***Leptadapis magnus***	AMNH 127411	25.21	17.30	7.58	9.55	12.02	13.45	10.65	7.71	19.74	10.80	5.51	6.18	6.02	8.84	4.80	4.85	12.33	9.04	9.73	89	20	85	109	17
Adapoidea	***Notharctus tenebrosus***	AMNH 11474	16.64	10.70	5.96	6.23	7.97	8.79	7.33	5.77	14.81	7.20	2.81	3.96	2.60	5.55	3.00	3.24	6.95	5.52	6.10	93	18	80	94	15
Adapoidea	***Adapis parisiensis***	AMNH 111935	10.64	7.15	3.61	4.09	5.85	6.85	5.29	4.11	8.71	5.23	2.38	2.53	2.31	3.89	2.33	2.41	5.39	4.05	4.41	90	23	89	102	2
Strepsirrhini	*Cheirogaleus medius*	DPC 0142	7.06	3.87	2.68	2.25	3.08	3.83	2.45	1.96	5.60	2.93	1.30	0.48	1.93	3.54	1.74	2.74	2.93	2.01	2.44	92	16	83	101	18
Strepsirrhini	*Eulemur fulvus*	DPC 095	14.83	9.23	4.78	4.66	8.20	9.66	5.91	4.51	12.31	6.58	2.75	3.09	3.91	5.15	3.83	3.39	5.73	5.09	5.71	98	26	75	111	-8
Strepsirrhini	*Galago senegalensis*	AMNH 86502	7.90	4.41	3.43	2.33	4.15	5.82	2.90	3.03	5.57	3.09	1.54	1.92	0.56	3.91	1.86	2.49	3.10	2.23	2.82	75	32	89	107	21
Strepsirrhini	*Galago senegalensis*	AMNH 83299	8.51	4.59	3.86	2.68	4.46	5.89	2.81	3.34	5.61	3.26	2.18	2.03	0.57	4.35	1.66	2.75	3.51	2.41	3.02	78	37	96	103	23
Strepsirrhini	*Loris tardigradus*	HTB 750	6.59	4.69	1.91	2.34	2.79	4.55	2.98	1.53	4.63	2.25	1.31	1.74	1.54	2.32	1.62	2.23	3.53	1.80	2.47	84	15	79	100	17
Strepsirrhini	*Loris tardigradus*	AMNH 150038	7.84	5.05	2.89	2.90	3.50	5.21	3.29	2.27	6.01	2.65	1.48	2.04	1.59	3.25	1.83	2.05	2.89	2.37	2.92	93	38	83	93	12
Strepsirrhini	*Loris tardigradus*	AMNH 165931	6.87	4.80	2.38	2.66	2.97	4.74	3.10	1.97	4.75	2.58	1.27	1.99	1.32	2.68	1.74	2.62	4.03	2.15	2.68	76	27	81	97	15
Strepsirrhini	*Otolemur crassicaudatus*	SBU1163	13.67	8.25	4.75	4.26	7.76	10.76	5.79	4.70	11.85	5.71	2.97	3.29	2.70	6.32	3.44	3.95	5.62	4.61	5.52	92	27	69	103	14
Strepsirrhini	*Propithecus sp.*	DPC 051	22.21	12.97	6.80	6.12	10.52	12.04	7.83	6.18	18.89	8.70	4.53	5.31	5.01	7.76	5.86	6.91	8.88	6.72	8.13	98	26	67	102	-21
Strepsirrhini	*Varecia variegata*	DPC049	20.31	11.98	7.13	7.32	10.23	12.35	7.65	6.13	17.37	8.04	3.82	3.90	4.33	7.76	4.99	7.46	8.79	6.67	7.65	91	20	70	103	14

See Fig. S3a for illustration of measurements 1-23. Fossil taxa in bold. GM = geometric mean.

Table S5. Measurement data for principle component analysis of calcaneus

Higher taxon	Taxon	Catalogue Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	GM	20	21	22	23	24	25
Adapisoriculidae	***Deccanolestes hislopi***	VPL/JU/NKIM/52	2.52	1.74	0.78	1.12	0.91	0.64	0.77	1.25	0.54	1.14	0.64	0.85	0.50	0.69	0.38	0.48	0.64	0.74	0.73	0.87	142	61	166	86	104	32
Cimolestidae	***Procerberus formicarum***	AMNH 117455	9.48	6.37	3.03	4.08	3.45	2.57	3.10	3.41	1.51	4.11	3.03	3.08	1.56	1.21	1.42	1.42	2.29	2.42	1.77	3.19	141	55	168	76	103	48
Cimolestidae	***Procerberus formicarum***	AMNH 119802	9.61	6.42	3.29	4.06	3.06	3.03	2.95	3.56	1.96	4.45	2.60	3.17	1.46	1.44	0.86	1.26	2.28	2.34	1.54	3.25	147	40	167	77	107	43
Condylarthra	***Protungulatum donnae***	AMNH 118060	11.93	8.95	2.89	4.72	3.45	3.41	3.28	3.75	1.50	5.09	3.89	3.18	1.98	1.74	1.74	1.46	2.89	2.43	2.67	3.68	147	50	175	72	122	19
Dermoptera	*Cynocephalus volans*	USNM 144662	12.07	6.89	5.23	4.64	4.98	2.87	4.66	4.85	1.93	5.64	4.88	5.55	2.18	1.53	2.25	1.16	4.05	4.08	3.32	4.48	138	74	180	76	105	47
Dermoptera	*Cynocephalus volans*	USNM 317118	14.69	7.46	7.00	5.05	5.90	4.16	4.99	5.51	2.57	6.24	5.66	5.68	2.16	2.35	2.48	1.00	3.32	4.67	3.74	5.14	142	70	166	76	106	37
Dermoptera	*Cynocephalus volans*	USNM 578084	13.66	7.34	6.56	5.46	5.82	3.21	5.26	5.17	2.26	5.48	6.29	5.19	2.65	2.08	2.48	1.21	3.60	4.74	3.51	5.00	146	77	168	68	110	34
Omomyoidea	***Omomys carteri***	UCM 69303	17.38	7.87	9.76	5.04	4.75	3.07	3.17	4.33	2.07	4.52	9.29	6.96	1.91	0.69	10.17	1.32	3.68	3.07	12.25	4.57	137	71	139	98	108	10
Omomyoidea	***Omomys carteri***	UCM 69065	16.38	7.51	8.89	5.18	4.87	3.01	3.24	4.57	2.02	4.56	8.27	6.07	1.91	0.95	9.41	1.15	3.26	3.06	11.09	4.45	123	72	144	93	114	10
Omomyoidea	***Omomys carteri***	UCM 68745	16.29	7.15	9.00	4.73	4.59	2.9	2.78	4.02	2.05	4.69	8.5	6.36	1.71	0.36	9.03	1.18	2.77	2.94	11.16	4.24	136	70	146	98	106	7.5
Haplorhini	*Cebuella pygmaea*	AMNH 244101	7.15	3.94	3.42	2.85	2.12	1.82	2.18	2.84	1.2	2.88	2.86	2.97	0.84	0.71	3.3	0.66	2.15	1.83	4.32	2.41	129	58	165	86	105	13
Haplorhini	*Cebuella pygmaea*	AMNH 244365	7.56	3.98	3.20	2.90	2.55	1.89	2.18	2.9	1.21	2.88	3.13	3.03	0.86	0.73	3.36	0.73	2	1.84	4.3	2.49	134	60	163	86	100	10
Haplorhini	*Cebuella pygmaea*	SBU NC1	7.66	4.12	3.25	3.12	2.76	1.64	2.25	3.1	1.24	2.83	3.23	3.06	0.9	0.71	3.4	0.65	1.97	1.71	4.35	2.49	135	58	168	82	102	12
Haplorhini	*Cebus apella*	AMNH 133606	28.57	14.47	12.86	10.36	9.30	9.07	7.43	10.97	5.48	10.58	10.89	11.97	4.18	4.01	12.61	3.71	8.55	5.6	16.26	9.44	133	61	166	85	90	46
Haplorhini	*Cebus apella*	AMNH 133608	24.8	12.78	11.42	9.06	8.46	7.33	6.88	9.75	5.05	9	11.66	11.13	3.55	3.43	13.2	3.45	7.96	4.67	16.88	8.46	130	58	165	85	91	46
Haplorhini	*Cebus apella*	AMNH 133764	24.27	12.82	11.29	9.11	8.8	7.43	6.9	9.85	4.36	9.26	10.97	10.42	3.44	2.96	11.32	2.92	7.41	6.34	15.13	8.54	148	63	174	87	91	47
Haplorhini	*Saguinus mystax*	AMNH 188177	11.77	6.15	5.45	4.69	3.88	2.84	3.16	3.99	1.94	4.44	4.94	4.98	1.53	1	5.58	0.87	3.22	2.25	6.19	3.78	111	58	161	89	130	28
Haplorhini	*Saimiri boliviensis*	AMNH 211613	17.11	9.18	7.89	6.27	5.64	4.34	4.84	6.07	2.59	6.01	7.65	7.76	2.78	1.53	8.2	1.22	5.11	2.99	9.14	5.45	104	62	151	87	122	40
Haplorhini	*Tarsius spectrum*	AMNH 109369	27.11	5.91	18.84	3.61	3.27	2.31	3.03	3.58	1.14	3.15	20.02	2.09	1.25	0.46	21.31	0.75	2.07	2.48	22.34	3.91	141	82	160	87	100	37
Plesiadapiform	***Carpolestes simpsoni***	UM 101963	6.79	4.03	2.78	2.98	2.30	1.65	2.52	3.50	1.38	3.48	2.4	2.78	1.29	1.11	0.86	0.95	1.71	2.12	2.22	2.46	141	68	162	79	107	44
Plesiadapiform	***Dryomomys szalayi***	UM 41870	3.32	2.20	1.12	1.42	1.08	0.80	1.03	1.51	0.62	1.48	1.00	1.30	0.72	0.67	0.49	0.68	0.84	0.72	1.10	1.09	129	67	166	80	103	35
Plesiadapiform	***Ignacius graybullianus***	USNM 442240	7.28	4.80	2.46	3.08	2.26	1.91	2.75	3.67	1.30	3.19	2.20	2.52	1.46	0.94	1.16	1.07	2.12	2.00	2.86	2.52	125	59	165	79	109	42
Plesiadapiform	***Nannodectes gidleyi***	AMNH 17379	10.43	6.48	3.49	4.10	3.84	2.84	3.20	4.60	1.85	4.53	3.60	3.54	2.07	1.37	3.26	1.13	2.03	2.45	3.92	3.43	145	69	175	81	105	20
Plesiadapiform	***Phenacolemur simonsi***	USNM 442238	6.65	4.26	2.38	2.54	1.93	1.37	2.21	3.08	1.10	2.72	2.03	2.25	1.37	1.11	1.19	0.74	1.68	1.53	2.67	2.08	124	63	171	78	99	44
Plesiadapiform	***Plesiadapis churchilli***	UM nn	12.30	7.94	4.09	4.67	4.39	2.96	4.00	4.93	2.14	5.10	4.61	4.29	2.67	2.18	3.01	1.79	2.52	3.30	4.25	4.07	152	75	173	75	104	25
Plesiadapiform	***Plesiadapis cookei***	UM 87990	18.80	11.80	6.50	7.50	6.70	5.50	6.80	7.90	3.31	7.90	8.75	7.00	3.65	3.34	4.67	2.19	5.14	5.19	7.63	6.81	148	73	162	75	103	32
Plesiadapiform	***Plesiadapis tricuspidens***	MNHN R 414	18.39	12.22	6.10	7.40	6.57	5.20	6.43	7.78	3.25	7.53	6.81	6.43	3.90	3.11	4.20	2.34	4.67	5.26	6.35	6.44	146	68	172	73	94	21
Plesiadapiform	***Plesiadapis tricuspidens***	MNHN R 611	16.99	10.88	5.68	6.41	5.46	4.55	5.66	7.05	2.91	7.45	5.52	5.43	3.11	3.00	4.70	2.11	4.23	4.33	6.36	5.66	150	73	166	73	100	21
Plesiadapiform	***Purgatorius***	UCMP 197517	5.30	3.87	1.46	2.04	1.47	1.40	1.69	2.22	0.78	2.15	1.56	1.79	0.81	1.00	0.75	0.78	1.41	1.33	1.69	1.68	129	64	164	71	107	44
Plesiadapiform	***Tinimomys graybulliensis***	USNM 461201	3.39	2.36	1.06	1.30	1.06	0.87	1.08	1.56	0.68	1.55	0.92	1.27	0.54	0.65	0.50	0.65	0.90	0.79	0.93	1.12	132	63	165	81	106	30
Scandentia	*Ptilocercus lowii*	YPM 6873	5.26	3.11	2.11	1.78	1.66	1.21	1.60	2.21	0.70	2.45	2.04	1.68	0.80	0.80	2.44	0.85	1.32	1.12	2.77	1.66	126	84	160	78	97	50
Scandentia	*Tupaii belangeri*	AMNH 113135	9.27	5.33	3.62	3.56	3.01	2.22	2.62	3.28	1.29	4.31	2.88	3.08	1.35	1.26	3.58	0.99	2.44	1.77	4.83	2.89	123	53	156	85	91	34
Scandentia	*Tupaii sp.*	SBU coll.	9.02	5.21	3.67	3.27	2.79	2.14	2.46	3.87	1.57	4.03	2.81	2.98	1.36	0.74	3.90	0.53	1.59	1.99	4.88	2.75	141	61	158	83	89	9
Scandentia	*Urogale everetti*	AMNH 203293	10.22	5.72	4.14	3.79	3.12	2.55	2.96	3.97	1.51	4.69	3.93	3.84	1.64	1.72	3.41	0.83	2.79	2.21	4.82	3.31	125	60	150	82	91	35
Adapoidea	***Adapis parisiensis***	AMNH 111937	19.50	12.73	6.92	6.52	5.91	5.05	5.60	7.55	3.53	7.32	5.39	7.09	2.99	0.44	8.47	1.28	5.74	3.72	10.12	6.03	167	76	180	102	104	42
Adapoidea	***Adapis parisiensis***	NMB QE741	17.13	11.99	4.94	6.33	6.81	4.48	5.46	5.39	2.21	6.99	5.38	6.99	3.08	1.13	8.86	1.38	5.28	4.57	10.07	5.70	143	84	154	89	111	17
Adapoidea	***Notharctus tenebrosus***	AMNH 131945	25.55	13.99	11.4	10.37	9.85	6.32	7.46	8.66	3.87	9.44	10.29	10.75	3.93	1.81	10.95	2.24	7.33	6.02	12.58	8.53	147	82	162	91	104	23
Adapoidea	***Notharctus tenebrosus***	AMNH 131766	23.56	13.56	10.17	8.37	8.03	6.21	7.11	8.23	2.91	8.99	8.75	9.02	3.53	1.99	9.32	2.29	6.42	5.07	11.62	7.44	145	81	163	92	97	17
Adapoidea	***Notharctus tenebrosus***	AMNH 11474	23.07	13.19	9.89	8.60	8.32	5.23	6.87	8.78	3.12	7.96	9.49	8.63	3.68	1.83	9.42	1.86	6.34	5.05	11.42	7.33	158	82	160	90	94	16
Adapoidea	***Leptadapis magnus***	NHMB QF 421	33.2	23.07	9.52	11.59	11.53	11.98	10.09	12.66	3.98	13.24	9.41	11.99	4.26	3.17	14.35	3.97	9.76	7.29	19.99	10.66	143	83	147	90	113	28
Strepsirrhini	*Cheirogaleus medius*	DPC 031	10.08	4.95	5.16	3.3	2.74	2.32	2.99	4.23	1.56	3.41	5.34	4.79	1.53	0.58	6.51	0.72	2.68	1.97	7.17	3.15	129	86	161	86	107	36
Strepsirrhini	*Cheirogaleus medius*	DPC 1023	10.53	5.03	5.43	3.47	2.93	3.12	2.81	4.22	1.44	3.30	5.73	5.14	1.61	0.51	6.72	0.85	2.66	2.05	7.22	3.27	148	84	157	83	110	39
Strepsirrhini	*Cheirogaleus medius*	AMNH 80072	12.59	6.15	6.40	4.42	2.24	3.52	3.29	4.84	1.56	4.14	5.89	5.95	1.91	0.5	7.56	0.74	2.79	2.41	8.33	3.60	136	78	152	85	110	43
Strepsirrhini	*Eulemur fulvus*	AMNH 170717	23.64	12.55	10.57	8.67	7.20	6.09	6.97	8.40	2.43	8.44	10.61	9.99	3.45	0.79	14.53	2.13	6.46	4.52	16.1	7.24	145	83	142	88	97	23
Strepsirrhini	*Eulemur fulvus*	AMNH 100528	25.85	14.14	11.57	9.1	6.51	6.3	6.65	8.37	2.13	8.99	12.1	10.36	3.65	0.7	17.04	1.8	6.8	4.6	18.4	7.36	144	84	148	85	105	22
Strepsirrhini	*Eulemur fulvus*	DPC 095	22.95	11.78	11.00	8.83	7.5	6.58	6.24	7.17	2.32	7.93	10.57	9.85	3.19	0.59	16.01	2.04	6.27	4.62	17.44	7.15	140	79	144	89	108	26
Strepsirrhini	*Galago senegalensis*	AMNH 86502	27.03	7.38	19.55	4.25	4.09	2.76	2.87	2.89	1.52	3.64	19.13	4.22	1.27	0.65	21.31	0.78	2.51	2.48	26.34	4.35	157	81	166	86	114	26
Strepsirrhini	*Loris tardigradus*	AMNH 34256	9.61	4.68	4.9	3.6	1.96	1.32	2.76	3.7	1.53	2.77	4.22	4.22	1.5	0.71	4.62	0.61	3.14	2.04	5.15	2.79	149	79	175	87	135	13
Strepsirrhini	*Loris tardigradus*	AMNH 150038	9.94	5.24	4.65	4.19	2.52	1.65	3.3	4.26	1.48	3.29	3.94	4.03	1.56	0.97	4.31	0.59	3.35	2.53	5.77	3.14	157	84	176	86	125	13
Strepsirrhini	*Loris tardigradus*	HTB 750	8.62	4.82	3.63	3.64	2.57	1.60	3.57	5.17	1.70	3.54	3.44	3.41	1.66	0.63	4.49	0.67	2.87	2.35	5.87	3.03	160	90	180	93	114	9
Strepsirrhini	*Otolemur crassicaudatus*	SBU coll.	34.66	12.69	22.10	8.24	7.01	4.15	5.68	8.19	3.57	6.56	22.13	8.31	3.57	1.57	24.83	1.42	6.16	4.94	25.83	7.72	157	78	180	91	100	42
Strepsirrhini	*Otolemur crassicaudatus*	AMNH 216240	33.09	9.87	22.26	7.32	6.13	4.38	4.91	7.2	2.48	6.64	20.75	2.94	2.73	0.48	24.39	1.74	5.48	4.21	25.71	6.92	121	78	141	88	129	33
Strepsirrhini	*Propithecus verreauxi*	AMNH 170471	25.61	14.22	11.24	9.67	9.05	6.26	7.53	9.13	1.65	9.23	12.01	11.44	4.03	1.04	18.17	2.18	7.31	5.28	18.68	7.71	99	85	172	84	102	45
Strepsirrhini	*Varecia variegate*	AMNH 201384	27.7	15.44	11.76	10.68	8.61	7.07	7.92	9.77	3.88	10.38	11.61	10.93	3.64	0.41	18.08	2.62	8.83	5.81	19.82	8.98	137	79	153	83	101	12

See Fig. S3b for illustration of measurements 1-25. Fossil taxa in bold. GM = geometric mean.

Table S6. Principle component analysis results for astragalus

Variance distribution			Component loadings								
PC	**Eigenvalue**	**%var**	**Variable**	**PC- 1**	**PC-2**	**PC-3**	**PC- 4**	**PC-5**	**PC-6**	**PC-7**	**PC-8**
1	6.03	26.21	**1**	0.31	0.20	0.00	0.08	-0.11	-0.11	0.35	0.04
2	3.16	13.73	**2**	0.02	-0.20	0.00	0.53	0.12	-0.17	-0.04	-0.23
3	2.57	11.20	**3**	0.21	0.33	-0.12	-0.26	-0.05	-0.04	0.29	0.21
4	2.32	10.07	**4**	-0.24	0.16	-0.01	0.11	-0.03	-0.48	0.03	0.23
5	1.56	6.79	**5**	0.12	0.22	0.18	0.02	0.49	0.06	-0.09	-0.36
6	1.40	6.09	**6**	0.28	0.17	-0.07	-0.10	-0.14	0.01	-0.19	-0.27
7	1.06	4.63	**7**	0.11	-0.36	-0.31	0.02	0.13	-0.08	0.06	-0.07
8	0.90	3.90	**8**	0.16	0.12	0.25	-0.19	0.26	-0.14	-0.32	0.33
9	0.77	3.34	**9**	0.13	0.05	0.48	0.25	-0.02	0.07	0.21	-0.08
10	0.59	2.57	**10**	0.13	-0.09	-0.14	-0.02	0.56	0.13	0.39	-0.02
11	0.54	2.34	**11**	-0.09	0.17	-0.36	-0.30	-0.03	-0.01	0.14	-0.31
12	0.40	1.73	**12**	-0.32	-0.07	0.05	-0.10	0.12	-0.01	-0.26	0.16
13	0.37	1.60	**13**	-0.21	-0.22	0.16	-0.05	-0.40	-0.03	0.12	-0.25
14	0.31	1.35	**14**	0.25	0.27	-0.08	0.06	-0.14	-0.10	-0.19	0.05
15	0.26	1.13	**15**	-0.01	0.05	-0.06	0.21	-0.09	0.72	0.05	0.32
16	0.24	1.05	**16**	0.13	0.26	-0.13	0.37	-0.23	0.17	-0.17	-0.10
17	0.16	0.68	**17**	-0.18	-0.06	-0.44	0.18	0.07	0.00	0.08	0.23
18	0.13	0.58	**18**	0.27	-0.23	0.11	0.08	-0.02	-0.13	0.02	0.28
19	0.10	0.44	**19**	-0.20	-0.01	0.38	-0.09	-0.04	0.03	0.42	0.04
20	0.06	0.26	**20**	-0.31	0.26	0.08	-0.02	0.14	0.16	-0.10	0.12
21	0.05	0.20	**21**	-0.29	0.19	0.03	-0.04	0.10	0.15	-0.09	-0.28
22	0.02	0.08	**22**	0.24	-0.33	0.06	-0.13	0.04	0.17	-0.26	0.00
23	0.01	0.03	**23**	-0.15	0.23	-0.07	0.40	0.16	-0.15	0.02	0.04

Table S7. Principle component analysis results for calcaneus

Variance distribution				Component loadings								
PC	**Eigenvalue**	**%var**		**Variable**	**PC- 1**	**PC-2**	**PC-3**	**PC- 4**	**PC-5**	**PC-6**	**PC-7**	**PC-8**
1	8.99	35.96		**1**	0.24	-0.07	0.30	-0.06	-0.23	-0.04	0.20	0.12
2	3.02	12.08		**2**	-0.15	-0.10	0.39	0.27	-0.30	0.08	-0.05	0.12
3	2.29	9.17		**3**	0.29	0.03	-0.03	-0.24	0.02	-0.11	0.19	0.04
4	1.75	7.01		**4**	-0.05	0.14	0.44	-0.09	-0.25	-0.19	-0.20	-0.16
5	1.64	6.55		**5**	-0.02	-0.26	-0.36	0.16	-0.26	-0.12	-0.01	-0.37
6	1.32	5.28		**6**	0.00	-0.37	0.08	0.32	0.18	0.22	-0.12	0.42
7	1.26	5.05		**7**	-0.19	0.36	-0.01	0.28	0.11	-0.10	0.04	-0.11
8	0.92	3.69		**8**	-0.13	0.30	0.25	-0.09	0.23	0.23	0.31	-0.18
9	0.76	3.05		**9**	-0.16	0.06	0.00	-0.54	0.08	0.35	0.02	0.06
10	0.55	2.21		**10**	-0.23	-0.17	0.20	0.10	-0.07	0.02	0.15	-0.24
11	0.54	2.15		**11**	0.30	0.01	-0.04	-0.11	0.02	-0.19	0.22	0.16
12	0.42	1.67		**12**	0.29	0.08	0.06	-0.06	0.21	-0.10	0.07	0.10
13	0.36	1.44		**13**	-0.17	0.20	0.19	0.15	-0.04	-0.11	0.40	0.12
14	0.31	1.26		**14**	-0.28	-0.08	0.05	-0.18	0.05	-0.10	0.11	0.01
15	0.22	0.89		**15**	0.31	0.01	0.08	0.11	0.04	0.07	0.08	-0.10
16	0.16	0.63		**16**	-0.21	-0.19	0.23	-0.04	0.06	0.03	0.13	-0.03
17	0.13	0.53		**17**	0.13	0.24	0.13	0.19	0.26	0.05	-0.48	-0.21
18	0.11	0.42		**18**	-0.18	0.21	-0.33	-0.02	-0.19	-0.21	0.13	0.07
19	0.08	0.33		**19**	0.31	0.01	0.12	0.06	0.05	0.11	0.12	-0.15
20	0.06	0.25		**20**	-0.05	0.23	-0.19	0.11	-0.28	0.53	0.01	0.38
21	0.04	0.17		**21**	0.15	0.29	-0.11	0.42	0.01	0.06	0.28	-0.01
22	0.03	0.12		**22**	-0.20	0.27	-0.10	-0.08	0.11	0.08	-0.18	-0.04
23	0.01	0.04		**23**	0.24	0.02	0.07	-0.06	-0.09	0.37	-0.10	-0.26
24	0.01	0.03		**24**	0.06	0.28	0.15	-0.09	-0.15	-0.33	-0.35	0.38
25	0.01	0.02		**25**	-0.12	-0.14	0.01	0.10	0.59	-0.15	0.02	0.15

Table S8. Modified character matrix of (6) in TNT format. See (6-8) for character descriptions and states. All modifications in bold.

xread ‘Purgatorius analysis modified Goswami 2011’
415 85

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Peramus
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Vincelestes
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Kielantherium
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Deltatheridium
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000010001100000002111??

Acristatherium
000[01]001100000204100010010 10?0?10010000000000000001000000000000111111011000000
011000000000100?12000000??0?1??00000100?1?0111?100000???010001?01????????001??0??
???0000011010?001001001100??????????????01000010?0???????1?02?00??????01100?1[01]?
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Eomaia
0001000000000?000?000001010?0?100101000101?????010010010?00?100[02]10?1?0?002?[0
1]0100?00??1111012??00?0??001?1010?010?01?02??01?000002101011120110020001001020 0
1010110001 1??0??010?100?1??0??????????????0?00001?????????????????????????0?0?0????????
??????????????????1????0???????????????11???
?????????????????????0????00?0?00???110?000??0???1?0?111?0???????11?0??0??10?00?????
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Prokennalestes
000?00?0???????????0?0???00??0?1????10001[01]1000000000[01]00[01]000[01]0100[12]1001
100010200100000011111012000000??0010000000100110021111000000110101112011002000
10?100001010????011?1??????????????????????????????0?0?????????????????????????????1
1[01]??????????????????????????????????10000?00111?0001110000??1100001000000 0?00?00
0?????????1?00??02???11?0???
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Murtoilestes
00??0111?21000102111000000
11112012000000??0?1??000101?01110211110000???
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Bobolestes
000?00?0??????0???0?0???11??0?1??????????????00000000120000100110?20010022[01]110
0100111122112010100??00100000001001110211110000002[12]01??01?01??????????010000
21??
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Montanalestes
00[01]????[012]????????????????????[01]?1????????????????????100110001110?????????????
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01?021??
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Sheikhdzheilia
00?????????????????????????????????????[12]??????????????1010?1100121010200021011111
02101122122010200?00?1??000?010011[12]1223?20000?[01]?20??????????????????????????
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Alostera
00??0121?2021002222111021
111221221102220 00?1??0?0?01?01131223?20000??
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Lainodon
00???0???????????????????????
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Avitotherium
00????????????????0?????01??1??????????????????00??000????????0121?20210022[02]21111
02111122122010[12]11000?1??001002100131221?20001??????????????????????????????????
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Gallolestes
00???0012?????10???????????????????????
?221?2110?1[12]00??1??0000021001302231200010??2????????????????????????????????????
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Parazhelestes
000???????????0?0?00????0[01]0?0?1????1000111000010010010021?0?10012212121002 2221
111021111221221112220000100000002111121223020001001201???1201??????????????1?121
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?????????????????????10[12]?0?201?1??002100100??????0[01]?0?0000?000??[12]??????????
?00??020?111?0?0??
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Aspanlestes
000?0??[012]????????????????????0?1?1?01??011111001000001002100110022212121002202
1111021111221221102220000 1??000?01111121223020001 00[12]101??11201??????????????1
?121??
?????????????????????????10[12]?0?201?1??002100100??????0[01]?0?0000?000??[12]??????
?????00??020?111?0?0??
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Zhelestes
00010?????????????????01010?0?1?1011000 11111?01001001 0021???10022212121002[12]221
111021[01]11???22110[12][12]200001000000011111212230200010 0120?0?1120?1002000100
1???1?121?????11??
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??????????00??020?111?0?0???02
0110011100??????0

Paranyctoides
000?0??????????????0?????11??0?1????1[01]001[12]2000?0001010000[01]001100111011010[0
2]22[01]11111001111121121111111000?1??00000100113122112000100[13]201??11?0????????
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Eozhelestes
000????0???????????0?????11??0?????????????????000[01]?1?????????1?0???????????????????
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Cimolestes
001[03]00?1??????021?001001010?1?1?10?10012[01][01]0000010??000000000100110010210
02200101100111122112010 1[01][01]0000100000000001110211120[01]00001[12]0100112001
0????000?00[01]01?121???11[01]?10??0????01?110???????2010??01??????????????????10?
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???001???????????????????????????????
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Maelestes
000[03]00?1??????0?100?1?0[01]010?0?1010110011021100011110000000101002221202 1002
1001011001011 00?1201011100001000000021111102121210000023010021201100200001020 0
01?1???11001100???0???10??1000????11021011001000011101100000 01?[01]000????0?11???
1111?0112120???[23]???1100?0110010003000 10000?01111002021100000001001[12]?[12]001
00011111[12]00[01]100?0?00??100211111 10[03]01100010???????000?1000011100?????????
????????01100???11??0???????????????????

Batodon
001???????????????0?????01??1?1????100?112000?010??000110001100221?10210021211011
0011112211201011100001000000010111[12]02121[12]00000022?1??????????????????0001??
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Bulaklestes
001???????????????0?0???00??1?1????1000???????000??000100001100112111210022[02][01]
1011001111211200110 0??001?0000?010011102112100000002?1??????1???????????0001??2
1??
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Daulestes
001???????????????0?????00??1?1????10001120000000??000101011100111[01]10000022001
011001111121120001[01][01]000?1??000?02001110211?10000?0?2????????1??????????????1
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Uchkudukodon
001[03]00?[01]??????[01]???0?000?0000101????10001020000??0??000?0101?1001101110000
22001011001111121120001[01][01]000?100000002001110211210000001[23]0101112011002 0
0010010201?121??0?011000?1110?100111000???0[01]0210110?1000011001[013]?00000?02?
?010?00210???1111???1?00?021[23]00?1?00?0111012?1?0001000000011100?1?1?0000??????
1??????00?????????????00?0?000?????????????0?100???
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Kennalestes
001000[012]1?00001000?0?000000000101000?1001112110000 1??000001010100212021200022
0010110011111211200111200001000000010111102111100000012010021200100200000??1000
1?121110001101 0?0?10?101111000???0000101100?0000110?10000000??2???10100???00011
11?01?2?20?11300?1000?0110121?3000101?000111100?1?10000000?1?11??[01]0010021110
1100110?1?00000?00211112??20?110???
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Asioryctes
0010000000000001000?000000000?1?1000?20011220000001??1001010101002100102100220 01
0110011111[02]112001100??0010000000201111021111000000010100212001002000100 1000
1?121110001101 0?0010?1001110000000??01011000001011 0?10000000??2??010100[02]1000
01111?01110200113 00?1000101110121?3000101?00011110001?10000000?1111??[01]001002
111011001100 1?00000?0??????2??10111001101??????????????????000??????????????0011?
0?11111?00??1000000?0???????

Ukhaatherium
0010000000000010000000001010?1?1001?20011220000001??1001010101002100102100220 01
0110011111011200110 0??001000000020?111021111000000020100212001002000100 10001??
21110001101000010?10111100000000??0101100000101 1?01?0??00??02??01010??1?0001111?
01110200?1?00?100010111012103000101?000111100?1?10000000?1?11[01]1[01]001002111?
11000100110?0001002???12??2011????????????1000100000 11?00?0?00??01?00?11?0011001
112100001010200?220????0?0

Deccanolestes_hislopi
001?0[01]???????????????????011?1?0???010011030000001001011211001101110100000220[0
1]1[01]010011002[02]11211[12][01]00??00100000[01]00[01]011111[12]1211000001101011??
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???00011???????????????????0220011011100
0201101111011110111

Deccanolestes_cf_hislopi
00???0[12][12][12]0[01]0000022
0[01]11010011002[02]1[12]2111[01]00??0010000000010111111121100 00?????????????????
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Deccanolestes_robustus
00??01110001000220111010 01
10012012112[01]00??0?1??000000001111111211 0000???????????????????????????????????
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Deccanolestes_narmadensis
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Kharmerungulatum
00??2?????????????
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Afrodon_germanicus
00???1211????021[12]010000
02101110100110022 1[12]2111[01]00??001??000000001111121?21000??????????????????????
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0111111?1

Afrodon_chleuhi
00???1210????0[12]1[01]0[12]000002201
1101001100221 2211[01][01]00??001??0[01]100[01]0011111[12]12[12]1000????????????????
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Kulbeckia
001100[012]0????21?1?11100000??1?1000?2?111020000000???001211?11002200202100222
1111102111112122001200??001?00000022111[12]122211000000[12]101???1210???????????0
001?121110001100 00?0?0??00????101???[012]??????0010000????????????1?10?????????????
1?????????????????????????????????????10[12]?0?0[01]1?1?011?110000????1?011[01]00100?1
11?11????????????00???2???11?0?0???
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Zhangolestes
000?00?1??????1?1?211???111?0?????????????????00011???121??0100?????????????????????
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Alymlestes
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Zalambdalestes
00[12][01]00[23]11110?21211211000111?[12]?1000?21111120001000??000121000100220020
2100212111110210110 0?22001200??0011000100221113122312100000110101112 0[01]100200
001010001?12111000110000 0110?10001001010002 00[01]01101000001110120011010000001
0100101[01]001111001111200113 00?1000[12]0111012103000101?00011110011?1000000001
01111[01]00100211111[12]0000001101000?102???1100101???00?11?????11??100001???0???
??01???100??0??[12]2200?1?110[12]01201?30112?000000?0

Barunlestes
002[01]00?1??????1211211011111?2?1????201111200?000???0??121000100220020210021 21
111102101100?22001200??00110001002211131223121000 01?1010111200100200001010101?
121???0?11000????0?100?110?0???0220101001?00????1?1[13]01100??0????10?0??????011?1
??11112001130??1000?011101210300 0101?0?011110011?10000000?1?11???00100211111?00
000????1?0??1??????????011100?0???0?0?1???100001110?00100012111001?0??????????????
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Gypsonictops
00[01]?00?[012]??????????0?0???010?[01]?1?????2[01]11222111000010[01]1[12]12110110022
10102100222111110011112212201122200001000000 02[12]111312[12]1120000002201???120
0??020000??????1?121?????11???
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Leptictis
0013003110000000000000001110?101001?1111222111001 0??0001212011002200202100222 11
111021111221120112120000110000002[12]1113122112000000120101112001002000011 20?0
1?121110011211101111010101100100000201110000001010110000000010 2??0110001001001
1111110201012120101100201100110011001000000011110011?10000001?10001?1001002100?
1111100001011001002110 12??301?111????00020111100000 1110?000101001110 02?00102200
0102102002010111121000 00000

Purgatorius
001?00?1??300?0?1?0?**1**???**1**1??1??????????2[12]1**11**00010??000200101100 22**[01]**0202100222
2[12]1110211**0**112112112222000?1??001**0**011011**2**12211**2**000000**2**200?????????????????????
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???**02200110110200201111111100**????
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Protungulatum
001??**?**????????**??**?**???**?01010?1?2????10112[01]11100010??10011000111022102021002222**[**
12]11102111211022102222000011000[01]001101111[12]1312000100[12][12]01002120010020
1001020001?121??
1????????????????????????????????????00000?011?1?001?10???0??211?0[12]?[12]001002101
011?????????1?00??0201112???0????????????????????**000011**????????????????????022100?01
11000211011101200000?0

Oxyprimus
001?????????????????????????1????????????????????????10012000111022102021002222**[12]**11
102111211022102222000001?0000001101111[12]121200010[01]?101002120010??00??2????
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Vulpavus
00[12]00021000000000000000001010?[12]?0111?00011230000011??00000000?12022002021002
22211110211100?22101111[01]100110011002101111122131000010[12][12]0?0011?00?00000
01112??01?1??11[01]011001[12]010110001111001?0?01[02]?????01?0010[01]?0??????????00
00110?01?01001111??110?0???2120111000?01100?011300000000?0?11010?1?12000102[01]1
[01]0010[01]000000100?1[12]10102???01?00?????????????0??????????00??1?001??000110000
[01]???10111001???00220001021010020102011100001111 0

Miacis
00100021000000000000000?01010?1?0111?0000123000101???000100000120220020210022210
11102111100?221001[02][01]010011001100100111110231000001[01]?10100?10000?0????111
1???1?1[123]1?????10012?10?10????????????????20???0???????10?10000001100000?10?010010
?111111?101011?21[23]0111000?011000111[13]00000000?0111010?1?12000111111000???000
00010101[12]10002???01?00?????????????0??????????0010????10?000????0?00??????1?????0
00?????????1?1?0???????1???00111?0

Gujaratia
00100021?0000?04000000001110?1?2001?2001200110001 1??00020100111111200202100222 21
11102111122122102223000010000 0?021011122222120001002[12]01001100000003000 01[01]20
00?????1110111010?0011010101100???????1103?03000000??00200100111000010000000001
1111??1?1010021200?1000101100???1300000000????1?1??1???0?01??????????????02????1?1
1[01]0102?01000????????2??30???????1???010????10011??11?010101??111?121000122100 10
20120110101210110000000 0

Hyopsodus
00130021010000000000000011110?102110?10012001100010??0[01]122110011112002021002 22
21111021120220221012232[01]00110[01]00002101112222221000100[012]2010111010000[02]
01001110?01?12111101110000111100010 11?012000[012]00103?000000000??00?000??02??
011?0?111001111011101010021201?100020110001011001 00000?0?1101011?100101002[01]?
002??00100200101[12]101?10???1?00?00201?11???0???111?0?1?0200101110001111010101
100?10021000012100102112002010111010000 1?1?0

Meniscotherium
00110021004000040000001111 0?102001?2001220111001 1??000221100112120020111022221
111121220201221012232100110000001101112220 31?000000211012100000000100112001 1?1
21111011[12]0100[01]011000101100121?0[01]02000000?0000001?0001000??000001100?210
0011110??101010?[12]12011100?20110001013001000 00?011101011?1001000011000 2???0?0
0210101[12]0?111????1?00?0???1??1???0?01111011100201111100101111101010111111 0021
000012000002100002010111112 0000?0?0

Phenacodus
0010002110400004000000001110?1?2010?210?2201110?11??0[012]0221[12]001[01]11200201
1102222211111212202202210222321001100010021011122222110001000201 00[01]1000?00001
001120?0?????111011[12]0000?0110001011001210022 0?03?00000[01]0000?00000001012??0
11?0021??011110????1010?212011100?201100010130010 0??002[12]1101011?10010000?1??0
2??10?002100?12100[01]10???1?00?0??????100[03]0?01111???10020111?100101111101 0101
011110121000022?001021?00020101?112?000000?0

Ptilocercus
002000311000002110001010111**1**0200000?10011020100?????00022100110012202021002212 2
1110011010 0?22111122010010000**0**0110213122312000100310100112000002000010200 01?1
3111**2**0010112000111**1**01**1**01001000000011**1**00**0**000111111100100011000111010020111011 10
1110101002120101000001100110111**11**000010?111110211?1210100211100[01]1110000200**10**
1201100101011001002111 12??30101111?11[01]101011**0**100**0**0001100000011000010011000 02
2101102102 0**0**101121111001111111

Plesiadapis
00[23][01]103**3**013000101020-0[12]12**--**?[23]?20[01]0-2[01]012[12]011[01]0-----
0000[01]1[12]0011122[01]02021[01]02222[12]11102110122022102223 20001
[01]0011**1**00210213122102000100321000212000002000110**1**1**2**01-13111
201120020111101010010000000000113-01000000110?10??01?02-001
0?**0**1?120001111?1112?20011200-1100201110010110000 2000-211110**2**11-
121000031??[02]02?2111112002 01[12]11100?10110001???????2--
30111111?1??00101?000000001100000?1100[01]01**0**01?**0**?00220011011000020111111101111
1111

Notharctus
0010003200400004000000001010010 2011?20002[12]01100010??0[01]02211001112210202100
22221111021101221221012232000110 1?????10212222**1**02000100121[01]00[12]12000002000
01021[01]11?131111011000111011000100110100000 00**1**13?0000001001?000**1**?1???0001110?
0?[01]120001110?11110200?1200?1100?011**0**0000110000 2010?111110211?12101003111?0[0
1]11?1111200201[12]1110010011000?????11?2??30?1111 1???00010??0?0010001100001 0110
0001002100002210100210?111011221122111111 11

Adapis
0013003200400004000000[01]11100102010?[12]0002201100010??00022110011122[01]02021
002222[12]11102110120022101223200001001?????10212222002?001001210001100000030010
1021[01]11?13111101[01][01]0021101100010011010000010113?00000[01]0001100011011?00
01110?010120001110?110102001121 0?1100101100000110000 2010?11111 0211?1210100311?
?0[01]11?1111200201[12]1110010011 00010??0???2??30??????????????????????????0???10?00??11
???????2????0221010021001110112211121111 11?1

Tribosphenomys
0032114301221?121131?02?2???3?2????0002???????????????0210?01012200202100222221 11
22?10122022102 2031?001111?????2131312210201 0001?2100?102100?02??0???10101?131?1?
??1110???????????????????????????10?????1??
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???00022100101102002010111 11?0???????

Paramys
0032114301221?121131?02?2???[23]?2????00022201110????????0211?0101[01]33?????1??22
2211?22?22?2202210222320001111?????2131322210101000[01]32100110210000[02]??01022
0101?1311120?11102000110001 11110?0100002113?0200000001??3011001?02??01010000100
0111011102020020201110212001200001300010000?011110001?1010000012000011101 00210
0?11111020?001000?0??????2???0?011110??00010??0?0000[01]011?10?00?112111002100002
20001011020020101111210 0000000

Rhombomylus
0032114301221?121131?02?2???3?2?????2[01]0?2[01]10200?????0112202001 11233?????0??02
1201?22?20100?221022032?1?1111?????11013121112 0000003[12]1000112100002100000201
01?1211120?11102000110001 11110?0100002003?010000101110101100100000110101212000
111111112020021 20[01]010212001100002[13]000102???211110[12]11?121001031202 02?2?0
1002000?1210[01]02021110000002010 12??201???1??1??0?1?1?011000011 1010????11011101
21000022100101102002110111012 00000000

Gomphos
00[23]21132012110121131102?2???[23]?2????210?2100000?????0220212001 01233?????1??0
22211?22?20102022102 2032?0?1111?????11313122102010000321000112100002100100 20101
?1211120?111010001?01??11110??100?02003?0100001011?010??00??02??01??0??0???01111
?1101010??1201?10311001200 00210?0002??????1????????????????????????????????1??0?0
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1101111100???????

Mimotona
00[23]21132012110121131102?2???[23]?2????20002000000?????00002100010123 3?????[01]?
?022211?22?20100?221022032?0?1011?????11?131221020000003?1??????10???????????01??
????11[12]0?1110?????1??01?1?????1??????????000000?1?????????????????????????????????
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Blarina
00[23]3002[23]11201[01]1110310011[12]?1?[23]?0????10021200201?????000222?001001100
20011020222111101001 00?121101022?1111000110111213112332000011?3010020000000000
101110101?1311110112011110111101101?0??0?02011010001 1???21?00?1?????102???12?00?
10000111111010100021[23]00?1100??10???111300001000?011110031?12000000110100010 0
00021120121010001001001 00?101012??00?01111001[01]000010011000001100000111001010
01100102200011210000201011101?10000100

Erinaceus
00[23]0002211000[01]10100010101110[23]00????[01]00[01]1000100?????0002200001001200
2021000222211?02100100?22010223201111000100211213122032?0011[01]3[23]0101210000
0030010102010 1?1311120010011111111111??01101200100111100100101111?0101110[01]002
??01001000200011111110101002120 0?104020111?11001110 01000?011110011?10101002100
000110010001110121010201 00[01]000100201?1110[23]010111110110010110110011011 0000
1111020110011001022101101112012010101011 00000000

Solenodon
00230021013001200000000101 10?2?1000?10011020100?????0001200001002000202001 2213??
1120111100?12010001 1?0010000000201001000030?0000013010021100000301111010101?13
1111011[02]111111111101111001200001111100001???21110101110000 2???10000000001111
10110100?02120111100?0110?12113000000000?011110011?1100000011000111001002112012
110000110100110??????2??30101110101110201101010000110101001100101001100002 2100
10211?00201010102 11??10110

Eoryctes
002?00?[23]??????????0?????01??2?1????1001122000 1?????0001000?01002200202100 22[01]
010110211200 0?120?0100??0?100000?02000110203?20000?0[23]2????????????????????010??
????????1001???0?10?11?110?????0?2210100?0????2???????00?0??2???10?00?00?001111?11
??0???2120111100?0110?1[12]0111101?010?1?1110????1210100211000[01]11001000111 01?1
000?01?01???????????????0??
?????????????????

Potamogale
002300210120002300001010110020200 0?200122100 00????110120011100211020221022120
01100111100?22000100??001000000002111110200 32?000001301002000000000000001010201?1
311110112101110111111??111?1000032100000001???210?00100001002???1001101101011110
110100?02120111100?0110?021121110100 0?011100011?110000111101011100100010201210
1000110100110020111100001011111011100010101101101100000 111100 10?021001012 00?11
110201??1?00102?0000?010

Orycteropus
01[23]???54??????????????2?2???[23]?2???????0??????0????????????0?10?0???????????????
??100[123]010110010000300101020201?1311
001?[01]2010111110100101 20?2000401101010000001000001000001000001010000000001110
0110100?021200?10412010??020110002000 0?01110101 1?10000000111001101010 02100?111
110001101000102202?12??[123]01?11110??000201101111001110001010101111102?1101220
10111100002?101?112????????0

Rhynchocyon
00210051?????10310001100100010 2001?12011220201001??11[01]221200222033?????0??021
211?02?10100?22101100??0?1??00001110312 2220?2?000?012011100000000300101020201?1
311100110011011110100111001200002101001000010100000100000100100101110200001121
01101011021200?10402001010101 1110?1010?111100031?101010011202?011?0???10?201[12
]?1000011111011002 11112??20101111101000101111110101110001010100111012111112211
011211201221010102010000000

Procavia
00121[01]4201221?031000102?2???1?2020?22032201200000??12122110010 2033?????1??021
211?12?12300?2210112320231010000101111112 2032?010000111112001000030110102 0211?
1211111?111000111100010 1100?2000[01]0[01][01]1001[01]00000001101011000[01]0010110
1012000101121111010110212110104100 10??02011001001?00211110011?100000001200 02?2
100002000?02101010211110010210 0112??011011110011002011201001111110010101 01111[
01]121011022011111012012210301022 00000000

Moeritherium
00211[01]2202000102100010112???2?2????22012201100?????12122111011 1033?????0??022
211?02?02300?22101223210010 11?????11214222102001001?1101131010100001001020011?1
??1110111?0100011001?????000001[01]110000200101 0?1?1?001101002??010?01000100111
00110100 0011?11010400000??0001?00???????????01??????????????????????0??02??????102?0
???01?0???0?12?0????1?0111100?1102011201101101 1????????00110001??????????????????
?????????????????

Chaetophractus
01130054?????0????????1111??
??00000012001010030010112 0201?1311101 11?101
00101010100100100103?100200?00000001101011001102??010200120100111111 0200?1212
00?103120111112011000101?012111101 21?1100000122100 2?2001002000?110111002111100
10020001010001011110111112111001010001100010111011010021011022000001102002 0101
110010???????

Bradypus
0133??54?????????????112???
???????????????????????????????????????0031001200101000000010212 11?131100102??01
1[01]011000110100020003?000200?0000020110001100110 2??0102010001001120111020 0?02
1[23]00?11002010??0001100000 1?0120111002 1?1100001112100 2?2001002000?1200[01]0002
101110100102?110100101111010111211010000010110000011112010002100003200010100 20
112101001000001111 0

Tamandua
1???
??????????????????????????????????????1?00?0?000?0100000111020201?13111?1?1?01101
111010110[01]00?20003?10020??001002?000000000010 2??010201020100112 0?111200?0212
00?11002010??010010000000 0?211110??1?1?0000???????2?2?0?002000?12101100210110010
020101[12]0100?011110011112110000010001100010111100100021000022001101002002210
10110001110110

Dilambdogale
002?????????????????????1??2?0???????01000000???????0120100100[12]1100000112211000
1101101[01]2022001200??001100010010[01]3110111010000[01]02301??????0?????????????
??????????100???
??
?????????????????????????????0?0111???0?1?1
??

Widanelfarasia
002?00?1???????????????01??2?0000?00101000000?????000120100100211000100?22100001
1011010202210200???0011000100[12]0131101110100000???01012?100?0000100100??01?1??
?????100????????????????????????????00???
??
??

Todralestes
002????????????????????????20????????01000000-----
00022000?1002200100000222010010111 12[02]2012001221000011000100110 31[12]11110[12]
00000033010?[23]?200??000?10?01??01?13??????100????????????????????????????????
???
??000011?????????????
??????????????????????????????00101??

Microgale
00210021111000200000100101002000 00-10010000000-----00012001?1102020001001220 3 --
012--1--000210000000-0011000100101301000030000001 3-0101300000000000001000201-
121111001110011010110110 1?00100020010000001---211?01111101002-0010210011000 1
1111111101112121101100-0110010122011000 00-011100011-1000001-210111-1001012?1
201110100000010001 0?21001???0010111?101100?010011[01]000[01]1100000111011 1?0?10
011220011011[01]200211100010[12]00110010

Foxomomys_fremdi
002?0??3???????11?2?-???111?2?0???-00011221100-----
000000[01]0111022[01]02021002222[12]11102110112112112222000011000100100113122112
0001002200?0??200000??????????????31???
???
???
??????????????????????????????????

Dryomomys_szalayi
00210033013000111020-0?0111?2?0000-20112221101-----
000000101111221020210022221111021101221221122220000110000001101131221020001003
2000011200000200011021101-
1311110111110???1??00?0?1??????0?2??????000???01?????????????2-
0?????????0???1?????????????????1100?01110?1????????010-0111102?1-
12?0?0??????????????01?00201??????10??1??0??????????????????????????01???000000????00
0???0000??01?0?00220011011020020111211100????11

Tinimomys_graybulliensis
00310033013000111030-0?0111?[23]?0000-2[01]012221101-----
000[01]00101111221020210022221111021101221221122221100110001001101131221020001
0032000011200000200011021101-
1311???11111???????????????????????????000?????1????????????????????????0?????????????
???????????????????????????010-0111102?1-
12?0?0??????????????01?00201???1?????????????????????????????????????0????000000110000
001100001001?00002200110110200201112111001111111

Carpolestes_simpsoni
00[23]-0022013000111020102-111?[23]?0010-21112200011--------00---
011122102021002222111102110122122111222100010001100210113122102000101321000112
00000200011011201-131111011011201011010100110-?001?00103-00000010111100??00??02-
0010?0??020?0?1?1?11?20200112?0-1100201100110?11?002000-0111102?1-
12?0?0?31??????????01200201?01100???0???0?????????2--
?0?111???????0?0????00100011000?0?1100001001?0?002200110110200201111111011111111

Cynocephalus
0033003112[13]000241000101010003-2020-02012200010-----
00102121110222102021002222[12]111101101220221122000-
001000010021031322230200001002110111100000201001111211-
13111111110000101111001110012000002113-
0000000010010010001100001101000211101110111111111021300-10000010--0011100000----
2-1110011-1110001012020---1?-01000101201100021111001??211112--
00111111??0[01]002111010000011100001011000110011000022001102102002011111110001
11011
;

Table S9. Modified character matrix of (11) in TNT format. See (11) for character descriptions and states. All modifications in bold.

xread ‘Purgatorius analysis modified Bloch 2007’
173 20

Asioryctes_nemegetensis
0000000000000000000000000000000000000000000000000000000000000000000000000000
000000000000000000000?0000??00??????????????00?00?0?0000?00??????????0???0?0?0????
????000?????0

Purgatorius
00?10??120?000??01200[01]0[01]0000000111110000001000000[01]0[01]001010[01]0100100
[01]10[01]0000[01]200000??**10[01]0[01]10**??
?????????????????????????????????

Palaechthon_nacimienti
00?10????011101001200?[01]?00[01]00[02]01111100[02]1[01]210[01]0100[01]200001110112
01100[01]11210[01]012[01]0[01]00???????001??01000?10?0??????????????????????????????
?????????????????????????????????????

Paromomyidae
10110[12]??3[01]?1001001200000001000001[01]11[01]0210[12]10101111200101010112111O
011121100121010002111111001021000?10022001010110011001110100 00?210101100111101
[02]0010000111101 0000[01]00??010110

Chronolestes_simul
100101011121110020000010100001101011110110111100 0[01]21000111111200110011210000
0200101???
???????????

Carpolestidae
000102113011100120020110210111111101001111111110002100010111121011001121001020
01011?0?001100100101011010200101011001 11?1?1??00001200001001111101 20?1?0100101
020011100?0110011

Plesiadapidae
10110211311110103012020200010101111[01][01]0110210111[01]10210001011112 1[01]1110
11210000[12]1010?1?11201100100101010011200111 0[01]000110011100000 0?11010110[01][
01][01]11012001000001110100 00[01]0000?10100

Saxonellidae
11?1010132?12010[03]0[02]2100[02]0001111111110[01]001011111000220[01]001011112[01]0
1000112100002[01]0101??
??????????????????????????

Microsyopidae
111102011101101001[12]000110010000010110120101010001010001111010100100101110011
2001010?0?001001100100000??100001010001?1?111??????????????????????????0?0????????
????????????????

Micromomyidae
11110101210100102 1[12]00002201000000111000000000010[01][01]001011110101[01]01000
11010001200000 1?1?00?1001?????0?????0001010100011001111000 00?210[01]011001111012
0010010011101001110?0011011?

Atliatlasius_koulchii
?????????????0???????????0????????????????????010200001001 1??00101??0010000[12][01]
0101??
????????

Altanius_orlovi
10?01????01000000120011011000000 10?0?0?????110000121000100111210110111100110200
101???
???????

Omomyidae
10101101101[01]101101[12]00[01]1100000000101110200210110011200001001 10[12]001[01]
01111100002001011001111112000101 0?12?11001010100011101 11??????1?010101101110101
00002??0??3?2100?0?????1?2?1

Adapidae
10101000001000000[01]1[01][01][01]10000000000010002100101100 1[01]2000010011010011
[01]1111000[01]1[12]101011001111112 10[01]100[01]112?110010101000111011100000 01011
0111111110101000020001030210000 00??010211

Elpidophorus
?001030????10?3[01]13[01]011[02]11000301111001?1?000011[01]0110102010011112 10001
0000111201110??
?????????????????

Plagiomene
0001030??0?0100311310112110203010100001100000111012000201001111200011000010121
11101?1?101?0?10210?0???????0??
??????????

Cynocephalidae
020003000001[02]0121131[01]11200100301111[01]1001??00011102200120100110000000000
0020000110002102010011110101001020100011 00111[01]010111111110212001101112001 21
1010111012110111111111121100

Ptilocercus_lowii
0200000100011110301[02]011200000000010111[01]2???10101001100020000000101001000?1
211110101010110100201010100010000100100000111011001001001000121001111012010000
0010101001111111110100

Tupaia_glis
0200000100111010301[02]011200[01]0000010111000??10100002100020000100101001000?1
21100101002011010020101111012101010000000100000000000010000000200000000000000000
0100[01]00010000000000000

Berruvius
?0?1010??1???0??01[02]0001100???20??11?00?1?00010000010[01]001[01]101011010010111
0011200100???
???????????????
;

Table S10. Modified character matrix of (24) in TNT format. See (24) for character descriptions and states. All modifications in bold.

xread 'Purgatorius analysis modified Silcox 2010'
240 34

Ukhaatherium
10100010000000000000??00?1001100100000000020020000?1001?000101000?000000110?021
0?11100?101??021?00110?0000?0000000000001000200210010102000100000110000000102
?000111000110000200100000000101010000000020100012002001100000010000000002000000
000000

Leptictidae
?0110001000010000?1??210?211011100110011000010102000000001?10000?101221001100
020101000101001110100101100?02200110?0?011002002101021020002010000030000000100
00100010011000000011000000001000102000001 20[01]1000000000110000 0?0000000000300
000000000

Erinaceus
200101102000210011000001001010001001 02?00200121101001 1?0001000000002011210001 10
021100101100012100011101000?0010001100001110102001010002100011111110101101 1000
1111001130001100101110000000001011001 2?1120012113111101010001 1???2000020002000
200000

Echinosorex
210101112000?10012000011002110011001??0102000211000011000010000000100121000010
0201001011000110000110?1000?0010001100001010100210010102100111100110101101 1100
1111001130001101101001100000001000000100120000103211001010001 1???2000000002000
200000

Hemiechinus
210110102000210000????0110100000100112???????????????????0???01020102100012012[
01]100101110012100011101000?0010001100001110200200010102100111110110101011011100
111100112?0011011011101000000010110012?112000010321100102000110000000020002000
300000

Ottoryctes
??0???????????????021[01]00??2?0?010
100011?0011011111011110021001100??01011210210110002000101100010000000000000011
11010110000200100000000020000000110002100001200200110000200000000100211000000000
0

Pararyctes
????????????????????????1?????????110??????????????????????????????02?000??1?020?0?0?
?11??011?0111101?00?0210?10??????01110120001000200020110011000000001000000 10102
?1101000001000000003???01001101120000002002001100002000000001011110000000000

Paleoryctes
???????10??0??0??0??????0?????0??
01???12?????10????????????1???????012002001100020000001110?10001000010 2?000111?0011
0000200100000?002000000011000210000120020001000020000000000002110000000000

Uintacyon
???0??1???????????????
??????????????????????0?0?????0?0002010110100020012011001101010000000000000001101010
000120????000000????100000000200011110120010000020???200000001200000000

'Vulpavus_profectus'
?010000100000?0?0010??21??100?0000100000200000001020000?1?00011?00??0011100?1100
0??0?01000?1112000?00?0002?0010?0?0000010002000110100020010011001101011000001 00
0001012000010 1?0110000000010001000000012000111211000100000000???20000100020000 0
0000

Solenodon
10110111011000001200000110100010101111011201010100000000000100000101001201000 01
00010100[01]00001020?011100000?001001[012]1000010100?1011000002010201000110101 1
011002?000?11?2?0101001001?000?000201110000002?23012113012001100012????20001002
01000000000

'Sorex_cinereus_sorex_sp.'
2011100001000000?2????1110101010100 10?00020102?[01]0000110000101000002000001000
010010000?0000000200011100000?00110001110010011020010000021001111001101010010 1
1001020011000001010011100130 0?0111210112?2?0311211301000100000111020000000101 1
00200000

'Suncus_murinus'
201111000110?100??11000120001010101102?10201121100001100001010 0?00100020100001
0011000100000102000111000000?001100?111002101102001000002000101100110100001011 0
000200112?00010100111001300001102101 12?2?0310211301000100000111020000000101000
200000

Rhombomylus
20000111000?100?00?0?0?1??201001100010?111000100110?00??00??1?0?00??12211100200
201000??01?0000?1021100122?0010?0120?1101210?0010[01]10102110101101[01]101000100
102?12001112?011101100001102?113???212212?0020010000000000220000111010001011 01
111000111

'Ptilocercus_lowii'
1010000110110001001 0??10110?0000000000100000200102010001010010110211112210112 1
01010001001100101010110111111211001100002111200010000102100 10?11010010111[01]1
1010112001 12?000101001100000000101000001101 12301[02]01301000100000011020000000
001010200000

'Tupaia_glis'
1001000100000000001000210221001100000010000022010201000001001000002?00222101120
0200000000110011101010?1111102100011000021012002100000[01]020001011101000011101
112?00201102?00010000110001300010100000110012301[02]01301000100000111020000000
001010300000

Genetta
201000110000100001100011021010010010000112000111020000000000001000030122100101[
01]0100010[01]01011020000100?1002?020010100000100020021001010200120110011010100
01000?001010?2?00000021?1??0000001000100100000200121131120010000000???2011???00
2000000000

'Cynocephalus_volans'
1010001000100111001010001100000000000000001002000021001100100102110311211101120
021100000000100002?10200?1022?01011010000020110?02111000021002011110031000000112
?1020100000100012000000030001?10001010?012101100001100100100101120000010002000
301000

Gypsonictops
??
???0110110102000201100013100001?100000?0??001100
000200100000?????????0?000012101000[01]000101110001???000000000201010000000

'Carcinella_sigei'
???111??1??001?01001?
010?01?0000?1?00000?0?20???1???02121113????????110000110010011?1000102?01001112?
10010000?100000???000?

'Labidolemur_kayi'
1011000100000000001002021121100110000000110002100120000000?00100002201011?1000?
100?00100001011000001101000?0?00000111002121113????????20000011001101000001102?
010010011000100000100000001021021221111113101102110111111001100001000002110103
00000

Apatemys
?01?00?10?00??0?0???2021?20??01?0000000???00????12?0??000?001?0????01??0?1?00?????
?????????1????00???0??????2??0?111002121113????????20?0000110000??0?00110000100111
110001000001000000001021021221112?[02]310??03110111101001?0000100101411010300000

'Heterohyus_nanus'
?0??00??0???0?0?0?0020?1?2??????00000001100??10????0??000?001?0?0??02??1?1?00?????
??1??????1????????????????2???011?002121113????????01100?010000?10?0001102?0100111
10010100100101100001021021221112?03??????11011110100100000100111112111300100

Jepsenella
??
????????????????????????00????????????????????????0???????????????0102?000011011100100
00000000000002102122111 1?0310??030101111000010000000000041101000000?0

Sinclairella
???2101???00??0???????
?0??110?00???????????21?001?0202121203????????1[01]1000011011010000011 02?01001111
1010100100101100011021021221112?03??????11111010100100000100112111111300100

Purgatorius
???????????????????????????????????????**001002001021000**???????????????????????????????
??????????????????????????1120???????02101001020001011000000000100100000000000000[
01]00[01]0000100000?0?0?1?10000000120000001010000[01]10000[01]0000000010110[01]110
0000?0

Carpolestidae
?01000011011000?00002101111001 10?0000000010020010210001110011020???01221000021
12100?0??01?0021?0??111?100?0??0?0?113002000100100101102100211101011110110010000
11001000101012100000010000002111000110202201201201010100110110000000011230211 00
00000

Plesiadapidae
?010000100100000000000111100010000000000000002001 02[01]00001000?001000101221010
121?210??0??01?0021001?1111102?1?00?011130011012101101011011100011[01]100110011
0010[01]111001010101002100000010200002111101110012320201311[01]1010[01]110110000
00011210211 1000100

Paromomyidae
?110000110100001000011111210010000000000000000200102[01]00000000?102?01?0120100?0
211211??0??1111121?1021101112?1220001113001101 2?001?000002100[02]011[01]01001001
1001000100000111000021001000100000 0[12]10110[01]1000020100001111011110001100000
1011210221220 1000

Microsyopidae
???????????10??????????????????????????????????????1??????????????????1101101001101 0000
00101112[01]11??0101000?0?10001111002111201001000 00100?1111001000001110100011 00
11001000110001100100000031021011100120110001110011 10?001001100000013011 1000000
0

Micromomyidae
001000010010000101001110110002?010000000010020010210000 00?00102???101??1???02?1
?????????1???21?1021???10??1????01112002111200211000002000101100000100000010000 0
000000100000000010010000001102101100012230000[13][01]10010100001[01]011010010130
0110[01]00000

'Altanius_orlovi'
??
?????????????????????????????????002?0210000102000?01100100011 1?0010001110100000 10
111201000100??01?0?110000001200100010101010011011000000011210201020 0000

Adapidae
?01000011011000000002121122?020100000000000020010211011110011000 0?102122000111
02100000001100211010111111111010?0100000[12]100200010010102100101101100001 1100
10[01]0110010100000[01]11201000100000100011000000120[01]1[01][01][01]3110101001101
00001000101102010[02]00[01]00

Omomyidae
?01100011?11000???????????111211100000000010022000211 01??1??1????????2?220?0121021
?000?011??021101?1111111?10?0?0?[01][01]100[12]1001001110001021000011[01][01]10000
11100100011001000[01]010[01]1120[01]0001000001[01]00110001001200100011 10101001[01
]010000000010[12]302[01]10200000
;