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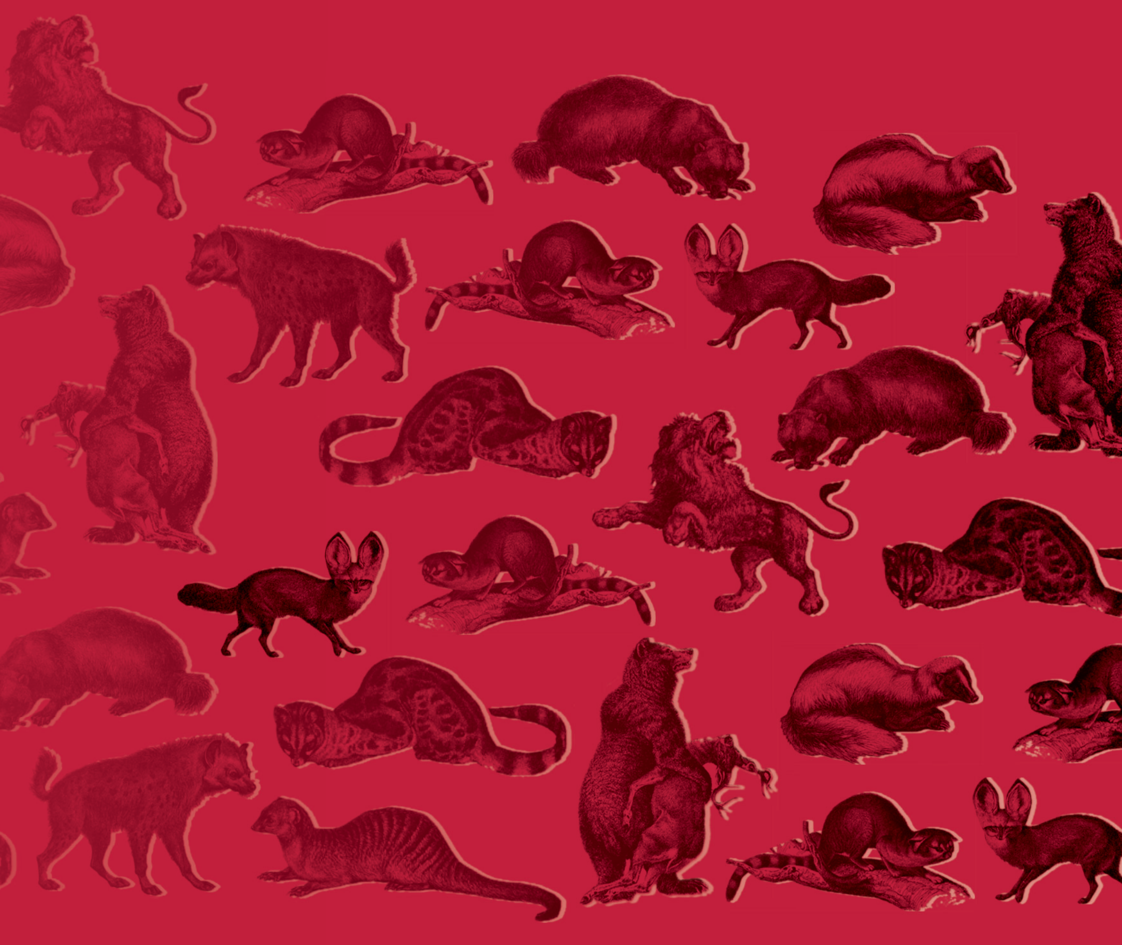

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Ecometrics and Neogene faunal turnover: the roles of cats and hindlimb morphology in the assembly of carnivoran communities in the New World

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ABSTRACT

Cats possess some of the highest ankle gear ratios of any extant carnivorans, a feature that facilitates leaping and sprinting involved in ambush predation and scansorial lifestyles. In today's North American carnivoran communities, the high gear ratio of cats contributes to an overall high ecometric average for this trait and contributes strongly to measures of ecometric disparity at the community level. But cats were late additions to North American communities, arriving from Eurasia about 17 Ma at the end of the "cat gap". This paper uses ecometric analysis to document changes in hindlimb functional diversity in North American carnivoran communities over the last 19 million years in order to better understand the roles of trait evolution, clade turnover, and environmental change in community assembly. To accomplish this, I look at the phylogenetic history of ankle gear ratios of cats and other carnivorans, and the history of their occupation of high gear ratio niches in North American communities. The primary focus is on the Great Plains, which experienced profound changes in vegetation and climate through this period. Across all Carnivoramorpha, including a variety of extinct clades, it was found that gear ratios range from 1.08 (with extant ursids and viverrids and extinct miacids and barbourofelids, one of the three cat groups considered in this paper, having the lowest values) to 1.46 (with extant felids, herpestids, and canids having the highest values). Using the fossil record combined with phylogenetic ancestor reconstruction, it is shown that stem carnivorans and early felids had gear ratios about halfway between these extremes, consistent with a semidigitigrade or mildly digitigrade stance that was not overly specialized for either leaping or sprinting. Barbourofelids and some machairodontines evolved lower gear ratios that emphasized mechanical efficiency over advantage. When cats first entered North American communities in the Miocene they did not occupy high gear ratio niches and, in fact, occupied some of the lowest gear ratio niches during the Barstovian, Clarendonian, and Hemphillian. A major restructuring of gear ratio distributions in North American carnivoran communities occurred during the Blancan that appears to have resulted from clade sorting processes involving the selective loss of low gear ratio groups, as well as the evolution of increased gear ratios in felids and canids.

KEY WORDS
Carnivora,
Felidae,
ecometrics,
functional trait ecology,
locomotor morphology.

RÉSUMÉ
L'assemblage des communautés félines du Nouveau Monde : écométrie et changements fauniques du Néogène. Les félins possèdent une cheville avec un indice calcanéal parmi les plus élevés chez les carnivores actuels, un caractère qui facilite le saut et le sprint impliqués dans la prédation par ambuscade et dans un mode de vie de grimpeur. Cet article pose des questions sur l'origine phylétique de cet indice et sur l'histoire de l'occupation par les félins de niches nécessitant un indice élevé. Parmi tous les carnivoramorphes, on a trouvé que l'indice varie de 1.08 (ursidés ou viverridés actuels, miacidés et barbourofelidés ayant les plus faibles valeurs) jusqu'à 1.46 (félidés, herpestidés et canidés ayant les plus hautes valeurs). En utilisant la reconstruction d'un ancêtre phylogénétique, on a montré que le Carnivora ancestral et le félidé ancestral avaient des indices à mi-chemin entre les extrêmes, correspondant à des attitudes digitigrades ou semi-digitigrades qui n'étaient pas complètement spécialisées pour la course ou le saut. Les bardourofélidés et quelques machairodontes possédaient des indices très bas mettant l'accent sur l'efficacité mécanique plutôt que sur les autres avantages. Les félidés du Miocène d'Amérique du Nord n'occupaient pas des niches nécessitant un indice élevé et, de fait, occupaient des niches avec indices faibles pendant le Barstovien, le Clarendonien et l'Hemphillien. Une restructuration majeure de la distribution des indices dans les communautés de Carnivora en Amérique du Nord s'est produite durant le Blancan avec des processus de tri des clades en fonction de la perte sélective des groupes possédant des indices faibles.

MOTS CLÉS
Carnivora,
Felidae,
écométrie,
écologie des traits fonctionnels,
morphologie locomotrice.

INTRODUCTION

Cats make a unique contribution to the locomotor diversity of extant carnivoran communities. Predominantly leapers and springers, cats are among the most digitigrade of living carnivores and have higher ankle gear ratios than most other carnivorans, including their cursorial canid cousins (Fig. 1). While canids and felids share a pronounced digitigrade stance, the function of felid limbs is more strongly differentiated between fore and hind than in canids (Meachen-Samuels & Van Valkenburgh 2009; Kitchener *et al.* 2010). The felid forelimb is less suited for parasagittal cursorial locomotion and more suited for grappling with prey (Gonyea 1976a). Unlike dogs and foxes, most felids retain five full-length manus digits, retractile claws, and the ability to supinate their forearms and are thus able to grasp prey or negotiate steep or vertical surfaces in ways that canids cannot (Gonyea & Ashworth 1975; Gonyea 1978; Walmsley *et al.* 2012). The extant felid hindlimb, in contrast, has strongly hinged joints, long distal elements, and tightly bound metatarsals that provide cats with substantial leverage for leaping or sprinting (Harris & Steudel 1997, 2002; Kitchener *et al.* 2010). Combined with a flexible vertebral column (Hildebrand 1961; MacPherson & Fung 1998; Boszczyk *et al.* 2001), the high ankle gear ratio facilitates the bounding, leaping, and climbing behaviors that differentiate felid locomotion from the almost fully terrestrial cursoriality of canids in terms of form, function, and energetics (English 1978; Van Valkenburgh 1987; Taylor 1989; Van Valkenburgh *et al.* 2004; Kitchener *et al.* 2010; Morales & Giannini 2010, 2013; Williams *et al.* 2014). The hindlimb of cats can therefore be thought of as specialized for saltatory or "pseudocursorial" manoeuvres in contrast to canids whose similarly high gear ratios are associated with cursoriality.

Community assembly processes involve the filtering effects of form-function relationships between the species that make up a community and the environment in which the community is situated (Ricklefs & Travis 1980; Poff 1997; McGill *et al.* 2006). Ecometrics is an evolutionary ecological approach to the study of community assembly that breaks the specializations of its species down into quantitative functional traits, whose distributions and evolution can be studied across space and through time (Polly *et al.* 2011; Polly & Head 2015). By focusing on distributions of individual traits instead of species, ecometrics recognizes that species are composites of traits, often with unique combinations that collectively differentiate it from other taxa, as in felids and canids, which have similar hind limb gear ratios but different combinations of forelimb and vertebral column traits and correspondingly different locomotor and ecological niches. This amalgam of traits can make it difficult to assess how any one of them contributes to community assembly. Instead, ecometrics measures the commonalities and differences of a single trait among the members of a community to characterize the full range of capacity the community has for the associated function. By comparing the distribution of that trait among communities in different environments or over time, the contribution of the associated function to community assembly processes can be assessed.

Extant North American carnivoran communities have higher mean gear ratios in open or heterogeneous habitats, whereas it is typically lower in communities inhabiting extensively forested regions where there are more species with lower gear ratios associated with ambulatory locomotion and plantigrade climbing (Polly 2010; Polly & Sarwar 2014). Ankle gear ratio is an ecometric trait that measures the mechanical efficiency of hindfoot extension as the ratio of the length of the calcaneum to the length between the distal edge of the sustentacular process to the end of the calcaneal tuber (Fig. 1). This ratio is an easy-to-measure proxy of the in-lever for hindfoot extension, which in practice is the distance between the centre of the astragalar trochlea to the insertion of the gastrocnemius and

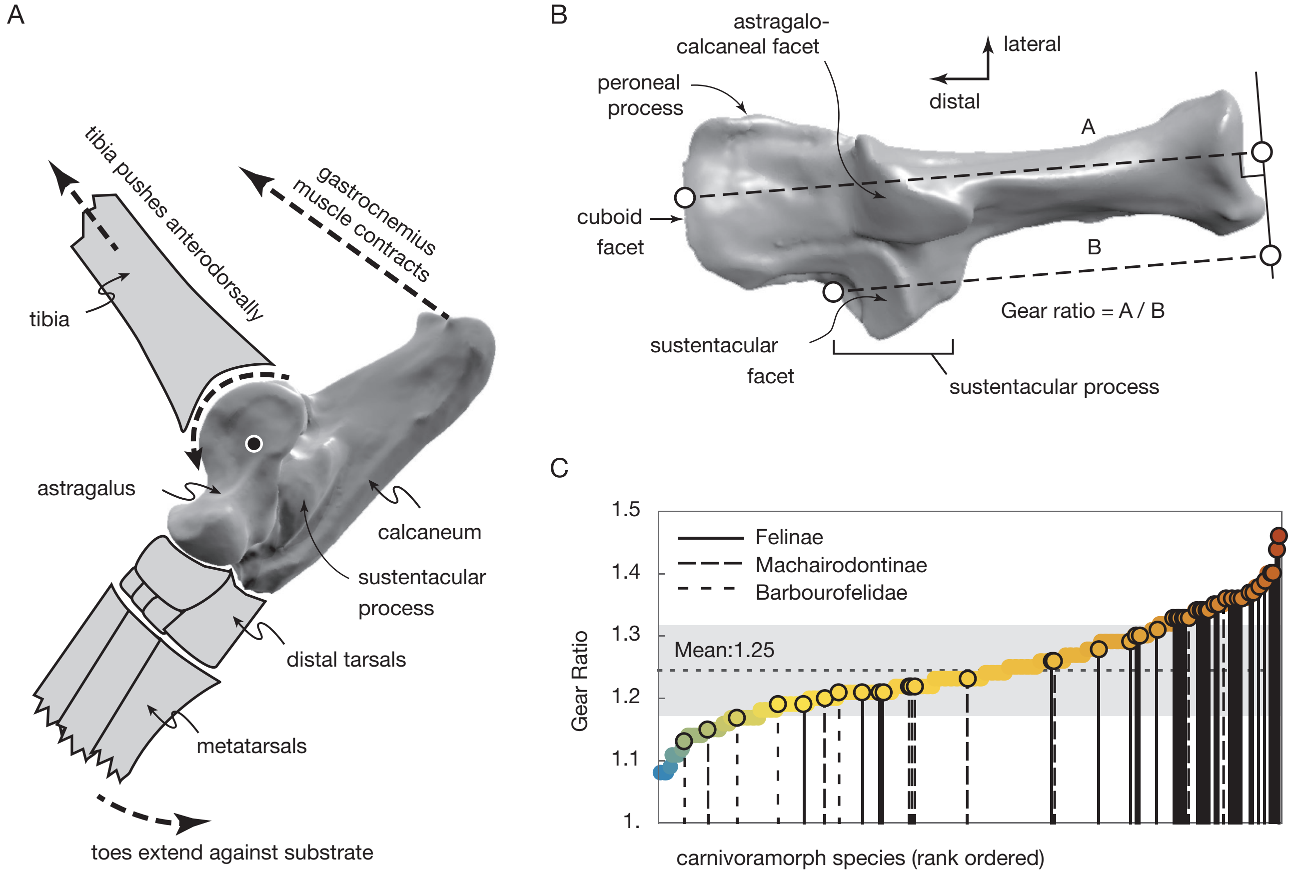

Fig. 1. — Ankle gear ratio in Carnivoramorpha: **A**, plantarflexion in the carnivoran ankle joint (medial view). Black dot marks the approximate centre of rotation. Distance between dot and insertion of gastrocnemius is the approximate out-lever for plantarflexion. Scans of astragalus and calcaneum from *Puma concolor* (WRAZL 0210086); **B**, calcaneal anatomy and gear ratio (dorsal view); **C**, ecometric distribution of ankle gear ratio (y-axis) for 215 carnivormorphan species in rank order (x-axis). Felid and barbourofelid ratios are highlighted with **black circles** and **stem lines**. **Horizontal broken line**, mean value; **grey band**, 1 standard deviation. Colour coding matches Figure 2.

soleus muscles. Because the sustentacular process supports the base of the neck of the astragalus just below the distal edge of the trochlea, its position relative to the long axis of the calcaneum captures much of the relationship between the upper ankle joint's in-lever and the out-lever of the foot (Polly 2008). Ankle gear ratio is correlated with stance (digitigrade, semidigitigrade, or plantigrade) and metatarsal-to-femur ratio (Polly 2010). It is not strictly the same thing as metatarsal-to-femur ratio or digitigrady, however. Metatarsal-to-femur ratio is an index that captures the gear ratio of hindlimb extension because the in-lever consists of muscle attachment points on the femur and the out-lever is the contact point between foot and substrate and is the classic measure of digitigrady in mammals (e.g., Gambaryan 1974). Metatarsal-to-femur ratio essentially measures stride length relative to the power put into hindlimb extension. Ankle gear ratio is specifically associated with foot extension, with high ratios achieving a greater degree of extension for a given contraction length of the calf muscles (mechanical efficiency) and low ratios achieving greater mechanical efficiency (or "strength") for the same amount of muscle contraction. Extant felids and canids, for example, both have high ankle gear ratios despite their different locomotor repertoires. In felids, hindlimb mechanics are important determinants of performance in leaping (Harris & Steudel 2002).

Despite the trait-environment focus of ecometrics, the association between taxa and traits is not easily untangled. In living carnivorans, ankle gear ratio is strongly sorted by phylogeny, with canids and felids as possessing high ratios as clades and ursids sharing very low ones (Polly 2010; Polly *et al.* 2017). Consequently, the sorting process of gear ratios appears to act at the clade level rather than the species level because entire family-level clades are overrepresented in habitats that favour high or low gear ratios (Polly *et al.* 2017). Felids are overrepresented in forested and topographically heterogeneous environments where ambush behaviors or scansoriality may be more important, whereas canids predominate in comparatively open environments where long-distance travel or pursuit predation may be more common, even though the two clades have similarly high gear ratios. Furthermore, the phylogenetic distribution of high gear ratios, which evolved convergently in crown felids and canids (Polly *et al.* 2017), and the long-term succession of climates and environments in North America (Graham 1999; Zachos *et al.* 2001; Figueirido *et al.* 2012) both suggest that the relationship between trait, clade, community, and environment is likely to have been different in the geological past.

This paper assesses the contribution of cats to hind limb gear ratio diversity in North American carnivoran communities through the Neogene. True cats were relative newcomers to these communities. The first true felid to immigrate to North America was *Pseudaelurus*, which arrived about 17 Ma during the Hemingfordian NALMA, thus ending the “cat gap” that followed the extinction of the last cat-like nimravid at the end of the Oligocene around 23 Ma (Van Valkenburgh 1991, 1999; Hunt 1996). Furthermore, barbourofelids and machairodontines were key members of Neogene carnivore communities, but had locomotion and lifestyles that were substantially different from living felines (Gonyea 1976b; Anyonge 1996; Van Valkenburgh 1999; Meachen-Samuels & Van Valkenburgh 2010; Meachen-Samuels 2012; Martín-Serra *et al.* 2017; DeSantis 2018; Lewis 2018). In fact, the extant feline crown group shared a last common ancestor less than 11 million years ago (Johnson *et al.* 2006). The locomotor diversity of the modern North American carnivore community – and the unique locomotor morphology of its felids – is therefore a geologically recent phenomenon. For the purposes of this paper, “cat” is used in the inclusive sense of all the clades with cat-like morphologies whose absence was used to define the “cat gap” – nimravids, barbourofelids, machairodontines, and felines. I follow Morales *et al.* (2001), Morlo *et al.* (2004), and Werdelin *et al.* (2010) in recognizing barbourofelids as the sibling-clade to Felidae (Felinae plus Machairodontinae) and distinct from nimravids, which are here treated as lying outside the carnivoran crown-group (Flynn *et al.* 2010; Spaulding & Flynn 2012). However, I use the term felid in a colloquial and broad sense for both Felidae *sensu stricto* and Barbourofelidae and feline for Felinae. I use carnivoran for members of the crown-clade Carnivora and Carnivoramorpha for the crown plus stem groups following Flynn & Wesley-Hunt (2005).

The question of how the ecometrics of communities has changed over this period involves trait evolution as well as community composition. Janis & Wilhelm (1993) argued that the origin of wolf-like pursuit hunting, and high limb gear ratios, in canids was linked to the expansion of cooler, more arid environments of the Pliocene and Quaternary, and that canids in the earlier warmer, more open habitats of the Miocene had different locomotor ecologies. They argued that pursuit hunting did not co-evolve with increasing limb lengths in their ungulate prey from the Oligocene onward, but that elongation of the distal limbs in canids first occurred later in the Clarendonian about 10 million years ago. The origin of migratory behaviours in ungulates in the colder, drier, and more seasonal habitats of the Pliocene, they argued, made pursuit hunting a viable strategy for canids (Janis & Wilhelm 1993; Figueirido *et al.* 2015). Today’s canids are second only to felids in having high ankle gear ratios. Did felids undergo a similar shift in locomotor behaviour such that they acquired their high ankle gear ratios after the end of the Miocene? Some evidence suggests this could be the case. Proportions of the fore- and hindlimbs differ in felids, and they distinguish later Felinae from Machairodontinae and Barbourofelidae along with other limb features (Anyonge 1996; Lewis 2018). Analysis by Panciroli and colleagues (2016) of calcaneal shape in extant and fossil carnivores, aspects of which are directly related to gear-ratio metrics, found striking differences between the three cat groups, as well as heterogeneity within machairodontines and felines of the sort that would be required for the late Neogene turnover in locomotor specializations.

In this paper, I analyse the phylogenetic evolution of felid ankle gear ratios and how they contributed to turnover in carnivore locomotor diversity in the Neogene of North America. First, I assess whether the ancestral felid had a low or high gear ratio and how they differ as a clade from other carnivoramorphs, present and past. I then assess the extent to which barbourofelids and machairodontines differ from felines in the strict sense. Was the putatively ambulatory locomotion of barbourofelids and many machairodontines characteristic of the felid component of Miocene carnivore locomotor diversity? Where phylogenetically did the high felid gear ratio originate? Are felines derived in having high ratios or are barbourofelines and machairodontines derived in having lower ones? Then I measure how felid ankle gear ratio changed on average through the Neogene and Quaternary in North America. Finally, I assess how the appearance of felids on the Great Plains changed carnivoran locomotor diversity and how hindlimb locomotor traits were reorganized in the (re)assembly of modern North American carnivoran communities. Is the high gear ratio contribution of extant felines to modern North American communities also the role they played in Miocene communities or is that role peculiar to post-Miocene communities like pursuit predation in canids?

MATERIAL AND METHODS

Ankle gear ratio

A total of 1076 calcanea were measured representing a total of 213 carnivoramorph species, 132 of them extant and the other 81 extinct (see Appendices for raw measurements and specimen metadata). Of the latter, priority was placed on obtaining data for species from the North American Miocene. Data were analysed at the species level, so a mean ratio was calculated for each species. Within species variation is comparatively small compared to the full range of differences between species, but nevertheless there is considerable overlap in the individual ranges of variation between taxa with similar gear ratios. The standard error on the species’ means is considered to be negligible for purposes of these analyses, but readers should be aware that small between-species differences in mean gear ratio may be illusory for taxa represented by sample sizes less than five. A full evaluation of within species variation, including geographic patterns, is presented elsewhere (Polly 2010; Polly *et al.* 2017).

Phylogenetic tree

A composite, time-scaled, species-level phylogenetic tree was assembled from the literature for the 213 species for which I had ankle gear ratios. Relationships of the extant species were extracted from the maximum likelihood tree built by

Humphreys & Barraclough (2014) for 285 carnivoran species using *cytochrome b* sequences. For some family-level clades, the topology agrees surprisingly well with some phylogenies built from more heterogeneous sequence data (e.g., Johnson *et al.* 2006 for Felidae), but is at odds with others (e.g., Sato *et al.* 2012 for Mustelidae). Where necessary, genus names were altered to match Wilson & Reeder (2005). Four extant species were inserted into this tree as siblings to their known nearest relatives with an arbitrary but reasonable divergence time of 10 ka (*Canis familiaris* and *C. f. dingo* inserted as siblings to *C. lupus*, *Urocyon littoralis* to *U. cinereoargenteus*, and *Felis catus* to *F. sylvestris*). The original scaling of this tree, which was based on molecular clock estimates, was retained for most nodes, but some of the deeper nodes were adjusted to match minimum divergence times in the fossil record to be consistent with the fossil clades. The resulting tree of extant Carnivora, with branch lengths, is presented in Newick format in Appendix 4.

Trees of extinct clades were drawn from the following works and grafted onto the extant base tree following the overarching phylogenetic and temporal framework of Polly *et al.* (2006), Flynn *et al.* (2010), Spaulding & Flynn (2012): Amphicyonidae (Hunt 1998a, 2002, 2009); Canidae (Wang 1994; Wang *et al.* 1999; Tedford *et al.* 2009); Felidae (Werdelin 1981; Morlo *et al.* 2004; Christiansen & Harris 2009; Werdelin *et al.* 2010; Christiansen 2013; Robles *et al.* 2013; Werdelin & Flink 2018); Mustelidae (Berta & Morgan 1985; Baskin 1998; Qiu & Schmidt-Kittler 1982; Wang *et al.* 2004a, 2005; Finarelli 2008; Sato *et al.* 2012; Valenciano *et al.* 2016); Nimravidae (Barrett 2016); Ursidae (Trajano & Ferrarezzi 1995; Hunt 1998b; Loreille *et al.* 2001; Salesa *et al.* 2006; Mitchell *et al.* 2016; Wang *et al.* 2017). The resulting tree, with branch lengths, is presented in Newick format in Appendix 5. Note that some studies have placed amphicyonids, nimravines, and barbourofelines in different phylogenetic positions than adopted here (e.g., Spaulding & Flynn 2012; Sole *et al.* 2014); this uncertainty is taken into account when drawing conclusions in this paper, especially with regard to reconstruction of ancestral conditions.

Geographic and stratigraphic occurrences

The MioMap and FaunMap databases were used as authorities for geographic and stratigraphic occurrences (FaunMap Working Group 1994; Carrasco *et al.* 2005; Graham & Lundelius 2010). Species identifications were also updated from relevant literature for a few key sites that served as sources for calcaneum measurements (Webb 1981; Webb *et al.* 1981; Becker 1985; Baskin 1998; Baskin 2005; Hochstein 2007; Tedford *et al.* 2009). Where necessary, taxonomy of extant species was updated for consistency with Wilson & Reeder (2005). Measurement data was linked to these occurrences based on species identity.

Analyses

Trait changes were mapped onto the phylogenetic tree using Brownian-motion based ancestor reconstruction (Maddison 1991; Martins & Hansen 1997; Schluter *et al.* 1997). Note that ancestor reconstructions are the same for all single-rate models of evolution, including Brownian-motion and Ornstein-Uhlenbeck, because they all imply the same proportional change in the trait along each branch. Note also that the model of evolution is less important for ancestor reconstructions if empirical measurements of the trait value from fossil taxa near the time of splitting are available, which is the case for most nodes in this study.

Blomberg's K (kappa) was used to measure how much of a trait's variance can be explained by closeness of phylogenetic relationship (Blomberg *et al.* 2003). K takes on a value of 1.0 when the trait's covariance among taxa is equal to what is expected under Brownian motion and 0.0 when there is no covariance with phylogeny. K can be larger than 1.0 if the phylogenetic pattern is stronger than expected under Brownian motion. The extent to which K departs from 1.0 is a measure of the extent to which the evolutionary process departs from Brownian motion.

To characterize ecometric change in ankle gear ratio, fossil taxa were grouped into communities by region and North American Land Mammal Age (NALMA), from which ecometric means and disparities were calculated. Grouping by region was done to avoid combining species that live allopatrically in radically different habitats so that geographically independent turnovers in traits and environment were not conflated. Grouping by NALMA was done in order to maximize representation of the species that make up the regional fauna. Carnivores are rare and thus have a low probability of being represented at a given site. Furthermore, the number of sites in a given region that belong to the same sub-NALMA temporal interval is usually small. Only when binned by NALMA did the carnivore faunas appear to be representative of the kind of diversity one would expect (e.g., in terms of range of body mass and taxonomic diversity). This means that temporal averaging is present in the analysis. Binning is probably of little consequence for trait-environment relationships in the Miocene and Pliocene because changes in climate, environment, and faunas were comparatively slow and linear. However, in the Quaternary the Irvingtonian and Rancholabrean faunas undoubtedly contain a mixture of glacial and interglacial species that can be expected to increase trait variance (e.g., Bush *et al.* 2002). Focus was placed on Nebraskan faunas because all NALMA's from Miocene to present are represented there and because calcaneal measurements were available for most of the species on the high planes.

Phylogenetic patterns of community change were measured using median pairwise phylogenetic distances (MPD) between species making up each community. Here community refers simply to taxa that are found in a spatial area and temporal interval of interest, with no assumptions of whether they interacted with one another directly (e.g., Rosenzweig 1985). MPD is the median value of all the pairwise patristic distances between members of the community of interest measured in millions of years (Ma). This metric is similar to the mean pairwise phylogenetic distance measure (Webb 2000; Kraft & Ackerly 2010) except that the median is used because pairwise patristic distances tend to have a skewed distribution driven by pairs of taxa whose last common ancestor is at the root of the tree that tend to make mean values overly similar between communities.

Ecometric diversity of ankle gear ratios within communities is displayed using rank-ordered scree plots that show the trait's mean and standard deviation as well as the differences in trait value between species (Polly 2010). Ecometric disparity within communities was measured as either the standard deviation or the variance of gear ratios among the constituent species (*c.f.* Foote 1997). Standard deviation is an intuitive measure of disparity with units in the same scale as the trait itself. Variance is less intuitive because its units are squared, but the variance of a trait scales linearly with time since common ancestry under a Brownian motion model of evolution (e.g., Felsenstein 1988) and thus has a more intuitive relationship to phylogenetic history than does the standard deviation.

One-way ANOVA was used to test for differences in gear ratio between clades. Tukey's test for honestly significant differences was used for post-hoc pairwise comparisons.

Abbreviations

Non-institutional

KA	(kilo annum), thousands of years ago;
MA	(mega annum), millions of years ago;
NALMA	North American Land Mammal Age;
PGLS	phylogenetic generalized least squares (Martins & Hansen 1997).

Institutional

AMNH-FM	American Museum of Natural History, Fossil Mammal Collection, New York;
AMNH-M	American Museum of Natural History, Mammalogy Collection, New York;
CENIEH	Centro National de Investigatión sobre la Evolución Humana, Burgos;
DMNH	Denver Museum of Science and Nature, Denver;
FLMNH	Florida Museum of Natural History, Gainesville;
FMNH	Field Museum of Natural History, Chicago;
INSM	Indiana State Museum, Indianapolis;
KU-M	University of Kansas, Mammalogy, Lawrence;
MNCN	Museo Nacional de Ciencias Naturales, Madrid;
MSB	Museum of Southwestern Biology;
MUZA	University of Missouri Zooarchaeology, Columbia;
MVZ	Museum of Vertebrate Zoology, University of California, Berkeley;
NCSM	North Carolina State Museum, Raleigh;
NMW	Naturhistorisches Museum Wien, Geologisch-Paläontologische Abteilung, Vienna;
NRM	Naturhistoriska Riksmuseet, Stockholm;
OMNH-VP	Sam Noble Museum, Paleontology Collection, Norman;
OMNH-M	Sam Noble Museum, Mammalogy Collection, Norman;
UCMP	University of California Museum of Paleontology, Berkeley;
UMMZ	University of Michigan Museum of Zoology, Ann Arbor;
UNIVA	Universidad de Valladolid, Museo Anatómico, Valladolid;
UNSM	University of Nebraska State Museum of Natural History, Lincoln;
USNHM	US Natural History Museum, Smithsonian Institution, Washington;
UTVPL	University of Texas Vertebrate Paleontology Lab, Austin;
WRAZL	William R. Adams Zooarchaeology Lab, Indiana University;
YPM-VZ	Yale Peabody Museum, Vertebrate Zoology, New Haven.

RESULTS AND DISCUSSION

Ankle gear ratio in Carnivoramorpha

Among extant carnivorans for which calcaneum measurements are available, ankle gear ratio ranged from a low of 1.08 in the sloth bear, *Melursus ursinus*, to high of 1.46 in the white-tailed mongoose, *Ichneumia albicauda* (Appendix 6). This sample contains 138 out of the 251 non-pinniped species recognized by Wilson & Reeder (2005). The unmeasured species are unlikely to extend the lower end of this range, but it is feasible that some of the unmeasured felids or herpestids have marginally higher gear ratios than *I. albicauda*. Extant felids are dominantly at the high end of this range (Fig. 1C). Based on ANOVA, the extant subfamily Felinae had significantly higher gear ratios than all other extant carnivoran groups (Appendix 7). Six of the 10 highest ratios are possessed by felids, with the other four being herpestids and canids. Only four extant felids have gear ratios below the carnivoramorph mean (1.25): *Felis margarita* (1.21), *Panthera tigris* (1.21), *Panthera pardus* (1.21), and *Panthera leo* (1.19). *F. margarita*, the sand cat, is a small burrow-dwelling species that inhabits desert environments in northern Africa, the Arabian Peninsula, and Central Asia, often ones that are nearly devoid of vegetation, and hunts its gerbil prey by digging into their burrows (Jackson & Nowell 1996; Huang *et al.* 2002). The other three species all have comparatively large body size that requires a greater compromise in hind limb structure between springing and weight bearing (Gonyea 1976a). The African lion, *Panthera leo*, which has the lowest gear ratio of any felid, is also one of the few highly social feline cooperative hunters and is also perhaps the only extant cat species with proportionally shorter distal limb elements in the hind limb than fore limb (Gonyea 1976a).

Gear ratios of extinct carnivoramorphs fall within the range of extant species (Appendix 6). The lowest is found in the short-faced bear *Arctodus simus* at 1.08, equal to the lowest extant gear ratio. But the highest is 1.36 in *Lynx issiodorensis*, the putative ancestor of the extant *Lynx* clade (Werdelin 1981), much lower than the highest extant species. In fact, 17 of 133 extant species (12.8%) have gear ratios equal or greater than the highest gear ratio in extinct carnivorans. This fossil sample only contains 99 extinct species, which represents an unknown but probably small proportion of extinct carnivoramorphs dominated by Miocene taxa from North America. Nevertheless, the sample contains members of most family-level clades, including two members of the carnivoramorphs stem group (*Miacis parvivorus* and *Vulpavus palustris*), and is probably broadly representative of the range of gear ratios. Most fossil felids are included, including key Eurasian species, so it is unlikely that other extinct cats would

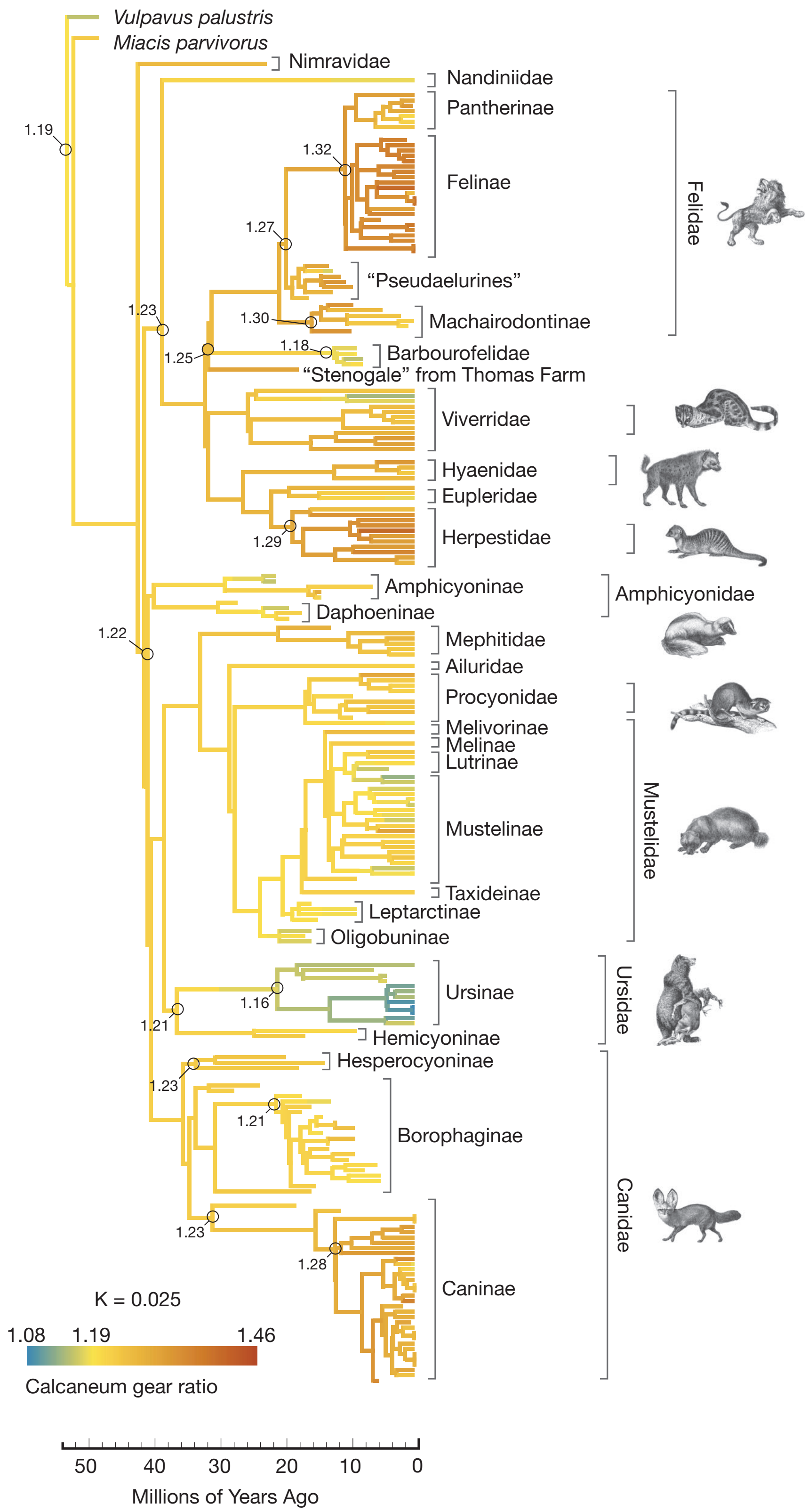

FIG. 2. — The evolution of calcaneal gear ratio in Carnivoromorpha. Gear ratio is mapped onto a time-scaled phylogenetic tree with 214 tip taxa using PGLS. The value at the root node (1.19) is represented by yellow; values less than the ancestor are scaled in a yellow to blue colour spectrum, values higher than the ancestor in a yellow to red spectrum. A large-scale version of this tree with tip species labels can be found in the supplemental files (Appendix 1).

have higher gear ratios than *L. issiodorensis*. Note, however, that this sample does not include extinct herpestids, which would be the prime candidates for having higher gear ratios than *L. issiodorensis*.

Despite having systematically lower gear ratios than extant carnivorans, eight out of 10 of the highest gear ratios in extinct carnivoramorphs are felids (Appendix 6). The two extinct non-felid species in the top 10 are the cursorial *Eucyon davisi*, a member of the canine crown group (Tedford *et al.* 2009), and the amphicyonid *Cynelos caroniavorus*. That *Eucyon* has a high gear ratio is unsurprising because it is part of the origin of cursorial, potentially pursuit-hunting specializations in crown-group Canini (Janis & Wilhelm 1993; Wang *et al.* 2004b). But the high gear ratio of *Cynelos* (1.32) is unexpected. Its congener *C. lemanensis*, like most amphicyonines, has generally been interpreted as having ursid-like, and presumably plantigrade, postcranial specializations (Ginsburg 1977). However, its ankle gear ratio is higher than all other amphicyonids (Appendices 1, 6), including those like *Daphoenodon* that have been interpreted as digitigrade cursorial, den-dwelling scavengers (Hunt *et al.* 1983; Hunt 2003, 2009). The high ankle gear ratio in *Cynelos* suggests the need for reinvestigation of its locomotor morphology. Based on morphometrics it was previously concluded that the shape of the calcaneum of *C. lemanensis* was like those of digitigrade, terrestrial species (Polly & MacLeod 2008) and that *C. sinapius* was like arboreal ones (Panciroli *et al.* 2017). However, Ginsberg's data show that *C. lemanensis* had a small metatarsal/femur ratio (0.23) more like a plantigrade bear such *Ursus arctos* (0.22) than a digitigrade cursor like *Lynx rufus* (0.46) or *Canis lupus* (0.44) (Janis & Wilhelm 1993). Presuming that *C. lemanensis* and *C. caroniavorus* were similar, the combination of high gear ratio and low metatarsal/femur ratio would be unusual for carnivorans, outside the range found in living species but most similar to the honey badger (*Mellivora capensis*), hog-nosed skunk (*Conepatus chinga*), and coatimundi (*Nasua nasua*) (Appendix 2; Polly 2010). Regardless of the unexpected state of *Cynelos*, felids dominate the high end of the range of ankle gear ratios in extinct carnivoramorphs as they do today, but their ratios are substantially lower than most living felids.

Ankle gear ratio evolution in felids

Based on node reconstructions, the ancestral felid (last common ancestor of Felidae and Barbourofelidae) had a comparatively high ankle gear ratio of 1.25 (Fig. 2). This value is the same as the extant coyote (*Canis latrans*) or Pallas's cat (*Otocolobus manul*) and ranks higher than 45% of living carnivorans, although it is somewhat lower than the mean value of 1.33 in extant felids (Appendix 6). Ancestor reconstructions should be treated with some caution since they assume that the phylogeny is known correctly and that the trait in question has evolved under a Brownian motion model of evolution, which means that the reconstruction will always lie within the range of its descendant tips and may have a large standard error due to the inherent variability of Brownian motion processes (Felsenstein 1985; Garland & Ives 2000; Polly 2001). However, much of this uncertainty is alleviated when the nodes are estimated from data that include fossil taxa near the nodes, which have substantially shorter branch lengths and thus pull the estimate close to taxa that lie close to the ancestry of the clade in question (Finarelli & Flynn 2006; Slater *et al.* 2012; Gómez-Robles *et al.* 2013). The estimates of ankle gear ratio presented here include data fossil species both inside and outside the felid clade and the standard error of the estimate of the ancestral felid gear ratio is ± 0.13 (Appendix 10).

The ancestral felid already had an ankle gear ratio that was associated with a semidigitigrade or digitigrade stance and capable of scansorial or springing behaviours, even though it was not as derived as many extant felids. The ancestor's gear ratio (1.25) was considerably higher than the ancestral carnivoramorphan value of 1.19, the latter of which is equal to the spectacled bear (*Tremarctos ornatus*), which is the only extant short-faced bear, the badger (*Meles meles*), and the African lion (*Panthera leo*). This reconstruction is strongly influenced by the stem taxon *Vulpavus palustris*. *Vulpavus palustris* was a small to medium sized (3.5 kg) animal that was if anything more arboreal, perhaps like a coatimundi (*Nasua nasua*) (Heinrich & Rose 1997). The last common ancestor of crown-group Carnivora had a somewhat higher gear ratio (1.22) that was equal to the extant striped skunk (*Mephitis mephitis*) and the Ringtail (*Bassariscus astutus*) (Appendix 6). The ancestral felid condition appears to be derived relative to the ancestral carnivorans, but in practice it is almost identical to the stem carnivoramorphan *Miacis parvivorus*. *M. parvivorus*, a small (1.2 kg) Bridgerian carnivoramorph, has an intermediate gear ratio (1.25) equal to the extant gray fox (*Urocyon cinereoargenteus*), aardwolf (*Proteles cristata*), or American marten (*Martes americana*) and has been interpreted as being scansorial or arboreal (Matthew 1909; Heinrich & Rose 1995).

Contrary to some accounts of a transition from plantigrade to digitigrade in felid evolution, low gear ratios are independently derived conditions found in both Barbourofelidae and Machairodontinae (Figs 2, 3; Appendix 6). Barbourofelids have an average gear ratio of only 1.18, lower than even the ancestral carnivoramorphan, much less their last common ancestor with felids *sensu stricto*. Barbourofelids also had considerably lower gear ratios than nimravids, the two of which were long presumed to have an ancestor-descendant relationship. Barbourofelid gear ratios are significantly lower than in any extant felid (see ANOVA post-hoc test results in Appendix 7). Machairodontines have a quite high ancestral gear ratio (1.30) equivalent to the extant fennec (*Vulpes zerda*) or Indian civet (*Viverra zibetha*), both of which are markedly digitigrade. Some machairodontines, notably *Machairodus alberdiae* evolved even higher gear ratios (1.35) equivalent to spotted hyenas (*Crocuta crocuta*) but others evolved lower gear ratios, the most extreme in *Smilodon gracilis* (1.20), which approached the low values seen in barbourofelids. ANOVA post-hoc tests indicate that machairodontines, like barbourofelids, have lower gear ratios than extant felines, but the two groups are not significantly different from one another. Barbourofelids and at least some machairodontines

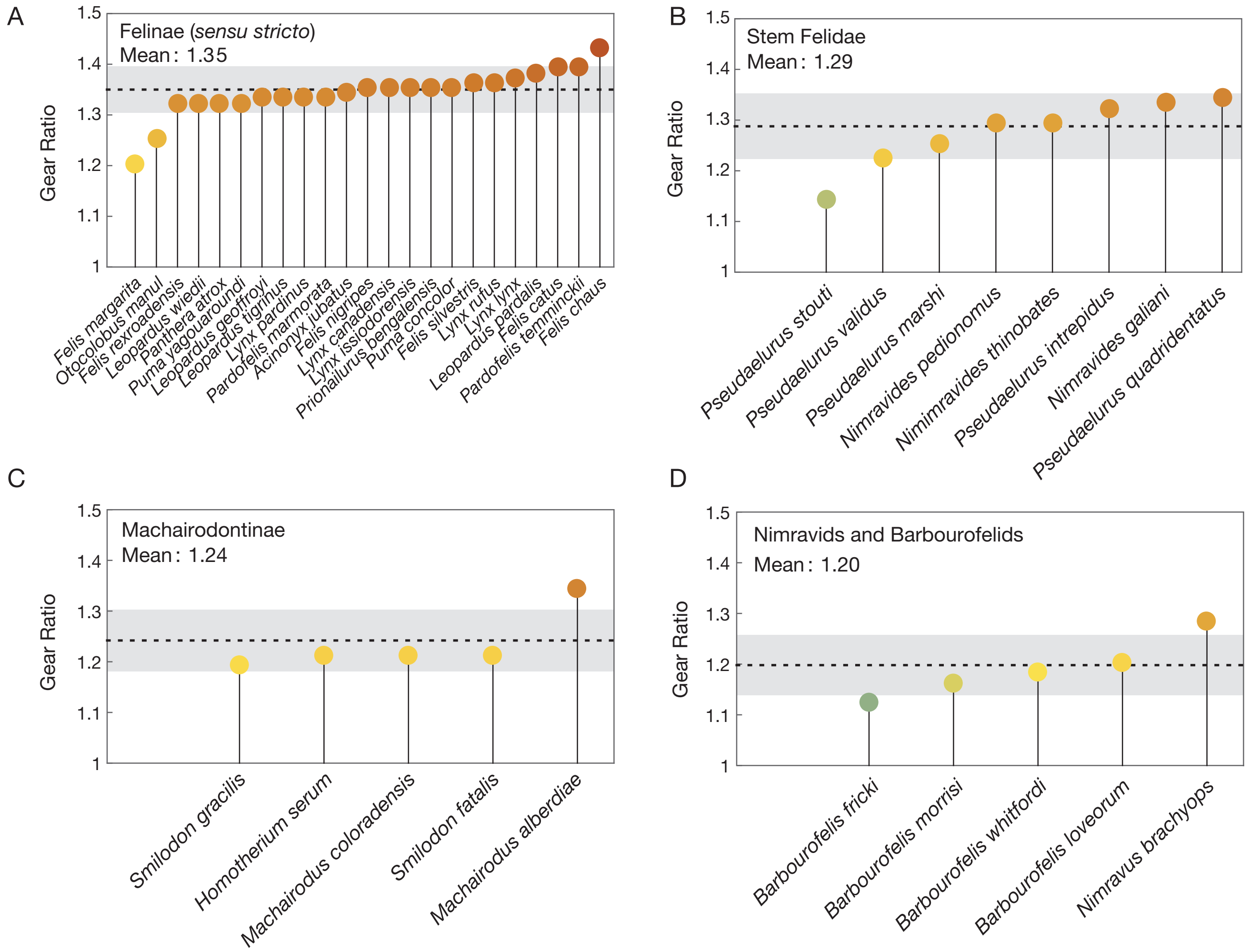

Fig. 3. — Ecometric comparison of ankle gear ratio in four felid subgroups: **A**, extant and extinct crown-group Felinae; **B**, stem felids that are considered to be more closely related to the crown group than to machairodontines (*sensu* Werdelin *et al.* 2010); **C**, Machairodontinae; **D**, Barbourofelidae and Nimravidae. Colour coding matches Figure 2.

have shorter hind limbs than fore limbs with proportionally short distal elements (Anyonge 1996; Lewis & Lague 2010). The Miocene taxa most closely related to crown-group felids had similar gear ratios to the ancestral machairodontines, but with a considerable range of variation. Several, such as *Nimravides galiani* and *Pseudaelurus quadridentatus* had gear ratios of 1.34-1.35, but others such as *Pseudaelurus stouti* had bear-like ratios of 1.15. Crown group felids evolved in the opposite trajectory. Starting from an ancestor with a gear ratio of 1.32, more than half of those sampled achieved a ratio greater than or equal to 1.35, with the highest, up to 1.44, in the jungle cat (*Felis chaus*).

The functional differences between these groups can be seen in features of their calcanea (Fig. 4). *Pardofelis marmorata*, a small, highly scansorial extant cat, is typical of Felinae with mid-range ankle gear ratios. The sustentacular process is proximally positioned, the sustentacular facet is oriented distally rather than dorsally (a feature associated with distribution of weight onto the digitigrade foot), the peroneal process is robust (and somewhat atypically elongate in this species), and the astragalo-calcaneal facet is smoothly curved with a long proximal extension along the calcaneum body. The stem felid *Nimravides galiani* shares most of those features, despite its much larger body size, except that neither the peroneal process nor the astragalo-calcaneal facet are as elongated. The calcanea of *Smilodon gracilis* and *Barbourofelis loveorum* stand in stark contrast to these felids and to one another. Both *Smilodon* and *Barbourofelis* have sustentacular processes that are positioned more distally (giving them their smaller gear ratios) and sustentacular facets that are oriented more dorsally than distally. This latter feature suggests these two taxa were less digitigrade than the other two felids. *Smilodon* differs from both the first two felines and *Barbourofelis* in having a strongly convex astragalo-calcaneal facet with what could almost be considered a ridge running transversely between the distal and proximal portions. This feature is similar to canids and is associated with an astragalus that is tightly locked into a single position. In canids it provides a stable ankle joint associated with cursoriality, but the locking in *Smilodon* was likely associated with other functions since these animals have no cursorial features. The calcaneal process of *Smilodon* is proportionally thicker than the other three species, sug-

Fig. 4. — Calcanea (dorsal view) representing four major felid clades: **A**, crown-group Felinae, *Pardofelis marmorata* (AMNH-FM 35399); **B**, stem-group Felinae, *Nimravides galiani* (UF 25171); **C**, Machairodontinae, *Smilodon gracilis* (AMNH-FM 95534); **D**, Barbourofelidae, *Barbourofelis loveorum* (UF 25189). Scale bars: 10 mm.

gesting that more force was transmitted by the extensors of the ankle. The calcaneum of *Barbourofelis* has several unique features, most notable of which is the extension of the sustentacular facet all the way to the distal end of the calcaneum to the margin of the cuboid facet. The distal portion of the astragalo-calcaneal facet is also extended toward the distal end of the calcaneum literally parallel to the sustentacular facet. The proportions of the proximal and distal portions of the astragalo-calcaneal facet are nearly opposite of *P. marmorata*. The elongate parallel facets suggest that the astragalus could slide along them. *Barbourofelis* also has an elongate peroneal process. Exactly what *Barbourofelis* did with its hind foot cannot be determined from these features alone, but it was very different from the movements that the other three taxa would have made.

Anyonge (1996) concluded that *Barbourofelis morrisi* and *Smilodon fatalis* had ursid-like ambulatory locomotor proportions (a finding consistent with their low ankle gear ratios), that *Nimravides galiani and Panthera atrox* had ambush predator proportions (consistent with their medium to high gear ratios), and that *Machairodus coloradensis* and *Homotherium serum* were cursorial (the former is consistent with gear ratios, but the latter is highly inconsistent, perhaps in keeping with the low p-values that Anyonge reported for the latter classification based on his discriminant function analysis).

Ecometric turnover in ankle gear ratio in the Neogene of North America

Trait turnover in felids

Felids arrived in North America in the early Miocene around 18 Ma during the mid Hemingfordian, ending the "cat gap" that began with the extinction of the nimravids at the end of the Oligocene (Hunt 1996; Qiu 2003). North American felid diversity changed through the remainder of the Cenozoic via a combination of in situ evolution and new immigration events, which are summarized in Figure 5 based on first and last appearances recorded in the FaunMap and MioMap databases (FaunMap Working Group 1994; Carrasco *et al.* 2005). The approximate times of key immigration events are shown with horizontal arrows (based on summaries by Tedford *et al.* 1987; Hunt 1996; Qiu 2003) and standing species diversity is shown as a grey silhouette graph.

The history of ankle gear ratio in North American carnivorans started with a mean value of 1.23, approximately the same as the ancestral value of felids, and increased to 1.25 by the Clarendonian (*c.* 11 Ma) with the diversification of *Pseudaelurus* and *Nimravides* (Fig. 5). There was considerable variation among species, however, with *P. stouti* having a gear ratio of 1.15, slightly lower than the extant African lion (1.19), and *P. intrepidus* having a gear ratio of 1.33 like extant jaguarundis (*Puma yagouarundi*) and margays (*Leopardus wiedii*) and only slightly lower than the cheetah (*Acinonyx jubatus*; 1.35) (Appendix 6). Even though gear ratios in this mid Miocene cat assemblage overlapped with modern felids, the range of locomotor performance was much different than modern communities. The mean gear ratio in extant North American felids is 1.35 and the lowest mean for any extant North American carnivoran community as a whole, not just felids, is only slightly lower at 1.19 (Polly 2010; Polly & Head 2015). This suggests that while these early felid communities were probably composed of digitigrade animals, they were not, on whole, specialized for leaping or sprinting like today. Janis & Wilhelm (1993) suggested that Miocene ungulates may have evolved digitigrady for efficiency in long distance locomotion rather than for outpacing fast prey. The mid-level gear ratios of the earlier Miocene felid community may have been associated with similar long-distance movements, something that is compatible with the comparatively large body size of *Pseudaelurus* and *Nimravides* species.

Average gear ratio had declined somewhat by the Hemphillian (*c.* 7 Ma) due to the immigration and subsequent diversification of barbourofelids and the loss of diversity among pseudailu-

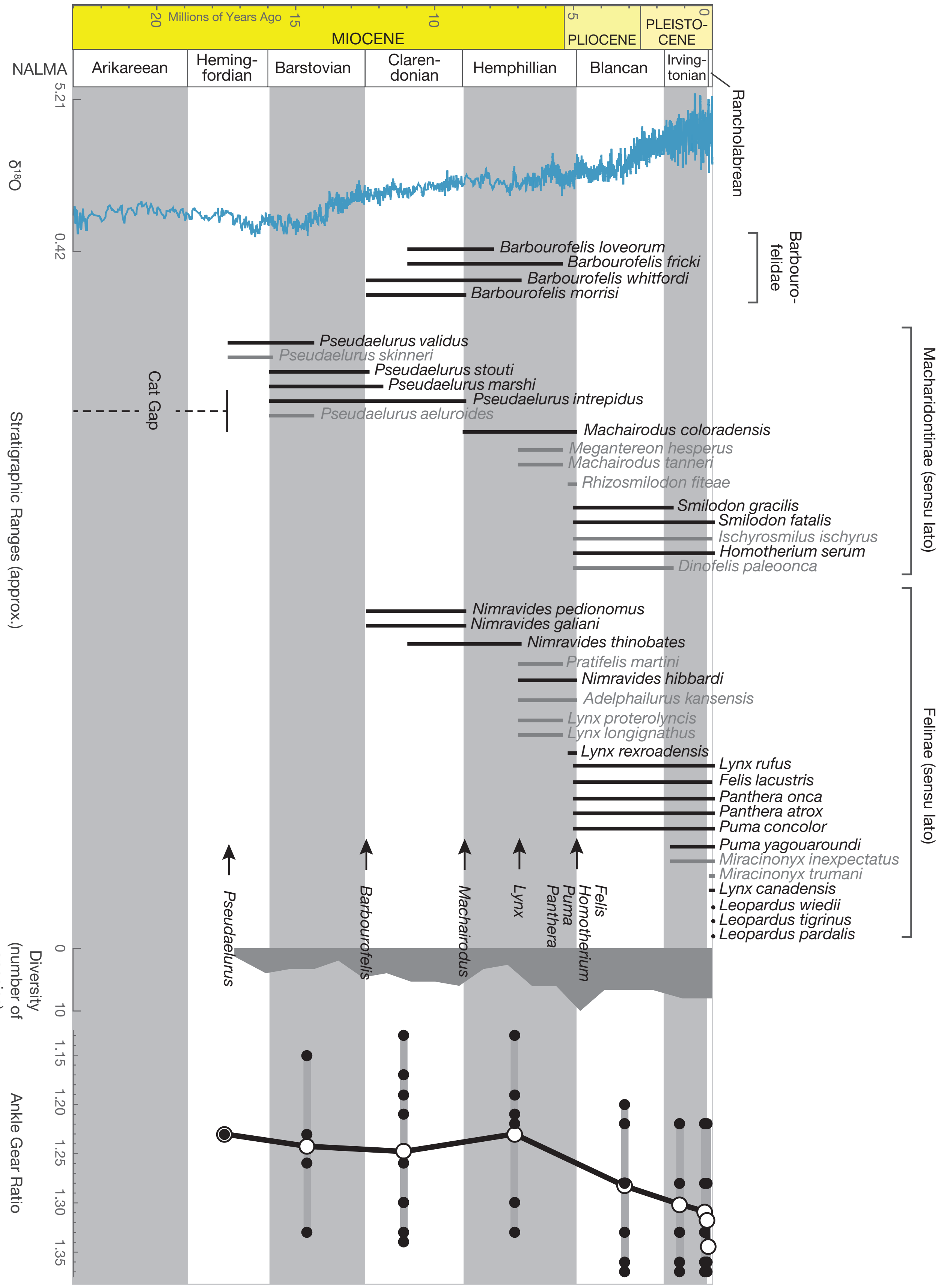

Fig. 5. — Changes in North American felid diversity and ankle gear ratio over the last 24 million years. Stratigraphic ranges of species are based on first and last appearances in the MioMap and FaunMap databases and standing diversity is recorded from them. Approximate ages of immigration events are indicated with horizontal arrows. Cenozoic climate is represented by the δ18O curve from Zachos *et al.* (2001). Mean and range of ankle gear ratio in felids is shown at the right (calcaneum measurements from taxa in grey were not available).

rines and *Nimravides* (Fig. 5). North American felid diversity as a whole was low in the early Hemphillian, dominated by barbourofelids, and increased again in the late Hemphillian with the immigration of machairodontines and strict-sense felids. Whatever kind of locomotor and prey capture strategy barbourofelids may have had, it was unlikely to be long distance travel, as discussed above. They had the lowest of felid gear ratios, which indicate foot extension performance that emphasized strength over speed.

Turnover in felid locomotor traits accelerated in the Blancan (Pliocene and earliest Pleistocene) and Irvingtonian after the last of the barbourofelids became extinct and there was a wave of immigration by crown-felid lineages, including *Felis*, *Puma*, and *Panthera* (Fig. 5). By the Rancholabrean (late Pleistocene) mean ankle gear ratio had increased to 1.31 in felids. The loss of barbourofelids narrowed the range of variation in gear ratio. With the end-Pleistocene extinction of the machairodontines, which have lower gear ratios than felines, the average gear ratio in North American felids jumped even higher to its current value of 1.35.

The turnover in felid clades and gear ratios may have been facilitated by trait-based habitat filtering. Grasslands, especially tall grass habitats became increasingly widespread in North America during the Hemphillian, replacing earlier non-analogue woodlands in regions like the Great Plains (Janis *et al.* 2002, 2004; Fox & Koch 2003; Edwards *et al.* 2010). Tectonic processes also accelerated changes in the topography of the western half of the continent through this time. Extension of the Great Basin accelerated between 10 and 3 Ma (Surpless *et al.* 2002; Horton *et al.* 2004), increasing relief of the Pacific coastal ranges had a more pronounced effect on environmental diversity by 7 Ma (Wolfe *et al.* 1997; Kohn *et al.* 2002; Retallack 2004), tundra and alpine biomes became established at high latitudes and high elevations around the same time (Graham 1999, 2011), and aridity and seasonality increased at low elevations across much of the west (Retallack *et al.* 2002). By the late Pliocene grasslands were partially on the wane, replaced by expanding deciduous and boreal forests and true deserts (Graham 1999, 2011). These transitions impacted mammalian species diversity (Davis 2005; Finarelli & Badgley 2010; Badgley *et al.* 2017). The turnover between barbourofelid-dominated felid communities to ones dominated by machairodontines and felids *sensu stricto* may have been favoured by the addition of these new biome types and the habitat fragmentation caused by increasing topographic relief in the west. While felids are present in nearly all North American habitats, they are a significantly larger component of the carnivoran community than expected by chance in the rugged areas of western Mexico and in the Central American tropics (Polly *et al.* 2017). Some biomes that support several felid species, such as desert scrub, basin and range, and boreal forest increased their areal extent from the mid Miocene to present. Was this because high gear ratio leaping, sprinting, and ambush hunting are favoured in the open grasslands, closed forests, and rugged terrains of the Late Miocene and Quaternary? This question is arguably too complex to test directly in the fossil record, but the pattern of trait turnover is compatible with such an interpretation.

Ecometric trait turnover in carnivoran communities

How did the ecometric turnover in gear ratio within the felid clade change the locomotor diversity of North American carnivoran communities as a whole? To address this question, it is necessary to filter out the cross-continent habitat variation that was ignored in the previous discussion by focusing on change in communities and traits in a single region that it environmentally similar at any given time. Because of its comparatively rich late Cenozoic fossil record, I looked at the fossil record of the Great Plains of Nebraska.

Figure 6 shows the diversity of ankle gear ratios in Great Plains carnivoran communities from the Arikareean (*c.* 21 Ma) to the present. In the Arikareean, prior to the "cat gap" ankle gear ratio diversity was low with a standard deviation that was half what it is today. Interestingly, *Nimravus brachyops*, a cat avatar of sorts, had the highest ratio, analogous with true cats later in the Miocene. Borophagine and hesperocyonine canids otherwise possess the highest gear ratios, analogous to their crown-group canine cousins later in the Cenozoic. None of these taxa, nimravid or canid, had gear ratios as high as canids or felids in the Quaternary. Hind limb diversity remained low in the Hemingfordian, despite the arrival of the first felid *Pseudaelurus validus*, which had an ankle gear ratio very similar to the borophagine canids in its community. Trait disparity increased considerably in the later Miocene NALMAs. Remarkably, the high and low Barstovian gear ratios were both possessed by felids (*Pseudaelurus intrepidus* and *P. stouti* respectively). The high end of the gear ratio spectrum continued to be co-occupied by borophagine canids, but the low end was increasingly disparate with amphicyonids, hemicyonine bears, and, in the Clarendonian, barbourofelids and leptarctid mustelids, followed by the addition of true ursids in the Hemphillian. Even though the ecometric disparity of gear ratios was markedly higher in the Hemphillian than in the Arikareen, the average gear ratio did not change much. Through most of the later Miocene, felids possessed the highest gear ratios, but they were surpassed in the Hemphillian by the crown-group canine *Eucyon*, despite the felids having earlier overtaken the borophagine canids. Canids and felids continue to vie for the highest gear ratios in Carnivora (Figs 1; 2). In the early Plio-Pleistocene gear ratio diversity dropped substantially, as did species diversity, even as phylogenetic diversity appeared to increase with the entry of procyonids and mephitids in the Blancan. *Smilodon fatalis* and *Ischyrosmilus ischyrus* were the only felids on the Nebraska Great Plains in the Blancan, the latter of which has no available calcaneum measurements. *Smilodon* is in the middle of the range of Blancan gear ratio values and *Ischyrosmilus* was also likely to have had a middling ratio given its putatively close relationship to *Homotherium serum* (Churcher 1984; Martin *et al.* 1988).

As members of top trophic levels, carnivores are rare in biological communities and even rarer in fossil assemblages. No one fossil site is likely to record all the carnivorans that were present so I binned sites by North American Land Mammal age (NALMA) because only at that level of amalgamation did species-level diversity seem to be reasonably represented. This

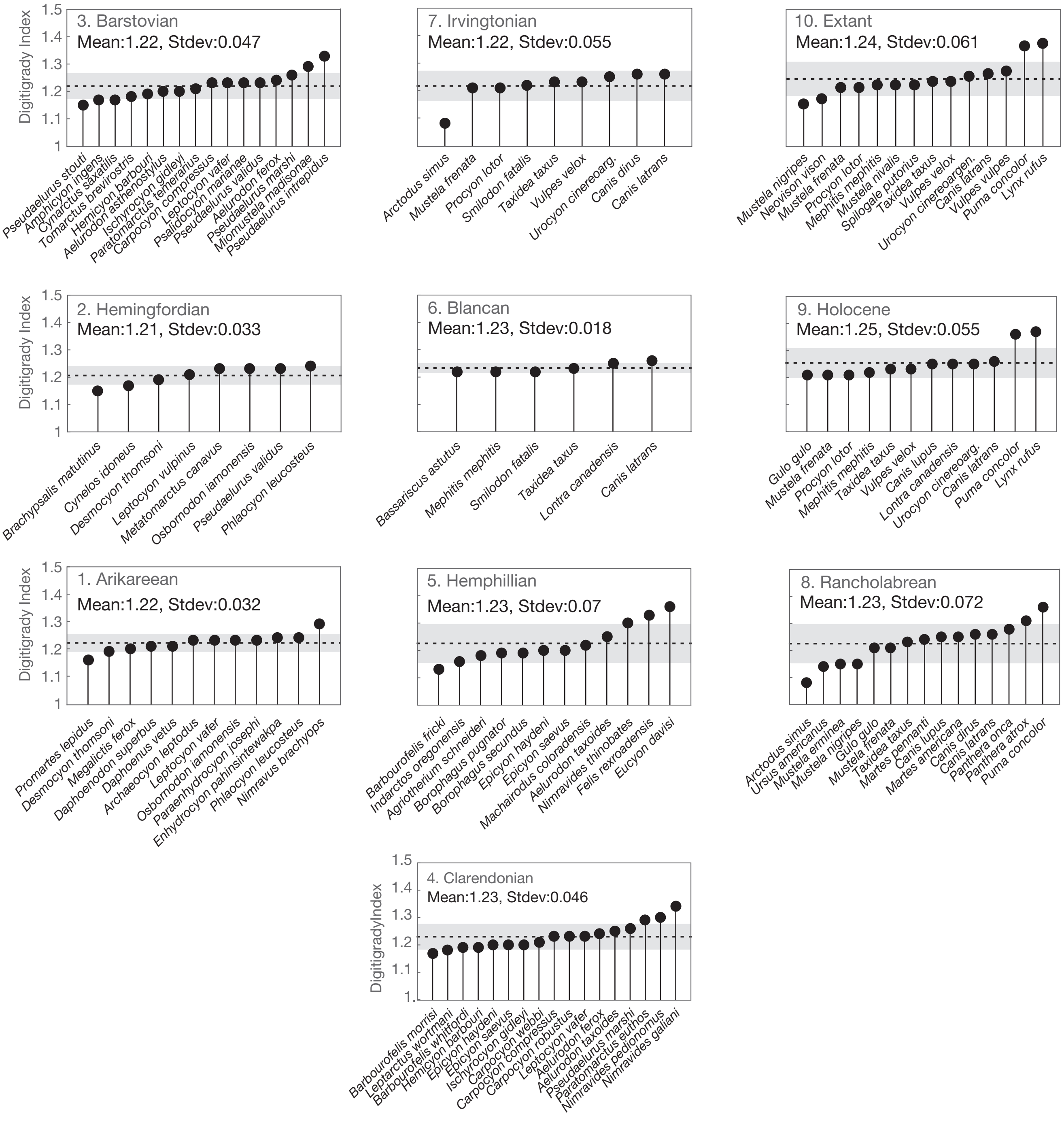

Fig. 6. — Ecometric plots of ankle gear ratio in carnivoran assemblages from the Arikareean (latest Oligocene and earliest Miocene) through the present. The mean and standard deviation of each assemblage is indicated by the broken line and grey bands respectively. Family-level classification of each species can be found in Appendix 6.

binning inevitably causes some temporal mixing to taxa that did not overlap in time, but NALMAs are nevertheless short enough that the amount of mixing is unlikely to distort the basic pattern of faunal turnover presented here. Perhaps of greater concern for considering the distribution of traits in a community is incomplete sampling of its constituent species. Even with binning sites by region and NALMA, some taxa are not represented in this sample because postcrania are unavailable. The interpretations drawn here assume that sampling is random with respect to ankle gear ratio. This assumption is likely to be reasonable because the factor that is most frequently biased in the fossil record – body size – is uncorrelated with ankle gear ratio (Appendix 3; Polly 2010), which is consistent with lack of correlation between limb posture and joint angles with respect to body size in felids (Day & Jayne 2007) and the pattern of body-mass scaling in other felid calcaneal traits (Gálvez-López & Casinos 2012). Nevertheless, one should be suspicious of the Hemingford-

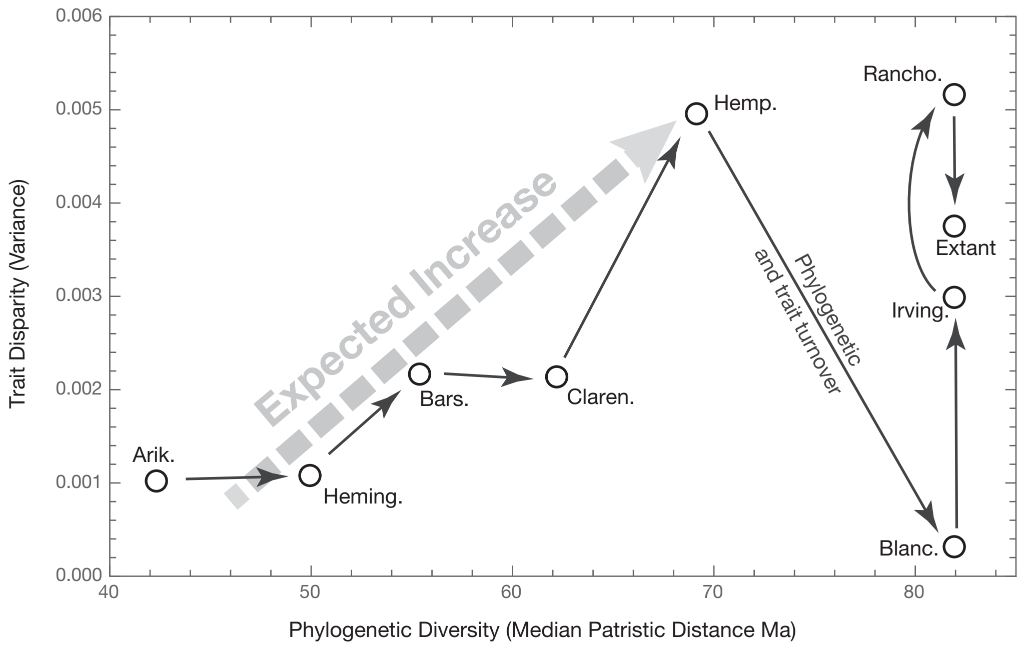

FIG. 7. — Relationship between phylogenetic diversity (median pairwise patristic distance in Ma) and ecometric trait disparity (variance of ankle gear ratio) in the Nebraskan Great Plains carnivoran communities from Figure 6.

ian and Blancan samples reported here, both of which have notably fewer species than other intervals. In the Blancan, machairodonts (now represented by *Smilodon*, *Ischyrosmilus*, *Homotherium*, and *Dinofelis*) were joined on the Great Plains by the true feline *Felis lacustris*, for which measurements are also unavailable. Based on its congeners, *F. lacustris* is likely to have been on the high end of gear ratio diversity in the Irvingtonian. Werdelin (1985) said that its postcranial proportions may have approached those of *Lynx issiodorensis*, which has a gear ratio of 1.36, much higher than any of the other Irvingtonian taxa in this sample. By the Late Pleistocene (Rancholabrean), several large cats with markedly higher gear ratios had invaded the Great Plains, as had true bears at the low end, restoring gear ratio diversity to what it had been in the Hemphillian at the close of the Miocene and bringing it to its modern configuration.

Phylogenetic components of trait turnover

Even though each sub-clade of felids had some diversity in ankle gear ratio, the overall pattern of trait turnover in felids and in Great Plains communities involved turnover in subclades. This pattern of correlated change in trait composition and phylogenetic diversity suggests that trait-based clade sorting may have been an important process in the assembly of modern carnivoran communities (Polly *et al.* 2017). What is clade sorting? *Species sorting* in community ecology refers to the effects of environmental filters that permit a subset of species to aggregate into a community based on performance of functional traits (Poff 1997; McGill *et al.* 2006; Webb *et al.* 2010). Clade sorting is essentially the same process but one in which species that share traits due to recent common ancestry are sorted together by the filtering process (Stanley 1975; Jablonski 2008; Polly *et al.* 2017). One way of detecting clade sorting is to monitor change in trait disparity as a function of phylogenetic diversity (Webb 2000; Kraft *et al.* 2007; Kraft & Ackerly 2010).

While phylogenetic community assembly processes have usually been studied between spatially disparate but contemporaneous communities, the same principles can be applied to a temporal series of communities in the same location. Phylogenetic disparity is measured as the median value of the pairwise patristic distances (the sum of branch lengths connecting each pair of taxa) scaled in millions of years. Two contemporaneous taxa with a last common ancestor 40 million years ago would have a patristic distance of 80 Ma. If a clade evolves by random processes (e.g., a constant birth Yule process), we would expect median patristic distance to increase as a linear function of the time elapsed since the last common ancestor of the clade (Yule 1924; Raup 1985). Selective extinction of subclades, immigration events, or other factors could cause departures from this expectation. Trait disparity is measured as the variance of ankle gear ratio in each assemblage. Under a Brownian motion model of evolution, variance in trait values among tips is expected to increase linearly as time since common ancestry increases (e.g., Felsenstein 1985, 1988). Thus, random cladogenesis and trait evolution should produce a linear relationship between phylogenetic diversity and trait disparity.

Figure 7 shows the relationship between trait disparity and phylogenetic disparity in carnivoran communities of the Great Plains of Nebraska from the Arikareean to present. From the Arikareen through Hemphillian phylogenetic diversity increases in fairly regular steps of about 6 Ma per NALMA, which is approximately equal to the time elapsed from one NALMA to the next (compare with Fig. 5). Trait variance also increases fairly regularly through that period, albeit in a bursty pattern that puts most of the increase in the Hemingfordian to Barstovian and Clarendonian to Hemphillian intervals. Overall the Miocene trend meets the expectations for stochastically constant divergence in both traits and phylogenetic distance, despite immigration events. No major subclades became extinct during this interval except hesperocyonine canids, oligobunine mustelids, and daphoenine amphicyonids (see Fig. 2). Drastic change occurred between the Hemphillian and Blancan, however, coinciding with the start of the climatic downturn that culminated in Quaternary glacial-interglacial cycles. Median phylogenetic distance increased by almost twice as much as between previous intervals, despite the actual time elapsed being roughly the same. The increase in phylogenetic distance was driven by the culling of clades like the amphicyonids, hemicyonines, barbourofelids, and especially borophagines that contributed many shorter pairwise distances, leaving behind species from clades with deep phylogenetic ancestries. The phylogenetic diversity has remained almost constant from the Blancan to the present. At the same time trait disparity plummeted in the Blancan to a value lower than the Arikareean. The Blancan Great Plains carnivore community thus consisted of a phylogenetically diverse set of species with unusually homogeneous ankle gear ratios. The Great Plains appear to have been significantly colder, moister, and more completely covered in open C4 grasslands in the latest Hemphillian and Blancan than they were before and the geographic ranges of large herbivore species increased (Passey *et al.* 2002; Maguire & Stigall 2009). The reduction in locomotor disparity in the Blancan could have been a consequence of changed, more homogeneous habitats with prey species that had less patchy distribution. One must be somewhat cautious with this interpretation because the Blancan sample is so small. The Great Plains were also home to the last of the borophagines, *Borophagus hilli*, four extinct mustelids (*Buisnictis burrowsi*, *Sahatherium piscinarium*, *Trigonictis cooki*, and *T. macrodon*), and the machairodontine *Ischyrosmilus ischyrus* for which calcaneum measurements are unavailable. Based on their closest relatives, these taxa were unlikely to have ankle gear ratios that were substantially different from the ones sampled here, but nevertheless they may have increased Blancan disparity. The quick recovery of disparity in the Irvingtonian and Rancholabrean has been discussed above.

The linear increase in phylogenetic diversity and trait disparity in the Miocene seems to be driven by the stepwise addition of clades to the Great Plains carnivore fauna and the absence of any major clade extinctions. Borophagines, felines, hemicyonines, barbourofelids, ursines, and canines appear sequentially through this period, each with a characteristically different ankle gear ratio. The drop in both metrics in the Blancan appears to be from the selective loss of clades with low gear ratios, notably the barbourfelines, ursines, and borophagines, consistent with the hypothesis of clade sorting. Gear-ratio based clade sorting has already been demonstrated in assembly of modern North American communities based on analyses of extant carnivorans (Polly *et al.* 2017). The pool of extant North American carnivorans has a somewhat stronger phylogenetic pattern to gear ratio (Blomberg's $K = 0.58$; Polly *et al.* 2017) than do carnivorans as a whole ($K = 0.29$ for the global extant taxa and $K = 0.33$ for the combined extinct and extant taxa in Fig. 2) largely because the extant North American carnivorans consist of only a few families (Felidae, Canidae, Ursidae, Mephitidae, Mustlidae, and Procyonidae) each represented by only a few species and each separated from the other by very deep ancestry. The data presented here suggest that pattern originated by sorting at the end of the Miocene that resulted in the selective extinction or extirpation of clades with low ankle gear ratios. This reorganization of North American carnivoran communities appears to parallel reorganizations in South America and Africa (Werdelin & Lewis 2005; Morales & Giannini 2010, 2013).

CONCLUSIONS

Extant felids have some of the highest ankle gear ratios of any carnivorans, with only a few canids and herpestids rivalling them. High ankle gear ratios provide high mechanical advantage ("speed") but low mechanical efficiency ("strength") for plantar flexion of the hind foot. While high advantage for this action can facilitate many locomotor actions, including running, in cats it is most closely associated with springing and sprinting, actions that are important for ambush hunting tactics and scansorial habits.

However, the high gear ratios of extant felids are a Quaternary phenomenon. Ancestral felids had gear ratios more like foxes, viverrids, or semidigitigrade mustelids. And many Miocene felids, especially barbourofelids and some machairodontines, had substantially lower gear ratios that offered high efficiency but low advantage, more like those found in extant bears, otters, or weasels. These felids are unlikely to have been leapers like their modern relatives, although some, like the pseudaelurines, could have been long distance cursors.

The appearance of felids in North America following the "cat gap" did not at first increase the ecometric disparity of ankle gear ratios, but as they diversified they came to occupy both high and low gear ratio niches by the Barstovian and Clarendonian. The extinction of low gear ratio clades at the end of the Miocene resulted in a correlated phylogenetic and trait turnover that left crown-clade felines and canines, occupying new high gear ratio niches, considerably higher than any in the Miocene. The canines typically utilize their high mechanical advantage for pursuit or pounce style hunting (Janis & Wilhelm 1993), whereas felines tend to utilize it for jumping while negotiating rugged territory (e.g., forest vegetation or high-relief topography) or ambushing prey. These results suggest that, like with the pre-Quaternary absence of pursuit predation in canids (Janis & Wilhelm 1993), pre-Quaternary felids may have had markedly different locomotor and hunting repertoires than do extant cats. The differences in barbourofelids and machairodontines in this respect have long been evident, but even taxa that are most closely related to crown-clade felids had substantially lower gear ratios in the Miocene.

The immigration of cats into North America changed the disparity of gear ratios in carnivoran communities, but did not have a pronounced effect on the mean. The first taxa after the "cat gap" occupied both high (*Nimravides*) and low (*Barbourofelis*) gear ratio niches. In the later Miocene the highest gear ratio niches were taken by borophagine canids and the lowest by ursids after barbourofelids became extinct. Only in the Quaternary did crown group felids come to dominate the high gear ratio niches of North American carnivoran communities, increasing their ecometric means and adding to their overall disparity.

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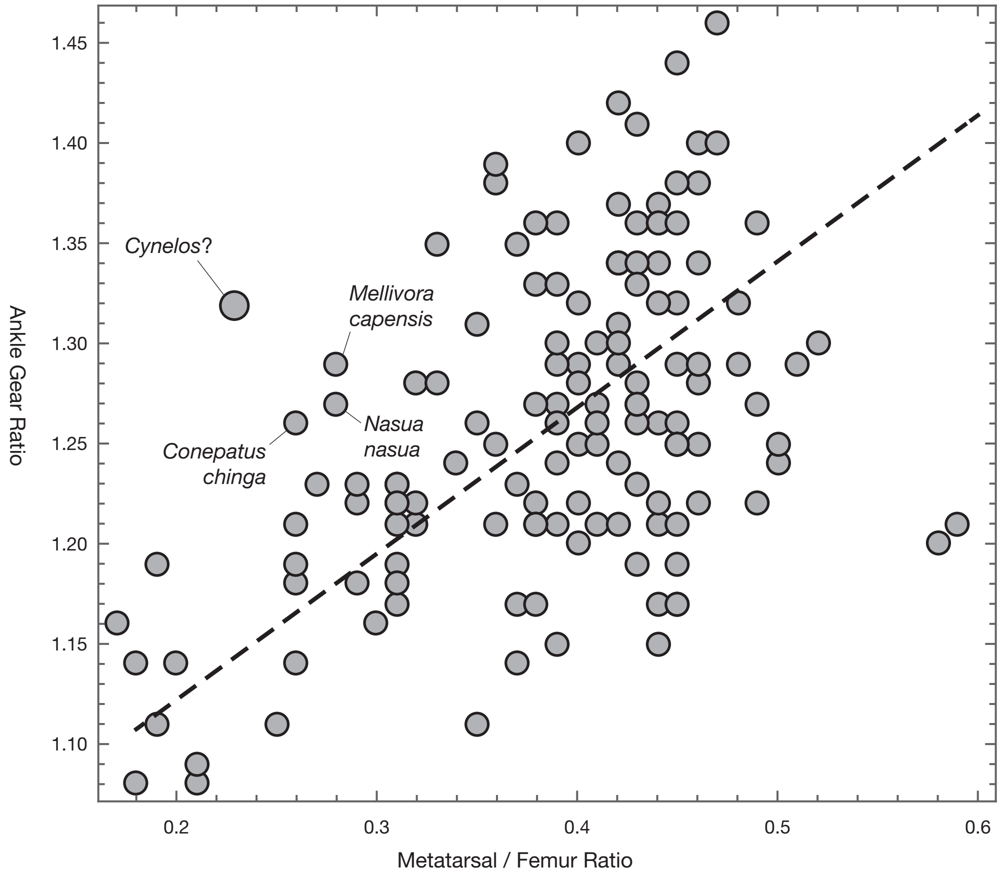
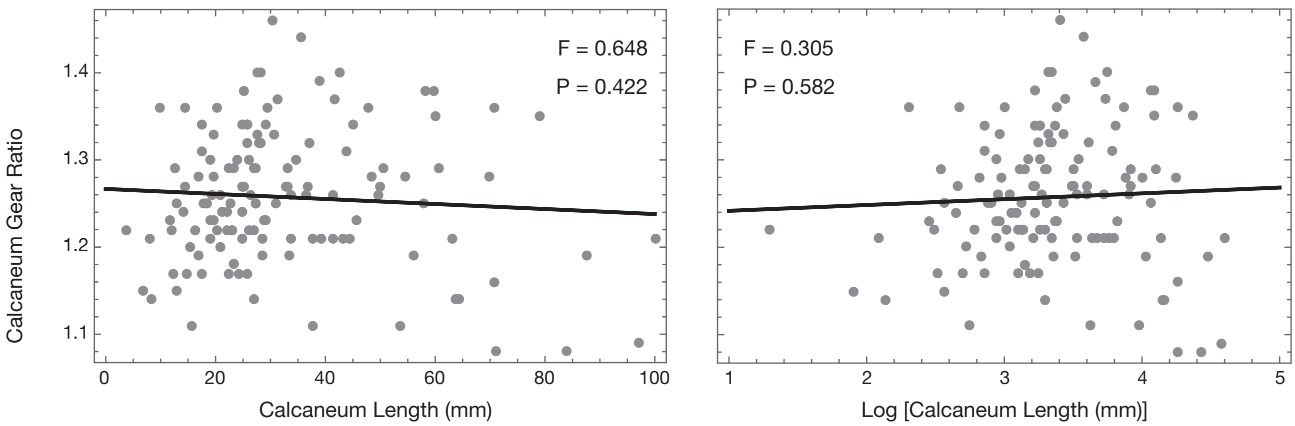
APPENDICES

Appendix 1. — The evolution of calcaneal gear ratio in Carnivoromorpha. Gear ratio is mapped onto a time-scaled phylogenetic tree with 214 tip taxa using PGLS. The value at the root node (1.19) is represented by yellow; values less than the ancestor are scaled in a yellow to blue colour spectrum, values higher than the ancestor in a yellow to red spectrum. This document is available at the following address: http://sciencepress.mnhn.fr/sites/default/files/documents/en/appendix1-the_evolution_of_calcaneal_gear_ratio_in_carnivoromorpha.pdf

Appendix 2. — Relationship between metatarsal/femur ratio and ankle gear ratio in extant carnivorans. The hypothetical position of *Cynelos* based on metatarsal/femur ratio in *C. lemanensis* and ankle gear ratio in *C. caroniavorus* is shown in red for comparison. Dashed line is the reduced major axis regression.



Appendix 3. — Relationship between ankle gear ratio and size: **A**, Gear ratio regressed onto calcaneum length; **B**, Gear ratio regressed onto the natural log of calcaneum length.



Appendix 4. — Phylogenetic tree of extant carnivorans from Humphreys & Barraclough (2014) in Newick format. This tree was used as the scaffolding for the time-scaled tree of extant and extinct carnivorans. This document (zipped PLY file) is available at the following address: http://sciencepress.mnhn.fr/sites/default/files/documents/en/appendix4-humphryandbarraclough2018tree.zip

Appendix 5. — Time-scaled phylogenetic tree of extant and extinct carnivorans in Newick format. See text for details. This document is available at the following address: http://sciencepress.mnhn.fr/sites/default/files/documents/en/appendix5-extantandextinctcarnivoratree.zip

Appendix 6. — Mean ankle gear ratio for 214 extant and fossil species of Carnivormorpha. The Excel version of this document is available at the following address: http://sciencepress.mnhn.fr/sites/default/files/documents/en/appendix6-species_gear_ratios.xlsx

Taxon ID	Species	N	Gear Ratio	Extant ?
Ailuridae				
6532	*Ailurus fulgens*	3	1.22	Y
Amphicyonidae				
30036	*Adilophontes brachykolos*	1	1.14	N
30104	*Amphicyon ingens*	5	1.17	N
30105	*Amphicyon longiramus*	2	1.15	N
30280	*Cynelos caroniavorus*	2	1.32	N
30282	*Cynelos idoneus*	5	1.17	N
32871	*Daphoenodon niobrarensis*	2	1.23	N
30310	*Daphoenodon superbus*	1	1.21	N
30317	*Daphoenus vetus*	2	1.21	N
30504	*Ischyrocyon gidleyi*	2	1.2	N
Barbourofelidae				
30163	*Barbourofelis fricki*	1	1.13	N
30164	*Barbourofelis loveorum*	2	1.21	N
30165	*Barbourofelis morrisi*	3	1.17	N
30167	*Barbourofelis whitfordi*	1	1.19	N
Canidae				
30039	*Aelurodon asthenostylus*	3	1.2	N
30040	*Aelurodon ferox*	3	1.24	N
30044	*Aelurodon taxoides*	1	1.25	N
30121	*Archaeocyon leptodus*	2	1.23	N
30122	*Archaeocyon pavidus*	1	1.22	N
6299	*Atelocynus microtis*	3	1.27	Y
30187	*Borophagus pugnator*	2	1.19	N
30018	*Borophagus secundus*	4	1.19	N
6301	*Canis adustus*	2	1.32	Y
10843	*Canis arensis/mosbachensis*	3	1.25	N
6302	*Canis aureus*	2	1.27	Y
7063	*Canis dirus*	20	1.26	N
7059	*Canis familiaris*	1	1.29	Y
7060	*Canis familiaris dingo*	2	1.28	Y
6303	*Canis latrans*	106	1.26	Y
6304	*Canis lupus*	18	1.25	Y
6305	*Canis mesomelas*	4	1.26	Y
10842	*Canis mosbachensis*	1	1.31	N
7061	*Canis rufus*	2	1.26	Y
6306	*Canis simensis*	1	1.23	Y
30235	*Carpocyon compressus*	1	1.23	N
30237	*Carpocyon robustus*	1	1.23	N
30238	*Carpocyon webbi*	1	1.21	N
6308	*Cerdocyon thous*	2	1.4	Y
6310	*Chrysocyon brachyurus*	2	1.38	Y
6312	*Cuon alpinus*	1	1.21	Y
30277	*Cynarctus saxatilis*	1	1.17	N
30324	*Desmocyon thomsoni*	2	1.19	N
30379	*Enhydrocyon pahinsintewakpa*	1	1.24	N
30388	*Epicyon haydeni*	2	1.2	N
30389	*Epicyon saevus*	3	1.2	N
30393	*Eucyon davisi*	1	1.36	N
30402	*Euoplocyon spissidens*	4	1.22	N
30534	*Leptocyon vafer*	3	1.23	N
30535	*Leptocyon vulpinus*	1	1.21	N
6316	*Lycalopex culpaeus*	2	1.19	Y
6318	*Lycalopex griseus*	2	1.29	Y
6319	*Lycalopex gymnocercus*	2	1.29	Y
6320	*Lycalopex sechurae*	1	1.17	Y
6321	*Lycalopex vetulus*	2	1.24	Y
6323	*Lycaon pictus*	3	1.28	Y
30632	*Metatomarctus canavus*	10	1.23	N
6325	*Nyctereutes procyonoides*	6	1.27	Y
30765	*Osbornodon iamonensis*	9	1.23	N
6327	*Otocyon megalotis*	2	1.34	Y
30823	*Paraenhydrocyon josephi*	3	1.23	N
30841	*Paratomarctus euthos*	1	1.29	N
30842	*Paratomarctus temerarius*	1	1.21	N
30866	*Phlaocyon leucosteus*	1	1.24	N
31050	*Psalidocyon marianae*	1	1.23	N

Taxon ID	Species	N	Gear Ratio	Extant ?
Canidae (continuation)				
6329	*Speothos venaticus*	2	1.17	Y
31200	*Tomarctus brevirostris*	1	1.18	N
6331	*Urocyon cinereoargenteus*	136	1.25	Y
6332	*Urocyon littoralis*	2	1.22	Y
6286	*Vulpes lagopus*	9	1.32	Y
6287	*Vulpes macrotis*	2	1.29	Y
6295	*Vulpes velox*	2	1.23	Y
6296	*Vulpes vulpes*	34	1.27	Y
6297	*Vulpes zerda*	5	1.3	Y
Eupleridae				
6209	*Cryptoprocta ferox*	3	1.21	Y
6213	*Fossa fossana*	2	1.28	Y
6223	*Salanoia concolor*	2	1.17	Y
Felidae				
6097	*Acinonyx jubatus*	6	1.35	Y
6105	*Felis catus*	1	1.4	Y
6106	*Felis chaus*	1	1.44	Y
6108	*Felis margarita*	1	1.21	Y
6109	*Felis nigripes*	1	1.36	Y
30405	*Felis rexroadensis*	3	1.33	N
6110	*Felis silvestris*	5	1.37	Y
7069	*Homotherium serum*	4	1.22	N
6114	*Leopardus geoffroyi*	3	1.34	Y
6118	*Leopardus pardalis*	2	1.39	Y
6119	*Leopardus tigrinus*	2	1.34	Y
6120	*Leopardus wiedii*	2	1.33	Y
6122	*Leptailurus serval*	3	1.41	Y
6124	*Lynx canadensis*	3	1.36	Y
10844	*Lynx issiodorensis*	1	1.36	N
6125	*Lynx lynx*	7	1.38	Y
6126	*Lynx pardinus*	2	1.34	Y
6127	*Lynx rufus*	47	1.37	Y
10857	*Machairodus alberdiae*	2	1.35	N
30016	*Machairodus coloradensis*	6	1.22	N
6143	*Neofelis nebulosa*	2	1.31	Y
30732	*Nimravides galiani*	2	1.34	N
30734	*Nimravides pedionomus*	3	1.3	N
30735	*Nimravides thinobates*	3	1.3	N
6107	*Otocolobus manul*	1	1.26	Y
30011	*Panthera atrox*	11	1.31	N
6145	*Panthera leo*	1	1.19	Y
6146	*Panthera onca*	7	1.28	Y
6147	*Panthera pardus*	1	1.21	Y
6148	*Panthera tigris*	1	1.21	Y
6129	*Pardofelis marmorata*	1	1.34	Y
6102	*Pardofelis temminckii*	1	1.4	Y
6131	*Prionailurus bengalensis*	1	1.36	Y
31055	*Pseudaelurus intrepidus*	6	1.33	N
31057	*Pseudaelurus marshi*	9	1.26	N
10856	*Pseudaelurus quadridentatus*	1	1.35	N
31060	*Pseudaelurus stouti*	1	1.15	N
31062	*Pseudaelurus validus*	2	1.23	N
6139	*Puma concolor*	13	1.36	Y
6140	*Puma yagouaroundi*	1	1.33	Y
7070	*Smilodon fatalis*	8	1.22	N
31139	*Smilodon gracilis*	2	1.2	N
31148	*Stenogale*	1	1.33	N
6150	*Uncia uncia*	1	1.29	Y

Appendix 6. — Continuation.

Taxon ID	Species	N	Gear Ratio	Extant ?
Herpestidae				
6229	*Atilax paludinosus*	2	1.3	Y
6233	*Bdeogale nigripes*	1	1.32	Y
6235	*Crossarchus alexandri*	1	1.21	Y
6240	*Cynictis penicillata*	2	1.34	Y
6247	*Galerella sanguinea*	2	1.29	Y
6253	*Herpestes edwardsi*	2	1.31	Y
6255	*Herpestes ichneumon*	1	1.29	Y
6256	*Herpestes javanicus*	2	1.25	Y
6257	*Herpestes naso*	1	1.38	Y
6263	*Ichneumia albicauda*	2	1.46	Y
6274	*Suricata suricatta*	3	1.36	Y
Hyaenidae				
6277	*Crocuta crocuta*	1	1.35	Y
6279	*Hyaena brunnea*	1	1.27	Y
6280	*Hyaena hyaena*	1	1.21	Y
6282	*Proteles cristata*	1	1.25	Y
Mephitidae				
6493	*Conepatus chinga*	1	1.26	Y
6498	*Mephitis macroura*	2	1.28	Y
6499	*Mephitis mephitis*	5	1.22	Y
6506	*Spilogale gracilis*	5	1.23	Y
6507	*Spilogale putorius*	3	1.22	Y
Miacidae				
30648	*Miacis parvivorus*	1	1.25	N
31278	*Vulpavus palustris*	1	1.12	N
Mustelidae				
6390	*Arctonyx collaris*	1	1.14	Y
30196	*Brachypsalis matutinus*	2	1.15	N
6392	*Eira barbara*	2	1.22	Y
6437	*Enhydra lutris*	1	1.21	Y
30375	*Enhydritherium terraenovae*	2	1.14	N
6394	*Galictis cuja*	1	1.11	Y
6395	*Galictis vittata*	2	1.17	Y
6397	*Gulo gulo*	4	1.21	Y
6399	*Ictonyx libyca*	2	1.14	Y
6400	*Ictonyx striatus*	1	1.2	Y
30524	*Leptarctus ancipidens*	2	1.2	N
31748	*Leptarctus webbi*	1	1.18	N
30531	*Leptarctus wortmani*	3	1.18	N
6441	*Lontra canadensis*	2	1.25	Y
6443	*Lontra longicaudis*	2	1.22	Y
6404	*Martes americana*	3	1.25	Y
6406	*Martes foina*	1	1.22	Y
6408	*Martes martes*	1	1.19	Y
6410	*Martes pennanti*	2	1.24	Y
30594	*Megalictis ferox*	2	1.2	N
6415	*Meles meles*	1	1.19	Y
6417	*Mellivora capensis*	1	1.29	Y
6422	*Melogale personata*	1	1.24	Y
30665	*Miomustela madisonae*	1	1.29	N
6372	*Mustela erminea*	3	1.15	Y
6373	*Mustela eversmanii*	1	1.2	Y
6377	*Mustela frenata*	60	1.21	Y
6382	*Mustela nigripes*	2	1.15	Y
6383	*Mustela nivalis*	2	1.22	Y
6425	*Neovison vison*	23	1.17	Y
6427	*Poecilogale albinucha*	2	1.36	Y
30999	*Promartes lepidus*	2	1.16	N
31158	*Sthenictis lacota*	1	1.23	N
6429	*Taxidea taxus*	6	1.23	Y
10854	*Trocherion albanense*	1	1.19	N

Taxon ID	Species	N	Gear Ratio	Extant ?
Nandiniidae				
6226	*Nandinia binotata*	2	1.17	Y
Nimravidae				
31678	*Nimravus brachyops*	4	1.29	N
Procyonidae				
30150	*Arctonasua floridana*	2	1.2	N
6513	*Bassaricyon gabbii*	2	1.25	Y
6517	*Bassariscus astutus*	13	1.22	Y
6518	*Bassariscus sumichrasti*	2	1.33	Y
6520	*Nasua narica*	5	1.23	Y
6521	*Nasua nasua*	2	1.27	Y
30835	*Paranasua biradica*	2	1.21	N
6525	*Potos flavus*	4	1.18	Y
6527	*Procyon cancrivorus*	4	1.21	Y
6528	*Procyon lotor*	134	1.21	Y
Ursidae				
32685	*Agriotherium gregoryi*	2	1.15	N
30020	*Agriotherium schneideri*	2	1.18	N
6455	*Ailuropoda melanoleuca*	1	1.14	Y
30009	*Arctodus simus*	4	1.08	N
6457	*Helarctos malayanus*	2	1.11	Y
32026	*Hemicyon barbouri*	1	1.19	N
30496	*Indarctos oregonensis*	2	1.16	N
6459	*Melursus ursinus*	2	1.08	Y
30877	*Phoberocyon johnhenryi*	3	1.24	N
6461	*Tremarctos ornatus*	2	1.19	Y
6463	*Ursus americanus*	5	1.14	Y
6464	*Ursus arctos*	4	1.08	Y
6465	*Ursus maritimus*	2	1.09	Y
6466	*Ursus thibetanus*	1	1.16	Y
Viverridae				
6186	*Arctictis binturong*	2	1.11	Y
6158	*Civettictis civetta*	1	1.26	Y
6164	*Genetta genetta*	2	1.23	Y
6166	*Genetta maculata*	2	1.26	Y
6170	*Genetta servalina*	2	1.24	Y
6173	*Genetta victoriae*	1	1.25	Y
6205	*Hemigalus derbyanus*	2	1.23	Y
6194	*Paradoxurus hermaphroditus*	2	1.18	Y
6176	*Poiana richardsonii*	1	1.27	Y
6180	*Viverra tangalunga*	2	1.32	Y
6181	*Viverra zibetha*	2	1.3	Y
6183	*Viverricula indica*	2	1.3	Y

APPENDIX 7. — ANOVA results: One-way analysis of variance was used to test for differences between clades of living and extinct carnivorans in ankle gear ratio. Overall results were significant at P < 0.001. Post-hoc pairwise tests were performed using Tukey's honestly significant difference test. The Word version of this document is available at the address: http://sciencepress.mnhn.fr/sites/default/files/documents/en/appendix7-anova_test.docx

ANOVA TABLE

	DF	SS	MSS	F-Ratio	P-Value
Model	15	0.6621	0.0441	16.9977	< 0.001
Error	196	0.5090	0.0026	–	–
Total	211	1.1711	–	–	–

PAIRWISE TEST RESULTS

Significant pairwise tests (Tukey)	
Amphicyonidae	Caninae
Amphicyonidae	Herpestidae
Barbourofelidae	Herpestidae
Borophaginae	Herpestidae
Borophaginae	Ursidae
Caninae	Mustelidae
Caninae	Mustelinae
Caninae	Ursidae
Felinae	Amphicyonidae
Felinae	Barbourofelidae
Felinae	Borophaginae
Felinae	Caninae
Felinae	Machairodontinae
Felinae	Mephitidae
Felinae	Mustelidae
Felinae	Mustelinae
Felinae	Pantherinae
Felinae	Procyonidae
Felinae	Ursidae
Felinae	Viverrinae
Herpestidae	Mephitidae
Herpestidae	Mustelidae
Herpestidae	Mustelinae
Herpestidae	Procyonidae
Herpestidae	Ursidae
Hyaenidae	Ursidae
Machairodontinae	Mustelidae
Machairodontinae	Mustelinae
Machairodontinae	Ursidae
Pantherinae	Ursidae
Procyonidae	Ursidae
Ursidae	Viverrinae

Appendix 8. — Original measurements from 867 extant carnivoran specimens. The Excel version of this document is available at the following address: http://sciencepress.mnhn.fr/sites/default/files/documents/en/appendix8-extant_specimen_measurements.xlsx

ID	Species	Inst	Specimen No	Locality	Calc Len	Sust Pos	Gear Ratio
Ailuridae							
164	*Ailurus fulgens*	FMNH	65803	Zoo: Brookfield Zoo, Chicago	26.05	20.11	1.30
165	*Ailurus fulgens*	FMNH	104950	Zoo: Lincoln Park Zoo, Chicago	27.66	22.81	1.21
1	*Ailurus fulgens*	WRAZL	8910070	Indianpolis Zoo	24.70	21.28	1.16
Canidae							
10	*Atelocynus microtis*	FMNH	60674	Zoo: Brookfield Zoo, Chicago	34.05	26.67	1.28
11	*Atelocynus microtis*	FMNH	110949	Zoo: Brookfield Zoo, Chicago	32.61	25.66	1.27
12	*Atelocynus microtis*	FMNH	121286	Zoo: Brookfield Zoo, Chicago	32.68	25.80	1.27
13	*Canis adustus*	FMNH	95933	Zimbabwe, East Mashonaland, Salisbury, Calgary Farm	38.35	29.50	1.30
14	*Canis adustus*	FMNH	95999	Zimbabwe, East Mashonaland, Salisbury, Komani Farm	36.09	26.82	1.35
16	*Canis aureus*	FMNH	57264	Iraq, Baghdad	40.16	31.42	1.28
15	*Canis aureus*	FMNH	92898	Iran, Khuzistan, near Gutuand Village, Karun River, breaks onto Khuzistan Plains, N. of Shustar	33.29	26.19	1.27
448	*Canis familiaris*	UTVPL	M-3383	Texas, Menard Co.	47.32	36.73	1.29
18	*Canis familiaris dingo*	FMNH	57807	Australia, Queensland	49.73	38.52	1.29
19	*Canis familiaris dingo*	FMNH	57808	Australia, Queensland	47.01	36.76	1.28
536	*Canis latrans*	DMNH	8503	Colorado, Arapaho Co., Aurora, Alameda and Buckley	38.98	30.87	1.26
535	*Canis latrans*	DMNH	9455	Colorado, Arapahoe Co., Mexico & Helena Sts.	40.72	33.34	1.22
538	*Canis latrans*	DMNH	9811	Colorado, Arapahoe Co., Aurora, Blackhawk & Alameda	40.74	32.62	1.25
537	*Canis latrans*	DMNH	10295	Colorado, Arapahoe Co., Hwy 83 at Douglas-Arapahoe County Line	38.70	30.58	1.27
20	*Canis latrans*	FMNH	135222	Kansas, Leavenworth Co., 3 mi N, 3.5 mi E. of Douglas Co. Courthouse	39.46	31.97	1.23
21	*Canis latrans*	FMNH	138815	Alaska, Game Mangement Unit 20B, Salcha River	42.35	33.80	1.25
623	*Canis latrans*	KU-M	2124	Montana, Dawson Co.	39.57	31.55	1.25
589	*Canis latrans*	KU-M	2125	Kansas, Douglas Co.	34.99	28.20	1.24
627	*Canis latrans*	KU-M	2154	Minnesota, Marshall Co.	43.86	34.53	1.27
591	*Canis latrans*	KU-M	4357	Kansas, Douglas Co.	42.24	33.88	1.25
593	*Canis latrans*	KU-M	4363	Kansas, Douglas Co.	43.22	34.30	1.26
615	*Canis latrans*	KU-M	5440	Kansas, Morton Co.	40.40	32.70	1.24
613	*Canis latrans*	KU-M	5442	Kansas, Morton Co.	41.45	32.13	1.29
619	*Canis latrans*	KU-M	5444	Kansas, Morton Co.	41.43	33.20	1.25
618	*Canis latrans*	KU-M	5446	Kansas, Morton Co.	41.55	33.24	1.25
616	*Canis latrans*	KU-M	6683	Kansas, Morton Co.	37.88	30.16	1.26
622	*Canis latrans*	KU-M	7035	Texas, Hemphill Co.	39.93	31.14	1.28
625	*Canis latrans*	KU-M	7036	Idaho, Bannock Co.	43.16	33.91	1.27
595	*Canis latrans*	KU-M	8270	Kansas, Douglas Co.	41.55	34.32	1.21
602	*Canis latrans*	KU-M	11092	Kansas, Greenwood Co.	42.81	34.82	1.23
596	*Canis latrans*	KU-M	12106	Kansas, Douglas Co.	37.58	30.08	1.25
614	*Canis latrans*	KU-M	12224	Kansas, Morton Co.	38.53	31.05	1.24
590	*Canis latrans*	KU-M	12225	Kansas, Douglas Co.	40.38	33.22	1.22
592	*Canis latrans*	KU-M	12723	Kansas, Douglas Co.	40.91	33.61	1.22
621	*Canis latrans*	KU-M	13272	North Dakota, Cavalier Co.	44.13	35.12	1.26
610	*Canis latrans*	KU-M	13599	Kansas, Nemaha Co.	40.75	32.06	1.27
626	*Canis latrans*	KU-M	13600	North Dakota, Cavalier Co.	41.97	33.56	1.25
594	*Canis latrans*	KU-M	13601	Kansas, Douglas Co.	39.55	31.68	1.25
606	*Canis latrans*	KU-M	14372	Kansas, Wilson Co., W of Coyville	43.31	33.22	1.30
599	*Canis latrans*	KU-M	14620	Kansas, Greenwood Co., 3 mi S, 2 mi W of Toronto	40.24	31.38	1.28
597	*Canis latrans*	KU-M	14621	Kansas, Greenwood Co., 8 mi SW of Toronto (Sec 4, T27S, R13E)	40.30	32.85	1.23
604	*Canis latrans*	KU-M	14622	Kansas, Greenwood Co., 6 mi SW Toronto	43.02	33.57	1.28
609	*Canis latrans*	KU-M	16087	Kansas, Nemaha Co, Sabetha	40.74	33.86	1.20
607	*Canis latrans*	KU-M	16088	Kansas, Nemaha Co, Sabetha	41.80	33.09	1.26
624	*Canis latrans*	KU-M	18771	North Dakota, Burleigh Co., Near Bismark	42.07	34.48	1.22
603	*Canis latrans*	KU-M	143228	Kansas, Franklin Co., Ottawa, 2.75 Mi S, 7 Mi W of	46.66	35.12	1.33
605	*Canis latrans*	KU-M	145193	Kansas, Leavenworth Co., Lawrence, 3 Mi N, 4 Mi E of Courthouse	42.40	33.66	1.26
601	*Canis latrans*	KU-M	145342	Kansas, Jackson Co., Dennison, 2 Mi S of	39.32	31.96	1.23
598	*Canis latrans*	KU-M	145357	Kansas, Jefferson Co., Winchester, 5 mi south of	40.68	31.27	1.30
612	*Canis latrans*	KU-M	145358	Kansas, Jefferson Co.	40.06	31.16	1.29
611	*Canis latrans*	KU-M	145984	Kansas, Jefferson Co.	40.14	32.14	1.25
600	*Canis latrans*	KU-M	146470	Kansas, Jackson Co., Potawatomie Indian Reservation	42.04	33.92	1.24
608	*Canis latrans*	KU-M	163744	Kansas, Jefferson Co., Lawrence, 14.5 KM NE of, Nelson Environmental Study Area	44.37	36.04	1.23
505	*Canis latrans*	MSB	5953	New Mexico, Sierra Co., Elephant Butte Reservoir State Park	42.33	35.19	1.20
503	*Canis latrans*	MSB	21263	New Mexico, Sandoval, Between Lajara and Bear Springs Canyon	44.31	35.85	1.24

Appendix 8. — Continuation.

ID	Species	Inst	Specimen No	Locality	Calc Len	Sust Pos	Gear Ratio
Canidae (continuation)							
507	*Canis latrans*	MSB	41039	New Mexico, Socorro Co., 20 Mi. N Red Rock, Juct. 84 and Forest Road 225	37.24	29.46	1.26
496	*Canis latrans*	MSB	41460	New Mexico, Bernalillo Co., Albuquerque, Junct. Hwy 14 and I-40	43.32	34.27	1.26
506	*Canis latrans*	MSB	42349	New Mexico, Socorro Co., 20 Mi. N Red Rock, Juct. 84 and Forest Road 225	40.03	31.97	1.25
491	*Canis latrans*	MSB	42746	Mexico, Sonora, Isla Tiburon	40.41	30.40	1.33
499	*Canis latrans*	MSB	43424	New Mexico, Bernalillo Co., Albuquerque, Alameda Dr, Washington and Edith Ave., near balloon	39.59	31.47	1.26
509	*Canis latrans*	MSB	57683	Texas, Reeves Co., 8.3 Mi SW Pecos, Hwy 285	40.82	32.89	1.24
495	*Canis latrans*	MSB	58790	Missouri, Lincoln Co., 10 Mi. W of Springfield on Hwy 44	38.91	31.87	1.22
501	*Canis latrans*	MSB	87724	New Mexico, Lea Co., 6 mi S, 3 mi E Maljamar	39.58	30.84	1.28
502	*Canis latrans*	MSB	88902	New Mexico, Lincoln National Forest, Smokey Bear Dist., Capital Mt.	39.12	30.77	1.27
500	*Canis latrans*	MSB	89012	New Mexico, Hidalgo Co.	41.66	33.73	1.24
497	*Canis latrans*	MSB	92553	New Mexico, Bernalillo Co., Albuquerque, I-25 @ 0.25 mi N of Exit 215	43.86	35.22	1.25
492	*Canis latrans*	MSB	101278	Colorado, Weld Co., 18 mi E. of Greeley	42.37	32.68	1.30
494	*Canis latrans*	MSB	101279	Colorado, Weld Co. 18 Mi. E. of Greeley	38.58	30.26	1.27
493	*Canis latrans*	MSB	101280	Kansas, Morton Co.	40.51	32.40	1.25
508	*Canis latrans*	MSB	101281	Oklahoma, Wichita National Forest	42.49	34.89	1.22
511	*Canis latrans*	MSB	101282	Wyoming, Johnson Co., Buffalo	43.01	33.37	1.29
510	*Canis latrans*	MSB	101283	Wyoming, Johnson Co., Buffalo	40.64	32.50	1.25
498	*Canis latrans*	MSB	103152	New Mexico, Bernalillo Co., Albuquerque, Indiana School Road and Harvard N of Golf Course	39.03	30.37	1.29
504	*Canis latrans*	MSB	140076	New Mexico, Sandoval Co., Corrales	40.58	32.39	1.25
700	*Canis latrans*	MUZA	329	Oregon, Columbia Co.	41.22	33.19	1.24
685	*Canis latrans*	MUZA	32 (P-6)	Oklahoma, Holdenville	44.36	34.90	1.27
686	*Canis latrans*	MUZA	743 (P-8)	Arizona, Prescott, vicinity of Prescott College	36.51	30.39	1.20
2054	*Canis latrans*	NCSM	2450	North Carolina, Johnston Co., Smithfield, , CR1343 - 1 mi SW of CR 1341	42.73	32.82	1.30
2066	*Canis latrans*	NCSM	5281	North Carolina, Burke Co., Morganton, S of, South Mountain Area	44.87	34.17	1.31
2053	*Canis latrans*	NCSM	5282	North Carolina, Duplin County, Cedar Grove near Onslow Co. Line	43.55	35.64	1.22
2067	*Canis latrans*	NCSM	5285	North Carolina, Tyrell Co.	43.73	34.39	1.27
2064	*Canis latrans*	NCSM	5564	North Carolina, Iredell Co.,	41.63	33.67	1.24
2065	*Canis latrans*	NCSM	7116	North Carolina, Columbus Co.	41.43	33.39	1.24
2061	*Canis latrans*	NCSM	8187	North Carolina, Bertle/Washington Co., SR 99/45 and SR 32, 3 mi SE JCT	40.88	32.54	1.26
2062	*Canis latrans*	NCSM	8205	North Carolina	43.70	35.89	1.22
2063	*Canis latrans*	NCSM	8207	North Carolina, Hyde Co., SR 99/45 and SR 32, 7 mi S of JCT.	44.11	35.54	1.24
2069	*Canis latrans*	NCSM	8326	North Carolina, Haywood Co., Crabtree Bald	45.35	37.27	1.22
2072	*Canis latrans*	NCSM	8388	Arizona, Pima Co., Tuscon, Campbell Ave., N of River Road.	41.40	33.92	1.22
2071	*Canis latrans*	NCSM	8517	North Carolina	40.13	30.48	1.32
2070	*Canis latrans*	NCSM	8963	North Carolina, Macon Co., Franklin, Runaway Knob	42.29	34.46	1.23
2047	*Canis latrans*	OMNH-M	16558	Oklahoma, Canadian County	43.80	34.23	1.28
793	*Canis latrans*	USNHM	261745	Ouichita Mountains, Oklahoma	43.23	34.71	1.25
803	*Canis latrans*	USNHM	263786	near Afton, Wyoming	46.07	37.10	1.24
799	*Canis latrans*	USNHM	291937	Morton County, North Dakota	42.30	33.13	1.28
800	*Canis latrans*	USNHM	291938	Morton County, North Dakota	40.87	32.08	1.27
792	*Canis latrans*	USNHM	513418	SW Alabama	44.84	33.82	1.33
801	*Canis latrans*	USNHM	533111	29 Mi SW Delta, Smokehouse Campground, in woods, 9300ft, Montrose County, Colorado	40.95	33.22	1.23
798	*Canis latrans*	USNHM	A01326	Fort Kearney, Platte River	40.93	33.08	1.24
797	*Canis latrans*	USNHM	A21496	Nebraska	41.40	32.53	1.27
795	*Canis latrans*	USNHM	A22660	Porcupine Creek, Montana	38.45	29.12	1.32
794	*Canis latrans*	USNHM	A22661	Dawson County, Montana	37.91	29.93	1.27
796	*Canis latrans*	USNHM	A22662	Dawson County, Montana	39.94	31.98	1.25
802	*Canis latrans*	USNHM	A49899	near Burns, Oregon	41.84	33.39	1.25
437	*Canis latrans*	UTVPL	M-2090	Texas, Presido Co., Rooney Ranch	39.05	31.33	1.25
438	*Canis latrans*	UTVPL	M-2094	Texas, Travis Co., 12 miles S. Austin on I-35	40.33	32.79	1.23
436	*Canis latrans*	UTVPL	M-2121	Texas, Travis Co., 12 miles S. Austin, I-35	39.01	29.68	1.31
439	*Canis latrans*	UTVPL	M-2275	Texas, Presidio Co.	41.61	31.78	1.31

Appendix 8. — Continuation.

ID	Species	Inst	Specimen No	Locality	Calc Len	Sust Pos	Gear Ratio
Canidae (continuation)							
440	*Canis latrans*	UTVPL	M-2327	Texas, Brewster Co.	44.54	34.92	1.28
445	*Canis latrans*	UTVPL	M-2409	Texas, Fayette Co.	40.24	31.55	1.28
446	*Canis latrans*	UTVPL	M-3357	Texas, Presidio Co.	41.45	32.31	1.28
447	*Canis latrans*	UTVPL	M-3455	Texas, 10 Mi. North of Laredo	38.77	30.24	1.28
452	*Canis latrans*	UTVPL	M-3978	Texas, Bastrop Co., Red Rock, 2 mi. W on Highway 812, on Frank Carrol Ranch	39.69	30.70	1.29
449	*Canis latrans*	UTVPL	M-3981	Texas, Bastrop Co., Red Rock, 2 mi W on Highway 812, Frank Carrol Ranch	42.38	32.62	1.30
451	*Canis latrans*	UTVPL	M-3983	Texas, Bastrop Co., Red Rock	40.95	30.83	1.33
450	*Canis latrans*	UTVPL	M-4005	Texas, Bastrop Co., Red Rock	46.19	35.27	1.31
453	*Canis latrans*	UTVPL	M-4990	Colorado, Gunnison Co.	37.30	30.07	1.24
22	*Canis lupus*	FMNH	147636	Minnesota, Beltrami Co., Gary Loonhardt Farm, T155N, R30W, Sec 27	62.07	48.03	1.29
23	*Canis lupus*	FMNH	153800	Minnesota, St Louis Co., North of Cotton, Hwy 53	59.43	46.67	1.27
1962	*Canis lupus*	UNIVA	727	Quintanilla de Onâˆ□Â©simo, Spain	60.06	46.94	1.28
1964	*Canis lupus*	UNIVA	924	Vega-Sicilia, Valbuena de Duero, Spain	56.15	45.35	1.24
1950	*Canis lupus*	UNIVA	1407		52.27	43.01	1.22
1963	*Canis lupus*	UNIVA	1690	Bercero, Valladolid, Spain	51.55	40.54	1.27
1957	*Canis lupus*	UNIVA	2264	Cen. Rec. Aves, Pollos, Valladolid, Spain	60.43	49.29	1.23
1952	*Canis lupus*	UNIVA	2580	La Muderra, Spain	57.70	45.91	1.26
1959	*Canis lupus*	UNIVA	2627	Spain	55.56	44.68	1.24
1960	*Canis lupus*	UNIVA	2655	Quintanilla de Onsoâˆ□Â±a, Valladolid, Spain	54.82	43.33	1.27
1955	*Canis lupus*	UNIVA	3527	Cen. Rec. Aves, Valladolid, Spain	56.27	46.74	1.20
1956	*Canis lupus*	UNIVA	3562	Cen. Rec. Aves, Pollos, Valladolid, Spain	58.02	47.82	1.21
1949	*Canis lupus*	UNIVA	3563	Valwo Parque de la Naturaleza (Valladolid)	57.22	45.22	1.27
1958	*Canis lupus*	UNIVA	3684	Caâˆ□Â±izo-Zamora (C.R.A.) Valladolid, Spain	61.11	50.59	1.21
1948	*Canis lupus*	UNIVA	3692	Valwo Parque de la Naturaleza (Valladolid)	56.38	43.84	1.29
1953	*Canis lupus*	UNIVA	4589	Valwo Parque de la Naturaleza (Valladolid)	63.25	49.12	1.29
1961	*Canis lupus*	UNIVA	4645	Ceinos de Campos, Valladolid, Spain	58.76	47.16	1.25
454	*Canis lupus*	UTVPL	M-6540	Alaska	61.52	49.94	1.23
24	*Canis mesomelas*	FMNH	127807	Tanzania, Mara Prov., Serengeti Plains, Seronera	34.82	26.80	1.30
25	*Canis mesomelas*	FMNH	127808	Tanzania, Mara Prov., Serengeti Plains, Seronera	35.54	28.07	1.27
1965	*Canis mesomelas*	UNIVA	1618	Zoo de Madrid	32.59	26.73	1.22
1966	*Canis mesomelas*	UNIVA	1986	Zoo de Madrid	34.55	27.46	1.26
29	*Canis rufus*	FMNH	104662	Zoo,	50.83	40.20	1.26
28	*Canis rufus*	FMNH	104995	Texas, Harris Co., Deer Park, Near Residence	48.58	38.80	1.25
30	*Canis simensis*	AMNH-M	81001	Abyssinia, Kaka Plateau, 2900 ft	45.64	37.17	1.23
31	*Cerdocyon thous*	FMNH	70758	Colombia, Antioquia, Urrao	26.77	18.70	1.43
32	*Cerdocyon thous*	FMNH	70759	Colombia, Huila, Pitalito, 1350 m	28.28	20.62	1.37
33	*Chrysocyon brachyurus*	FMNH	44534	Brazil, Mato Grosso, Descalvado, 142 m	56.17	40.37	1.39
34	*Chrysocyon brachyurus*	FMNH	127434	Zoo	63.12	45.99	1.37
35	*Cuon alpinus*	FMNH	104389	Nepal, Nawakot Dist., Phulung Ghyang, 11200’	43.18	35.66	1.21
43	*Lycalopex culpaeus*	AMNH-M	147547	N.Y. Zoological Society	34.51	29.50	1.17
42	*Lycalopex culpaeus*	AMNH-M	244656	Bolivia, Oruro, 8 km. No. of Oruro, 3700 m	32.38	26.76	1.21
45	*Lycalopex griseus*	FMNH	129839	Chile, Los Lagos, Osorno, ca 25 km w on road to San Juan	27.22	21.22	1.28
44	*Lycalopex griseus*	FMNH	154639	Argentina, Chubut, Port Deseado	26.94	20.81	1.29
46	*Lycalopex gymnocercus*	AMNH-M	205756	Uruguay, Dept. Cerro Largo, 20 km SE Melo Sierra de Vaz, Rio Tacuari	34.24	26.04	1.31
47	*Lycalopex gymnocercus*	AMNH-M	205771	Uruguay, Dept. Rio Negro, Arroyo Negro, 15 km. s. Paysandu	32.28	25.33	1.27
48	*Lycalopex sechurae*	AMNH-M	46525	Ecuador, Portovelo	24.32	20.79	1.17
50	*Lycalopex vetulus*	AMNH-M	100091	N.Y. Zoological Society	24.76	20.22	1.22
49	*Lycalopex vetulus*	AMNH-M	100100	N.Y. Zoological Society	25.23	20.04	1.26
36	*Lycaon pictus*	FMNH	127811	Tanzania, Mara Prov., Serengeti Plains, Seronera	53.99	41.89	1.29
37	*Lycaon pictus*	FMNH	127813	Tanzania, Mara Prov., Serengeti Plains, Seronera	53.86	42.03	1.28
1968	*Lycaon pictus*	UNIVA	1167	Zoo de Matapozuelos (Valladolid)	55.83	44.25	1.26
38	*Nyctereutes procyonoides*	FMNH	57837	Zoo: Brookfield Zoo, Chicago	24.37	19.77	1.23
39	*Nyctereutes procyonoides*	FMNH	59013	Zoo: Lincoln Park Zoo, Chicago	23.01	17.54	1.31
1972	*Nyctereutes procyonoides*	UNIVA	302	Zoo de Matapozuelos (Valladolid)	25.84	20.37	1.27
1971	*Nyctereutes procyonoides*	UNIVA	992	Zoo de Matapozuelos (Valladolid)	25.84	20.22	1.28
1970	*Nyctereutes procyonoides*	UNIVA	1641	Zoo de Madrid	27.62	23.04	1.20
1969	*Nyctereutes procyonoides*	UNIVA	3539	Zoo de Madrid	24.67	18.49	1.33
40	*Otocyon megalotis*	FMNH	127814	Tanzania, Mara Prov., Serengeti Plains, Seronera	25.95	18.97	1.37
41	*Otocyon megalotis*	FMNH	127818	Tanzania, Mara Prov., Serengeti Plains, Seronera	25.85	19.65	1.32
51	*Speothos venaticus*	FMNH	121544	Zoo: Lincoln Park Zoo, Chicago	23.31	19.74	1.18
52	*Speothos venaticus*	FMNH	125402	Zoo: Lincoln Park Zoo, Chicago	28.12	24.15	1.16

APPENDIX 8. — Continuation.

ID	Species	Inst	Specimen No	Locality	Calc Len	Sust Pos	Gear Ratio
Canidae (continuation)							
539	*Urocyon cinereoargenteus*	DMNH	9634	Colorado, Jefferson Co., Hwy 72, WNW of intersection with Hwy 93	29.00	22.92	1.27
540	*Urocyon cinereoargenteus*	DMNH	11105	Colorado, La Plata Co., Durango area	29.85	23.50	1.27
261	*Urocyon cinereoargenteus*	FMNH	55708	Illinois, Lake Co., Highland Park, Near Cook Co. Line	28.03	22.06	1.27
260	*Urocyon cinereoargenteus*	FMNH	55734	Illinois, Lake Co., Highland Park	29.93	22.96	1.30
270	*Urocyon cinereoargenteus*	FMNH	60658	Wisconsin, Kenosha Co., 15 Mi. W. Kenosha	28.12	22.26	1.26
250	*Urocyon cinereoargenteus*	FMNH	73735	Illinois, Cook Co., 17th Ave and Sauk Cr	29.81	23.32	1.28
268	*Urocyon cinereoargenteus*	FMNH	89856	Arkansas, Stone Co., Marcella	29.84	22.84	1.31
269	*Urocyon cinereoargenteus*	FMNH	113135	Wisconsin, Kenosha Co., 15 Mi. W. Kenosha	27.86	21.73	1.28
253	*Urocyon cinereoargenteus*	FMNH	121358	Illinois, Du Page Co., Downers Grove, Highland Ave., W. of George Williams College Campus	24.80	19.50	1.27
251	*Urocyon cinereoargenteus*	FMNH	121541	Illinois, Du Page Co., Downers Grove, Highland Ave., W. of George Williams College Campus	29.53	25.22	1.17
252	*Urocyon cinereoargenteus*	FMNH	121663	Illinois, Du Page Co., Downers Grove, Highland Ave., W. of George Williams College Campus	25.41	19.60	1.30
254	*Urocyon cinereoargenteus*	FMNH	124592	Illinois, Du Page Co., Hinsdale	27.65	21.42	1.29
271	*Urocyon cinereoargenteus*	FMNH	124593	Wisconsin, Milwaukee Co,, Milwaukee	31.14	24.60	1.27
272	*Urocyon cinereoargenteus*	FMNH	126807	Wisconsin, Racine Co., 5 Mi W. Rochester	27.50	22.13	1.24
259	*Urocyon cinereoargenteus*	FMNH	126808	Tennessee, Roane Co., 20 Mi SE of Rockwood	29.34	23.10	1.27
256	*Urocyon cinereoargenteus*	FMNH	129296	Illinois, Hardin Co., NE 1/2 of Sec 14, T125 R8E	27.93	21.50	1.30
257	*Urocyon cinereoargenteus*	FMNH	129297	Illinois, Hardin Co., NE 1/2 of Sec 14, T125 R8E	27.02	21.35	1.27
273	*Urocyon cinereoargenteus*	FMNH	129298	Texas, Brewster Co., S of Hwy 2627 N. of Sue Peaks	25.75	19.81	1.30
258	*Urocyon cinereoargenteus*	FMNH	152094	Illinois, Du Page Col., Lombard	29.40	23.18	1.27
255	*Urocyon cinereoargenteus*	FMNH	152095	Illinois, Du Page Co., Naperville	29.90	21.40	1.40
265	*Urocyon cinereoargenteus*	FMNH	160111	Minnesota, Olmsted Co, Hwy 42, 2 mi. S Elgin	29.23	23.88	1.22
267	*Urocyon cinereoargenteus*	FMNH	167187	Wisconsin, Brown Co., Suamico	30.01	24.50	1.22
263	*Urocyon cinereoargenteus*	FMNH	171143	Florida, Highlands Co., 5 mi W Okeechobee on SR 70	28.08	21.78	1.29
262	*Urocyon cinereoargenteus*	FMNH	171145	Florida, Highlands Co., Placid View Drive and Washington	27.61	22.04	1.25
264	*Urocyon cinereoargenteus*	FMNH	175292	Minnesota, Olmsted Co, Hwy 42, 2 mi. S Elgin	27.60	21.26	1.30
266	*Urocyon cinereoargenteus*	FMNH	178038	Wisconsin, Brown Co., Green Bay	29.16	23.44	1.24
99	*Urocyon cinereoargenteus*	INSM	71.02.0254	Indiana	31.30	25.16	1.24
97	*Urocyon cinereoargenteus*	INSM	71.09.0070	Indiana, Madison Co., Lick Creek (1/2 mile east of SR 9)	26.84	21.46	1.25
98	*Urocyon cinereoargenteus*	INSM	71.09.0093	Indiana, Madison Co., near Alexandria	27.94	22.00	1.27
638	*Urocyon cinereoargenteus*	KU-M	11086	Kansas, Douglas Co.	25.84	20.28	1.27
641	*Urocyon cinereoargenteus*	KU-M	11087	New York, Tompkins Co.	27.95	23.10	1.21
640	*Urocyon cinereoargenteus*	KU-M	11088	New York, Tompkins Co.	28.50	23.91	1.19
632	*Urocyon cinereoargenteus*	KU-M	11907	Oklahoma, Adair Co.	26.75	21.86	1.22
642	*Urocyon cinereoargenteus*	KU-M	14355	Texas, Kerr Co.	26.76	21.35	1.25
639	*Urocyon cinereoargenteus*	KU-M	34889	Kansas, Cherokee Co., Hollowell, 2 mi S, 0.5 mi W	27.58	21.73	1.27
636	*Urocyon cinereoargenteus*	KU-M	39442	Kansas, Shawnee Co., Topeka, 8 mi E State House	26.55	21.89	1.21
633	*Urocyon cinereoargenteus*	KU-M	47984	California, San Bernadino Co., Colorado River, 29 mi S. Needles	26.21	20.32	1.29
630	*Urocyon cinereoargenteus*	KU-M	47986	California, San Bernadino Co., Colorado River, 5 mi North of Needles	24.31	18.36	1.32
631	*Urocyon cinereoargenteus*	KU-M	52480	California, Riverside Co., 35 mi N. Blythe	27.65	23.40	1.18
644	*Urocyon cinereoargenteus*	KU-M	79714	New Mexico, Eddy Co., Black River Village	30.61	24.10	1.27
637	*Urocyon cinereoargenteus*	KU-M	92630	Kansas, Jefferson Co., E. Williamstown, 1.5 mi S and 2 mi E	28.64	23.99	1.19
628	*Urocyon cinereoargenteus*	KU-M	143461	California, Marin Co., Point Reyes National Seashore	28.61	22.96	1.25
629	*Urocyon cinereoargenteus*	KU-M	143462	California, Marin Co., Point Reyes National Seashore	29.08	24.36	1.19
643	*Urocyon cinereoargenteus*	KU-M	143463	California, Marin Co., Point Reyes National Seashore	25.14	19.46	1.29
634	*Urocyon cinereoargenteus*	KU-M	161052	Missouri, Adair Co., 6 mi north and 1 mi west of Kirksville	31.13	24.16	1.29
635	*Urocyon cinereoargenteus*	KU-M	163745	Missouri, Adair Co., 6 mi north and 1 mi west of Kirksville	25.89	22.01	1.18
512	*Urocyon cinereoargenteus*	MSB	37260	New Mexico, Bernalillo Co., Tijeras Canyon near Tijeras Creek	29.18	23.43	1.25
515	*Urocyon cinereoargenteus*	MSB	50573	New Mexico, Bernalillo Co., Cedar Crest	26.01	22.59	1.15
514	*Urocyon cinereoargenteus*	MSB	50761	New Mexico, Bernalillo Co., Cedar Crest	28.14	23.53	1.20
516	*Urocyon cinereoargenteus*	MSB	54630	New Mexico, Bernalillo Co., Cedar Crest	28.58	22.59	1.27
517	*Urocyon cinereoargenteus*	MSB	54905	New Mexico, Bernalillo Co., Cedar Crest	26.79	22.22	1.21
519	*Urocyon cinereoargenteus*	MSB	57639	New Mexico, Bernalillo Co., Cedar Crest	28.54	22.48	1.27
518	*Urocyon cinereoargenteus*	MSB	60983	New Mexico, Bernalillo Co., Cedar Crest	29.24	22.42	1.30
520	*Urocyon cinereoargenteus*	MSB	60986	New Mexico, Bernalillo Co., Cedar Crest	30.19	24.33	1.24
521	*Urocyon cinereoargenteus*	MSB	60987	New Mexico, Bernalillo Co., Cedar Crest	31.48	24.84	1.27
690	*Urocyon cinereoargenteus*	MUZA	25 (P-11)	Missouri, St. Clair Co.	26.79	21.56	1.24

APPENDIX 8. — Continuation.

ID	Species	Inst	Specimen No	Locality	Calc Len	Sust Pos	Gear Ratio
Canidae (continuation)							
691	*Urocyon cinereoargenteus*	MUZA	53 (P-11)	Missouri, Henry	28.19	21.66	1.30
692	*Urocyon cinereoargenteus*	MUZA	587 (Q-1)	Missouri, Benton Co., Rodgers Shelter	28.98	23.74	1.22
2077	*Urocyon cinereoargenteus*	NCSM	8374	North Carolina, Randolph Co., Ashboro, E. of; on US 64, across from JCT SR 2706.	29.83	23.62	1.26
2078	*Urocyon cinereoargenteus*	NCSM	15023	North Carolina, Wake Co., Raleigh, SW of Garner, SR 1006 (Old Stage Rd), 0.2 rdmi N of JCT SR 2713	28.07	22.01	1.28
2046	*Urocyon cinereoargenteus*	OMNH-M	629	Oklahoma, Cleveland Cty, 3 mi E, 5 mi N Lexington, T7N R1W Sec 24	26.20	20.90	1.25
2043	*Urocyon cinereoargenteus*	OMNH-M	662	United States, US 52	27.20	21.89	1.24
2044	*Urocyon cinereoargenteus*	OMNH-M	17006	Oklahoma, Cleveland, Noble, Etowah Rd, & 84th	27.80	21.64	1.28
2042	*Urocyon cinereoargenteus*	OMNH-M	36250	Oklahoma, Cleveland Cty, Norman, Highway 9 and Marshall Road	29.81	24.13	1.24
2045	*Urocyon cinereoargenteus*	OMNH-M	39276	Oklahoma, Cleveland, Hwy 9 (between Chautauqua and Jenkins)	25.92	21.08	1.23
412	*Urocyon cinereoargenteus*	UMMZ	61521	Mexico, Tamaulipas, Mulato	25.49	20.69	1.23
408	*Urocyon cinereoargenteus*	UMMZ	63186	Guatemala, Peten, Uaxactun	21.61	16.25	1.33
410	*Urocyon cinereoargenteus*	UMMZ	81033	Mexico, Baja California, Cape San Lucas	26.41	21.78	1.21
423	*Urocyon cinereoargenteus*	UMMZ	82484	New Mexico, Valencia Co., 1.5 mi. S. Grants	29.61	25.11	1.18
414	*Urocyon cinereoargenteus*	UMMZ	83967	Alabama, Lee Co., 5 mi. N. Opelika	28.27	23.27	1.21
415	*Urocyon cinereoargenteus*	UMMZ	83969	Alabama, Lee Co., 5 mi. E. Auburn	28.27	22.63	1.25
413	*Urocyon cinereoargenteus*	UMMZ	93303	Mexico, Quintana Roo, Esmeralda	21.96	17.18	1.28
409	*Urocyon cinereoargenteus*	UMMZ	99412	Guatemala, Dept. Santa Rosa, Finca La Morena	25.86	21.12	1.22
411	*Urocyon cinereoargenteus*	UMMZ	100757	Mexico, Durango, 25 mi NNW El Salto, La Lagurra	26.39	20.56	1.28
421	*Urocyon cinereoargenteus*	UMMZ	101194	Michigan, Jackson Co., T15 R3W, betwee sec. 5 & 6	28.22	22.51	1.25
420	*Urocyon cinereoargenteus*	UMMZ	103536	Kansas, Meade Co., 14 mi SW Mead	27.86	22.60	1.23
419	*Urocyon cinereoargenteus*	UMMZ	103647	Illinois, Ogle Co., Leaf River	26.73	22.71	1.18
425	*Urocyon cinereoargenteus*	UMMZ	113307	Texas, Travis Co.	28.09	22.24	1.26
426	*Urocyon cinereoargenteus*	UMMZ	114346	Texas, Travis Co.	25.69	19.80	1.30
427	*Urocyon cinereoargenteus*	UMMZ	114347	Texas, Travis Co.	27.37	21.21	1.29
428	*Urocyon cinereoargenteus*	UMMZ	115491	Texas, Travis Co.	24.66	20.26	1.22
424	*Urocyon cinereoargenteus*	UMMZ	116350	New York, Warren Co., 6 mi. N. Glen Falls	28.33	21.94	1.29
422	*Urocyon cinereoargenteus*	UMMZ	123396	Michigan, Washtenaw Co., Ann Arbor	27.77	22.94	1.21
417	*Urocyon cinereoargenteus*	UMMZ	176146	California, Meno, Hwy 395 north by Bodie State Historic Park	27.40	22.53	1.22
416	*Urocyon cinereoargenteus*	UMMZ	176207	California, Los Angles, Angeles National Forest, Angeles Crest Highway	24.18	19.46	1.24
418	*Urocyon cinereoargenteus*	UMMZ	176266	California, Santa Barbara, Highway 1	26.31	21.05	1.25
971	*Urocyon cinereoargenteus*	USNHM	235486	Largo, Maryland	28.15	21.84	1.29
970	*Urocyon cinereoargenteus*	USNHM	236960	Camp Mead, Anne Arundel County, Maryland	29.45	22.34	1.32
973	*Urocyon cinereoargenteus*	USNHM	240402	Rock Point, Maryland	28.02	22.22	1.26
994	*Urocyon cinereoargenteus*	USNHM	244918	Chuntuqui, El Salvador (or Guatemala)	22.59	16.97	1.33
988	*Urocyon cinereoargenteus*	USNHM	244919	Libertad, Peten, Guatemala	20.58	16.21	1.27
990	*Urocyon cinereoargenteus*	USNHM	244921	Libertad, Peten, Guatemala	22.05	17.37	1.27
993	*Urocyon cinereoargenteus*	USNHM	244922	Libertad, Peten, Guatemala	24.16	19.21	1.26
989	*Urocyon cinereoargenteus*	USNHM	244923	Libertad, Peten, Guatemala	19.86	16.68	1.19
991	*Urocyon cinereoargenteus*	USNHM	244926	Libertad, Peten, Guatemala	23.48	18.37	1.28
992	*Urocyon cinereoargenteus*	USNHM	244927	Libertad, Peten, Guatemala	21.86	16.82	1.30
984	*Urocyon cinereoargenteus*	USNHM	256058	Allendale County, Florida	30.21	24.27	1.24
976	*Urocyon cinereoargenteus*	USNHM	257652	Oxon Hill, Maryland	27.25	21.77	1.25
977	*Urocyon cinereoargenteus*	USNHM	258563	La Plata, Maryland	28.79	23.27	1.24
995	*Urocyon cinereoargenteus*	USNHM	258568	Zoo	26.51	21.88	1.21
975	*Urocyon cinereoargenteus*	USNHM	282140	Silver Spring, 1 mi NW, Maryland	28.32	23.09	1.23
978	*Urocyon cinereoargenteus*	USNHM	283642	Hagerstown, Maryland	28.68	22.84	1.26
981	*Urocyon cinereoargenteus*	USNHM	284892	Shenandoah National Park, Gooney Manor, Virginia	26.24	20.95	1.25
980	*Urocyon cinereoargenteus*	USNHM	311152	Whitetop Mt, 5300 ft, Smyth County, Virginia	26.09	20.62	1.27
982	*Urocyon cinereoargenteus*	USNHM	521046	Lee Highway, Next to Arlington national cemetery, Arlington County, Virginia	27.43	22.70	1.21
983	*Urocyon cinereoargenteus*	USNHM	521047	Lincolnia Avenue, near intersection of I95 and Route 236, Fairfax County, Virginia	27.67	23.01	1.20
967	*Urocyon cinereoargenteus*	USNHM	564257	Petersham, Worcester County, Massachusetts	27.80	21.62	1.29
968	*Urocyon cinereoargenteus*	USNHM	564258	Petersham, Worcester County, Massachusetts	25.99	20.02	1.30
985	*Urocyon cinereoargenteus*	USNHM	568477	South of Snell, before Partlow, on rte 738 near public dump, Spotsylvania County, Virginia	25.69	20.33	1.26
986	*Urocyon cinereoargenteus*	USNHM	568665	Partlow road rte 738, near Wallers church, Spotsylvania County, Virginia	26.16	20.93	1.25
972	*Urocyon cinereoargenteus*	USNHM	000064/ A00968	Washington DC	26.53	20.67	1.28

Appendix 8. — Continuation.

ID	Species	Inst	Specimen No	Locality	Calc Len	Sust Pos	Gear Ratio
Canidae (continuation)							
969	*Urocyon cinereoargenteus*	USNHM	000065/ A00974	Washington DC	26.85	21.04	1.28
979	*Urocyon cinereoargenteus*	USNHM	A00771	Perry County, Pennsylvania	27.85	21.92	1.27
997	*Urocyon cinereoargenteus*	USNHM	A21210	Shasta County, California	27.57	22.19	1.24
998	*Urocyon cinereoargenteus*	USNHM	A21211	Shasta County, California	27.56	21.51	1.28
999	*Urocyon cinereoargenteus*	USNHM	A21212	Shasta County, California	26.12	21.14	1.24
1000	*Urocyon cinereoargenteus*	USNHM	A21213	Shasta County, California	27.72	21.33	1.30
1001	*Urocyon cinereoargenteus*	USNHM	A21214	Shasta County, California	29.24	24.27	1.20
1002	*Urocyon cinereoargenteus*	USNHM	A21215	Shasta County, California	27.05	22.56	1.20
1003	*Urocyon cinereoargenteus*	USNHM	A21216	Shasta County, California	25.56	21.05	1.21
1004	*Urocyon cinereoargenteus*	USNHM	A21217	Shasta County, California	28.12	21.66	1.30
1005	*Urocyon cinereoargenteus*	USNHM	A21530	Shasta County, California	26.58	21.18	1.25
974	*Urocyon cinereoargenteus*	USNHM	A23115	Alexandria, Virginia	26.99	21.85	1.24
987	*Urocyon cinereoargenteus*	USNHM	A23117	Macon, Georgia	28.05	23.21	1.21
996	*Urocyon cinereoargenteus*	USNHM	A30618	Fort Davis, Texas	28.85	22.48	1.28
455	*Urocyon cinereoargenteus*	UTVPL	M-1120	Texas, Bastrop Co.	27.39	23.59	1.16
456	*Urocyon cinereoargenteus*	UTVPL	M-1874	Texas, Travis Co.	27.90	22.39	1.25
457	*Urocyon cinereoargenteus*	UTVPL	M-2063	Texas, Presidio Co., Rooney Ranch	28.56	22.41	1.27
458	*Urocyon cinereoargenteus*	UTVPL	M-2704	Texas, Travis Co., Austin, Gate of Balcones Research Center	29.05	23.20	1.25
459	*Urocyon cinereoargenteus*	UTVPL	M-3003	Texas, Travis Co., Austin, Balcones Trail near FM 2222	27.39	21.29	1.29
461	*Urocyon cinereoargenteus*	UTVPL	M-3979	Texas, Bastrop Co., Red Rock, 2 mi W. on Highway 812 on Frank Carrol Ranch	27.93	21.97	1.27
462	*Urocyon cinereoargenteus*	UTVPL	M-3984	Texas, Bastrop Co., Red Rock	25.32	20.48	1.24
464	*Urocyon cinereoargenteus*	UTVPL	M-4003	Texas, Bastrop Co., Red Rock	26.49	20.80	1.27
465	*Urocyon cinereoargenteus*	UTVPL	M-4988	Texas, Travis Co.	27.90	21.62	1.29
463	*Urocyon cinereoargenteus*	UTVPL	M-6602	Texas, Travis Co., Austin	27.83	22.61	1.23
53	*Urocyon cinereoargenteus*	WRAZL	10277	Indiana, Monroe Co.	28.13	22.07	1.27
2087	*Urocyon littoralis*	MVZ	38351	San Miguel Island, Santa Barbara, California, USA	22.68	18.91	1.20
2086	*Urocyon littoralis*	MVZ	38352	San Miguel Island, Santa Barbara County, California, USA	21.63	17.49	1.24
578	*Vulpes lagopus*	DMNH	7452		29.78	21.88	1.36
3	*Vulpes lagopus*	FMNH	60053	Zoo: Lincoln Park Zoo, Chicago	27.64	20.31	1.36
4	*Vulpes lagopus*	FMNH	60377	Zoo: Lincoln Park Zoo, Chicago	29.34	22.05	1.33
5	*Vulpes lagopus*	FMNH	60405	Zoo: Lincoln Park Zoo, Chicago	29.27	21.92	1.34
6	*Vulpes lagopus*	FMNH	101870	Zoo: Lincoln Park Zoo, Chicago	28.98	21.40	1.35
7	*Vulpes lagopus*	FMNH	129290	Alaska, Point Barrow, Game Management Unit 26	26.65	20.49	1.30
8	*Vulpes lagopus*	FMNH	129291	Alaska, Point Barrow, Game Management Unit 26	27.73	21.29	1.30
1945	*Vulpes lagopus*	UNIVA	1399	Unknown	29.18	24.21	1.21
9	*Vulpes lagopus*	WRAZL	9510028	Alaska, Barrow; Shot on (Gas Field or East Field??), Gaswell Road, 1st Station	25.70	19.55	1.31
227	*Vulpes macrotis*	FMNH	129299	Nevada, Clark Co.	21.66	15.90	1.36
226	*Vulpes macrotis*	FMNH	129300	Nevada, Clark Co.	23.32	19.13	1.22
55	*Vulpes velox*	AMNH-M	100190	N.Y. Zoological Society	26.12	21.16	1.23
54	*Vulpes velox*	AMNH-M	100215	N.Y. Zoological Society	24.56	20.01	1.23
699	*Vulpes vulpes*	MUZA	33	Missouri, Monroe Co.	29.81	23.48	1.27
689	*Vulpes vulpes*	MUZA	550	Missouri, Benton Co., Rodgers Shelter	29.82	22.81	1.31
688	*Vulpes vulpes*	MUZA	553 (P-10)	Missouri, Benton Co., Rodgers Shelter	29.76	22.54	1.32
687	*Vulpes vulpes*	MUZA	586 (P-10)	Missouri, Benton Co., Rodgers Shelter	29.48	22.26	1.32
361	*Vulpes vulpes*	NRM	955021	Sweden, Uppland, Enköpings-Näs, Brunnsholm	36.55	30.06	1.22
362	*Vulpes vulpes*	NRM	955158	Sweden, Uppland, Vassunda	34.59	27.89	1.24
363	*Vulpes vulpes*	NRM	965015	Sweden, Sö., Stockholm, Trangsund	29.27	25.76	1.14
359	*Vulpes vulpes*	NRM	2005316	Sweden, Lycksele lappmark, Sorsele, Björkfjället; Gardenhyttan	32.53	26.86	1.21
360	*Vulpes vulpes*	NRM	20035018	Sweden, Uppland, Stockholm, Ästra ryd, Säbyviken	36.43	30.08	1.21
336	*Vulpes vulpes*	NRM	58-0131	Sweden, Grillby	33.52	25.74	1.30
337	*Vulpes vulpes*	NRM	58-2840	Sweden,Roslagen	32.61	22.50	1.45
339	*Vulpes vulpes*	NRM	58-3635	Russia, Kamchatka,Petropavlovsk	29.59	23.31	1.27
338	*Vulpes vulpes*	NRM	58-5437	Sweden, Nacka,Nacka(s:n)	31.27	24.59	1.27
340	*Vulpes vulpes*	NRM	58-6662	Sweden, Stockholm,Freskati	32.31	26.29	1.23
341	*Vulpes vulpes*	NRM	58-6697	Sweden, Gotska Sandön	34.72	27.39	1.27
342	*Vulpes vulpes*	NRM	58-6725	Sweden, Lötskyrka, Mälaren	36.03	28.55	1.26
343	*Vulpes vulpes*	NRM	58-6726	Sweden, Gotska Sandön	31.63	25.22	1.25
345	*Vulpes vulpes*	NRM	58-6727	Sweden, Gotska Sandön	32.34	25.47	1.27
346	*Vulpes vulpes*	NRM	58-6728	Sweden, Gotska Sandön	31.74	23.69	1.34
347	*Vulpes vulpes*	NRM	59-0025	Sweden, Uppland	34.90	28.10	1.24
348	*Vulpes vulpes*	NRM	59-0026	Sweden, Grillby	33.06	27.13	1.22
349	*Vulpes vulpes*	NRM	59-0027	Sweden, Lidingö; Elfvik	35.35	27.88	1.27

Appendix 8. — Continuation.

ID	Species	Inst	Specimen No	Locality	Calc Len	Sust Pos	Gear Ratio
Canidae (continuation)							
350	*Vulpes vulpes*	NRM	59-0029	Sweden, Lidingö; Elfvik	34.23	27.51	1.24
351	*Vulpes vulpes*	NRM	59-0130	Sweden, Lidingö; Elfvik	33.03	26.72	1.24
352	*Vulpes vulpes*	NRM	68-0363	Sweden, Hasselby	33.28	26.45	1.26
353	*Vulpes vulpes*	NRM	69-0166	Sweden, Nattavara,12 km E	33.16	28.24	1.17
354	*Vulpes vulpes*	NRM	73-0001	Sweden, Veckholm	34.64	27.07	1.28
355	*Vulpes vulpes*	NRM	73-0002	Sweden, Veckholm	33.01	26.82	1.23
357	*Vulpes vulpes*	NRM	91-5128	Sweden, Sthlm.,Vallentuna,Grävelsta	36.03	27.30	1.32
356	*Vulpes vulpes*	NRM	98-5031	Sweden, Täby,galoppbana,E3 (Up.)	35.28	27.93	1.26
358	*Vulpes vulpes*	NRM	98-5772	Sweden, Up., Knivsta; Vallby	31.82	25.81	1.23
1980	*Vulpes vulpes*	UNIVA	150	Valladolid	33.46	24.93	1.34
1979	*Vulpes vulpes*	UNIVA	2138	Cen. Rec. Aves, Pollos, Valladolid, Spain	33.60	25.41	1.32
56	*Vulpes vulpes*	WRAZL	9610431	Indiana, Greene Co.	28.20	20.72	1.36
58	*Vulpes zerda*	AMNH-M	22881	N.Y. Zoological Society	18.19	14.20	1.28
57	*Vulpes zerda*	AMNH-M	90319	N.Y. Zoological Society	18.76	14.57	1.29
1974	*Vulpes zerda*	UNIVA	4	Zoo de Barcelona	17.29	13.49	1.28
1973	*Vulpes zerda*	UNIVA	3441	Faunia	18.02	13.60	1.33
1975	*Vulpes zerda*	UNIVA	4790	Zoo de Madrid	22.45	16.70	1.34
Eupleridae							
194	*Cryptoprocta ferox*	AMNH-M	100463	Madagascar, Province de Betroka, 170 km E (Julear), Toliara	31.85	26.92	1.18
195	*Cryptoprocta ferox*	AMNH-M	199544	Madagascar, Province de Toliara, 12 km NN Itampolo, Aven de Leilia, 90 m	37.08	30.46	1.22
2088	*Cryptoprocta ferox*	YPM-VZ	YPM 6813	Madagascar (from Kny-Scheerer Co)	32.69	26.37	1.24
197	*Fossa fossana*	AMNH-M	100454	Madagascar, Sianaka Forest (east of Toamasina, near Fito and Didy)	19.92	16.19	1.23
196	*Fossa fossana*	AMNH-M	188208	Madagascar, Province de Maroantsetra, Ambatondradama	19.54	14.61	1.34
117	*Salanoia concolor*	AMNH-M	100476	Madagascar, Sianaka Forest (east of Toamasina, near Fito and Didy)	15.15	12.72	1.19
118	*Salanoia concolor*	AMNH-M	100477	Madagascar, Sianaka Forest (east of Toamasina, near Fito and Didy)	14.59	12.76	1.14
Felidae							
1987	*Acinonyx jubatus*	UNIVA	2448	Zoo de Barcelona	74.67	54.26	1.38
1985	*Acinonyx jubatus*	UNIVA	2488	Zoo de Madrid	77.59	59.94	1.29
1984	*Acinonyx jubatus*	UNIVA	2656	Zoo de Barcelona	85.02	62.88	1.35
1981	*Acinonyx jubatus*	UNIVA	5257	Zoo de Madrid	80.79	60.05	1.35
1982	*Acinonyx jubatus*	UNIVA	5265	Selwo Aventura, Estepona, Spain	75.75	54.48	1.39
59	*Acinonyx jubatus*	WRAZL	9610404		79.78	58.77	1.36
60	*Caracal caracal*	FMNH	57220	Zoo: Brookfield Zoo, Chicago	39.87	27.85	1.43
2011	*Caracal caracal*	UNIVA	1518	Zoo de Matapozuelos (Valladolid)	42.14	29.86	1.41
64	*Felis catus*	WRAZL	W56	Unknown	28.27	20.24	1.40
62	*Felis chaus*	WRAZL	9810278		35.66	24.84	1.44
66	*Felis margarita*	FMNH	127295	Zoo:	24.84	20.50	1.21
67	*Felis nigripes*	AMNH-M	214381	South Africa, Cape, Grahamstown	20.25	14.84	1.36
2008	*Felis silvestris*	UNIVA	2879	Cen. Rec. Aves, Pollos, Valladolid, Spain	31.86	23.99	1.33
2007	*Felis silvestris*	UNIVA	5206	Burgos, Spain	29.45	20.88	1.41
2009	*Felis silvestris*	UNIVA	5210	Burgos, Spain	34.40	25.09	1.37
2005	*Felis silvestris*	UNIVA	5229	Boâˆ□Â±ar, Leâˆ□â‰¥n, Spain	30.61	22.47	1.36
2006	*Felis silvestris*	UNIVA	5230	Boâˆ□Â±ar, Leâˆ□â‰¥n, Spain	30.78	22.13	1.39
85	*Leopardus geoffroyi*	AMNH-M	205903	Uruguay, Deprt Carro Largo, 6 km, SE Melo	33.56	25.09	1.34
1989	*Leopardus geoffroyi*	UNIVA	1166	Zoo de Fuengirola (Malaga) spain	28.43	21.22	1.34
1988	*Leopardus geoffroyi*	UNIVA	1172	Zoo de Fuengirola (Malaga) spain	25.51	18.86	1.35
69	*Leopardus pardalis*	AMNH-M	133967	Brazil, Goyas, Annapolis	40.05	28.68	1.40
563	*Leopardus pardalis*	DMNH	2343	Brazil, Descalvos, Matto Grosso	37.63	27.28	1.38
333	*Leopardus tigrinus*	AMNH-M	119599	No data	27.22	20.63	1.32
332	*Leopardus tigrinus*	AMNH-M	143896	No data	22.68	16.70	1.36
331	*Leopardus wiedii*	AMNH-M	212546	No data	28.83	23.20	1.24
403	*Leopardus wiedii*	UMMZ	126123	Paraguay, Itapua, 3.5 Km E. San Rafael	26.22	18.39	1.43
70	*Leptailurus serval*	FMNH	95997	Zimbabwe, East Mashonaland, Salisbury Dist., Komani Farm	48.45	33.65	1.44
2003	*Leptailurus serval*	UNIVA	271	Zoo de Matapozuelos (Valladolid)	43.38	31.41	1.38
2004	*Leptailurus serval*	UNIVA	1547	Zoo de Matapozuelos (Valladolid)	45.96	32.67	1.41
71	*Lynx canadensis*	AMNH-M	15662	Canada, Newfoundland, Humber River	50.35	35.76	1.41
366	*Lynx canadensis*	NRM	58-2286	USA, Michigan, Lake Superior	48.11	36.30	1.33
367	*Lynx canadensis*	NRM	58-2287	USA, Michigan, Lake Superior	44.87	33.42	1.34
368	*Lynx lynx*	NRM	58-2815	Sweden, Junsele	57.20	40.59	1.41
369	*Lynx lynx*	NRM	58-2825	Sweden, Vännäs,Jämtlandsby	55.22	39.96	1.38

Appendix 8. — Continuation.

ID	Species	Inst	Specimen No	Locality	Calc Len	Sust Pos	Gear Ratio
Felidae (continuation)							
371	*Lynx lynx*	NRM	58-3721	Sweden, Pajala, Saltajärvi	56.06	43.12	1.30
2013	*Lynx lynx*	UNIVA	3555	Valwo Parque de la Naturaleza (Valladolid)	59.81	42.75	1.40
2014	*Lynx lynx*	UNIVA	3782	Valwo Parque de la Naturaleza (Valladolid)	56.17	39.41	1.43
2012	*Lynx lynx*	UNIVA	4632	Valwo Parque de la Naturaleza (Valladolid)	59.75	43.15	1.38
2015	*Lynx lynx*	UNIVA	4883	Valwo Parque de la Naturaleza (Valladolid)	62.42	45.51	1.37
72	*Lynx pardinus*	AMNH-M	169492	Spain, Toledo, Robledo	45.00	33.26	1.35
2016	*Lynx pardinus*	UNIVA	4170	Huelva (EBD), Spain	45.34	34.13	1.33
557	*Lynx rufus*	DMNH	5200	Texas, Kleberg Co., Kingsville	43.28	31.62	1.37
555	*Lynx rufus*	DMNH	7729	Colorado, Larimer Co., Virginia Dale	41.11	31.02	1.33
556	*Lynx rufus*	DMNH	8279	Colorado, Park Co., 16 KM NW of Tarryall Reservoir, elevation 9000'	41.35	31.07	1.33
682	*Lynx rufus*	KU-M	1899	New Mexico, McKinley Co., Mt. Tohotehi S., S. slope	41.00	30.89	1.33
677	*Lynx rufus*	KU-M	2641	Kansas, Scott Co., Scott City	47.27	35.13	1.35
679	*Lynx rufus*	KU-M	5321	Kansas, Logan Co., Elkader, 5 mi W	39.72	29.76	1.33
674	*Lynx rufus*	KU-M	6676	New Mexico, McKinley Co., Mt. Tohotehi S., S. slope	40.82	30.52	1.34
673	*Lynx rufus*	KU-M	6680	New Mexico, McKinley Co., Mt. Tohotehi S., S. slope	41.02	31.24	1.31
680	*Lynx rufus*	KU-M	7037	Idaho, Bannock Co.	43.91	34.05	1.29
681	*Lynx rufus*	KU-M	7585	Oregon, Lane Co.	39.39	28.74	1.37
678	*Lynx rufus*	KU-M	9643	Arizona, Maricopa Co., 7 mi NE Phoenix	38.82	28.94	1.34
676	*Lynx rufus*	KU-M	9792	Arizona, Maricopa Co., 7 mi NE Phoenix	43.60	32.17	1.36
672	*Lynx rufus*	KU-M	48085	Arizona, Yuma Co., Gila Mts., Tinajas Atlas	41.05	30.75	1.33
675	*Lynx rufus*	KU-M	48086	Arizona, Yuma Co., Gila Mts., Tinajas Atlas	35.88	26.19	1.37
2074	*Lynx rufus*	NCSM	6263	New York, Yancey Co., 6 mi. S. of Burnsville	41.93	30.55	1.37
2075	*Lynx rufus*	NCSM	13383	New York, Ulster Co., New Paltz	36.39	26.48	1.37
2076	*Lynx rufus*	NCSM	15020	North Carolina, Johnston Co, Smithfield, Dickinson Rd. (=SR 1505) between Cleveland Rd. and Crantock Rd.	40.40	29.13	1.39
713	*Lynx rufus*	USNHM	173028	Lake Okeechobee, Florida	46.22	32.97	1.40
725	*Lynx rufus*	USNHM	175012	South Dakota	42.83	30.82	1.39
706	*Lynx rufus*	USNHM	188754	Nicasio, California	41.40	30.48	1.36
717	*Lynx rufus*	USNHM	239931	Lexington, Kentucky	37.96	27.89	1.36
715	*Lynx rufus*	USNHM	249279	Maupin, 7 miles from, Oregon	46.43	35.44	1.31
716	*Lynx rufus*	USNHM	249280	Maupin, Oregon	48.10	34.60	1.39
718	*Lynx rufus*	USNHM	270262	Oxon Hill, 4 Miles S, Prince Georges County, Maryland	40.09	28.88	1.39
727	*Lynx rufus*	USNHM	271310	King Ranch (near Corpus Christi) Texas	44.64	32.05	1.39
722	*Lynx rufus*	USNHM	276360	2 Miles N Pierre, South Dakota	46.64	33.74	1.38
707	*Lynx rufus*	USNHM	282369	Santa Catalina Mts (Coronado Forest, Arizona)	46.45	35.08	1.32
719	*Lynx rufus*	USNHM	292037	Burleigh County, North Dakota	44.92	32.02	1.40
720	*Lynx rufus*	USNHM	292038	Burleigh County, North Dakota	43.40	31.08	1.40
723	*Lynx rufus*	USNHM	306264	Hardy County, West Virginia	38.04	27.45	1.39
711	*Lynx rufus*	USNHM	398557	Ardath Road, 1/4 mile W US 5 between Claiemont and La Jolla, San Diego County, California	41.34	29.69	1.39
728	*Lynx rufus*	USNHM	019078/ A34812	Kinney County, Texas	41.42	29.60	1.40
721	*Lynx rufus*	USNHM	A00637	Carlisle Caves, Pennsylvania	38.71	27.22	1.42
726	*Lynx rufus*	USNHM	A01376	Matamoras, Tamaulipas, Mexico	43.07	30.93	1.39
714	*Lynx rufus*	USNHM	A01874 (1853?)	Ft. Union, Texas (Crossed out and written Montana)	40.99	29.92	1.37
710	*Lynx rufus*	USNHM	A02032	Shoalwater Bay, Washington	39.40	28.38	1.39
709	*Lynx rufus*	USNHM	A21229	Shasta County, California	39.83	29.30	1.36
73	*Lynx rufus*	WRAZL	110377	Indiana, Dubois Co.	41.78	29.37	1.42
74	*Lynx rufus*	WRAZL	110377	Indiana, Dubois Co.	42.14	29.64	1.42
75	*Lynx rufus*	WRAZL	110377	Indiana, Dubois Co.	42.22	29.66	1.42
76	*Lynx rufus*	WRAZL	110377	Indiana, Dubois Co.	42.39	29.63	1.43
77	*Lynx rufus*	WRAZL	110377	Indiana, Dubois Co.	42.10	29.62	1.42
78	*Lynx rufus*	WRAZL	110377	Indiana, Dubois Co.	42.08	29.58	1.42
79	*Lynx rufus*	WRAZL	210001	Missouri, St. Louis	41.93	30.05	1.40
83	*Lynx rufus*	WRAZL	8910071		41.43	30.97	1.34
81	*Lynx rufus*	WRAZL	H07	Arizona, Cocomina Co.	37.55	26.18	1.43
82	*Lynx rufus*	WRAZL	H09	Minnesota, Itasca	43.77	31.74	1.38
84	*Neofelis nebulosa*	AMNH-M	238650		44.55	34.33	1.30
554	*Neofelis nebulosa*	DMNH	8309	Denver Zoo	43.37	32.65	1.33
65	*Otocolobus manul*	FMNH	60691	Zoo: Brookfield Zoo, Chicago	26.35	20.87	1.26
86	*Panthera leo*	WRAZL	9510380		100.00	83.78	1.19
90	*Panthera onca*	AMNH-M	135928	Mexico, Moreno Station, Box Canyon	60.61	46.41	1.31
2022	*Panthera onca*	UNIVA	123	Zoo de Barcelona	68.07	52.95	1.29
2025	*Panthera onca*	UNIVA	125	Zoo de Barcelona	71.87	55.76	1.29
2024	*Panthera onca*	UNIVA	2415	Zoo do Matapozuelos (Valladolid)	66.40	50.29	1.32
2027	*Panthera onca*	UNIVA	3119	Valwo Parque de la Naturaleza (Valladolid)	74.45	57.97	1.28

Appendix 8. — Continuation.

ID	Species	Inst	Specimen No	Locality	Calc Len	Sust Pos	Gear Ratio
Felidae (continuation)							
2021	*Panthera onca*	UNIVA	4857	Zoo de Madrid	74.25	59.88	1.24
2026	*Panthera onca*	UNIVA	4857	Zoo de Madrid	73.95	59.66	1.24
91	*Panthera pardus*	AMNH-M	90205		62.99	52.14	1.21
92	*Panthera tigris*	WRAZL	8610108		100.00	82.34	1.21
93	*Pardofelis marmorata*	AMNH-M	35399	N.Y. Zoological Society	25.88	19.29	1.34
61	*Pardofelis temminckii*	FMNH	605584	Zoo: Brookfield Zoo, Chicago	42.61	30.49	1.40
94	*Prionailurus bengalensis*	AMNH-M	22904	N.Y. Zoological Society	29.33	21.61	1.36
95	*Profelis aurata*	AMNH-M	185465	N.Y. Zoological Society	45.55	33.40	1.36
550	*Puma concolor*	DMNH	7732	Colorado, Douglas Co., Sedalia	70.28	51.99	1.35
551	*Puma concolor*	DMNH	8051	Colorado, Sagauche Co., Grove	71.59	52.82	1.36
553	*Puma concolor*	DMNH	11070	Colorado, Montezuma Co., Mesa Verde National Park, Prator Canyon 1 mi S. of Montezuma Overlock	68.86	51.37	1.34
669	*Puma concolor*	KU-M	2193	Kansas, Ellis Co., 1 mile north of Catherine, Ravine near Victoria Creek (see Dyche, Kansas Academy of Sciences, p. 160)	68.80	50.73	1.36
670	*Puma concolor*	KU-M	2194	New Mexico, Grant Co., Santa Rita	76.46	57.22	1.34
668	*Puma concolor*	KU-M	73933	Mexico, Chihuahua, 2 mi S, 5 mi W Rancho San Francisco, 5500 ft	72.27	54.04	1.34
671	*Puma concolor*	KU-M	159141	Utah, Carbon Co, Helper (W of), Wild Cattle Canyon	69.21	51.51	1.34
434	*Puma concolor*	UTVPL	M-2713	Texas, Brewster Co.,Black Gap	66.10	48.36	1.37
430	*Puma concolor*	UTVPL	M-2743	Texas, Presidio Co., Francis Rooney Ranch	66.80	49.06	1.36
432	*Puma concolor*	UTVPL	M-2747	Texas, Presidio Co., Rooney Ranch	75.31	53.93	1.40
429	*Puma concolor*	UTVPL	M-3177	Texas, Presidio Co., Chambers Ranch	67.70	49.05	1.38
435	*Puma concolor*	UTVPL	M-4057	Texas, West, Conneley Ranch	76.97	55.59	1.38
63	*Puma concolor*	WRAZL	B45	Arizona, Paul Spur	70.10	49.59	1.41
68	*Puma yagouaroundi*	AMNH-M	42958	N.Y. Zoological Society	30.75	23.09	1.33
96	*Uncia uncia*	WRAZL	9910160	Unknown	60.57	47.12	1.29
Herpestidae							
100	*Atilax paludinosus*	AMNH-M	83337	Kenya, Central Province, Aberdare Mts., Kikuyu, above Kijabe (Kajabi) station	26.39	19.76	1.34
101	*Atilax paludinosus*	AMNH-M	83339	Kenya, Central Province, Aberdare Mts., Kikuyu, above Kijabe (Kajabi) station	25.72	20.26	1.27
102	*Bdeogale nigripes*	AMNH-M	51581	Zaire, Haut Zaire, Akenge	27.94	21.12	1.32
103	*Crossarchus alexandri*	AMNH-M	53979	Zaire, Haut Zaire, Faradje	18.89	15.59	1.21
105	*Cynictis penicillata*	AMNH-M	54095	South Africa, Tranvaal Province, Pretoria	18.43	13.10	1.41
104	*Cynictis penicillata*	AMNH-M	90282	N.Y. Zoological Society	16.40	12.82	1.28
106	*Dologale dybowskii*	AMNH-M	51608	Zaire, Haut Zaire, Nangaraa	13.84	10.62	1.30
114	*Galerella sanguinea*	AMNH-M	51019	Zaire, Haut Zaire, Faradje	12.05	9.02	1.34
113	*Galerella sanguinea*	AMNH-M	169434	South Africa/Botswana	13.39	10.85	1.23
110	*Herpestes edwardsi*	AMNH-M	22907	N.Y. Zoological Society	17.34	12.94	1.34
109	*Herpestes edwardsi*	AMNH-M	35441	N.Y. Zoological Society	17.56	13.68	1.28
111	*Herpestes ichneumon*	AMNH-M	82779	Kenya	23.25	18.07	1.29
107	*Herpestes javanicus*	AMNH-M	232720	Virgin Islands, St Croix, Christiansted (collected by DW Nellis, with 100s of individuals)	12.12	9.61	1.26
108	*Herpestes javanicus*	AMNH-M	232721	Virgin Islands, St Croix, Christiansted (collected by DW Nellis, with 100s of individuals)	13.87	11.13	1.25
112	*Herpestes naso*	AMNH-M	51610	Zaire, Haut Zaire, Medje, Forest 15 mi. S. Gamangui	25.16	18.17	1.38
116	*Ichneumia albicauda*	AMNH-M	51594	Zaire, Haut Zaire, Faradje	29.38	19.45	1.51
115	*Ichneumia albicauda*	AMNH-M	187767	Kenya, Central Province, Nyeri Dist., South Laikipia Forest, 10 mi NE Bellevue, 7200 ft	31.15	22.20	1.40
Hyaenidae							
121	*Crocuta crocuta*	FMNH	18855	Somaliland, East Africa	60.03	44.52	1.35
122	*Hyaena brunnea*	FMNH	34584	Botswana, Ghanzi	50.08	39.33	1.27
123	*Hyaena hyaena*	FMNH	7665	Zoo: Lincoln Park Zoo, Chicago	44.30	36.67	1.21
124	*Proteles cristata*	FMNH	186435	Zoo:	30.89	24.69	1.25
Mephitidae							
126	*Conepatus chinga*	AMNH-M	133946	Brazil, Mato Grosso, Maracaju	19.29	15.31	1.26
127	*Conepatus leuconotus*	AMNH-M	136415	Texas, Brewster Co., Chisos Mts, Juniper, Canon, 6500 ft	19.79	16.26	1.22
404	*Conepatus leuconotus*	UMMZ	61391	Mexico, Tamaulipas, Mulato	23.50	20.53	1.14
365	*Conepatus semistriatus*	NRM	58-4869	Unknown	16.92	15.10	1.12
364	*Conepatus semistriatus*	NRM	58-4991	Unknown, obtained from K. Scheerer, New York	22.66	18.96	1.20
146	*Mephitis macroura*	AMNH-M	188731	Chihuahua, Rancho La Campana, 1470 ft	19.53	15.21	1.28
683	*Mephitis macroura*	KU-M	106889	Nicaragua, Riva, 70 m, 9 km. NE San Juan del Sur	14.19	11.19	1.27
558	*Mephitis mephitis*	DMNH	6823	Colorado, Weld Co., 7 mi E. of Prospect Homestead Grange	20.80	16.67	1.25

Appendix 8. — Continuation.

ID	Species	Inst	Specimen No	Locality	Calc Len	Sust Pos	Gear Ratio
Mephitidae (continuation)							
559	*Mephitis mephitis*	DMNH	7830	Colorado, Jefferson Co., Evergreen	21.57	18.39	1.17
560	*Mephitis mephitis*	DMNH	8154	Colorado, Denver Co., Denver	21.96	17.90	1.23
149	*Mephitis mephitis*	INSM	71.09.0100	Indiana, Harrison Co., Fair-to-Middl'in Well Pit, 1.5 Mi NW of Mauckport (Holocene)	18.16	14.77	1.23
148	*Mephitis mephitis*	WRAZL	A20	Indiana, Monroe Co.	19.30	16.06	1.20
324	*Spilogale gracilis*	AMNH-M	121840	New Mexico, Colfax Co, 8 mi W Cimarron, mouth of Cimarroncito Canyon 7800' Elevation	12.25	9.59	1.28
327	*Spilogale gracilis*	AMNH-M	135961	Arizona, Molino Canyon, 18 mi ENE of Tucson	11.20	9.96	1.12
328	*Spilogale gracilis*	AMNH-M	135962	Arizona, Molino Canyon, 18 mi ENE of Tucson	10.60	9.48	1.12
326	*Spilogale gracilis*	AMNH-M	137373	Colorado, Costilla Co., 5 mi SSE of Ft. Garland	12.41	9.71	1.28
325	*Spilogale gracilis*	AMNH-M	183843	Colorado, Colorado Springs	11.81	8.89	1.33
159	*Spilogale putorius*	AMNH-M	245674	Nebraska, Brown Co.	12.54	10.17	1.23
160	*Spilogale putorius*	AMNH-M	245675	Nebraska, Brown Co.	12.91	10.52	1.23
158	*Spilogale putorius*	INSM	71.20.0412	Indiana, Miami Co.	10.92	9.03	1.21
119	*Suricata suricatta*	AMNH-M	35637	N.Y. Zoological Society	14.86	11.31	1.31
120	*Suricata suricatta*	AMNH-M	35646	N.Y. Zoological Society	14.53	10.68	1.36
212	*Suricata suricatta*	WRAZL	9510083		13.96	10.01	1.39
Mustelidae							
125	*Arctonyx collaris*	AMNH-M	57118	China, Sichuan, Wanhsien	26.89	23.65	1.14
129	*Eira barbara*	AMNH-M	389	Brazil, Matto Grosso, Chapada	30.62	25.29	1.21
130	*Eira barbara*	AMNH-M	134947	Colombia, Hulamâ̂Â°	23.29	19.08	1.22
128	*Enhydra lutris*	WRAZL	9310894	Alaska, Oil spill	39.20	32.30	1.21
131	*Galictis cuja*	AMNH-M	133944	Brazil, Goyas, Annapolis	15.54	14.06	1.11
132	*Galictis vittata*	AMNH-M	35257	N.Y. Zoological Society	16.40	14.16	1.16
133	*Galictis vittata*	AMNH-M	100250	N.Y. Zoological Society	18.55	15.81	1.17
405	*Gulo gulo*	UMMZ	17854	Detroit Zoo, Royal Oak	38.39	30.84	1.24
407	*Gulo gulo*	UMMZ	111093	Montana, Missoula, Cramer Creek, 8 mi E of Clinton	42.44	36.02	1.18
406	*Gulo gulo*	UMMZ	176277	Detroit Zoo, Royal Oak	44.84	35.51	1.26
134	*Gulo gulo*	WRAZL	9310464	Alaska	40.46	34.57	1.17
136	*Ictonyx libyca*	AMNH-M	70083	N.Y. Zoological Society	8.50	7.23	1.18
135	*Ictonyx libyca*	AMNH-M	70093	N.Y. Zoological Society	8.41	7.55	1.11
137	*Ictonyx striatus*	AMNH-M	80664	Angola, Chipengo	20.82	17.31	1.20
565	*Lontra canadensis*	DMNH	7392	Alaska, Minto Flats	27.75	23.02	1.21
138	*Lontra canadensis*	WRAZL	9010009	Indiana, Mesker Park Zoo	27.07	20.76	1.30
329	*Lontra longicaudis*	AMNH-M	133950	Brazil, Goyaz, Anapolis	23.55	19.96	1.18
330	*Lontra longicaudis*	AMNH-M	207729	New York Zoological Society	22.39	17.74	1.26
568	*Martes americana*	DMNH	7824	Alaska, North Star Borough, Fairbanks	18.89	14.71	1.28
567	*Martes americana*	DMNH	7838	Alaska, Fairbanks	18.14	15.05	1.21
139	*Martes americana*	WRAZL	891212	Wyoming, Yellowstone National Park	18.10	14.45	1.25
140	*Martes foina*	FMNH	121676	Zoo: Brookfield Zoo, Chicago	22.90	18.83	1.22
141	*Martes martes*	AMNH-M	183359	Kazakhstan, Kyzl-Kum Desert, Aralsk Dist., Verchneje	17.01	14.31	1.19
698	*Martes pennanti*	MUZA	45	New Hampshire	24.99	20.00	1.25
142	*Martes pennanti*	WRAZL	9510032	Alaska	19.01	15.55	1.22
143	*Meles meles*	FMNH	97837	Iran, Kordistan, Akinlou	28.66	24.00	1.19
144	*Mellivora capensis*	FMNH	43298	Iraq, Al Anbar, Iraq Pipeline Station T-1	27.31	21.13	1.29
145	*Melogale personata*	AMNH-M	31806	Java	14.10	11.37	1.24
151	*Mustela erminea*	AMNH-M	18	–	7.36	6.38	1.15
150	*Mustela erminea*	AMNH-M	245008	–	4.84	4.24	1.14
2051	*Mustela erminea*	OMNH-M	2318	Alaska, Tanena R. Bridge (reassigned to M. erminea based on location by PDP)	7.93	6.82	1.16
152	*Mustela eversmanii*	AMNH-M	57338	Mongolia, Tze Tzen Wang	15.29	12.69	1.20
285	*Mustela frenata*	AMNH-M	40028	New York, Long Island	9.32	7.31	1.27
283	*Mustela frenata*	AMNH-M	70362	New Jersey, Bear Fort Mts.	7.67	6.13	1.25
282	*Mustela frenata*	AMNH-M	100346	New Jersey	9.11	7.20	1.27
300	*Mustela frenata*	AMNH-M	121541	Canada, Briitish Columbia, West of Hudson's Hope	9.96	8.78	1.13
299	*Mustela frenata*	AMNH-M	121542	Canada, Briitish Columbia, West of Hudson's Hope	7.92	6.61	1.20
298	*Mustela frenata*	AMNH-M	121543	Canada, British Columbia, West of Hudson's Hope	8.20	6.49	1.26
288	*Mustela frenata*	AMNH-M	122393	New York, Suffolk Co., Mastic	5.80	5.03	1.15
292	*Mustela frenata*	AMNH-M	129338	New York, Westchester Co., Yorktown Heights	5.76	4.69	1.23
291	*Mustela frenata*	AMNH-M	129339	New York, Westchester Co., Yorktown Heights	7.43	5.99	1.24
290	*Mustela frenata*	AMNH-M	129340	New York, Westchester Co., Yorktown Heights	7.97	6.62	1.20
293	*Mustela frenata*	AMNH-M	129397	New York, Westchester Co., Yorktown Heights	5.53	4.83	1.14
281	*Mustela frenata*	AMNH-M	130137	New Hampshire, Lake Sunapee	8.36	6.95	1.20
296	*Mustela frenata*	AMNH-M	130142	New York, Westchester Co., 2 mi. N. of Poundridge	6.00	5.03	1.19
280	*Mustela frenata*	AMNH-M	131843	New Mexico, Colfax Co., Mouth of Cimarroncito Canyon	6.85	6.44	1.06
287	*Mustela frenata*	AMNH-M	135415	New York, Nassau Co, Long Island, Roslyn	8.17	6.68	1.22
295	*Mustela frenata*	AMNH-M	139910	New York, Westchester Co., Yorktown Heights	8.13	6.42	1.27

Appendix 8. — Continuation.

ID	Species	Inst	Specimen No	Locality	Calc Len	Sust Pos	Gear Ratio
Mustelidae (continuation)							
294	*Mustela frenata*	AMNH-M	146847	New York, Westchester Co., Katanah, Heels Road	7.70	6.88	1.12
284	*Mustela frenata*	AMNH-M	150009	New York, Long Island, Lawrence	7.14	6.04	1.18
279	*Mustela frenata*	AMNH-M	164460	Nebraska, Sioux Co., Bald Butte	8.32	7.40	1.12
278	*Mustela frenata*	AMNH-M	164461	Nebraska, Sioux Co, Bald Butte	6.43	5.71	1.13
277	*Mustela frenata*	AMNH-M	164856	Nebraska, Brown Co., Long Lake	8.45	7.19	1.18
297	*Mustela frenata*	AMNH-M	206669	New York, Westchester Co., Township of Lewisboro, at Cross River	9.91	7.07	1.40
289	*Mustela frenata*	AMNH-M	238253	New York, Suffolk Co., E. Hampton, Scoy Pond	7.91	6.77	1.17
301	*Mustela frenata*	AMNH-M	255653	FLorida, Highlands Co., Lake Placid, SE Tract, Pimitive Road, Foot Trail 13	9.52	7.69	1.24
695	*Mustela frenata*	MUZA	55	New Hampshire	9.26	7.50	1.23
696	*Mustela frenata*	MUZA	65	New Hampshire	7.06	6.07	1.16
2079	*Mustela frenata*	NCSM	4983	North Carolina, Yancey Co., Mt. Mitchell	7.39	6.66	1.11
2082	*Mustela frenata*	NCSM	6331	Maryland, Garrett Co., Oakland, 1.25 mi E of Oakland Sang Run Road/Mayhew Inn Road JCT	8.79	7.11	1.24
2081	*Mustela frenata*	NCSM	8424	Pennsylvania	8.54	7.06	1.21
2084	*Mustela frenata*	NCSM	15014	North Carolina, Wilkes Co., Hays, 3 mi NNE, on SR 1002, 0.1 rdmi N of JCT with SR 1951.	8.46	7.23	1.17
2085	*Mustela frenata*	NCSM	15015	North Carolina, Wilkes Co., Traphill, nr. center of; on SR 1002, <0.1rdmi. NW JCT SR 1749	8.65	7.40	1.17
2080	*Mustela frenata*	NCSM	16924	New York, Sullivan Co.,Callicoon, Pleasant Valley	9.04	7.27	1.24
2049	*Mustela frenata*	OMNH-M	16777	New York, Wayne County, 2 mi. S, 0.5 mi, W Macedon	6.10	5.44	1.12
2052	*Mustela frenata*	OMNH-M	19064	Michigan, Kalamazoo, Ross Twp	5.98	5.50	1.09
2050	*Mustela frenata*	OMNH-M	26626	Oklahoma	7.72	6.63	1.16
2048	*Mustela frenata*	OMNH-M	26627	Oklahoma	7.24	6.35	1.14
742	*Mustela frenata*	USNHM	167891	Lozier, Terrell County, Texas	9.39	7.55	1.24
749	*Mustela frenata*	USNHM	188425	Locust Grove, Lewis County, New York	9.18	7.08	1.30
750	*Mustela frenata*	USNHM	218330	Falls Church, Fairfax County, Virginia	8.07	6.39	1.26
756	*Mustela frenata*	USNHM	234047	Fargo, North Dakota	8.55	6.74	1.27
745	*Mustela frenata*	USNHM	236646	Alexandria, Fairfax County, Virginia	8.81	7.09	1.24
751	*Mustela frenata*	USNHM	297766	Laurel, Prince Georges County, Maryland	7.69	6.20	1.24
744	*Mustela frenata*	USNHM	398682	Gaybird Farms, Carversville, Bucks County, Pennsylvania	5.87	4.72	1.24
741	*Mustela frenata*	USNHM	415202	Caripe, 3km N and 4km W, near San Agustin, Monagas, Venezuela	10.93	8.96	1.22
760	*Mustela frenata*	USNHM	503396	Grady County, Georgia	9.28	7.52	1.23
743	*Mustela frenata*	USNHM	514189	La Jolla, Ardath Road, about .5 miles W of US 5, Orange County, California	8.50	7.13	1.19
752	*Mustela frenata*	USNHM	529890	5 Mi W Chincoteague, Accomack County, Virginia	8.08	6.27	1.29
759	*Mustela frenata*	USNHM	545050	Cotopaxi National Park, 12500 ft Cotopaxi, Ecuador	9.35	7.98	1.17
758	*Mustela frenata*	USNHM	560817	Camp VII, Cerro Neblina, Territorio Fed. Amazonas, Venezuela	10.60	8.92	1.19
754	*Mustela frenata*	USNHM	564265	Buffalo, Johnson County, Wyoming	8.56	7.15	1.20
753	*Mustela frenata*	USNHM	564266	Buffalo, Johnson County, Wyoming	7.43	6.04	1.23
748	*Mustela frenata*	USNHM	564268	Atlanta (VIC), Montmorency County, Michigan	6.17	5.39	1.14
755	*Mustela frenata*	USNHM	564269	Grady County, Georgia	8.09	6.88	1.18
746	*Mustela frenata*	USNHM	567917	Plot 4539, Patuxent Research Refuge, Prince Georges County, Maryland	8.64	6.76	1.28
747	*Mustela frenata*	USNHM	000017/ A00624	Carlisle, Pennsylvania	9.70	7.15	1.36
738	*Mustela frenata*	USNHM	000443/ A01392	Matamoras, Tamaulipas, Mexico	8.27	6.95	1.19
740	*Mustela frenata*	USNHM	A01393	Matamoras, Tamaulipas, Mexico	8.76	7.32	1.20
757	*Mustela frenata*	USNHM	A22041	Fresno, California	7.61	6.26	1.22
274	*Mustela frenata*	WRAZL	B83	New York	8.07	6.55	1.23
275	*Mustela frenata*	WRAZL	DD52	Indiana, Posey Co	7.52	6.41	1.17
302	*Mustela nigripes*	AMNH-M	140397	Colorado, Ft. Garland, Buck Mt.	12.78	11.27	1.13
153	*Mustela nigripes*	WRAZL	10299		13.16	11.26	1.17
303	*Mustela nivalis*	AMNH-M	130141	Ohio, Bowling Green, Erie Co.	3.87	2.99	1.29
276	*Mustela nivalis*	WRAZL	8910202		3.41	2.97	1.15
305	*Neovison vison*	AMNH-M	20	Indiana	13.93	12.60	1.11
320	*Neovison vison*	AMNH-M	22749	Maine	13.38	11.38	1.18
306	*Neovison vison*	AMNH-M	35189	Connecticut, Bridgeport	14.23	12.37	1.15
307	*Neovison vison*	AMNH-M	63981	Connecticut	11.38	9.56	1.19
315	*Neovison vison*	AMNH-M	99728	New York, Rockland Co., Bear Mountain Interstate Park	13.87	12.08	1.15
308	*Neovison vison*	AMNH-M	119419	New Jersey, Kinnedon	11.02	9.76	1.13
321	*Neovison vison*	AMNH-M	128508	Maine, Somerset Co., Crocker Pond	11.01	9.13	1.21

Appendix 8. — Continuation.

ID	Species	Inst	Specimen No	Locality	Calc Len	Sust Pos	Gear Ratio
Mustelidae (continuation)							
322	*Neovison vison*	AMNH-M	128509	Maine, Somerset Co.	10.22	8.47	1.21
318	*Neovison vison*	AMNH-M	128510	Maine, Somerset Co.	12.20	10.38	1.18
319	*Neovison vison*	AMNH-M	128511	Maine, Somerset Co.	13.70	12.14	1.13
323	*Neovison vison*	AMNH-M	128512	Maine, Somerset Co.	11.15	9.53	1.17
309	*Neovison vison*	AMNH-M	141147	New Jersey, Boonton	12.73	11.11	1.15
310	*Neovison vison*	AMNH-M	176566	New Jersey, RD #3, Sussex Co.	12.13	10.02	1.21
311	*Neovison vison*	AMNH-M	180386	New Jersey, Sussex Co., Beemersville, R.D. 3	11.53	9.84	1.17
314	*Neovison vison*	AMNH-M	180387	New Jersey, Sussex Co., Beemesville, RD 3	11.71	10.75	1.09
313	*Neovison vison*	AMNH-M	180388	New Jersey, Sussex Co., Beemesville, RD 3	11.02	8.19	1.35
312	*Neovison vison*	AMNH-M	180389	New Jersey, Sussex Co., Beemesville, RD 3	13.81	11.07	1.25
316	*Neovison vison*	AMNH-M	207118	New Hampshire, Grafton Co., Wentworth	11.56	10.25	1.13
317	*Neovison vison*	AMNH-M	275984	Pennsylvania, Wayne Co., Lake Starlight	11.54	10.36	1.11
702	*Neovison vison*	MUZA	52	Missouri, Callaway Co.	14.25	12.55	1.14
694	*Neovison vison*	MUZA	82	New Hampshire	11.98	10.53	1.14
154	*Neovison vison*	WRAZL	9110677		10.14	8.73	1.16
155	*Neovison vison*	WRAZL	HH20		15.33	13.21	1.16
156	*Poecilogale albinucha*	FMNH	177235	Mozambique, Zambezia, Mt Namuli area	9.49	6.88	1.38
157	*Poecilogale albinucha*	FMNH	177236	Mozambique, Zambezia, Mt Namuli area	10.50	7.84	1.34
574	*Taxidea taxus*	DMNH	2018	Colorado, Weld Co., Horsetail Creek	28.06	23.46	1.20
162	*Taxidea taxus*	FMNH	122619	Michigan, Washtenaw Co.	31.83	23.89	1.33
163	*Taxidea taxus*	FMNH	122620	Michigan, Washtenaw Co.	28.03	23.23	1.21
701	*Taxidea taxus*	MUZA	157	Oregon, Garfield Co.	30.85	25.17	1.23
693	*Taxidea taxus*	MUZA	486	North Dakota, Oliver Co., Cross Ranch	30.30	24.90	1.22
161	*Taxidea taxus*	WRAZL	AB68	Indiana, Owen Co.	26.46	21.88	1.21
Nandiniidae							
207	*Nandinia binotata*	AMNH-M	51461	Zaire, Haut Zaire, Medje	22.10	18.50	1.19
208	*Nandinia binotata*	AMNH-M	51469	Zaire, Haut Zaire, Medje	22.46	19.50	1.15
Procyonidae							
166	*Bassaricyon gabbii*	FMNH	70723	Colombia, Antioquia, Urrao, Guapantal	17.10	14.16	1.21
167	*Bassaricyon gabbii*	FMNH	70727	Colombia, Huila, San Agustin, San Antonio	18.66	14.35	1.30
548	*Bassariscus astutus*	DMNH	2665	Texas, Palo Pinto Co., Mineral Wells	16.84	13.93	1.21
549	*Bassariscus astutus*	DMNH	10988	Colorado, Jefferson Co.	15.66	12.92	1.21
169	*Bassariscus astutus*	FMNH	29303	Texas, Travis Co., Central Texas Uplift, near Jonestown	16.03	12.41	1.29
168	*Bassariscus astutus*	FMNH	129306	Texas, Travis Co., Central Texas Uplift, near Jonestown	16.62	13.30	1.25
667	*Bassariscus astutus*	KU-M	4865	Texas, Valverde Co.	15.83	12.95	1.22
666	*Bassariscus astutus*	KU-M	146602	Oregon, Douglas Co., Roseburg, 7 mi S, 10 mi E of	15.53	13.38	1.16
481	*Bassariscus astutus*	UTVPL	M-3276	Texas, Kerr Co., Hwy pickup between Mountain Home and Rock Springs	17.38	14.37	1.21
480	*Bassariscus astutus*	UTVPL	M-3452	Texas, Travis Co., 5 mi west of Austin	15.91	13.31	1.20
479	*Bassariscus astutus*	UTVPL	M-3898	Texas, Hays Co., Dripping Springs	15.44	12.30	1.26
478	*Bassariscus astutus*	UTVPL	M-3908	Texas, Hays Co., Dripping Springs	16.21	13.36	1.21
477	*Bassariscus astutus*	UTVPL	M-3909	Texas, Hays Co., Dripping Springs	15.96	13.04	1.22
483	*Bassariscus astutus*	UTVPL	M-6709	Texas, Crockett Co.	16.77	13.06	1.28
482	*Bassariscus astutus*	UTVPL	M-7319	Texas, Travis Co.	15.84	13.22	1.20
401	*Bassariscus sumichrasti*	UMMZ	114646	Mexico, Veracruz, 3.5 mi N. San Andres Tuxtla	18.84	14.44	1.30
402	*Bassariscus sumichrasti*	UMMZ	114647	Mexico, Veracruz, 3.5 mi N. San Andres Tuxtla	20.24	15.02	1.35
225	*Nasua narica*	FMNH	57167	Central America, Zoo	30.93	24.34	1.27
224	*Nasua narica*	FMNH	129310	Arizona, Santa Cruz Co.	29.50	24.05	1.23
399	*Nasua narica*	UMMZ	61301	Mexico, Tamaulipas, San Jose	27.94	22.45	1.24
398	*Nasua narica*	UMMZ	63074	Belize, Mt. Pine Ridge	27.46	22.61	1.21
400	*Nasua narica*	UMMZ	63164	Guatemala, Peten, Uaxactun	28.70	23.59	1.22
170	*Nasua nasua*	FMNH	70728	Colombia, Huila, Urrao	24.56	19.44	1.26
171	*Nasua nasua*	FMNH	70731	Colombia, Huila, Urrao	25.11	19.63	1.28
569	*Potos flavus*	DMNH	6305	Thornton Animal Hospital (pet)	23.28	19.83	1.17
172	*Potos flavus*	FMNH	8611	Zoo: Lincoln Park Zoo, Chicago	24.20	21.42	1.13
173	*Potos flavus*	FMNH	127430	Zoo: Lincoln Park Zoo, Chicago	22.84	19.63	1.16
174	*Potos flavus*	WRAZL	W29		22.96	18.32	1.25
334	*Procyon cancrivorus*	AMNH-M	215129	Bolivia, Dept. Beni, 20 Km S. San Joaquin, Estanncia Yutiole	37.62	31.85	1.18
335	*Procyon cancrivorus*	AMNH-M	261314	Bolivia, Santa Cruz, San afael de Amboro	35.80	28.57	1.25
394	*Procyon cancrivorus*	UMMZ	46409	British Guiana, Dunoon	39.02	31.86	1.22
393	*Procyon cancrivorus*	UMMZ	146503	Paraguay, Dept. Presidente Hayes, 8 km E. Juan de Zalazar	38.81	33.22	1.17
542	*Procyon lotor*	DMNH	7418	Colorado, Jefferson Co., Littleton, Ken Caryl Road	29.87	24.50	1.22
544	*Procyon lotor*	DMNH	8495	Colorado, Arapahoe Co., Aurora, 12700 E. Colfax	30.73	27.66	1.11
541	*Procyon lotor*	DMNH	9042	Colorado, Arapahoe Co., Quincy and Buckley	30.33	25.39	1.19
543	*Procyon lotor*	DMNH	9285	Colorado, Adams Co., Brighton East of Barr Lake	33.40	28.16	1.19

APPENDIX 8. — Continuation.

ID	Species	Inst	Specimen No	Locality	Calc Len	Sust Pos	Gear Ratio
Procyonidae (continuation)							
545	*Procyon lotor*	DMNH	9317	Colorado, Denver Co., Highline Canal, btw Alameda and Mississippi	30.83	26.77	1.15
546	*Procyon lotor*	DMNH	9820	Colorado, Boulder Co., Boulder	34.32	28.42	1.21
547	*Procyon lotor*	DMNH	11019	Colorado, Montezuma Co., Mesa Verde National Park	31.54	25.85	1.22
249	*Procyon lotor*	FMNH	49057	New York, Monroe Co., Black Creek	29.52	24.30	1.21
230	*Procyon lotor*	FMNH	49895	Louisiana, Iberia Parish, Avery Island	29.24	25.84	1.13
240	*Procyon lotor*	FMNH	58663	Illinois, Du Page Co., Downers Grover, Jct 63rd St. and Hobson Road	25.41	21.14	1.20
241	*Procyon lotor*	FMNH	58800	Illinois, Du Page Co., Downers Grove, Highland Ave., W. of George Williams College Campus	29.16	23.61	1.24
239	*Procyon lotor*	FMNH	58965	Illinois, Du Page Co., Downers Grove, Highland Ave., W. of George Williams College Campus	29.98	24.25	1.24
236	*Procyon lotor*	FMNH	91196	Illinois, Cook Co., Homewood	27.93	22.80	1.23
248	*Procyon lotor*	FMNH	104968	Wisconsin, Dodge Co., S. End	29.36	22.78	1.29
233	*Procyon lotor*	FMNH	106281	Illinois, Cook Co., US Hwy 41 (40 mi. S. Knosha, Wisconsin	29.76	25.81	1.15
231	*Procyon lotor*	FMNH	134393	Texas, Jeff Davis Co., Ft Davis, 7 mi S on SR 118	29.62	23.06	1.28
237	*Procyon lotor*	FMNH	134576	Illinois, Cook Co., Chicago	29.23	25.32	1.15
243	*Procyon lotor*	FMNH	135303	Illinois, Dupage Co., Downers Grove, Maple Grove Forest Preserve	29.16	23.68	1.23
247	*Procyon lotor*	FMNH	154709	Wisconsin, Brown Co., Green Bay	29.25	24.71	1.18
235	*Procyon lotor*	FMNH	156863	Illinois, Cook Co., Palatine, near corner of Delgado Dr and Knox	29.21	25.28	1.16
234	*Procyon lotor*	FMNH	156864	Illinois, Cook Co., Palatine, near corner of Delgado Dr and Knox	29.81	24.83	1.20
238	*Procyon lotor*	FMNH	156865	Illinois, Cook Co., Palatine, near corner of Delgado Dr and Knox	27.25	22.83	1.19
245	*Procyon lotor*	FMNH	167058	Illinois, Greene Co., Carrollton, 3 mi NE	27.88	23.23	1.20
244	*Procyon lotor*	FMNH	167060	Illinois, Lake Co., Lake Forest	25.10	21.22	1.18
246	*Procyon lotor*	FMNH	167061	Illinois, Will Co., Naperville, South	27.83	23.44	1.19
232	*Procyon lotor*	FMNH	167062	Illinois, Carrol Co., Mt Carol, 1 mi S.	33.33	25.65	1.30
229	*Procyon lotor*	FMNH	171148	Florida, Highlands Co., Archbold Biological Station, OSR 8	29.13	25.25	1.15
242	*Procyon lotor*	FMNH	175311	Illinois, Du Page Co., Oakbrook	27.01	22.45	1.20
653	*Procyon lotor*	KU-M	1581	Kansas, Douglas Co.	28.09	24.41	1.15
661	*Procyon lotor*	KU-M	4125	Kansas, Douglas Co., near Clinton	31.19	26.22	1.19
660	*Procyon lotor*	KU-M	4274	Kansas, Douglas Co.	29.82	24.62	1.21
657	*Procyon lotor*	KU-M	4276	Kansas, Douglas Co., near Clinton	30.88	24.91	1.24
655	*Procyon lotor*	KU-M	4277	Kansas, Douglas Co., near Clinton	29.78	24.98	1.19
654	*Procyon lotor*	KU-M	4283	Kansas, Atchison Co., 6 mi NE of Muscotah	30.26	23.67	1.28
646	*Procyon lotor*	KU-M	4286	Kansas, Atchison Co.	32.10	26.42	1.21
649	*Procyon lotor*	KU-M	4287	Kansas, Atchison Co., 21 mi NE Muscotah	28.94	23.85	1.21
650	*Procyon lotor*	KU-M	4288	Kansas, Atchison Co.	29.95	24.37	1.23
659	*Procyon lotor*	KU-M	4364	Kansas, Douglas Co., 7.5 mi SW of KU	28.97	23.63	1.23
656	*Procyon lotor*	KU-M	6632	Kansas, Douglas Co.	30.44	26.34	1.16
647	*Procyon lotor*	KU-M	6641	Kansas, eastern	27.34	23.07	1.19
648	*Procyon lotor*	KU-M	6652	Kansas, eastern	29.24	24.23	1.21
651	*Procyon lotor*	KU-M	6657	Kansas, eastern	28.60	23.02	1.24
652	*Procyon lotor*	KU-M	7574	Kansas, eastern	31.38	26.79	1.17
662	*Procyon lotor*	KU-M	14311	Kansas, Meade Co.	28.05	23.50	1.19
663	*Procyon lotor*	KU-M	14312	Kansas, Meade Co.	31.03	25.53	1.22
645	*Procyon lotor*	KU-M	14604	Georgia, Talbot Co., 2.5 mi E. of Geneva	24.98	20.36	1.23
664	*Procyon lotor*	KU-M	18572	North Dakota, Cass Co., near Fargo	32.04	25.54	1.25
665	*Procyon lotor*	KU-M	35031	Kansas, Meade Co., State Park	30.50	25.86	1.18
527	*Procyon lotor*	MSB	43026	New Mexico, Bernalillo Co., Cedar Crest	30.82	25.49	1.21
523	*Procyon lotor*	MSB	49874	New Mexico, Bernalillo Co.	27.81	23.04	1.21
524	*Procyon lotor*	MSB	49876	New Mexico, Bernalillo Co., Cedar Crest	30.10	24.14	1.25
525	*Procyon lotor*	MSB	49877	New Mexico, Bernalillo Co., Cedar Crest	29.85	25.34	1.18
529	*Procyon lotor*	MSB	52950	New Mexico, Hidalgo Co., Animas Valley, 20 mi S Animas	28.47	23.57	1.21
526	*Procyon lotor*	MSB	54908	New Mexico, Bernalillo Co.	26.74	23.25	1.15
530	*Procyon lotor*	MSB	56919	New Mexico, Colfax Co., NM	30.87	26.01	1.19
534	*Procyon lotor*	MSB	82505	Nex Mexico, Socorro Co., Near Bernardo Overpass, Hwy. 60 at Rio Grande, DOR	30.28	25.37	1.19
522	*Procyon lotor*	MSB	85581	Mexico, Sonora, 6.5 KM North, 7.75 KM W of San Carlos	28.58	22.46	1.27
531	*Procyon lotor*	MSB	140702	New Mexico, Chaves Co., 10.2 mi N NW of intersection of US 245 and Macho Draw	32.26	27.24	1.18

Appendix 8. — Continuation.

ID	Species	Inst	Specimen No	Locality	Calc Len	Sust Pos	Gear Ratio
Procyonidae (continuation)							
528	*Procyon lotor*	MSB	142758	New Mexico, Bernalillo Co., Cedar Crest	31.64	25.93	1.22
532	*Procyon lotor*	MSB	142875	New Mexico, Los Alamos Co., near Los Alamos	32.79	27.93	1.17
533	*Procyon lotor*	MSB	156771	New Mexico, Santa Fe Co., 132A nine mile road, Santa Fe	30.19	25.31	1.19
2073	*Procyon lotor*	NCSM	2674	North Carolina, Johnston Co., Smithfield	24.97	20.57	1.21
2038	*Procyon lotor*	OMNH-M	14869	Oklahoma, Cleveland County, Norman	29.12	23.62	1.23
2037	*Procyon lotor*	OMNH-M	15029	Oklahoma, Cleveland, 6.5 mi E Norman, Hwy 9	31.87	25.89	1.23
2041	*Procyon lotor*	OMNH-M	15649	Oklahoma, Cleveland Cty. 0.5 mi SW Noble, T8N, R2W, Sec 27	28.19	23.54	1.20
2032	*Procyon lotor*	OMNH-M	15780	Oklahoma, Texas County, 0.5 mi N., 2.5 mi E. Four Corners	30.65	24.18	1.27
2028	*Procyon lotor*	OMNH-M	16582	OklahomaMurray County	29.08	23.44	1.24
2035	*Procyon lotor*	OMNH-M	16583	Oklahoma, Cleveland, S of Norman (intersection of Classen and Hwy 9)	30.22	25.39	1.19
2033	*Procyon lotor*	OMNH-M	16747	Oklahoma, Cleveland County, Norman, Hwy 9 & Chautauqua	26.18	21.54	1.22
2040	*Procyon lotor*	OMNH-M	16975	Oklahoma, Cleveland, Little Axe	30.55	24.65	1.24
2031	*Procyon lotor*	OMNH-M	31847	Oklahoma, Cleveland County, Oklahoma City (5700 block of SW 134)	28.99	24.38	1.19
2029	*Procyon lotor*	OMNH-M	32235	Tennessee, Fayette County, Ames Plantation, site 311, evening course	26.34	22.27	1.18
2036	*Procyon lotor*	OMNH-M	33637	Oklahoma, Cleveland Cty, Norman, DOR	30.14	25.17	1.20
2030	*Procyon lotor*	OMNH-M	36244	Tennessee, Shelby County, Meeman Biological Station	25.96	21.35	1.22
2039	*Procyon lotor*	OMNH-M	38295	Oklahoma, Cleveland County, 8 mi. E Norman	26.03	21.34	1.22
384	*Procyon lotor*	UMMZ	52733	Michigan, Berrien Co., Warren Woods	26.80	21.59	1.24
385	*Procyon lotor*	UMMZ	55180	Michigan, Charlevoix Co., Susan Lake	27.20	22.75	1.20
395	*Procyon lotor*	UMMZ	61518	Mexico,Tamaulipas, Marmolejo	30.80	24.55	1.25
380	*Procyon lotor*	UMMZ	64101	Belize, San Lorenzo, Near Cayo	25.01	21.50	1.16
383	*Procyon lotor*	UMMZ	65802	Minnesota, Ottertail Co.	30.50	25.69	1.19
392	*Procyon lotor*	UMMZ	88090	Michigan, Washtenaw Co., Ann Arbor	26.90	22.47	1.20
396	*Procyon lotor*	UMMZ	88401	Texas, Cameron Co.	28.83	25.18	1.14
379	*Procyon lotor*	UMMZ	90832	Michigan, Washtenaw Co., 3 Mi. E. Ann Arbor	25.20	21.31	1.18
377	*Procyon lotor*	UMMZ	98975	Michigan, Washtenaw Co., 6mi. E. Ann Arbor	28.35	23.52	1.21
391	*Procyon lotor*	UMMZ	99305	Michigan, Washtenaw Co., Ann Arbor	27.48	22.16	1.24
397	*Procyon lotor*	UMMZ	116345	Mexico, vic. Tenochtitlan, Veracruz.	30.49	25.40	1.20
386	*Procyon lotor*	UMMZ	122699	Michigan, Alpena Co., NE 1/4 Sec. 11	27.87	24.18	1.15
375	*Procyon lotor*	UMMZ	123401	Michigan, Washtenaw Co., Ann Arbor	28.30	23.22	1.22
389	*Procyon lotor*	UMMZ	159616	Michigan, Schoolcraft Co., Sency Wildlife Refuge Headquarters	27.22	23.63	1.15
390	*Procyon lotor*	UMMZ	159617	Michigan, Schoolcraft Co., Sency Wildlife Refuge Headquarters	28.27	24.59	1.15
387	*Procyon lotor*	UMMZ	162697	Michigan, Livingston Co., E. S. George Reserve	26.56	22.05	1.20
382	*Procyon lotor*	UMMZ	168355	Michigan, Washtenaw Co., Ann Arbor	24.85	19.92	1.25
381	*Procyon lotor*	UMMZ	168398	Wasthington, King Co. NE of 98th Str, E of 41sst Pl NE, S & W of 43rd PL NE	28.30	24.20	1.17
376	*Procyon lotor*	UMMZ	170525	Michigan, Washtenaw Co.	29.85	24.54	1.22
374	*Procyon lotor*	UMMZ	170526	Michigan, Washtenaw Co.	30.07	24.24	1.24
763	*Procyon lotor*	USNHM	91427	Severance, Essex County, New York	28.54	23.37	1.22
768	*Procyon lotor*	USNHM	91428	Severence, Essex County, New York	24.62	20.48	1.20
772	*Procyon lotor*	USNHM	91429	Severance, Essex County, New York	26.09	21.29	1.23
762	*Procyon lotor*	USNHM	187907	Locust Grove, Lewis County, New York	28.67	23.00	1.25
785	*Procyon lotor*	USNHM	251154	Peten, Guatemala	29.73	24.34	1.22
788	*Procyon lotor*	USNHM	256028	Hilton Head Island, Beaufort County, South Carolina	23.36	18.99	1.23
790	*Procyon lotor*	USNHM	256029	Hilton Head Island, Beaufort County, South Carolina	24.06	19.92	1.21
791	*Procyon lotor*	USNHM	256030	Hilton Head Island, Beaufort County, South Carolina	25.92	21.26	1.22
787	*Procyon lotor*	USNHM	256031	Hilton Head Island, Beaufort County, South Carolina	24.52	19.37	1.27
789	*Procyon lotor*	USNHM	256032	Hilton Head Island, Beaufort County, South Carolina	24.76	20.68	1.20
786	*Procyon lotor*	USNHM	271097	La Venta, Tabasco, Mexico	27.09	21.93	1.24
769	*Procyon lotor*	USNHM	276356	Blackwater Wildlife Refuge, Dorchester County, Maryland	26.39	21.60	1.22
777	*Procyon lotor*	USNHM	283182	Hazel Run, 2400ft, Shenandoah National Park, Virginia	27.36	22.11	1.24
770	*Procyon lotor*	USNHM	349917	1.5 Mi N Wolfsville, 1300ft, Fredrick County, Maryland (393545 N 0773230W)	27.22	22.69	1.20
776	*Procyon lotor*	USNHM	360971	Raleigh, Wake County, North Carolina	26.61	21.71	1.23
764	*Procyon lotor*	USNHM	396237	Near Annapolis, Anne Arundel County, Maryland	26.30	21.10	1.25
761	*Procyon lotor*	USNHM	396274	373, 2 Mi W of Junction with 210, Prince Georges County, Maryland	28.18	23.15	1.22

Appendix 8. — Continuation.

ID	Species	Inst	Specimen No	Locality	Calc Len	Sust Pos	Gear Ratio
Procyonidae (continuation)							
775	*Procyon lotor*	USNHM	396277	US 220 3 Mi N of Jct with Rainsburg Road, Bedford County, Pennsylvania	26.69	21.77	1.23
780	*Procyon lotor*	USNHM	514512	Great Falls, Fairfax County, Virginia	25.02	19.54	1.28
782	*Procyon lotor*	USNHM	532412	Brackenridge Research Tract, Austin, Texas	25.93	22.14	1.17
783	*Procyon lotor*	USNHM	564263	Bay Ronde, Mississippi Delta Bay, Plaquemines Parish, Louisiana	23.70	19.09	1.24
784	*Procyon lotor*	USNHM	564264	near Forks, Beaver Creek on Sol Duc River, Clallam County, Washington	28.16	22.40	1.26
765	*Procyon lotor*	USNHM	567940	Bottomland Forest, Plot 2705, Patuxent Research Refuge, Prince Georges County, Maryland	26.41	20.81	1.27
766	*Procyon lotor*	USNHM	567941	Plot 3701, Margin of Patuxent River, Prince Georges County, Maryland	24.61	19.91	1.24
767	*Procyon lotor*	USNHM	567942	Plot 5483, Kluckuhn Loop Road near north storage barn, Patuxent Research Refuge, Prince Georges County, Maryland	25.51	20.86	1.22
778	*Procyon lotor*	USNHM	568664	Partlow, near 10200 Wallers Road, Spotsylvania County, Virginia	26.85	21.75	1.23
779	*Procyon lotor*	USNHM	569082	Partlow, near 10200 Wallers Road, Spotsylvania County, Virginia	24.21	20.69	1.17
773	*Procyon lotor*	USNHM	A00575	Carlisle, Cumberland County, Pennsylvania	28.08	22.84	1.23
781	*Procyon lotor*	USNHM	A01386	St. Cauch, Matamoras, Tamaulipas, Mexico	31.02	25.46	1.22
771	*Procyon lotor*	USNHM	A21136	East Penfield, New York	23.98	19.78	1.21
774	*Procyon lotor*	USNHM	A22243	Pennsylvania	24.79	20.83	1.19
468	*Procyon lotor*	UTVPL	M-1806	Texas, Travis Co.	27.33	21.62	1.26
467	*Procyon lotor*	UTVPL	M-1818	Texas, Bee Co.	28.59	23.47	1.22
469	*Procyon lotor*	UTVPL	M-1851	Texas, Karns Co., Runge	29.56	25.43	1.16
471	*Procyon lotor*	UTVPL	M-2106	Texas, Burnet Co., approx. 4 miles south of Burrnet of on Highway 181	29.42	24.44	1.20
470	*Procyon lotor*	UTVPL	M-2222	Texas, Travis Co., Austin, Balcones Research Center	27.77	22.11	1.26
472	*Procyon lotor*	UTVPL	M-3182	Texas, Hays Co., W of Kyle, Kuykendall Ranch	27.74	22.56	1.23
466	*Procyon lotor*	UTVPL	M-363	Texas, Travis Co.	27.54	23.01	1.20
175	*Procyon lotor*	WRAZL	10265	Indiana, Monroe Co.	27.46	22.93	1.20
Ursidae							
2	*Ailuropoda melanoleuca*	FMNH	36758	China, Sichuan, Yaan Pref, Dun Shih Goh, above Baoxing	64.48	56.74	1.14
176	*Helarctos malayanus*	FMNH	54201	Zoo: Brookfield Zoo, Chicago	54.35	48.84	1.11
177	*Helarctos malayanus*	FMNH	54316	Zoo: Brookfield Zoo, Chicago	53.18	47.80	1.11
178	*Melursus ursinus*	FMNH	27441	India, Uttar radesh, Kheri, North Oudh	68.72	62.43	1.10
179	*Melursus ursinus*	FMNH	27442	India, Uttar radesh, Kheri, North Oudh	73.37	68.92	1.06
180	*Tremarctos ornatus*	FMNH	41294	Peru, Prov Lambayque, Chiclay	60.28	50.33	1.20
181	*Tremarctos ornatus*	FMNH	142010	Zoo: Brookfield Zoo, Chicago	51.80	43.95	1.18
183	*Ursus americanus*	FMNH	18864	Florida, Brevard Co., Banana R.	59.39	52.11	1.14
184	*Ursus americanus*	FMNH	57282	Zoo: Lincoln Park Zoo, Chicago	57.12	49.47	1.15
182	*Ursus americanus*	INSM	71.09.0233	Indiana, Harrison Co., Fair-to-Middl'in Well Pit, 1.5 Mi NW of Mauckport (Holocene)	68.89	59.68	1.15
697	*Ursus americanus*	MUZA	755	Montana, Yellowstone National Park (Montana Fish and Game)	65.38	59.83	1.09
185	*Ursus americanus*	WRAZL	210076		67.16	58.06	1.16
186	*Ursus arctos*	FMNH	63802	Alaska, Alaska Penninsula, Game Management Unit 9, Mother Goose Lake	100.00	102.41	0.98
187	*Ursus arctos*	FMNH	63803	Alaska, Alaska Penninsula, Game Management Unit 9, Mother Goose Lake	84.86	74.48	1.14
373	*Ursus arctos*	UMMZ	197532	Alaska, Baranof Island, Red Bluff Bay	82.92	76.14	1.09
484	*Ursus arctos*	UTVPL	M-3773	Wyoming, Yellowstone National Park, Slough Creek	68.33	62.16	1.10
188	*Ursus maritimus*	FMNH	53989	Canada, Region of Hudson Bay	94.06	79.86	1.18
189	*Ursus maritimus*	FMNH	58827	Zoo: Lincoln Park Zoo, Chicago	100.00	100.76	0.99
190	*Ursus thibetanus*	FMNH	99349	Zoo: Brookfield Zoo, Chicago	70.80	60.84	1.16
Viverridae							
192	*Arctictis binturong*	AMNH-M	80163		37.97	33.77	1.12
191	*Arctictis binturong*	AMNH-M	119600		37.53	34.15	1.10
193	*Civettictis civetta*	AMNH-M	51797	Zaire, Haut Zaire, Akenge	36.41	28.80	1.26
198	*Genetta genetta*	AMNH-M	114190	Kenya, Coast Provine, Ucase, Wacamba Country, 1750 ft	16.56	14.01	1.18
199	*Genetta genetta*	AMNH-M	187725	Kenya, Northeastern Prov., Garissa Dist., 1 mi. W. Galmagalla, 270 ft	21.41	16.76	1.28
200	*Genetta maculata*	AMNH-M	216345	Mozambique, Manica and Sofala, Alvez de Lima Camp	21.95	16.68	1.32

Appendix 8. — Continuation.

ID	Species	Inst	Specimen No	Locality	Calc Len	Sust Pos	Gear Ratio
Viverridae (continuation)							
201	*Genetta maculata*	AMNH-M216346		Mozambique, Manica and Sofala, Alvez de Lima Camp	19.92	16.46	1.21
202	*Genetta servalina*	AMNH-M51543		Zaire, Haut Zaire, Medje	20.31	16.78	1.21
203	*Genetta servalina*	AMNH-M150447		Zaire, Kivu Prov. Lubutu	21.81	17.31	1.26
204	*Genetta victoriae*	AMNH-M51406		Zaire, Haut Zaire, Medje	22.85	18.29	1.25
206	*Hemigalus derbyanus*	AMNH-M32658			18.35	15.23	1.20
205	*Hemigalus derbyanus*	AMNH-M106623		Indonesia, Sumatra, Propinsi Bengkul (Benkoelen), Bunkit Sanggul (Boekit Sanggoel), 500 m.	20.67	16.36	1.26
209	*Paradoxurus hermaphroditus*	AMNH-M113032		Burma, Sagaing Div., E. band Chindwin Riv, Kindat	23.53	19.80	1.19
210	*Paradoxurus hermaphroditus*	AMNH-M113771		Vietnam (S.), Lagna River	22.86	19.51	1.17
211	*Poiana richardsonii*	AMNH-M51438		Zaire, Haut Zaire, Medje	14.33	11.26	1.27
214	*Viverra tangalunga*	AMNH-M20790		N.Y. Zoological Society	26.13	19.42	1.35
213	*Viverra tangalunga*	AMNH-M226805		Indonesia, Sulawesi (Central), Gunung, Lokilalaki (Nokilalaki)	25.42	19.60	1.30
216	*Viverra zibetha*	AMNH-M35450		N.Y. Zoological Society	35.96	26.42	1.36
215	*Viverra zibetha*	AMNH-M113482		Burma, Upper Chindwin Prov., Homalin, E bank	33.27	26.64	1.25
217	*Viverricula indica*	AMNH-M54831		Indian (? Tamil Nadu, Medura Dist.)	23.77	18.14	1.31
218	*Viverricula indica*	AMNH-M54832		Indian (? Tamil Nadu, Medura Dist.)	24.23	18.78	1.29

Appendix 9. — Original measurements from 224 fossil carnivoran specimens. The Excel version of this document is available at the following address: http://sciencepress.mnhn.fr/sites/default/files/documents/en/appendix9-fossil_specimen_measurements.xlsx

ID	Species	Coll Code	Specimen No.	Age	Locality	Calc Len	SustFac ToPost	Gear Ratio
Amphicyoninae								
156	*Amphicyon ingens*	AMNH-FM	68117	E. Barstovian	Olcott, Boulder Qu., Sioux Co., Nebraska	125.33	110.25	1.137
157	*Amphicyon ingens*	AMNH-FM	68117-A	E. Barstovian	Olcott, Boulder Qu., Sioux Co., Nebraska	116.61	99.74	1.169
158	*Amphicyon ingens*	AMNH-FM	68142-L	Barstovian	Olcott Fm, Humbug Quarry, Nebraska	108.27	87.87	1.232
159	*Amphicyon ingens*	AMNH-FM	68142-P	Barstovian	Olcott Fm., West Sand Quarry, Sioux Co., Nebraska	116.45	98.03	1.188
160	*Amphicyon ingens*	AMNH-FM	68142-O	L. Hemingfordian	Sheep Creek Fm., Pliohippus Draw	110.87	96.6	1.148
241	*Amphicyon longiramus*	FLMNH	UF 173920	Hemingfordian	Thomas Farm, Gilchrist Co., Florida	103.5	88.16	1.174
242	*Amphicyon longiramus*	FLMNH	UF 5774	Hemingfordian	Thomas Farm, Gilchrist Co., Florida	88.79	78.46	1.132
237	*Cynelos caroniavorus*	FLMNH	UF 204441	Hemingfordian	Thomas Farm, Gilchrist Co., Florida	46.88	34.84	1.346
238	*Cynelos caroniavorus*	FLMNH	UF 257683	Hemingfordian	Thomas Farm, Gilchrist Co., Florida	42.03	32.61	1.289
161	*Cynelos idoneus*	AMNH-FM	68114	L. Hemingfordian	Sheep Cr., Hilltop Q, Sioux Co, Nebraska	72.93	63.94	1.141
162	*Cynelos idoneus*	AMNH-FM	68114-F	L. Hemingfordian	Sheep Cr., Thompson Q, Sioux Co, Nebraska	89.77	73.7	1.218
163	*Cynelos idoneus*	AMNH-FM	68114-C	L. Hemingfordian	Sheep Cr., Hilltop Q, Sioux Co, Nebraska	80.14	69.8	1.148
164	*Cynelos idoneus*	AMNH-FM	68114-B	L. Hemingfordian	Sheep Cr., Long Q, Sioux Co, Nebraska	80.87	68.33	1.184
165	*Cynelos idoneus*	AMNH-FM	68114-H	L. Hemingfordian	Sheep Cr., Long Q, Sioux Co, Nebraska	96.86	82.34	1.176
346	*Ischyrocyon gidleyi*	AMNH-FM	68180a	L. Clarendonian, Miocene, Upper Ash Hollow Beds	Leptarctus Quarry	86.75	73.82	1.175
311	*Ischyrocyon gidleyi*	UNSM	21174	Early Clarendonian	Penny Creek LF	78.47	64.5	1.217
Barbourofelidae								
221	*Barbourofelis fricki*	AMNH-FM	61989	Hemphillian	Jack Swayze Qu, Clark Co, Kansas	68.86	60.8	1.133
293	*Barbourofelis loveorum*	FLMNH	UF 25189	Clarendonian	Love Bone Bed, Alachua, Florida	72.25	60.08	1.203
294	*Barbourofelis loveorum*	FLMNH	UF 25192	Clarendonian	Love Bone Bed, Alachua, Florida	67.79	55.66	1.218
222	*Barbourofelis morrisi*	AMNH-FM	61882	Lt. Clarendonian	Ash Hollow Fm, Merritt Reservoir Member, Cherry Co., Nebraska	66.41	55.92	1.188
223	*Barbourofelis morrisi*	AMNH-FM	61883	Lt. Clarendonian	Ash Hollow Fm, Merritt Reservoir Member, Cherry Co., Nebraska	66.42	55.15	1.204
224	*Barbourofelis morrisi*	AMNH-FM	61881	Lt. Clarendonian	Ash Hollow Fm, Merritt Reservoir Mbr, Hans Johnson Qu, Cherry Co. Nebraska	65.06	57.83	1.125
225	*Barbourofelis whitfordi*	AMNH-FM	FAM 61885	M. Clarendonian	Ash Hollow Fm, Cap Rock Mbr, Brown Co, Nebraska	63.28	53.18	1.190
Borophaginae								
144	*Aelurodon asthenostylus*	AMNH-FM	27162	Lower Barstovian	Barstow Fm., Second Division, San Bernardino Co., California	46.41	38.12	1.217
145	*Aelurodon asthenostylus*	AMNH-FM	28332-4	Lower Barstovian	Horse Quarry, Colorado	56.53	47.05	1.201
146	*Aelurodon asthenostylus*	AMNH-FM	28355	Lower Barstovian	Horse Quarry, Logan Co., Colorado (Pawnee Creek Fm.)	59.22	49.68	1.192
143	*Aelurodon ferox*	AMNH-FM	61746	Lower Barstovian	W. Fork of Deep Cr, Brown Co., Nebraska. 25' below contact with Burge	57.99	45.25	1.282
314	*Aelurodon ferox*	UNSM	UNSM 76631	Miocene, Late Barstovian,	Type Valentine Quarry (CR-12)	59.84	49.19	1.217
315	*Aelurodon ferox*	UNSM	UNSM 46815	Miocene, Clarendonian, Upper Valentine	Bug Prospect (KX-119), «9mi west and 1.5 miles north of Creighton, Knox Co. NE, 15» below base of (local) «Caprock» in u	56.6	45.93	1.232
324	*Aelurodon taxoides*	UNSM	4477	Late Clarendonian, Ash Hollow	Or Sh-0	71.41	57.19	1.249
151	*Archaeocyon leptodus*	AMNH-FM	50299	Whitneyan	Three Tubs locality, n. 66 Mountain, Whitney Member, Brule Formation (Whitneyan), Goshen County, Wyoming	19.68	16.25	1.211

Appendix 9. — Continuation.

ID	Species	Coll Code	Specimen No.	Age	Locality	Calc Len	SustFac ToPost	Gear Ratio
Borophaginae (continuation)								
153	*Archaeocyon leptodus*	AMNH-FM	49096	Early Arikareean	Horse Creek area, lower Arikaree Group (early Arikareean), Goshen County, Wyoming	32.51	25.88	1.256
149	*Archaeocyon pavidus*	AMNH-FM	63970	Arikareean	east side of Roundhouse Rock, 5 mi southwest of Bridgeport, Morrill Co., Nebraska (Whitney Fm.)	15.74	12.94	1.216
126	*Arnette Canid? Sp. 1*	OMNH-VP	8975	Tertiary, Miocene, Hemphillian, Ogallala Fm., 7.5 Ma	V54, Arnett, Ellis Co., Oklahoma, Ogallala Fm.	71.12	57.46	1.238
243	*Borophagus pugnator*	FLMNH	UF 65664	Hemphillian (Early Pliocene)	Fort Green Mine, #13 Dragline (PO019), Polk Co. Florida	53.1	44.8	1.185
244	*Borophagus pugnator*	FLMNH	UF 1566	Hemphillian (Early Pliocene)	Kingsford Mine (PO018), Polk Co., Florida	52.85	44.39	1.191
118	*Borophagus secundus*	OMNH-VP	11789	Tertiary, Miocene, Hemphillian, Ogallala Fm.	V52, Optima, Texas County, Oklahoma, Ogallala Fm.	43.81	36.38	1.204
119	*Borophagus secundus*	OMNH-VP	11790	Tertiary, Miocene, Hemphillian, Ogallala Fm.	V52, Optima, Texas County, Oklahoma, Ogallala Fm.	44	36.86	1.194
120	*Borophagus secundus*	OMNH-VP	11791	Tertiary, Miocene, Hemphillian, Ogallala Fm.	V52, Optima, Texas County, Oklahoma, Ogallala Fm.	41.02	35.71	1.149
121	*Borophagus secundus*	OMNH-VP	15200	Tertiary, Miocene, Hemphillian, Ogallala Fm.	V52, Optima, Texas County, Oklahoma, Ogallala Fm.	45.02	37.05	1.215
325	*Carpocyon compressus*	UNSM	2037-90	Late Barstovian, Ogallala Group	Hazard Homestead	41.04	33.44	1.227
322	*Carpocyon robustus*	UCMP	UCMP 33569	Clarendonian, Ricardo Fm.	Ricardo Amphitheater 14,	45.54	37.03	1.230
326	*Carpocyon webbi*	UNSM	unnumbered	Late Clarendonian, Ash Hollow	Harrisburg Loc A1	54.32	44.89	1.210
327	*Cynarctus saxatilis*	UNSM	45074	Late Barstovian, Valentine Fm.	Myers Farm	38.76	33.22	1.167
152	*Desmocyon thomsoni*	AMNH-FM	49018	Late Arikareean	25 mi southeast of Lusk, Upper Harrison beds (late Arikareean),Goshen County, Wyoming	27.41	23.11	1.186
328	*Desmocyon thomsoni*	UNSM		Hemingfordian, Runningwater		35.46	29.76	1.192
245	*Epicyon haydeni*	FLMNH	UF 37879	Clarendonian	Love Bone Bed, Alachua, Florida	58.08	47.78	1.216
246	*Epicyon haydeni*	FLMNH	UF 37879	Clarendonian	Love Bone Bed, Alachua, Florida	57.45	48.65	1.181
247	*Epicyon saevus*	FLMNH	UF 37881	Clarendonian	Love Bone Bed, Alachua, Florida	53.55	43.86	1.221
248	*Epicyon saevus*	FLMNH	UF 37868	Clarendonian	Love Bone Bed, Alachua, Florida	50.64	41.38	1.224
323	*Epicyon saevus*	UCMP	UCMP 29584	Clarendonian, Ash Hollow Formation	Little Beaver B	41.29	36.08	1.144
262	*Euoplocyon spissidens*	FLMNH	UF 17674	Hemingfordian	Thomas Farm, Gilchrist Co., Florida	33.07	26.67	1.240
265	*Euoplocyon spissidens*	FLMNH	UF 271243	Hemingfordian	Thomas Farm, Gilchrist Co., Florida	32.99	26.47	1.246
266	*Euoplocyon spissidens*	FLMNH	UF 259350	Hemingfordian	Thomas Farm, Gilchrist Co., Florida	31.89	26.6	1.199
267	*Euoplocyon spissidens*	FLMNH	UF 177779	Hemingfordian	Thomas Farm, Gilchrist Co., Florida	35.04	29.02	1.207
148	*Metatomarctus canavus*	AMNH-FM	49199	Middle Hemingfordian	Pebble Creek, Dawes Co. Nebraska	39.96	32.36	1.235
264	*Metatomarctus canavus*	FLMNH	UF 94781	Hemingfordian	Thomas Farm, Gilchrist Co., Florida	33.65	26.54	1.268
270	*Metatomarctus canavus*	FLMNH	UF 271346	Hemingfordian	Thomas Farm, Gilchrist Co., Florida	36.85	31.28	1.178
271	*Metatomarctus canavus*	FLMNH	UF 9089	Hemingfordian	Thomas Farm, Gilchrist Co., Florida	37.51	28.61	1.311

Appendix 9. — Continuation.

ID	Species	Coll Code	Specimen No.	Age	Locality	Calc Len	SustFac ToPost	Gear Ratio
Borophaginae (continuation)								
272	*Metatomarctus canavus*	FLMNH	UF 9088	Hemingfordian	Thomas Farm, Gilchrist Co., Florida	38.24	31.68	1.207
273	*M. canavus*	FLMNH	UF 9092	Hemingfordian	Thomas Farm, Gilchrist Co., Florida	37.9	30.83	1.229
274	*M. canavus*	FLMNH	UF 9091	Hemingfordian	Thomas Farm, Gilchrist Co., Florida	37.18	30.14	1.234
275	*M. canavus*	FLMNH	UF 17660	Hemingfordian	Thomas Farm, Gilchrist Co., Florida	37.37	30.84	1.212
276	*M. canavus*	FLMNH	UF 9094	Hemingfordian	Thomas Farm, Gilchrist Co., Florida	37.03	30.3	1.222
332	*M. canavus*	UNSM		Hemingfordian, Runningwater	Bridgeport Quarry A Q6	42.24	35.72	1.183
320	*Paratomarctus euthos*	UNSM	None	Miocene, Early Clarendonian,	Buffalo Creek, Penny Creek Local Fauna (WT-104)	53.59	41.48	1.292
168	*Paratomarctus temerarius*	AMNH-FM	63290	Early Barstovian	Fleming Fm., Locality: Back of Mann Place, 1 mi. N of Mann Home, about 4mi. SE of Oakhurst, TX	45.83	37.93	1.208
150	*Phlaocyon leucosteus*	AMNH-FM	8768	Late Arikareean	Martin Canyon,head of Dorby Creek, Martin Canyon beds,Logan County, Colorado.	20.54	16.51	1.244
154	*Psalidocyon marianae*	AMNH-FM	27397	Early Barstovian	White Operation, Skull Ridge Member, Tesuque Formation (early Barstovian), Santa Fe County, New Mexico	43.33	35.33	1.226
147	*Tomarctus brevirostris*	AMNH-FM	67866	Lower Barstovian	3 Point, West Side, Pawnee Creek area, Colorado (Pawnee Creek Fm.)	42.74	36.3	1.177
Caninae								
41	*Canis arensis/ mosbachensis*	CENIEH	ATA97 TE10 61	1.22 MYA (or younger)	Atapuerca, Sima del Elefante, Layer TE10 (see Rodríguez *et al.*, 2010)	46.99	37.62	1.249
42	*Canis arensis/ mosbachensis*	CENIEH	ATA99 TE13 No. 18	Younger than 1.22 mya	Atapuerca, Sima del Elefante, Layer TE13 (see Rodríguez *et al.*, 2010)	43.08	35.49	1.214
43	*Canis arensis/ mosbachensis*	CENIEH	ATA96 TE12A, no 27	Younger than 1.22 mya	Atapuerca, Sima del Elefante, Layer TE12a (see Rodríguez *et al.*, 2010)	42.16	32.64	1.292
9	*Canis dirus*	AMNH-FM	92488		Florida, Pinellas Co., Seminole Field	61.48	48.06	1.279
10	*Canis dirus*	INSM	Uncatalogued	Late Pleistocene	Harrodsburg Fissure	53.97	42.82	1.260
61	*Canis dirus*	UCMP	26650	RLB	El Tajo, Mexico, Locality V2501	62.1	48.2	1.288
62	*Canis dirus*	UCMP	26650 (mislabelled 27650)	RLB	El Tajo, Mexico, Locality V2501	62.2	47.4	1.312
63	*Canis dirus*	UCMP	192632	11-15K rcybp	McKittrick, Locality -1370	68.3	54.3	1.258
64	*Canis dirus*	UCMP	192627	11-15K rcybp	McKittrick, Locality -1370	67.2	53.5	1.256
65	*Canis dirus*	UCMP	192628	11-15K rcybp	McKittrick, Locality -1370	60.3	47.3	1.275
66	*Canis dirus*	UCMP	192629	11-15K rcybp	McKittrick, Locality -1370	64.8	50.8	1.276
67	*Canis dirus*	UCMP	192630	11-15K rcybp	McKittrick, Locality -1370 (E1 4ft 5/18/21)	64.2	50.7	1.266
68	*Canis dirus*	UCMP	192631	11-15K rcybp	McKittrick, Locality -1370 (E1 4ft 5/18/21)	63.2	50.5	1.251
69	*Canis dirus*	UCMP	13577	22 692 rcybp mean	Rancho La Brea, Locality 1059	66.3	52.4	1.265
70	*Canis dirus*	UCMP	13580	22 692 rcybp mean	Rancho La Brea, Locality 1059	63.2	50.3	1.256
71	*Canis dirus*	UCMP	13956	22 692 rcybp mean	Rancho La Brea, Locality 1059	62.1	48.7	1.275
72	*Canis dirus*	UCMP	14721	22 692 rcybp mean	Rancho La Brea, Locality 1059	65.3	52.8	1.237
73	*Canis dirus*	UCMP	14973	22 692 rcybp mean	Rancho La Brea, Locality 1059	62.7	50.7	1.237
74	*Canis dirus*	UCMP	15648	22 692 rcybp mean	Rancho La Brea, Locality 1059	63.4	50.2	1.263
75	*Canis dirus*	UCMP	38195	RLB	San Pedro Lumber Yard, Loc. 2047	64.1	49.8	1.287
33	*Canis dirus*	UTVPL	30967-172	Rancholabrean	Texas, Ingleside	72.97	57.58	1.267
35	*Canis dirus*	UTVPL	30967-955	Rancholabrean	Texas, Ingleside	66.71	55.13	1.210
36	*Canis dirus*	UTVPL	30967-172	Rancholabrean	Texas, Ingleside	73.17	58.24	1.256
40	*Canis mosbachensis*	CENIEH	ATA08 TD3-TDR4 E10 No. 145	731 KYA	Atapuerca, Gran Dolina, Layer TDW3-TDW4 (see Rodríguez *et al.*, 2010)	43.56	33.18	1.313
342	*Eucyon davisi*	AMNH-FM	63017	Miocene, Late Hemphillian, Big Sandy Fm.	Clay Bank Quarry, near Wikiup, Mohave County, Arizona	36.38	26.75	1.360

Appendix 9. — Continuation.

ID	Species	Coll Code	Specimen No.	Age	Locality	Calc Len	SustFac ToPost	Gear Ratio
Caninae (continuation)								
171	*Leptocyon vafer*	AMNH-FM	62780	Barstovian/ Clarendonian?	Tesuque Fm., Pojoaque mbr., New Mexico?	26.38	21.38	1.234
172	*Leptocyon vafer*	AMNH-FM	62779		Jemez Cr. Area, Sandoval Co., N. Mexico (from west tributary of Canyada de zia, about 40' above the green zone at top of	24.02	19.13	1.256
173	*Leptocyon vafer*	AMNH-FM	62779		Jemez Cr. Area, Sandoval Co., N. Mexico (from west tributary of Canyada de zia, about 40' above the green zone at top of	23.62	19.78	1.194
174	*Leptocyon vulpinus*	AMNH-FM	12883	Thompson	Rosebud formation, lower beds. Porcupine Crk. S. Dak.	28.56	23.61	1.210
Daphoeninae								
155	*Adilophontes brachykolos*	AMNH-FM	54140	(Miocene)	Goshen Harrison Formation, Spoon Butte SW, Wyoming	80.64	70.44	1.145
169	*Daphoenodon niobrarensis*	AMNH-FM	107601	E. Hemingfordian	Brown Quarry, Nebraska	81.33	66.61	1.221
345	*Daphoenodon niobrarensis*	AMNH-FM	FAM 107601	E. Hemingfordian	Brown Quarry, Nebraska	81.61	66.22	1.232
166	*Daphoenodon superbus*	AMNH-FM	107759	Lt. Arikareean	U. Harrison Fm., Agate Springs Q., Sioux Co., Nebraska	62.71	51.87	1.209
167	*Daphoenus vetus*	AMNH-FM	63344	no data	2 mi S.E. of Scenic L.O.	52.87	44.53	1.187
310	*Daphoenus vetus*	UNSM		Early Arikareean, Whitney	Birdcage Gap	31.66	25.7	1.232
Felinae								
185	*Felis rexroadensis*	AMNH-FM	PAN 419-137	Blancan	Writ. Q., Panaca area, Nevada	55.77	44.02	1.267
186	*Felis rexroadensis*	AMNH-FM	BEAU 31-102		Sec. 15, Aguanga Horizon	49.36	36.38	1.357
282	*Felis rexroadensis*	FLMNH	UF/TRO 1445	Hemphillian (Early Pliocene)	Palmetto Mine (Agrico) (PO001), Polk Co., Florida	52.83	38.38	1.376
45	*Lynx issiodorensis*	CENIEH	ATA08 TE9C L30 No 43	1.22 MYA	Atapuerca, Sima del Elefante, Layer TE9c (see Rodríguez *et al.*, 2010)	48.59	35.78	1.358
278	*Nimravides galiani*	FLMNH	UF 25173	Clarendonian	Love Bone Bed, Alachua, Florida	93.11	67.76	1.374
279	*Nimravides galiani*	FLMNH	UF 25179	Clarendonian	Love Bone Bed, Alachua, Florida	96.29	74.1	1.299
187	*Nimravides pedionomus*	AMNH-FM	none		Bx2 Amarillo, Texas	73.19	56.12	1.304
188	*N. pedionomus*	AMNH-FM	62158	Clarendonian	MCD.Q.	94.14	70.38	1.338
334	*N. pedionomus*	UCMP	UCMP 29186	Chadronian, Ash Hollow Formation	North Rim Locality, Minnechaduza	71.77	57.2	1.255
178	*Nimravides thinobates*	AMNH-FM	HIG-160-1555	Hemphillian	Box T, W Draw, Sandy Clay, Lipscomb Co, Texas	133.38	106.7	1.250
179	*Nimravides thinobates*	AMNH-FM	HIG-228-1873	Hemphillian	V.V. Parker, Lipscomb Co., Texas	101.78	78.06	1.304
180	*Nimravides thinobates*	AMNH-FM	HIG-217-1707	Hemphillian	V.V. Parker, Lipscomb Co., Texas	99.1	74.38	1.332
1	*Panthera atrox*	AMNH-FM	69086	Rancholabrean	Alaska, Fairbanks, Fairbanks Creek	120.17	91.75	1.310
2	*Panthera atrox*	AMNH-FM	69087	Rancholabrean	Alaska, Fairbanks, 53 Pedro Creek	116.67	93.74	1.245
3	*Panthera atrox*	AMNH-FM	69089	Rancholabrean	Alaska, Fairbanks, Fairbanks Creek	126.94	94.62	1.342
4	*Panthera atrox*	AMNH-FM		Rancholabrean	Alaska, Fairbanks, Ikpikpuk River	107.99	82.31	1.312
5	*Panthera atrox*	AMNH-FM	69088	Rancholabrean	Alaska, Fairbanks, Goldstream	116.73	91.56	1.275
93	*Panthera atrox*	UCMP	20016	22 692 rcybp mean	Rancho La Brea, Locality 2050	125.6	94.4	1.331
94	*Panthera atrox*	UCMP	21025	22 692 rcybp mean	Rancho La Brea, Locality 2051	118.7	91.5	1.297
95	*Panthera atrox*	UCMP	21052	22 692 rcybp mean	Rancho La Brea, Locality 2051	128.1	96.7	1.325
96	*Panthera atrox*	UCMP	21106	22 692 rcybp mean	Rancho La Brea, Locality 2051	123.4	93.4	1.321
97	*Panthera atrox*	UCMP	No #, Grid 6-F-18	22 692 rcybp mean	Rancho La Brea, Locality 2051	128.8	95.2	1.353
98	*Panthera atrox*	UCMP	22283	22 692 rcybp mean	Rancho La Brea, Locality 2051	132.9	98.8	1.345
46	*Pseudaelurus quadridentatus*	MNCN	46.598a 46.601	Vallesian	Los Valles de Fuentidueña (Segovia, Spain)	50.61	37.6	1.346

Appendix 9. — Continuation.

ID	Species	Coll Code	Specimen No.	Age	Locality	Calc Len	SustFac ToPost	Gear Ratio
Hemicyoninae								
232	*Hemicyon barbouri*	AMNH-FM	68165b	E. Clarendonian	Valentine Fm., Lucht Quarry, Brown Co., Nebraska	78.84	66.43	1.187
301	*Phoberocyon johnhenryi*	FLMNH	UF 270997	Hemingfordian	Thomas Farm, Gilchrist Co., Florida	58.55	47.36	1.236
302	*Phoberocyon johnhenryi*	FLMNH	UF 1458	Hemingfordian	Thomas Farm, Gilchrist Co., Florida	81.2	63.82	1.272
303	*Phoberocyon johnhenryi*	FLMNH	UF 164791	Hemingfordian	Thomas Farm, Gilchrist Co., Florida	70.13	58.26	1.204
Hesperocyoninae								
331	*Enhydrocyon pahinsintewakpa*	UNSM		, Early Arikareean, Gering	Mo-103, Courthouse Rock, 59' below Gering Ash	61.29	49.6	1.236
253	*Osbornodon iamonensis*	FLMNH	UF 17647	Hemingfordian	Thomas Farm, Gilchrist Co., Florida	45.86	37.4	1.226
254	*O. iamonensis*	FLMNH	UF 277890	Hemingfordian	Thomas Farm, Gilchrist Co., Florida	40.79	32.21	1.266
255	*O. iamonensis*	FLMNH	UF 188657	Hemingfordian	Thomas Farm, Gilchrist Co., Florida	40.97	33.42	1.226
256	*O. iamonensis*	FLMNH	UF 213042	Hemingfordian	Thomas Farm, Gilchrist Co., Florida	40.19	32.74	1.228
257	*O. iamonensis*	FLMNH	UF 60549	Hemingfordian	Thomas Farm, Gilchrist Co., Florida	40.12	31.62	1.269
258	*O. iamonensis*	FLMNH	UF 201560	Hemingfordian	Thomas Farm, Gilchrist Co., Florida	40.02	33.87	1.182
259	*O. iamonensis*	FLMNH	UF 94780	Hemingfordian	Thomas Farm, Gilchrist Co., Florida	38.51	31.63	1.218
260	*O. iamonensis*	FLMNH	UF 160978	Hemingfordian	Thomas Farm, Gilchrist Co., Florida	39.19	32.53	1.205
261	*O. iamonensis*	FLMNH	UF 94777	Hemingfordian	Thomas Farm, Gilchrist Co., Florida	41.41	33.17	1.248
175	*Paraenhydrocyon josephi*	AMNH-FM	54097	Arikareean?	3 mi W of Muddy Crk loro Wyoming	35.89	27.89	1.287
176	*Paraen. josephi*	AMNH-FM	54115		4 mi E of Tremaine	30.14	25.25	1.194
177	*Paraen. josephi*	AMNH-FM	54107	Arikareean?	north of keeline, WY	35.37	29.25	1.209
Leptarctinae								
290	*Leptarctus ancipidens*	FLMNH	UF 262052	Hemingfordian	Thomas Farm, Gilchrist Co., Florida	27.48	23.26	1.181
291	*Leptarctus ancipidens*	FLMNH	UF 9097	Hemingfordian	Thomas Farm, Gilchrist Co., Florida	24.58	20.05	1.226
286	*Leptarctus webbi*	FLMNH	UF38005	Clarendonian	Love Bone Bed, Alachua, Florida	30.42	25.77	1.180
212	*Leptarctus wortmani*	AMNH-FM	S 110 -Th	L. Hemingfordian/ E. Barstonian	Sheep Cr., Sioux Co, Nebraska	33.3	28.6	1.164
213	*Leptarctus wortmani*	AMNH-FM	AINS.564.266	M. Clarendonian	Hollow Horn Bear Quarry, Todd Co., SD	28.79	23.89	1.205
214	*Leptarctus wortmani*	AMNH-FM	AINS.572.541	M. Clarendonian	Hollow Horn Bear Quarry, Todd Co., SD	32.58	27.93	1.166
37	*Trocherion albanense*	NMW	Unnumbered Vienna	Middle Miocene (MN 5)	Neudorf / Spalte, Czechoslovakia (Zapfe, 1949)	1.91	1.61	1.186
Lutrinae								
284	*Enhydritherium terraenovae*	FLMNH	UF 58385	Early Hemphillian	Haile 19A, Alachua Co., Florida	36.29	32.13	1.129
288	*Enhydritherium terraenovae*	FLMNH	UF 100000	Early Hemphillian	Moss Acres S. Racetrack, Sec 11, T14S, R19E, Morriston Quad, Marion Co., Florida	38.38	33.21	1.156
Machairodontinae								
24	*Homotherium serum*	UTVPL	933-2139	Pleistocene	Texas, Friesenhahn Cave	82.19	67.63	1.215
25	*Homotherium serum*	UTVPL	933-2938	Pleistocene	Texas, Friesenhahn Cave	81.76	68.72	1.190
26	*Homotherium serum*	UTVPL	933-3340	Pleistocene	Texas, Friesenhahn Cave	83.89	67.8	1.237
27	*Homotherium serum*	UTVPL	933-148	Pleistocene	Texas, Friesenhahn Cave	76.97	62.64	1.229
48	*Machairodus alberdiae*	MNCN	65809-65810	Vallesian	Los Valles de Fuentidueña (Segovia, Spain)	87.16	65.97	1.321
49	*Machairodus alberdiae*	MNCN	65808	Vallesian	Los Valles de Fuentidueña (Segovia, Spain)	97.87	70.94	1.380
181	*Machairodus coloradensis*	AMNH-FM	Bx-16 384-1933	Hemphillian	Coffee Ranch, Hemphill Co., Texas (? - written on drawer)	105.51	82.79	1.274
182	*Machairodus coloradensis*	AMNH-FM	CLAR 412-8402	Hemphillian	Hill Quarry, 20 mi. S.W. Claude, Texas. Horace Baker Ranch	93.45	74.7	1.251
183	*Machairodus coloradensis*	AMNH-FM	107673	Lt. Hemphillian	Guymon, Texas Co., Oklahoma	97.86	78.68	1.244
184	*Machairodus coloradensis*	AMNH-FM	38-1209		R.R. Sand, Oklahoma	94.39	77.98	1.210
283	*Machairodus coloradensis*	FLMNH	UF24727	Early Hemphillian	Withlacoochee River 4A Citrus Co., Florida	83.64	72.78	1.149
114	*Machairodus coloradensis*	OMNH-VP	11711	Tertiary, Miocene, Hemphillian, Ogallala Fm.	V52, Optima, Texas County, Oklahoma, Ogallala Fm.	89.99	74.04	1.215
189	*Pseudaelurus intrepidus*	AMNH-FM	62183	Lt. Barstovian-Lt. Clarendonian	Hollow Horn Bear Quarry, Todd Co., SD	56.56	43.37	1.304

Appendix 9. — Continuation.

ID	Species	Coll Code	Specimen No.	Age	Locality	Calc Len	SustFac ToPost	Gear Ratio
Machairodontinae (continuation)								
190	*Pseudaelurus intrepidus*	AMNH-FM	62228	Hemphillian		65.06	48.51	1.341
191	*P. intrepidus*	AMNH-FM	62233	Hemphillian	BX 15 Colorado Location-B	65.98	48.37	1.364
192	*P. intrepidus*	AMNH-FM	62237		Bx14 Canadian Texas, Lower Layer	62.06	46.3	1.340
193	*P. intrepidus*	AMNH-FM	62183C	Lt. Barstovian-Lt. Clarendonian	Hollow Horn Bear Quarry, Todd Co., SD	54.79	41.39	1.324
194	*P. intrepidus*	AMNH-FM	ESP 490-3298(B)	Barstovian	Lower Pojoaque Bluffs, New Mexico	55.41	41.49	1.336
195	*Pseudaelurus marshi*	AMNH-FM	27453	Barstovian	Arroyo Ojito Fm., New Mexico	51.16	40.8	1.254
196	*Pseudaelurus marshi*	AMNH-FM	62136	Clarendonian	BX113 New Mexico	62.81	49.6	1.266
197	*Pseudaelurus marshi*	AMNH-FM	62170	Lt. Barstovian-Lt. Clarendonian	Ainsworth, Xmas Quarry	59.47	46.72	1.273
198	*Pseudaelurus marshi*	AMNH-FM	27340-G	Clarendonian	BX85	73.83	58.16	1.269
199	*Pseudaelurus marshi*	AMNH-FM	62170-A		Nebraska	61.61	48.03	1.283
200	*Pseudaelurus marshi*	AMNH-FM	62183A	Late Barstovian-Lt. Clarendonian	Hollow Horn Bear Quarry, Todd Co., SD	55.65	43.57	1.277
201	*Pseudaelurus marshi*	AMNH-FM	62183B	Lt. Barstovian-Lt. Clarendonian	Hollow Horn Bear Quarry, Todd Co., SD	52.55	41.89	1.254
202	*Pseudaelurus marshi*	AMNH-FM	62719-A	Barstovian	Pawnee Creek Fm, Colorado	59.23	47.11	1.257
335	*Pseudaelurus marshi*	UNSM	123556	Late Barstovian, Valentine Fm.	South end of Harlan County Dam	58.35	46.7	1.249
203	*Pseudaelurus stouti*	AMNH-FM	61825	L. Hemingfordian	Sheep Creek Fm, Sioux Co, Nebraska	34.7	30.14	1.151
204	*Pseudaelurus validus*	AMNH-FM	62128	L. Hemingfordian	Tesque Fm, Nambe Mbr, E. Cuyamunque, Santa Fe Co., New Mexico	53.38	43.97	1.214
205	*Pseudaelurus validus*	AMNH-FM	62128	L. Hemingfordian	Tesque Fm, Nambe Mbr, E. Cuyamunque, Santa Fe Co., New Mexico	54.74	43.84	1.249
8	*Smilodon fatalis*	AMNH-FM	69252	Late Pleistocene	Florida, Devil's Den Mine, 8» Redeposited Fissure	85.13	64	1.330
103	*Smilodon fatalis*	UCMP	15052	22 692 rcybp mean	Rancho La Brea, Locality 1059	95.1	79.5	1.196
104	*Smilodon fatalis*	UCMP	16448	22 692 rcybp mean	Rancho La Brea, Locality 1059	97	79.5	1.220
105	*Smilodon fatalis*	UCMP	19136	22 692 rcybp mean	Rancho La Brea, Locality 1059	94.6	77.9	1.214
106	*Smilodon fatalis*	UCMP	19238	22 692 rcybp mean	Rancho La Brea, Locality 1059	99.2	82	1.210
107	*Smilodon fatalis*	UCMP	19320	22 692 rcybp mean	Rancho La Brea, Locality 1059	97.1	80.2	1.211
108	*Smilodon fatalis*	UCMP	19321	22 692 rcybp mean	Rancho La Brea, Locality 1059	97.3	80.5	1.209
30	*Smilodon fatalis*	UTVPL	933-4498	Pleistocene	Texas, Friesenhahn Cave	82.77	70.58	1.173
206	*Smilodon gracilis*	AMNH-FM	95533	Irvingtonian	McLeod Lime Rock Mine, Levy Co., FL. 2.2 mi north of Williston	82.04	67.26	1.220
207	*Smilodon gracilis*	AMNH-FM	95534	Irvingtonian	McLeod Lime Rock Mine, Levy Co., FL. 2.2 mi north of Williston	79.37	67.53	1.175
Miacidae								
340	*Miacis parvivorus*	AMNH-FM	13087	Bridger B5	Mouth of Summer's Dry Creek, Bridger Basin, Wyoming	18.08	14.46	1.250
344	*Vulpavus palustris*	AMNH-FM	11497	Bridgerian, Eocene, Bridger B2	Grizzly Buttes E, Bridger Basin, Wyoming	27.38	24.43	1.121
Mustelidae								
347	*Plesictis genettoides*	AMNH-FM	11001	Oligocene/ Miocene	Peu Blanc (Allier), Puy de Dome, France (Poirrier Collection)	14.79	12.31	1.201
Mustelinae								
292	*Miomustela madisonae*	FLMNH	UF 406545	Hemingfordian	Thomas Farm, Gilchrist Co., Florida	13.66	10.56	1.294
285	*Sthenictis lacota*	FLMNH	UF 38002	Clarendonian	Love Bone Bed, Alachua, Florida	41.38	33.65	1.230

Appendix 9. — Continuation.

ID	Species	Coll Code	Specimen No.	Age	Locality	Calc Len	SustFac ToPost	Gear Ratio
Nimravidae								
226	*Nimravus brachyops*	AMNH-FM	62151	Arikarrean	3/5 mi. E of Tremain R.R. Station, E Side, Horse Cr. Basin, Upper White Layer, Wyoming	70.77	54.84	1.290
227	*Nimravus brachyops*	AMNH-FM	6940	Arikarrean	John Day Formation, Oregon	64.82	49.43	1.311
228	*Nimravus brachyops*	AMNH-FM	6940	Arikarrean	John Day Formation, Oregon	65.38	50.05	1.306
229	*Nimravus brachyops*	AMNH-FM	none		John Day	63.5	50.33	1.262
Oligobuninae								
210	*Brachypsalis matutinus*	AMNH-FM	AINS-577-688	Clarendonian	Hollow Horn Bear Quarry, Todd Co., SD	42.07	36.96	1.138
211	*Brachypsalis matutinus*	AMNH-FM	AINS-577-688	Clarendonian	Hollow Horn Bear Quarry, Todd Co., SD	42.93	36.71	1.169
219	*Megalictis ferox*	AMNH-FM	FAM 144568	Hemingfordian	16 Mile District, Goshen Co., Wyoming, USA, middle brown sand formation	58.42	49.28	1.185
220	*Megalictis ferox*	AMNH-FM	54079	no data	no data	55.34	45.47	1.217
215	*Promartes lepidus*	AMNH-FM	27462	M. Hemingfordian	Canyada Piedra Parada, 50 yds E. of Standing Rock Q., Sandova/Co., N. Mex, Zia sand Fm.	20.35	17.52	1.162
216	*Promartes lepidus*	AMNH-FM	27583	Lower Arikareean	Royal Valley, Niobara Co., Wyo., L. Marshland Fm.	20.58	17.89	1.150
Procyonidae								
298	*Arctonasua floridana*	FLMNH	UF 37996	Clarendonian	Love Bone Bed, Alachua, Florida	36.09	30.19	1.195
299	*Arctonasua floridana*	FLMNH	UF 37999	Clarendonian	Love Bone Bed, Alachua, Florida	36.19	30.27	1.196
296	*Paranasua biradica*	FLMNH	UF 38004	Clarendonian	Love Bone Bed, Alachua, Florida	33.74	28.31	1.192
297	*Paranasua biradica*	FLMNH	UF 37998	Clarendonian	Love Bone Bed, Alachua, Florida	34.13	27.9	1.223
Ursinae								
234	*Agriotherium gregoryi*	AMNH-FM	RED 181-3527	L. Hemphillian	Quibiris Fm., Old Cabin Quarry, Redington area, Pima Co., Arizona	100.51	88.76	1.132
235	*Agriotherium gregoryi*	AMNH-FM	103-586	L. Hemphillian	Big Sand Fm., Wikieup, Mohave Co., Arizona	94.53	80.68	1.172
300	*Agriotherium schneideri*	FLMNH	UF 24182	Hemphillian (Early Pliocene)	North Palmetto Mine (PO021) Polk Co., Florida	110.58	89.49	1.236
122	*Agriotherium schneideri*	OMNH-VP	13676	Tertiary, Miocene, Hemphillian, Ogallala Fm.	V52, Optima, Texas County, Oklahoma, Ogallala Fm.	100.59	89.71	1.121
56	*Arctodus simus*	UCMP	3719	L. Pleist-E. Holo.	Potter Creek Cave, Locality 1055	100.5	96.8	1.038
57	*Arctodus simus*	UCMP	10214	L. Pleist-E. Holo.	Potter Creek Cave, Locality 1055	107.5	98.1	1.096
58	*Arctodus simus*	UCMP	8324	L. Pleist-E. Holo.	Potter Creek Cave, Locality 1055	95.6	88.6	1.079
59	*Arctodus simus*	UCMP	3450	L. Pleist-E. Holo.	Potter Creek Cave, Locality 1055	102.2	93.8	1.090
233	*Indarctos oregonensis*	AMNH-FM	HIG 33-514	E. Hemphillian	Box T Pit 1, Lipscomb Co., Texas	122.75	108.03	1.136
305	*Indarctos oregonensis*	FLMNH	UF13796	Early Hemphillian	Withlacoochee River 4A Citrus Co., Florida	104.89	89.14	1.177

Appendix 10. — Reconstructed ancestral gear ratio values for the nodes of the tree shown in Appendix 1. Uncertainties are one standard error (**SE**). The Excel version of this document is available at the following address: http://sciencepress.mnhn.fr/sites/default/files/documents/en/appendix10-node_reconstructions.xlsx

Node	Best estimate	Uncertainty (SE)
0	1.189	0.125
1	1.203	0.119
2	1.223	0.129
3	1.221	0.116
4	1.228	0.147
5	1.253	0.128
6	1.254	0.129
7	1.253	0.134
8	1.271	0.112
9	1.268	0.099
10	1.317	0.093
11	1.300	0.106
12	1.263	0.099
13	1.260	0.089
14	1.273	0.085
15	1.288	0.072
16	1.217	0.078
17	1.318	0.092
18	1.329	0.082
19	1.335	0.081
20	1.354	0.091
21	1.357	0.087
22	1.358	0.073
23	1.364	0.065
24	1.336	0.081
25	1.342	0.103
26	1.344	0.091
27	1.337	0.087
28	1.348	0.091
29	1.349	0.091
30	1.303	0.060
31	1.385	0.006
32	1.334	0.093
33	1.333	0.085
34	1.334	0.086
35	1.358	0.062
36	1.338	0.099
37	1.370	0.025
38	1.259	0.083
39	1.262	0.082
40	1.257	0.087
41	1.271	0.087
42	1.298	0.083
43	1.303	0.084
44	1.295	0.113
45	1.289	0.108
46	1.295	0.107
47	1.253	0.133
48	1.212	0.077
49	1.181	0.090
50	1.180	0.083
51	1.176	0.081
52	1.253	0.130
53	1.244	0.151
54	1.237	0.162
55	1.170	0.169
56	1.246	0.154
57	1.253	0.155
58	1.249	0.119
59	1.247	0.099
60	1.242	0.091
61	1.275	0.169
62	1.281	0.158
63	1.300	0.130
64	1.263	0.156
65	1.270	0.169
66	1.283	0.123
67	1.251	0.086
68	1.269	0.145
69	1.257	0.159
70	1.231	0.172
71	1.289	0.138
72	1.288	0.158
73	1.299	0.138
74	1.332	0.120
75	1.331	0.125
76	1.339	0.118
77	1.322	0.119
78	1.308	0.144
79	1.320	0.143
80	1.284	0.094
81	1.219	0.113
82	1.216	0.126
83	1.195	0.156
84	1.165	0.080
85	1.235	0.092
86	1.242	0.057
87	1.205	0.115
88	1.187	0.103
89	1.205	0.085
90	1.219	0.114
91	1.215	0.133
92	1.220	0.157
93	1.257	0.166
94	1.248	0.139
95	1.244	0.126
96	1.248	0.109
97	1.231	0.106
98	1.209	0.147
99	1.207	0.142
100	1.213	0.128
101	1.215	0.119
102	1.243	0.125
103	1.235	0.118
104	1.219	0.101
105	1.214	0.114
106	1.219	0.091
107	1.225	0.105
108	1.237	0.123
109	1.194	0.117
110	1.199	0.103
111	1.210	0.114
112	1.211	0.112
113	1.212	0.098
114	1.209	0.088
115	1.207	0.088
116	1.206	0.088
117	1.197	0.100
118	1.181	0.101
119	1.155	0.111
120	1.179	0.103
121	1.216	0.123
122	1.204	0.101
123	1.197	0.105
124	1.189	0.105
125	1.190	0.106
126	1.176	0.059
127	1.193	0.116
128	1.217	0.113
129	1.240	0.112
130	1.208	0.096
131	1.212	0.106
132	1.212	0.109
133	1.225	0.115
134	1.219	0.092
135	1.219	0.089
136	1.180	0.127
137	1.196	0.089
138	1.195	0.082
139	1.180	0.093
140	1.210	0.153
141	1.160	0.166
142	1.158	0.154
143	1.159	0.153
144	1.165	0.058
145	1.137	0.162
146	1.114	0.081
147	1.116	0.080
148	1.130	0.081
149	1.111	0.082
150	1.086	0.034
151	1.135	0.116
152	1.219	0.167
153	1.224	0.117
154	1.227	0.135
155	1.230	0.152
156	1.224	0.114
157	1.224	0.113
158	1.224	0.110
159	1.222	0.141
160	1.207	0.096
161	1.209	0.083
162	1.213	0.074
163	1.215	0.068
164	1.215	0.070
165	1.210	0.072
166	1.201	0.069
167	1.206	0.062
168	1.239	0.026
169	1.212	0.073
170	1.212	0.026
171	1.213	0.077
172	1.216	0.080
173	1.218	0.088
174	1.202	0.103
175	1.201	0.096
176	1.196	0.106
177	1.226	0.152
178	1.254	0.119
179	1.277	0.106
180	1.235	0.006
181	1.278	0.105
182	1.282	0.109
183	1.282	0.116
184	1.284	0.110
185	1.282	0.102
186	1.285	0.072
187	1.268	0.054
188	1.303	0.094
189	1.283	0.090
190	1.278	0.086
191	1.276	0.072
192	1.249	0.063
193	1.252	0.057
194	1.258	0.053
195	1.240	0.004
196	1.310	0.068
197	1.324	0.066
198	1.288	0.071
199	1.282	0.069
200	1.276	0.080
201	1.275	0.060
202	1.274	0.060
203	1.275	0.063
204	1.259	0.064
205	1.260	0.019
206	1.271	0.065
207	1.269	0.060
208	1.273	0.005
209	1.272	0.070