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**ONTOGENETIC NICHE SHIFT AS A DRIVER OF
COMMUNITY STRUCTURE AND DIVERSITY IN
NON-AVIAN DINOSAURS**

by

KATLIN M. SCHROEDER

B.S., Biology, University of New Mexico, 2011

M.S., Biology, University of New Mexico, 2017

DISSERTATION

Submitted in Partial Fulfillment of the
Requirements for the Degree of

Doctor of Philosophy

Biology

The University of New Mexico
Albuquerque, New Mexico

July, 2022

DEDICATION

To Mom-

Your hard work, love, and dedication saved me from a life of violence, anger and
mediocrity.

And in memory of Aunt Pat- who always knew it wasn't a phase. I wish you were here to
see what you and your satchel of books have wrought.

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I emphatically thank Dr. Felisa Smith, my advisor and dissertation chair, for taking a chance on me when no one else would. Her uncompromising standards and trust in my abilities have been invaluable throughout the entirety of my graduate career, and her enthusiasm for non-avian dinosaurs always brightened my day.

To my committee members- Dr. Lyons I thank for her compassion and unparalleled support in addition to her scientific insights and eloquence. Dr. Erickson I thank for his research endeavors, which have served as the basis and support for my own, and for his depth of knowledge, shared freely and openly in the pursuit of science. Dr. Wolf I thank for his unbridled curiosity and enthusiasm for avian physiology. Appreciation is also extended to Sandia National Labs, for not only tolerating, but encouraging the pursuit of this degree, despite its complete irrelevance to my job.

Thank you to all of my friends and colleagues for obliging my rants and for your continued fascination with my work. Dr. Mel Pardi, thank you especially for your guidance, and for introducing me to Dr. Smith in the first place. To the Schapperts, Brehms and Murphys, thank you for teaching me how to trust, for your constant support and encouragement, and for the slightly out of date newspaper clippings on dinosaurs.

To my puppers, Tiernan, Murphy, Reiley, Seamus and Bela, and the kittens, Lana, Krieger and Archer- your emotional support made this possible. Now stop scratching the doors.

ONTOGENETIC NICHE SHIFT AS A DRIVER OF COMMUNITY STRUCTURE AND DIVERSITY IN NON-AVIAN DINOSAURS

by

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ABSTRACT

As some of the most charismatic megafauna to ever walk the earth, the physiology, morphology, growth and evolution of non-avian theropods has been studied exhaustively, yet little is understood about their roles in ecosystems as juveniles. For carnivorous megatheropods, which exceed 1,000kg in mass yet hatched from eggs of limited size, the likelihood of utilizing different prey through ontogeny was high, simply by proxy of the immense difference in size between adults and juveniles. We found these ontogenetic niche shifts, evidenced by significantly different dental microwear in Tyrannosaurids, to have excluded dinosaurian mesocarnivores from Mesozoic communities. The few dinosaurian mesocarnivores that did co-occur with megatheropods exhibited indications of competition similar to those seen in modern mammalian carnivores, and may have

relied on highly efficient locomotion to remain competitive. Such impacts of juvenile megatheropods highlight their importance within Mesozoic ecosystems.

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Chapter 1

The influence of juvenile dinosaurs on community structure and diversity

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Abstract

Despite dominating biodiversity in the Mesozoic, dinosaurs were not speciose. Oviparity constrained even gigantic dinosaurs to <15kg at birth; growth through multiple morphologies led to consumption of different resources at each stage. Such disparity between neonate and adults could have influenced the structure and diversity of dinosaur communities. Here we quantify this effect for 43 communities across 136 Ma and seven continents. We find megatheropods (>1,000kg), such as tyrannosaurs, had unique effects on dinosaur community structure. While herbivores spanned the body-size range, communities with megatheropods lacked carnivores weighing 100-1,000kg. We demonstrate that juvenile megatheropods likely filled the mesocarnivore niche, resulting in reduced overall taxonomic diversity. The consistency of this pattern suggests ontogenetic niche shift was an important factor in generating dinosaur community structure and diversity.

Introduction

Dinosaurs were the dominant terrestrial vertebrates for over 150 million years, yet their species diversity, particularly at sizes below 60kg, remained well below that of other

fossil groups (1). Moreover, their overall body size distribution differed from other vertebrates. Because small-bodied vertebrates can finely partition resources and have high turnover between environments (2, 3), they typically have the highest diversity across regions. Yet curiously, large-bodied dinosaurs were the most diverse. This was particularly true for herbivorous sauropods and ornithischians, while the predominantly carnivorous theropods exhibited a more uniform range of sizes globally (4). While the preponderance of large-bodied forms may partially be due to taphonomy (5), some 90% of dinosaur species below 60kg would have to be missing from the fossil record for the body mass distribution of dinosaurs to resemble that of extinct mammals, which display a pattern less skewed by size (4). Rather, dinosaurs' global body mass distribution patterns may have been linked to their physiology; as oviparous organisms, the largest dinosaurs grew from disproportionately small infants (6). Many dinosaurs exhibited significant morphological differences between juveniles and adults (7-8), resulting in the utilization of different resources through growth and development(9-12), a relatively rare terrestrial life-history strategy observed mostly in large egg-laying reptiles (13). Moreover, rapid growth combined with low adult survivorship (14-16) resulted in large populations of juvenile dinosaurs (17), which may have competed with dinosaurs that were small and medium-sized as adults.

Here we test whether low dinosaur species diversity and their unique body size distribution was, at least partially, owing to the large disparity between neonate and adult body size, with juveniles of larger-bodied species filling ecological niches that might have otherwise been available to other taxa. This concept of 'ontogenetic niche shift' (ONS) in dinosaurs is widely assumed based on modern correlates (10, 13-14, 18-19).

For example, based on modelling of hypothetical dinosaur communities, Codron et al. (9, 11) predicted that ONS led to reduced dinosaur diversity between 1-1000kg. Despite these predictions, little work has empirically explored juveniles' influence on community structure and overall dinosaur diversity (11, 19). Thus, we examine small-scale body size patterns for evidence of competitive interactions using fossil evidence from dozens of communities representing a wide variety of environments spanning the majority of dinosaur evolution, and evaluate the potential effects of spatial scale and trophic affiliation using well constrained groups of biologically interacting species.

Our analyses are based on 43 dinosaur communities constructed from data extracted from the Paleobiology Database (20-21) (Table S1.1). From this baseline, each species' occurrence and taxonomic validity were checked individually against the literature, with taxa deemed synonymous by most experts removed, and novel taxa absent from the PBDB added. Masses were derived using averages from the primary literature (Table S1.1). Wherever possible, formations were limited to smaller subsets of co-occurring species. Our dataset represents seven continents spanning 136 million years, including >550 species. We predicted dinosaur communities with strong local drivers would diverge from the global distribution (2, 22-23). As ecological interactions such as competition might not have influenced carnivorous and herbivorous dinosaurs equally (24) the shape of each carnivore and herbivore dinosaur guild within each community was compared against the global distribution (4).

Results

We find the overall body size distributions within communities are consistently bimodal regardless of continent, taxa, and time, resulting in less extreme skew towards

large size than evidenced in the global distribution (global skew = -0.577, community average skew = -0.365; Table S1.2). The disparity between the local and global distributions is driven primarily by small (10-100kg) carnivorous dinosaurs (Table S1.4, Fig 1); when examined separately, local herbivore body mass distributions closely reflect their global distribution, suggesting ecological interactions have little effect on their distribution (K-S test $p < 0.05$ in 40% of communities; Table S1.3).

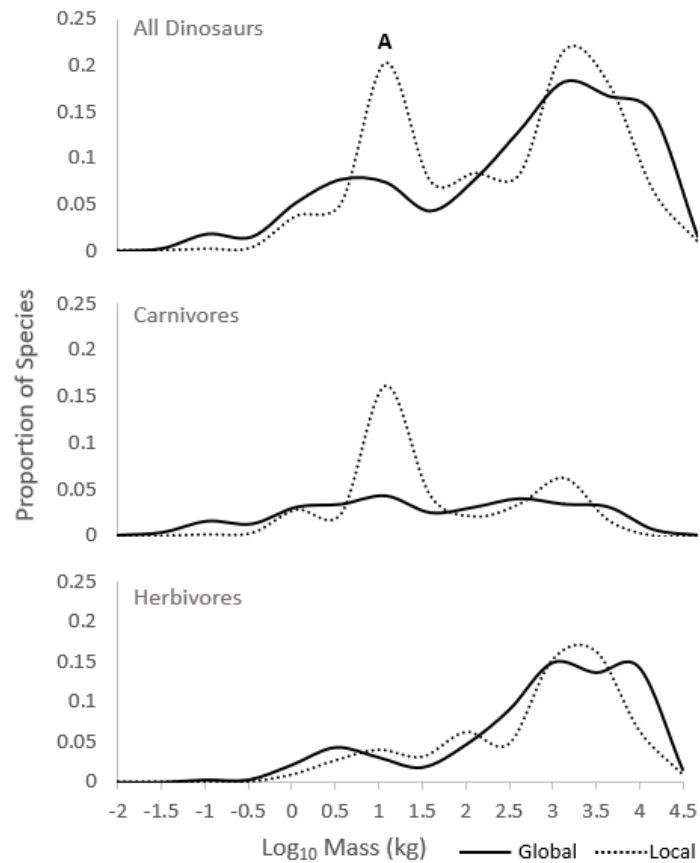


Figure 1.1 Community divergence from global distributions. Distributions comparing 1,303 global taxa to local community taxa (median). Overall, global taxa are more left-skewed and communities are more bimodal. A: largest deviation from the global distribution- the same deviation is clearly shown in the carnivore distribution.

In contrast, most carnivorous guilds within communities differ from the global carnivore pattern (K-S test $p < 0.05$ for 64% of communities; Table S1.4), as predicted

for strong local interactions. Pairwise comparisons between carnivore guild distributions are non-significant in 92% of tests (Two tailed t-test, $\alpha=0.05$; Bonferroni correction for multiple comparisons: $\alpha=0.000058$ non-significant in 99.7%, Table S1.7) despite differing variances, means and sample sizes, suggesting similar underlying drivers across communities. The only exceptions are formations lacking megatheropods (carnivores >1,000kg) (e.g., Tremp, Bissekty), those dominated by very small taxa (e.g., Yixian), or those containing multiple sauropods (e.g., Morrison, Lameta). The availability of multiple enormous prey species may have reduced interspecific competition and allowed the coexistence of an unusually diverse assortment of carnivores.

Community distributions exhibit a persistent lack of carnivorous dinosaurs weighing between 100-1,000kg (Fig 2). The least likely body size of carnivorous taxa is consistently in the 100-300kg range (Fig S1). For perspective, if the modern mammal carnivore assemblage of Kruger National Park were similarly structured, there would be no carnivores between the size of an African lion (190kg) and a bat-eared fox (4kg) (Fig 3). The carnivore ‘gap’ is above the expected limit of taphonomic size bias against small dinosaurs (5), and the drivers of such bias are unlikely to selectively affect carnivores but not herbivores, suggesting the gap represents a true biological signal. Moreover, it is unlikely that other clades, such as mammals or crocodylomorphs occupied this body size niche, as no known Mesozoic mammals exceeded 15kg (22), and crocodylomorphs were predominantly semi-aquatic after the Triassic (25). Furthermore, the width of the carnivore body size gap is correlated with the size of the largest carnivore (Kendall Rank $\tau = 0.437$, $p = 0.000652$). The presence of megatheropods in the community decreases the likelihood of co-occurring species between 100-1,000kg even further (Table S1.5).

Strikingly, formations without megatheropods, such as Yixian Lujiantun, do not exhibit body size discontinuities in their carnivorous dinosaur assemblages.

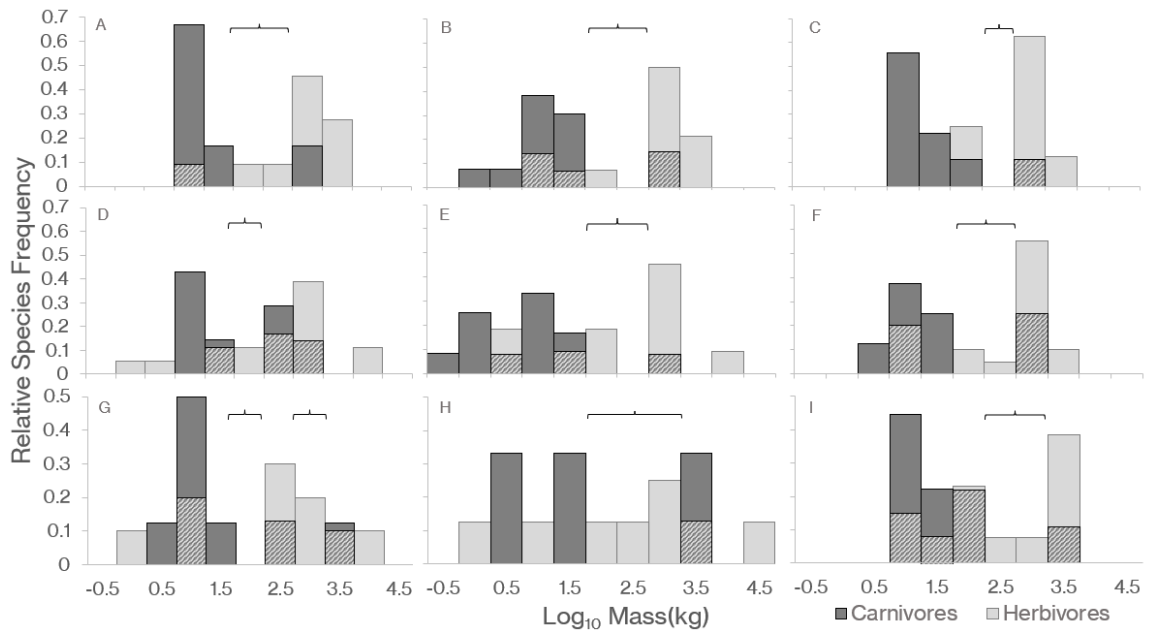


Figure 1.2 M-S distributions of nine formations (A Judith River, B Dinosaur Park, C Two Medicine, D Bayan Shireh, E Barun Goyot, F Horseshoe Canyon, G Cedar Mountain, H Cloverly, I Hell Creek). Brackets illustrate the gaps in carnivore distributions.

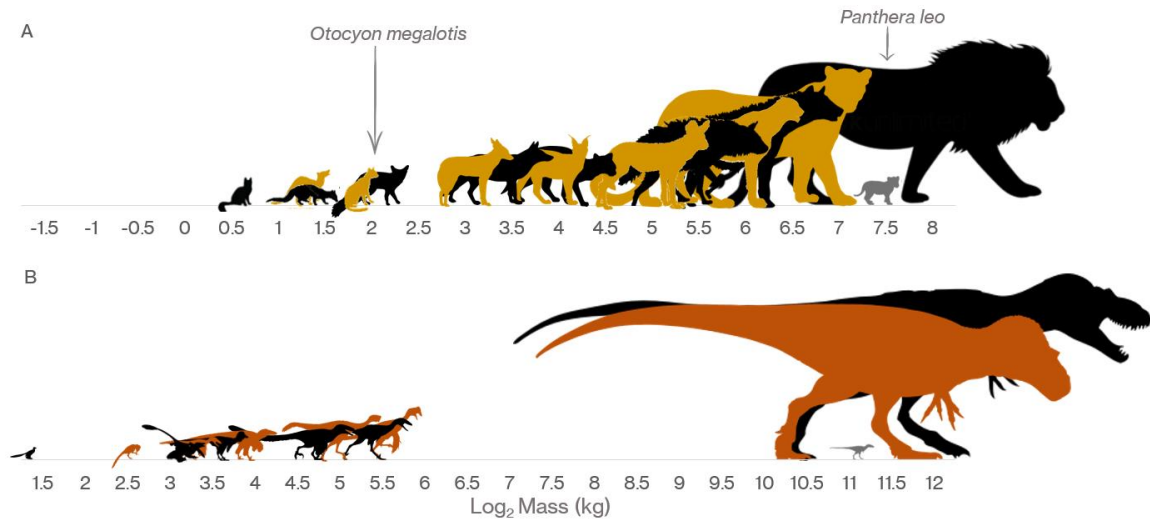


Figure 1.3 The dinosaur gap vs modern carnivorous mammals. A Carnivorous mammals of Kruger National Park organized to scale by mass. B Carnivorous dinosaurs of Dinosaur Park Formation if the largest carnivore were scaled equal to the largest mammalian carnivore in Kruger. Infants of largest species below adult for relative growth requirement.

While the overall distribution of carnivore body size is consistent, the gap itself is dynamic. From the Jurassic to the Cretaceous the size gap in carnivore species shifts towards larger sizes, mirroring the evolutionary increase in overall dinosaur size (26) and widens from an average of 436kg to over 2,060kg. We suspect the shift and expansion of the body size gap is due to a number of changes from the Jurassic to the Cretaceous resulting in increased competition, including 1) decrease by half of average prey body mass, limiting the potential for size partitioning (26), 2) the diversification of small, potentially endothermic carnivorous dinosaurs (27), and 3) heightened ONS in Cretaceous megatheropods.

A smaller size gap is found in Jurassic communities, which are characterized by multiple large allosauroids and medium sized ceratosaurs. Allosauroides is a morphologically diverse clade (28), which likely facilitated the co-occurrence of multiple carnivores within communities. Juvenile allosaurs were more similar to adults than Cretaceous megatheropods (29), resulting in fewer feeding niche shifts through ontogeny. Predation on sauropods (30) may have reduced allosaurs' competition with ceratosaurs, which have been associated piscivory or omnivory, respectively (31). This relatively high morphological differentiation and associated dietary niche partitioning, combined with limited ONS in megatheropods may have allowed for the coexistence of large and medium sized Jurassic carnivores.

The end of the Jurassic saw a drastic reduction in the diversity of both sauropods and stegosaurs, and may have led to the disappearance of many allosauroid taxa (32). Replacing the diverse megatheropod guilds of the Jurassic were Cretaceous communities dominated by a single clade; tyrannosaurs in the north and abelosaurs in the south. Both

tyrannosaurs and abelisaurids have been associated with extensive morphological changes through ontogeny (7, 33). Concurrent diversification of dromaeosaurs added competitive pressure on the truncated prey base (34). The ornithischian prey that replaced sauropods likely travelled in multigenerational herds (35) limiting the possibility of predation of isolated juveniles. We suggest competition for a limited prey source by both large and small carnivores, and the broadening of megatheropod niches resulted in a widening of the carnivore gap.

For juvenile megatheropods to exclude smaller species from the community, they must represent a non-negligible proportion (>50%) of the biomass. Moreover, juvenile peak biomass must fall predominantly within the carnivore gap. To evaluate the effect of juveniles (<16 yrs (12, 33)) on community composition, we calculated the proportion of juvenile biomass using published growth rates derived from lines of arrested growth and survivorship curves based on relative age abundance from mass-death assemblages recorded in the fossil record (17, 36–38).

We calculated biomass through ontogeny for 1,000-individual cohorts of six tyrannosaurs and four allosaurs by multiplying the mass (M_a) and survivorship (S_a) at age (a) such that the proportion of any species' biomass represented by juveniles (BM_J) is

$$BM_J = \sum \left(\frac{M_1 * S_1}{\sum (M_1 * S_1, M_2 * S_2 \dots M_{max} * S_{max})} \right), \left(\frac{M_2 * S_2}{\sum (M_1 * S_1 \dots M_{max} * S_{max})} \right) \dots \left(\frac{M_{16} * S_{16}}{\sum (M_1 * S_1 \dots M_{max} * S_{max})} \right)$$

We then related (BM_J) to the proportion of mass contained in adults, set to 1, so that relative juvenile species proportion (RSP_J) is equal to

$$RSP_J = BM_J * \left[\frac{1}{1 - BM_J} \right]$$

For example, if juveniles represented 60% of the biomass of *Tyrannosaurus rex*, the juvenile ‘morphospecies’ would be equivalent to 1.5x the taxonomic species.

Tyrannosaurs and other megatheropods did not live long past somatic maturity (16), and juvenile growth rate approached that of mammals and birds (12). This supports our finding that megatheropod biomass peaked at sexual maturity (age 16-19) and followed a log-normal distribution (Fig S2). For all 10 species examined, juvenile biomass is proportional to least 60% of adult conspecifics (Table S1.6), and exceeds adult biomass in five tyrannosaur species. Substantial proportions of juvenile biomass, including peak biomass, fall within the range of the size gap in all communities (Fig 4). Thus, juvenile megatheropods represent taxonomically identical, but ecologically disparate ‘morphospecies’ within their communities, with the greatest potential influence in the mass range of 300-1000kg. Our results support the hypothesis that juvenile megatheropods effectively filled the niche of medium-sized, or meso-carnivores and therefore likely limited diversification of theropods with adult body sizes that fell within this range.

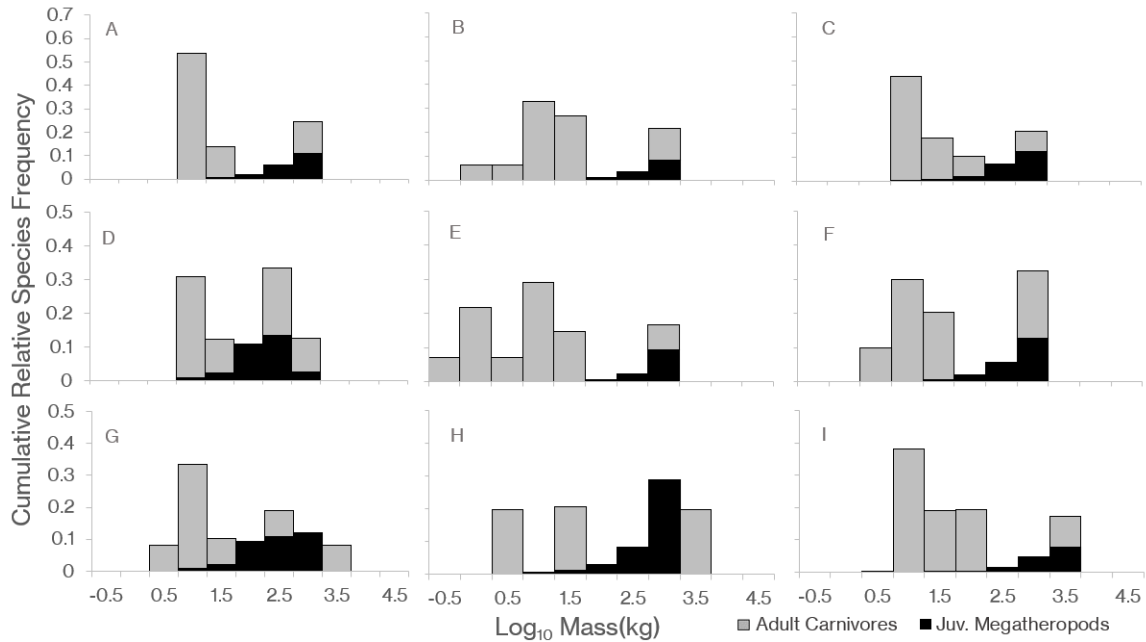


Figure 1.4 Community distributions with juvenile megatheropods as morphospecies stacked with adult conspecifics (Formations as in Fig. 2). The influence of juveniles is highest within the carnivore gap and is proportional to at least 60% adults in all measured communities. Megatheropods less than 3,000kg exert the most influence, matching or outweighing their adult conspecifics in over half of the measured formations.

That large carnivorous dinosaurs may have filled multiple niches through ontogeny is not a new assertion (7, 9, 11-12, 32), yet despite their morphological disparity, adults and juveniles continue to be grouped together in diversity indices, which is accurate taxonomically, but not ecologically. Our analysis demonstrates the influence juvenile megatheropods would have had as morphospecies on their community. We find a gap in the community body size distribution of carnivorous dinosaurs regardless of continent, biome, formation size, or species examined. Our analysis demonstrates this gap was likely filled by juvenile megatheropods and suggests that low taxonomic diversity in carnivorous dinosaurs was not caused solely by taphonomy or collection bias, but rather competition for resources within and among body size niches filled by juveniles. Dinosaurs existed in a unique terrestrial community structure, largely organized as a

result of their extreme size, ovipary and resulting ontogenetic niche shift. The grow fast, die young approach of megatheropods resulted in a predominance of juveniles in the local communities, filling the morphological and functional role of mesocarnivores, which as a result are absent from the fossil record as unique species, artificially deflating diversity indices of dinosaurs as a whole.

Chapter 2

Sinking teeth into ontogeny: Dental Microwear Texture Analysis quantifies niche partitioning in tyrannosaurs

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Abstract

Given the immense separation of body size between juvenile and adult tyrannosaurs it is likely they consumed different prey. However, reconstructing the dietary niche of these non-analogue carnivores is challenging, as their dentition provides relatively few clues to specialized dietary ecology. While dental microwear texture analysis (DMTA) has been effective in characterizing generalized diet in modern reptiles, recent studies fall short of identifying specific dietary components that contribute to dental microwear. Further, as inferences of tyrannosaur diet from extant reptiles may be limited due to reptiles' relatively small body size, and inferences from oft-studied carnivorous mammals may be misleading due to differences in form and function, it is necessary to calibrate interpretations of DMTA across these taxa before they can be applied to tyrannosaurs. Here we examine patterns of both DMTA and International Organization for Standardization (ISO) texture analysis within and between mammalian and reptilian carnivores and identify specific dietary components that correlate to dental microwear in each. We then utilize these results to interpret the dental microwear of in-situ teeth of four tyrannosaur genera at three age classes (juvenile, subadult and adult) between and within each genus through ontogeny. We find significant differences in dental wear

through ontogeny within all genera, and among multiple age classes between genera, indicating ontogenetic and taxonomic dietary separation. Specifically, our results indicate adult and juvenile tyrannosaurs consumed brittle foods with relatively little bone interaction, possibly indicative of consuming thick integument and flesh mostly whole. Conversely, sub-adult tyrannosaurs, particularly *Tyrannosaurus* consumed more malleable foods, with high instance of durophagy, potentially through the utilization of defleshed carcasses as a dietary supplement. Finally, we find significant differences in dental wear between multiple age classes of co-occurring tyrannosaurs, a possible avenue of competition avoidance within these genera.

Introduction

The debate surrounding the feeding ecology of tyrannosaurs has continued for at least 60 years (379–386). While coprolites (387, 388), tooth traces (32, 389–391) and finite element analysis (392–394) have characterized tyrannosaurs’ general carnivore niche, the specifics of prey preference and prey acquisition strategy remain largely elusive. This debate is further complicated by the potential for dietary niche shifts through ontogeny in tyrannosaurs. Both the immense separation in size between juveniles and adults, and changes in morphological characteristics such as bite force (395–397), gracility and cursoriality (8, 12, 33, 398, 399) would have made the utilization of different prey and prey acquisition techniques very likely through ontogeny (14, 19, 400–402). However, the precise nature of these dietary shifts has yet to be quantitatively assessed.

One powerful technique for assessing the dietary ecology of animals is Dental Microwear Texture Analysis (DMTA). DMTA examines the microscopic features left in enamel during the processing of food items using scale sensitive fractal analysis (403,

404). Its engineering cousin, developed by the International Organization for Standardization (ISO), uses a variety of metrics to assess surface textures similarly to DMTA. Both DMTA and ISO textural analysis have been applied to a wide variety of extinct and extant vertebrates, including mammals (405–407), lepidosaurs (408), mosasaurs (409), archosaurs (410, 411) and dinosaurs (412). As such, both DMTA and ISO textural analysis have been demonstrated as reliable proxies for diet within a wide variety of taxa, particularly as a proxy for durophagy in carnivores (413).

However, with few exceptions (408) DMTA and ISO have yet to be compared across taxonomic classes, where feeding structures and mechanics can vary significantly (414, 415). It is therefore unclear whether factors influencing microwear in mammalian and reptilian carnivores are the same. This understanding is essential, as the majority of interpretations underlying DMTA have been based on the diets of modern mammals (405, 413, 416, 417). While we might expect tyrannosaurs to have diets analogous to extant carnivorous mammals, tyrannosaurs' use of reptilian food processing strategies (414, 418) may significantly influence microwear patterns.

Here we compared published DMTA and ISO values for extant carnivorous lepidosaurs, archosaurs and mammals against common dietary components to identify drivers of microwear. Using these extant dietary correlations as a guide, we then characterized the dental microwear patterns of four Late Cretaceous North American tyrannosaurids (*Albertosaurus*, *Gorgosaurus*, *Daspletosaurus* and *Tyrannosaurus*) to assess dietary niche partitioning between and within each genus through ontogeny. Were ontogenetic niche shift an important life history strategy in tyrannosaurs, we would expect to observe significant separation in dental microwear between ontogenetic stages within genera.

Further, as competition was likely a significant factor in the formation of megatheropod (carnivorous dinosaurs >1,000kg) assemblages (401, 402), we would expect dental microwear to significantly differ between the co-occurring tyrannosaurs *Gorgosaurus* and *Daspletosaurus* (419).

Materials and Methods

DMTA and ISO Calibration

As DMTA and ISO are utilized unequally among studies of reptiles and mammals, we identified metrics which approximate similar qualities in microwear texture. We used simple linear regression on values recorded for our 33 tyrannosaur specimens to identify covariance (coefficient of determination > 90%) between 5 DMTA and 20 ISO metrics. We then examined the formulas underlying these metrics to identify which, if any, approximate similar textural characteristics, but are calculated in such a way that decorrelates them. For example, two metrics may assess the directionality of scratches, but are poorly correlated because one calculates the average contiguous length of scratches, while the other calculates the average angle of scratches.

To identify specific contributions to dental microwear among extant carnivorous mammals and reptiles we collected published scat and stomach content data (Table S2.1, (46, 48–101)) for 11 mammal species from 4 families and 26 reptile species from 12 families spanning from 1-700kg in body mass. These species were selected based on the availability of dental microwear values in the literature (408, 410, 474, 475). As exact diet information was not available for each specimen, and as specimens within species were collected from differing geographic locations, we used the average of percent diet by volume recorded for species. We estimated percent carrion use based on recorded

scavenge rates for mammals, and rate of carcass sharing for large reptiles, recorded as a percentage of the portion of large mammals within each species' diet. When available, rates of bone marking were included from the literature. "Small" mammals were defined for each species, based on the possibility of being consumed without dismemberment. We then compared dietary proportions against averaged species values for each DMTA and ISO metric using Kendall Rank correlation ($\alpha = 0.05$). Prior to averaging, values were normalized to a scan area of 102x138 μm to limit variation due to collection technique.

Dental Microwear Collection

The tyrannosaur genera used in this study were selected based on the number of occurrences of North American Tyrannosauroids recorded in the Paleobiology Database (20) (Figure S2.1). We used teeth from the Museum of the Rockies (MOR), the Royal Tyrrell Museum (RTMP), the Field Museum of Natural History (FMNH), the Burpee Museum of Natural History (BMRP) and the University of California Museum of Paleontology (UCMP). Specimens lacking provenance, containing obvious modifications outside regular preservation were not used. In-situ teeth were collected preferentially, although teeth no longer situated in the jaw were used when their source specimen could be unequivocally identified (Table 2.1). An exception were "*Aublysodon*" teeth, which are likely the juveniles of *Daspletosaurus* (476). These are so exceedingly small that they cannot be mistaken for the teeth of older individuals, and were collected from formations with only one tyrannosaur.

Specimen	Age	Source	Scanned Tooth			Facet Location	Asfc	epLsar	Tfv	lx3HASf	lx9HASf	Sdr	Vmp	spk	smr1	Sq	Ssk	Sku
			Position	Side	Area													
Albertosaurus																		
TMP79-14-1056	8* (485)		PostDent	Labial	Distal Posterior	Distal Labial	1.0388	0.0042	10696.2	0.3250	0.5684	0.6943	0.0148	0.3182	9.2151	0.5237	-0.4367	3.2386
TMP07-7-1	8* (489)		LDent3	Lingual			1.3730	0.0057	3117.9	0.2194	0.5150	1.3428	0.0205	0.2683	9.9899	0.4546	0.0288	3.4595
TM93-36-539	8* (490)		LMax	Lingual	Anterior		2.0198	0.0058	9753.1	0.3314	0.5810	0.8976	0.0308	0.4840	9.7289	0.6484	-0.0906	3.1512
TMP85-98-1	12 (53)		MidDent	Labial		Labial	2.2109	0.0046	6956.2	0.4546	0.7464	1.6687	0.0177	0.2838	5.9852	0.6380	-0.2736	2.7668
TMP86-64-1	15 (8)		Premax2	Lingual	Mesial	Lingual	1.8248	0.0069	11672.4	0.4348	0.5493	0.9556	0.0094	0.1337	4.0018	0.4731	-0.8221	3.3765
MOR020-5	Adult*		AntLat	Lingual	Mesial Anterior	Anterior	3.4485	0.0041	12567.8	0.5604	0.7748	2.6975	0.0267	0.4881	7.9344	0.8552	-0.4257	4.9001
TM98-63-88	23* (53)		LMax	Lingual	Mesial Anterior	Anterior	1.9806	0.0021	12663.9	0.2669	0.5386	1.0316	0.0313	0.6320	9.8063	0.5720	0.0029	4.0534
TMP81-10-1	24 (53, 480)		LMax11	Labial	Mesial		1.1656	0.0028	6294.3	0.3271	0.6122	0.7281	0.0086	0.1894	6.3496	0.3205	-0.8062	3.9994
Daspletosaurus																		
TMP99-55-249*	2 (481)		Premax	Lingual	Mesial		1.7162	0.0068	11445.3	0.7585	1.0029	1.5992	0.0568	1.0055	10.3849	0.9081	0.0067	3.0427
TMP01-12-199*	2 (481)		Premax	Labial			2.2822	0.0009	15942.4	0.3084	0.5453	1.4857	0.0160	0.3775	5.0600	0.5856	-0.5636	3.0223
TMP90-117-6*	2 (481)		MidLat	Labial	Anterior		3.5538	0.0018	15907.5	0.1773	0.4513	2.3799	0.0243	0.3211	7.3581	0.8659	-0.5325	3.6504
TMP94-143-1	10 (53)		RDent6	Labial	Distal		2.6211	0.0041	8261.6	0.7273	1.1206	1.6953	0.0174	0.3275	8.0782	0.4838	-0.8571	4.9034
MOR590	18 (8)		RDent8		Distal		3.0967	0.0044	10237.0	0.2834	0.5878	2.2401	0.0589	1.4718	14.6339	1.5124	0.1350	3.1713
TMP01-36-1	21 (482)		Premax3	Lingual		Lingual	6.1116	0.0030	12836.8	0.3253	0.5586	4.2356	0.0237	0.4475	8.3707	0.6658	-1.1754	6.0966
TMP85-62-1	23 (53)		AntRMax	Labial	Mesial Anterior	Anterior Labial	2.0737	0.0051	2171.1	0.5151	0.6908	1.3911	0.0166	0.6124	9.0527	0.4988	-0.7748	4.1478
Gorgosaurus																		
TMP09-12-14	8* (491)		RMax5	Labial	Distal Posterior	Distal Anterior	3.0285	0.0031	3243.2	0.2925	0.6490	1.7684	0.0130	0.2501	8.2170	0.4420	-0.8771	3.7466
TMP91-36-500	10 (53)		RMax5	Labial	Distal	Distal	1.0977	0.0036	4388.0	0.3722	0.6192	0.6222	0.0097	0.3682	6.4893	0.2578	-0.5059	4.1839
TMP95-5-1	12 (53)		RMax4	Labial	Distal		2.3915	0.0071	9381.6	0.2900	0.5007	1.4929	0.0199	0.2918	10.0155	0.4487	-0.1652	3.0833
TMP00-12-11	13* (487)		LDent6	Labial	Mesial Anterior		2.1708	0.0021	9652.8	0.2716	0.5635	1.2263	0.0127	0.2366	6.5524	0.8108	-0.6408	2.7014
TMP97-12-223	17 (16)		RMax10	Labial	Distal Anterior	Anterior Labial	1.7008	0.0051	13516.1	0.6492	0.8026	1.2958	0.0208	0.3361	5.5034	1.0816	-0.9221	3.9360
TMP94-12-602	18 (53)		RMax11	Lingual		Labial & Lingual	1.6848	0.0116	2776.7	0.4080	0.6051	0.9657	0.0084	0.1341	7.5703	0.4456	-0.2337	2.1106
TMP67-9-164	21 (53)		LDent7	Lingual	Mesial Anterior		3.2000	0.0041	11701.8	0.5847	1.2135	2.3372	0.0168	0.3162	6.9474	0.7238	-0.8509	4.9063
TMP91-163-1	21 (483)		Premax1	Lingual	Mesial	Lingual	5.4482	0.0020	14144.8	0.2399	0.4196	3.6091	0.0298	0.6068	10.5791	0.5477	-0.1529	4.0439
Tyrannosaurus																		
BMRP2002-4-1	11 (33)		LMax2				0.7719	0.0025	3523.0	0.3084	0.4634	0.4287	0.0113	0.2110	6.2686	0.2828	-0.3025	3.3336
MOR3044	Juv*		PostLDent	Lingual	Distal Anterior		2.2620	0.0034	16147.8	0.3903	0.7825	1.4600	0.0310	0.6701	9.9132	0.6495	-0.2754	4.0440
TMP14-8-1	15* (486)		RDent7	Labial			2.6778	0.0070	12423.3	0.2785	0.6923	2.1333	0.0222	0.2782	7.0816	1.5028	-0.3605	2.4800
TMP81-6-1	18 (8, 33)		RDent7	Lingual	Distal	Distal Lingual	4.9719	0.0060	11190.7	0.6179	0.7710	4.1013	0.0270	0.1940	7.0224	0.7072	-0.2318	2.8608
MOR1125	19 (33, 484)		AntLMax	Lingual	Mesial	Lingual	7.6016	0.0057	11758.8	0.5211	0.8383	6.0142	0.0311	0.9025	7.4649	1.4814	-0.5655	3.4616
MOR980	21 (33, 502)		mg				0.9687	0.0035	10065.7	0.2453	0.4705	0.5901	0.0184	0.1414	6.9544	0.8168	-0.4122	2.5453
MOR008	22 (33, 53)		RDent7	Labial	Distal		0.8695	0.0030	10140.7	0.4437	0.6749	0.6225	0.0224	0.4125	9.2181	0.4732	-0.2442	3.1113
MOR1128	22 (484)		MidLat				1.8533	0.0029	740.6	0.4011	0.5204	1.2470	0.0113	0.2357	8.3954	0.2663	-1.3522	9.9927
UCMP131583	25* (488)		RDent5				1.4527	0.0028	10788.5	0.6293	1.3896	1.6255	0.0165	0.3124	6.0411	1.0018	-0.6466	3.4648
FMNHPR2081	28 (33)		LMax4	Labial	Distal Posterior		1.2723	0.0020	12177.6	0.5191	0.8372	1.1044	0.0306	0.6163	9.4859	0.7596	-0.2981	3.0990

Table 2.1: Age, tooth information, facet location and DMTA and ISO values for all tyrannosaur teeth analyzed

We examined microwear from both the lingual and labial sides of lateral maxillary and dentary teeth. Anterior dentary teeth and premaxillary teeth were used only when lateral teeth were unavailable or did not yield viable microwear. While it would be ideal to obtain microwear from teeth in the same jaw position and from the same tooth location, the limitations of the fossil record of tyrannosaurs makes this unfeasible. The dental microwear of premaxillary teeth might be expected to vary the most from more posterior teeth due to their position in the mouth and slightly different morphology, yet using a two tailed t-test with unequal variance ($\alpha < 0.05$) premaxillary teeth could only be discerned from other teeth in one of twelve significant microwear metrics (*Tfv*, $p = 0.003$).

We selected teeth with visible wear facets in the enamel whenever possible. Although it has been hypothesized that the wear facets on archosaur teeth may be due to accidental occlusion with other teeth, and might therefore obliterate microwear caused by food (409), other authors have noted the presence of similar wear facets on non-occluding saber teeth of *Smilodon fatalis* (477). The existence of facets on both the labial and lingual sides of individual tyrannosaur teeth (Table S2.2) also contradict this hypothesis (477–479). Regardless, wear was never recorded from the centers of such facets on the tyrannosaur teeth in this study, where tooth-on-tooth wear is most likely to have influenced results.

Teeth were cleaned with cotton swabs soaked in 91% Isopropyl Alcohol to remove dust and debris. We then created high resolution molds using President Jet Regular Body Polyvinylsiloxane (Coltene/Whaledent ltd.) Molds were retaken if visible debris detached from the tooth surface. We then made casts from the molds using EpoTek 301 low

viscosity medical grade clear epoxy resin and hardener, centrifuged at 1000rpm in 50mL falcon tubes for 10 minutes to remove air bubbles. Casts were filled slowly using disposable pipettes and left undisturbed to cure between 1-7 days due to the large size (>3" deep) of some molds.

Casts of teeth were cleaned with 91% alcohol on cotton swabs and examined using white-light confocal microscopy at 20x magnification to identify areas showing non-diagenetic wear within the enamel. As many areas within facets were entirely worn through into dentin, great care was taken to select areas entirely within the enamel surface. Images of these areas were taken using a Sensofar PL μ profiler at 10x magnification, generating 5nm vertical resolution 3D point clouds at lateral intervals of 0.166 μ m. For each tooth, four adjacent 102x138 μ m images were sampled covering a total area of 204x276 μ m. Generated point clouds were analyzed with SSFA software (ToothFrax and SFrax, Surfract Corp) to identify variation in 25 DMTA and ISO metrics, which are described in the supplemental material (Table S2.3)

Tyrannosaur age assessment

Because we used teeth associated with cranial or post cranial anatomy, it was possible to age all 33 specimens. While the majority of age estimates had already been assigned by previous investigators (Table 2.1) (8, 17, 33, 53, 480–484), the ages of 9 specimens were estimated based on the size of associated skeletal elements (53, 485–491). Although some intraspecific variation is admitted likely in tyrannosaurs, we are not relying on exact ages in any analysis, thus this variation is not likely to affect our results.

We categorized specimens into three age classes: “juvenile”, “sub-adult” and “adult” such that “juveniles” were specimens that had yet to reach the rapid growth phase, “sub-

adults” were currently in the rapid growth phase, and “adults” had achieved relative asymptotic growth following the rapid growth phase. The timing of the “sub-adult” phase of rapid growth used to delineate our groups was based on growth curves of dozens of specimens (33, 37, 398, 492), and occurs at approximately 10-18 years for the smaller *Albertosaurus*, *Gorgosaurus* and *Daspletosaurus* and at approximately 15-20 years for the larger *Tyrannosaurus*.

Tyrannosaur Microwear Analysis

To assess the potential for dietary separation between species of tyrannosaurs, we transformed the values of 4 DMTA metrics and 7 ISO metrics (those found to be significantly correlated with diet in reptiles) into ranked data. This allowed for the parametric analysis of nonparametric data; a more statistically powerful method for small datasets. We then used Kruskal-Wallis analysis of variance ($\alpha = 0.05$) (403) to compare mean values between genera and ontogenetic group. As ANOVA testing only determines whether all groups tested have identical means, we followed each ANOVA with the conservative Dunn’s multiple comparison test (493) to identify if any group mean varied from any other.

As a test for dietary niche partitioning among genera, we compared the four tyrannosaurs against one another as whole, with no consideration of ontogenetic grouping. This test also acted as a general control with which to compare variation through ontogeny. To more accurately assess taxonomic dietary separation through the isolation of ontogenetic variation, we then compared the four tyrannosaurs within each ontogenetic group: juveniles compared to juveniles, sub-adults to sub-adults and adults to adults. To further identify potential dietary separation between genera, particularly those

that co-occur, we compared variation in across ontogenetic stages between genera (e.g. juvenile *Daspletosaurus* against adult *Gorgosaurus*). Finally, we assess variation within each genus across ontogenetic grouping to identify shifts in diet with age.

Results

Tyrannosaur Dental Microwear

Our results indicate significant variation across ontogeny in the dental microwear of tyrannosaurs (Kruskall-Wallis with post-hoc Dunn's test, $\alpha = 0.05$). Generally, sub-adult tyrannosaurs exhibited the most distinct microwear patterns in all four genera (Figure 2.1). We observed a trend of many sharp, tall peaks (high *Sku* and *SmrI*) in juveniles and adults in *Albertosaurus*, *Gorgosaurus* and *Tyrannosaurus*, while sub-adults of these genera had rounder peaks (Figure 2.2). Similarly, we observed high directionality of scratches (high *epLsar*) in all four tyrannosaur genera.

We also found significant variation between tyrannosaurs at multiple stages of ontogeny. Both juveniles and subadults of the Albertosaurine tyrannosaurs (*Gorgosaurus* and *Albertosaurus*) had less pitting than the Tyrannosaurines (*Daspletosaurus* and *Tyrannosaurus*), demonstrated by lower values of Textural Fill Volume (*Tfv*) and Peak Volume (*Vmp*). Further, we found subadult Albertosaurines exhibited shallower wear (low *SmrI*), and fewer tall peaks (low *Spk*), and exhibited lower complexity values (*Asfc*, *Sdr*) when compared to Tyrannosaurines. Surprisingly, microwear complexity was significantly lower in adult specimens of *Tyrannosaurus* than in both *Daspletosaurus* and *Gorgosaurus*, whereas subadult *Tyrannosaurus* specimens exhibit the highest complexity values of all specimens (*Asfc* and *Sdr*) (Figure 2.2).

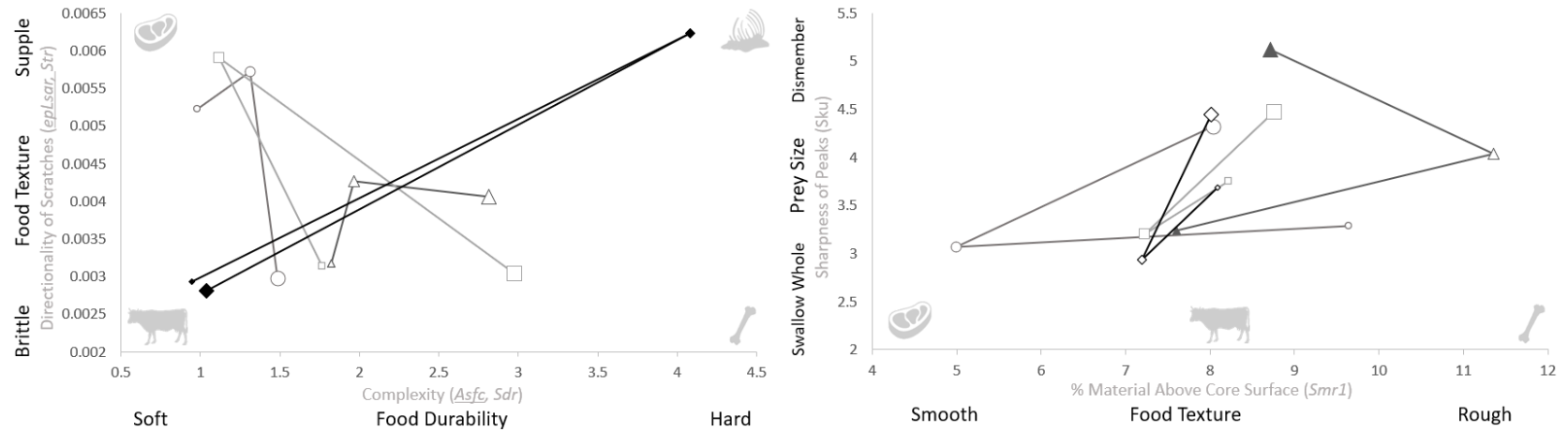


Figure 2.1: Separation in dental microwear characteristics for *Albertosaurus* (circles), *Daspletosaurus* (triangles), *Gorgosaurus* (squares) and *Tyrannosaurus* (diamonds). Ontogenetic stages shown as shape size (smallest = juveniles). Significantly different values shown by filled shape.

Results also indicated significantly lower complexity (*Sdr*) values in *Albertosaurus*, and lower peak height (*Spk*) values in *Gorgosaurus* when species were compared as a whole (Figure 2.3, Table S2.2). *Spk* and *Sdr* values were also relatively low within subadults and juveniles of *Albertosaurus*, and subadults of *Gorgosaurus*, although not significantly different from members of their age group in other genera. As such, we suspect this reflects a lack of statistical power within the smaller ontogenetic groupings, rather than an error in the significance of the variation between genera as a whole.

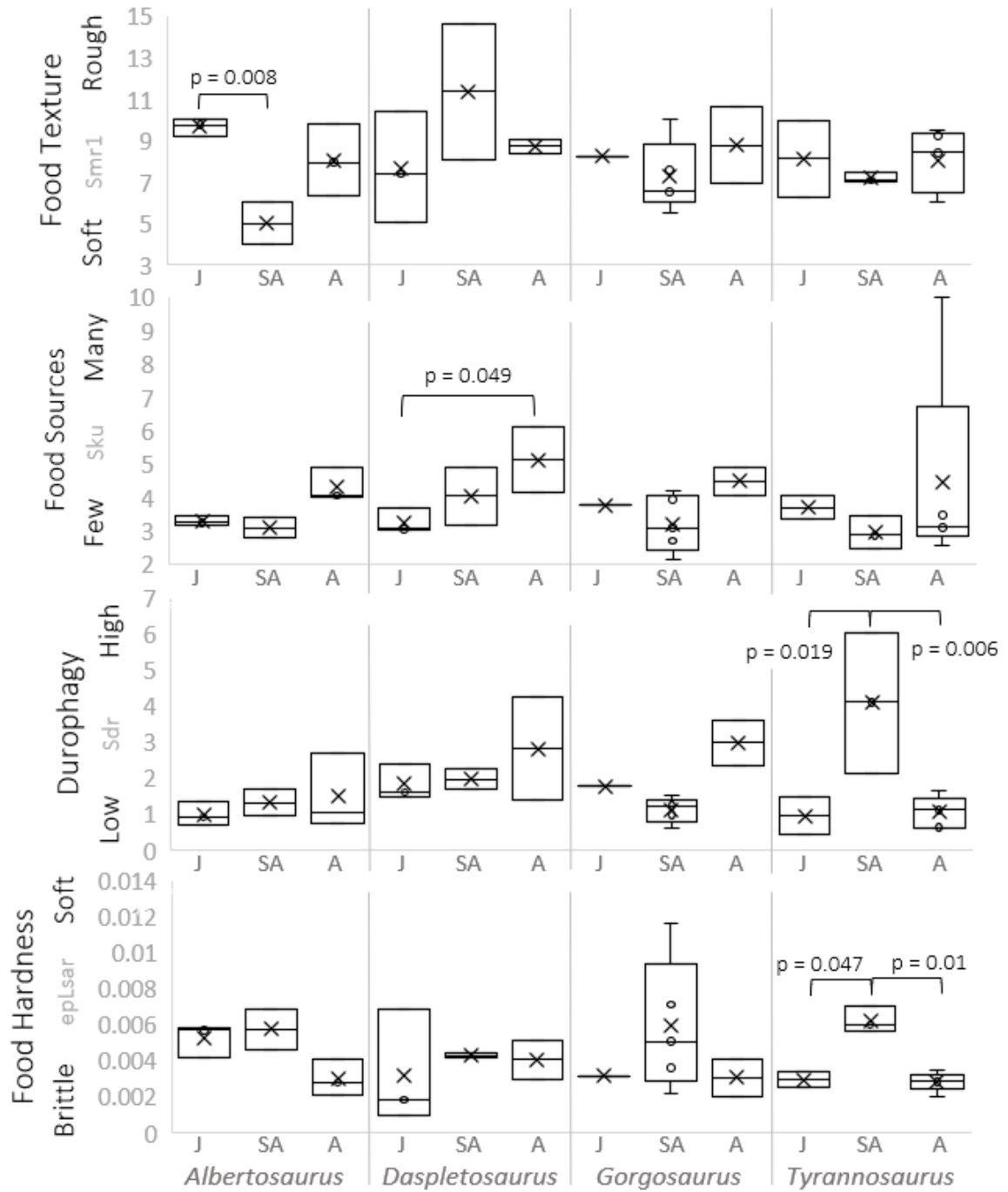


Figure 2.2: Distribution of microwear values for DMTA and ISO values with significant difference in at least one genus for genera through ontogeny. See supplementals for actual values (Table S2.2). Center lines represent group median, box extents show interquartile range for data, bars demonstrate minimum and maximum, non-outlier (open points above distributions) values. Significantly different distributions indicated by p-values in brackets above distributions (Dunn's procedure, $\alpha = 0.05$)

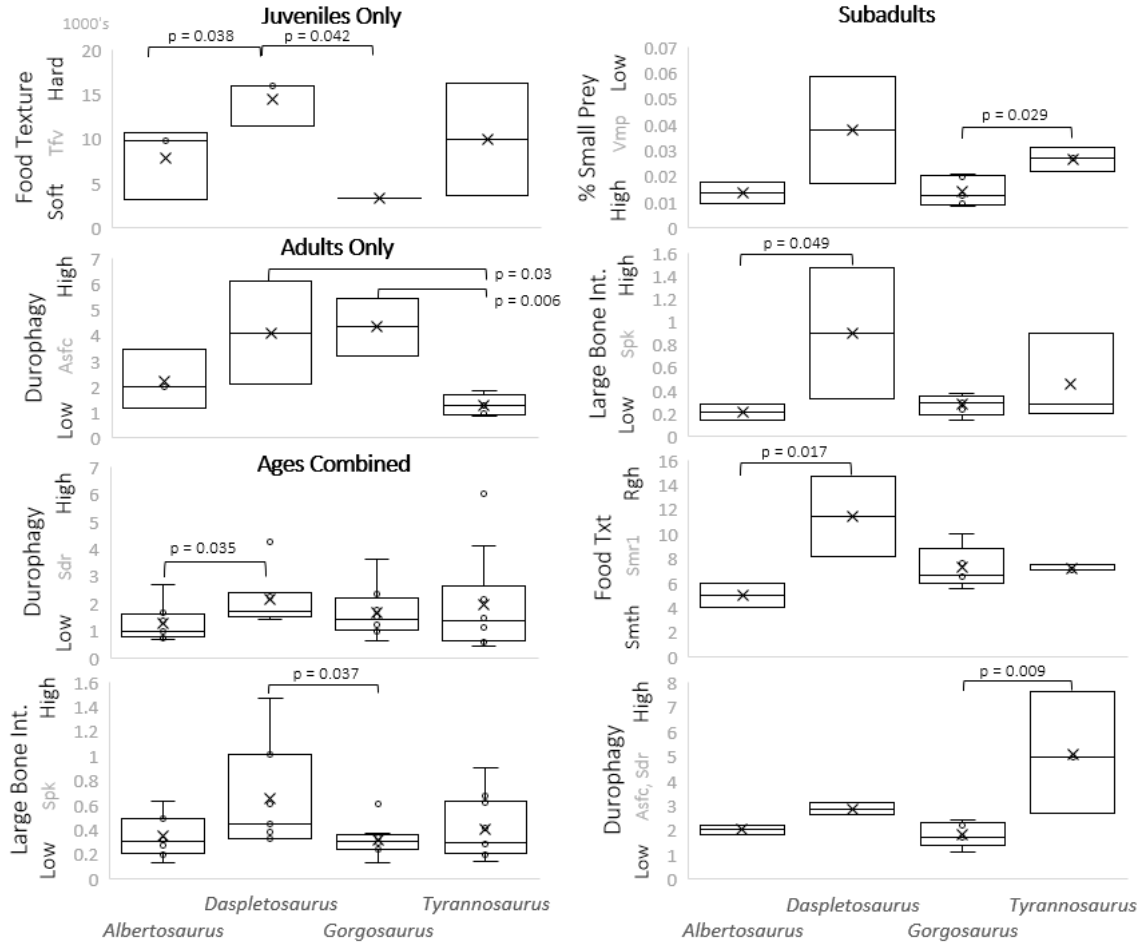


Figure 2.3: Distribution of microwear values for DMTA and ISO juveniles alone, subadults alone, adults alone and whole genera irrespective of age. Only metrics with significant differences shown. Results of all ANOVA testing listed in supplementals (Table S2.4). Center lines represent group median, box extents show interquartile range for data, bars demonstrate minimum and maximum, non-outlier (open points above distributions) values. Significantly different distributions indicated by p-values in brackets above distributions (Dunn's procedure, $\alpha = 0.05$)

DMTA and ISO Correlation

Overall we found poor correspondence between DMTA and ISO metrics based on tyrannosaur microwear values, with only *Asfc* and *Sdr* following a linear relationship. However, although not directly correlated, the DMTA metric *epLsar* and the ISO metric *Str* are both good measures of the directionality of scratches. It is reasonable, therefore, to

assume that within a certain group, *epLsar* and *Str*, and *Asfc* and *Sdr* represent the influence of the same dietary components on tooth microwear (Table S2.3).

Our results indicate that the dietary drivers of dental microwear are likely not the same between carnivorous mammals and reptiles. While we identified a significant correlation between percent carrion use and *Asfc* in mammals (Kendal Rank Correlation, $p = 0.003$), this trend was not observed in reptiles or when mammals and reptiles were grouped ($p = 0.105$). Further, significant differences in reptile and mammal *epLsar* and percent insect values ($p = 0.046$) were not reflected in either reptiles ($p = 0.903$) or mammals ($p = 0.851$) alone (Figure 2.4).

Within carnivorous reptiles we identified multiple significant correlations between dietary components and microwear. Of the 9 ISO metrics found to be correlated with diet in reptiles, 7 were strongly correlated with the percent of vertebrates and/or percent faunivory in reptile diets (Kendal Rank Correlation $\tau > [.3]$, $p < 0.05$), indicating carnivory as a significant driver of microwear in the reptiles examined. The ISO metrics *Sq*, *Ssk*, *Sku*, *Vmp*, *Spk*, and *Str* were all significantly correlated with more specific dietary components (e.g. piscivory, carrion use, invertivory, etc) (Table S2.3). Neither body size nor taxonomic family displayed significant correlation with microwear metrics in reptiles.

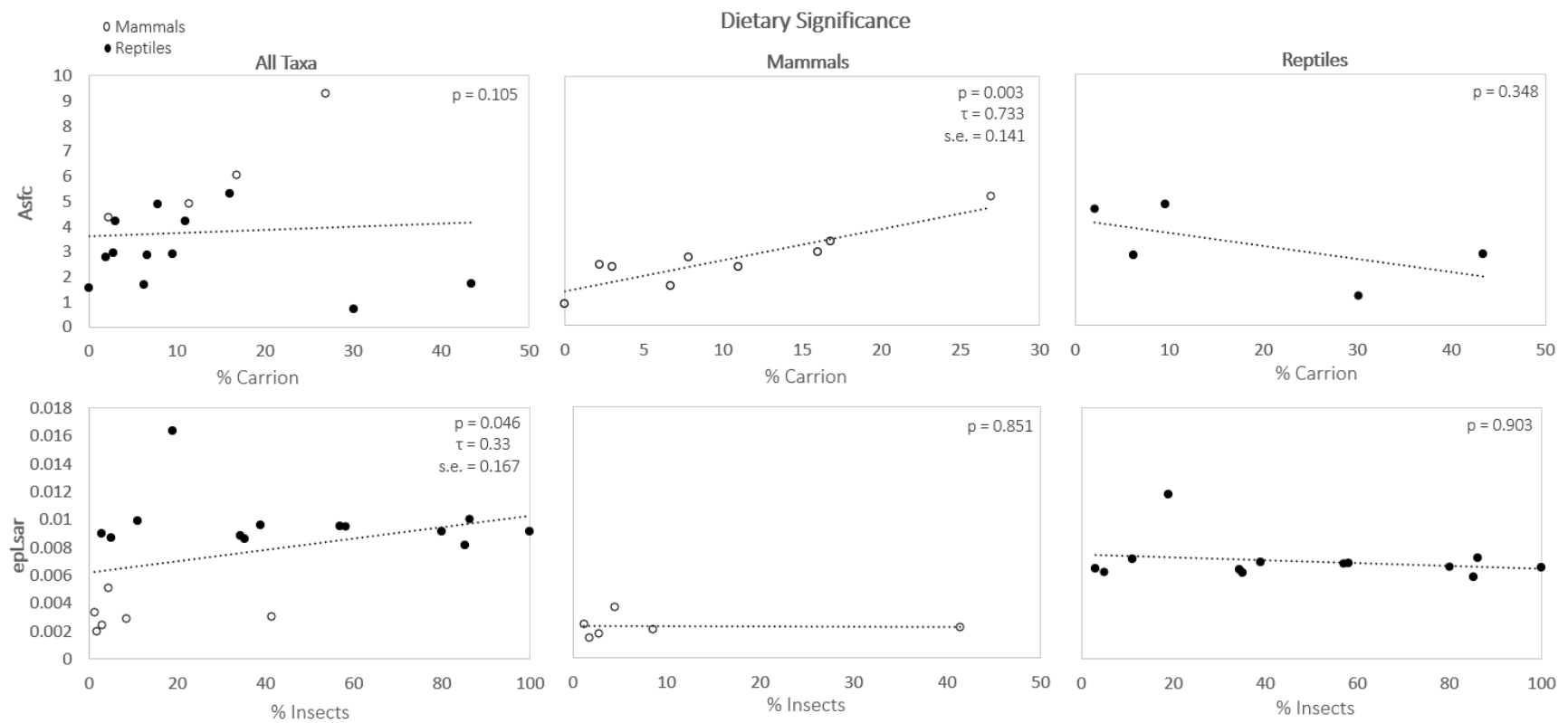


Figure 2.4: Trends displaying different DTMA parameters across higher order taxa.

Discussion and Conclusions

Our dental microwear results indicate diet varied both between tyrannosaur genera, and through ontogeny, supporting the hypothesis of ontogenetic and interspecific niche partitioning in tyrannosaurs (Figure 2.5) (Figure 2.1). Specifically, juvenile *Albertosaurus*, *Gorgosaurus* and *Tyrannosaurus* regularly consumed relatively rough (high *SmrI*), brittle (low *epLsar*) food sources with little bone interaction (low *Sdr*) (Figure 2.2). Such microwear textures may have resulted from the piercing of rough integument during the oral manipulation of whole vertebrate prey. Indeed, the dental microwear values of all juvenile tyrannosaurs most closely resembled those of predominantly piscivorous and invertivorous crocodilians (*Albertosaurus* and *Tyrannosaurus* = Spectacled Caiman (*Caiman crocodilus chiapasius*), *Daspletosaurus* = American Crocodile (*Crocodylus acutus*), *Gorgosaurus* = Saltwater Crocodile (*Crocodylus porosus*)) (Table S2.1), which regularly consume prey whole (431, 433, 438). These findings are consistent with other features reflecting active predation of small vertebrates, including high resistance to torsional stress in the skull (399) and cursorially adapted limbs (398, 494).

Within juveniles, dental microwear also varied by genus. For example, juveniles of *Daspletosaurus* exhibited higher values of durophagy (high *Tfv*) (Figure 2.3). As the average age and mass for juvenile *Daspletosaurus* in our sample is just 2 years and 35kg, this increased durophagy may indicate consumption of shelled organisms, such as insects, crustaceans and turtles. Conversely, the older juveniles of *Albertosaurus* (avg. 8yrs)

appear to have consumed softer (low *Tfv*)(Figure 2.3), rougher (high *SmrI*) foods (Figure 2.2).

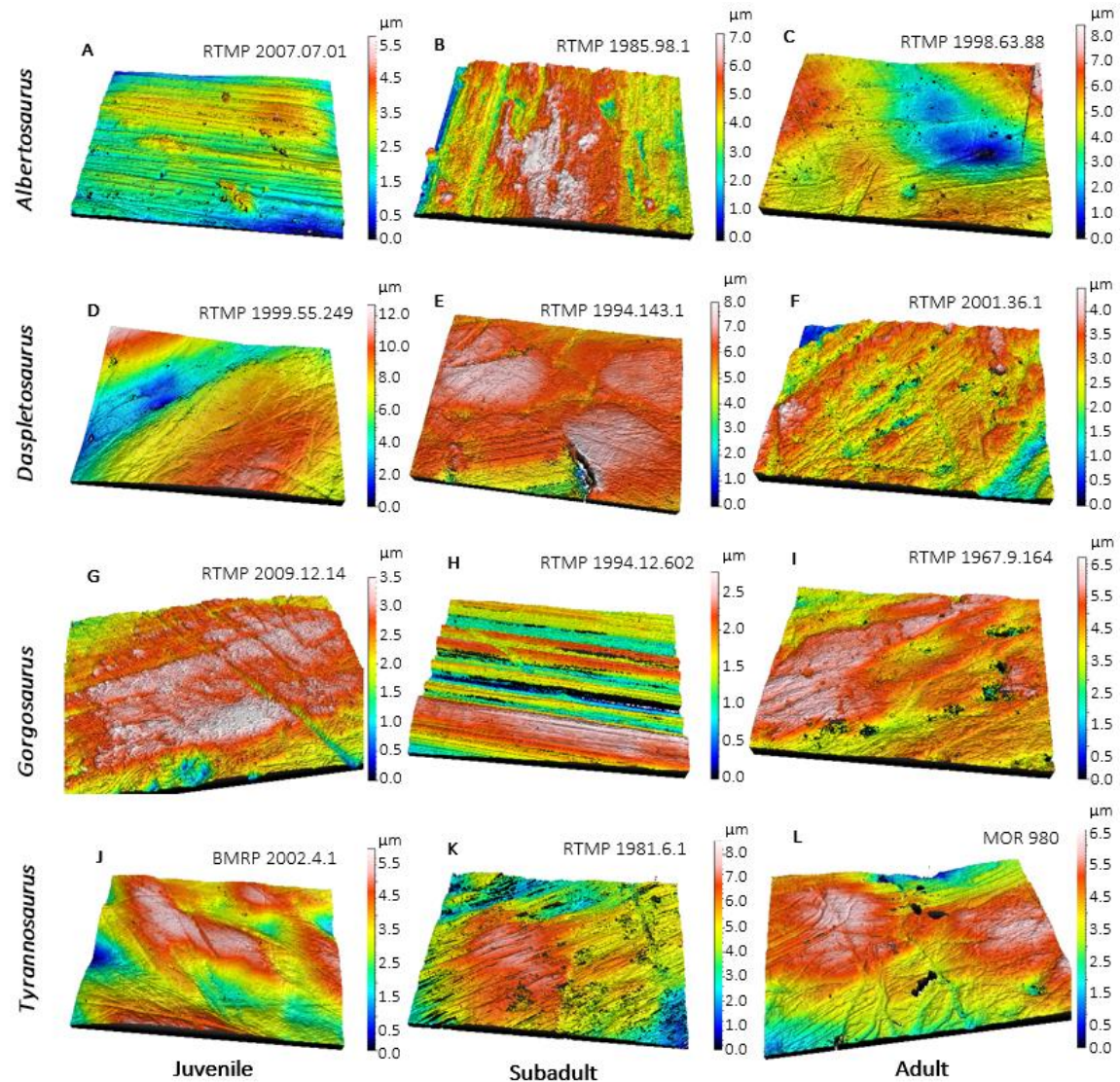


Figure 2.5: Typical dental microwear patterns of four tyrannosaur genera at each of our three ontogenetic stages

The dental microwear of subadult tyrannosaurs was the most distinctive from other ontogenetic stages (Figure 2.5). Subadults of all tyrannosaur genera exhibited more directional scratches (high *epLsar*), indicating the increased consumption of non-brittle foods. This trend was most obvious in *Tyrannosaurus* (Figure 2.1). High directionality in scratches may indicate the avoidance of integument, and combined with high durophagy

(*Sdr*) (Figure 2.2), *Tyrannosaurus* subadults may have regularly consumed defleshed carcasses, possibly through the use of kleptoparasitism. As the second largest carnivores in their communities, shared with a wide variety of carnivores between 10-300kg, it is not unrealistic to propose the use of intimidation to secure food resources obtained by other species or smaller conspecifics, a tactic employed in both mammal and reptilian carnivores (495–497). Indeed, these relatively light, long legged subadults would have been within the ideal mass for long distance travel between carcasses (498).

Both *Tyrannosaurus* and *Daspletosaurus* subadults exhibited higher instances of durophagy (high *Asfc* and *Sdr*, and high *Spk*, respectively) (Figure 2.3), than the Albertosaurine tyrannosaurs. High durophagy in Tyrannosaurines could be due to the consumption of stripped carcasses and increased consumption of bone. Indeed, the complexity values of subadult *Tyrannosaurus* were most similar to polar bears (*Ursus maritimus*), which have been known to crush bone when scavenging (465), and the durophagus roughneck monitor (*Varanus rudicollis*) (466). These findings are also consistent with tooth marks on low-nutrition bones (disarticulated, toes, ankles and lower legs) made by subadult *Tyrannosaurus* in the course of scavenging (391). Similarly, the consumption of apparent carcasses with minimal dismemberment by multiple *Daspletosaurus* subadults (326) correlates well with high durophagy and roughness values observed in this study.

Although often characterized as a regularly opportunistic or even obligate scavenger (381, 382, 385, 499), we found *Tyrannosaurus* adults had the lowest durophagy values (*Sdr*) of all genera in our study (Figure 2.2). Adult *Tyrannosaurus* also exhibited significantly less directional wear (*epLsar*) than subadults of their own genera (Figure

2.2). Similar to microwear seen in juvenile tyrannosaurs, our results indicate adult *Tyrannosaurus* likely consumed rough integument with relatively little bone interaction, possibly through the consumption of whole or large dismembered portions of vertebrate prey. These results strongly suggest active predation as a significant portion of adult *Tyrannosaurus*' dietary ecology, and are supported by healed *Tyrannosaurus* bite marks on *Triceratops* (500) and large hadrosaurs (390). Further, considering the known consumption of fresh dinosaur muscle and bone by *Gorgosaurus* (387), it is not unrealistic to conclude adult tyrannosaurs in general were largely active predators.

As the only two large North American tyrannosaurs known to co-occur, the apparent differences in the dental microwear of *Gorgosaurus* and *Daspletosaurus* may represent competitive avoidance through niche partitioning. Lower complexity (*Sdr*) values in *Gorgosaurus* subadults (Figure 2.2) may indicate more frequent active predation or more preferential carcass use, including the avoidance of hard integument, tendon and bone. Interestingly, the complexity and directionality (*epLsar*) values of *Gorgosaurus* most resemble those of *Varanus komodoensis*, an animal well known for both its aggressive removal of flesh from bones it cannot swallow whole (418), and frequent carcass use (467). Increased carcass utilization may have also been common in the adults of *Gorgosaurus* and *Daspletosaurus*, as evidenced by higher durophagy values (*Asfc*) than in other adult tyrannosaurs (Figure 2.3). These observations are consistent with bite marks attributable to either *Gorgosaurus* or *Daspletosaurus* adults on a theropod skeleton that had already undergone moderate decay (501). Indeed, these two tyrannosaur genera were found to have significantly different dental microwear between nearly every ontogenetic stage.

The separations we have observed between and within these genera strongly support the argument for ontogenetic niche shift in tyrannosaurs. Our results indicate that juvenile tyrannosaurs were predominantly active predators, transitioning from insects to small vertebrates to small and medium dinosaurs as they grew. The “awkward teenager” subadult tyrannosaurs- too big to chase down small vertebrates, but not yet experienced enough to take on large prey- may have heavily supplemented a diet of small to medium dinosaurs with kleptoparasitism or scavenging. Adult tyrannosaurs were likely predominantly active predators, although readily utilized carcasses in areas of higher competition.

These separations in dietary niche played a particularly important part in the structuring of Cretaceous communities. By decreasing both intraspecific and interspecific competition with other tyrannosaurs through the dietary partitioning of nearly every ontogenetic stage, tyrannosaurs were able to successfully assimilate the niches of medium sized carnivores as they grew (401, 402). This life history strategy may well have been influential in the dominance of tyrannosaurs in Laurasia, and exemplifies the importance of juvenile giants in community ecology.

Making a run for it: the impact of flight-adaptive traits on niche partitioning in carnivorous non-avian theropods

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Abstract

Due to the disparity between infant and adult megatheropod mass, it is likely juvenile megatheropods utilized separate feeding niches through ontogeny. This may have caused dietary overlap with medium sized carnivorous dinosaurs. While many communities lack mesocarnivores, a few species of giant paravians (100-1000kg) did co-occur with megatheropods despite potential competition with juveniles. The traits that enabled giant paravians to compete with megatheropods, the role of ancestral flight-adaptations and whether paravians exhibited the effects of competition are unknown. Here we examine the locomotor capabilities of volant and non-volant paravians and non-paravian theropods across body size to determine top speed and efficiency. We assess prey availability and competitive overlap based on body size and running speed in four dinosaur assemblages containing giant paravians. Finally, we re-examine the phylogenetic placement of the giant paravian *Dakotaraptor steini* to contextualize its competitive capacity. We identify two distinct non-volant paravian cursorial styles: giant paravians had limited top speeds, but were highly efficient runners, while small non-volant paravians were fast, but inefficient. We further find volant paravians among the least adapted to cursorial locomotion. Giant paravians may have competed with megatheropods such as

Tyrannosaurus rex, and relied on highly efficient locomotion to utilize large hunting ranges.

Introduction

During the Mesozoic, small-bodied carnivore niches were dominated by paravians (369, 370, 376). As the dinosaurian clade most closely related to modern birds, many paravians exhibited adaptations for flight, such as small body size, feathered forelimbs and gracile bauplans. Such flight adaptations may have provided a physiological release in hindlimb structuring that enabled the utilization of niches previously unavailable to non-avian theropods (507). Indeed, in modern aves, flight-enabled hindlimb variations have been correlated with the use of at least a half dozen different habitats or foraging styles (508). Vertical niche partitioning has also been identified as an effective way of avoiding competition for food resources in modern volant birds and mammals (509, 510).

However, at least four paravian lineages evolved giant size (100-1000kg) (511). These larger-bodied paravians had limited potential for flight, were likely unable to use arboreal habitats, and displayed adaptations for terrestrial foraging. For example, the relatively short, robust metatarsals of eudromaeosaurs, combined with elongate pre-ungual distal pedal phalanges indicate they were strong graspers (512), and may have used their posteriorly positioned first pedal digit to restrain larger prey (513). Conversely, the elongate metatarsals and increased horizontal range of motion in the second pedal digit of Unenlagiids and Troodontids likely sacrificed grasping abilities in favor of rapid movements of the feet, a possible adaptation for hunting insects and small vertebrates (512). This increase in body size is intriguing, as it likely resulted in dietary niche

overlaps between giant paravians and juvenile megatheropods (carnivorous dinosaurs >1,000kg).

Owing to the giant sized attained by many dinosaurs combined with restricted birth mass, changes in the diet through ontogeny were likely common. This may have been a major driver of community structure. For example, by occupying different ecological niches at different body sizes, juveniles of the largest theropods may have outcompeted other carnivores, leading to the wide-scale absence of medium-sized carnivores (100-1,000kg) in their communities (401, 402). Certainly in terms of biomass, juvenile megatheropods were abundant enough within medium body size classes to present a significant competitive force within Mesozoic carnivore guilds. How then did other carnivorous dinosaur species coexist? Likely explanations include the utilization of niches not available to megatheropods, or the possession of adaptations that enabled effective competition.

Here we examine cursoriality in giant paravians and whether enhanced running abilities may have enabled co-occurrence with juvenile megatheropods. While all clades containing giant paravians have been interpreted as cursorially adapted, it remains unclear whether the running abilities of giant paravians exceeded those of megatheropods. We focus on *Dakotaraptor steini*, one of the few medium sized carnivorous theropods known to co-occur with megatheropods in the Cretaceous. Using speed and efficiency metrics such as femur strength, cost of transport, and cursorial limb proportion we identify trends within the running abilities of both volant and non-volant paravians, and compare these to the running ability of non-paravian carnivorous

theropods. We then assess food resource partitioning in dinosaur assemblages inhabited by giant paravians based on prey available in terms of body size and running speeds.

Methods

Phylogenetic Analysis

Because the phylogenetic affinities of the formerly chimeric *D. steini* are unstable (514), and characteristics suggested as ancestral cursorial adaptations may instead be novel adaptations to non-cursorial foraging strategies, we re-examined its evolutionary relationships. The phylogenetic affinities inferred for *D. steini* were calculated using datasets from DePalma, et al., (2015), Hartman, et al., (2019) and Jasinski, et al., (2020). These three datasets were themselves derived from the Theropod Working Group (TWiG), whose theropod experts have compiled over 850 species level characters and created coelurosaurian phylogenetic brackets for the last 20 years (515). We updated each of the three datasets to reflect character scores confidently assigned to *Dakotaraptor*. This included the recodification of the furcula, which was described in the holotype but later determined to be a turtle endoplastron (516–518), as a character of unknown state (“?”). Matrices were analyzed for parsimony using protocol modified from Madzia and Cau, (2017) (519), using TNT 1.5 (520) with equally weighted, unordered multistate characters. Using equally weighted characters avoids placing undue importance on certain characters over others, and is the most commonly used method. Likewise, using unordered characters ignores the number of steps required to transform a character from one state to another, effectively making all character states equally likely (521).

Tree Analysis Using New Technology (TNT) utilizes algorithms to identify the most parsimonious trees, allowing for the analysis of much larger datasets in less time. We ran

100 "New Technology" search replicants on each of the three matrices, using sectorial searches and tree-fusing. Sectorial searches randomly generate near-optimal portions of a tree through repetitive random addition sequence (RAS) and tree bisection reconnection (TBR). Tree-fusing then identifies all possible exchanges between these near-optimal tree portions, maintaining swaps that improve parsimony to create globally optimal trees (522). We then used TBR (via TNT "Traditional Search") on the shortest trees generated by the "New Technology" analysis to identify the most parsimonious tree from each of the three published matrices.

Morphometric Analysis

We collected measurements of femur, tibia/tibiotarsus, and metatarsal length for 25 non-volant and 37 volant adult paravian genera (Table 3.1), as well as 18 carnivorous and 51 herbivorous dinosaurs that co-occurred with giant paravians (Table 3.2) from the literature. Published skeletal measurements were used preferentially. For a subset of taxa (7 of 62), we estimated dimensions from illustrations of elements published with scale bars using ImageJ software (523). Limb measurements were then used to calculate several metrics of running speed and efficiency.

Taxa	Body Mass (kg)	Proximodistal Length (cm)			Midshaft Width (cm)		Limb Meas. Source	CoT (l/kg ⁺ m)	Femur Strength (m ² /GN)	% Difference CLP		Speed at Transition (km/h)		
		Mt	Tibia	Femur	Femur					Theropod	Paravian	Walk-Trot	Trot-Run	Max
Non-volant														
<i>Achillobator</i>	269.00	23.44	49.04	50.50	6.73	(554)		2.22	4.46E-04	19.53	-6.37	13.54	21.81	21.81
<i>Adasaurus</i>	36.56	14.70	30.30	27.30	2.21	(557, 558)		3.34	2.14E-04	24.19	2.13	10.38	16.72	32.82
<i>Almas</i>	0.41 *	5.65	9.45	6.83	0.71	(559)		8.38	2.57E-03	32.88	21.93	5.72	9.21	13.57
<i>Austroraptor</i>	376.21	33.00	56.25	56.00	7.10	(560)		1.95	3.38E-04	34.99	4.87	14.72	23.70	23.70
<i>Bambiraptor</i>	2.47	7.80	16.80	11.90	1.11	(324)		5.66	9.34E-04	36.04	19.47	7.38	11.88	21.79
<i>Buitreraptor</i>	4.72	8.85	16.79	14.53	0.70	(561)		5.26	9.94E-05	19.97	3.71	7.74	12.46	23.75
<i>Dakotaraptor</i>	371.87	29.00	67.30	55.80	6.43	(202)		1.89	2.55E-04	46.09	13.53	15.06	24.25	24.25
<i>Dalliansaurus</i>	3.36	11.01	19.01	13.08	0.86	(378)		4.98	2.88E-04	53.39	33.70	8.02	12.91	25.29
<i>Deinonychus</i>	71.71	16.44	36.80	33.60	2.96	(562)		2.90	2.14E-04	23.49	-0.10	11.38	18.33	31.73
<i>Gobivenator</i>	12.39	13.11	15.90	19.56	1.44	(563)		4.54	2.46E-04	5.86	-10.62	8.51	13.71	28.10
<i>Halszkaraptor</i>	0.58	5.02	10.55	7.62	0.65	(161)		8.02	1.20E-03	25.05	13.76	5.88	9.47	14.31
<i>Hesperornithoides</i>	2.08 *	8.17	16.80	11.28	1.09	(529)		5.69	1.10E-03	44.44	27.39	7.35	11.84	21.65
<i>Liaoningvenator</i>	1.97	10.55	16.20	11.10	0.95	(376)		5.50	7.79E-04	56.82	38.48	7.51	12.10	22.52
<i>Linheraptor</i>	20.96	12.50	25.50	23.00	3.90	(556)		3.81	2.45E-03	21.05	0.91	9.54	15.36	31.58
<i>Mahakala</i>	0.65	8.20	11.00	7.90	0.64	(556)		7.12	1.01E-03	49.62	35.72	6.36	10.24	16.56
<i>Mei</i>	0.71	5.80	10.60	8.10	0.65	(564)		7.69	9.55E-04	25.15	13.30	6.05	9.73	15.07
<i>Neuquenraptor</i>	27.48	17.27	31.00	25.00	1.57	(557)		3.31	1.12E-04	43.40	18.75	10.45	16.83	34.92
<i>Saurornitholestes</i>	16.59	11.01	21.80	21.40	1.53	(565)		4.17	1.99E-04	11.01	-6.93	8.99	14.48	27.96
<i>Shri</i>	14.43 *	11.70	24.60	20.50	2.08	(566)		4.02	6.09E-04	27.33	7.11	9.20	14.82	31.81
<i>Sinornithoides</i>	4.19	11.10	19.06	14.00	1.10	(567)		4.89	4.51E-04	45.58	26.21	8.12	13.07	25.84
<i>Sinonasus</i>	3.72	8.61	17.38	13.50	0.94	(568)		5.33	3.32E-04	29.28	12.40	7.67	12.36	23.39
<i>Talos</i>	16.02	17.59	23.10	21.17	1.89	(219)		3.77	3.96E-04	38.92	16.56	9.61	15.47	33.53
<i>Tianyuraptor</i>	14.85	14.39	26.56	20.68	1.78	(569)		3.78	3.66E-04	42.58	19.85	9.59	15.44	33.89
<i>Utahraptor</i>	407.53	21.12	50.50	57.40	7.95	(535)		2.14	4.27E-04	6.11	-17.72	13.87	22.34	22.34
<i>Velociraptor</i>	17.88	10.13	24.92	21.90	1.61	(556)		4.02	2.11E-04	16.31	-2.67	9.22	14.84	30.41
<i>Zhenyuanlong</i>	11.95	12.98	26.03	19.34	1.90	(370)		3.94	5.91E-04	43.67	21.41	9.33	15.02	32.88
Volant														
<i>Ambopteryx</i>	0.05 *	3.10	5.31	3.68	0.36	(570)		13.25	4.51E-03	24.18	19.66	4.25	6.84	7.67
<i>Anchiornis</i>	0.37	5.52	10.64	6.62	0.32	(571)		8.13	2.57E-04	46.01	34.31	5.83	9.39	14.07
<i>Archaeopteryx</i>	0.17 *	3.70	7.10	5.22	0.30	(572)		10.67	6.04E-04	19.06	11.59	4.89	7.87	10.06
<i>Archaeorhynchus</i>	0.05 *	2.20	4.06	3.58	0.34	(573)		15.52	4.39E-03	-5.37	-8.62	3.83	6.17	6.27
<i>Aurornis</i>	0.36	4.40	9.05	6.60	0.55	(574)		8.97	1.38E-03	21.83	12.10	5.47	8.81	12.47
<i>Caihong</i>	0.46 *	4.90	8.20	7.09	0.39	(575)		8.93	3.62E-04	11.76	2.25	5.49	8.84	12.55
<i>Changyuraptor</i>	5.59	11.12	17.72	15.30	1.16	(369)		4.89	3.61E-04	29.23	11.25	8.11	13.06	25.83
<i>Chongmingia</i>	0.29 *	3.73	6.94	6.16	0.49	(576)		10.27	1.30E-03	2.40	-5.27	5.01	8.07	10.55
<i>Confuciusornis</i>	0.05	2.19	4.73	3.50	0.51	(577)		14.86	1.64E-02	6.56	3.09	3.94	6.35	6.63
<i>Cruralispennia</i>	0.01 *	1.97	2.31	1.98	0.18	(573)		22.01	7.42E-03	6.42	7.72	3.05	4.92	4.02
<i>Eoconfuciusornis</i>	0.06	2.29	4.38	3.70	0.39	(577)		14.91	5.86E-03	-1.91	-5.51	3.93	6.33	6.60
<i>Eosinopteryx</i>	0.13	3.55	6.95	4.85	0.48	(578)		11.02	3.37E-03	23.10	16.05	4.78	7.70	9.66
<i>Epidexipteryx</i>	0.16	3.10	6.30	5.10	0.52	(579)		11.52	3.39E-03	5.66	-0.78	4.65	7.49	9.14
<i>Hongshanornis</i>	0.01 *	2.10	3.70	2.04	0.22	(573)		18.49	1.20E-02	40.39	41.74	3.42	5.51	5.02
<i>Jeholornis</i>	0.23	4.70	6.72	5.73	1.25	(577)		10.12	2.95E-02	16.44	8.34	5.06	8.14	10.74
<i>Jinfengopteryx</i>	0.45 *	6.10	10.05	7.03	0.49	(580)		8.02	7.33E-04	38.73	27.01	5.88	9.47	14.31
<i>Jinguoortis</i>	0.17	3.09	5.86	5.26	0.40	(576)		11.71	1.34E-03	-2.03	-8.23	4.60	7.41	8.96
<i>Longsunguis</i>	0.05 *	2.14	4.18	3.58	0.28	(573)		15.45	2.46E-03	-4.47	-7.74	3.84	6.19	6.31
<i>Microraptor</i>	0.85	6.71	12.64	8.56	0.52	(581)		6.96	3.85E-04	40.99	27.09	6.45	10.39	17.02
<i>Parabohaiornis</i>	0.05 *	1.95	4.00	3.60	0.33	(573)		15.89	3.96E-03	-10.48	-13.59	3.77	6.08	6.09
<i>Pengornis</i>	0.11 *	2.65	5.00	4.50	0.43	(573)		13.20	3.25E-03	-4.51	-9.44	4.26	6.85	7.70
<i>Piscivorenanthornis</i>	0.05 *	2.18	4.13	3.50	0.29	(573)		15.56	3.07E-03	-2.80	-5.96	3.83	6.16	6.25
<i>Pterygornis</i>	0.01 *	1.70	2.86	2.38	0.23	(573)		20.31	8.03E-03	-2.99	-3.24	3.22	5.18	4.46
<i>Rahonavis</i>	0.89	4.82	12.00	8.70	0.43	(557)		7.45	2.08E-04	20.90	8.84	6.17	9.93	15.66
<i>Sapeornis</i>	0.51	4.12	8.51	7.32	0.76	(573)		9.01	2.34E-03	4.91	-4.26	5.46	8.78	12.41
<i>Scansoriopteryx</i>	0.00	1.19	1.89	1.62	0.17	(579)		27.42	1.49E-02	-9.58	-7.03	2.65	4.26	3.03
<i>Schizoura</i>	0.11 *	3.60	6.11	4.55	0.44	(573)		11.67	3.30E-03	20.08	13.79	4.61	7.43	9.00
<i>Serikornis</i>	0.39 *	4.85	9.52	6.74	0.64	(582)		8.62	2.01E-03	27.90	17.49	5.61	9.04	13.10
<i>Sinornithosaurus</i>	5.01	9.30	12.50	14.80	0.81	(583)		5.65	1.40E-04	0.44	-13.30	7.39	11.90	21.84
<i>Wulong</i>	0.87 *	5.67	11.70	8.62	0.71	(584)		7.35	9.52E-04	25.83	13.35	6.23	10.03	15.93
<i>Xiaotingia</i>	0.80	2.71	9.37	8.40	0.63	(585)		8.83	7.27E-04	-10.54	-19.25	5.53	8.90	12.73
<i>Yangavis</i>	0.07 *	2.32	5.03	4.01	0.45	(577)		13.90	6.35E-03	1.11	-3.22	4.12	6.63	7.21
<i>Yanornis</i>	0.17 *	3.80	7.80	5.20	0.59	(586)		10.28	4.62E-03	28.29	20.28	5.01	8.06	10.53
<i>Yi</i>	0.41	4.89	8.17	6.85	0.60	(587)		9.02	1.55E-03	14.68	5.20	5.45	8.77	12.39
<i>Yixianornis</i>	0.08	2.70	5.29	4.11	0.50	(573)		13.24	7.76E-03	7.59	2.78	4.25	6.84	7.67
<i>Zhongjianosaurus</i>	0.25 *	3.90	7.80	5.90	0.35	(588)		9.92	5.70E-04	16.41	8.06	5.12	8.25	11.01

Table 3.1: Measurements and calculated values for cursoriality tests performed. All masses from Schroeder, et al., 2021 (402) unless noted. (m = meters, GN = Giganewton)
 *Mass estimated based on theropod regression from O’Gorman & Hone, 2012 (4)

Assemblage	Herbivores	Body Mass (kg)	Hip Height (m)	Height Source	Speed at Transition (km/h)				CoT (J/kg*m)	Carnivores	Body Mass (kg)	Hip Height (m)	Height Source	Max. Prey Mass (kg)	Min. Prey Mass (kg)	Speed at Transition (km/h)				CoT (J/kg*m)
					Walk-Trot	Trot-Run	Max									Walk-Trot	Trot-Run	Max		
Allen Argentina Campanian- Maastrichtian	<i>Bonaitan</i>	808.01	1.54	(70)	16.01	25.78	14.99	1.76		<i>Dromaeosaurid A</i>	15.14	0.66 *	(370)	20.31	8.90E-04	10.50	16.91	31.03		3.57
	<i>Nodosaurid</i>	1788.28	1.17 *	(590)	13.95	22.47	12.19	2.31		<i>Bonapartenykus</i>	20.50	0.75	(83)	27.76	1.69E-03	11.16	17.96	31.58		3.26
	<i>Bonapartesaurus</i>	2071.49	1.96	(74)	18.06	29.08	18.06	1.55		<i>Austroraptor</i>	373.85	1.30	(560)	518.91	0.69	14.72	23.70	23.70		2.12
	<i>Hadrosaurid A</i>	2071.49	1.96 *	(67)	18.06	29.08	18.06	1.55		<i>Quilmesaurus</i>	460.00	1.52	(85)	638.66	1.06	15.93	25.65	25.65		1.88
	<i>Lapampasaurus</i>	2071.49	2.36	(591)	19.82	31.91	19.82	1.34		<i>"Neibla"</i>	491.67	0.55 *	(589)	682.68	1.22	9.53	15.34	29.94		4.15
	<i>Saltausaurid</i>	3741.30	2.17 *	(592)	19.00	30.60	17.79	1.43												
	<i>Saltausaurine</i>	3741.30	2.17 *	(592)	19.00	30.60	17.79	1.43												
	<i>Hadrosaurid B</i>	4000.00	4.19 *	(593)	26.40	42.52	26.40	0.86												
	<i>Aelosaurus</i>	6000.00	1.74	(594)	17.02	27.40	15.93	1.61												
	<i>Laplatasaurus</i>	8395.23	3.47	(595)	24.03	38.69	22.50	1.00												
	<i>Panamericansaurus</i>	11629.23	1.61	(78)	16.37	26.36	15.33	1.79												
	<i>Antarctosaurus</i>	20817.15	2.47	(80)	20.27	32.64	18.98	1.22												
	<i>Titansaurian</i>	22385.94	2.97 *	(596)	22.23	35.80	20.82	1.13												
Bayan Shireh Mongolia Cenomanian- Santonian	<i>Yamaceratops</i>	2.00	0.36	(601)	7.74	12.46	12.46	5.72		<i>Avimimus</i>	13.28	0.54	(597)	19.22	8.00E-04	9.44	15.21	29.83		4.21
	<i>Graciliceratops</i>	4.34	0.20	(108)	5.77	9.29	13.80	8.99		<i>Velociraptor</i>	18.73	0.51	(556)	27.18	1.62E-03	9.22	14.84	29.52		4.37
	<i>Amtocephale</i>	50.00	0.31 *	(602)	7.18	11.56	20.74	6.42		<i>Saurornithoides</i>	21.75	0.46	(563)	31.59	2.21E-03	8.72	14.04	28.80		4.76
	<i>Garudimimus</i>	99.61	0.99	(603)	12.83	20.67	43.04	2.62		<i>Deinonychosaurian A</i>	90.00	0.98 *	(562)	131.23	0.04	12.75	20.53	32.27		2.65
	<i>Archaeornithomimus</i>	146.89	2.27	(604)	19.44	31.29	58.51	1.39		<i>Achillobator</i>	373.85	1.10	(554)	545.65	0.77	13.54	21.81	21.81		2.42
	<i>Amtoasaurus</i>	300.00	0.82 *	(282)	11.68	18.81	31.91	3.03		<i>Tarbosaurus (j)</i>	376.00	1.40	(598)	548.79	0.78	15.26	24.58	24.58		2.01
	<i>Erlikosaurus</i>	430.00	0.96 *	(605)	12.64	20.35	32.25	2.69		<i>Alectrosaurus</i>	601.03	1.69	(599)	877.33	2.04	16.76	26.98	26.98		1.74
	<i>Tsaganetia</i>	500.00	0.88	(606)	12.10	19.48	10.57	2.87		<i>Tarbosaurus</i>	1742.73	1.65	(600)	2544.21	18.17	16.56	26.67	26.67		1.77
	<i>Enigmosaurus</i>	960.17	1.47 *	(607)	15.64	25.18	25.18	1.94												
	<i>Talarurus</i>	1020.25	0.89	(608)	12.17	19.60	10.63	2.85												
	<i>Pinacosaurus</i>	1100.81	0.83	(609)	11.75	18.92	10.27	3.01												
	<i>Gillmoreosaurus</i>	1136.29	1.93	(610)	17.92	28.86	17.92	1.57												
	<i>Bactrosaurus</i>	1472.77	1.77	(610)	17.16	27.63	17.16	1.68												
	<i>Gobihadros</i>	1712.60	2.20	(113)	19.13	30.81	19.13	1.42												
	<i>Gigantoraptor</i>	2216.11	1.97	(115)	18.11	29.15	18.11	1.54												
	<i>Segnosaurus</i>	2633.20	2.43 *	(605)	20.11	32.38	20.11	1.31												
	<i>Erketu</i>	11225.59	2.61 *	(611)	20.84	33.56	19.51	1.14												
	<i>Quaesitosaurus</i>	25418.09	3.01	(612)	22.38	36.04	20.96	1.05												
Cedar Mountain (Yellowcat Member) United States Berriasian- Hauterivian	<i>Nedcolbertia</i>	18.00	0.83	(613)	11.75	18.92	31.94	3.01		<i>Geminiraptor</i>	5.69	0.54 *	(567)	8.13	1.40E-04	9.48	15.27	29.88		4.18
	<i>Falcarius</i>	109.00	0.87	(614)	12.03	19.37	32.07	2.90		<i>Yurgovuchia</i>	67.04	0.73	(562)	97.71	0.02	11.00	17.72	31.46		3.33
	<i>Hippodraco</i>	471.00	1.29	(615)	14.65	23.59	23.59	2.14		<i>Utahraptor</i>	410.58	1.16	(535)	599.28	0.93	13.87	22.34	22.34		2.33
	<i>Gastonia</i>	1269.00	0.96	(616)	12.64	20.35	11.04	2.69												
	<i>Iguanacolossus</i>	2500.00	2.56	(615)	20.64	33.23	20.64	1.26												
	<i>Iguanodon</i>	2897.00	3.03	(617)	22.45	36.16	22.45	1.11												
	<i>Mierasaurus</i>	4300.00	2.21	(618)	19.18	30.88	17.96	1.32												
	<i>Camarasaurid</i>	6900.00	2.53 *	(619)	20.52	33.04	19.21	1.27												
Hell Creek United States Maastrichtian	<i>Moabosaurus</i>	11937.00	2.41	(620)	20.03	32.24	18.75	1.25												
	<i>Cedrosaurus</i>	11965.00	2.03	(621)	18.38	29.59	17.21	1.27												
	<i>Orodromeus</i>	15.17	0.66	(624)	10.48	16.87	31.01	3.59		<i>Richardoestesia</i>	10.33	0.21 *	(565)	14.91	4.70E-04	5.91	9.52	14.45		8.66
	<i>Stegoceras</i>	27.66	0.49	(625)	9.03	14.54	29.26	4.51		<i>Acheroraptor</i>	18.50	0.65 *	(556)	26.84	1.58E-03	10.42	16.78	30.95		3.62
	<i>Citipes</i>	56.36	0.71	(49)	10.87	17.50	31.35	3.39		<i>Saurornitholestes</i>	23.70	0.49	(565)	34.44	2.64E-03	8.99	14.48	29.20		4.54
	<i>Sphaeratholus</i>	68.34	0.88 *	(625)	12.10	19.48	32.10	2.87		<i>Pectinodon</i>	47.38	0.97 *	(219)	69.00	0.01	12.71	20.47	28.17		2.66
	<i>Thescelosaurus</i>	170.39	0.83	(626)	11.75	18.92	31.94	3.01		<i>Anzu</i>	246.01	1.17	(201)	359.01	0.33	13.97	22.50	22.50		2.30
	<i>Leptoceratops</i>	212.98	0.77	(253)	11.32	18.23	18.23	3.18		<i>Dakotaraptor</i>	285.00	1.36	(202)	415.93	0.44	15.06	24.25	24.25		2.05
	<i>Ornithomimus</i>	221.46	1.95	(627)	18.01	29.00	55.31	1.56		<i>Tyrannosaurus (j)</i>	1245.90	1.91	(622)	1818.84	9.12	17.83	28.71	28.71		1.58
	<i>Pachycephalosaurus</i>	342.02	1.63 *	(625)	16.47	26.52	26.52	1.79		<i>Tyrannosaurus</i>	6428.60	2.73	(623)	9385.59	265.42	21.32	34.32	21.32		1.20
	<i>Ankylosaurus</i>	3872.27	1.85	(191)	17.55	28.25	15.33	1.62												
	<i>Edmontosaurus</i>	4596.00	4.26	(65)	26.62	42.87	26.62	0.85												
	<i>Torosaurus</i>	7598.52	2.21	(628)	19.18	30.88	19.18	1.41												
	<i>Triceratops</i>	8318.22	2.42	(628)	20.07	32.31	20.07	1.32												

Table 3.2: Body mass, running speeds and cost of transport for non-avian dinosaurs found in communities with giant paravians. Body mass from Schroeder, et al., 2021

*Hip height estimated from closest available relative

Sprinting Capacity

a) Femur Strength (S_F). To evaluate the capacity for sprinting ideally we would employ a calculation that incorporated the material properties of all bone tissues being directly loaded, as these are differentially deposited during growth and have complex physical responses to stress. However, because data on bone histology and/or cross sections were lacking, we used a generalized calculation based on femoral diameter. Following Alexander's index of athletic ability (524), as modified by Farlow (525) we roughly estimated the impact resistance of the femur in square meters per giganewton,

$$[1] \quad \text{Femur Strength } (S_F) = \frac{D_F}{0.5m * L_F * g}$$

where D_F is the midshaft diameter of the femur in cm, L_F is the proximodistal length of the femur in cm, m is body mass in kg, and g is the gravitational constant 9.8m/s^2 .

Top Speed

b) Velocity (v). While femoral strength can provide a relative estimate for sprinting capacity, it falls short of an estimate of actual locomotor speeds, which may influence dietary overlap in carnivorous dinosaurs. Thus, we employed the method of Thulborn (526) to estimate the locomotor speeds in meters per second for all 131 dinosaur genera,

$$[2a] \quad \text{Velocity } (v) = \sqrt{gH \left(\frac{LH * H}{1.8H} \right)^{2.564}}$$

where H is the hip height in meters, and LH is stride length by height in meters.

c) Maximum Velocity (v_{max}). As the calculation in equation [2a] assumes the capacity for a genus to achieve certain stride lengths which may not be plausible, we physiologically constrained maximum speeds,

$$[2b] \quad \text{Max Velocity } (v)_{\text{Max}} = \frac{LH}{H} * f$$

where LH/H is maximum stride length in meters, and f is maximum stride frequency in strides per second. In the event that any locomotor speed derived from equation [2a] exceeded this speed, the lesser of the two values was used. For quadrupedal dinosaurs, the shorter of the limbs was used to calculate maximum speed.

d) Hip Height (H). Hip height in meters was calculated based on the lengths of the major hindlimb elements held above the ground. To adjust (H) for the crouched stance employed by bipedal dinosaurs (527, 528), total hindlimb length was multiplied by a constant calculated based on the average ratio of hip heights in rigorous skeletal diagrams to the sum of limb bone lengths for 8 theropod dinosaurs between approximately 1-6,000kg in mass (529–533),

$$[2c] \quad \text{Hip Height } (H)_{\text{Biped}} = 0.8964(F_L + T_L + MT_L)$$

where F_L is the proximodistal length of the femur, T_L is the proximodistal length of the tibia or tibiotarsus, and MT_L is the proximodistal length of the longest metatarsal in meters.

e) Maximum Stride Length (LH_{max}). The ratio of maximum stride length in meters per height was calculated by distributing a physiologically appropriate range proportional to the body size range of a given taxa. For example, in theropods with $H < 1\text{m}$, LH_{max} was distributed between 3-4 (526), with smaller animals achieving rates closest to 4, using the equation,

$$[2d] \quad \text{Stride Length } (LH_{3-4}) = 4 - \left(\frac{H_1, H_2, H_3 \dots H_{\text{max}-1} - H_{\text{min}}}{\frac{H_{\text{max}}}{H_{\text{min}}}} \right)$$

where H is ranked in order from smallest to largest.

f) Maximum Stride Frequency (f). The fastest cadence at which a dinosaur can move was calculated per Thulborn (526) using the longer of the front or rear limbs for quadrupedal dinosaurs,

$$[2e] \quad \text{Max Stride Frequency (f)} = 3H^{-0.63}$$

and limited to an absolute maximum of 5 (526).

The calculations of formulas [2a-e] were repeated for speeds at walk-trot transition, trot-run transition and at maximum sprint speed, setting LH equal to 2, 2.9 LH_{max}, respectively.

Cursorial Limb Proportion

As sprinting potential does not necessarily equate to habitual running speeds, a measurement of relative limb proportions was also used to assess cursoriality. As the majority of forward motion during the gait of a theropod is achieved with the lower portion of the limb, it is to be expected that theropods with relatively longer tibia and metatarsals will be more capable of rapid cursorial locomotion. Cursorial Limb Proportion (CLP), which relates known upper and lower limb lengths to an “expected” ratio by body size was calculated following Persons and Currie, (2016) (483).

g) Cursorial Limb Proportion (CLP). The percent deviance from the expected CLP indicates the relative cursorial ability, with positive values indicating better than average cursoriality, given in Persons and Currie, (2016) as:

$$[3a] \quad \text{Cursorial Limb Proportion (CLP)} = (T_L + MT_L) - (L_{xE}/100L_{xE})$$

where T_L is the proximodistal length of the tibia, MT_L is the proximodistal length of the longest metatarsal and L_{xE} is the expected lower limb length based on theropods (L_{TE}) or paravians (L_{PE}) in mm.

h) Expected Lower Limb Length (L_{TE} , L_{PE}). We compared volant and non-volant paravians to both the theropod ratio derived in Persons and Currie, (2016) and an equation derived using simple linear regression of the limb lengths of 62 paravians to calculate an “expected” ratio for paravians,

$$[3b] \quad \textit{Theropod Expected Length} (L_{TE}) = 4.178(F_L^{0.8371})$$

$$[3c] \quad \textit{Paravian Expected Length} (L_{PE}) = 2.2818 (F_L^{0.9162})$$

where F_L is proximodistal length of the femur in mm.

Cost of Transport

i) Cost of Transport (COT). Finally, as the ability to sprint at a certain speed does not equate to unlimited capacity to move at such speeds, the energetic cost of transport (COT) in joules/kg*meter was calculated following Pontzer, et al., 2009 (534):

$$[4] \quad \textit{Cost of Transport} (COT) = 90.284H^{-0.77}$$

j) Percent Change COT (Δe). As exceedingly high cost of transport in one stage of locomotion may indicate a reticence to maintain such speed for extended periods, we calculated the percent change in energetic requirements between low and high speeds over a set period of time,

$$[5] \quad \% \textit{ Change COT} (\Delta e) = \frac{(v_{tr} * COT) - (v_{wt} * COT)}{v_{wt} * COT}$$

where v_{tr} is the velocity at the trot-run transition and v_{wt} is the velocity at the walk-trot transition in meters per second.

Niche Overlap

We examined four dinosaur assemblages with giant paravians: the South American Campanian-Maastrichtian Allen Formation (84), the North American Berriasian-Cenomanian Yellow Cat Member of the Cedar Mountain Formation (535) and

Maastrichtian Hell Creek Formation (202), and the Mongolian Cenomanian-Santonian Bayan Shireh Formation (117). Using estimated body size and maximum running speeds for both carnivorous and herbivorous dinosaurs, we evaluated the likely predator-prey relationships within these communities.

k) Prey size (m_{prey} , n_{prey}). Prey utilization for carnivorous dinosaurs was estimated based on carnivorous dinosaur stomach contents and coprolites, and modern predator-prey mass allometry. We calculated maximum prey mass from the allometry developed for modern mammalian carnivores (400):

$$[6] \quad \text{Max Prey Mass } (m_{\text{prey}}) = 1.39m_{\text{predator}} - 0.74$$

where m is mass in kg. This allometry yields accurate estimates when applied to modern carnivorous reptiles (536). Minimum prey mass was derived from the log-log body mass relationship ($r^2 = 0.99$) of small terrestrial prey consumed by large crocodilians and theropods (387, 388, 537, 538),

$$[7] \quad \text{Min Prey Mass } (n_{\text{prey}}) = 2.05m_{\text{predator}} - 5.74$$

where n is mass in kg.

We then limited the subset of herbivorous dinosaurs within the mass range prescribed by equations [6] and [7] by maximum sprint speed calculated for predators in equations [2a] and [2b]. Although specialized ambush predation styles could enable slower predators to consume faster prey items (418, 539), lacking clear evidence of this specific hunting style in dinosaur taxa, we assumed a limitation on prey availability based on maximum predator speed. Therefore, the area prescribed by carnivore running speeds and available prey body size was used to identify prey overlap between potentially competing

carnivorous dinosaurs by simply counting the number of carnivorous dinosaurs competing for the prey items within these prescribed areas.

Results

Phylogenetic Reassessment

The phylogenetic affinities of *Dakotaraptor* remain uncertain at best. However, based on reanalysis with updated characters in three separate matrices our results indicate the placement of *D. steini* near or within the Unenlagiidae was the most plausible, as this placement was supported by the largest percentage of scores available (Hartman = 17% of 700 characters, Jasinski = 14% of 180, DePalma = 14% of 361). While parsimony analysis using the matrix from DePalma, et al., (2015) did place *D. steini* as sister to *U. ostrommaysi* and *Dromaeosaurus albertensis* (540) (Figure S3.1), we believe results from the DePalma database were potentially influenced by the a priori constriction to a limited number of only non-volant taxa (Depalma = 86). Widening the phylogenetic bracket to include all of deinonychosauria, as in the Jasinski, et al., 2020 matrix, resulted in the placement of *D. steini* outside of the dromaeosauridae, on the basal branch leading to *Zhenyulong suni*, *Tianyuraptor ostromi*, and *Hulsanpes perlei* (Figure 3.1). Similarly, parsimony analysis using the matrix from Hartman, et al., (2019) placed *D. steini* outside of dromaeosauridae, as sister to the South American *Unenlagia* ‘sensu lato’ (Figure S3.2).

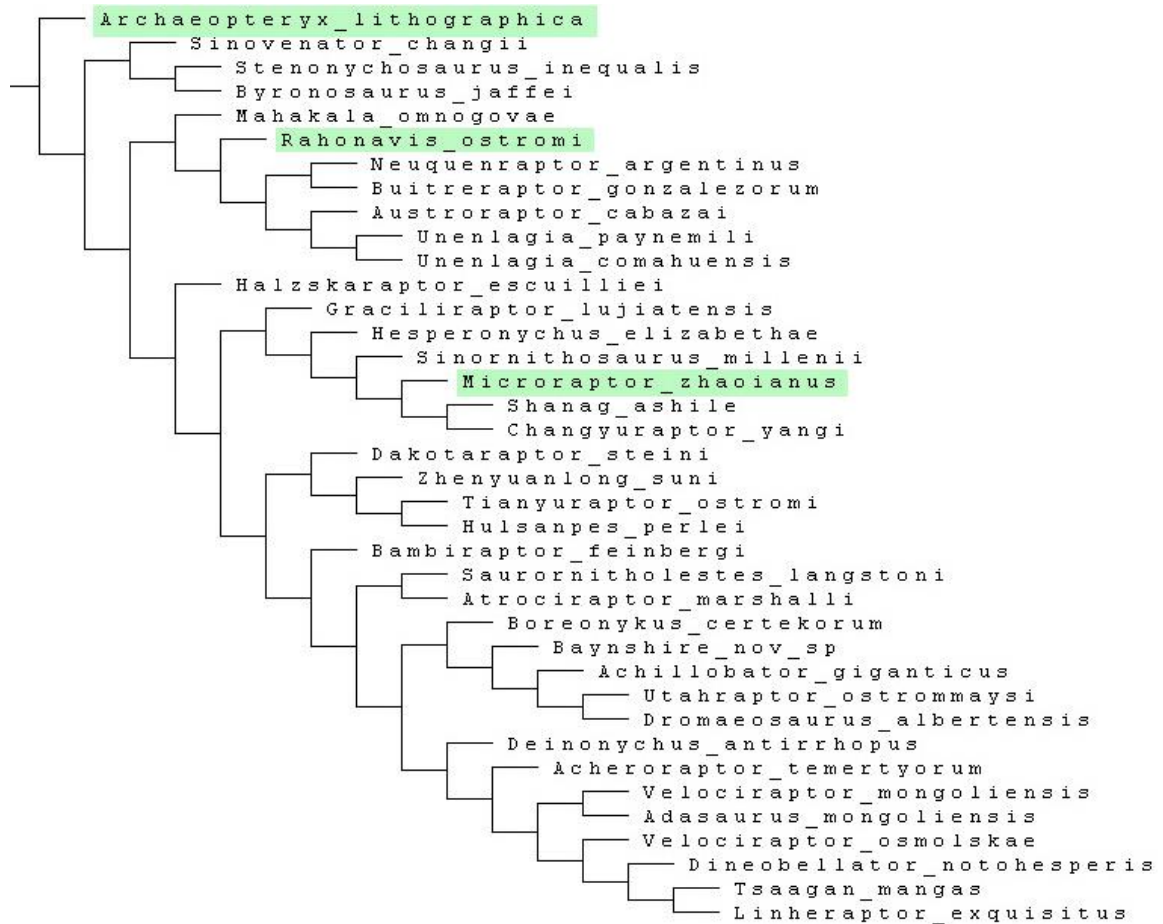


Figure 3.1: Result of parsimony analysis using matrix from Jasinski, et al., 2020. *Dakotaraptor* recovered as sister to Dromaeosaurs with *Zhenyuanlong*, *Tianyuraptor* and *Hulsanpes*. Volant taxa highlighted in green.

Cursorial Ability

Among paravians, femur strength (S_f) was significantly negatively correlated with body size in volant taxa (Fisher corrected Pearson's $\rho = -0.787$, $p = 5.44E^{-10}$) (Figure 3.2; Table 3.1). A similar negative correlation was found in non-volant taxa ($\rho = -0.491$, $p = 0.011$). However, as the confidence interval is large enough for the trend to approach zero ($\rho = -0.118$), and linear regression explained a limited amount of variation in the data ($r^2 = 0.241$), this trend may be biologically noninformative. Femur

strength decreased more rapidly with body size in volant taxa compared to non-volant taxa, and was highest among small volant taxa.

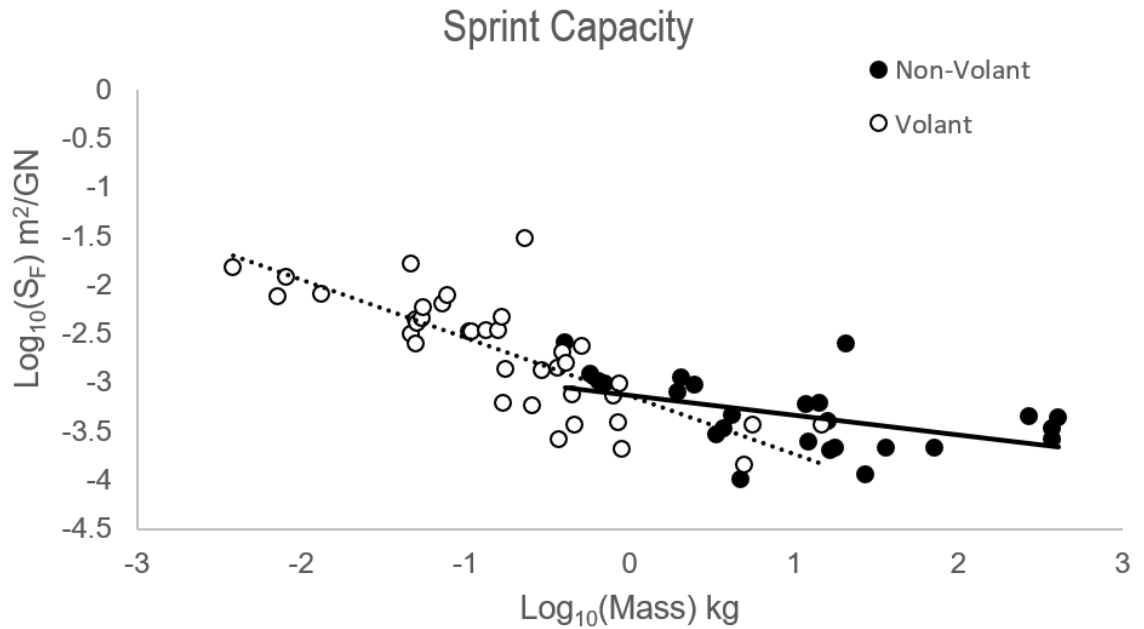


Figure 3.2: Sprinting capacity in paravians based on femur strength per body size. Linear trend for volant taxa shown by dotted line ($r^2 = 0.6198$) and for non-volant taxa by solid line.

Although femur strength implied that volant taxa had stronger femora, and therefore larger capacity for high sprint speeds, the cursorial limb proportion (CLP) of volant taxa were frequently below expected for theropods as a whole (Figure 3.3A). Furthermore, of the nearly $1/3^{\text{rd}}$ of paravians that had below expected CLP values compared to other paravians, all were volant (Figure 3.3B). In contrast with femoral strength index, CLP scores generally increased with body size in both volant and non-volant paravians (volant $\log_{10}(\text{CLP}) = 0.292\log_{10}(m) + 1.231$, $r^2 = 0.94$; non-volant $\log_{10}(\text{CLP}) = 0.241\log_{10}(m) + 1.289$, $r^2 = 0.957$). Among non-volant paravians, members of the Unenlagiidae and *Dakotaraptor* fell consistently above expected values (Figure 3.3B). However, we did not find a trend toward increased CLP within giant paravians as a whole.

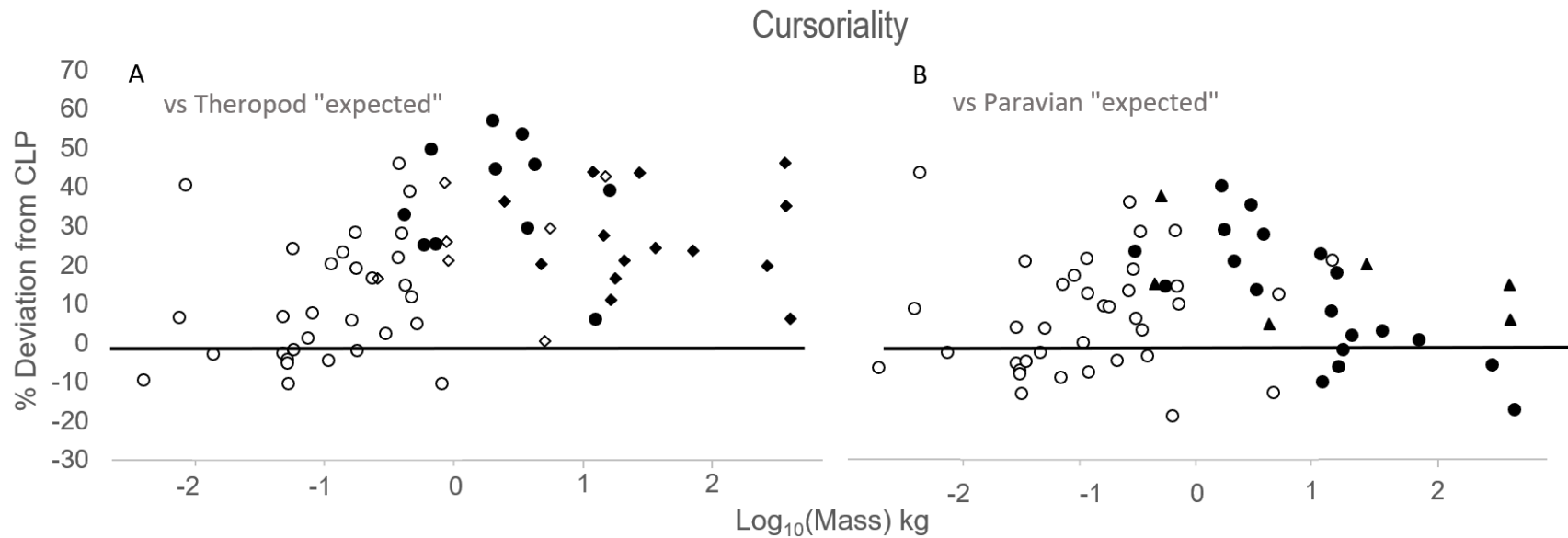


Figure 3.3: Deviation from expected CLP for theropods (A) and paravians (B) by volant (open shapes) and non-volant (filled shapes). Dromaeosaurids shown in diamonds in (A) and Unenlagiids shown in triangles in (B).

Generally, both running efficiency (as shown by lower COT) and running speed increased with size among paravians (Figure 3.4). This trend was most robust for large, non-volant taxa (Figure 3.4). Perhaps unsurprisingly, most volant taxa had relatively poor running efficiency. Interestingly, the trend of increasing top speed with size plateaued significantly (two tailed t-test with equal variance, $p = 0.005$, $df = 142$) above body sizes of approximately 75kg, with the highest potential top speeds found in non-volant paravians ranging from 15-30kg. This did not appear to be a physiological limitation in speed, as the increasing top speed trend was continued outside of paraves in ornithomimosaurs.

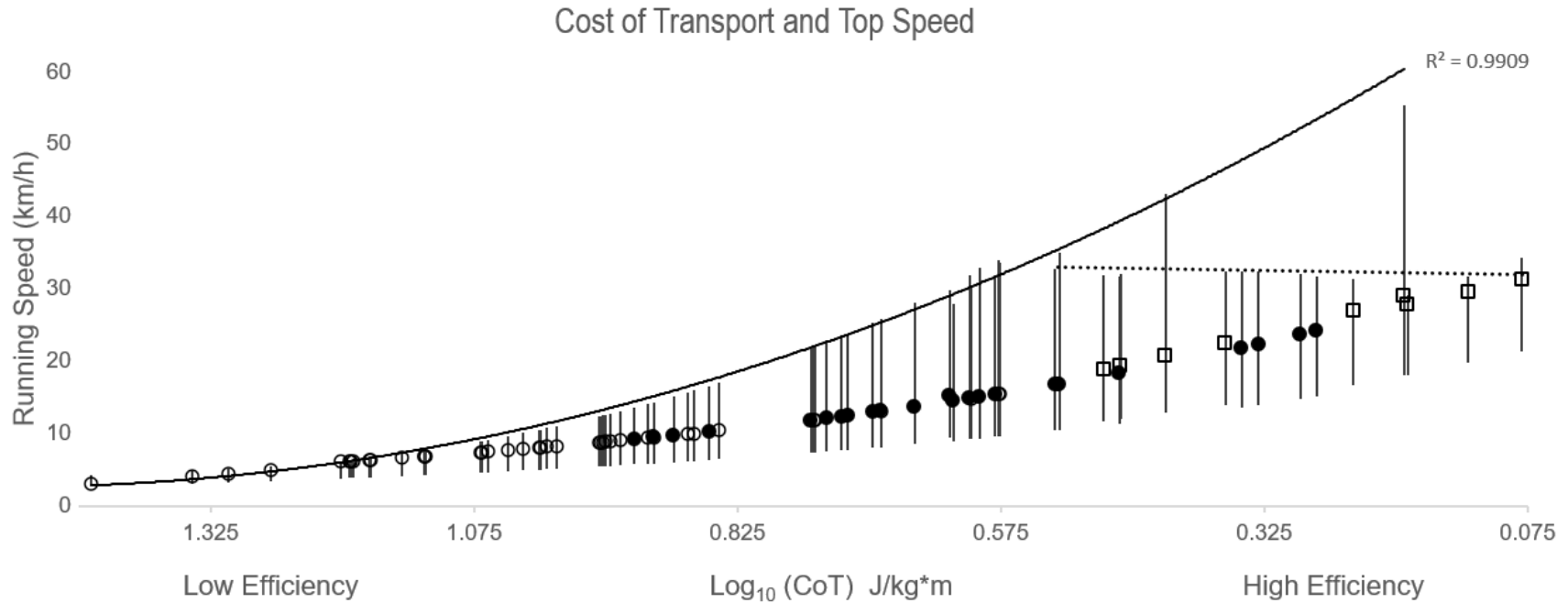


Figure 3.4: Running efficiency and speeds in theropods at walk-trot transition (low line extent), trot-run transition (center point) and maximum top speed (upper line extent). Volant paravians shown in open circles, non-volant paravians shown in filled circles and non-paravian theropods shown in open squares. Increasing top speed trend shown by solid line, plateau shown by dotted line. Body mass increases from left to right across x-axis.

Curiously, when we examined the percent change in energetic expenditure from walking speeds to running speeds, we found that non-volant taxa between 10-30kg had the greatest increase in energy required between walking and running (Figure 3.5). Conversely, paravians above 75kg had decreasing separation between their walking and running energetic expenditures, and resemble other medium and large theropods in this respect.

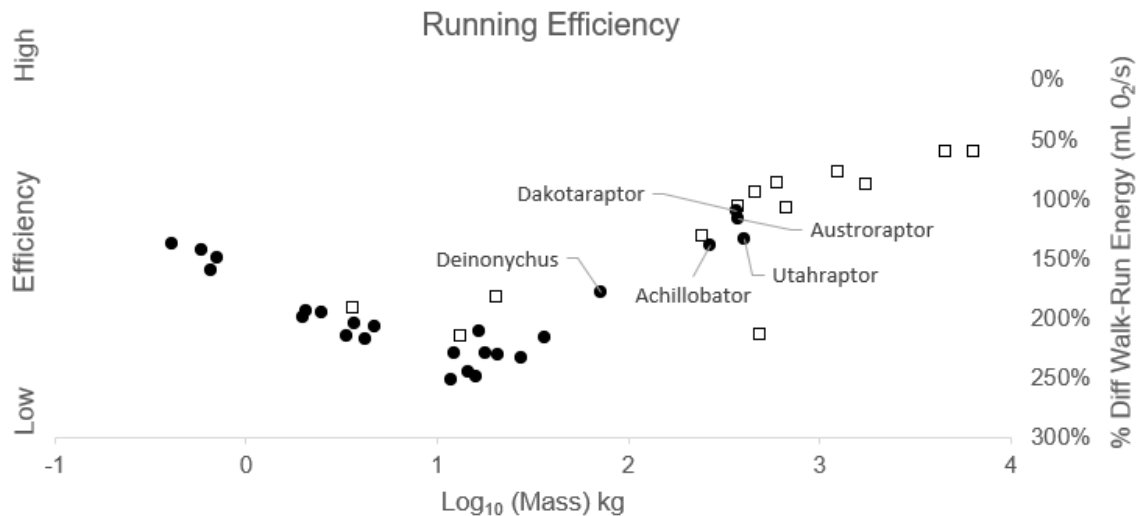


Figure 3.5: Increase in energy expenditure from walking speed to running speeds in theropods. Non-volant paravians shown by filled circles, non-paravian theropods in open squares.

Niche Assessment

Based on overlapping regions of top speed and body size, giant paravians appear to have been limited in terms of prey availability; no dinosaur assemblages contained herbivorous dinosaurs available only to giant paravians (Figure 3.6). Paravians commonly filled the small-carnivore body size niche, and with relatively high running speeds could have easily consumed both small herbivorous dinosaurs or small mammals and reptiles. Competitive overlap was highest at low speeds and small body size in all communities examined, and higher overall at small body sizes (1.4-2.6 predator:prey ratio) in the Bayan Shireh and Hell Creek Formations (Figure 3.6C and D).

Both the Allen and Cedar Mountain Formations lacked herbivorous dinosaurs within the top speed and mass likely to be consumed by the giant paravians present, *Austroraptor* and *Utahraptor*, respectively (Figure 3.6A and B). However, numerous mammals, turtles and crocodilians within this range are present in both formations. Interestingly, within the Allen Formation all herbivorous dinosaurs fell outside the likely

prey body size margins for carnivores, which may indicate the consumption of juvenile herbivores, or that carnivorous dinosaurs exceed the predator-prey mass relationship seen in modern carnivorous mammals.

Giant paravians were generally the slowest of all carnivorous dinosaurs in assemblages examined, outrunning only adult megatheropods (Table 3.2). Giant paravians overlapped both in size and running capacity with juveniles of cohabitant megatheropods (e.g. *Dakotaraptor* with *Tyrannosaurus*, and *Achillobator giganticus* with *Tarbosaurus bataar*) (Figure 3.6C and D).

Discussion

While an exact understanding of Cretaceous Food webs is still largely elusive, it is clear that niche partitioning was common both within and between dinosaur species (12, 142, 402, 541–543). Among paravians, three distinct locomotion styles may have enabled the co-occurrence of these dinosaurs with juvenile megatheropods. The most apparent of these was the ability to fly. It is unlikely that volant paravians, who had access to arboreal niches and fed on prey below the body size cut off for juvenile megatheropods would have been in direct competition. These paravians were poorly adapted to running, with low top speeds and high energetic requirements. Although the finding of high femur strength in small, volant paravians seems to contradict this claim (Figure 3.2), we argue the majority of this finding was a result of post mortem crushing (544–546) and the use of femur diameter. Instead, running was likely a mostly superfluous adaptation in these species, as the capacity for flight would have expanded the available niche vertically beyond that of larger, non-volant carnivores.

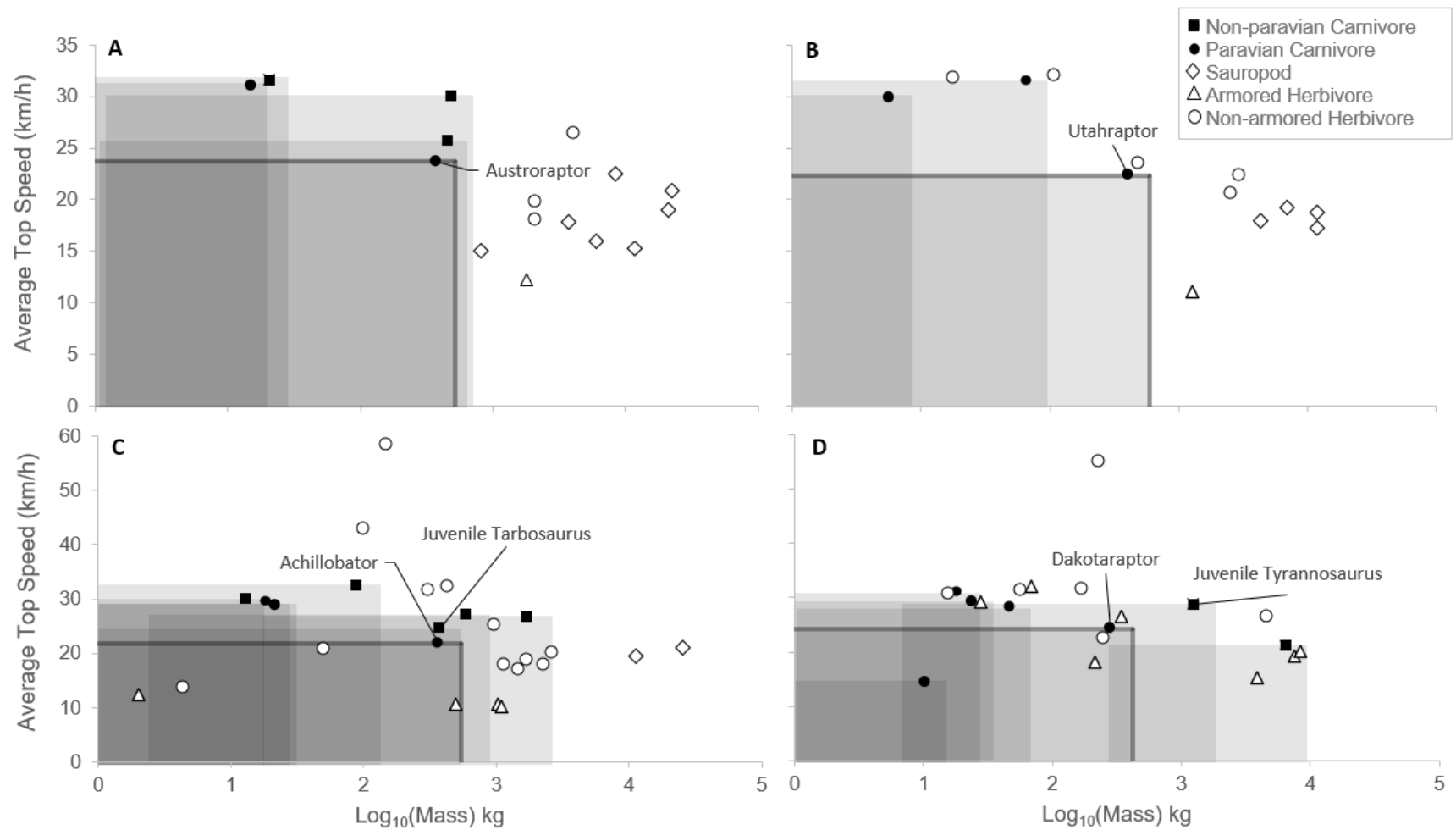


Figure 3.6: Speed and body mass for communities with the four largest giant paravians. A) Allen Formation, B) Cedar Mountain Formation, C) Bayan Shireh Formation, and D) Hell Creek Formation. Dinosaurian prey availability by mass and top speed for each carnivore shown by grey box. Prey availability box for giant paravians outlined in grey. Darker areas represent high functional areas of competition.

Among non-volant paravians, a divide in locomotion style was evident between small and large body sizes. Small (10-30kg) paravians were capable of rapid, but costly, cursorial locomotion, which likely translated into ambush or short-range pursuit hunting, analogous to modern cheetahs (*Acinonyx jubatus*) (Figures 3.4, 3.5). This rapid, cheetah-esque cursoriality likely enabled small non-volant paravians to co-occur with larger, slower theropods, who likely pursued somewhat larger, slower prey. Conversely, our results indicated paravians exceeding 75kg in body mass had limited top speeds (Figure 3.4). Indeed, they were regularly the slowest carnivores in their communities, outpaced by both smaller deinonychosaurs and juvenile megatheropods. As a result, there were no prey items available exclusively to giant paravians in terms of speed or body size, and therefore limited potential for food resource partitioning (Figure 3.6).

As megatheropods appear to regularly utilize all available habitats (547), the opportunity for spatial partitioning by carnivores may have been reduced in assemblages with megatheropods. As such, the presence of both the large tyrannosaur *Tarbosaurus* and the smaller tyrannosaur *Alectrosaurus* may have been in direct competition with the giant paravian *Achillobator* in the Bayan Shireh Formation. Similarly, the presence of the megatheropod *Tyrannosaurus* may have been in direct competition with the giant paravian *Dakotaraptor* in the Hell Creek Formation.

Intraguild competition has been found to result in low population densities in modern mammalian carnivores such as the African wild dog *Lycaon pictus*, which competes for food resources with lions (*Panthera leo*) and hyenas (*Crocutta crocutta*) (548). This appears to have been the case for giant paravians co-occurring with megatheropods. For example, despite over 150 years of collection in the Hell Creek Formation (499), only a

single specimen of the giant paravian *Dakotaraptor* has been identified, despite the presence dozens of much smaller and much larger carnivorous dinosaur specimens. This same census frequently identified sub-adult megatheropods in the same size class as *Dakotaraptor*. Conversely, in communities where giant paravians occurred without megatheropods, their relative abundance is much higher. For example the Yellow Cat Member of the Cedar Mountain Formation has produced abundant giant paravian tracks (549) and skeletal remains from rigorous censusing has shown the giant paravian *Utahraptor* to be relatively abundant (550).

A potential response to direct competition for food resources is the utilization of large home range (509, 548), a tactic that giant paravians' superb locomotor efficiency and moderate size may have allowed. The ability to traverse long distances through high locomotor efficiency and moderate size may also have made scavenging an effective strategy to supplement the diets of giant paravians (498). This approach may have been particularly effective within giant Unenlagiid paravians, which exhibited consistently above average cursorial limb proportions even when compared to other paravians (Figure 3.3). The rapid foot maneuverability enabled by the gracile lower limb morphology of Unenlagiids (512) could have been employed to avoid retaliation during persistence hunting of larger herbivores, a strategy sometimes employed by *Varanus komodoensis* (467, 536, 551) and frequently by *Lycaon pictus* (552, 553).

The placement of *D. steini* as either a uniquely derived member of the Unenlagiidae, or as a non-dromaeosaurid deinonychosaur allows for a more contextualized interpretation of its morphology. Rather than an extraordinarily gracile member of the dromaeosauridae, which were relatively robust, stocky animals at large size (512, 535,

554), *D. steini* was likely an unusually large relative of the more gracile Unenlagiids. As such, *Dakotaraptor* was likely an extremely efficient runner, which may have made it particularly well suited to long distance foraging, a strategy that may have facilitated its cohabitation with larger megatheropods like *Tyrannosaurus rex* (399, 502).

The evolution of flight and flight-adapted features in many paravians likely enabled their expansive radiation in the Cretaceous (376, 555, 556) and the domination of small-body size carnivore niches across the globe. However, at least some paravian clades evolved away from characteristically small size. The loss of rapid locomotion with the development of medium body size resulted in large overlaps in prey availability and potential competition, particularly in dinosaur assemblages containing megatheropods. Co-occurring with carnivorous dinosaurs that underwent significant shifts in morphology through ontogeny likely amplified competitive pressures on giant paravians. However, ancestrally flight-adapted frames may have enabled giant paravians to avoid competitive exclusion through highly efficient cursorial locomotion, although still potentially suffering the effects of enhanced competition with juvenile megatheropods. It is clear that while for some paravians, adaptations away from flight and towards gigantism were advantageous in reducing competition with the multitude of small, agile dromaeosaurs, for those co-occurring with the niche-shifting megatheropods of the Cretaceous, it was “out of the frying pan, into the fire”.

Appendix 1

Materials and Methods

Data

Dinosaur assemblages were identified by downloading all vertebrate occurrences known to species or genus level between 200Ma and 65MA from the Paleobiology Database (PaleoDB <https://paleobiodb.org/#/> download 6 August, 2018). Using associated depositional environment and taxonomic information, the vertebrate database was limited to only terrestrial organisms, excluding amphibians, pseudosuchians, champsosaurs and ichnotaxa. Taxa present in formations were confirmed against the most recent available literature, as of November, 2020. Synonymous taxa or otherwise duplicated taxa were removed. Taxa that could not be identified to genus level were included as “Taxon X”. GPS locality data for all formations between 200MA and 65MA was downloaded from PaleoDB to create a minimally convex polygon for each possible formation.

Any attempt to recreate local assemblages must include all potentially interacting species, while excluding those that would have been separated by either space or time. We argue it is acceptable to substitute formation for home range in the case of non-avian dinosaurs, as range increases with body size. Reaching masses of 80,000kg, it is not unrealistic for gigantic non-avian dinosaurs to have home ranges that spanned the entirety of a geologic formation, particularly as none of the included formations exceed the modern range of some mammalian megafauna (39). Further, our research is focused on the overall shape of body size diversity distributions, so while there is time-averaging in our dataset, this is also acceptable, as we are examining the presence/absence of body

sizes, rather than the exact species identified within the assemblage. Wherever possible, formations were reduced to biostratigraphic groups recognized in the literature to remedy this potential issue, resulting in an average time span of 4.8 million years for our formations. Only formations with at least 5 species were included in the overall dataset, and only formations containing at least 3 carnivores were included in the carnivore test set.

Mass estimates from the literature were added to the final dataset of terrestrial vertebrates. When a range of masses were available for one species, the average was used to normalize for variability within mass estimate techniques, which included, (but were not limited to) volumetric, limb bone circumference, limb bone length, and polynomial regression. Where no mass estimate was available, estimates from similarly sized species within the same genus, family or order were substituted. Species were assigned to a 0.5 log(10) bin based on mass. While it is noted that a wide variety of mass estimate techniques are included within this dataset, as all analyses were performed on log10 scale, variability between estimates did not have an appreciable effect on our results.

All species were assigned a basic trophic level designator based on species morphological and ecological descriptions in the literature. Species were categorized individually, regardless of taxonomic affinity in order to most accurately capture the intricacies of dinosaur community structuring. “Carnivores” and “Herbivores” were identified as any organism never having been contested in the literature as a non-carnivore or non-herbivore, respectively. As only a small percentage of the species included in our analyses fell outside of these two main categories, we subdivided the “omnivore” group in two, which were then added to either the “carnivore” or “herbivore”

group as appropriate. “Meat-dominant omnivore” was assigned to any species that had been suggested as an omnivore after an initial designation of carnivore, or which was identified as an omnivore with identifiable faunivore morphology, and were grouped with carnivores for analysis. A similar method was used to designate “plant-dominant omnivore”, which were grouped with herbivores. Recent accounts of dietary remnants, such as stomach contents and coprolites, were also considered when grouping species into trophic categories. While we endeavored to be as accurate as possible with these descriptions, some species, particularly enigmatic species within caenagnathidae and oviraptoridae, have yet to be definitively described within a single dietary category. Our inclusion of these species within the “meat-dominant omnivore” group may prove to be inaccurate as more evidence is presented in the literature. However, these enigmatic species represent an exceedingly small portion of the overall sample tested (1.6%) and therefore are unlikely to significantly change our results when grouped as herbivores rather than carnivores.

Statistical Analysis

To determine the shape of the M-S distribution, each dinosaur assemblage, as well as each carnivore and herbivore assemblage was tested for fit with K-S Goodness of Fit ($\alpha=0.05$) against the global dataset, bootstrapped 1,000 times. Bimodality was assessed with Sarle’s Bimodality Coefficient, summary statistics, and fit to quadratic and 4th degree polynomial regressions. Bimodality was further tested through likelihood of bin occupancy for the entire dataset, as well as on carnivores and herbivores separately. To determine the effect of the presence of megatheropods in an assemblage, a Kendal

Rank test was performed on 39 carnivore guild distributions. Likelihood of bin occupancy was further tested in relation to occupancy of surrounding mass bins to determine the influence of any larger species on occupancy.

Ontogenetic Biomass Calculations

In order to identify potential competitive exclusion in dinosaur assemblages, biomass was calculated for megatheropods from nine formations from the total dataset. These formations were selected because they represent multiple geographic locations and geologic periods, and contain theropods for which growth and survivorship curves have been calculated. Growth rates from Erickson and Bybee were multiplied by survivorship of the same species from Erickson, using a 1,000-individual cohort. As it has been hypothesized that giant theropods would all employ a similar rapid growth curve, and as neither growth curves nor survivorship curves for *Acrocanthosaurus atokensis* and *Siats meekerorum* were available in the primary literature, growth curves for these species were created by averaging growth rates from *Tyrannosaurus rex* for its increased size, and *Allosaurus fragilis* for its taxonomic similarity to *A.atokensis* and *S. meekerorum*, Survivorship curves from *Daspletosaurus torosus* were substituted directly, as the mass of all three species is similar. The same method was utilized for *Tarbosaurus bataar*, averaging curves from *T. rex* and *D. torosus*. Biomass estimates for *Achillobator giganticus* were not included as there are no existing comparable growth curves or survivorship estimates available.

The relative biomass for juveniles and adults of each species was multiplied by the proportional biomass for each mass bin, normalized so the adult proportion = 1.

Juveniles were defined as individuals in the cohort that had not reached somatic maturity based on asymptotic growth (approximately age 16).

Supplementary Text

Inclusion and exclusion of taxa

Our database of 557 non-avian dinosaur taxa are based on downloads from the Paleobiology Database, an extensive recording of all published taxa, updated and maintained by a group of paleontologists from around the globe. Downloads from the PBDB provided a baseline of all potential taxa to be found in a community, which was then independently verified against the literature, as of November, 2020. Sources for every occurrence of every species were identified independent from the PBDB to confirm their accuracy temporally and spatially, and are listed in Table S3.1. All obsolete taxa (e.g. *Deinodon*) were excluded. Morphological and phylogenetic reassessments were followed as much as possible, and taxonomy was updated accordingly, specifically pertaining to the following species:

Amtosaurus archibaldi- fragmentary remains that have been described with ankylosaur or hadrosaur affinities have since been renamed as *Bissektipelta* (40)

Anatotitan copei- hadrosaur material from western North America which most recently has been demonstrated to be the remains of *Edmontosaurus* (41).

Chialingosaurus kuani- based solely on juvenile remains from the Shaximiao formation that cannot be distinguished as a unique taxon, and is therefore a nomen dubium (42)

Chungkingosaurus jiangbeiensis- has been identified as a possible juvenile of *Tuojiangosaurus* (43)

Compsosuchus solus- based on fragmentary remains from the Lameta formation, has since been determined to be a nomen dubium and is therefore listed as “Noosaurid C” in this paper (44)

Drinker nisti- neornithischian remains from this species were reclassified together with at least one other taxon as a single taxon *Nanosaurus agilis* (45)

Iguanodon dawsoni- limited post-cranial material from the Wadhurst Clay formation that has since been reclassified as *Barilium dawsoni* (46)

Iguanodon orientalis- poorly described skull material from Khuren Dukh that has since been reclassified as *Altirhinus kurzanovi* (47)

Jubbulpuria tenuis- based on fragmentary remains from the Lameta formation, has been determined to be a nomen dubium and is therefore listed as “Theropod B” in this paper (44)

Koutalisaurus kohlerorum- synonymous with *Pararhabdodon* (48)

Leptorhynchos elegans- caenagnathid redescribed as *Citipes elegans* (49)

Majungatholus atopus- originally described as a new pachycephalosaur, material has been re-assigned to *Majungasaurus* (50)

Maleevus disparoserratus- originally described as a new ankylosaur from the Bayan Shireh formation, has since been determined to be a junior synonym of *Pinacosaurus* (51)

Nanotyrannus- based on a skull originally described as *Gorgosaurus lancensis* from the Hell Creek formation, *Nanotyrannus* was erected as a new genus of pygmy tyrannosaur (52). Following the discovery of a second, more complete skeleton,

numerous morphological analyses have overwhelmingly shown the two specimens attributed to *N. lancensis* to be juvenile specimens of *Tyrannosaurus rex* (8, 12, 53–56)

Ornithomimus minutus- based on isolated toe bones from the Laramie formation with likely Alvarezsaurid affinity (57), is listed as “Alvarezsauridae” in this paper

Richardoestesia asiatica- although likely a valid species, this tooth taxon cannot be distinguished from *R. isosceles* and has been included within this taxon in this paper (58)

Styracosaurus ovatus- ceratopsian remains from the Two Medicine formation that have since been reclassified as *Rubeosaurus* (59)

Titanosaurus madagascariensis- based on fragmentary remains from the Maeveryano formation, has been identified as synonymous with *Laplatasaurus* (60)

Triceratops / *Torosaurus*- although the validity of the genus *Torosaurus* has been called into question (61-62) as a possible ontogenetic stage of the earlier named *Triceratops*, we feel this assertion has yet to be definitively proven, particularly in light of more recent morphometric analyses (63-64). As such, we include both genera in our paper.

Ugrunaaluk kuukpikensis- hadrosaurid remains from the Prince Creek formation that have since been reclassified as remains of juvenile *Edmontosaurus* (65)

Wuerhosaurus mongoliensis- informally named stegosaur material from the Dzundbain formation which has since been formally described as *Mongolostegus exspectabilis* (66)

Willinakaqe salitralensis- originally described as a new saurolophine hadrosaur from the Allen formation(67), *W. salitralensis* has since been determined to refer to multiple species and is therefore a nomen dubium (68).

Yunnanosaurus robustus- material from the Lufeng formation represents an ontogenetic series, synonymous with *Y. huangi* (69)

In the interest of capturing as much biodiversity as possible, we removed as few “problematic” taxa as possible. Only those that we found to be definitively synonymous, or those that showed a preponderance of evidence towards synonymizing were excluded.

Figure S1.1. Number of species in each mass bin, by guild, in formations from the Jurassic and Cretaceous periods (bars) appears more normal than global distribution. Herbivores (light grey) mirror their left-skewed global distribution, while carnivores exhibit a unique bimodal trend. Likelihood of at least one species existing in mass bin in any formation (lines) shows the distinctly more platykurtic distribution at local scales, as well as the severe drop in likelihood in medium size carnivore bins.

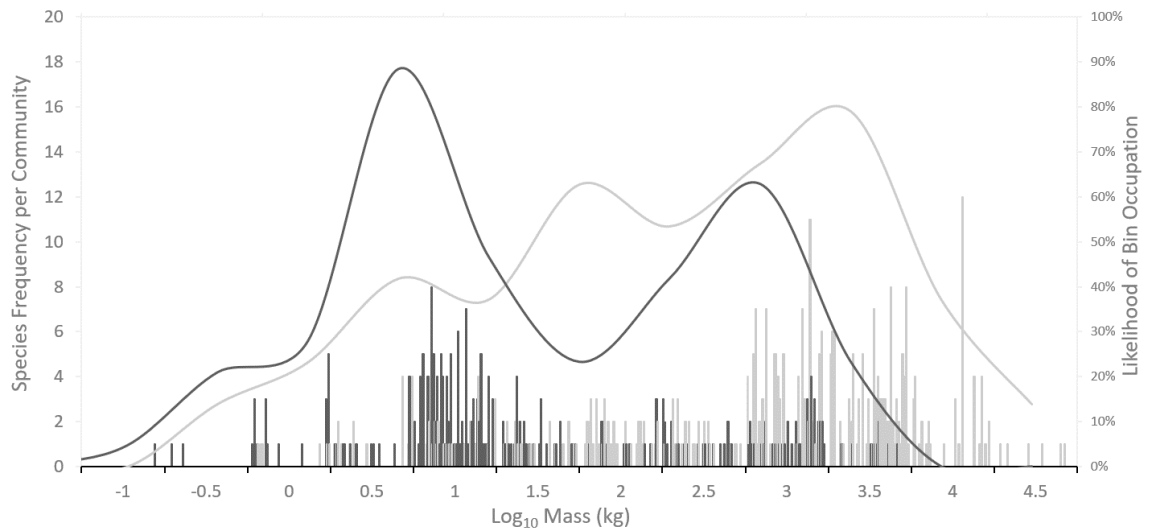


Figure S1.2. Growth vs survivorship of three megatheropods shows biomass is highest at sexual maturity, which occurs shortly before somatic maturity in dinosaurs.

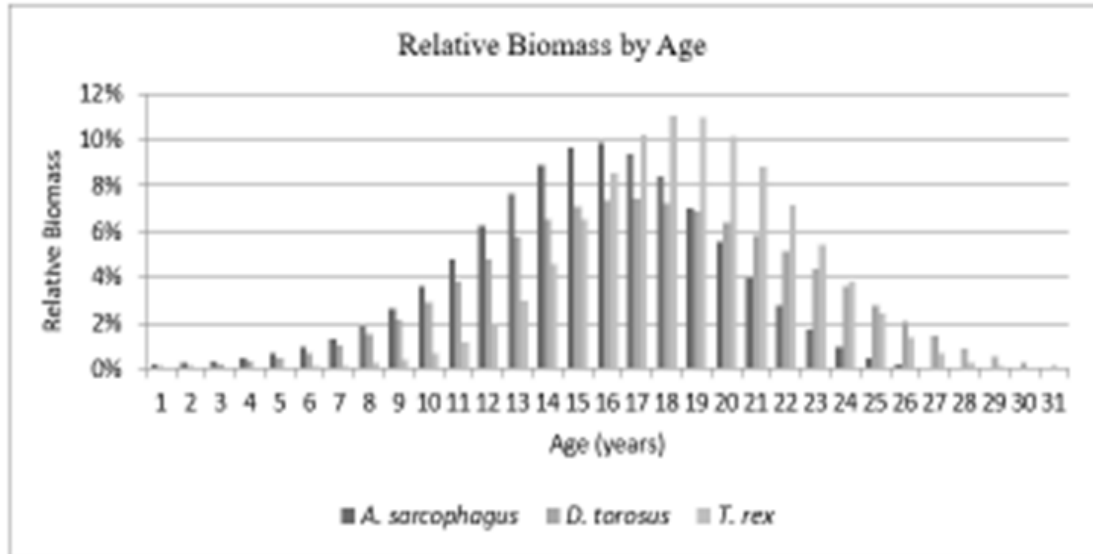


Table S1.1. Taxon list for each community with mass in kg and references

Assemblage	Herbivores / Plant Dominant Omnivores		Locality		Carnivores / Meat Dominant Omnivores	Locality	
			Ref	Mass (kg) Mass Ref		Ref	Mass (kg) Mass Ref
Allen Argentina 79-69MYA	<i>Bonatitan reigi</i>	(70)	808.0086	(26, 71)	<i>Dromaeosaurid A</i>	(76)	15.142 (43)
	<i>Nodosaurid A</i>	(72)	1788.277	(4, 9, 26, 43, 73)	<i>Bonapartenykus ultimus</i>	(83)	20.5 (57)
	<i>Bonapartesaurus rionegrensis</i>	(74)	2071.494	(43, 57, 73)	<i>Austroraptor cabazai</i>	(84)	373.849 (4, 26-27, 43)
	<i>Hadrosaurid A</i>	(67)	2071.494	(43, 57, 73)	<i>Quilmesaurus curriei</i>	(85)	460 (43, 57, 86)
	<i>Lapampasaurus cholinoi</i>	(75)	2071.494	(43, 57, 73)	<i>Carcharodontosaurid A</i>	(70)	491.667 (86)
	<i>Saltasaurid A</i>	(76)	3741.3	(4, 43, 57, 71, 73)			
	<i>Saltasaurine A</i>	(76)	3741.3	(4, 43, 57, 71, 73)			
	<i>Hadrosaurid B</i>	(70)	4000	(43)			
	<i>Aeolosaurus</i>	(77)	6000	(43)			
	<i>Laplatasaurus araukanicus</i>	(72)	8395.233	(4, 43, 71)			
	<i>Panamericasaurus schroederi</i>	(78)	11629.23	(26, 71)			
Anacleto Argentina 84-79MYA	<i>Antarctosaurus wichmannianus</i>	(79)	20817.15	(4, 26, 43, 71, 80)			
	<i>Titanosaurian A</i>	(81)	22385.94	(43, 82)			
	<i>Gasparinisaura cincosaltensis</i>	(87)	8.96212	(4, 26, 43)	<i>Aerosteon riocoloradensis</i>	(93)	672.43 (26, 43, 86)
	<i>Saltasaurine B</i>	(87)	3741.3	(4, 43, 57, 71, 73)	<i>Aucasaurus garridoi</i>	(87)	734.233 (4, 26, 43, 86)
	<i>Neuquensaurus australis</i>	(87)	3802.349	(4, 26-27, 43, 71)	<i>Abelisaurus comahuensis</i>	(87)	2325 (43, 86)
	<i>Overosaurus paradasorum</i>	(88)	5250	(43, 71)			
	<i>Pitekunsaurus macayai</i>	(89)	5500	(43, 57)			
	<i>Laplatasaurus araukanicus</i>	(87)	8395.233	(4, 43, 71)			
	<i>Narambuenatitan palomoi</i>	(90)	8919.105	(27, 43, 57, 73, 86)			
	<i>Barrosasaurus casamiquelai</i>	(91)	13500	(71)			
	<i>Nemegtosaurid A</i>	(92)	14139.36	(43, 71)			
Bajo de la Carpa Argentina 85-84MYA	<i>Antarctosaurus wichmannianus</i>	(87)	20817.15	(4, 26, 43, 71, 80)			
	<i>Pellegrinisaurus powelli</i>	(87)	29050	(43, 71)			
	<i>Ornithopod D</i>	(94)	8.96212	(4, 26, 43)	<i>Neuquenornis volans</i>	(95)	0.3795 (73)
	<i>Elasmarian Ornithopod</i>	(94)	300	(43)	<i>Alvarezsaurus calvoi</i>	(95)	2.79242 (26-27, 43, 86)
	<i>Rinconosaurus caudamirus</i>	(95)	3426.56	(26, 43, 71)	<i>Velocisaurus unicus</i>	(95)	3.94576 (26, 86)
	<i>Bonitasaura salgadoi</i>	(95)	5250	(43, 71)	<i>Achillesaurus manazzoni</i>	(96)	16.5 (43, 86)
	<i>Lithostrotian Sauropod A</i>	(95)	5250	(43, 71)	<i>Viavenator exxoni</i>	(95)	700 (43)
	<i>Lithostrotian Sauropod B</i>	(95)	5250	(43, 71)	<i>Tratayenia rosalesi</i>	(97)	1150 (43, 86)
	<i>Overosaurus paradasorum</i>	(95)	5250	(43, 71)	<i>Carnotaurine A</i>	(98)	1925 (43, 86)
	<i>Laplatasaurus</i>	(87)	6488.299	(4, 43, 71, 73)			
	<i>Traukutitan eocaudata</i>	(95)	32064.56	(26, 71)			
Baruungoyot Mongolia 79-70MYA	<i>Bagaceratops rozhdestvenskyi</i>	(99)	4.271304	(4, 26, 43)	<i>Parvicursor remotus</i>	(99)	0.16883 (26-27, 43, 86)
	<i>Magnirostris dodsoni</i>	(99)	4.271304	(4, 26, 43)	<i>Ceratomykus oculus</i>	(103)	0.57999 (26-27, 43, 86)
	<i>Tylocephale gilmorei</i>	(100)	40	(43)	<i>Hulsanpes perlei</i>	(104)	1.36383 (105)
	<i>Protoceratops hellenikorhinus</i>	(100)	180	(43)	<i>Shuvuuia deserti</i>	(103)	2.9821 (26-27, 43, 86)
	<i>Ornithomimid B</i>	(100)	315.6433	(4, 26-27, 43, 73)	<i>Mononykus olecranus</i>	(99)	3.95592 (4, 26, 43, 86)
	<i>Pinacosaurus mephistocephalus</i>	(99)	1100.806	(4, 43)	<i>Machairasaurus</i>	(99)	10 (86)
	<i>Saichania chulsanensis</i>	(99)	1305.986	(26, 43)	<i>Avimimus</i>	(99)	13.2792 (4, 26, 43, 86)
	<i>Tarchia gigantea</i>	(99)	2000	(43)	<i>Velociraptor osmolskae</i>	(100)	18.734 (4, 26-27, 43, 73)
	<i>Zaraapelta nomadis</i>	(101)	2500	(101)	<i>Conchoraptor gracilis</i>	(99)	24.5 (43, 86)
	<i>Hadrosaurid C</i>	(100)	3062.165	(4, 26, 43, 57, 73)	<i>Oviraptor philoceratops</i>	(100)	33.0698 (4, 43, 86)
	<i>Quaesitosaurus</i>	(100)	12172.7	(43, 71, 102)	<i>Ingenia</i>	(99)	43.4805 (26)
Bayan Shireh / Iren Dabasu Mongolia 101-90MYA	<i>Tarbosaurus bataar</i>	(106)	3103.15	(26, 43, 73, 86)			
	<i>Yamaceratops dorn gobiensis</i>	(107)	2	(43)	<i>Avimimus</i>	(112)	13.2792 (4, 26, 43, 86)
	<i>Graciliceratops mongoliensis</i>	(108)	4.335756	(4, 26)	<i>Velociraptor</i>	(112)	18.734 (4, 26-27, 43, 73)
	<i>Amtocephale gobiensis</i>	(109)	50	(109)	<i>Saurornithoides mongoliensis</i>	(112)	21.7546 (26, 43, 86)
	<i>Garudimimus brevipes</i>	(100)	99.61264	(26-27, 43, 73, 86)	<i>Deinonychosaurian A</i>	(116)	90 (4, 26, 43, 86)
	<i>Archaeornithomimus</i>	(110)	146.8911	(26, 86)	<i>Achillobator giganticus</i>	(117)	373.849 (4, 26-27, 43)
	<i>Amtocephale magnus</i>	(100)	300	(40)	<i>Alectrosaurus olseni</i>	(100)	601.026 (26, 86)
	<i>Erlikosaurus andrewsi</i>	(100)	430	(43, 86)	<i>Theropod A</i>	(116)	1742.73 (4, 26, 43, 73, 86)
	<i>Tsaganetia longicranialis</i>	(107)	500	(43)			
	<i>Enigmosaurus mongoliensis</i>	(100)	960.1667	(43, 57, 86)			
	<i>Talarurus plicatospinus</i>	(100)	1020.246	(4, 26, 43)			
Bayan Shireh / Iren Dabasu Mongolia 101-90MYA	<i>Pinacosaurus disparoserratus</i>	(100)	1100.806	(4, 43)			
	<i>Gilmoreosaurus mongoliensis</i>	(111)	1136.287	(4, 26, 43)			
	<i>Bactrosaurus</i>	(112)	1472.773	(4, 26, 43)			
	<i>Gobihadros mongoliensis</i>	(113)	1712.598	(43, 73)			
	<i>Gigantoraptor erlianensis</i>	(114)	2216.107	(4, 26, 43, 86, 115)			
	<i>Segnosaurus galbinensis</i>	(100)	2633.2	(26, 43, 86)			
	<i>Erketu ellisoni</i>	(116)	11225.59	(43, 71, 116)			
	<i>Quaesitosaurus orientalis</i>	(107)	25418.09	(102)			

Table S1.1 (continued)

Assemblage	Herbivores / Plant Dominant Omnivores	Locality		Carnivores / Meat Dominant Omnivores	Locality	
		Ref	Mass (kg) Mass Ref		Ref	Mass (kg) Mass Ref
Bissekty Uzbekistan 92-90MYA	<i>Levnesovia transoxiana</i>	(118)	175 (43)	<i>Caenagnathasia martinsoni</i>	(122)	1.4 (43)
	<i>Bissektipelta archibaldi</i>	(110)	300 (40)	<i>Richardoestesia isosceles</i>	(123)	10.1954 (9, 86)
	<i>Ornithomimid C</i>	(119)	315.6433 (4, 26-27, 43, 73)	<i>Urbacodon itemirensis</i>	(123)	10.8333 (57, 86)
	<i>Turanoceratops tardabilis</i>	(120)	483.7592 (26, 43)	<i>Itemirus medullaris</i>	(124)	12.422 (26)
	<i>Bactrosaurus</i>	(104)	1472.773 (4, 26, 43)	<i>Paronychodon asiaticus</i>	(123)	12.9875 (86)
	<i>Therizinosauroida</i>	(120)	4750 (43, 86)	<i>Timurlengia euotica</i>	(125)	220 (125)
	<i>Non-lithostrotian Titanosaur A</i>	(121)	7000 (43)			
Callovian Oxford Clay United Kingdom 166-163.5MYA	<i>Callovosaurus leedsi</i>	(126)	108.3666 (4, 27)	<i>Eustreptospondylus oxoniensis</i>	(131)	348.725 (4, 26, 43, 86)
	<i>Sarcolestes leedsi</i>	(127)	187.5 (57)	<i>Metriacanthosaurus parkeri</i>	(132)	1184.89 (26, 86)
	<i>Lexovisaurus durobrivensis</i>	(126)	2155.233 (4, 43)			
	<i>Omosaurus durobrivensis</i>	(128)	2155.233 (4, 43)			
	<i>Loricatosaurus priscus</i>	(104)	2257.871 (4, 26, 57, 73)			
	<i>Cetiosauriscus stewarti</i>	(129)	12160.95 (4, 26, 43, 71)			
	<i>Cetiosaurus</i>	(130)	12232.49 (4, 26, 43, 71)			
Cedar Mountain Mussentuchit United States 102-95.64MYA	<i>Neoceratopsian A</i>	(133)	1.5 (134)	<i>Velociraptorine A</i>	(142)	5.82906 (4, 43, 86)
	<i>Zephyrosaurus</i>	(135)	20 (43)	<i>Richardoestesia</i>	(142)	10.2398 (9, 43, 86)
	<i>Pachycephalosaurid A</i>	(136)	27.6576 (4, 26, 43)	<i>Paronychodon</i>	(142)	12.9875 (9, 26, 43, 86)
	<i>Animantax ramaljonesi</i>	(137)	411.8695 (4, 26, 43)	<i>Caenagnathoid A</i>	(136)	13.2792 (4, 26, 43, 86)
	<i>Ornithopod E</i>	(136)	500 (43)	<i>Troodontid C</i>	(142)	21.7546 (26, 43, 86)
	<i>Tenontosaurus</i>	(138)	818.362 (4, 26-27, 43)	<i>Dromaeosaurine A</i>	(142)	83.1907 (4, 26, 43, 86)
	<i>Eolambia caroljonesa</i>	(139)	1000 (43)	<i>Alectrosaurus</i>	(135)	601.026 (26, 86)
	<i>Peloroplites cedrimontanus</i>	(140)	2000 (43)	<i>Siats meekerorum</i>	(143)	3950 (86, 143)
	<i>Cedarpelta bilbeyhallorum</i>	(140)	5000 (43)			
	<i>Astrodon</i>	(135)	10800 (71, 141)			
Cloverly United States 113-100.5MYA	<i>Aquilops americanus</i>	(134)	1.5 (134)	<i>Microvenator celer</i>	(144)	3.62685 (4, 26)
	<i>Zephyrosaurus schaffi</i>	(144)	20 (43)	<i>Deinonychus antirrhopus</i>	(144)	83.1907 (4, 26, 43, 86)
	<i>Ornithomimus velox</i>	(104)	175.6667 (9, 43, 86)	<i>Acrocanthosaurus atokensis</i>	(144)	4558.8 (4, 26, 43, 86)
	<i>Tenontosaurus tilletti</i>	(144)	818.362 (4, 26-27, 43)			
	<i>Sauropelta edwardsorum</i>	(144)	2000 (43)			
	<i>Tatankacephalus cooneyorum</i>	(144)	2505.082 (43, 145)			
	<i>Rugocaudia coonevi</i>	(146)	6300 (71)			
	<i>Sauroposeidon proteles</i>	(144)	34146.02 (26, 43, 147)			
Dinosaur Park MAZ- 1b Canada 76-75.5MYA	<i>Stegoceras validum</i>	(148)	27.6576 (4, 26, 43)	<i>Hesperonychus elizabethae</i>	(152)	2.55 (43, 86)
	<i>Hanssuesia sternbergi</i>	(148)	28.07162 (43)	<i>Bambiraptor feinbergi</i>	(153)	5.82906 (4, 43, 86)
	<i>Prencephale</i>	(148)	38.50373 (26, 43)	<i>Richardoestesia isosceles</i>	(153)	10.1954 (9, 86)
	<i>Struthiomimus altus</i>	(149)	215.0365 (4, 26-27, 43, 73)	<i>Richardoestesia gilmorei</i>	(153)	10.3284 (9, 43, 86)
	<i>Panoplosaurus mirus</i>	(150)	1436.424 (26, 43)	<i>Zapsalis abradens</i>	(153)	12.3333 (86, 104)
	<i>Euoplocephalus tutus</i>	(150)	1617.899 (4, 26, 43)	<i>Dromaeosaurus albertensis</i>	(153)	14.7467 (9, 43, 86)
	<i>Centrosaurus apertus</i>	(150)	2214.703 (4, 26, 43)	<i>Saurornitholestes langstoni</i>	(153)	23.4053 (4, 9, 26, 43, 57)
	<i>Chasmosaurus belli</i>	(150)	2244.365 (4, 26, 43)	<i>Pectinodon</i>	(153)	47.3759 (26)
	<i>Chasmosaurus russelli</i>	(151)	2258.128 (4, 26-27, 43)	<i>Caenagnathus collinsi</i>	(154)	61.5 (43, 155)
	<i>Edmontonia rugosidens</i>	(150)	2265.253 (26, 43)	<i>Troodon formosus</i>	(153)	68.1649 (4, 26, 43, 86)
	<i>Corythosaurus intermedius</i>	(104)	2977.832 (26, 43)	<i>Chirostenotes pergracilis</i>	(154)	74.7759 (9, 43, 73, 86)
	<i>Lambeosaurus lambei</i>	(150)	3248.555 (4, 26, 43)	<i>Gorgosaurus libratus</i>	(156)	2554.78 (4, 26, 43, 86)
	<i>Lambeosaurus clavinitialis</i>	(150)	3300 (43)	<i>Daspletosaurus</i>	(156)	2565.55 (4, 43, 73, 86)
	<i>Parasaurolophus walkeri</i>	(150)	3549.646 (4, 26, 43)			
Djadokhta Mongolia 75-71MYA	<i>Bagaceratops</i>	(157)	4.271304 (4, 26, 43)	<i>Parvicursor remotus</i>	(159)	0.16883 (26-27, 43, 86)
	<i>Goyocephale lattermorei</i>	(100)	27.6576 (4, 26, 43)	<i>Mahakala omnogovae</i>	(160)	0.53745 (26, 43, 86)
	<i>Oviraptor philoceratops</i>	(100)	33.06984 (4, 43, 86)	<i>Halszkaraptor escuilliei</i>	(161)	0.76234 (26, 161)
	<i>Protoceratops andrewsi</i>	(100)	99.57581 (4, 26, 43)	<i>Shuvuuia deserti</i>	(162)	2.9821 (26-27, 43, 86)
	<i>Aepyornithomimus tugrikinensis</i>	(158)	105.9753 (158)	<i>Gobivenator mongoliensis</i>	(113)	12.7809 (26, 43, 86)
	<i>Udanoceratops tschizhovi</i>	(110)	736.087 (26, 43)	<i>Avimimus portentosus</i>	(100)	13.2792 (4, 26, 43, 86)
	<i>Pinacosaurus grangeri</i>	(100)	1100.806 (4, 43)	<i>Byronosaurus</i>	(163)	13.6 (43, 86)
	<i>Nemegtosaurus</i>	(100)	14139.36 (43, 71)	<i>Velociraptor mongoliensis</i>	(100)	18.734 (4, 26-27, 43, 73)
				<i>Kol ghuvu</i>	(164)	20 (43)
				<i>Tsaagan mangas</i>	(165)	20.5 (43, 86)
				<i>Saurornithoides mongoliensis</i>	(100)	21.7546 (26, 43, 86)
				<i>Khaan mckennai</i>	(166)	23.9839 (26-27)
				<i>Citipati osmolskae</i>	(116)	93.9976 (26, 43, 86)
				<i>Tyrannosauroid</i>	(99)	3103.15 (26, 43, 73, 86)

Table S1.1 (continued)

Assemblage	Herbivores / Plant Dominant Omnivores	Locality Ref	Mass (kg)	Mass Ref	Carnivores / Meat Dominant Omnivores	Locality Ref	Mass (kg)	Mass Ref
Griman Creek Australia 99.6-93.5MYA	<i>Iguanodontian A</i>	(167-168)	6	(43)	<i>Noasaurid A</i>	(174)	13.7896	(4, 26, 43)
	<i>Ornithopod A</i>	(169)	8.9165	(43, 57)	<i>Noasaurid B</i>	(174)	26.5	(43, 86)
	<i>Ornithopod B</i>	(169-170)	20	(43)	<i>Rapator ornitholestoides</i>	(167)	156.745	(4, 26, 43, 57, 73)
	<i>Weewarrasaurus poheni</i>	(168-169)	50	(169)	<i>Megaraptorid A</i>	(175)	201.729	(26, 43, 86)
	<i>Ornithopod C</i>	(169, 171)	90	(43)	<i>Avetheropoda A</i>	(175)	672.43	(26, 43, 86)
	<i>Ankylosaurian A</i>	(168)	300	(43)				
	<i>Fostoria dhimbangunmal</i>	(168, 172)	355.8834	(27, 43)				
	<i>Ankylopollexian A</i>	(168-169)	910.3948	(4, 26-27, 43)				
	<i>Iguanodontian B</i>	(169)	4225.792	(4, 9, 27, 73)				
	<i>Titanosaurian B</i>	(168, 173)	6000	(43)				
Hanson Antarctica 194-188MYA	<i>Prosauropod A</i>	(104)	554.9922	(4, 9, 71, 73, 176)	<i>Coelophysoid A</i>	(178-179)	6	(43, 178, 180)
	<i>Glacialisaurus hammeri</i>	(177)	745	(71, 177)	<i>Coelophysoid B</i>	(179)	25.0459	(26, 43, 86)
					<i>Cryolophosaurus ellioti</i>	(181)	349.387	(26, 43)
Hell Creek United States 66.8-66MYA	<i>Orodromeus makelai</i>	(182)	15.1695	(4, 26)	<i>Richardoestesia isosceles</i>	(196)	10.1954	(9, 86)
	<i>Stegoceras</i>	(183)	27.6576	(4, 26, 43)	<i>Richardoestesia gilmorei</i>	(197)	10.3284	(9, 43, 86)
	<i>Citipes elegans</i>	(184)	56.36128	(9, 43, 185)	<i>Acheroraptor temertyorum</i>	(198)	18.5	(86, 199)
	<i>Sphaerotholus buchholtzae</i>	(186)	68.33955	(43, 57, 73)	<i>Saurornitholestes</i>	(197)	23.7026	(4, 9, 26, 43, 57)
	<i>Thescelosaurus</i>	(187)	170.3897	(4, 26, 43)	<i>Pectinodon bakkeri</i>	(200)	47.3759	(26)
	<i>Leptoceratops gracilis</i>	(188)	212.9821	(4, 26, 43)	<i>Anzu wyliei</i>	(201)	246.013	(43, 86, 201)
	<i>Ornithomimus</i>	(189)	221.4634	(4, 9, 26-27, 43)	<i>Dakotaraptor steini</i>	(202)	285	(43, 86)
	<i>Pachycephalosaurus wyomingensis</i>	(190)	342.0206	(4, 26, 43)	<i>Tyrannosaurus rex</i>	(55)	6428.6	(4, 26, 43, 73, 86)
	<i>Ankylosaurus magniventris</i>	(191)	3872.272	(4, 26, 43)				
	<i>Edmontosaurus annectens</i>	(192)	4595.999	(4, 26, 43)				
	<i>Torosaurus</i>	(63, 193)	7598.517	(4, 26-27, 43, 73)				
	<i>Triceratops horridus</i>	(194)	8318.221	(4, 26-27, 43, 73)				
Horseshoe Canyon Drumheller-Horsethief Canada 73.1-71.5MYA	<i>Ornithomimus edmontonicus</i>	(149)	138.7235	(4, 26-27, 73)	<i>Richardoestesia gilmorei</i>	(203)	10.3284	(9, 43, 86)
	<i>Struthiomimus</i>	(149)	215.0365	(4, 26-27, 43, 73)	<i>Paronychodon</i>	(149)	12.9875	(9, 26, 43, 86)
	<i>Arrhinoceratops brachyops</i>	(149)	1300	(43)	<i>Dromaeosaurus</i>	(149)	13.56	(9, 43, 86)
	<i>Edmontonia longiceps</i>	(149)	1985.43	(4, 26, 43)	<i>Atrociraptor marshalli</i>	(203)	15.25	(43, 86)
	<i>Anodontosaurus lambei</i>	(203)	2164.816	(43, 204)	<i>Troodontid D</i>	(203)	22.496	(86)
	<i>Anchiceratops ornatus</i>	(149)	2229.013	(26, 43)	<i>Albertavenator</i>	(203)	50	(205)
	<i>Pachyrhinosaurus canadensis</i>	(149)	3139.13	(4, 26, 43)	<i>Epichirostenotes</i>	(149)	98.0518	(86)
	<i>Edmontosaurus regalis</i>	(149)	5260.076	(4, 26, 43)	<i>Apatoraptor</i>	(203)	115.552	(206)
					<i>Albertosaurus sarcophagus</i>	(149)	2345.18	(4, 26, 43, 86)
Judith River Coal Ridge Canada 76.2-75.2MYA	<i>Pachycephalosaurid B</i>	(207)	27.6576	(4, 26, 43)	<i>Richardoestesia gilmorei</i>	(208)	10.3284	(9, 43, 86)
	<i>Hypsilophodontid A</i>	(207-208)	170.3897	(4, 26, 43)	<i>Zapsalis abradens</i>	(208)	12.3333	(86, 104)
	<i>Avaceratops lammersi</i>	(208)	579.6361	(4, 43)	<i>Paronychodon</i>	(207)	12.9875	(9, 26, 43, 86)
	<i>Nodosaurid B</i>	(208)	1436.424	(26, 43)	<i>Dromaeosaurus albertensis</i>	(208)	14.7467	(9, 43, 86)
	<i>Mercuriceratops gemini</i>	(208)	2070.972	(43, 209)	<i>Troodon formosus</i>	(208)	68.1649	(4, 26, 43, 86)
	<i>Monoclonius crassus</i>	(207)	2396.318	(43, 210)	<i>Gorgosaurus libratus</i>	(104)	2554.78	(4, 26, 43, 86)
	<i>Zuul crurivastator</i>	(211)	2500	(211)				
	<i>Lambeosaurus</i>	(207)	3117.374	(4, 26, 43)				
	<i>Gryposaurus</i>	(208)	3428.063	(4, 26, 43)				
	<i>Spiclypeus shipporum</i>	(208)	3500	(208)				
	<i>Hadrosaurid D</i>	(207-208)	4000	(43)				
Kaiparowits United States 76.1-74MYA	<i>Stegoceras validum</i>	(104)	27.6576	(4, 26, 43)	<i>Richardoestesia</i>	(213)	10.2398	(9, 43, 86)
	<i>Hypsilophodontid B</i>	(212)	40.23712	(26, 43)	<i>Paronychodon</i>	(213)	12.9875	(9, 26, 43, 86)
	<i>Ornithomimus velox</i>	(213)	175.6667	(9, 43, 86)	<i>Dromaeosaurid B</i>	(213)	13.56	(9, 43, 86)
	<i>Akainacephalus johnsoni</i>	(214)	1500	(43)	<i>Velociraptorine B</i>	(213)	23.7026	(4, 9, 26, 43, 57)
	<i>Nasutoceratops titusi</i>	(215)	1500	(43)	<i>Talos sampsoni</i>	(219)	29	(43, 219)
	<i>Kosmoceratops richardsoni</i>	(216)	1850	(43, 216)	<i>Hagryphus giganteus</i>	(220)	80	(43, 86)
	<i>Utahceratops gettyi</i>	(216)	2750	(43, 216)	<i>Teratophoneus curriei</i>	(221)	1532.18	(26, 43, 86)
	<i>Gryposaurus monumentensis</i>	(217)	3000	(43)				
	<i>Parasaurolophus cyrtocristatus</i>	(218)	3292.803	(4, 43)				
Kayenta/Navajo Sandstone United States 199-182MYA	<i>Segisaurus</i>	(222)	6	(43, 178, 180)	<i>Kayentavenator elysiae</i>	(227)	17.75	(43, 57)
	<i>Scutellosaurus lawleri</i>	(223)	14.8132	(26, 43)	<i>Coelophysis kayentakatae</i>	(228)	30.1113	(26, 43)
	<i>Seitaad ruessi</i>	(224)	85	(43, 71)	<i>Dilophosaurus wetherilli</i>	(229)	340.609	(4, 26-27, 43, 86)
	<i>Sarhsaurus aurifontanalis</i>	(225)	163.7259	(26-27, 43, 71)				
	<i>Ammosaurus</i>	(222)	355.1782	(4, 26, 43, 71)				
	<i>Scelidosaurus</i>	(226)	500	(86)				

Table S1.1 (continued)

Assemblage	Herbivores / Plant Dominant Omnivores	Locality Ref	Mass (kg)	Mass Ref	Carnivores / Meat Dominant Omnivores	Locality Ref	Mass (kg)	Mass Ref
Khuren Dukh Mongolia 107-100MYA	<i>Psittacosaurus mongoliensis</i>	(230)	14.01595	(4, 26, 43)	<i>Troodontid A</i>	(230)	2.5	(43)
	<i>Harpymimus okladnikov</i>	(230)	99.94297	(4, 43, 86)	<i>Troodontid B</i>	(232)	10.8333	(86)
	<i>Ornithomimid A</i>	(230)	146.8911	(26, 86)	<i>Carnosaurian A</i>	(116)	1742.73	(4, 26, 43, 73, 86)
	<i>Mongolostegus exspectabilis</i>	(66)	950	(43, 57)				
	<i>Choyrodon barsboldi</i>	(231)	1000	(43, 231)				
	<i>Altirhinus kurzanovi</i>	(104)	1100	(43)				
	<i>Shamosaurus scutatus</i>	(230)	2000	(43)				
	<i>Sauropod A</i>	(116)	11225.59	(43, 71)				
Kirtland Hunter- Willow Washes United States 75-73MYA	<i>Stegoceras validum</i>	(233)	27.6576	(4, 26, 43)	<i>Richardoestesia</i>	(238)	10.2398	(9, 43, 86)
	<i>Sphaerotherolus goodwini</i>	(233)	64.06949	(43, 57, 73)	<i>Dromaeosaurid C</i>	(239)	13.56	(9, 43, 86)
	<i>Ornithomimus edmontonicus</i>	(234)	138.7235	(4, 26-27, 73)	<i>Troodontid E</i>	(240)	17	(86)
	<i>Ornithomimus antiquus</i>	(233)	221.4634	(4, 9, 26-27, 43)	<i>Saurornitholestes langstoni</i>	(233)	23.4053	(4, 9, 26, 43, 57)
	<i>Nodocephalosaurus kirtlandensis</i>	(233)	1500	(43)	<i>Troodon</i>	(239)	68.1649	(4, 26, 43, 86)
	<i>Ziapelta sanjuanensis</i>	(235)	2164.816	(43, 204)	<i>Bistahieversor sealeyi</i>	(241)	2900	(43, 86)
	<i>Anasazisaurus horneri</i>	(233)	2500	(43)				
	<i>Parasaurolophus tubicen</i>	(233)	3183.813	(4, 26, 43)				
	<i>Kritosaurus navajovius</i>	(233)	4000	(43)				
	<i>Naashoibitosaurus ostromi</i>	(233)	4000	(43)				
	<i>Pentaceratops sternbergii</i>	(233)	5471.06	(4, 26, 43)				
	<i>Titanoceratops ouranos</i>	(236)	5500	(43, 236)				
	<i>Alamosaurus sanjuanensis</i>	(233)	37468.47	(4, 26, 43, 71, 237)				
Kota India 152-139MYA	<i>Ankylosaurian B</i>	(242)	500	(86)	<i>Dandakosaurus indicus</i>	(86)	2300	(86)
	<i>Thyreophoran A</i>	(243)	3374.023	(4, 26, 43, 73)				
	<i>Kotasaurus yamanpalliensis</i>	(244)	5366.125	(4, 26-27, 43)				
	<i>Barapasaurus tagorei</i>	(245)	9286.718	(4, 43, 71)				
Lameta India 72-66MYA	<i>Titanosaurus blanfordi</i>	(60)	8650	(57, 71)	<i>Theropod B</i>	(248)	9.12639	(4, 9, 43, 57, 73)
	<i>Titanosaurus indicus</i>	(246)	10362.15	(4, 43, 71)	<i>Noasaurid C</i>	(249)	12	(86)
	<i>Isisaurus colberti</i>	(246)	15000	(43)	<i>Laevisuchus indicus</i>	(246)	34.5	(86, 250)
	<i>Jainosaurus septentrionalis</i>	(247)	15555.35	(26-27, 43)	<i>Indosaurus matleyi</i>	(246)	491.25	(86)
					<i>Indosuchus raptorius</i>	(246)	1500	(43, 57, 86, 251)
					<i>Rahiolisaurus gujaratensis</i>	(252)	2519.65	(43, 86, 252)
					<i>Rajasaurus narmadensis</i>	(246)	3500	(43, 86)
Lance United States 66.8-66MYA	<i>Leptoceratops gracilis</i>	(253)	212.9821	(4, 26, 43)	<i>Richardoestesia</i>	(196)	10.2398	(9, 43, 86)
	<i>Thescelosaurus neglectus</i>	(104)	214.9144	(4, 26, 43)	<i>Paronychodon</i>	(196)	12.9875	(9, 26, 43, 86)
	<i>Pachycephalosaurus wyomingensis</i>	(254)	342.0206	(4, 26, 43)	<i>Dromaeosaurus</i>	(256)	13.56	(9, 43, 86)
	<i>Ornithomimus sedens</i>	(255)	350	(43)	<i>Saurornitholestes langstoni</i>	(153)	23.4053	(4, 9, 26, 43, 57)
	<i>Edmontonia longiceps</i>	(104)	1985.43	(4, 26, 43)	<i>Pectinodon bakkeri</i>	(153)	47.3759	(26)
	<i>Ankylosaurus magniventris</i>	(191)	3872.272	(4, 26, 43)	<i>Chirostenotes</i>	(104)	65.5686	(43, 86)
	<i>Edmontosaurus annectens</i>	(256)	4595.999	(4, 26, 43)	<i>Troodon</i>	(104)	68.1649	(4, 26, 43, 86)
	<i>Dyslocosaurus polyonychi</i>	(257)	5000	(43)	<i>Anzu</i>	(258)	246.013	(43, 86, 201)
	<i>Torosaurus</i>	(63)	7598.517	(4, 26-27, 43, 73)	<i>Tyrannosaurus rex</i>	(259)	6428.6	(4, 26, 43, 73, 86)
	<i>Triceratops horridus</i>	(63)	8318.221	(4, 26-27, 43, 73)				
	<i>Triceratops prorsus</i>	(63)	8902.168	(4, 26-27, 43)				
Laramie United States 69-68MYA	<i>Thescelosaurus</i>	(260)	170.3897	(4, 26, 43)	<i>Alvarezsauridae</i>	(104)	8.93	(43)
	<i>Edmontonia</i>	(260)	2125.341	(4, 26, 43)	<i>Paronychodon</i>	(104)	12.9875	(9, 26, 43, 86)
	<i>Edmontosaurus annectens</i>	(261)	4595.999	(4, 26, 43)	<i>Dromaeosaurus</i>	(260)	13.56	(9, 43, 86)
	<i>Torosaurus</i>	(260)	7598.517	(4, 26-27, 43, 73)	<i>Tyrannosaurus rex</i>	(260)	6428.6	(4, 26, 43, 73, 86)
	<i>Triceratops horridus</i>	(260)	8318.221	(4, 26-27, 43, 73)				
	<i>Triceratops prorsus</i>	(261)	8902.168	(4, 26-27, 43)				
Lourinhã Spain 152-146MYA	<i>Draconyx loureiroi</i>	(262)	322.0178	(27, 43)	<i>Coelurosaurian A</i>	(264)	10.2398	(9, 43, 86)
	<i>Miragaia longicollum</i>	(263)	4729.744	(26, 43)	<i>Lourinhanosaurus antunesi</i>	(262)	249.344	(26, 43, 86)
	<i>Dinheirosaurus lourinhanensis</i>	(262)	5000	(43)	<i>Ceratosaurus nasicornis</i>	(262)	580.377	(4, 26-27, 43, 73)
	<i>Dacentrurus armatus</i>	(262)	6121.788	(4, 26-27, 43)	<i>Allosaurus</i>	(262)	1742.73	(4, 26, 43, 73, 86)
	<i>Lourinhasaurus alenquerensis</i>	(262)	18201.68	(26, 43, 71)	<i>Torvosaurus</i>	(262)	3483.33	(26, 43, 86)
	<i>Lusotitan atalaiensis</i>	(262)	32249.65	(26, 43, 71)				
Lufeng BII "Zhangjia"ao China 199-190.8MYA	<i>Eshanosaurus deguchianus</i>	(265)	26	(86, 265)	<i>Panguraptor lufengensis</i>	(265)	9.7	(86, 266)
	<i>Yunnanosaurus huangi</i>	(265)	591.7413	(26-27, 43, 57, 71)	<i>Coelophysis</i>	(265)	25.0459	(26, 43, 86)
	<i>Chuxiongosaurus lufengensis</i>	(265)	650	(43, 71)	<i>Sinosaurus triassicus</i>	(265)	324.792	(4, 43)
	<i>Lufengosaurus huenei</i>	(265)	1884.985	(4, 26, 43, 71)				
	<i>Jingshanosaurus xinwaensis</i>	(265)	3158.544	(4, 26-27, 43)				
Maevarano Madagascar 70-66MYA	<i>Rapetosaurus krausei</i>	(267)	4581.365	(4, 26, 71)	<i>Rahonavis ostromi</i>	(269)	0.84205	(26, 43, 86)
	<i>Vahiny depereti</i>	(268)	8672.855	(26, 71)	<i>Masiakasaurus knopfleri</i>	(104)	13.7896	(4, 26, 43)
					<i>Majungasaurus crenatissimus</i>	(104)	1195.68	(26, 43, 57, 73, 86)

Table S1.1 (continued)

Assemblage	Herbivores / Plant Dominant Omnivores	Locality		Carnivores / Meat Dominant Omnivores	Locality	
		Ref	Mass (kg) Mass Ref		Ref	Mass (kg) Mass Ref
Milk River Canada 84.5-83.5MYA	<i>Acrotholus audeti</i>	(270)	40 (270)	<i>Richardoestesia isosceles</i>	(272)	10.1954 (9, 86)
	<i>Gryphoceratops morrisoni</i>	(271)	50 (271)	<i>Richardoestesia gilmorei</i>	(272)	10.3284 (9, 43, 86)
	<i>Brachyceratops</i>	(104)	1300 (43)	<i>Zapsalis</i>	(272)	12.3333 (86, 104)
	<i>Paleoscincus</i>	(104)	1617.899 (4, 26, 43)	<i>Atrociraptor</i>	(272)	15.25 (43, 86)
	<i>Nodosaurid C</i>	(272)	2125.341 (4, 26, 43)	<i>Saurornitholestes langstoni</i>	(104)	23.4053 (4, 9, 26, 43, 57)
	<i>Ankylosaurid A</i>	(272)	2297.224 (43)	<i>Saurornitholestes</i>	(272)	23.7026 (4, 9, 26, 43, 57)
	<i>Hadrosaurid E</i>	(272)	3428.063 (4, 26, 43)	<i>Tyrannosaurid A</i>	(272)	2554.78 (4, 26, 43, 86)
Morrison Brushy Basin Zone 3 United States 150-149.2MYA	<i>Centrosaurine A</i>	(104)	3500 (43)			
	<i>Nanosaurus agilis</i>	(273)	24.29303 (4, 43, 57, 73)	<i>Coelurus fragilis</i>	(273)	20.3806 (26, 43, 86)
	<i>Mymoorapelta maysi</i>	(273)	300 (43)	<i>Stokesosaurus clevelandi</i>	(273)	92.5 (43, 86)
	<i>Camptosaurus</i>	(273)	910.3948 (4, 26-27, 43)	<i>Marshosaurus bicentesimus</i>	(273)	212.5 (43, 86)
	<i>Stegosaurus stenops</i>	(273)	3353.66 (4, 26, 43)	<i>Ceratopsaurus nasicornis</i>	(273)	580.377 (4, 26-27, 43, 73)
	<i>Ankylosaurus</i>	(273)	3872.272 (4, 26, 43)	<i>Allosaurus fragilis</i>	(273)	1913.75 (4, 26, 43, 73, 86)
	<i>Stegosaurus unglatus</i>	(273)	5376.958 (26, 43)	<i>Allosaurus jimmadseni</i>	(273, 278)	1913.75 (4, 26, 43, 73, 86)
	<i>Diplodocus carnegii</i>	(273)	10877.24 (9, 43, 71, 274)	<i>Torvosaurus</i>	(273)	3483.33 (26, 43, 86)
	<i>Camarasaurus lewisi</i>	(273)	12499.94 (4, 26, 43)	<i>Saurophaganax maximus</i>	(273)	3758.72 (26, 43, 86)
	<i>Camarasaurus lentus</i>	(273)	13254.41 (4, 26, 43, 71, 275)			
	<i>Haplocanthosaurus</i>	(273)	14217.57 (4, 26, 43, 71)			
	<i>Camarasaurus grandis</i>	(273)	14224.85 (26, 43, 71)			
	<i>Diplodocus longus</i>	(273)	17338.44 (4, 26, 43, 71)			
	<i>Barosaurus</i>	(273)	21136.82 (4, 26, 43, 71)			
	<i>Barosaurus lentus</i>	(273)	21136.82 (4, 26, 43, 71)			
	<i>Camarasaurus supremus</i>	(273)	22974.7 (4, 43, 71)			
Oldman Canada 77.5-76.5MYA	<i>Apatosaurus louisae</i>	(273)	25385.81 (4, 26, 43, 71)			
	<i>Diplodocus hallorum</i>	(273, 276)	26689.4 (26, 43)			
	<i>Apatosaurus ajax</i>	(273)	29708.57 (4, 26-27, 43, 71)			
	<i>Prenocephale brevis</i>	(148)	10 (43)	<i>Saurornitholestes langstoni</i>	(286)	23.4053 (4, 9, 26, 43, 57)
	<i>Hanssuesia sternbergi</i>	(148)	28.07162 (43)	<i>Daspletosaurus torosus</i>	(53)	2631.11 (4, 43, 73, 86)
	<i>Struthiomimus altus</i>	(279)	215.0365 (4, 26-27, 43, 73)			
	<i>Wendiceratops pinhornensis</i>	(280)	1250 (43, 281)			
	<i>Ankylosaurid B</i>	(282)	1617.899 (4, 26, 43)			
	<i>Spinops sternbergorum</i>	(283)	1896.318 (43, 283)			
	<i>Coronosaurus brinkmani</i>	(150)	2000 (43)			
	<i>Nodosaurid D</i>	(150)	2125.341 (4, 26, 43)			
	<i>Centrosaurus apertus</i>	(284)	2214.703 (4, 26, 43)			
Prince Creek Alaska 70.6-69.1MYA	<i>Chasmosaurine A</i>	(150)	2244.365 (4, 26, 43)			
	<i>Hypacrosaurus stebingeri</i>	(150)	3293.245 (4, 43)			
	<i>Albertaceratops nesmoi</i>	(285)	3500 (43)			
	<i>Brachylophosaurus canadensis</i>	(150)	5729.18 (26, 43)			
	<i>Hypsilophodontid C</i>	(287)	82.79609 (4, 26-27, 43, 288)	<i>Dromaeosaurus albertensis</i>	(34)	14.7467 (9, 43, 86)
	<i>Alaskacephale gangloffii</i>	(287)	130 (289)	<i>Saurornitholestes langstoni</i>	(34)	23.4053 (4, 9, 26, 43, 57)
	<i>Ornithomimid D</i>	(287)	221.4634 (4, 9, 26-27, 43)	<i>Troodon formosus</i>	(34)	68.1649 (4, 26, 43, 86)
	<i>Ceratopsid A</i>	(290)	1300 (43)	<i>Nanuqsaurus hoglundi</i>	(294)	750 (43, 294)
Scollard Canada 66.8-66MYA	<i>Pachyrhinosaurus perotorum</i>	(291)	2260.778 (4, 26, 43)			
	<i>Pachyrhinosaurus canadensis</i>	(287)	3139.13 (4, 26, 43)			
	<i>Lambeosaurine A</i>	(292)	3594.614 (4, 26, 43)			
	<i>Edmontosaurus annectens</i>	(293)	4595.999 (4, 26, 43)			
	<i>Leptoceratops gracilis</i>	(203)	212.9821 (4, 26, 43)	<i>Richardoestesia</i>	(203)	10.2398 (9, 43, 86)
Shangshaximiao China 170.3-166.1MYA	<i>Thescelosaurus neglectus</i>	(203)	214.9144 (4, 26, 43)	<i>Paronychodon</i>	(203)	12.9875 (9, 26, 43, 86)
	<i>Pachycephalosaurus</i>	(104)	342.0206 (4, 26, 43)	<i>Dromaeosaurus albertensis</i>	(203)	14.7467 (9, 43, 86)
	<i>Ankylosaurus magniventris</i>	(203)	3872.272 (4, 26, 43)	<i>Troodon</i>	(203)	68.1649 (4, 26, 43, 86)
	<i>Triceratops horridus</i>	(203)	8318.221 (4, 26-27, 43, 73)	<i>Tyrannosaurus rex</i>	(203)	6428.6 (4, 26, 43, 73, 86)
	<i>Gongbusaurus shiyii</i>	(295)	20.05596 (4, 26, 43, 73, 296)	<i>Sinocoelurus fragilis</i>	(295)	25.0459 (26, 43, 86, 298)
Shangshaximiao China 170.3-166.1MYA	<i>Yandusaurus hongheensis</i>	(295)	140 (43)	<i>Chienkosaurus ceratosauroides</i>	(295)	420 (86)
	<i>Yingshanosaurus jichuanensis</i>	(295)	1277.148 (4, 43, 73)	<i>Szechuanosaurus campi</i>	(295)	1001.33 (57, 86, 299)
	<i>Gigantspinosaurs sichuanensis</i>	(295)	1460.431 (26, 43)	<i>Yangchuanosaurus shangyouensis</i>	(295)	2950 (43, 86)
	<i>Daanosaurus zhangii</i>	(295)	3517.054 (4, 43, 71, 73)	<i>Yangchuanosaurus hepingensis</i>	(295)	3000 (43)
	<i>Tuojiangosaurus multispinus</i>	(295)	3532.595 (4, 26-27, 43)			
	<i>Omeisaurus maoi</i>	(295)	6232.125 (43, 71, 73)			
	<i>Mamenchisaurus youngi</i>	(295)	6746.814 (26, 43, 71)			
	<i>Omeisaurus changshouensis</i>	(295)	6900 (71-71)			
	<i>Mamenchisaurus fuxiensis</i>	(295)	6967.05 (43, 57, 73, 297)			
	<i>Omeisaurus fuxiensis</i>	(295)	7400 (71)			
	<i>Mamenchisaurus constructus</i>	(295)	11334.89 (4, 26, 43, 71)			
	<i>Mamenchisaurus hochuanensis</i>	(295)	14411.76 (4, 43, 71, 73, 80)			
	<i>Mamenchisaurus anyueensis</i>	(295)	25000 (43)			
	<i>Mamenchisaurus jingyanensis</i>	(295)	28500 (43, 71)			

Table S1.1 (continued)

Assemblage	Herbivores / Plant Dominant Omnivores	Locality Ref	Mass (kg)	Mass Ref	Carnivores / Meat Dominant Omnivores	Locality Ref	Mass (kg)	Mass Ref
Tendaguru Middle Saurian Tanzania 157-152MYA	<i>Dryosaurus lettowvorbecki</i>	(300)	80	(43)	<i>Abelisaurid A</i>	(303)	10.742	(86)
	<i>Dicraeosaurus hansemanni</i>	(301)	7268.766	(4, 9, 43, 71, 274)	<i>Non-coelurosaurian Tetanuran A</i>	(303)	15.1685	(4, 26, 43)
	<i>Giraffatitan brancai</i>	(302)	36554.87	(4, 26-27, 43, 71)	<i>Elaphrosaurus bambergi</i>	(303)	248.155	(4, 26, 43)
					<i>Ceratosaurid B</i>	(303)	481.333	(86)
					<i>Ceratosaurid C</i>	(300)	712.644	(86)
					<i>Abelisaurid A</i>	(303)	1002.5	(86)
					<i>Veterupristisaurus milneri</i>	(303)	1175	(57, 86)
					<i>Allosaurus tendagurensis</i>	(300)	2143.4	(4, 26, 43, 73, 86)
					<i>Carcharodontosaurid B</i>	(303)	2981.55	(86)
Tendaguru Upper Saurian Tanzania 152-145MYA	<i>Kentrosaurus aethiopicus</i>	(305)	1149.464	(4, 26, 43)	<i>Abelisaurid A</i>	(303)	10.742	(86)
	<i>Australodocus bohetti</i>	(305)	4000	(43)	<i>Ceratosaurid A</i>	(300)	481.333	(86)
	<i>Dicraeosaurus sattleri</i>	(301)	7154.417	(26, 43, 71)	<i>Abelisaurid A</i>	(303)	1002.5	(86)
	<i>Tendaguria tanzaniensis</i>	(305)	10000	(57, 71)	<i>Ostafrikasaurus crassiserratus</i>	(307)	1150	(86)
	<i>Tornieria africana</i>	(305)	12025.71	(26-27, 43, 71)	<i>Megalosauroid A</i>	(303)	1966.67	(86)
	<i>Janenschia robusta</i>	(305)	12332.74	(4, 27, 43, 71)	<i>Megalosaurus ingens</i>	(303)	5700	(86, 251)
	<i>Wamweracaudia keranji</i>	(306)	12332.74	(4, 27, 43, 71)				
	<i>Giraffatitan brancai</i>	(302)	36554.87	(4, 26-27, 43, 71)				
Trempt Spain 67.6-66MYA	<i>Euhadrosaurian A</i>	(308)	600	(43)	<i>Richardoestesia</i>	(311)	10.2398	(9, 43, 86)
	<i>Pararhabdodon isonensis</i>	(309)	1250	(43, 57)	<i>Euronychodon</i>	(311)	12.9875	(86)
	<i>Nodosaurid E</i>	(104)	1817.855	(4, 9, 43, 73)	<i>Paronychodon</i>	(311)	12.9875	(9, 26, 43, 86)
	<i>Hadrosaurid F</i>	(309)	3274.599	(4, 26, 43, 57, 73)	<i>Dromaeosaurus</i>	(311)	13.56	(9, 43, 86)
	<i>Lambeosaurine B</i>	(309)	3363.898	(4, 26, 43)	<i>Pyroraptor olymptus</i>	(311)	14.7361	(86, 312)
	<i>Hypselosaurus</i>	(310)	6300	(57, 71)	<i>Theropod C</i>	(311)	757	(313)
	<i>Titanosaurus indicus</i>	(309)	10362.15	(4, 43, 71)				
Two Medicine United States 82.6-74MYA	<i>Orodromeus makelai</i>	(314)	15.1695	(4, 26)	<i>Bambiraptor feinbergi</i>	(324)	5.82906	(4, 43, 86)
	<i>Prenoceratops pieganensis</i>	(315)	20	(43)	<i>Richardoestesia isosceles</i>	(323)	10.1954	(9, 86)
	<i>Stegoceras validum</i>	(314)	27.6576	(4, 26, 43)	<i>Dromaeosaurus</i>	(314)	13.56	(9, 43, 86)
	<i>Hanxuesia sternbergi</i>	(314)	28.07162	(43)	<i>Saurornitholestes</i>	(323)	23.7026	(4, 9, 26, 43, 57)
	<i>Montanaceratops</i>	(316)	134.4206	(4, 43)	<i>Troodon formosus</i>	(323)	68.1649	(4, 26, 43, 86)
	<i>Cerasinops hodgskissi</i>	(317)	151.9703	(4, 26-27, 43)	<i>Caenagnathus sternbergi</i>	(314)	74.7759	(9, 43, 73, 86, 325)
	<i>Einiosaurus procurvicornis</i>	(318)	974.7027	(4, 43)	<i>Daspletosaurus horneri</i>	(326)	2500	(43)
	<i>Brachyceratops montanensis</i>	(318)	1300	(43)	<i>Gorgosaurus</i>	(314)	2554.78	(4, 26, 43, 86)
	<i>Stellasaurus ancellae</i>	(319)	1521.933	(319)				
	<i>Prosaurolophus blackfeetensis</i>	(314)	1532.758	(4)				
	<i>Euoplocephalus tutus</i>	(314)	1617.899	(4, 26, 43)				
	<i>Achelousaurus horneri</i>	(318)	1709.393	(4, 26, 43)				
	<i>Oohkotokia horneri</i>	(320)	1750	(43, 320)				
	<i>Chasmosaurus</i>	(314)	2251.247	(4, 26-27, 43)				
	<i>Edmontonia rugosidens</i>	(314)	2265.253	(26, 43)				
	<i>Rubeosaurus ovatus</i>	(314)	2289.302	(43, 57, 321)				
	<i>Maiaasaura peeblesorum</i>	(314)	2873.436	(4, 26, 43)				
	<i>Acristavus gagslarsoni</i>	(322)	3000	(43)				
	<i>Hypacrosaurus stebingeri</i>	(323)	3293.245	(4, 43)				
	<i>Gryposaurus latidens</i>	(323)	3365.19	(26, 43)				
Upper Elliot Lesotho 201-199.3MYA	<i>Abriotesaurus consors</i>	(327)	1.797141	(4, 26-27, 43)	<i>Coelophysis rhodesiensis</i>	(336)	13.0264	(26, 43)
	<i>Lycorhinus angustidens</i>	(327)	3.763795	(43, 328)	<i>Dracovenator regenti</i>	(337)	217.5	(43, 86)
	<i>Pegomastax africanus</i>	(329)	4	(329)				
	<i>Heterodontosaurus tucki</i>	(327)	4.02759	(4, 26, 43)				
	<i>Lesothosaurus diagnosticus</i>	(327)	4.959149	(4, 26, 43)				
	<i>Stormbergia dangershoekei</i>	(327)	35.54129	(4, 26-27)				
	<i>Arcusaurus pereirabdalorum</i>	(330)	51.32899	(331)				
	<i>Massospondylus kaalae</i>	(332)	280	(43, 71)				
	<i>Massospondylus carinatus</i>	(330)	430.3565	(4, 26, 43, 71)				
	<i>Melanorosaurus</i>	(333)	1300	(43)				
	<i>Aardonyx celestae</i>	(330)	2604.76	(4, 71, 334)				
	<i>Pulanesaura eocollum</i>	(330)	3200	(43, 71, 335)				

Table S1.1 (continued)

Assemblage	Herbivores / Plant Dominant Omnivores	Locality		Carnivores / Meat Dominant Omnivores	Locality	
		Ref	Mass (kg) Mass Ref		Ref	Mass (kg) Mass Ref
Wadhurst Clay United Kingdom 141-137MYA	<i>Valdosaurus canaliculatus</i>	(338)	29.05354 (27, 43)	<i>Maniraptoran A</i>	(351)	0.1 (43)
	<i>Valdoraptor oweni</i>	(339)	435 (86)	<i>Ornithodesmus</i>	(352)	13.56 (9, 43, 57, 86)
	<i>Polacanthus foxii</i>	(340)	1148.738 (4, 26, 43)	<i>Altispinax dunkeri</i>	(353)	1070.9 (43, 73, 353)
	<i>Stegosaurian A</i>	(340)	1149.464 (4, 26, 43)	<i>Baryonyx walkeri</i>	(352)	1600 (43, 86)
	<i>Pleurocoelus valdensis</i>	(341)	1194.873 (26, 71, 73)			
	<i>Hylaeosaurus armatus</i>	(340)	1676.957 (26, 43)			
	<i>Hypselospinus fittoni</i>	(342)	2773.986 (27, 43)			
	<i>Barillium dawsoni</i>	(343)	3589.012 (27, 43, 344)			
	<i>Haestasaurus becklesii</i>	(345)	4047.026 (71, 345)			
	<i>Xenoposeidon proneneukos</i>	(346)	7300 (71, 347)			
Wahweap United States 80.6-76.1MYA	<i>Cetiosaurus brevis</i>	(348)	9000 (71)			
	<i>Ornithopsis hulkei</i>	(349)	15854.83 (71, 350)			
	<i>Thescelosaurus</i>	(104)	170.3897 (4, 26, 43)	<i>Richardoestesia</i>	(104)	10.2398 (9, 43, 86)
	<i>Diabloceratops eatoni</i>	(354)	1300 (43)	<i>Paronychodon</i>	(104)	12.9875 (9, 26, 43, 86)
	<i>Nodosaurid F</i>	(355)	1436.424 (26, 43)	<i>Dromaeosaurid D</i>	(355)	13.56 (9, 43, 86)
	<i>Ankylosaurid C</i>	(356)	1500 (43)	<i>Velociraptorine C</i>	(213)	18.734 (4, 26-27, 43, 73)
	<i>Hadrosaurine A</i>	(357)	2873.436 (4, 26, 43)	<i>Troodon</i>	(213)	68.1649 (4, 26, 43, 86)
	<i>Acristavus gagslarsoni</i>	(322)	3000 (43)	<i>Lythronax argestes</i>	(360)	1466.67 (43, 86, 360)
	<i>Gryposaurus monumentensis</i>	(357)	3000 (43)	<i>Tyrannosaurid B</i>	(213)	1532.18 (26, 43, 86)
	<i>Adelolophus hutchisoni</i>	(357)	3342.087 (4, 26, 43)			
Xiashaximiao China 172-170MYA	<i>Machairoceratops cronusi</i>	(358)	3500 (359)			
	<i>Brachylophosaurus</i>	(358)	5729.18 (26, 43)			
	<i>Xiaosaurus dashanpensis</i>	(295)	5.24155 (26-27)	<i>Chuangdongocoelurus primitivus</i>	(295)	86.5221 (26, 86)
	<i>Agilisaurus louderbacki</i>	(295)	85.7595 (26, 43)	<i>Gasosaurus constructus</i>	(295)	201.054 (4, 26, 86)
	<i>Yandusaurus hongheensis</i>	(295)	140 (43)	<i>Gasosaurus lini</i>	(295)	201.054 (4, 26, 86)
	<i>Huayangosaurus taibaii</i>	(295)	440.5137 (4, 43)	<i>Xuanhanosaurus qilixiaensis</i>	(295)	250 (43)
	<i>Abrosaurus dongpoi</i>	(361)	4550 (43, 71)	<i>Yangchuanosaurus zigongensis</i>	(364)	1745 (43, 86)
	<i>Omeisaurus junghsiensis</i>	(295)	5100.288 (26, 43, 71)	<i>Yangchuanosaurus shangyouensis</i>	(365)	2950 (43)
	<i>Shunosaurus lili</i>	(295)	5776.958 (4, 26-27, 43)			
	<i>Protognathosaurus oxyodon</i>	(295)	6300 (71)			
Yixian Jianshangou China 125-122.5MYA	<i>Datousaurus bashanensis</i>	(295)	7196.814 (4, 43, 71)			
	<i>Dashanpusaurus dongi</i>	(362)	7511.192 (26, 71)			
	<i>Omeisaurus luquanensis</i>	(295)	8000 (71)			
	<i>Omeisaurus puxiani</i>	(363)	8000 (57)			
	<i>Omeisaurus jiaoi</i>	(363)	10090.81 (26, 71)			
	<i>Omeisaurus tianfuensis</i>	(295)	11952.59 (4, 9, 26-27, 43)			
	<i>Ningyuansaurus wangi</i>	(366)	2.3 (86-86)	<i>Sinosauropteryx prima</i>	(367)	1.12591 (4, 26-27, 43, 86)
	<i>Beipiaosaurus inexpectus</i>	(367)	69.72641 (26, 43, 86)	<i>Caudipteryx zoui</i>	(367)	2.2 (43)
	<i>Dongbeititan dongi</i>	(368)	6450 (43, 71)	<i>Changyuraptor yangi</i>	(369)	3.06667 (43, 86, 369)
				<i>Sinornithosaurus millenii</i>	(367)	3.47873 (4, 43, 86)
Yixian Lujiantun China 130-128.2MYA				<i>Protarchaeopteryx robusta</i>	(367)	4.70168 (4, 26, 43, 86)
				<i>Caudipteryx dongi</i>	(367)	6.14309 (4, 43)
				<i>Zhenyuanlong suni</i>	(370)	7.2 (43, 86)
				<i>Dilong paradoxus</i>	(367)	11.7091 (4, 26-27, 43, 86)
				<i>Huaxiagnathus orientalis</i>	(367)	17.3632 (26-27, 43, 86)
				<i>Jianchangosaurus yixianensis</i>	(371)	20 (43)
				<i>Sinocallopteryx gigas</i>	(372)	35.4102 (26-27, 43, 86)
				<i>Yutyrannus huali</i>	(373)	1300 (43, 86)
	<i>Liaoceratops yanzigouensis</i>	(367)	2 (43)	<i>Mei long</i>	(367)	0.55869 (26, 43, 86)
	<i>Hexing qingyi</i>	(374)	4.33697 (26, 86)	<i>Liaoningvenator curriei</i>	(376)	0.78033 (4, 43, 73, 376)
	<i>Incisivosaurus gauthieri</i>	(367)	4.701678 (4, 26, 43, 86)	<i>Sinovenator changii</i>	(367)	1.90301 (26, 43, 86)
	<i>Psittacosaurus lujiatunensis</i>	(375)	5 (43)	<i>Daliansaurus liaoningensis</i>	(377)	1.90903 (378)
	<i>Jeholosaurus shangyuanensis</i>	(367)	5.667104 (4, 26)	<i>Changyuraptor yangi</i>	(369)	3.06667 (43, 86, 369)
	<i>Shenzhousaurus orientalis</i>	(367)	13.08922 (26, 43, 86)	<i>Sinusonasus magodens</i>	(367)	3.19335 (26, 43, 86)
	<i>Hongshanosaurus houi</i>	(367)	15 (43)	<i>Graciliraptor lujiatunensis</i>	(367)	3.47873 (4, 43, 86)
	<i>Psittacosaurus major</i>	(375)	18 (43)	<i>Dilong paradoxus</i>	(367)	11.7091 (4, 26-27, 43, 86)
				<i>Jianchangosaurus yixianensis</i>	(371)	20 (43)

Table S1.2 Summary Statistics, KS Test and polynomial tests for full communities. $\alpha = 0.05$, Sarle's $b = .555$

Formation		Raw Data = Log2(mass(kg))									M-S Distribution				KS Goodness of Fit (vs Global)		Quadratic Regression (bins)			4th degree polynomial regression			Bimodality Coefficient		
	Jurassic	N	Min	Max	IQR	Q1	Q3	Median	Mean	P _{Mean}	Skew	P _{Skew}	kurtosis	P _{kurt}	D	P	F	P	R ²	F	P	R ²	b1	b2	b (Sarle)
Upper Elliot		14	1.8	3200.0	643.7	4.0	647.8	43.4	582.2	0.032	0.3142	0.157	-1.201	0.555	0.4535	0.0090	3.0044	0.1064	0.4289	1.8307	0.2420	0.5496	0.1159	1.7870	0.1983
Lufeng Bil "Zhangjia'ao"		8	9.7	3158.5	1551.0	25.3	1576.2	458.3	833.9	0.254	-0.5714	0.994	-1.729	0.335	0.5249	0.0020	1.3960	0.3020	0.2587	0.5478	0.7084	0.2675	0.4444	1.5102	0.2253
Kayenta/Navajo Sandstone		9	6.0	500.0	331.6	16.3	347.9	85.0	168.1	0.040	0.0363	0.320	-1.818	0.316	0.6402	0.0000	2.5982	0.1351	0.3938	1.5300	0.3051	0.5050	0.0017	1.4454	0.1665
Hanson		5	6.0	745.0	634.5	15.5	650.0	349.4	336.1	0.132	-0.7560	0.794	-2.479	0.171	0.6402	0.0000	0.7537	0.5013	0.1585	0.3046	0.8651	0.1688	1.0160	1.3802	0.2149
Xiashaximiao		21	5.2	11952.6	7183.5	170.5	7354.0	2950.0	3844.0	0.608	-0.6533	0.919	-0.453	0.926	0.2532	0.2620	1.5944	0.2613	0.2850	1.3187	0.3622	0.4678	0.4728	2.3752	0.2503
Shangshaximiao		21	20.1	28500.0	6044.3	1139.2	7183.5	3532.6	6398.5	0.188	-1.4961	0.146	1.883	0.129	0.1693	0.7670	1.8521	0.2183	0.3165	6.5876	0.0220	0.8145	2.4802	4.1911	0.4520
Callovian Oxford Clay		10	108.4	12232.5	4565.9	167.7	4733.6	1670.1	3290.0	0.472	0.3895	0.134	-0.782	0.827	0.3249	0.1280	1.4842	0.2830	0.2706	1.1403	0.4209	0.4319	0.1920	2.0123	0.1877
Tendaguru Middle Saurian		12	10.7	36554.9	2650.0	122.0	2772.0	741.9	4370.2	0.967	0.0157	0.335	-0.113	0.698	0.3582	0.1280	2.4018	0.1524	0.3752	1.2333	0.3890	0.4512	0.0003	2.4675	0.1539
Tendaguru Upper Saurian		14	10.7	36554.9	10989.7	1112.7	12102.5	4850.0	7561.5	0.087	-1.4106	0.186	3.114	0.053	0.2170	0.4850	3.6299	0.0755	0.4757	7.9123	0.0143	0.8406	2.3352	4.7080	0.3901
Kota		5	500.0	9286.7	5926.4	1400.0	7326.4	3374.0	4165.4	0.152	-1.2578	0.277	0.313	0.449	0.3485	0.1280	0.9583	0.4236	0.1933	1.9624	0.2196	0.5668	2.8125	2.0781	0.3783
Morrison Brushy Basin Zone 3		27	20.4	29708.6	16428.0	910.4	17338.4	3872.3	9554.0	0.132	-1.1571	0.346	0.228	0.495	0.1476	0.7670	1.8688	0.2158	0.3184	2.2611	0.1778	0.6012	1.4481	2.9734	0.3853
Lourinhã		11	10.2	32249.7	5799.8	322.0	6121.8	3483.3	6608.3	0.254	-0.7265	0.824	0.552	0.360	0.1667	0.7670	2.5311	0.1407	0.3875	1.9438	0.2226	0.5644	0.6516	2.8312	0.2360
Cretaceous																									
Wadhurst Clay		17	0.1	15854.8	3065.1	753.0	3818.0	1600.0	3204.3	0.657	-2.0267	0.040	4.173	0.023	0.2896	0.2620	1.1494	0.3641	0.2232	2.0168	0.2111	0.5735	4.6736	5.7093	0.6057
Yixian Lujiantun		17	0.6	20.0	10.4	2.0	12.4	4.3	6.7	0.000	0.1170	0.264	-1.516	0.407	0.8865	0.0000	2.1308	0.1812	0.3476	14.2267	0.0032	0.9046	0.0156	1.5610	0.1946
Yixian Jianshangou		15	1.1	6450.0	32.3	3.1	35.4	7.2	529.0	0.000	1.4492	0.002	1.636	0.145	0.6675	0.0000	2.1760	0.1760	0.3523	16.7500	0.0021	0.9178	2.4359	3.7646	0.4561
Cloverly		11	1.5	34146.0	4538.8	20.0	4558.8	818.4	4601.1	0.608	-0.1915	0.535	-0.889	0.761	0.2576	0.2620	1.7993	0.2263	0.3103	0.8358	0.5491	0.3578	0.0453	1.9665	0.1704
Khuren Dukh		12	2.5	11225.6	1546.5	35.5	1582.0	975.0	1616.0	0.562	-0.5796	0.997	-0.370	0.874	0.4416	0.0090	1.0199	0.4032	0.2032	0.5282	0.7206	0.2604	0.4065	2.3054	0.2219
Cedar Mountain Mussentuchit		18	1.5	10800.0	1236.8	13.2	1250.0	247.5	1404.3	0.204	0.1482	0.239	-1.251	0.530	0.3624	0.1280	1.2570	0.3352	0.2391	0.5752	0.6917	0.2772	0.0248	1.7546	0.1909
Bayan Shireh / Iren Dabasu		25	2.0	25418.1	1522.7	70.0	1592.7	500.0	2131.6	0.562	-0.4327	0.828	-0.348	0.854	0.4449	0.0090	2.7860	0.1207	0.4106	1.3721	0.3466	0.4777	0.2039	2.4874	0.2040
Griman Creek		15	6.0	6000.0	652.4	20.0	672.4	156.7	869.2	0.152	0.3391	0.146	-0.654	0.914	0.5068	0.0020	6.0900	0.0247	0.6036	2.9697	0.1131	0.6644	0.1334	2.1694	0.1908
Bissekty		14	1.4	7000.0	719.0	12.0	731.0	197.5	1055.6	0.132	0.2035	0.210	-0.676	0.899	0.4357	0.0410	1.4119	0.2984	0.2609	0.5693	0.6953	0.2751	0.0486	2.1422	0.1753
Bajo de la Carpa		15	2.8	32064.6	5233.5	16.5	5250.0	1925.0	4472.4	0.967	-0.7169	0.834	-0.828	0.799	0.2818	0.2620	0.4695	0.6415	0.1050	0.9024	0.5177	0.3756	0.5960	2.0483	0.2743
Milk River		17	10.2	4000.0	2406.7	19.3	2426.0	50.0	1237.2	0.345	0.1520	0.237	-2.035	0.256	0.3485	0.1280	0.8039	0.4807	0.1673	0.3644	0.8261	0.1955	0.0263	1.1828	0.2120
Anacleto		14	9.0	29050.0	11732.5	1927.3	13659.8	5375.0	8346.8	0.119	-2.1792	0.022	5.608	0.005	0.2072	0.4850	1.5445	0.2709	0.2786	5.3188	0.0356	0.7800	5.5734	6.3964	0.6421
Two Medicine		28	5.8	3365.2	2255.5	27.8	2283.3	1411.0	1263.3	0.562	-0.4497	0.854	-1.528	0.402	0.4535	0.0090	1.1325	0.3689	0.2207	0.5157	0.7284	0.2558	0.2181	1.5248	0.2491
Wahweap		18	10.2	5729.2	3029.7	55.8	3085.5	1483.3	1928.0	0.967	-0.7784	0.756	-1.135	0.599	0.3485	0.1280	1.0083	0.4069	0.2013	0.7372	0.5994	0.3295	0.6840	1.8407	0.3088
Allen		18	15.1	22385.9	6115.1	483.8	6598.8	2071.5	5049.0	0.307	-1.1339	0.370	1.116	0.224	0.1818	0.7670	2.3972	0.1529	0.3747	6.1289	0.0259	0.8034	1.4514	3.5131	0.3440
Oldman		15	10.0	5729.2	2416.1	215.0	2631.1	2000.0	1918.6	0.812	-1.1793	0.327	-0.116	0.699	0.3485	0.1280	0.8121	0.4774	0.1688	0.7073	0.6155	0.3204	1.6130	2.5440	0.4139
Judith River Coal Ridge		17	10.3	4000.0	2814.9	21.2	2836.1	1436.4	1523.5	0.657	-0.3687	0.745	-1.696	0.343	0.3485	0.1280	1.3925	0.3028	0.2582	0.6884	0.6259	0.3146	0.1547	1.4299	0.2270
Kaiparowits		16	10.2	3292.8	1745.9	24.7	1770.5	127.8	989.9	0.276	0.1364	0.248	-1.965	0.278	0.4624	0.0090	1.1112	0.3751	0.2174	0.4196	0.7900	0.2186	0.0214	1.2443	0.2062
Dinosaur Park MAZ-1b		27	2.6	3549.6	2241.8	23.4	2265.3	74.8	1143.5	0.276	-0.0515	0.390	-1.495	0.419	0.4138	0.0410	1.3834	0.3048	0.2570	0.5585	0.7019	0.2713	0.0029	1.5534	0.2033
Djadokhta		21	0.2	14139.4	88.3	8.5	96.8	20.5	785.2	0.001	1.0087	0.023	1.686	0.138	0.6104	0.0000	1.2975	0.3250	0.2449	1.0873	0.4405	0.4202	1.1274	4.0377	0.2819
Kirtland Hunter-Willow Washes		19	10.2	37468.5	3972.3	27.7	4000.0	1500.0	3645.9	0.812	-0.0008	0.351	-1.421	0.441	0.2958	0.2620	1.2698	0.3319	0.2410	0.5260	0.7220	0.2596	0.0000	1.6262	0.1923
Horseshoe Canyon Drumheller-H		17	10.3	5260.1	2178.0	18.9	2196.9	138.7	1124.4	0.345	0.0459	0.313	-1.725	0.336	0.4661	0.0090	1.8652	0.2163	0.3180	0.7229	0.6070	0.3252	0.0024	1.4091	0.1979
Baruungoyot		23	0.2	12172.7	1301.7	4.3	1306.0	33.1	1127.9	0.024	0.2470	0.190	-1.047	0.656	0.4814	0.0090	1.4630	0.2874	0.2678	0.7251	0.6058	0.3259	0.0670	1.9175	0.1985
Lameta		11	9.1	15555.3	10327.7	34.5	10362.2	2519.6	5239.5	0.562	-0.8124	0.718	-0.696	0.885	0.1476	0.7670	1.8320	0.2213	0.3141	4.3288	0.0550	0.7427	0.8149	2.0825	0.2904
Prince Creek		12	14.7	4596.0	2847.7	71.8	2919.5	485.7	1348.4	0.608	-0.1062	0.456	-1.484	0.422	0.3582	0.1280	5.9497	0.0261	0.5980	2.9375	0.1153	0.6620	0.0137	1.6044	0.1798
Maevarano		6	0.8	8672.9	5593.7	10.6	5604.2	2888.5	3174.3	0.812	-1.0837	0.418	-0.839	0.793	0.3485	0.1280	0.1531	0.8605	0.0369	1.0161	0.4686	0.4038	1.8351	1.8551	0.3498
Laramie		10	8.9	8902.2	7765.0	13.4	7778.4	3360.7	3817.5	0.967	-0.6980	0.863	-1.521	0.404	0.3485	0.1280	0.4370	0.6605	0.0985	0.6667	0.6381	0.3077	0.6166	1.5944	0.2724
Hell Creek		22	10.2	8902.2	4026.5	26.7	4053.2	217.2	1975.3	0.390	0.3287	0.153	-1.481	0.423	0.3578	0.1280	1.9890	0.1990	0.3321	0.7490	0.5931	0.3330	0.1191	1.5737	0.2214
T																									

Table S1.3 Summary Statistics, KS Test and polynomial tests for herbivore guilds. $\alpha = 0.05$, Sarle's $b = .555$

Formation		Raw Data = Log2(mass(kg))								M-S Distribution				KS Goodness of Fit (vs Global)		Quadratic Regression (bins)			4th degree polynomial regression			Bimodality Coefficient		
	N	Min	Max	IQR	Q1	Q3	Median	Mean	P _{Mean}	Skew	P _{Skew}	kurtosis	P _{kurt}	D	P	F	P	R ²	F	P	R ²	b1	b2	b (Sarle)
Jurassic																								
Upper Elliot	12	1.8	3200.0	1078.6	4.0	1082.6	43.4	660.0	0.006	0.2829	0.110	-1.4683	0.391	0.7917	0.0000	1.2707	0.3317	0.2411	0.8434	0.5454	0.3599	0.0968	1.6143	0.1942
Lufeng BII "Zhangjia'ao"	5	26.0	3158.5	2212.9	308.9	2521.8	650.0	1262.3	0.262	-1.7356	0.246	3.2510	0.176	0.6667	0.0000	1.3061	0.3229	0.2462	0.8051	0.5643	0.3493	5.3551	2.8128	0.5877
Kayenta/Navajo Sandstone	6	6.0	500.0	378.8	12.6	391.4	124.4	187.5	0.007	-0.3827	0.441	-1.4813	0.387	0.7273	0.0000	4.1315	0.0586	0.5081	2.7250	0.1313	0.6450	0.2289	1.6350	0.1559
Xishaximiao	15	5.2	11952.6	7860.0	140.0	8000.0	5777.0	5019.3	0.957	-1.2712	0.616	0.8317	0.695	0.2051	0.8430	0.7981	0.4830	0.1663	1.0851	0.4414	0.4197	1.8740	3.2042	0.4121
Shangshaximiao	16	20.1	28500.0	8376.6	1974.6	10351.2	6489.5	7935.8	0.452	-2.0360	0.132	4.4682	0.082	0.5000	0.0510	1.3932	0.3026	0.2583	3.6460	0.0774	0.7085	4.7586	5.8361	0.6033
Callovian Oxford Clay	8	108.4	12232.5	9557.0	128.1	9685.2	2155.2	3920.8	0.859	0.2765	0.112	-1.3917	0.418	0.5278	0.0510	1.0217	0.4026	0.2035	0.6426	0.6519	0.2999	0.1041	1.6706	0.1680
Tendaguru Middle Saurian	3	80.0	36554.9	36474.9	80.0	36554.9	7268.8	14634.5	0.684	-0.9352	0.967			0.3333	0.1700	1.1120	0.3749	0.2175	0.6273	0.6607	0.2949	3.4985		
Tendaguru Upper Saurian	8	1149.5	36554.9	7544.1	4788.6	12332.7	11012.9	11943.7	0.076	-0.4877	0.539	0.4208	0.882	0.3750	0.1700	4.7277	0.0441	0.5417	6.1118	0.0261	0.8029	0.3238	2.5337	0.1781
Kota	4	500.0	9286.7	7088.1	1218.5	8306.6	4370.1	4631.7	0.528	-2.0000	0.145	4.0000	0.111	0.6389	0.0090	0.5768	0.5834	0.1260	0.9225	0.5086	0.3808	9.0000	2.3333	0.6316
Morrison Brushy Basin Zone 3	19	24.3	29708.6	17783.2	3353.7	21136.8	13254.4	12946.5	0.213	-2.0478	0.131	3.8594	0.118	0.6316	0.0090	1.4041	0.3002	0.2598	1.4557	0.3238	0.4925	4.7014	5.6160	0.6204
Lourinhã	6	322.0	32249.7	18085.9	3627.8	21713.7	5560.9	11104.1	0.171	-0.4401	0.492	1.3350	0.530	0.3333	0.1700	2.5238	0.1413	0.3869	1.8270	0.2426	0.5491	0.3026	2.6006	0.1472
Cretaceous																								
Wadhurst Clay	13	29.1	15854.8	4524.4	1149.1	5673.5	2774.0	3983.7	0.776	-2.0090	0.144	5.5074	0.040	0.1099	1.0000	1.3285	0.3175	0.2493	3.3187	0.0925	0.6887	4.8031	6.1775	0.5743
Yixian Lujiamtun	8	2.0	18.0	10.1	4.4	14.5	5.3	8.5	0.000	-0.4041	0.456	-0.2286	0.826	0.9333	0.0000	1.2138	0.3464	0.2328	4.0217	0.0639	0.7283	0.2222	2.2245	0.1716
Yixian Jianshangou	3	2.3	6450.0	6447.7	2.3	6450.0	69.7	2174.0	0.007	0.4233	0.078			0.6667	0.0000	0.1035	0.9029	0.0252	0.2206	0.9174	0.1282	0.7166		
Cloverly	8	1.5	34146.0	5292.4	58.9	5351.3	1409.2	5745.8	0.262	-0.4742	0.526	0.0175	0.931	0.1389	0.8430	0.9205	0.4367	0.1871	0.4167	0.7919	0.2174	0.3061	2.3417	0.1804
Khuren Dukh	9	14.0	11225.6	1426.6	123.4	1550.0	1000.0	1959.6	0.377	-0.3645	0.427	-0.1324	0.867	0.1111	0.8430	1.6962	0.2432	0.2978	0.9844	0.4817	0.3962	0.1735	2.3305	0.1700
Cedar Mountain Mussentuchit	10	1.5	10800.0	2724.3	25.7	2750.0	659.2	2057.9	0.171	-0.6523	0.716	-0.3727	0.763	0.1545	0.8430	1.0059	0.4077	0.2009	0.7075	0.6154	0.3205	0.5386	2.2437	0.2337
Bayan Shireh / Iren Dabasu	18	2.0	25418.1	1703.4	135.1	1838.5	990.2	2801.6	0.262	-0.8488	0.908	0.7106	0.756	4.0000	0.0000	1.5294	0.2739	0.2766	1.0649	0.4491	0.4152	0.8134	3.2122	0.2657
Griman Creek	10	6.0	6000.0	1722.0	17.2	1739.2	195.0	1196.7	0.033	0.2376	0.128	-1.1019	0.505	0.5000	0.0510	2.8299	0.1176	0.4143	1.1395	0.4212	0.4317	0.0714	1.8312	0.1736
Bissekty	7	175.0	7000.0	4450.0	300.0	4750.0	483.8	2071.0	0.528	0.3587	0.100	-2.0895	0.273	0.6234	0.0090	1.8306	0.2215	0.3140	1.4175	0.3340	0.4859	0.1852	1.3794	0.1748
Bajo de la Carpa	9	9.0	32064.6	4005.9	1863.3	5869.1	5250.0	7032.0	0.776	-1.6337	0.309	2.9275	0.200	0.2222	0.4490	0.5202	0.6132	0.1151	0.5317	0.7184	0.2617	3.4860	3.9370	0.5272
Milk River	9	40.0	4000.0	2789.0	675.0	3464.0	2125.3	2039.8	0.776	-1.2468	0.649	0.1714	0.993	0.3778	0.1700	1.0227	0.4022	0.2036	1.0745	0.4454	0.4174	2.0305	2.4900	0.4292
Anacleto	11	9.0	29050.0	10337.0	3802.3	14139.4	8395.2	10284.0	0.313	-2.9477	0.006	9.2967	0.003	0.8091	0.0000	1.1022	0.3777	0.2160	3.1630	0.1010	0.6783	10.7269	8.0780	0.9577
Two Medicine	20	15.2	3365.2	2144.5	138.8	2283.3	1575.3	1506.1	0.377	-1.0316	0.850	-0.4318	0.744	0.2000	0.8430	0.9518	0.4258	0.1922	0.6369	0.6552	0.2980	1.1858	2.3831	0.3691
Wahweap	11	170.4	5729.2	2063.6	1436.4	3500.0	3000.0	2871.0	0.776	-1.5076	0.393	3.5232	0.141	0.6591	0.0090	0.9631	0.4219	0.1941	1.6611	0.2753	0.5255	2.8061	4.6139	0.4335
Allen	13	808.0	22385.9	7940.7	2071.5	10012.2	3741.3	6886.2	0.377	-0.2108	0.322	-0.5456	0.684	0.3846	0.1700	2.0947	0.1855	0.3437	19.3094	0.0014	0.9279	0.0529	2.2142	0.1714
Oldman	13	10.0	5729.2	2036.3	732.5	2768.8	2000.0	2009.6	0.684	-1.4499	0.437	1.0172	0.620	0.3077	0.4490	0.8705	0.4549	0.1787	0.8863	0.5251	0.3714	2.5018	3.2375	0.4888
Judith River Coal Ridge	11	27.7	4000.0	2848.4	579.6	3428.1	2396.3	2111.5	0.776	-1.6202	0.318	2.7817	0.220	0.5273	0.0510	1.4354	0.2933	0.2641	1.8759	0.2340	0.5557	3.2409	4.1690	0.5088
Kaiparowits	9	27.7	3292.8	2767.0	108.0	2875.0	1500.0	1570.7	0.377	-0.1076	0.863	-0.2875	0.804	0.6667	0.0000	1.0694	0.3876	0.2109	0.7037	0.6175	0.3193	1.3525	2.2491	0.3449
Dinosaur Park MAZ-1b	14	27.7	3549.6	2874.6	170.9	3045.5	2229.5	1815.9	0.528	-1.0848	0.788	-0.2373	0.822	0.3143	0.4490	1.0604	0.3904	0.2095	0.8893	0.5237	0.3722	1.3810	2.4394	0.3791
Djadokhta	8	4.3	14139.4	980.6	29.0	1009.6	102.8	2030.9	0.042	0.5879	0.044	-0.0778	0.893	0.5000	0.0510	4.6877	0.0449	0.5396	2.2795	0.1756	0.6031	0.4705	2.2963	0.2043
Kirtland Hunter-Willow Wash	13	27.7	37468.5	4555.4	180.1	4735.5	2500.0	5095.4	0.859	-0.5558	0.616	-0.2175	0.830	0.6923	0.0000	1.4919	0.2814	0.2716	1.0225	0.4660	0.4053	0.3676	2.4290	0.2152
Horseshoe Canyon Drumheller	8	138.7	5260.1	2425.3	486.3	2911.6	2075.1	2054.0	0.776	-0.9129	0.996	-0.1270	0.870	0.2143	0.8430	0.9315	0.4328	0.1889	0.8808	0.5277	0.3700	1.1343	2.2729	0.2975
Baruungoyot	11	4.3	12172.7	2460.0	40.0	2500.0	1100.8	2062.3	0.171	-0.5413	0.597	-0.5608	0.675	0.5894	0.0090	0.7931	0.4850	0.1655	0.4015	0.8018	0.2111	0.3618	2.1635	0.2151
Lameta	4	8650.0	15555.3	6338.5	9078.0	15416.5	12681.1	12391.9	0.058	-2.0000	0.145	4.0000	0.111	0.6731	0.0000	1.5461	0.2706	0.2788	1.8944	0.2308	0.5581	9.0000	2.3333	0.6316
Prince Creek	8	82.8	4596.0	3327.9	152.9	3480.7	1780.4	1915.6	0.607	-0.5176	0.572	-1.3423	0.435	0.1528	0.8430	1.8825	0.2138	0.3200	1.5478	0.3008	0.5078	0.3647	1.6942	0.2070
Maevvarano	3	4581.4	8672.9	4091.5	4581.4	8672.9	4581.4	5945.2	0.262					0.3333	0.1700	0.4018	0.6819	0.0913	0.8214	0.5562	0.3538			
Laramie	6	170.4	8902.2	6827.6	1636.6	8464.2	6097.3	5285.1	0.684	-1.9517	0.159	3.6570	0.130	0.7500	0.0000	0.7206	0.5155	0.1526	1.1472	0.4185	0.4334	5.9518	3.3967	0.7206
Hell Creek	13	15.2	8902.2	5977.9	119.4	6097.3	342.0	2794.7	0.313	-0.3149	0.386	-1.4689	0.391	0.1346	0.8430	1.6267	0.2554	0.2891	0.8608	0.5371	0.3646	0.1180	1.6096	0.2019
Tremp	7	600.0	10362.2	5050.0	1250.0	6300.0	3274.6	3852.6	0.452	-0.2767	0.370	0.0420	0.938	0.3333	0.1700	1.8404	0.2200	0.3151	9.2714	0.0097	0.8607	0.1102	2.2675	0.1448
Lance	12	213.0	8902.2	6604.9	344.0	6948.9	4234.1	3832.4	0.859	-0.8715	0.940	-1.0103	0.531	0.1667	0.8430	0.9629	0.4220	0.1940	1.2439	0.3855	0.4533	0.9191	1.9026	0.3233
Scollard	5	213.0	8318.2	5881.3	213.9	6095.2	342.0	2592.1	0.607	0.3154	0.104	-3.0813	0.151	0.6316	0.0090	1.2132	0.3466	0.2327	0.8350	0.5495	0.3576	0.1768	1.2297	0.1275

Table S1.4 Summary Statistics, KS Test and polynomial tests for carnivore guilds. $\alpha = 0.05$, Sarle's $b = .555$

Formation		Raw Data = Log2(mass(kg))								M-S Distribution				KS Goodness of Fit (vs Global)		Quadratic Regression (bins)			4th degree polynomial regression			Bimodality Coefficient		
	N	Min	Max	IQR	Q1	Q3	Median	Mean	P _{Mean}	Skew	P _{skew}	kurtosis	P _{kurt}	D	P	F	P	R ²	F	P	R ²	b1	b2	b (Sarle)
Jurassic																								
Lufeng BII "Zhangjia'ao"	3	9.7	324.8	315.1	9.7	324.8	25.0	119.8	0.391	1.2933	0.016			0.4424	0.0170	1.0215	0.4026	0.2034	0.7075	0.6154	0.3205			
Kayenta/Navajo Sandstone	3	17.8	340.6	322.9	17.8	340.6	30.1	129.5	0.669	1.7321	0.004			0.4424	0.0170	0.6646	0.5407	0.1425	0.3818	0.8147	0.2029			
Hanson	3	6.0	349.4	343.4	6.0	349.4	25.0	126.8	0.391	1.2933	0.016			0.4424	0.0170	1.0215	0.4026	0.2034	0.7075	0.6154	0.3205			
Xiaohaximiao	6	86.5	2950.0	1873.8	172.4	2046.3	225.5	905.6	0.170	0.4899	0.266	-1.4667	0.442	0.2242	0.4720	1.6356	0.2538	0.2902	1.1923	0.4027	0.4429	0.3750	1.6400	0.1743
Shangshaximiao	5	25.0	3000.0	2752.5	222.5	2975.0	1001.3	1479.3	0.034	-1.9245	0.006	3.6667	0.006	0.3309	0.1270	0.8279	0.4712	0.1715	0.5481	0.7082	0.2676	6.5844	2.9167	0.6948
Tendaguru Middle Saurian	9	10.7	2981.6	1527.5	131.7	1659.2	481.3	948.8	0.128	-1.0103	0.190	-0.5336	0.783	0.2216	0.4720	1.6278	0.2552	0.2892	0.8973	0.5200	0.3743	1.3331	2.1198	0.3487
Tendaguru Upper Saurian	6	10.7	5700.0	2536.3	363.7	2900.0	1076.3	1718.5	0.012	-1.7628	0.013	3.5586	0.006	0.3643	0.1270	1.1351	0.3682	0.2210	1.0644	0.4493	0.4151	4.8553	3.3629	0.6091
Morrison Brushy Basin Zone 3	8	20.4	3758.7	2968.4	122.5	3090.9	1247.1	1496.9	0.034	-0.5401	0.577	-1.0500	0.783	0.1559	0.7580	4.4837	0.0494	0.5285	3.4725	0.0850	0.6983	0.3970	1.8333	0.2075
Lourinhã	5	10.2	3483.3	2483.2	129.8	2613.0	580.4	1213.2	0.090	-0.5901	0.513	-0.0219	0.374	0.1840	0.7580	3.8576	0.0672	0.4909	2.3152	0.1714	0.6068	0.6191	1.9945	0.1620
Cretaceous																								
Wadhurst Clay	4	0.1	1600.0	1464.3	3.5	1467.7	542.2	671.1	0.669	-0.8546	0.301	-1.2893	0.574	0.2758	0.2480	0.4395	0.6590	0.0990	0.2361	0.9081	0.1360	1.6431	1.6281	0.1747
Yixian Lujiantun	9	0.6	20.0	6.3	1.3	7.6	3.1	5.2	0.000	0.8248	0.107	-1.0794	0.760	0.7758	0.0000	1.9772	0.2006	0.3308	3.9698	0.0655	0.7258	0.8885	1.8333	0.2949
Yixian Jianshangou	12	1.1	1300.0	16.2	3.2	19.3	6.7	117.7	0.024	1.7714	0.004	4.0246	0.004	0.6091	0.0030	2.1738	0.1762	0.3521	13.7609	0.0035	0.9017	3.7970	5.0714	0.5269
Cloverly	3	3.6	4558.8	4555.2	3.6	4558.8	83.2	1548.5	0.724	0.9352	0.068			0.2826	0.2480	0.2955	0.7519	0.0688	0.3571	0.8309	0.1923			
Khuren Dukh	3	2.5	1742.7	1740.2	2.5	1742.7	10.8	585.4	0.391	0.9352	0.068			0.4424	0.0170	0.3759	0.6982	0.0859	0.3571	0.8309	0.1923			
Cedar Mountain Mussentuchit	8	5.8	3950.0	460.6	10.9	471.6	17.5	587.3	0.669	1.4286	0.010	1.3571	0.055	0.4008	0.0500	1.0008	0.4093	0.2001	0.8257	0.5541	0.3550	2.7778	2.9796	0.4794
Bayan Shireh / Iren Dabasu	7	13.3	1742.7	582.3	18.7	601.0	90.0	408.8	0.796	0.3830	0.345	-2.1066	0.171	0.2437	0.4720	1.6756	0.2467	0.2952	0.7696	0.5824	0.3391	0.2112	1.3723	0.1788
Griman Creek	5	13.8	672.4	416.9	20.1	437.1	156.7	214.2	0.976	-0.1656	0.948	-2.4074	0.106	0.3866	0.0500	1.7421	0.2355	0.3034	1.1822	0.4062	0.4407	0.0488	1.3981	0.1116
Bissekty	7	1.4	220.0	2.8	10.2	13.0	12.4	40.1	0.105	0.0000	0.717	3.0000	0.008	0.6329	0.0000	0.6446	0.5501	0.1388	0.6248	0.6622	0.2940	0.0000	3.5000	0.1124
Bajo de la Carpa	6	2.8	1925.0	1340.1	3.7	1343.8	358.3	633.0	0.976	-0.1526	0.923	-2.5338	0.083	0.2758	0.2480	0.7064	0.5218	0.1501	0.4831	0.7491	0.2436	0.0364	1.2741	0.1377
Milk River	8	10.2	2554.8	12.9	10.8	23.7	19.3	334.2	0.308	2.8284	0.000	8.0000	0.000	0.6508	0.0000	0.3976	0.6845	0.0904	0.3656	0.8254	0.1959	10.8889	6.1429	1.0766
Anacleto	3	672.4	2325.0	1652.6	672.4	2325.0	734.2	1243.9	0.012	1.7321	0.004			0.5309	0.0070	0.9709	0.4193	0.1953	0.9243	0.5078	0.3813			
Two Medicine	8	5.8	2554.8	1882.7	11.0	1893.7	45.9	656.4	0.796	0.9570	0.064	-0.5060	0.762	0.3660	0.1270	1.4517	0.2898	0.2663	0.8841	0.5261	0.3708	1.2466	2.0924	0.3213
Wahweap	7	10.2	1532.2	1453.7	13.0	1466.7	18.7	446.1	0.920	1.0879	0.040	-1.0282	0.796	0.3472	0.1270	0.7415	0.5065	0.1564	0.3938	0.8069	0.2079	1.7044	1.8216	0.3745
Allen	5	15.1	491.7	458.0	17.8	475.8	373.8	272.2	0.622	-0.6086	0.497	-3.3333	0.041	0.3866	0.0500	0.7967	0.4836	0.1661	0.3728	0.8207	0.1990	0.6584	1.1667	0.1809
Judith River Coal Ridge	6	10.3	2554.8	678.0	11.8	689.8	13.9	445.6	0.519	2.1482	0.001	4.6399	0.004	0.4493	0.0170	0.7093	0.5205	0.1506	0.5267	0.7215	0.2599	7.2104	3.7337	0.8224
Kaiparowits	7	10.2	1532.2	67.0	13.0	80.0	23.7	243.1	0.427	2.3466	0.000	5.5804	0.003	0.4901	0.0170	0.6368	0.5538	0.1373	0.5111	0.7313	0.2541	7.9297	4.5751	0.8952
Dinosaur Park MAZ-1b	13	2.6	2565.6	61.2	10.3	71.5	23.4	419.3	0.427	0.9280	0.069	1.0217	0.077	0.4621	0.0170	1.5507	0.2697	0.2794	1.2414	0.3863	0.4528	1.0249	3.2404	0.2825
Djadokhta	14	0.2	3103.1	19.9	2.4	22.3	16.2	239.0	0.012	0.8632	0.097	2.5585	0.022	0.6989	0.0000	0.9229	0.4359	0.1875	0.7649	0.5848	0.3377	0.8745	4.3319	0.2294
Kirtland Hunter-Willow Washe	6	10.2	2900.0	763.4	12.7	776.1	20.2	505.4	0.519	2.1482	0.001	4.6399	0.004	0.4493	0.0170	0.7093	0.5205	0.1506	0.5267	0.7215	0.2599	7.2104	3.7337	0.8224
Horseshoe Canyon Drumheller	9	10.3	2345.2	93.5	13.3	106.8	22.5	298.2	0.572	1.7708	0.004	3.0326	0.008	0.3938	0.0500	1.2662	0.3329	0.2404	0.9668	0.4892	0.3919	4.0957	3.9921	0.5950
Baruungoyot	12	0.2	3103.1	29.2	1.8	30.9	11.6	271.3	0.028	0.8791	0.085	1.4872	0.049	0.5326	0.0070	2.5866	0.1360	0.3927	2.0331	0.2086	0.5754	0.9352	3.4744	0.2578
Lameta	7	9.1	3500.0	2507.6	12.0	2519.6	491.3	1152.4	0.278	-0.3718	0.770	-1.6856	0.325	0.1024	0.9670	2.4335	0.1494	0.3783	1.1934	0.4023	0.4431	0.1990	1.5477	0.1726
Prince Creek	4	14.7	750.0	562.6	16.9	579.5	45.8	214.1	0.669	1.4142	0.011	1.5000	0.049	0.3866	0.0500	1.4257	0.2954	0.2628	0.9957	0.4770	0.3990	4.5000	2.0000	0.3548
Maefarano	3	0.8	1195.7	1194.8	0.8	1195.7	13.8	403.4	0.391	0.9352	0.068			0.4424	0.0170	0.3759	0.6982	0.0859	0.3571	0.8309	0.1923			
Laramie	4	8.9	6428.6	4814.9	9.9	4824.8	13.3	1616.0	0.669	1.8128	0.004	3.4835	0.008	0.5258	0.0070	0.3585	0.7094	0.0823	0.7780	0.5780	0.3415	7.3941	2.2645	0.5325
Hell Creek	9	10.2	6428.6	251.1	14.4	265.5	47.4	791.8	0.865	1.7271	0.004	3.2998	0.008	0.3580	0.1270	1.6144	0.2576	0.2875	1.1516	0.4169	0.4343	3.8962	4.1324	0.5625
Tremp	6	10.2	757.0	188.0	12.3	200.3	13.3	136.9	0.308	2.4495	0.000	6.0000	0.003	0.6091	0.0030	0.4964	0.6263	0.1104	0.4113	0.7955	0.2152	9.3750	4.2000	0.9928
Lance	11	10.2	6428.6	55.2	13.0	68.2	23.4	630.8	0.572	2.3002	0.000	5.8097	0.003	0.4342	0.0500	1.0868	0.3824	0.2136	0.9146	0.5121	0.3788	6.5318	5.9858	0.7419
Scollard	5	10.2	6428.6	3236.8	11.6	3248.4	14.7	1306.9	0.865	2.0315	0.003	4.1512	0.004	0.4160	0.0500	0.5525	0.5960	0.1214	0.4500	0.7703	0.2308	7.3371	3.0378	0.7553

Table S1.5 The likelihood of bin occupation by guild with and without larger species present

		Percentage of Communities Containing at least one Species											
	Log(kg)	-1	-0.5	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5
All	Carnivores	2	5	21	28	88	47	23	42	63	23	0	0
	Herbivores	0	0	14	23	42	37	63	53	67	79	37	14
	Carnivores with larger Carnivore	2	5	21	28	86	47	19	26	9	0	0	0
	Herbivores with larger Herbivore	0	0	14	23	40	37	63	49	65	35	5	0
Cretaceous	Carnivores	2	5	21	23	67	42	12	21	44	16	0	0
	Herbivores	0	0	12	16	33	28	49	35	53	60	23	7
	Carnivores with larger Carnivore	2	5	21	23	65	42	9	12	2	0	0	0
	Herbivores with larger Herbivore	0	0	12	16	30	28	49	35	53	21	0	0
Jurassic	Carnivores	0	0	0	5	21	5	12	21	19	7	0	0
	Herbivores	0	0	2	7	9	9	14	19	14	19	14	7
	Carnivores with larger Carnivore	0	0	0	5	21	5	9	14	7	0	0	0
	Herbivores with larger Herbivore	0	0	2	7	9	9	14	14	12	14	5	0

Table S1.6 Proportional biomass for 10 species of large theropods

Species	Biomass Proportion		
	Adult	Juvenile	RSP _J
<i>Acrocanthosaurus atokensis</i>	0.32	0.68	211%
<i>Albertosaurus sarcophagus</i>	0.31	0.69	219%
<i>Alectrosaurus olsenii</i>	0.31	0.69	219%
<i>Alioramus altai</i>	0.31	0.69	217%
<i>Allosaurus fragilis</i>	0.55	0.45	82%
<i>Daspletosaurus torosus</i>	0.63	0.37	60%
<i>Gorgosaurus libratus</i>	0.40	0.60	148%
<i>Siats meekerorum</i>	0.32	0.68	211%
<i>Tarbosaurus bataar</i>	0.36	0.64	179%
<i>Tyrannosaurus rex</i>	0.40	0.60	148%

Table S1.7 Pairwise t-test of communities with Bonferroni correction alpha value

Pairwise t-test
 $\alpha = 0.05$ (bold)
 Bonferroni Correction
 $\alpha = 0.000058$ (bold & outlined)

	Baruungoyot	Bayan Shireh / Iren Dabasu	Cedar Mountain Mussentuchit	Cloverly	Dinosaur Park MAZ-1b	Hell Creek	Horseshoe Canyon D-H	Oldman	Two Medicine	Allen	Anacleto	Bajo de la Carpa	Bissekty	Callovian Oxford Clay	Djadokhta	Griman Creek	Hanson	Judith River Coal Ridge	Kaiparowits	Kayenta / Navajo Sandstone	Khuren Dukh	Kirtland Hunter-Willow Washes
Baruungoyot		0.729265	0.569573	0.352394	0.673321	0.480607	0.943344	0.356891	0.439320	0.998085	0.165487	0.439290	0.485196	0.475251	0.297476	0.887606	0.777779	0.741626	0.941639	0.781428	0.653161	0.681036
Bayan Shireh / Iren Dabasu			0.726212	0.397203	0.972291	0.589137	0.726543	0.393318	0.578107	0.633004	0.170936	0.565271	0.122716	0.503026	0.026798	0.505895	0.441953	0.936694	0.587117	0.444621	0.768572	0.849629
Cedar Mountain Mussentuchit				0.519951	0.705182	0.799543	0.565334	0.583282	0.909003	0.599342	0.466442	0.940619	0.281075	0.855663	0.127217	0.536510	0.553150	0.831276	0.523471	0.555124	0.998293	0.906541
Cloverly					0.100648	0.454536	0.126263	0.908169	0.318064	0.230588	0.827003	0.351604	0.097866	0.645463	0.021352	0.213137	0.312906	0.283974	0.153918	0.313586	0.505034	0.319193
Dinosaur Park MAZ-1b						0.616205	0.758362	0.434402	0.640992	0.730186	0.250455	0.658381	0.287860	0.632805	0.126872	0.633755	0.593130	0.961576	0.663504	0.595950	0.818006	0.882727
Hell Creek							0.495448	0.757959	0.868222	0.573300	0.721669	0.857393	0.336152	0.986554	0.177765	0.532584	0.577715	0.707012	0.493313	0.579107	0.871626	0.761648
Horseshoe Canyon D-H								0.354737	0.448250	0.940051	0.151086	0.436545	0.364511	0.448626	0.179901	0.810012	0.697440	0.766319	0.873151	0.701261	0.658786	0.701022
Oldman									0.294997	0.134147	0.929922	0.297150	0.035031	0.621191	0.003123	0.119310	0.211543	0.228171	0.080737	0.212062	0.465116	0.277879
Two Medicine										0.451769	0.461801	0.965617	0.156130	0.896107	0.046720	0.390928	0.422691	0.725118	0.379598	0.424484	0.929678	0.812055
Allen											0.078189	0.269307	0.020650	0.195622	0.000550	0.695930	0.376163	0.670934	0.894651	0.376219	0.544816	0.613504
Anacleto												0.197453	0.003232	0.495325	0.000048	0.028365	0.068389	0.151430	0.021442	0.068450	0.366141	0.211698
Bajo de la Carpa													0.053121	0.827871	0.006891	0.248778	0.273210	0.706965	0.272156	0.274520	0.941734	0.813503
Bissekty														0.046028	0.329954	0.152406	0.412991	0.316496	0.332545	0.379684	0.283627	0.311185
Callovian Oxford Clay																0.000022	0.050514	0.089188	0.474650	0.078317	0.088767	0.754914
Djadokhta																	0.088996	0.259365	0.283347	0.274944	0.224997	0.250510
Griman Creek																		0.617165	0.574878	0.897706	0.622519	0.479606
Hanson																			0.441261	0.591082	0.983972	0.394576
Judith River Coal Ridge																				0.629844	0.584513	0.851787
Kaiparowits																					0.728603	0.559353
Kayenta / Navajo Sandstone																						0.396308
Khuren Dukh																						0.888570

Table S1.7 (continued)

	Lameta	Lance	Laramie	Lourinhã	Lufeng BII Zhangjia'ao	Maewarano	Milk River	Morrison Brushy Basin Zone 3	Prince Creek	Scollard	Shangshaximiao	Tendaguru Middle Saurian	Tendaguru Upper Saurian	Trempe	Upper Elliot	Wadhurst Clay	Wahweap	Xishaximiao	Yixian Jianshangou	Yixian Lujiantun
Baruungoyot	0.151888	0.561999	0.370516	0.191532	0.766834	0.826132	0.883459	0.050491	0.901597	0.404466	0.096290	0.130141	0.105236	0.718764	0.801885	0.478391	0.674811	0.275308	0.571215	0.361625
Bayan Shireh / Iren Dabasu	0.191977	0.707040	0.417112	0.230195	0.428881	0.991169	0.839699	0.065727	0.569816	0.462116	0.115424	0.171109	0.131303	0.324349	0.505634	0.575554	0.913084	0.342136	0.158295	0.056649
Cedar Mountain Mussentuchit	0.427843	0.949345	0.516761	0.456840	0.546842	0.825387	0.648141	0.199946	0.584780	0.585633	0.291448	0.509255	0.247000	0.417812	0.618606	0.910747	0.800398	0.650418	0.238317	0.194272
Cloverly	0.685267	0.300063	0.970736	0.773010	0.310670	0.418533	0.167609	0.955709	0.269784	0.876460	0.952114	0.458838	0.887555	0.151292	0.411741	0.468468	0.227351	0.530402	0.038924	0.054711
Dinosaur Park MAZ-1b	0.237495	0.735396	0.425992	0.275904	0.583632	0.979839	0.848119	0.086392	0.676367	0.475950	0.147304	0.244592	0.146167	0.478369	0.647525	0.666246	0.950821	0.410992	0.297523	0.188766
Hell Creek	0.694646	0.846078	0.639324	0.698074	0.573622	0.752206	0.558842	0.427804	0.578702	0.728879	0.527076	0.834224	0.422541	0.440179	0.643458	0.911072	0.670355	0.904051	0.263603	0.254223
Horseshoe Canyon D-H	0.150732	0.582807	0.378361	0.189815	0.684860	0.846191	0.927940	0.050044	0.834971	0.413276	0.094301	0.124146	0.107810	0.619278	0.731914	0.471649	0.697037	0.272768	0.448467	0.242804
Oldman	0.808651	0.326816	0.859907	0.894498	0.209171	0.341552	0.107668	0.809446	0.172011	0.988004	0.858670	0.500880	0.689811	0.071339	0.320285	0.423997	0.155405	0.563981	0.009195	0.013975
Two Medicine	0.451106	0.968723	0.534203	0.473170	0.416127	0.727199	0.516255	0.203366	0.449606	0.611102	0.291328	0.552962	0.253279	0.276309	0.500800	0.982079	0.668423	0.696266	0.118390	0.090718
Allen	0.107061	0.529964	0.366936	0.143873	0.342781	0.717347	0.843183	0.034086	0.765611	0.394201	0.067639	0.061222	0.093840	0.366578	0.387697	0.305545	0.525598	0.191631	0.216083	0.002575
Anadeto	0.876298	0.326507	0.806504	0.964821	0.066710	0.199485	0.049703	0.667131	0.054793	0.959637	0.733283	0.487265	0.584605	0.012544	0.130446	0.316770	0.071077	0.550714	0.000478	0.000663
Bajo de la Carpa	0.374574	0.997084	0.512756	0.400480	0.265705	0.676128	0.459546	0.150100	0.316536	0.584942	0.224745	0.444105	0.215951	0.146504	0.353097	0.940991	0.624235	0.617877	0.041149	0.021409
Bissekty	0.042956	0.301782	0.286120	0.068232	0.420487	0.297738	0.341519	0.012289	0.303296	0.294756	0.028903	0.013324	0.051354	0.426099	0.426638	0.102374	0.135281	0.075643	0.470513	0.177315
Callovian Oxford Clay	0.478846	0.814986	0.578149	0.492269	0.085261	0.434289	0.228213	0.199589	0.100915	0.661170	0.283944	0.614634	0.271525	0.021791	0.165616	0.824215	0.316632	0.778701	0.001494	0.000398
Djadokhta	0.032941	0.280442	0.268264	0.053548	0.252880	0.254417	0.301173	0.008198	0.228091	0.277269	0.019693	0.008736	0.040697	0.312647	0.215375	0.078295	0.107299	0.060107	0.347201	0.107440
Griman Creek	0.089513	0.467570	0.348253	0.125013	0.581508	0.610220	0.704930	0.028216	0.999374	0.369960	0.058549	0.045859	0.083690	0.618222	0.614992	0.251333	0.407035	0.159696	0.448865	0.022857
Hanson	0.071672	0.381830	0.333442	0.108922	0.957783	0.456591	0.509440	0.023645	0.637118	0.343382	0.054680	0.029614	0.077546	0.940300	0.936196	0.184703	0.252562	0.123525	0.936711	0.043215
Judith River Coal Ridge	0.268549	0.769893	0.448039	0.308792	0.573105	0.948850	0.807274	0.106114	0.653535	0.498202	0.176093	0.282293	0.168980	0.459803	0.640067	0.709594	0.999074	0.449838	0.276769	0.184856
Kaiparowits	0.111611	0.510091	0.356947	0.148489	0.706195	0.727330	0.798874	0.035448	0.926440	0.384303	0.070539	0.073647	0.091109	0.670633	0.746051	0.349873	0.539202	0.203470	0.503878	0.196893
Kayenta/Navajo Sandstone	0.072107	0.384113	0.334159	0.109410	0.939909	0.459093	0.514081	0.023786	0.643860	0.344311	0.054894	0.029864	0.077862	0.955548	0.918512	0.185586	0.255065	0.124278	0.917481	0.031735
Khuren Dukh	0.356913	0.941384	0.508498	0.391452	0.386938	0.766606	0.559520	0.149467	0.434907	0.570356	0.231768	0.407641	0.217819	0.244270	0.479177	0.878944	0.736029	0.580443	0.092704	0.059350
Kirtland Hunter-Willow Washes	0.330960	0.847367	0.477055	0.368051	0.556242	0.887962	0.728156	0.140272	0.615470	0.534601	0.220485	0.371885	0.199569	0.433624	0.626426	0.801310	0.903243	0.533459	0.251524	0.184618
Lameta		0.452720	0.769241	0.942016	0.208158	0.385717	0.158278	0.620495	0.193284	0.906555	0.694687	0.710914	0.556090	0.087749	0.297142	0.529074	0.224564	0.727007	0.016412	0.018987
Lance			0.564147	0.569874	0.639218	0.840759	0.682720	0.305348	0.661545	0.638700	0.408346	0.650529	0.326473	0.524233	0.699092	0.967817	0.805447	0.756151	0.352369	0.319817
Laramie				0.777010	0.394401	0.492021	0.240084	0.916118	0.354629	0.860065	0.922979	0.510007	0.942165	0.230625	0.487802	0.533715	0.306850	0.575409	0.085106	0.109864
Lourinhã					0.192364	0.354642	0.132877	0.682494	0.173391	0.943443	0.749126	0.629253	0.599568	0.075233	0.281110	0.480613	0.190293	0.663442	0.012092	0.015230
Lufeng BII Zhangjia'ao						0.443809	0.494597	0.023020	0.605639	0.340630	0.053567	0.028293	0.076393	0.897459	0.973162	0.178718	0.241454	0.120237	0.984887	0.039313
Maewarano							0.850461	0.072886	0.579942	0.470148	0.131724	0.171765	0.144498	0.331036	0.525886	0.573236	0.900123	0.345145	0.159955	0.058768
Milk River								0.065602	0.793753	0.436711	0.118937	0.168754	0.125413	0.594590	0.723701	0.549040	0.786799	0.325936	0.421580	0.257902
Morrison Brushy Basin Zone 3									0.107258	0.887222	0.983776	0.351793	0.821464	0.039620	0.206152	0.319241	0.099144	0.431730	0.004245	0.006481
Prince Creek										0.375022	0.065654	0.051411	0.089101	0.661654	0.690676	0.272436	0.425429	0.169590	0.491465	0.068330
Scollard											0.895942	0.701309	0.758198	0.294707	0.539883	0.646242	0.409564	0.731641	0.131943	0.153182
Shangshaximiao												0.334925	0.801472	0.031289	0.187613	0.297727	0.084176	0.418844	0.002619	0.004309
Tendaguru Middle Saurian													0.387895	0.068003	0.253061	0.647740	0.274191	0.942696	0.011140	0.009429
Tendaguru Upper Saurian														0.068749	0.273733	0.326044	0.119503	0.379767	0.010470	0.017028
Trempe															0.920849	0.188794	0.281382	0.121716	0.884677	0.177766
Upper Elliot																0.186276	0.235523	0.124136	0.982221	0.010413
Wadhurst Clay																	0.550284	0.665645	0.027094	0.014583
Wahweap																		0.393635	0.150794	0.067228
Xishaximiao																			0.028748	0.026346
Yixian Jianshangou																				0.355788

Table S1.8 Global taxon list with mass in kg

Log ₁₀ Bin	Carnivores / Meat Dominant Omnivores	Mass(kg)	Herbivores / Plant Dominant Omnivores	Mass(kg)
-2	<i>Scansoriopteryx heilmanni</i>	0.005		
-1.5	<i>Zhongornis haoae</i>	0.024		
-1	<i>Confuciusornis dui</i>	0.066		
	<i>Eosinopteryx brevipenna</i>	0.100		
	<i>Maniraptora sp.</i>	0.100		
-0.5	<i>Saltopus elginensis</i>	0.110	<i>Epidexipteryx hui</i>	0.312
	<i>Confuciusornis jianchangensis</i>	0.115		
	<i>Eoconfuciusornis zhengi</i>	0.128		
	<i>Parvicursor remotus</i>	0.169		
	<i>Scipionyx samniticus</i>	0.213		
	<i>Aurornis xui</i>	0.260		
0	<i>Omnivoropteryx sinousaorum</i>	0.379	<i>Pneumatoraptor fodori</i>	0.510
	<i>Confuciusornis sanctus</i>	0.390	<i>Pedopenna daohugouensis</i>	0.590
	<i>Juravenator starki</i>	0.420	<i>Tianyulong confuciusi</i>	0.644
	<i>Ligabueino andesi</i>	0.425	<i>Echinodon becklesii</i>	0.728
	<i>Alnashetri cerropoliciensis</i>	0.500	<i>Fruitadens haagarorum</i>	0.764
	<i>Yi qi</i>	0.520	<i>Aquilops americanus</i>	1.500
	<i>Anchiornis huxleyi</i>	0.530	<i>Neoceratopsia sp.</i>	1.500
	<i>Mahakala omnogovae</i>	0.537	<i>Abriotosaurus consors</i>	1.797
	<i>Dalianraptor cuhe</i>	0.540	<i>Alwalkeria maleriensis</i>	2.000
	<i>Xixianykus zhangii</i>	0.546	<i>Liaoceratops yanzigouensis</i>	2.000
	<i>Mei long</i>	0.559	<i>Yamaceratops dornogobiensis</i>	2.000
	<i>Ceratonykus oculus</i>	0.580	<i>Ningyuansaurus wangi</i>	2.300
	<i>Microaptor zhaoianus</i>	0.617	<i>Ornithomimus minutus</i>	2.300
	<i>Xiaotingia zhengi</i>	0.743	<i>Wannanosaurus yansiensis</i>	2.360
	<i>Shenzhouraptor sinensis</i>	0.756	<i>Agrosaurus macgillivrayi</i>	2.800
	<i>Halszkaraptor escuilliei</i>	0.762	<i>Psittacosaurus xinjiangensis</i>	2.821
	<i>Liaoningvenator curriei</i>	0.780	<i>Eocursor parvus</i>	2.916
	<i>Jeholomis palmipennis</i>	0.796	<i>Sacisaurus agudoensis</i>	3.150
	<i>Albinykus baatar</i>	0.809		
	<i>Rahonavis ostromi</i>	0.842		
	<i>Jinfengopteryx elegans</i>	0.887		
	<i>Confuciusornis feducciai</i>	0.887		
	<i>Yixianosaurus longimanus</i>	0.908		
	<i>Shanag ashile</i>	1.000		
	<i>Yandangornis longicaudus</i>	1.000		
	<i>Sinosauropteryx prima</i>	1.126		
	<i>Jixiangornis orientalis</i>	1.158		
	<i>Procompsognathus triassicus</i>	1.172		
	<i>Dromomeron romeri</i>	1.200		
	<i>Linhenykus monodactylus</i>	1.221		
	<i>Banji long</i>	1.250		
	<i>Aorun zhaoi</i>	1.268		

Table S1.8 (continued)

Log ₁₀ Bin	Carnivores / Meat Dominant		Herbivores / Plant Dominant	
	Omnivores	Mass(kg)	Omnivores	Mass(kg)
0	<i>Hulsanpes perlei</i>	1.364		
	<i>Caenagnathasia martinsoni</i>	1.400		
	<i>Sidormimus sp.</i>	1.450		
	<i>Sapeornis chaoyangensis</i>	1.508		
	<i>Microraptor gui</i>	1.552		
	<i>Sinovenator changii</i>	1.903		
	<i>Daliansaurus liaoningensis</i>	1.909		
	<i>Compsognathus longipes</i>	2.087		
	<i>Caudipteryx zoui</i>	2.200		
	<i>Paronychodon caperatus</i>	2.200		
	<i>Xixiasaurus henanensis</i>	2.300		
	<i>Yaverlandia bitholus</i>	2.300		
	<i>Koparion douglassi</i>	2.400		
	<i>Jeholomis prima</i>	2.498		
	<i>Troodontidae sp.3</i>	2.500		
	<i>Hesperonychus elizabethae</i>	2.550		
	<i>Pamparaptor micros</i>	2.600		
	<i>Alvarezsaurus calvoi</i>	2.792		
0.5	<i>Shuvuuia deserti</i>	2.982		
	<i>Changyuraptor yangi</i>	3.067		
	<i>Sinornithoides youngi</i>	3.087		
	<i>Sinusonasus magodens</i>	3.193	<i>Lycorhinus angustidens</i>	3.764
	<i>Graciliraptor lujiatunensis</i>	3.479	<i>Nqwebasaurus thwazi</i>	3.780
	<i>Sinornithosaurus millenii</i>	3.479	<i>Pegomastax africanus</i>	4.000
	<i>Microvenator celer</i>	3.627	<i>Heterodontosaurus tucki</i>	4.028
	<i>Velocisaurus unicus</i>	3.946	<i>Gobiceratops minutus</i>	4.200
	<i>Mononykus olecranus</i>	3.956	<i>Yueosaurus tiantaiensis</i>	4.240
	<i>Daemonosaurus chauliodus</i>	4.100	<i>Psittacosaurus sinensis</i>	4.253
	<i>Tawa hallae</i>	4.388	<i>Bagaceratops sp.</i>	4.271
	<i>Protarchaeopteryx robusta</i>	4.702	<i>Bagaceratops rozhdestvenskyi</i>	4.271
	<i>Buitreraptor gonzalezorum</i>	4.737	<i>Magnirostris dodsoni</i>	4.271
	<i>Segisaurus halli</i>	4.741	<i>Microceratops gobiensis</i>	4.304
	<i>Albertonykus borealis</i>	5.060	<i>Graciliceratops mongoliensis</i>	4.336
	<i>Bradyneme draculae</i>	5.100	<i>Hexing qingyi</i>	4.337
	<i>Bambiraptor feinbergi</i>	5.268	<i>Incisivosaurus gauthieri</i>	4.702
	<i>Vitakrisaurus saraiki</i>	5.300	<i>Gongbusaurus wucaiwansensis</i>	4.930
	<i>Aviatyrannis jurassica</i>	5.500	<i>Lesothosaurus diagnosticus</i>	4.959
	<i>Eodromaeus murphi</i>	5.640	<i>Buriolestes schultzi</i>	5.000
	<i>Mirischia asymmetrica</i>	5.724	<i>Psittacosaurus lujiatunensis</i>	5.000
	<i>Bambiraptor feinbergi</i>	5.829	<i>Xiaosaurus dashanpensis</i>	5.242
	<i>Velociraptorinae sp.2</i>	5.829	<i>Micropachycephalosaurus hongtuyanensis</i>	5.263
	<i>Podokesaurus holyokensis</i>	5.965	<i>Gideonmantellia amosanjuanensis</i>	5.468
	<i>Coelophysoidea sp.</i>	6.000	<i>Jeholosaurus shangyuanensis</i>	5.667
	<i>Caudipteryx dongi</i>	6.143	<i>Leaellynasaura amicagraphica</i>	5.706
	<i>Santanaraptor placidus</i>	6.270	<i>Pantydraco caducus</i>	5.922

Table S1.8 (continued)

Log ₁₀ Bin	Carnivores / Meat Dominant		Herbivores / Plant Dominant	
	Omnivores	Mass(kg)	Omnivores	Mass(kg)
0.5	<i>Julieraptor sp.</i>	7.100	<i>Iguanodontia sp.</i>	6.000
	<i>Luanchuanraptor henanensis</i>	7.150	<i>Segisaurus sp.</i>	6.000
	<i>Zhenyuanlong suni</i>	7.200	<i>Pampadromaeus barberenai</i>	6.222
	<i>Eoraptor lunensis</i>	7.315	<i>Yandusaurus sp.</i>	6.600
	<i>Variraptor mechinorum</i>	7.636	<i>Archaeoceratops yujingziensis</i>	6.884
	<i>Aristosuchus pusillus</i>	8.000	<i>Psittacosaurus meileyingensis</i>	8.000
	<i>Ornithodesmus cluniculus</i>	8.000	<i>Psittacosaurus gobiensis</i>	8.428
	<i>Elopteryx nopsai</i>	8.202	<i>Ornithopoda sp.2</i>	8.917
	<i>Luoyanggia liudianensis</i>	8.500	<i>Gasparinisaura cincosaltensis</i>	8.962
	<i>Pterospondylus trielbae</i>	8.700	<i>Ornithopoda sp.1</i>	8.962
	<i>Alvarezsauridae sp.</i>	8.930	<i>Ignavusaurus rachelis</i>	9.969
	<i>Jubbulpuria tenuis</i>	9.126		
	<i>Panguraptor lufengensis</i>	9.700		
1	<i>Machairasaurus sp.</i>	10.000	<i>Changchunsaurus parvus</i>	10.000
	<i>Machairasaurus leptonychus</i>	10.000	<i>Prenocephale brevis</i>	10.000
	<i>Richardoestesia isosceles</i>	10.195	<i>Panphagia protos</i>	10.148
	<i>Coelurosauria sp.</i>	10.240	<i>Palaeopteryx thompsoni</i>	11.500
	<i>Richardoestesia sp.</i>	10.240	<i>Liaoningosaurus paradoxus</i>	12.000
	<i>Richardoestesia gilmorei</i>	10.328	<i>Chromogisaurus novasi</i>	12.526
	<i>Abelisauroid sp.</i>	10.742	<i>Haya griva</i>	12.670
	<i>small abelisauroida sp.</i>	10.742	<i>Kinnareemimus khonkaenensis</i>	13.000
	<i>Troodontidae sp.4</i>	10.833	<i>Richardoestesia asiatica</i>	13.000
	<i>Urbacodon itemirensis</i>	10.833	<i>Technosaurus smalli</i>	13.000
	<i>Camposaurus arizonensis</i>	11.000	<i>Shenzhousaurus orientalis</i>	13.089
	<i>Dilong paradoxus</i>	11.709	<i>Yinlong downsi</i>	13.535
	<i>Compsosuchus solus</i>	12.000	<i>Asylosaurus yalensis</i>	14.000
	<i>Noasauridae sp.1</i>	12.000	<i>Psittacosaurus mongoliensis</i>	14.016
	<i>Zapsalis sp.</i>	12.333	<i>Scutellosaurus lawleri</i>	14.813
	<i>Zapsalis abradens</i>	12.333	<i>Hongshanosaurus houi</i>	15.000
	<i>Itemirus medullaris</i>	12.422	<i>Orodromeus makelai</i>	15.169
	<i>Gobivenator mongoliensis</i>	12.781	<i>Fulgurotherium australe</i>	15.193
	<i>Euronychodon sp.</i>	12.988	<i>Bagualosaurus agudoensis</i>	15.500
	<i>Euronychodon asiaticus</i>	12.988	<i>Albertadromeus syntarsus</i>	16.000
	<i>Paronychodon sp.</i>	12.988	<i>Hypsilophodon foxii</i>	16.071
	<i>Troodontidae sp.</i>	12.988	<i>Pelecanimimus polyodon</i>	17.000
	<i>Inosaurus tedreftensis</i>	13.000	<i>Limusaurus inextricabilis</i>	17.393
	<i>Ozraptor subotaii</i>	13.000	<i>Nedcolbertia justinhofmanni</i>	17.965
	<i>Coelophysis rhodesiensis</i>	13.026	<i>Psittacosaurus major</i>	18.000
	<i>Avimimus sp.</i>	13.279	<i>Fabrosaurus sp.</i>	19.702
	<i>Avimimus portentosus</i>	13.279	<i>Helioceratops brachygnathus</i>	20.000
	<i>Caenagnathoidea sp.</i>	13.279	<i>Ornithopoda sp.3</i>	20.000
	<i>Boreonykus certekorum</i>	13.500	<i>Prenoceratops pieganensis</i>	20.000
	<i>Megalosaurus cloacinus</i>	13.500	<i>Zephyrosaurus sp.</i>	20.000
	<i>Dromaeosauridae sp.1</i>	13.560	<i>Zephyrosaurus schaffi</i>	20.000

Table S1.8 (continued)

Log ₁₀ Bin	Carnivores / Meat Dominant		Herbivores / Plant Dominant	
	Omnivores	Mass(kg)	Omnivores	Mass(kg)
	<i>Dromaeosaurus sp.</i>	13.560	<i>Gongbusaurus shiyii</i>	20.056
	<i>Ornithodesmus sp.</i>	13.560	<i>Notohypsilophodon comodorensis</i>	20.275
	<i>Byronosaurus sp.</i>	13.600	<i>Stenopelix valdensis</i>	20.549
	<i>Ornitholestes hermanni</i>	13.755	<i>Psittacosaurus sibiricus</i>	20.557
	<i>Masiakasaurus knopfleri</i>	13.790	<i>Lamaceratops tereschenkoi</i>	22.000
	<i>Noasauridae sp.</i>	13.790	<i>Ganzhousaurus nankangensis</i>	23.000
	<i>Beelemodon sp.</i>	14.000	<i>Hexinlusaurus multidentis</i>	24.146
	<i>Tianyuraptor ostromi</i>	14.263	<i>Nanosaurus agilis</i>	24.293
	<i>Tugulusaurus faciles</i>	14.298	<i>Eshanosaurus deguchiianus</i>	26.000
	<i>Borogovia gracilicrus</i>	14.402	<i>Grusimimus tsuru</i>	27.000
	<i>Pyroraptor olympius</i>	14.736	<i>Goyocephale lattermorei</i>	27.658
	<i>Dromaeosaurus albertensis</i>	14.747	<i>Pachycephalosauridae sp.</i>	27.658
	<i>Heptasteornis andrewsi</i>	15.000	<i>Stegoceras sp.</i>	27.658
	<i>Dromaeosauridae sp.</i>	15.142	<i>Stegoceras validum</i>	27.658
	<i>noncoelurosaurian basal tetanuran s</i>	15.169	<i>Hanssuesia sternbergi</i>	28.072
	<i>Similicaudipteryx yixianensis</i>	15.190	<i>Anabisetia saldiviai</i>	28.611
	<i>Atrociraptor sp.</i>	15.250	<i>Valdosaurus canaliculatus</i>	29.054
	<i>Atrociraptor marshalli</i>	15.250	<i>Homalocephale calathocercos</i>	31.443
	<i>Paronychodon asiaticus</i>	16.000		
	<i>Achillesaurus manazzonei</i>	16.500		
	<i>Sauromitholestes robustus</i>	17.000		
	<i>Huaxiagnathus orientalis</i>	17.363		
1	<i>Coelophysis bauri</i>	17.611		
	<i>Eucoelophysis baldwini</i>	17.700		
	<i>Kayentavenator elysiae</i>	17.750		
	<i>Zanabazar junior</i>	18.000		
	<i>Zunityrannus sp.</i>	18.000		
	<i>Staurikosaurus pricei</i>	18.266		
	<i>Acheroraptor temertyorum</i>	18.500		
	<i>Velociraptor sp.</i>	18.734		
	<i>Velociraptor mongoliensis</i>	18.734		
	<i>Velociraptor osmolskae</i>	18.734		
	<i>Velociraptorinae sp.1</i>	18.734		
	<i>Chindesaurus bryansmalli</i>	19.000		
	<i>Haplocheirus sollers</i>	19.489		
	<i>Jianchangosaurus yixianensis</i>	20.000		
	<i>Kol ghuvu</i>	20.000		
	<i>Coelurus fragilis</i>	20.381		
	<i>Bonapartenykus ultimus</i>	20.500		
	<i>Tsaagan mangas</i>	20.500		
	<i>Linheraptor exquisitus</i>	20.984		
	<i>Sauromithoides mongoliensis</i>	21.755		
	<i>Troodontidae sp.1</i>	21.755		
	<i>Elmisaurus rarus</i>	22.250		
	<i>Troodontidae sp.2</i>	22.496		

Table S1.8 (continued)

Log ₁₀ Bin	Carnivores / Meat Dominant		Herbivores / Plant Dominant	
	Omnivores	Mass(kg)	Omnivores	Mass(kg)
1	<i>Sauromitholestes langstoni</i>	23.405		
	<i>Paronychodon lacustris</i>	23.703		
	<i>Sauromitholestes sp.</i>	23.703		
	<i>Velociraptorinae sp.</i>	23.703		
	<i>Khaan mckennai</i>	23.984		
	<i>Calamospondylus oweni</i>	24.000		
	<i>Conchoraptor gracilis</i>	24.500		
	<i>Coelophysis sp.</i>	25.046		
	<i>Coelophysoidea sp.1</i>	25.046		
	<i>Sinocoelurus fragilis</i>	25.046		
	<i>Leptorhynchus gaddisi</i>	26.111		
	<i>Noasauridae sp.2</i>	26.500		
	<i>Noasaurus leali</i>	26.500		
	<i>Linhevenator tani</i>	26.766		
	<i>Ingenia yanshini</i>	27.407		
	<i>Nemegtomaia barsboldi</i>	27.500		
	<i>Calamosaurus foxii</i>	29.000		
	<i>Talos sampsoni</i>	29.000		
	<i>Coelophysis kayentakatae</i>	30.111		
	<i>Sauromitholestes sullivanii</i>	31.000		
1.5	<i>Geminiraptor suarezorum</i>	31.688	<i>Heyuannia huangi</i>	31.740
	<i>Patagonykus puertai</i>	31.808	<i>Oviraptor philoceratops</i>	33.070
	<i>Wulatelong gobiensis</i>	31.883	<i>Guaibasaurus candelariensis</i>	33.717
	<i>Bicentenaria argentina</i>	33.000	<i>Aniksosaurus darwini</i>	35.144
	<i>Laevisuchus indicus</i>	34.500	<i>Stormbergia dangershoekei</i>	35.541
	<i>Shixinggia oblita</i>	35.000	<i>Prenecephale sp.</i>	38.504
	<i>Sinocalliopteryx gigas</i>	35.410	<i>Mochlodon vorosi</i>	38.519
	<i>Nomingia gobiensis</i>	37.416	<i>Hypsilophodon wielandi</i>	39.204
	<i>Fosterovenator churei</i>	40.570	<i>Acrotholus audeti</i>	40.000
	<i>Tachiraptor admirabilis</i>	42.000	<i>Tylocephale gilmorei</i>	40.000
	<i>Ingenia sp.</i>	43.480	<i>Hypsilophodontidae sp.1</i>	40.237
	<i>Lepidus praecisio</i>	44.000	<i>Oryctodromeus cubicularis</i>	40.237
	<i>Rinchenia mongoliensis</i>	44.362	<i>Saturnalia tupiniquim</i>	42.509
	<i>Ojoraptorsaurus boerei</i>	44.552	<i>Comanchesaurus kuesi</i>	44.000
	<i>Yurgovuchia doellingi</i>	45.500	<i>Adeopapposaurus magnai</i>	47.837
	<i>Pectinodon sp.</i>	47.376	<i>Elrhazosaurus nigeriensis</i>	48.107
	<i>Pectinodon bakkeri</i>	47.376	<i>Amtoccephale gobiensis</i>	50.000
	<i>Adasaurus mongoliensis</i>	48.609	<i>Gryphoceratops morrisoni</i>	50.000
	<i>Dromaeosauroides bomholmensis</i>	49.000	<i>Weewarrasaurus pobeni</i>	50.000
	<i>Neuquenraptor argentinus</i>	49.705	<i>Prenocephale prenes</i>	51.259
	<i>Albertavenator sp.</i>	50.000	<i>Arcusaurus pereirabdalorum</i>	51.329
	<i>Elmisaurus elegans</i>	50.000	<i>Parksosaurus warreni</i>	52.832
	<i>Velocipes guerichi</i>	53.000	<i>Huanansaurus ganzhouensis</i>	60.000
	<i>Xinjiangovenator parvus</i>	53.660	<i>Unaysaurus tolentinoi</i>	60.000
	<i>Leptorhynchus elegans</i>	56.361	<i>Coelosaurus antiquus</i>	61.500

Table S1.8 (continued)

Log ₁₀ Bin	Carnivores / Meat Dominant		Herbivores / Plant Dominant	
	Omnivores	Mass(kg)	Omnivores	Mass(kg)
1.5	<i>Tochisaurus nemegtensis</i>	57.262	<i>Sphaerotherolus goodwini</i>	64.069
	<i>Megalosaurus lonzeensis</i>	60.000	<i>Saltillomimus rapidus</i>	66.000
	<i>Caenagnathus collinsi</i>	61.500	<i>Sphaerotherolus buchholtzae</i>	68.340
	<i>Chirostenotes elegans</i>	63.000	<i>Beipiaosaurus inexpectus</i>	69.726
	<i>Sanjuansaurus gordilloi</i>	63.000	<i>Leoneriasaurus taquetensis</i>	70.000
	<i>Chirostenotes sp.</i>	65.569	<i>Leyesaurus marayensis</i>	70.000
	<i>Zuolong salleei</i>	65.707	<i>Thecocoelurus daviesi</i>	70.000
	<i>Troodon sp.</i>	68.165	<i>Qiupalong henanensis</i>	77.883
	<i>Troodon formosus</i>	68.165	<i>Dryosaurus lettowvorbecki</i>	80.000
	<i>Zupaysaurus rougieri</i>	70.000	<i>Sinornithomimus dongi</i>	80.618
	<i>Chirostenotes pergracilis</i>	74.776	<i>Hypsilophodontidae sp.2</i>	82.796
	<i>Unenlagia paynemili</i>	75.000	<i>Seitaad ruessi</i>	85.000
	<i>Unenlagia comahuensis</i>	76.125	<i>Agilisaurus louderbacki</i>	85.760
	<i>Bagaraatan ostromi</i>	76.748	<i>Dryosaurus grandis</i>	90.000
	<i>Hagryphus giganteus</i>	80.000	<i>Ornithopoda sp.4</i>	90.000
	<i>Betasuchus bredai</i>	83.000	<i>Unescoceratops koppelhusae</i>	91.000
	<i>Deinonychus antirrhopus</i>	83.191	<i>Macrocollum itaquii</i>	95.000
	<i>Dromaeosaurinae sp.</i>	83.191	<i>Walgettosuchus woodwardi</i>	95.000
	<i>Kakuru kujani</i>	85.000	<i>Nankangia jiangxiensis</i>	97.170
	<i>Sarcosaurus woodi</i>	86.153	<i>Protoceratops andrewsi</i>	99.576
	<i>Chuangdongocoelurus primitivus</i>	86.522	<i>Garudimimus brevipes</i>	99.613
	<i>Deinonychosauria sp.</i>	90.000	<i>Harpymimus okladnikovi</i>	99.943
	<i>Tarascosaurus salluvicus</i>	90.000		
	<i>Stokesosaurus clevelandi</i>	92.500		
	<i>Citipati osmolskae</i>	93.998		
	<i>Proceratosaurus bradleyi</i>	95.000		
	<i>Liliensternus liliensterni</i>	96.762		
	<i>Epichirostenotes sp.</i>	98.052		
2	<i>Nuthetes destructor</i>	100.000	<i>Chilesaurus diegosuarezi</i>	100.000
	<i>Genusaurus sisteromis</i>	101.071	<i>Aepyornithomimus tugrikinensis</i>	105.975
	<i>Apatoraptor sp.</i>	115.552	<i>Callovosaurus leedsii</i>	108.367
	<i>Lukousaurus yini</i>	120.000	<i>Thescelosaurus assiniboiensis</i>	108.545
	<i>Timimus hermani</i>	125.552	<i>Falcarius utahensis</i>	109.262
	<i>Guanlong wucaili</i>	128.431	<i>Gyposaurus sinensis</i>	112.141
	<i>Newtonsaurus cambrensis</i>	130.000	<i>Dysalotosaurus lettowvorbecki</i>	119.984
	<i>Tanycolagreus topwilsoni</i>	134.841	<i>Nambalia roychowdhurii</i>	125.000
	<i>Eotyrannus lengi</i>	135.000	<i>Tototlmimus packardensis</i>	125.000
	<i>Lophostropheus airelensis</i>	136.000	<i>Anchisaurus polyzelus</i>	125.941
	<i>Orthogoniosaurus matleyi</i>	145.000	<i>Alaskacephale gangloffii</i>	130.000
	<i>Dahalokely tokana</i>	150.000	<i>Montanaceratops sp.</i>	134.421
	<i>Rapator ornitholestoides</i>	156.745	<i>Ornithomimus edmontonicus</i>	138.724
	<i>Gojirasaurus quayi</i>	185.008	<i>Yandusaurus hongheensis</i>	140.000
	<i>Gasosaurus constructus</i>	201.054	<i>Archaeornithomimus sp.</i>	146.891
	<i>Gasosaurus lini</i>	201.054	<i>Ornithomimidae sp.</i>	146.891

Table S1.8 (continued)

Log ₁₀ Bin	Carnivores / Meat Dominant		Herbivores / Plant Dominant	
	Omnivores	Mass(kg)	Omnivores	Mass(kg)
	<i>Megaraptoridae sp.</i>	201.729	<i>Neimongosaurus yangi</i>	148.542
	<i>Herrerasaurus ischigualastensis</i>	211.599	<i>Archaeornithomimus bissektensis</i>	150.000
	<i>Marshosaurus bicentesimus</i>	212.500	<i>Loncosaurus argentinus</i>	150.000
	<i>Dracovenator regenti</i>	217.500	<i>Centrosaurus brinkmani</i>	151.076
	<i>Berberosaurus liassicus</i>	220.000	<i>Thecodontosaurus antiquus</i>	151.297
	<i>Magnosaurus nethercombensis</i>	220.000	<i>Cerasinops hodgskissi</i>	151.970
	<i>Timurlengia euotica</i>	220.000	<i>Montanoceratops cerorhynchus</i>	152.147
	<i>Xiongguanlong baimoensis</i>	223.410	<i>Anserimimus planinychus</i>	160.550
	<i>Anzu sp.</i>	246.013	<i>Sarhsaurus aurifontanalis</i>	163.726
	<i>Anzu wyliei</i>	246.013	<i>Dryosaurus altus</i>	163.868
	<i>Elaphrosaurus bambergi</i>	248.155	<i>Struthiosaurus transylvanicus</i>	164.118
	<i>Lourinhanosaurus antunesi</i>	249.344	<i>Archaeornithomimus asiaticus</i>	164.423
	<i>Sciurumimus albersdoerferi</i>	250.000	<i>Arkansaurus fridayi</i>	170.000
	<i>Siamosaurus fusuiensis</i>	250.000	<i>Hypsilophodontidae sp.</i>	170.390
	<i>Xuanhanosaurus qilixiaensis</i>	250.000	<i>Thescelosaurus sp.</i>	170.390
	<i>Siamosaurus suteethorni</i>	255.000	<i>Levnesovia transoxiana</i>	175.000
	<i>Coeluroides largus</i>	265.000	<i>Ornithomimus velox</i>	175.667
	<i>Camarillasaurus cirugedae</i>	270.000	<i>Protoceratops hellenikorhinus</i>	180.000
	<i>Utahraptor ostrommaysi</i>	277.693	<i>Sarcolestes leedsi</i>	187.500
	<i>Dakotaraptor steini</i>	285.000	<i>Gargantuavis philoinos</i>	188.847
	<i>Bayosaurus pubica</i>	295.000	<i>Erlansaurus bellamanus</i>	192.296
			<i>Dromiceiomimus brevitertius</i>	193.689
2			<i>Bolong yixianensis</i>	200.000
			<i>Efraasia minor</i>	201.122
			<i>Zalmoxes shqiperorum</i>	204.335
			<i>Leptoceratops gracilis</i>	212.982
			<i>Thescelosaurus neglectus</i>	214.914
			<i>Struthiomimus sp.</i>	215.036
			<i>Struthiomimus altus</i>	215.036
			<i>Ornithomimidae sp.2</i>	221.463
			<i>Ornithomimus sp.</i>	221.463
			<i>Ornithomimus antiquus</i>	221.463
			<i>Zalmoxes robustus</i>	229.265
			<i>Xixiposaurus suni</i>	231.599
			<i>Jaklapallisaurus asymmetrica</i>	237.000
			<i>Kangnasaurus coetzei</i>	242.119
			<i>Tethyshadros insularis</i>	258.003
			<i>Planicoxa venenica</i>	261.767
			<i>Camptosaurus prestwichii</i>	268.400
			<i>Scelidosaurus arizonensis</i>	270.000
			<i>Massospondylus hislopi</i>	280.000
			<i>Massospondylus kaalae</i>	280.000
			<i>Scelidosaurus harrisonii</i>	288.915
			<i>Amtosaurus magnus</i>	300.000
			<i>Ankylosauria sp.</i>	300.000

Table S1.8 (continued)

Log ₁₀ Bin	Carnivores / Meat Dominant		Herbivores / Plant Dominant	
	Omnivores	Mass(kg)	Omnivores	Mass(kg)
2			<i>Bissektipelta archibaldi</i>	300.000
			<i>Dracopelta zbyszewskii</i>	300.000
			"large elasmarian"	300.000
			<i>Meroktenos thabanensis</i>	300.000
			<i>Mymoorapelta maysi</i>	300.000
			<i>Orosaurus capensis</i>	310.000
			<i>Minmi paravertebrata</i>	311.766
			<i>Fendosaurus eldoni</i>	315.000
			<i>Ornithomimidae sp.1</i>	315.643
2.5	<i>Kaifangosaurus lini</i>	316.288	<i>Draconyx loureiroi</i>	322.018
	<i>Sinosaurus triassicus</i>	324.792	<i>Alxasaurus elesitaiensis</i>	327.554
	<i>Dilophosaurus wetherilli</i>	340.609	<i>Huayangosaurus taibii</i>	341.214
	<i>Unquillosaurus ceibalii</i>	342.000	<i>Pachycephalosaurus sp.</i>	342.021
	<i>Achillobator giganticus</i>	342.079	<i>Pachycephalosaurus wyomingensis</i>	342.021
	<i>Eustreptospondylus oxoniensis</i>	348.725	<i>Ornithomimus sedens</i>	350.000
	<i>Cryolophosaurus ellioti</i>	349.387	<i>Ammosaurus sp.</i>	355.178
	<i>Condorraptor curumili</i>	364.544	<i>Fostoria dhimbangunmal</i>	355.883
	<i>Fukuiraptor kitadaniensis</i>	372.394	<i>Gallimimus bullatus</i>	362.702
	<i>Austroraptor cabazai</i>	373.849	<i>Uteodon aphanocetes</i>	365.027
	<i>Duriavenator hesperis</i>	380.000	<i>Crichtonsaurus benxiensis</i>	373.004
	<i>Australovenator wintonensis</i>	381.840	<i>Nipponosaurus sachalinensis</i>	389.441
	<i>Spinostropheus gautieri</i>	400.000	<i>Animantarx ramaljonesi</i>	411.870
	<i>Streptospondylus altdorfensis</i>	410.000	<i>Blikanasaurus cromptoni</i>	420.000
	<i>Chienkosaurus ceratosauroides</i>	420.000	<i>Amurosaurus riabinini</i>	425.196
	<i>Dilophosaurus sinensis</i>	455.802	<i>Erlikosaurus andrewsi</i>	430.000
	<i>Quilmesaurus curiei</i>	460.000	<i>Massospondylus carinatus</i>	430.356
	<i>Ceratosauridae sp.</i>	481.333	<i>Valdoraptor oweni</i>	435.000
	<i>Indosaurus matleyi</i>	491.250	<i>Huayangosaurus taibaii</i>	440.514
	<i>Carcharodontosauridae sp.</i>	491.667	<i>Gryponyx africanus</i>	447.500
	<i>Cruxicheiros newmanorum</i>	505.000	<i>Xingxiulong chengi</i>	460.000
	<i>Piatnitzkysaurus floresi</i>	508.921	<i>Hippodraco scutodens</i>	471.176
	<i>Ilokelesia aguadagrandensis</i>	520.000	<i>Talenkauen santacrucensis</i>	471.176
	<i>Shaochilong maortuensis</i>	525.000	<i>Turanoceratops tardabilis</i>	483.759
	<i>Monolophosaurus jiangi</i>	549.754	<i>Beishanlong grandis</i>	491.308
	<i>Mifunesaurus sp.</i>	550.000	<i>Nanyangosaurus zhugeii</i>	497.040
	<i>Ceratosaurus magnicornis</i>	560.000	<i>Gargoylesaurus parkpinorum</i>	497.540
	<i>Rugops primus</i>	580.000	<i>Ankylosauria sp.1</i>	500.000
	<i>Ceratosaurus nasicornis</i>	580.377	<i>Ornithopoda sp.</i>	500.000
	<i>Leshansaurus qianweiensis</i>	580.532	<i>Palaeosaurus fraserianus</i>	500.000
	<i>Concavenator corcovatus</i>	582.418	<i>Scelidosaurus sp.</i>	500.000
	<i>Phaedrolosaurus ilikensis</i>	600.000	<i>Theiophytalia kerri</i>	500.000
	<i>Alectrosaurus sp.</i>	601.026	<i>Tsagantegia longicranialis</i>	500.000
	<i>Alectrosaurus olseni</i>	601.026	<i>Prosauropoda sp.</i>	554.992
	<i>Erectopus superbus</i>	614.055	<i>Sefapanosaurus zastronensis</i>	555.000
	<i>Juratyran langhami</i>	627.090	<i>Eucnemesaurus entaxonis</i>	560.000

Table S1.8 (continued)

Log ₁₀ Bin	Carnivores / Meat Dominant		Herbivores / Plant Dominant	
	Omnivores	Mass(kg)	Omnivores	Mass(kg)
2.5	<i>Xenotarsosaurus bonapartei</i>	638.837	<i>Avaceratops lammersi</i>	579.636
	<i>Aerosteon riocoloradensis</i>	672.430	<i>Coloradisaurus brevis</i>	590.000
	<i>Avetheropoda sp.</i>	672.430	<i>Yunnanosaurus huangi</i>	591.741
	<i>Megalosaurus pannoniensis</i>	675.000	<i>Pleurocoelus nanus</i>	592.309
	<i>Saltriosaurus sp.</i>	680.000	<i>Euhadrosauria sp.</i>	600.000
	<i>Qianzhousaurus sinensis</i>	699.172	<i>Telmatosaurus transsylvanicus</i>	600.000
	<i>Kileskus aristotocus</i>	700.000	<i>Lophorhynchon atopus</i>	622.293
	<i>Viavenator exxoni</i>	700.000	<i>Nothronychus mckinleyi</i>	636.204
	<i>Aucasaurus garridoi</i>	734.233	<i>Chuxiongosaurus lufengensis</i>	650.000
	<i>Nanuqsaurus hoglundi</i>	750.000	<i>Hungarosaurus tormai</i>	657.294
	<i>Alioramus altai</i>	757.000	<i>Nanshiungosaurus brevispinus</i>	665.000
	<i>Theropoda sp.1</i>	757.000	<i>Hoplitosaurus marshi</i>	688.739
	<i>Genyodectes serus</i>	790.000	<i>Probactrosaurus gobiensis</i>	694.469
	<i>Prodeinodon kwangshiensis</i>	790.000	<i>Iguanodon mantelli</i>	705.277
	<i>Poekilopleuron bucklandii</i>	800.000	<i>Tenontosaurus dossi</i>	707.109
	<i>Eoabelisaurus mefi</i>	822.610	<i>Udanoceratops tschizhovi</i>	736.087
	<i>Deltadromeus agilis</i>	855.967	<i>Glacialisaurus hammeri</i>	745.000
	<i>Chingkankousaurus fragilis</i>	890.000	<i>Chialingosaurus kuani</i>	800.406
	<i>Dryptosaurus macropus</i>	890.000	<i>Bonatitan reigi</i>	808.009
	<i>Afrovenator abakensis</i>	894.787	<i>Sanchusaurus sp.</i>	815.000
	<i>Ceratosaurus dentisulcatus</i>	917.368	<i>Rhabdodon priscus</i>	816.332
	<i>Arcovenator escotae</i>	950.000	<i>Tenontosaurus sp.</i>	818.362
	<i>Shidaisaurus jinae</i>	950.000	<i>Tenontosaurus tilletti</i>	818.362
	<i>Appalachiosaurus montgomeriensis</i>	994.492	<i>Ahshislepelta minor</i>	820.065
			<i>Pradhania gracilis</i>	830.000
			<i>Tianzhenosaurus youngi</i>	833.010
			<i>Crichtonsaurus bohlini</i>	836.715
			<i>Ingentia prima</i>	850.000
			<i>Magyarosaurus dacus</i>	897.626
			<i>Zhejiangosaurus lishuiensis</i>	904.925
			<i>Ankylopollexia sp.</i>	910.395
			<i>Camptosaurus sp.</i>	910.395
			<i>Camptosaurus dispar</i>	910.395
			<i>Gresslyosaurus ingens</i>	920.000
			<i>Europasaurus holgeri</i>	922.613
			<i>Niobrariasaurus coleii</i>	929.836
			<i>Martharaptor greenriverensis</i>	946.530
			<i>Mongolostegus exspectabilis</i>	950.000
			<i>Enigmosaurus mongoliensis</i>	960.167
			<i>Einosaurus procurvicornis</i>	974.703
			<i>Nothronychus graffami</i>	986.962
3	<i>Allosaurus europaeus</i>	1000.000	<i>Arkharavia heterocoelica</i>	1000.000
	<i>Austrocheirus isasii</i>	1000.000	<i>Choyrodon barsboldi</i>	1000.000
	<i>Szechuanosaurus campi</i>	1001.333	<i>Dakotadon lakotaensis</i>	1000.000

Table S1.8 (continued)

Log ₁₀ Bin	Carnivores / Meat Dominant		Herbivores / Plant Dominant	
	Omnivores	Mass(kg)	Omnivores	Mass(kg)
	<i>Abelisauridae sp.</i>	1002.500	<i>Eolambia caroljonesa</i>	1000.000
	<i>Altispinax dunkeri</i>	1070.905	<i>Ornithopsis greppini</i>	1000.000
	<i>Skorpiovenator bustingorryi</i>	1086.942	<i>Osmakasaurus depressus</i>	1000.000
	<i>Nototyrannus violantei</i>	1100.000	<i>Silvisaurus condrayi</i>	1000.000
	<i>Siamotyrannus isanensis</i>	1125.000	<i>Talarurus plicatospineus</i>	1020.246
	<i>Megaraptor namunhuaiquii</i>	1150.000	<i>Claosaurus agilis</i>	1090.589
	<i>Ostafrikasaurus crassiserratus</i>	1150.000	<i>Altirhinus kurzanovi</i>	1100.000
	<i>Tratayenia rosalesi</i>	1150.000	<i>Ohmdenosaurus liasicus</i>	1100.000
	<i>Ekrixinatosaurus novasi</i>	1152.675	<i>Pinacosaurus disparoserratus</i>	1100.806
	<i>Veterupristisaurus milneri</i>	1175.000	<i>Pinacosaurus grangeri</i>	1100.806
	<i>Metriacanthosaurus parkeri</i>	1184.892	<i>Pinacosaurus mephistocephalus</i>	1100.806
	<i>Majungasaurus crenatissimus</i>	1195.680	<i>Eucnemisaurus fortis</i>	1106.028
	<i>Chilantaisaurus zheziangensis</i>	1200.000	<i>Gilmoresaurus mongoliensis</i>	1136.287
	<i>Suchosaurus cultridens</i>	1218.333	<i>Arenysaurus ardevoli</i>	1139.207
	<i>Dryptosaurus aquilunguis</i>	1225.067	<i>Polacanthus foxii</i>	1148.738
	<i>Prodeinodon mongoliense</i>	1282.500	<i>Kentrosaurus aethiopicus</i>	1149.464
	<i>Yutyrannus huali</i>	1300.000	<i>Stegosauria sp.</i>	1149.464
	<i>Megalosaurus insignis</i>	1383.333	<i>Lamplughsaura dharmarensis</i>	1154.337
	<i>Antrodemus valens</i>	1400.000	<i>Jinzhouosaurus yangi</i>	1163.918
	<i>Chilantaisaurus sibiricus</i>	1400.000	<i>Ruehleia bedheimensis</i>	1172.114
	<i>Orkoraptor burkei</i>	1400.000	<i>Astrodon valdensis</i>	1194.873
	<i>Neovenator salerii</i>	1405.533	<i>Sanpasaurus yaoi</i>	1200.000
3	<i>Lythronax argestes</i>	1466.667	<i>Tiantaosaurus sifengensis</i>	1200.000
	<i>Megalosaurus bucklandii</i>	1497.270	<i>Plateosaurus longiceps</i>	1243.333
	<i>Dryptosauroides grandis</i>	1500.000	<i>Mantellisaurus atherfieldensis</i>	1247.345
	<i>Indosuchus raptorius</i>	1500.000	<i>Pararhabdodon isonensis</i>	1250.000
	<i>Teratophoneus curriei</i>	1532.177	<i>Wendiceratops pinhornensis</i>	1250.000
	<i>Tyrannosauridae sp.2</i>	1532.177	<i>Gastonia burgei</i>	1269.754
	<i>Kelmayisaurus petrolicus</i>	1550.000	<i>Yingshanosaurus jichuanensis</i>	1277.148
	<i>Baryonyx walkeri</i>	1600.000	<i>Arrhinoceratops brachyops</i>	1300.000
	<i>Embasaurus minax</i>	1700.000	<i>Brachyceratops sp.</i>	1300.000
	<i>Allosaurus sp.</i>	1742.726	<i>Brachyceratops montanensis</i>	1300.000
	<i>Camosauria sp.</i>	1742.726	<i>Ceratopsidae sp.</i>	1300.000
	<i>Theropoda sp.</i>	1742.726	<i>Diabloceratops eatoni</i>	1300.000
	<i>Yangchuanosaurus zigongensis</i>	1745.000	<i>Isanosaurus attavipachi</i>	1300.000
	<i>Sinraptor dongi</i>	1748.619	<i>Melanorosaurus sp.</i>	1300.000
	<i>Sinotyrannus kazouensis</i>	1850.000	<i>Paludititan nalatzensis</i>	1300.000
	<i>Kryptops palaios</i>	1900.000	<i>Saichania chulsanensis</i>	1305.986
	<i>Allosaurus fragilis</i>	1913.752	<i>Dyoplosaurus acutosquameus</i>	1312.354
	<i>Allosaurus jimmadseni</i>	1913.752	<i>Melanorosaurus readi</i>	1324.002
	<i>Camotaurinae sp.</i>	1925.000	<i>Plateosaurus cullingworthi</i>	1347.136
	<i>Camotaurus sastrei</i>	1964.887	<i>Mussaurus patagonicus</i>	1350.000
	<i>Megalosauroides sp.</i>	1966.667	<i>Chondrosteosaurus gigas</i>	1400.000
	<i>Datanglong guangxiensis</i>	2100.000	<i>Nodosauridae sp.2</i>	1436.424
	<i>Allosaurus tendagurensis</i>	2143.402	<i>Nodosauridae sp.5</i>	1436.424

Table S1.8 (continued)

Log ₁₀ Bin	Carnivores / Meat Dominant		Herbivores / Plant Dominant	
	Omnivores	Mass(kg)	Omnivores	Mass(kg)
3	<i>Dandakosaurus indicus</i>	2300.000	<i>Panoplosaurus mirus</i>	1436.424
	<i>Abelisaurus comahuensis</i>	2325.000	<i>Gigantspinosauros sichuanensis</i>	1460.431
	<i>Albertosaurus sarcophagus</i>	2345.182	<i>Bactrosaurus sp.</i>	1472.773
	<i>Ichthyovenator laosensis</i>	2400.000	<i>Probactrosaurus mazongshanensis</i>	1488.336
	<i>Daspletosaurus homeri</i>	2500.000	<i>Akainacephalus johnsoni</i>	1500.000
	<i>Rahiolisaurus gujaratensis</i>	2519.649	<i>Ankylosauridae sp.2</i>	1500.000
	<i>Gorgosaurus sp.</i>	2554.782	<i>Brohisaurus kirthari</i>	1500.000
	<i>Gorgosaurus libratus</i>	2554.782	<i>Campylodoniscus ameghinoi</i>	1500.000
	<i>Tyrannosauridae sp.1</i>	2554.782	<i>Nasutoceratops titusi</i>	1500.000
	<i>Daspletosaurus sp.</i>	2565.553	<i>Nodocephalosaurus kirtlandensis</i>	1500.000
	<i>Labocania anomala</i>	2600.000	<i>Regaliceratops peterhewsi</i>	1500.000
	<i>Daspletosaurus torosus</i>	2631.106	<i>Sousatitan sp.</i>	1500.000
	<i>Torvosaurus tanneri</i>	2844.424	<i>Yizhouosaurus sunae</i>	1500.000
	<i>Bistahieversor sealeyi</i>	2900.000	<i>Bactrosaurus johnsoni</i>	1501.805
	<i>Yangchuanosaurus shangyouensis</i>	2950.000	<i>Stellasaurus ancellae</i>	1521.933
	<i>Carcharodontosauridae sp.1</i>	2981.552	<i>Sellosaurus gracilis</i>	1530.443
	<i>Yangchuanosaurus hepingensis</i>	3000.000	<i>Prosaurolophus blackfeetensis</i>	1532.758
	<i>Tarbosaurus bataar</i>	3103.146	<i>Nodosaurus textilis</i>	1543.311
	<i>Tyrannosauridae sp.</i>	3103.148	<i>Ouranosaurus nigeriensis</i>	1590.264
			<i>Ankylosauridae sp.1</i>	1617.899
			<i>Euoplocephalus tutus</i>	1617.899
			<i>Paleoscincus sp.</i>	1617.899
			<i>Leinkupal laticauda</i>	1650.000
			<i>Omosaurus lennieri</i>	1672.636
			<i>Hylaeosaurus armatus</i>	1676.957
			<i>Nebulasaurus taito</i>	1700.000
			<i>Achelousaurus homeri</i>	1709.393
			<i>Gobihadros mongoliensis</i>	1712.598
			<i>Riojasaurus incertus</i>	1713.256
			<i>Sauropelta edwardsi</i>	1730.632
			<i>Oohkotokia homeri</i>	1750.000
			<i>Nodosauridae sp.</i>	1788.277
			<i>Zizhongosaurus chuanchengensis</i>	1800.000
			<i>Nodosauridae sp.4</i>	1817.855
			<i>Kosmocerotops richardsoni</i>	1850.000
			<i>Zhuchengtitan zangjiazhuangensis</i>	1850.000
			<i>Yimenosaurus youngi</i>	1852.053
			<i>Lufengosaurus huenei</i>	1884.985
			<i>Spinops sternbergorum</i>	1896.318
			<i>Kaatedocus siberi</i>	1900.000
			<i>Pachyrhinosaurus lakustai</i>	1903.981
			<i>Jaxartosaurus aralensis</i>	1907.761
			<i>Euskelosaurus browni</i>	1948.480
			<i>Karongasaurus gittelmani</i>	1950.000
			<i>Nigersaurus taqueti</i>	1950.000

Table S1.8 (continued)

Log ₁₀ Bin	Carnivores / Meat Dominant	Herbivores / Plant Dominant	
	Omnivores	Mass(kg)	Mass(kg)
3		<i>Aletopelta coombsi</i>	1955.471
		<i>Plateosaurus engelhardti</i>	1968.405
		<i>Edmontonia longiceps</i>	1985.430
		<i>Atsinganosaurus velauciensis</i>	2000.000
		<i>Coronosaurus brinkmani</i>	2000.000
		<i>Judiceratops tigris</i>	2000.000
		<i>Nicksaurus razashahi</i>	2000.000
		<i>Peloroplites cedrimontanus</i>	2000.000
		<i>Sarmientosaurus musacchioi</i>	2000.000
		<i>Sauropelta edwardsorum</i>	2000.000
		<i>Shamosaurus scutatus</i>	2000.000
		<i>Tarchia gigantea</i>	2000.000
		<i>Xenoceratops foremostensis</i>	2000.000
		<i>Agujaceratops mariscalensis</i>	2061.417
		<i>Mercuriceratops gemini</i>	2070.972
		<i>Hadrosauridae sp.</i>	2071.494
		<i>Lapampasaurus cholinoi</i>	2071.494
		<i>Willinakaqe salitralensis</i>	2071.494
		<i>Pachysuchus imperfectus</i>	2100.000
		<i>Edmontonia sp.</i>	2125.341
		<i>Nodosauridae sp.3</i>	2125.341
		<i>Lexovisaurus durobrivensis</i>	2155.233
		<i>Omosaurus durobrivensis</i>	2155.233
		<i>Anodontosaurus lambei</i>	2164.816
		<i>Ziapelta sanjuanensis</i>	2164.816
		<i>Medusaceratops lokii</i>	2200.000
		<i>Centrosaurus apertus</i>	2214.703
		<i>Gigantoraptor erlianensis</i>	2216.107
		<i>Anchiceratops ornatus</i>	2229.013
		<i>Chasmosaurinae sp.</i>	2244.365
		<i>Chasmosaurus belli</i>	2244.365
		<i>Chasmosaurus sp.</i>	2251.247
		<i>Loricatosaurus priscus</i>	2257.871
		<i>Lessemsaurus sauropoides</i>	2257.905
		<i>Chasmosaurus russelli</i>	2258.128
		<i>Pachyrhinosaurus perotorum</i>	2260.778
		<i>Edmontonia rugosidens</i>	2265.253
		<i>Lufengosaurus magnus</i>	2279.506
		<i>Rubeosaurus ovatus</i>	2289.302
		<i>Ankylosauridae sp.</i>	2297.224
		<i>Lavocatisaurus agrioensis</i>	2300.000
		<i>Anodontosaurus inceptus</i>	2329.632
		<i>Platypelta coombsi</i>	2329.632
		<i>Scolosaurus cutleri</i>	2329.632
		<i>Scolosaurus thronus</i>	2329.632

Table S1.8 (continued)

Log ₁₀ Bin	Carnivores / Meat Dominant		Herbivores / Plant Dominant	
	Omnivores	Mass(kg)	Omnivores	Mass(kg)
3			<i>Styracosaurus albertensis</i>	2394.461
			<i>Monoclonius crassus</i>	2396.318
			<i>Amazonsaurus maranhensis</i>	2500.000
			<i>Anasazisaurus homeri</i>	2500.000
			<i>Iuticosaurus valdensis</i>	2500.000
			<i>Jiangjunosaurus junggarensis</i>	2500.000
			<i>Shunosaurus ziliujingensis</i>	2500.000
			<i>Zaraapelta nomadis</i>	2500.000
			<i>Zuul crurivastator</i>	2500.000
			<i>Tatankacephalus cooneyorum</i>	2505.082
			<i>Suzhousaurus megatheroides</i>	2532.784
			<i>Tanais sinensis</i>	2533.388
			<i>Yunnanosaurus youngi</i>	2600.000
			<i>Aardonyx celestae</i>	2604.760
			<i>Segnosaurus galbinensis</i>	2633.200
			<i>Uberabatitan riberoi</i>	2650.000
			<i>Bellusaurus sui</i>	2689.406
			<i>Stegosaurus armatus</i>	2701.647
			<i>Chinshakiangosaurus chunghoensis</i>	2750.000
			<i>Utahceratops gettyi</i>	2750.000
			<i>Hypselospinus fittoni</i>	2773.986
			<i>Tapuiasaurus macedoi</i>	2800.000
			<i>Lambeosaurus magnicristatus</i>	2803.569
			<i>Astrophocaudia slaughteri</i>	2850.000
			<i>Hadrosaurinae sp.</i>	2873.436
			<i>Maiasaura peeblesorum</i>	2873.436
			<i>Lirainosaurus astibiae</i>	2876.473
			<i>Hadrosaurus foulkii</i>	2897.941
			<i>Corythosaurus intermedius</i>	2977.832
			<i>Acristavus gagslarsoni</i>	3000.000
			<i>Gryposaurus monumentensis</i>	3000.000
			<i>Gondwanatitan faustoi</i>	3052.312
			<i>Hadrosauridae sp.2</i>	3062.165
			<i>Chungkingosaurus jiangbeiensis</i>	3065.789
			<i>Lambeosaurus sp.</i>	3117.374
			<i>Pachyrhinosaurus canadensis</i>	3139.130
			<i>Jingshanosaurus xinwaensis</i>	3158.544
3.5	<i>Bahariasaurus ingens</i>	3193.750	<i>Parasaurolophus tubicen</i>	3183.813
	<i>Suchomimus tenerensis</i>	3287.648	<i>Lohuecotitan pandafilandi</i>	3200.000
	<i>Megalosaurus chubutensis</i>	3400.000	<i>Pulanesaura eocollum</i>	3200.000
	<i>Torvosaurus sp.</i>	3483.326	<i>Neuquensaurus robustus</i>	3204.915
	<i>Rajasaurus narmadensis</i>	3500.000	<i>Hypacrosaurus altispinus</i>	3206.217
	<i>Pycnonemosaurus nevesi</i>	3600.000	<i>Tsintaosaurus spinorhinus</i>	3228.915
	<i>Teinurosaurus sauvagei</i>	3600.000	<i>Lambeosaurus lambei</i>	3248.555
	<i>Saurophaganax maximus</i>	3758.721	<i>Demandasaurus darwini</i>	3256.091

Table S1.8 (continued)

Log ₁₀ Bin	Carnivores / Meat Dominant		Herbivores / Plant Dominant	
	Omnivores	Mass(kg)	Omnivores	Mass(kg)
3.5	<i>Sauroniops pachytholus</i>	3800.000	<i>Hadrosauridae sp.5</i>	3274.599
	<i>Capitalsaurus potens</i>	3900.000	<i>Tonganosaurus hei</i>	3286.856
	<i>Siats meekerorum</i>	3950.000	<i>Parasaurolophus cyrtocristatus</i>	3292.803
	<i>Torvosaurus gumeyi</i>	4000.000	<i>Hypacrosaurus stebingeri</i>	3293.245
	<i>Zhuchengtyrannus magnus</i>	4000.000	<i>Amygdalodon patagonicus</i>	3300.000
	<i>Chilantaisaurus tashuikouensis</i>	4013.267	<i>Histriasaurus boscarollii</i>	3300.000
	<i>Acrocanthosaurus atokensis</i>	4558.800	<i>Lambeosaurus clavinitialis</i>	3300.000
	<i>Carcharodontosaurus iguidensis</i>	4600.000	<i>Sonidosaurus saihangaobiensis</i>	3300.000
	<i>Sigilmassasaurus brevicollis</i>	4700.000	<i>Tienhanosaurus chitaiensis</i>	3300.000
	<i>Oxalaia quilombensis</i>	5000.000	<i>Adelolophus hutchisoni</i>	3342.087
	<i>Carcharodontosaurus saharicus</i>	5247.366	<i>Stegosaurus stenops</i>	3353.660
	<i>Megalosaurus ingens</i>	5700.000	<i>Lambeosaurinae sp.1</i>	3363.898
	<i>Tyrannotitan chubutensis</i>	5761.379	<i>Rocasaurus muniozi</i>	3364.518
	<i>Spinosaurus aegyptiacus</i>	5983.333	<i>Gryposaurus latidens</i>	3365.190
	<i>Mapusaurus roseae</i>	6160.274	<i>Thyreophora sp.</i>	3374.023
	<i>Tyrannosaurus rex</i>	6428.604	<i>Ledumahadi mafube</i>	3400.000
	<i>Giganotosaurus carolinii</i>	7095.831	<i>Corythosaurus casuarius</i>	3426.501
			<i>Rinconsaurus caudamirus</i>	3426.560
			<i>Gryposaurus sp.</i>	3428.063
			<i>Hadrosauridae sp.4</i>	3428.063
			<i>Antetonitrus ingenipes</i>	3444.872
			<i>Angulomastacator daviesi</i>	3455.663
			<i>Aepisaurus elephantinus</i>	3500.000
			<i>Albertaceratops nesmoi</i>	3500.000
			<i>Baurutitan britoi</i>	3500.000
			<i>Centrosaurinae sp.</i>	3500.000
			<i>Gobisaurus domoculus</i>	3500.000
			<i>Hesperosaurus mjosi</i>	3500.000
			<i>Machairoceratops cronusi</i>	3500.000
			<i>Spiclypeus shipporum</i>	3500.000
			<i>Daanosaurus zhangji</i>	3517.054
			<i>Tuojiangosaurus multispinus</i>	3532.595
			<i>Parasaurolophus walkeri</i>	3549.646
			<i>Barilium dawsoni</i>	3589.012
			<i>Lambeosaurinae sp.</i>	3594.614
			<i>Thotobolosaurus mabeatae</i>	3600.000
			<i>Gryposaurus notabilis</i>	3659.581
			<i>Kazaklambia convincens</i>	3689.151
			<i>Saltasauridae sp.</i>	3741.300
			<i>Saltasaurinae sp.</i>	3741.300
			<i>Iguanodon bernissartensis</i>	3761.238
			<i>Zigongosaurus fuxiensis</i>	3800.000
			<i>Neuquensaurus australis</i>	3802.349
			<i>Lurdusaurus arenatus</i>	3833.292
			<i>Ankylosaurus sp.</i>	3872.272

Table S1.8 (continued)

Log ₁₀ Bin	Carnivores / Meat Dominant		Herbivores / Plant Dominant	
	Omnivores	Mass(kg)	Omnivores	Mass(kg)
3.5			<i>Ankylosaurus magniventris</i>	3872.272
			<i>Kunmingosaurus sp.</i>	3873.825
			<i>Chiayusaurus lacustris</i>	3900.000
			<i>Laplatasaurus madagascariensis</i>	3900.000
			<i>Shingopana songwensis</i>	3900.000
			<i>Tengrisaurus starkovi</i>	3900.000
			<i>Nanningosaurus dashiensis</i>	3914.659
			<i>Australodocus bohetti</i>	4000.000
			<i>Hadrosauridae sp.1</i>	4000.000
			<i>Hadrosauridae sp.3</i>	4000.000
			<i>Kritosaurus sp.</i>	4000.000
			<i>Kritosaurus navajovius</i>	4000.000
			<i>Naashoibitosaurus ostromi</i>	4000.000
			<i>Soriatitan golmayensis</i>	4000.000
			<i>Yibinosaurus zhoui</i>	4000.000
			<i>Haestasaurus becklesii</i>	4047.026
			<i>Saltasaurus loricatus</i>	4072.108
			<i>Zapalasaurus bonapartei</i>	4095.950
			<i>Olorotitan arharensis</i>	4132.471
			<i>Vagaceratops irvinensis</i>	4167.906
			<i>Pilmatueia faundezi</i>	4200.000
			<i>Camelotia borealis</i>	4214.112
			<i>Iguanodontia sp.1</i>	4225.792
			<i>Muttaborrasaurus langdoni</i>	4225.792
			<i>Mierasaurus bobyouni</i>	4300.169
			<i>Normanniasaurus genceyi</i>	4400.000
			<i>Saraikimasoom vitakri</i>	4400.000
			<i>Atacamatitan chilensis</i>	4491.649
			<i>Ischyrosaurus manseli</i>	4500.000
			<i>Liaoningotitan sinensis</i>	4500.000
			<i>Abrosaurus dongpoi</i>	4550.000
			<i>Rapetosaurus krausei</i>	4581.365
			<i>Rapetosaurus madagascariensis</i>	4581.365
			<i>Edmontosaurus annectens</i>	4595.999
			<i>Acanthopholis horrida</i>	4600.000
			<i>Saurolophus osborni</i>	4604.236
			<i>Katapultosaurus goicoecheai</i>	4700.000
			<i>Miragaia longicollum</i>	4729.744
			<i>Therizinosauroida sp.</i>	4750.000
			<i>Therizinosaurus cheloniformis</i>	4750.000
			<i>Volkheimeria chubutensis</i>	4797.765
			<i>Huangshanlong anhuiensis</i>	4900.000
			<i>Barsboldia sicinskii</i>	5000.000
			<i>Cedarpelta bilbeyhallorum</i>	5000.000
			<i>Dinheirosaurus lourinhanensis</i>	5000.000

Table S1.8 (continued)

Log ₁₀ Bin	Carnivores / Meat Dominant	Herbivores / Plant Dominant	
	Omnivores	Mass(kg)	Mass(kg)
3.5		<i>Dyslocosaurus polyonychius</i>	5000.000
		<i>Titanosaurus raholiensis</i>	5000.000
		<i>Galeamopus pabsti</i>	5100.000
		<i>Omeisaurus junghsiensis</i>	5100.288
		<i>Moshisaurus sp.</i>	5200.000
		<i>Qijianglong guokr</i>	5200.000
		<i>Bonitasaura salgadoi</i>	5250.000
		<i>Lithostrotia sp.</i>	5250.000
		<i>Overosaurus paradasorum</i>	5250.000
		<i>Edmontosaurus regalis</i>	5260.076
		<i>Mandschurosaurus amurensis</i>	5330.144
		<i>Natronasaurus longispinus</i>	5332.431
		<i>Hypselosaurus priscus</i>	5357.333
		<i>Kotasaurus yamanpalliensis</i>	5366.125
		<i>Stegosaurus unguatus</i>	5376.958
		<i>Euhelopus zdanskyi</i>	5402.830
		<i>Deinocheirus mirificus</i>	5442.743
		<i>Pentaceratops sternbergii</i>	5471.060
		<i>Borealosaurus wimani</i>	5500.000
		<i>Brasilotitan nemophagus</i>	5500.000
		<i>Muyelensaurus pecheni</i>	5500.000
		<i>Pitekunsaurus macayai</i>	5500.000
		<i>Titanoceratops ouranos</i>	5500.000
		<i>Eomamenchisaurus yuanmouensis</i>	5619.281
		<i>Qinlingosaurus luonanensis</i>	5700.000
		<i>Brachylophosaurus sp.</i>	5729.180
		<i>Brachylophosaurus canadensis</i>	5729.180
		<i>Shunosaurus lii</i>	5776.958
		<i>Balochisaurus malkani</i>	5900.000
		<i>Jiutaisaurus xidiensis</i>	5900.000
		<i>Aeolosaurus sp.</i>	6000.000
		<i>Baalsaurus mansillai</i>	6000.000
		<i>Pakisaurus balochistani</i>	6000.000
		<i>Titanosauriformes sp.</i>	6000.000
		<i>Xinghesaurus sp.</i>	6000.000
		<i>Dacentrurus armatus</i>	6121.788
		<i>Omeisaurus maoi</i>	6232.125
		<i>Saurolophus angustirostris</i>	6266.345
		<i>Anhuilong diboensis</i>	6300.000
		<i>Dongyangosaurus sinensis</i>	6300.000
		<i>Hypselosaurus sp.</i>	6300.000
		<i>Protognathosaurus oxyodon</i>	6300.000
		<i>Rugocaudia cooneyi</i>	6300.000
		<i>Gongxianosaurus shibeiensis</i>	6371.723
		<i>Tataouinea hannibalis</i>	6400.000

Table S1.8 (continued)

Log ₁₀ Bin	Carnivores / Meat Dominant	Herbivores / Plant Dominant	
	Omnivores	Mass(kg)	Mass(kg)
3.5		<i>Dongbeititan dongi</i>	6450.000
		<i>Laplatasaurus sp.</i>	6488.299
		<i>Cetiosauriscus leedsii</i>	6500.000
		<i>Khetranisaurus barkhani</i>	6500.000
		<i>Trigonosaurus pricei</i>	6500.000
		<i>Otogosaurus sarulai</i>	6700.000
		<i>Mamenchisaurus youngi</i>	6746.814
		<i>Malawisaurus dixeyi</i>	6822.435
		<i>Fukuititan nipponensis</i>	6863.042
		<i>Dystrophaeus viaemalae</i>	6869.800
		<i>Brontomerus mcintoshii</i>	6900.000
		<i>Mongolosaurus haplodon</i>	6900.000
		<i>Omeisaurus changshouensis</i>	6900.000
		<i>Mamenchisaurus fuxiensis</i>	6967.050
		<i>non-lithostrotian titanosaur sp.</i>	7000.000
		<i>Quetecsaurus rusconii</i>	7000.000
		<i>Amargasaurus cazaui</i>	7034.243
		<i>Ferganasaurus verzilini</i>	7052.482
		<i>Maxakalisaurus topai</i>	7097.311
		<i>Rayososaurus agrioensis</i>	7126.534
		<i>Dicraeosaurus sattleri</i>	7154.417
		<i>Datousaurus bashanensis</i>	7196.814
		<i>Amargatitanis macni</i>	7252.918
		<i>Dicraeosaurus hansemani</i>	7268.766
		<i>Xenoposeidon proneneukos</i>	7300.000
		<i>Suuwassea emilieae</i>	7334.927
		<i>Ampelosaurus atacis</i>	7352.433
		<i>Omeisaurus fuxiensis</i>	7400.000
		<i>Oplosaurus armatus</i>	7450.000
		<i>Archaeodontosaurus descouensi</i>	7500.000
		<i>Jiangshanosaurus lixianensis</i>	7500.000
		<i>Yongjinglong datangi</i>	7500.000
		<i>Dashanpusaurus dongi</i>	7511.192
		<i>Probrachylophosaurus bergei</i>	7586.500
		<i>Torosaurus sp.</i>	7598.517
		<i>Vulcanodon karibaensis</i>	7616.727
		<i>Rukwatitan biseptus</i>	7900.000
		<i>Lingwulong shenqi</i>	8000.000
		<i>Omeisaurus luquanensis</i>	8000.000
		<i>Omeisaurus puxiani</i>	8000.000
		<i>Venenosaurus dicrocei</i>	8000.000
		<i>Tambatitanis amicitiae</i>	8100.000
		<i>Epachthosaurus sciuttoi</i>	8173.881
		<i>Iguanacolossus fortis</i>	8268.264
		<i>Triceratops horridus</i>	8318.221

Table S1.8 (continued)

Log ₁₀ Bin	Carnivores / Meat Dominant		Herbivores / Plant Dominant	
	Omnivores	Mass(kg)	Omnivores	Mass(kg)
3.5			<i>Laplatasaurus araukanicus</i>	8395.233
			<i>Damalasaurus laticostalis</i>	8500.000
			<i>Magnapaulia laticaudus</i>	8590.844
			<i>Eucamerotus foxi</i>	8600.000
			<i>Pukyongosaurus milleniumi</i>	8600.000
			<i>Titanosaurus blanfordi</i>	8650.000
			<i>Vahiny depereti</i>	8672.855
			<i>Tazoudasaurus naimi</i>	8723.913
			<i>Savannasaurus elliotorum</i>	8800.000
			<i>Supersaurus lourinhanensis</i>	8800.000
			<i>Triceratops prorsus</i>	8902.168
			<i>Aegyptosaurus baharijensis</i>	8910.562
			<i>Narambuenatitan palomoi</i>	8919.105
			<i>Cetiosaurus brevis</i>	9000.000
			<i>Qingxiusaurus youjiangensis</i>	9048.166
			<i>Comahuesaurus windhauseni</i>	9065.746
			<i>Angolatitan adamastor</i>	9166.986
			<i>Vouivria damparisensis</i>	9200.000
			<i>Barapasaurus tagorei</i>	9286.718
			<i>Lapparentosaurus madagascariensis</i>	9306.661
			<i>Spinophorosaurus nigerensis</i>	9384.739
4			<i>Gigantosaurus megalonyx</i>	9500.000
			<i>Brachytrachelopan mesai</i>	9582.086
			<i>Torosaurus latus</i>	9658.961
			<i>Haplocanthosaurus priscus</i>	9781.545
			<i>Agustinia ligabuei</i>	9800.000
			<i>Austroposeidon magnificus</i>	10000.000
			<i>Eotriceratops xerinsularis</i>	10000.000
			<i>Galeamopus hayi</i>	10000.000
			<i>Tendaguria tanzaniensis</i>	10000.000
			<i>Omeisaurus jiao</i>	10090.807
			<i>Yuanmousaurus jiangyiensis</i>	10127.566
			<i>Limaysaurus tessonei</i>	10261.174
			<i>Dinodocus mackensoni</i>	10300.000
			<i>Titanosaurus indicus</i>	10362.151
			<i>Cetiosaurus mogrebiensis</i>	10700.000
			<i>Tastavinsaurus sanzi</i>	10748.307
			<i>Astrodon sp.</i>	10800.000
			<i>Wintonotitan wattsi</i>	10838.664
			<i>Klamelisaurus gobiensis</i>	10863.428
			<i>Diplodocus carnegii</i>	10877.238
			<i>Morinosaurus typus</i>	11000.000
			<i>Marisaurus jeffi</i>	11200.000
			<i>Erketu ellisoni</i>	11225.595

Table S1.8 (continued)

Log ₁₀ Bin	Carnivores / Meat Dominant		Herbivores / Plant Dominant	
	Omnivores	Mass(kg)	Omnivores	Mass(kg)
4			<i>Sauropoda sp.</i>	11225.595
			<i>Mamenchisaurus constructus</i>	11334.885
			<i>Cathartesaura anaerobica</i>	11379.410
			<i>Cardiodon rugolus</i>	11400.000
			<i>Aragosaurus ischiaticus</i>	11586.080
			<i>Panamericansaurus schroederi</i>	11629.229
			<i>Xianshanosaurus shijiangouensis</i>	11632.086
			<i>Phuwiangosaurus sirindhornae</i>	11744.952
			<i>Moabosaurus utahensis</i>	11937.282
			<i>Omeisaurus tianfuensis</i>	11952.594
			<i>Cedarosaurus weiskopfae</i>	11965.238
			<i>Tomiera africana</i>	12025.711
			<i>Cetiosauriscus stewarti</i>	12160.946
			<i>Quaesitosaurus sp.</i>	12172.697
			<i>Cetiosaurus sp.</i>	12232.489
			<i>Padillasaurus leivaensis</i>	12300.000
			<i>Janenschia robusta</i>	12332.736
			<i>Wamweracaudia keranji</i>	12332.736
			<i>Camarasaurus lewisi</i>	12499.939
			<i>Huanghetitan liujiaxiaensis</i>	12500.000
			<i>Drusilasaura deseadeensis</i>	13000.000
			<i>Qiaowanlong kangxii</i>	13000.000
			<i>Austrosaurus mckillopi</i>	13200.000
			<i>Camarasaurus lentus</i>	13254.405
			<i>Aeolosaurus colhuehuapensis</i>	13300.000
			<i>Opisthocoelicaudia skarzynskii</i>	13350.531
			<i>Barrosasaurus casamiquelai</i>	13500.000
			<i>Chuanjiesaurus anaensis</i>	13500.021
			<i>Aeolosaurus rionegrinus</i>	13636.407
			<i>Shantungosaurus giganteus</i>	13869.000
			<i>Galvesaurus herreroi</i>	13900.000
			<i>Brontosaurus parvus</i>	14000.000
			<i>Nemegtosauridae sp.</i>	14139.364
			<i>Nemegtosaurus sp.</i>	14139.364
			<i>Haplocanthosaurus sp.</i>	14217.567
			<i>Camarasaurus grandis</i>	14224.855
			<i>Duriatitan humerocristatus</i>	14360.906
			<i>Adamantisaurus mezzalirai</i>	14400.000
			<i>Mamenchisaurus hochuanensis</i>	14411.761
			<i>Andesaurus delgadoi</i>	14430.767
			<i>Petrobrasaurus puestohernandezii</i>	14457.244
			<i>Aeolosaurus maximus</i>	14740.399
			<i>Isisaurus colberti</i>	15000.000
			<i>Volgatitan simbirskiensis</i>	15000.000
			<i>Bothriospondylus madagascariensis</i>	15153.115

Table S1.8 (continued)

Log ₁₀ Bin	Carnivores / Meat Dominant		Herbivores / Plant Dominant	
	Omnivores	Mass(kg)	Omnivores	Mass(kg)
4			<i>Gobititan shenzhouensis</i>	15237.944
			<i>Cetiosaurus oxoniensis</i>	15551.982
			<i>Jainosaurus septentrionalis</i>	15555.349
			<i>Ornithopsis hulkei</i>	15854.831
			<i>Macrurosaurus semnus</i>	16000.000
			<i>Malarguesaurus florenciae</i>	16000.000
			<i>Diplodocus hayi</i>	16333.063
			<i>Atlasaurus imelakei</i>	16455.484
			<i>Maojandino afami</i>	16500.000
			<i>Diamantinasaurus matildae</i>	16538.392
			<i>Angloposeidon sp.</i>	17000.000
			<i>Morosaurus agilis</i>	17000.000
			<i>Triunfosaurus leonardii</i>	17000.000
			<i>Diplodocus longus</i>	17338.437
			<i>Patagosaurus fariasi</i>	17598.530
			<i>Antarctosaurus brasiliensis</i>	17715.547
			<i>Rhoetosaurus brownei</i>	17748.561
			<i>Choconsaurus baileywillisi</i>	18000.000
			<i>Lourinhasaurus alenquerensis</i>	18201.685
			<i>Baotianmansaurus henanensis</i>	18500.000
			<i>Nurosaurus qaganensis</i>	18500.000
			<i>Huabeisaurus allocotus</i>	18528.983
			<i>Brachiosaurus nougaredi</i>	18650.000
			<i>Ornithopsis leedsii</i>	20000.000
			<i>Ligabuesaurus leanzai</i>	20434.810
			<i>Rebbachisaurus garasbae</i>	20518.715
			<i>Sibirotititan astrosacralis</i>	20750.000
			<i>Antarctosaurus wichmannianus</i>	20817.151
			<i>Tangvayosaurus hoffeti</i>	20938.944
			<i>Mamenchisaurus anyuensis</i>	21000.000
			<i>Barosaurus sp.</i>	21136.821
			<i>Barosaurus lentus</i>	21136.821
			<i>Chubutisaurus insignis</i>	21157.381
			<i>Brontosaurus excelsus</i>	21180.642
			<i>Jobaria tiguidensis</i>	21216.121
			<i>Europatitan eastwoodi</i>	22000.000
			<i>Titanosaurus falloti</i>	22000.000
			<i>Haplocanthosaurus delfsi</i>	22028.589
			<i>Brontosaurus yahnahpin</i>	22270.963
			<i>Titanosauria sp.</i>	22385.941
			<i>Sonorosaurus thompsoni</i>	22455.917
			<i>Shantungosaurus sp.</i>	22467.100
			<i>Camarasaurus supremus</i>	22974.699
			<i>Astrodon johnstoni</i>	23000.000
			<i>Daxiatitan binglingi</i>	23000.000

Table S1.8 (continued)

Log ₁₀ Bin	Carnivores / Meat Dominant		Herbivores / Plant Dominant	
	Omnivores	Mass(kg)	Omnivores	Mass(kg)
4			<i>Bananabendersaurus sp.</i>	24000.000
			<i>Tehuelchesaurus benitezii</i>	24305.257
			<i>Gannansaurus sinensis</i>	25000.000
			<i>Mamenchisaurus anyueensis</i>	25000.000
			<i>Ultrasaurus tabriensis</i>	25000.000
			<i>Xinjiangtitan shanshanensis</i>	25000.000
			<i>Apatosaurus louisae</i>	25385.810
			<i>Nemegtosaurus mongoliensis</i>	25418.092
			<i>Quaesitosaurus orientalis</i>	25418.092
			<i>Abydosaurus mcintoshi</i>	26000.000
			<i>Liubangosaurus hei</i>	26000.000
			<i>Zby atlanticus</i>	26275.912
			<i>Diplodocus hallorum</i>	26689.405
			<i>Mendozasaurus neguyelap</i>	28000.000
			<i>Mamenchisaurus jingyanensis</i>	28500.000
			<i>Yunmenglong ruyangensis</i>	29000.000
			<i>Pellegrinisaurus powelli</i>	29050.000
			<i>Apatosaurus ajax</i>	29708.575
			<i>Huanghetitan ruyangensis</i>	30000.000
4.5			<i>Argyrosaurus superbus</i>	31696.028
			<i>Traukutitan eocaudata</i>	32064.564
			<i>Losillasaurus giganteus</i>	32145.991
			<i>Lusotitan atalaiensis</i>	32249.653
			<i>Elaltitan lilloi</i>	33723.230
			<i>Sauroposeidon proteles</i>	34146.021
			<i>Hudiesaurus sinojapanorum</i>	34500.000
			<i>Fusuisaurus zhaoi</i>	35000.000
			<i>Neosodon praecursor</i>	35000.000
			<i>Giraffatitan brancai</i>	36554.866
			<i>Alamosaurus sanjuanensis</i>	37468.469
			<i>Supersaurus vivianae</i>	37600.000
			<i>Turiasaurus riodevensis</i>	38818.533
			<i>Futalognkosaurus dukei</i>	39379.524
			<i>Notocolossus Gonzalezparejasi</i>	40000.000
			<i>Brachiosaurus brancai</i>	41754.800
			<i>Brachiosaurus altithorax</i>	41849.848
			<i>Ruyangosaurus giganteus</i>	43998.135
			<i>Amphicoelias altus</i>	44614.277
			<i>Paralititan stromeri</i>	46589.638
			<i>Francoposeidon charantensis</i>	47000.000
			<i>Dreadnoughtus schrani</i>	47183.794
			<i>Mamenchisaurus sinocanadorum</i>	49500.000
			<i>Puertasaurus reuili</i>	50000.000
			<i>Patagotitan mayorum</i>	55000.000
			<i>Antarctosaurus giganteus</i>	64666.667
			<i>Maraapunisaurus fragillimus</i>	70000.000
			<i>Argentinosaurus huinculensis</i>	80926.696
			<i>Bruhathkayosaurus matleyi</i>	95000.000

Appendix 2

Figure S2.1: Number of occurrences for North American Tyrannosauroids in the PBDB.

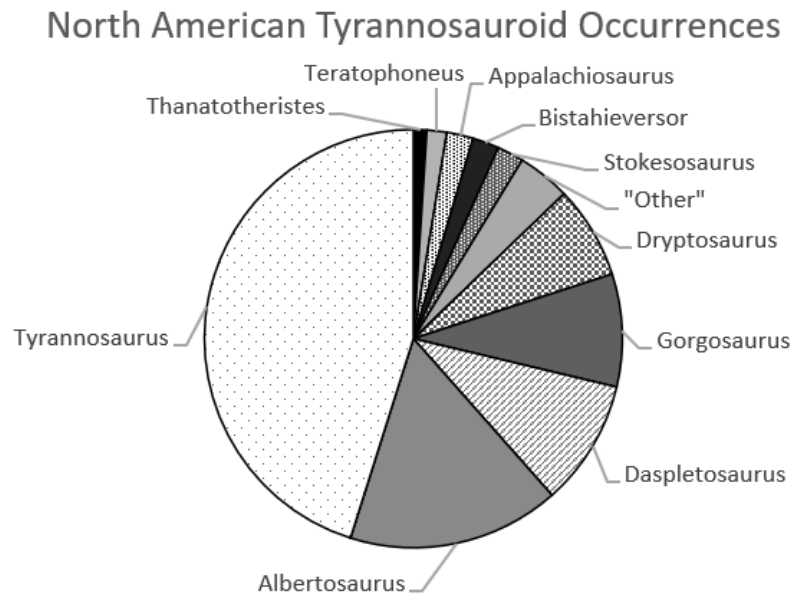


Figure S2.2: Correlations in dietary components and ISO values in extant carnivorous reptiles. Significance from Kendall Rank correlation, $\alpha = 0.05$

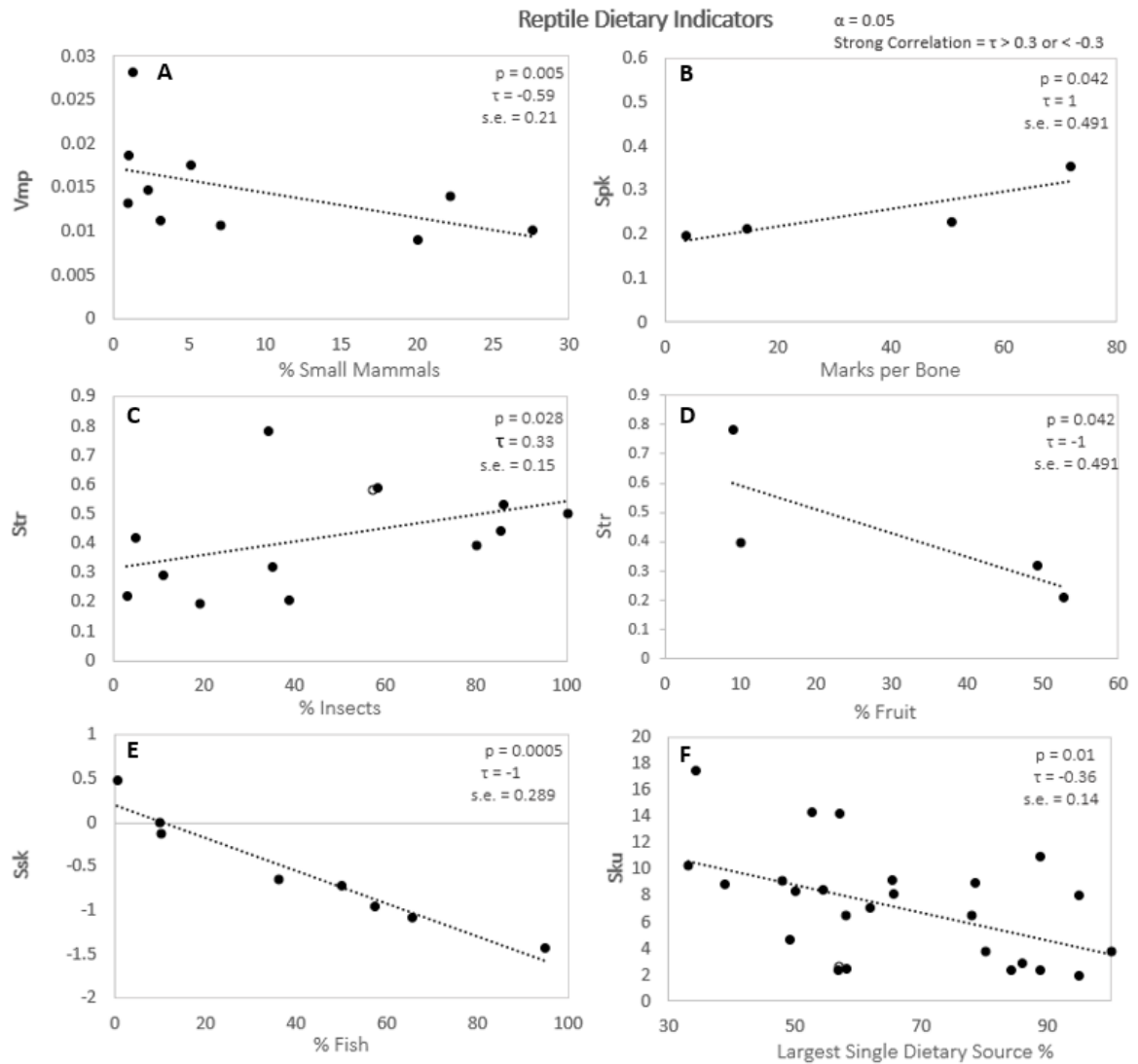


Table S2.1: Dietary components and DMTA/ISO values for extant mammalian and reptilian carnivores

Species	Herbaceous plants	Woody plants	Fruit	small mammal	large mammal	rept./amph.	fish	birds	insects	mol./crust.	Bone Marks	% carrion	Asfc	epLsar	Tfv	3x3 HAsfc	Sdr %	Vmp	Spk	Smr1 %	Str	Sq	Ssk	Sku	Diet	Wear
<i>Acinonyx jubatus</i>				23.48	65.93	2.21		3.96	4.42		0.083	0.01	1.5386	0.00513											(426, 435, 440, 506)	(474)
<i>Canis latrans</i>	19.84	7.42	15	38.22	11.96			5.83	1.71		18	16.8	6.045	0.00202	13523.7										(420, 421, 503)	(474)
<i>Canis lupus</i>			4.8	24.8	59.8			7.8	2.8		5	6.66	2.8265	0.00249	12531.9										(422-424)	(474)
<i>Crocotta crocutta</i>				5.5	92.45	1.3		0.75			50.2	26.9	9.3147	0.00312											(441, 444, 445)	(474)
<i>Lycan pictus</i>				2.76	95.86			1.38			3.38	3	4.2118	0.00183	14182										(425-427)	(474)
<i>Panthera leo</i>				1.96	97.52			0.52			5.3	16	5.3106	0.00279											(426, 441)	(474)
<i>Puma concolor</i>				85.37	14.63						0.004	7.8	4.8887	0.00367	8650										(442, 443)	(474)
<i>Tremarctos ornatus</i>	20.31	11.71	62.6	1.22	2.61		0.42	1.125				2.22	4.3475	0.00337	8543.51										(455, 456)	(475)
<i>Ursus americanus</i>	40.34	1.28	44.4		5.48			8.49			2.09	11	4.2074	0.0029	9992.05										(457-459)	(475)
<i>Ursus malayanus</i>	13.47		43.8		0.71		0.7	41.35					1.4386	0.00305	11057.4										(460)	(475)
<i>Ursus maritimus</i>	19		7.29		69.24			4.47			1	11.36	4.9144	0.00372	10649.8										(461-465)	(475)
<i>Alligator mississippiensis</i>				5.1		30.3	57	6.7		0.6	71.9	2.81	2.9422				2.2923	0.0176	0.3547	10.65	0.3633	0.2619	-0.947	14.227	(428-430, 504)	(410)
<i>Caiman crocodilus chiapasius</i>							9.9	1.23	58.2	30.86			1.3337				0.9122	0.0086	0.1795	9.9333	0.3638	0.1369	0.0116	6.5788	(431)	(410)
<i>Crocodylus acutus</i>				2.33			66	6.45		25.05							1.9011	0.0148	0.296	10.357	0.2759	0.2399	-1.08	9.2139	(432, 433)	(410)
<i>Crocodylus niloticus</i>				7.01	50.88	4.78	36			0.64	50.725	9.58	2.8825				2.241	0.0107	0.2275	10.35	0.2955	0.2063	-0.631	9.2133	(434-436)	(410)
<i>Crocodylus porosus (adult)</i>				20	10	5	50	5		10	3.625	2	2.7838				2.1563	0.009	0.1956	9.4167	0.4285	0.1681	-0.724	8.3246	(437, 505)	(410)
<i>Crocodylus porosus (juvenile)</i>				1.3			0.6	0.1		88.8			3.0228				2.3614	0.0282	0.5603	14.02	0.2264	0.3126	0.477	10.932	(438)	(410)
<i>Dracaena guianensis</i>									5	95			1.5871	0.00865		0.3358	4.4038	0.0261			0.4212	0.5132	-0.124	1.923	(447)	(408)
<i>Furcifer oustaleti</i>			10			8			80	2			4.8983	0.00917		0.244	10.297	0.0145			0.3971	0.3254	0.0056	3.7918	(448)	(408)
<i>Gavialis gangeticus</i>						5	95						2.1128				1.5806	0.0062	0.1332	8.6571	0.2843	0.1614	-1.425	8.0737	(439)	(408)
<i>Pogona barbata</i>	43.02								56.98				1.8416	0.00949		0.3665	3.7631	0.0144			0.5826	0.3341	-0.159	2.6549	(449)	(408)
<i>Pogona vitticeps</i>									100				2.2165	0.0091		0.3018	4.8295	0.0158			0.5045	0.3141	-0.218	3.8274	(450)	(408)
<i>Pseudopus apodus</i>									86.15	13.85			3.9105	0.01008		0.3174	8.9547	0.0225			0.5333	0.5453	-0.364	2.8442	(451)	(408)
<i>Smaug giganteus</i>	14.65								85.35				0.4619	0.00816		0.4642	1.2222	0.0117			0.4425	0.2269	0.117	2.3511	(452)	(408)
<i>Sphenodon punctatus</i>	40.49					0.3	1.02	58.19			1.6031	0.0095		0.241	3.2452	0.0096		0.5897	0.2304	-0.201	2.4857				(446)	(408)
<i>Tiliqua scincoides</i>	23.88		8.95			5.97		34.34	26.86				3.3155	0.00887		0.5993	7.3864	0.0161			0.7823	0.3798	-0.757	17.463	(453)	(408)
<i>Tupinambis teguixin</i>	4.23		49.3			5.61	1.42	35.22	1.42				0.9483	0.00859		0.2839	2.223	0.0135			0.3194	0.2737	-0.199	4.6725	(454)	(408)
<i>Varanus giganteus</i>						56.8	5	3					0.2755	0.00897		0.3341	0.7205	0.0085			0.2181	0.1883	0.1151	2.3739	(466)	(408)
<i>Varanus griseus</i>						88.85		11.15					0.2291	0.0099		0.2393	0.656	0.0112			0.2905	0.2189	0.1436	2.3403	(466)	(408)
<i>Varanus komodoensis</i>				27.6	62.1	10.3					14.42	43.4	1.6934				1.2208	0.0101	0.2121	11.425	0.2295	0.169	-0.488	7.0987	(418, 467-469)	(410)
<i>Varanus nebulosus</i>				1.02		1.02				19.39			2.9849				2.3289	0.0188	0.373	11.009	0.3497	0.2286	0.396	8.9774	(469)	(410)
<i>Varanus niloticus</i>				3.12		6.22	3.12			65.72			2.7528				2.1298	0.0112	0.2361	9.55	0.4388	0.2123	-0.548	8.1571	(466)	(410)
<i>Varanus olivaceus</i>			52.7				0.49	3.45	43.35				2.0491				1.526	0.0279	0.5168	13.133	0.208	0.2666	-0.012	14.313	(470)	(410)
<i>Varanus prasinus</i>				22.1									3.2403				2.548	0.0141	0.291	11.6	0.2857	0.1835	0.488	6.5442	(466)	(410)
<i>Varanus rudicollis</i>						54.5				3.5			4.208				3.3783	0.018	0.3717	10.725	0.2651	0.2527	0.2313	8.4889	(466)	(410)
<i>Varanus salvator</i>			0.9			18.19	10	30	19.1	21.81		6.25	1.6775	0.01636		0.664	1.7197	0.0133	0.2355	10.725	0.1978	0.3425	-0.118	10.332	(471)	(408, 410)
<i>Varanus varius</i>					30.98	1.77	6.19	38.94			21.28	30.1	0.7168	0.00962		0.2413	1.5294	0.0088			0.2084	0.1722	-0.182	8.8724	(472, 473)	(408)

Table S2.2: Average and standard deviation for all species at all ontogenetic stages

			<i>Asfc</i>	<i>epLsar</i>	<i>Tfv</i>	<i>3x3 HAsfc</i>	<i>9x9 HAsfc</i>	<i>Sdr</i>	<i>Vmp</i>	<i>Spk</i>	<i>Smr1</i>	<i>Sq</i>	<i>Ssk</i>	<i>Sku</i>
<i>Albertosaurus</i>	All	\bar{x}	1.8827	0.0045	9215.2	0.365	0.6107	1.252	0.02	0.3497	7.8764	0.6042	-0.4822	3.6259
		σ	0.7139	0.0015	3210.6	0.1037	0.0909	0.6244	0.0084	0.1586	2.0718	0.1725	0.2534	0.6384
	Juvenile	\bar{x}	1.4772	0.0052	7855.7	0.2919	0.5548	0.9782	0.022	0.3568	9.6447	0.5423	-0.1662	3.2831
		σ	0.4072	0.0007	3372.2	0.0514	0.0286	0.2708	0.0066	0.0922	0.3219	0.0802	0.1974	0.1297
	Subadult	\bar{x}	2.0179	0.0057	9314.3	0.4447	0.6479	1.3121	0.0135	0.2087	4.9935	0.5556	-0.5479	3.0717
		σ	0.1931	0.0011	2358.1	0.0099	0.0985	0.3566	0.0041	0.075	0.9917	0.0824	0.2743	0.3049
	Adult	\bar{x}	2.1982	0.003	10509	0.3848	0.6419	1.4857	0.0222	0.4365	8.0301	0.5826	-0.4097	4.3176
		σ	0.9446	0.0008	2980.3	0.1266	0.0987	0.8658	0.0098	0.1843	1.4128	0.2184	0.3305	0.4124
<i>Daspletosaurus</i>	All	\bar{x}	3.065	0.0037	10972	0.4422	0.7082	2.1467	0.0305	0.6519	8.9912	0.7886	-0.5374	4.0049
		σ	1.3698	0.0019	4441.8	0.2117	0.235	0.921	0.0175	0.4019	2.7549	0.3332	0.4333	1.0633
	Juvenile	\bar{x}	2.5174	0.0032	14432	0.4147	0.6665	1.8216	0.0324	0.568	7.601	0.7865	-0.3631	3.2385
		σ	0.7684	0.0026	2111.8	0.2489	0.2409	0.3975	0.0176	0.3102	2.1806	0.1432	0.2618	0.2914
	Subadult	\bar{x}	2.8589	0.0043	9249.3	0.5053	0.8542	1.9677	0.0381	0.8996	11.356	0.9981	-0.361	4.0373
		σ	0.2378	0.0001	987.68	0.2219	0.2664	0.2724	0.0207	0.5721	3.2779	0.5143	0.496	0.866
	Adult	\bar{x}	4.0927	0.0041	7504	0.4202	0.6247	2.8133	0.0202	0.5299	8.7117	0.5823	-0.9751	5.1222
		σ	2.0189	0.0011	5332.9	0.0949	0.0661	1.4222	0.0036	0.0824	0.341	0.0835	0.2003	0.9744
<i>Gorgosaurus</i>	All	\bar{x}	2.5903	0.0048	8600.6	0.3885	0.6716	1.6647	0.0164	0.3175	7.7343	0.5948	-0.5436	3.589
		σ	1.2642	0.003	4280.8	0.1422	0.2299	0.8787	0.0066	0.1285	1.6621	0.2457	0.3065	0.8419
	Juvenile	\bar{x}	3.0285	0.0031	3243.2	0.2925	0.649	1.7684	0.013	0.2501	8.217	0.442	-0.8771	3.7466
		σ	-	-	-	-	-	-	-	-	-	-	-	-
	Subadult	\bar{x}	1.8091	0.0059	7943	0.3982	0.6182	1.1206	0.0143	0.2733	7.2262	0.6089	-0.4935	3.203
		σ	0.4479	0.0033	3882.8	0.1353	0.101	0.301	0.0051	0.0825	1.5404	0.2966	0.276	0.7693
	Adult	\bar{x}	4.3241	0.003	12923	0.4123	0.8166	2.9732	0.0233	0.4615	8.7632	0.6357	-0.5019	4.4751
		σ	1.1241	0.0011	1221.5	0.1724	0.397	0.6359	0.0065	0.1453	1.8158	0.088	0.349	0.4312
<i>Tyrannosaurus</i>	All	\bar{x}	2.4702	0.0039	9895.7	0.4355	0.744	1.9327	0.0222	0.3974	7.7846	0.7941	-0.4689	3.8393
		σ	2.0791	0.0016	4256.1	0.1286	0.2545	1.6928	0.0073	0.2381	1.3061	0.4112	0.3221	2.0977
	Juvenile	\bar{x}	1.517	0.0029	9835.4	0.3493	0.623	0.9444	0.0212	0.4405	8.0909	0.4662	-0.289	3.6888
		σ	0.745	0.0004	6312.4	0.041	0.1595	0.5156	0.0099	0.2296	1.8223	0.1834	0.0135	0.3552
	Subadult	\bar{x}	5.0838	0.0062	11791	0.4725	0.7672	4.083	0.0267	0.4582	7.1896	1.2305	-0.3859	2.9341
		σ	2.0117	0.0006	503.7	0.1428	0.0597	1.5844	0.0036	0.316	0.1961	0.3701	0.1374	0.4041
	Adult	\bar{x}	1.2833	0.0028	8782.6	0.4477	0.7785	1.0379	0.0198	0.3437	8.019	0.6635	-0.5907	4.4426
		σ	0.3533	0.0005	4091.8	0.1274	0.3314	0.3915	0.0064	0.1628	1.3249	0.2612	0.4051	2.7906

Table S2.3: Correlations between ISO and DMTA values and carnivorous reptile and mammal diet. Explanation of metric and calculation included.

Metric	System	Reptile Diet Correlation	p- value	Cor. Coeff.	Source	Mammal Diet Correlation	p- value	Cor. Coeff.	Source	Description	Calculation
Complexity	Asfc	DMTA	None			% Carrion	0.0032	0.7333		How much the surface texture changes from small to large field of view	Maximum difference in surface texture between 87 scales between 0.02-100um
			Durophagy		Positive	(408)					
	Skv	ISO	# Sources	0.002	0.464						
			Marks per bone	0.05	0.8						
			% small verts	0.038	-0.44					Sharpness of peaks	Kurtosis of height profile
	Sa	ISO	None							Roughness of surface	Difference between average absolute distance from core surface
	Sdq	ISO	None							Difference in slope of features	Standard deviation of slopes
	Sdr	ISO	% Vertebrates	0.0446	-0.282					Deviation from flat plane	% of surface area contributed by peaks and pits
			% Fauna	0.0012	0.648						
	Smr1	ISO	Piscivory		Negative	(410)				Bearing surface (material remaining following initial abrasion)	% Material above core height (Sk)
Pitting			Durophagy		Positive	(410)					
	Tjv	DMTA	N/A			Durophagy		Positive	(474)	Number and depth of pits	Difference in volume filled by 10um vs 2um cuboids
	Ssk	ISO	% Fish	0.0005	-1					Ratio of surface above and below core material	Skewness of height distribution above or below core surface
			% vertebrates	0.002	-0.43						
			% Small Verts	0.005	-0.59						
	Vmp	ISO	Piscivory		Negative	(410)					
			Durophagy		Positive	(410)				Volume of material contained in peaks	Volume of material above areal material ratio 10%
	Vmc	ISO	None							Volume of core material	Volume of material between areal material ratio 10% and 80%
	Vvc	ISO	None							Volume of void in core material	Inverse of Vmc
	Vvv	ISO	None							Volume of void in pits	Inverse of Volume of material below 80% areal material ratio
Directionality	epLsar	DMTA	None			None					
			Carnivory		Positive	(408)	Meat slicing	Positive	(474)	Degree of parallelism in scratches	Average vector length (sum of profiles lengths taken at 5degree intervals)
			% Fruit	0.042	1						
Depth of Feature	Str	ISO	% Insects	0.028	-0.33					Uniformity of surface texture (texture aspect ratio)	Length of the least parallel features (autocorrelation decays to 0.2 fastest) divided by length of the most parallel features
			% Vertebrates/F	0.0109	-0.359						
			% Vertebrates	0.0008	-0.47						
	Sq	ISO	Marks per bone	0.014	1						
			% small verts	0.002	-0.64						
			% Fruit	0.042	-1					Height of surface above core material	Standard deviation of peak heights
	Sp	ISO	None							Maximum peak height	Height of the tallest feature above core surface
	Sv	ISO	None							Maximum pit depth	Depth of the lowest feature below core surface
	Sz	ISO	None							Maximum height	Difference between maximum depth and maximum height
	Smr	ISO	None							Height at which slope of secant line of height vs areal material ratio curve is lowest	
	Smc	ISO	None							Height of core surface	
			None							Height at which areal material reaches defined %	
	Sxp	ISO	None							Average height of peaks after removing extremes	Inverse of the areal material ratio
	Vm	ISO	None							Volume material	Height difference between core material and peaks below 97.5% areal material ratio
	Vv	ISO	None							Volume void	Volume material
			% Fauna	0.019	-0.47						
			Marks per bone	0.041	1						
	Spk	ISO	Piscivory		Negative	(410)					
			Durophagy		Positive	(410)				Average height of peaks	Average height of peaks
Heterogeneity	Hasfc3x3	DMTA	None			N/A				Difference in texture from one area to another	Difference in Asfc between 9 area subsamples
	Hasfc9x9	DMTA	N/A			N/A				Difference in texture from one area to another	Difference in Asfc between 81 area subsamples

Table S2.4: Percent difference between all species and all ontogenetic stages. Significant values (Dunn's $p < 0.05$) shown in bold face and dark grey.

		Asfc	ePlsar	Tfv	3x3 HASj	2x2 HASj	Sdr	Vmp	Spk	Smr1	Sq	Ssk	Sku		
Albertosaurus	Juvenile	Albertosaurus	S -36.60	-9.65	-18.57	-52.34	-16.78	-34.13	38.46	41.50	48.23	-2.45	-229.66	6.44	
		Albertosaurus	A -48.81	42.92	-33.77	-31.82	-15.70	-51.88	-1.04	-22.33	16.74	-7.44	-146.50	-31.51	
		Daspletosaurus	J -70.42	39.14	-83.71	-42.07	-20.14	-86.21	-46.97	-59.19	21.19	-45.05	-118.49	1.36	
		Daspletosaurus	S -93.54	18.23	-17.74	-73.11	-53.97	-101.15	-73.29	-152.13	-17.74	-84.07	-117.25	-22.97	
		Daspletosaurus	A -177.06	22.34	4.48	-43.94	-12.60	-187.59	8.44	-48.52	9.67	-7.39	-486.73	-56.02	
		Gorgosaurus	J -105.02	40.00	58.72	-0.21	-16.99	-80.78	40.74	29.92	14.80	18.48	-427.77	-14.12	
		Gorgosaurus	S -22.47	-13.10	-1.11	-36.40	-11.43	-14.55	34.95	23.39	25.08	-12.29	-196.97	2.44	
		Gorgosaurus	A -192.72	41.65	-64.51	-41.24	-47.19	-203.93	-5.80	-29.34	9.14	-17.24	-202.02	-36.31	
		Tyrannosaurus	J -2.69	43.78	-25.20	-19.67	-12.29	3.46	3.90	-23.46	16.11	14.03	-73.87	-12.36	
		Tyrannosaurus	S -244.15	-19.37	-50.09	-61.87	-38.29	-317.37	-21.38	-28.42	25.45	-126.92	-132.23	10.63	
		Tyrannosaurus	A 13.13	46.23	-11.80	-53.36	-40.33	-6.10	9.88	3.69	16.86	-22.37	-255.42	-35.32	
	Subadult	Albertosaurus	A -8.94	47.94	-12.82	13.47	0.92	-13.23	-64.20	-109.11	-60.81	-4.86	25.23	-40.56	
		Daspletosaurus	S -41.68	25.43	0.70	-13.63	-31.85	-49.96	-181.61	-330.98	-127.42	-79.66	34.10	-31.44	
		Daspletosaurus	A -102.82	29.17	19.44	5.51	3.58	-114.41	-48.79	-153.87	-74.46	-4.81	-77.98	-66.76	
		Gorgosaurus	S 10.34	-3.15	14.72	10.46	4.58	14.60	-5.71	-30.95	-44.71	-9.61	9.92	-4.28	
		Gorgosaurus	A -114.29	46.79	-38.75	7.29	-26.04	-126.59	-71.94	-121.08	-75.49	-14.44	8.39	-45.69	
		Tyrannosaurus	S -151.94	-8.87	-26.59	-6.26	-18.42	-211.17	-97.26	-119.52	-43.98	-121.48	29.55	4.48	
		Tyrannosaurus	A 36.40	50.96	5.71	-0.67	-20.17	20.90	-46.44	-64.64	-60.59	-19.44	-7.81	-44.63	
	Adult	Daspletosaurus	Adult	-86.18	-36.06	28.59	-9.19	2.68	-89.36	9.38	-21.40	-8.49	0.05	-138.03	-18.63
		Gorgosaurus	Adult	-96.71	-2.23	-22.98	-7.14	-27.22	-100.12	-4.71	-5.73	-9.13	-9.13	-22.52	-3.65
		Tyrannosaurus	Adult	41.62	5.80	16.42	-16.34	-21.29	30.14	10.81	21.27	0.14	-13.90	-44.19	-2.90
	Daspletosaurus	Juvenile	Albertosaurus	S 19.84	-80.15	35.46	-7.22	2.80	27.97	58.13	63.25	34.30	29.37	-50.88	5.15
			Albertosaurus	A 12.68	6.22	27.18	7.21	3.70	18.44	31.25	23.16	-5.65	25.93	-12.82	-33.32
			Daspletosaurus	S -13.57	-34.34	35.91	-21.84	-28.16	-8.02	-17.91	-58.38	-49.40	-26.90	0.57	-24.67
Daspletosaurus			A -62.57	-27.60	48.00	-21.84	6.28	-54.44	37.70	6.71	-14.61	25.97	-168.54	-58.17	
Gorgosaurus			J -20.30	1.43	77.53	-21.84	2.62	2.92	59.68	55.98	-8.10	43.80	-141.55	-15.69	
Gorgosaurus			S 28.14	-85.83	44.96	-21.84	7.25	38.48	55.74	51.88	4.93	22.58	-35.92	1.09	
Gorgosaurus			A -71.77	4.13	10.45	-21.84	-22.51	-63.22	28.01	18.75	-15.29	19.17	-38.23	-38.18	
Tyrannosaurus			J 39.74	7.63	31.85	-21.84	6.54	48.16	34.61	22.45	-6.45	40.73	20.42	-13.90	
Tyrannosaurus			S -101.94	-96.12	18.30	-21.84	-15.10	-124.14	17.41	19.33	5.41	-56.44	-6.29	9.40	
SA		Tyrannosaurus	A 49.02	11.66	39.14	-21.84	-16.80	43.02	38.68	39.50	-5.50	15.64	-62.67	-37.18	
		Albertosaurus	A 23.11	30.19	-13.62	23.85	24.86	24.49	41.69	51.48	29.29	41.63	-13.46	-6.94	
		Daspletosaurus	A -43.16	5.02	18.87	16.85	26.87	-42.98	47.16	41.09	23.29	41.66	-170.08	-26.87	
		Gorgosaurus	S 36.72	-38.32	14.12	21.20	27.63	43.05	62.46	69.62	36.37	38.99	-36.70	20.66	
		Gorgosaurus	A -51.25	28.64	-39.72	18.41	4.41	-51.10	38.94	48.70	22.83	36.31	-39.02	-10.84	
		Tyrannosaurus	S -77.82	-45.99	-27.48	6.49	10.19	-107.50	29.95	49.06	36.69	-23.28	-6.90	27.33	
		Tyrannosaurus	A 55.11	34.24	5.05	11.41	8.86	47.25	48.00	61.80	29.39	33.52	-63.60	-10.04	
		Gorgosaurus	Adult	-5.65	24.87	-72.22	1.88	-30.72	-5.68	-15.56	12.91	-0.59	-9.18	48.53	12.63
		Tyrannosaurus	Adult	68.64	30.77	-17.04	-6.55	-24.63	63.11	1.58	35.15	7.95	-13.95	39.42	13.27
Gorgosaurus	Juvenile	Albertosaurus	S 33.37	-82.76	-187.20	-52.02	0.18	25.80	-3.84	16.52	39.23	-25.68	37.54	18.02	
		Albertosaurus	A 27.42	4.86	-224.02	-31.55	1.11	15.99	-70.51	-74.56	2.27	-31.79	53.29	-15.24	
		Daspletosaurus	S 5.60	-36.29	-185.19	-72.75	-31.61	-11.27	-192.43	-259.77	-38.20	-125.79	58.84	-7.76	
		Daspletosaurus	A -35.14	-29.45	-131.38	-43.64	3.75	-59.09	-54.51	-111.92	-6.02	-31.73	-11.17	-36.72	
		Gorgosaurus	S 40.26	-88.52	-144.91	-36.12	4.75	36.63	-9.77	-9.31	12.06	-37.75	43.73	14.51	
		Gorgosaurus	A -42.78	2.75	-298.48	-40.94	-25.81	-68.12	-78.55	-84.55	-6.65	-43.82	42.77	-19.44	
		Tyrannosaurus	J 49.91	6.30	-203.26	-19.42	4.02	46.60	-62.18	-76.17	1.53	-5.45	67.06	1.54	
		Tyrannosaurus	S -67.87	-98.96	-263.56	-61.53	-18.20	-130.88	-104.84	-83.25	12.50	-178.35	56.00	21.69	
		Tyrannosaurus	A 57.63	10.38	-170.80	-53.04	-19.95	41.31	-52.07	-37.43	2.41	-50.10	32.66	-18.58	
	SA	Albertosaurus	A -21.51	49.53	-32.30	3.36	-3.83	-32.58	-55.33	-59.69	-11.13	4.33	17.00	-34.80	
		Daspletosaurus	A -126.22	31.33	5.53	-5.52	-1.05	-151.06	-40.75	-93.87	-20.56	4.37	-97.57	-59.92	
		Gorgosaurus	A -139.01	48.41	-62.70	-3.54	-32.09	-165.32	-62.65	-68.83	-21.27	-4.41	-1.70	-39.71	
		Tyrannosaurus	S -181.01	-5.54	-48.44	-18.67	-24.10	-264.36	-86.60	-67.64	0.51	-102.07	21.80	8.40	
		Tyrannosaurus	A 29.07	52.46	-10.57	-12.43	-25.93	7.38	-38.53	-25.72	-10.97	-8.97	-19.68	-38.70	
		Tyrannosaurus	A 70.32	7.85	32.04	-8.59	4.66	65.09	14.83	25.53	8.49	-4.37	-17.68	0.73	
Tyrannosaurus	Juvenile	Albertosaurus	S -33.02	-95.04	5.30	-27.30	-4.00	-38.94	35.97	52.62	38.28	-19.18	-89.60	16.73	
		Albertosaurus	A -44.91	-1.53	-6.84	-10.16	-3.04	-57.32	-5.14	0.92	0.75	-24.97	-41.77	-17.05	
		Daspletosaurus	S -88.46	-45.45	5.96	-44.66	-37.12	-108.36	-80.32	-104.21	-40.36	-114.12	-24.95	-9.45	
		Daspletosaurus	A -169.80	-38.15	23.70	-20.28	-0.28	-197.91	4.73	-20.29	-7.67	-24.91	-237.45	-38.86	
		Gorgosaurus	S -19.26	-101.19	19.24	-13.99	0.76	-18.66	32.31	37.95	10.69	-30.62	-70.80	13.17	
	SA	Gorgosaurus	A -185.05	-3.79	-31.40	-18.02	-31.08	-214.83	-10.09	-4.76	-8.31	-36.38	-73.70	-21.32	
		Tyrannosaurus	S -235.13	-112.33	-19.88	-35.27	-23.15	-332.35	-26.30	-4.02	11.14	-163.96	-33.57	20.46	
		Tyrannosaurus	A 15.40	4.36	10.70	-28.16	-24.97	-9.90	6.23	21.99	0.89	-42.34	-104.42	-20.44	
		Albertosaurus	Adult	56.76	52.18	10.88	18.56	16.34	63.61	16.76	4.74	-11.69	52.65	-6.14	-47.15
		Daspletosaurus	Adult	19.50	34.94	36.36	11.08	18.58	31.10	24.57	-15.65	-21.17	52.68	-152.65	-74.57
All Ages	Gorgosaurus	Adult	14.94	51.12	-9.60	12.75	-6.44	27.18	12.83	-0.71	-21.89	48.33	-30.05	-52.52	
	Tyrannosaurus	Adult	74.76	54.96	25.51	5.26	-1.48	74.58	25.76	25.00	-11.54	46.07	-53.05	-51.41	
Alberto. vs Daspleto.	Alberto. vs Daspleto.	-62.80	17.01	-19.06	-21.16	-15.96	-71.46	-52.75	-86.42	-14.15	-30.51	-11.45	-10.45		
	Alberto. vs Gorgo.	-37.58	-7.48	6.67	-6.45	-9.98	-32.96	17.91	9.21	1.80	1.57	-12.73	1.02		
	Alberto. vs Tyranno.	-31.20	14.34	-7.38	-19.32	-21.83	-54.37	-10.93	-13.65	1.17	-31.42	2.75	-5.88		
	Daspleto. vs Gorgo.	15.49	-29.51	21.61	12.14	5.16	22.45	46.26	51.30	13.98	24.58	-1.15	10.39		
	Daspleto. vs Tyranno.	19.41	-3.21	9.81	1.52	-5.06	9.97	27.38	39.04	13.42	-0.70	12.74	4.14		
	Gorgo. vs Tyranno.	4.64	20.30	-15.06	-12.09	-10.77	-16.10	-35.13	-25.18	-0.65	-33.52	13.74	-6.97		

Appendix 3

Character states used in each of the phylogenetic analyses

DePalma et al. 2015

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Hartman et al. 2019

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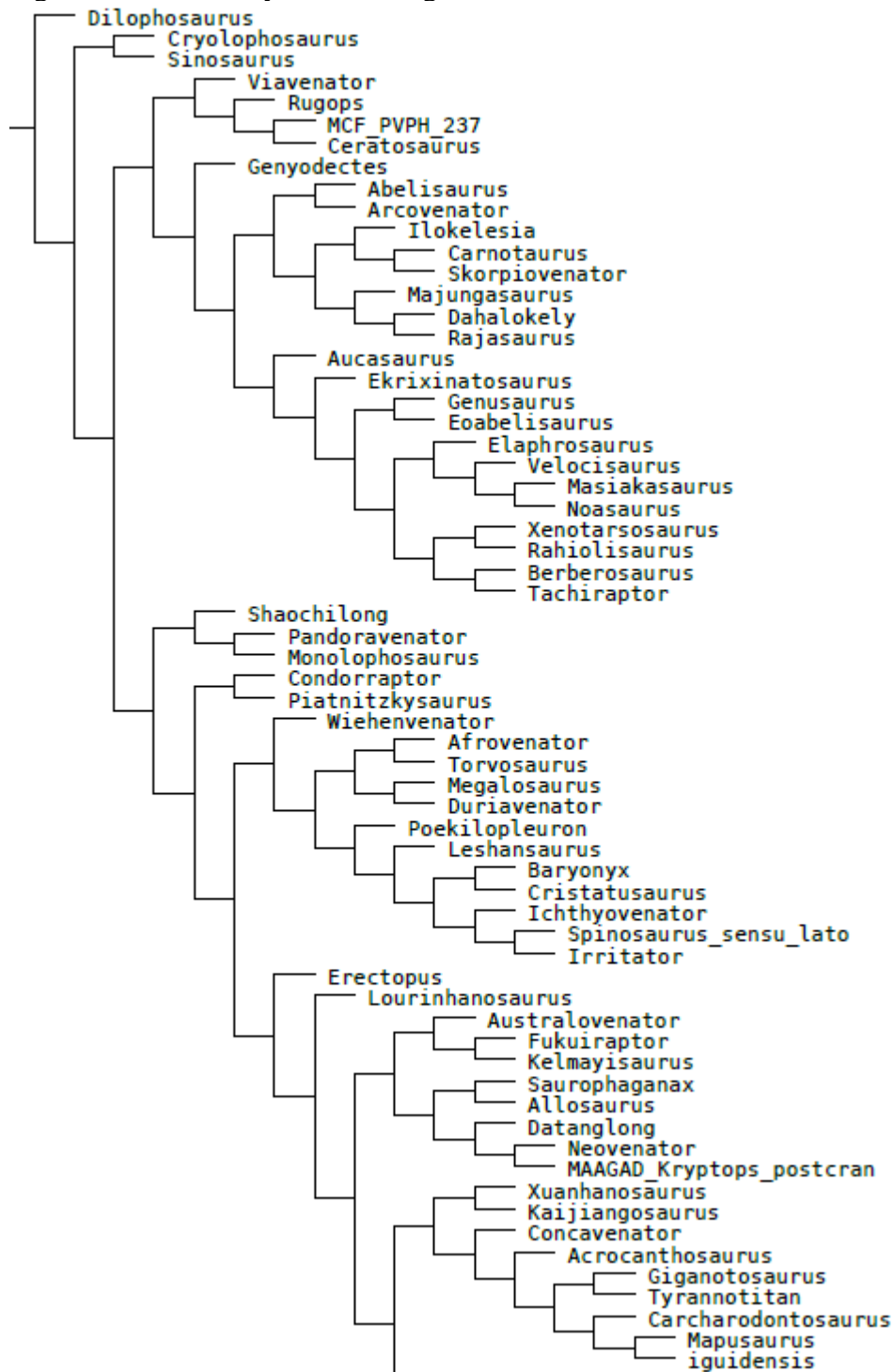
Jasinski et al. 2020

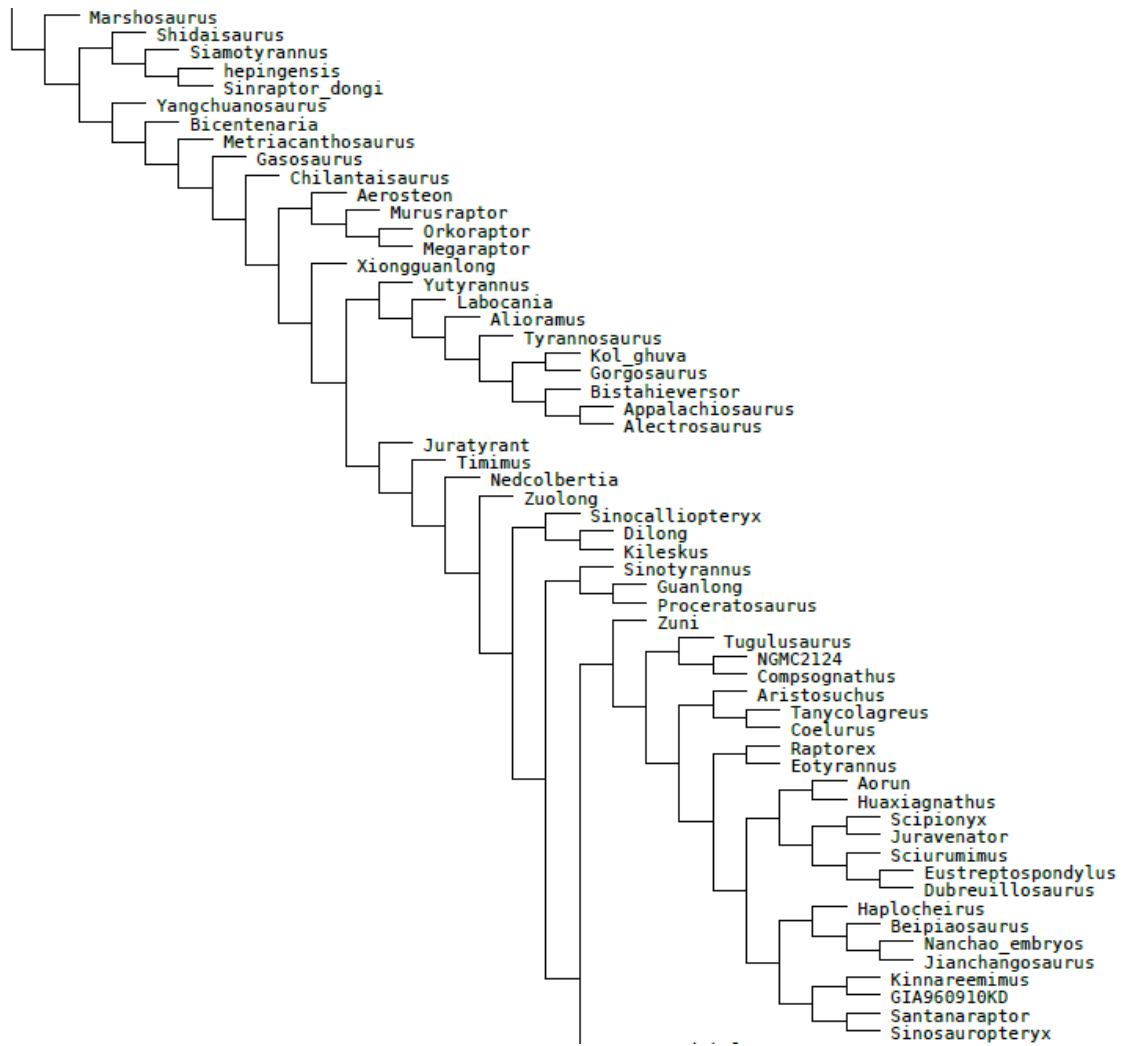
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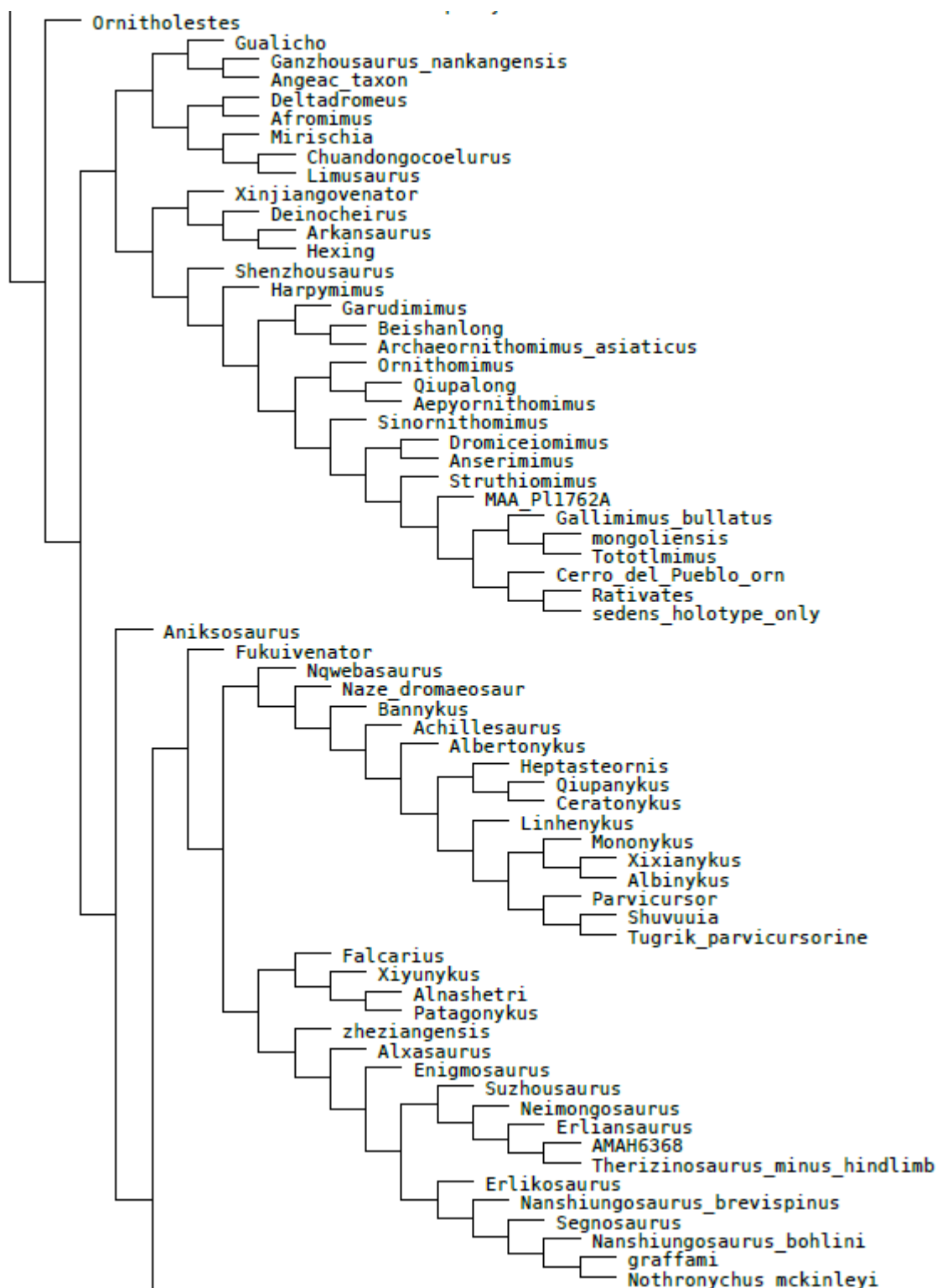
Figure S3.1: Parsimoy results using matrix from Depalma, et al., 2015

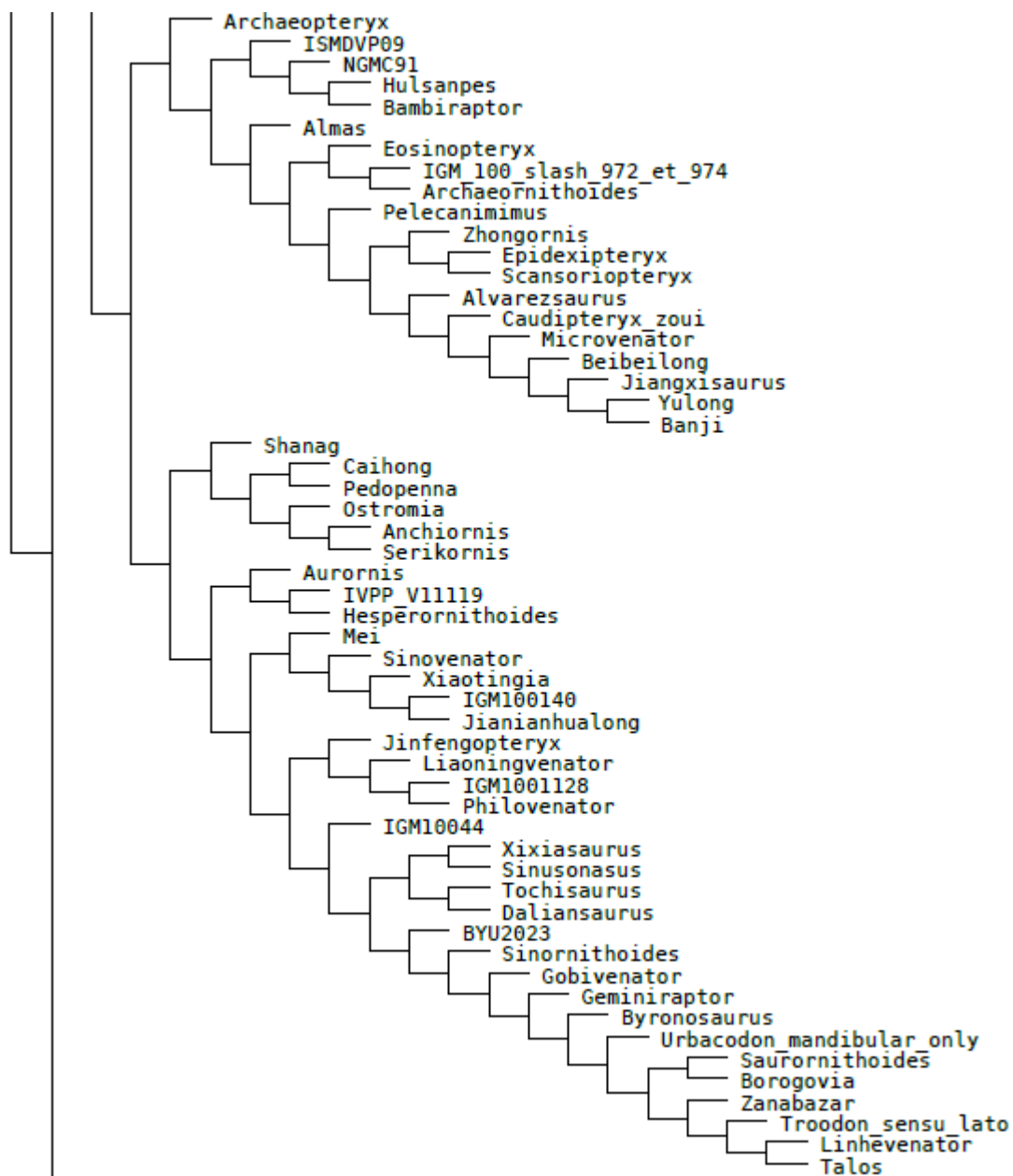


Figure S3.2: Parsimoy results using matrix from Hartman, et al., 2019

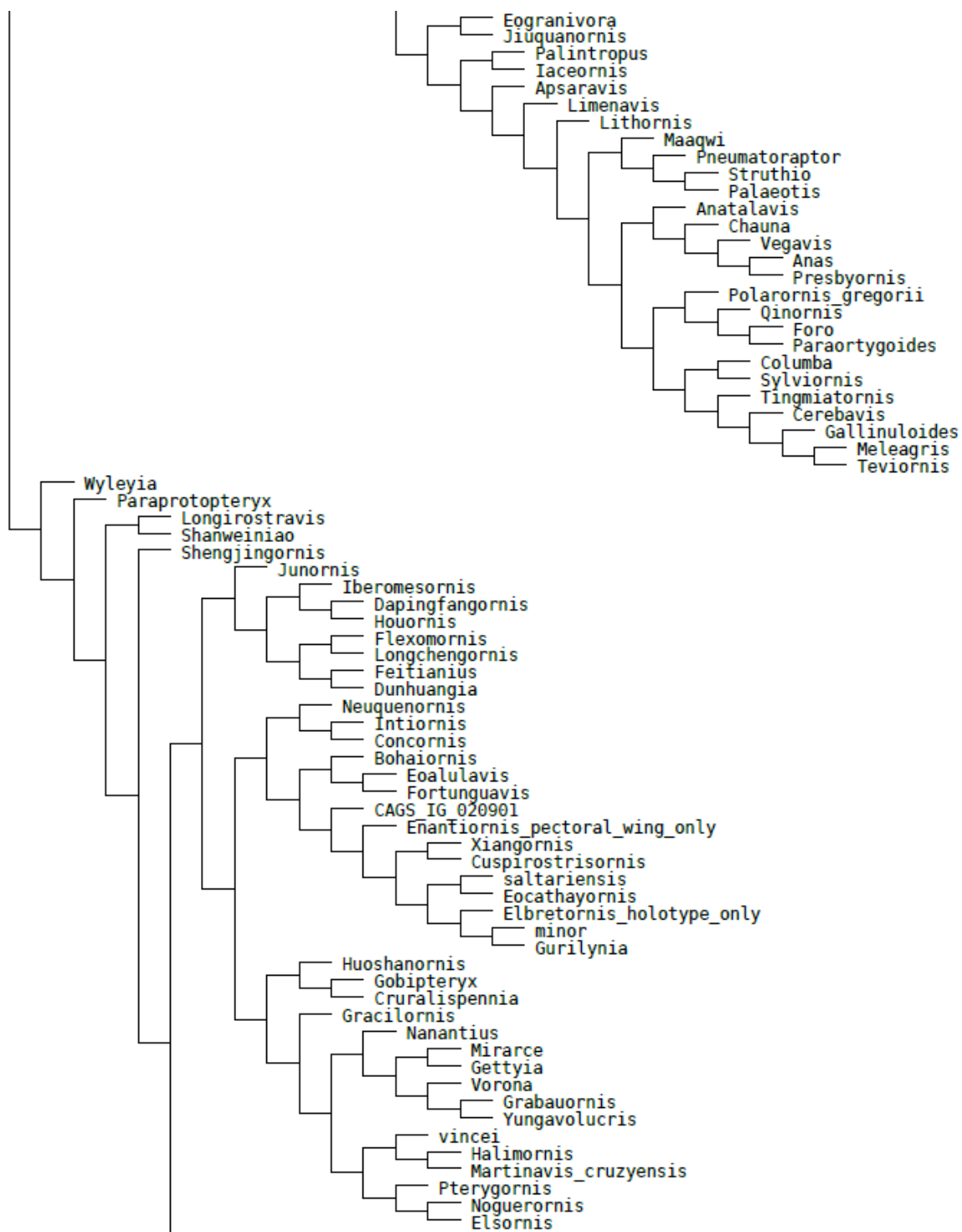


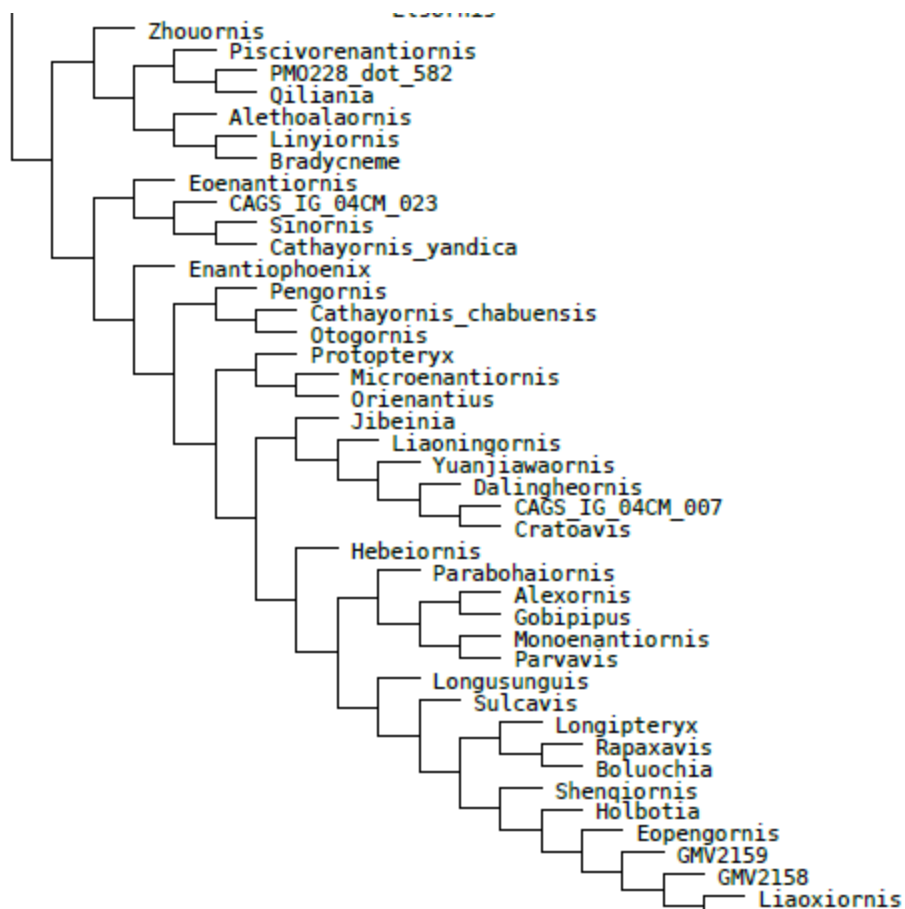












References

1. S. C. Wang, P. Dodson, Estimating the diversity of dinosaurs. *Proc. Natl. Acad. Sci. U. S. A.* (2006).
2. J. H. Brown, P. F. Nicoletto, Spatial scaling of species composition: body masses of North American land mammals. *Am. Nat.* (1991).
3. D. A. Kelt, J. H. Brown, E. J. Heske, P. A. Marquet, S. R. Morton, J. R. W. Reid, K. A. Rogovin, G. Shenbrot, Community structure of desert small mammals: comparisons across four continents. *Ecology* (1996).
4. E. J. O’Gorman, D. W. E. Hone, Body Size Distribution of the Dinosaurs. *PLoS One* (2012).
5. C. M. Brown, D. C. Evans, N. E. Campione, L. J. O’Brien, D. A. Eberth, Evidence for taphonomic size bias in the Dinosaur Park Formation (Campanian, Alberta), a model Mesozoic terrestrial alluvial-paralic system. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* (2013).
6. R. S. Seymour, Dinosaur Eggs: Gas Conductance Through the Shell, Water Loss During Incubation and Clutch Size. *Paleobiology* (1979).
7. N. O. Ratsimbaholison, R. N. Felice, P. M. O’Connor, Ontogenetic Changes in the Craniomandibular Skeleton of the Abelisaurid Dinosaur *Majungasaurus crenatissimus* from the Late Cretaceous of Madagascar. *Acta Palaeontol. Pol.* (2016).
8. T. D. Carr, Craniofacial ontogeny in Tyrannosauridae (Dinosauria, Coelurosauria). *J. Vertebr. Paleontol.* (1999).
9. D. Codron, C. Carbone, D. W. H. Müller, M. Clauss, Ontogenetic niche shifts in

- dinosaurs influenced size, diversity and extinction in terrestrial vertebrates. *Biol. Lett.* (2012).
10. E. E. Werner, J. F. Gilliam, The ontogenetic niche and species interactions in size-structured populations. *Annu. Rev. Ecol. Syst. Vol. 15* (1984).
 11. D. Codron, C. Carbone, M. Clauss, Ecological interactions in dinosaur communities: influences of small offspring and complex ontogenetic life histories. *PLoS One. 8* (2013).
 12. H. N. Woodward, K. Tremaine, S. A. Williams, L. E. Zanno, J. R. Horner, N. Myhrvold, Growing up *Tyrannosaurus rex*: Osteohistology refutes the pygmy “*Nanotyrannus*” and supports ontogenetic niche partitioning in juvenile *Tyrannosaurus*. *Sci. Adv.* (2020).
 13. D. Purwandana, A. Ariefiandy, M. Jeri Imansyah, A. Seno, C. Ciofi, M. Letnic, T. S. Jessop, Ecological allometries and niche use dynamics across komodo dragon ontogeny. *Sci. Nat.* (2016).
 14. G. M. Erickson, K. C. Rogers, S. A. Yerby, Dinosaurian growth patterns and rapid avian growth rates. *Nature* (2001).
 15. J. R. Horner, A. De Ricqlès, K. Padian, Long bone histology of the hadrosaurid dinosaur *maiasaura peeblesorum*: Growth dynamics and physiology based on an ontogenetic series of skeletal elements. *J. Vertebr. Paleontol.* (2000).
 16. G. M. Erickson, P. J. Currie, B. D. Inouye, A. A. Winn, *Tyrannosaurus* life tables: An example of nonavian dinosaur population biology. *Science (80-.).* (2006).
 17. G. M. Erickson, P. J. Currie, B. D. Inouye, A. A. Winn, A revised life table and survivorship curve for *albertosaurus sarcophagus* based on the dry island mass

- death assemblage. *Can. J. Earth Sci.* (2010).
18. P. Gignac, H. O'Brien, Suchian Feeding Success at the Interface of Ontogeny and Macroevolution. *Integr. Comp. Biol.* **56** (2016).
 19. D. J. Varricchio, A distinct dinosaur life history? *Hist. Biol.* (2011).
 20. The Paleobiology Database, (available at <https://paleobiodb.org/>).
 21. Materials and methods are available as supplementary materials at the Science website.
 22. F. A. Smith, A. G. Boyer, J. H. Brown, D. P. Costa, T. Dayan, S. K. M. Ernest, A. R. Evans, M. Fortelius, J. L. Gittleman, M. J. Hamilton, L. E. Harding, K. Lintulaakso, S. K. Lyons, C. McCain, J. G. Okie, J. J. Saarinen, R. M. Sibly, P. R. Stephens, J. Theodor, M. D. Uhen, The evolution of maximum body size of terrestrial mammals. *Science* (80-.). (2010).
 23. J. B. Foster, Evolution of mammals on Islands. *Nature* (1964).
 24. D. Codron, J. Codron, M. Sponheimer, M. Clauss, Within-population isotopic niche variability in savanna mammals: Disparity between carnivores and herbivores. *Front. Ecol. Evol.* (2016).
 25. S. L. Brusatte, M. J. Benton, M. Ruta, G. T. Lloyd, Superiority, competition, and opportunism in the evolutionary radiation of dinosaurs. *Science* (80-.). (2008).
 26. R. B. J. Benson, G. Hunt, M. T. Carrano, N. Campione, Cope's rule and the adaptive landscape of dinosaur body size evolution. *Palaeontology* (2018).
 27. R. B. J. Benson, N. E. Campione, M. T. Carrano, P. D. Mannion, C. Sullivan, P. Upchurch, D. C. Evans, Rates of Dinosaur Body Mass Evolution Indicate 170 Million Years of Sustained Ecological Innovation on the Avian Stem Lineage.

- PLoS Biol.* (2014).
28. K. T. Bates, R. B. J. Benson, P. L. Falkingham, A computational analysis of locomotor anatomy and body mass evolution in Allosauroidea (Dinosauria: Theropoda). *Paleobiology* (2012).
 29. C. Foth, B. P. Hedrick, M. D. Ezcurra, Cranial ontogenetic variation in early saurischians and the role of heterochrony in the diversification of predatory dinosaurs. *PeerJ* (2016).
 30. E. J. Rayfield, D. B. Norman, C. C. Horner, J. R. Horner, P. M. Smith, J. J. Thomason, P. Upchurch, Cranial design and function in a large theropod dinosaur. *Nature* (2001).
 31. R. Delcourt, Ceratosaur palaeobiology: New insights on evolution and ecology of the southern rulers. *Sci. Rep.* (2018).
 32. J. O. Farlow, T. R. Holtz, The Fossil Record of Predation in Dinosaurs. *Paleontol. Soc. Pap.* (2002).
 33. T. D. Carr, A high-resolution growth series of *Tyrannosaurus rex* obtained from multiple lines of evidence . *PeerJ* (2020).
 34. A. R. Fiorillo, R. A. Gangloff, Theropod teeth from the prince creek formation (cretaceous) of northern alaska, with speculations on arctic dinosaur paleoecology. *J. Vertebr. Paleontol.* (2001).
 35. M. J. Ryan, P. J. Currie, J. D. Gardner, M. K. Vickaryous, J. M. Lavigne, Baby hadrosaur material associated with an unusually high abundance of *Troodon* teeth from the Horseshoe Canyon Formation, Upper Cretaceous, Alberta, Canada. *Gaia* (2000).

36. S. Wang, J. Stiegler, R. Amiot, X. Wang, G. hao Du, J. M. Clark, X. Xu, Extreme Ontogenetic Changes in a Ceratosaurian Theropod. *Curr. Biol.* (2017).
37. G. M. Erickson, P. J. Makovicky, P. J. Currie, M. A. Norell, S. A. Yerby, C. A. Brochu, Gigantism and comparative life-history parameters of tyrannosaurid dinosaurs. *Nature* (2004).
38. P. J. Bybee, A. H. Lee, E. T. Lamm, Sizing the jurassic theropod dinosaur Allosaurus: Assessing growth strategy and evolution of ontogenetic scaling of limbs. *J. Morphol.* (2006).
39. D. Stiles, The ivory trade and elephant conservation. *Environ. Conserv.* (2004).
40. J. C. Parish, P. M. Barrett, A reappraisal of the ornithischian dinosaur Amtosaurus magnus Kurzanov and Tumanova 1978, with comments on the status of A. archibaldi Averianov 2002. *Can. J. Earth Sci.* (2004).
41. N. E. Campione, D. C. Evans, Cranial growth and variation in edmontosaurs (dinosauria: Hadrosauridae): Implications for latest cretaceous megaherbivore diversity in North America. *PLoS One* (2011).
42. S. C. R. Maidment, G. Wei, A review of the Late Jurassic stegosaurs (Dinosauria, Stegosauria) from the People's Republic of China. *Geol. Mag.* (2006).
43. G. S. Paul, *The Princeton field guide to dinosaurs, Second Edition* (2016).
44. F. E. Novas, F. L. Agnolín, S. Bandyopadhyay, Cretaceous theropods from India: a review of specimens described by Huene and Matley (1933). *Rev. del Mus. Argentino Ciencias Nat. nueva Ser.* **6**, 67–103 (2004).
45. K. Carpenter, P. Galton, A photo documentation of bipedal ornithischian dinosaurs from the Upper Jurassic Morrison Formation, USA. *Geol. Intermt. West* (2018).

46. D. B. Norman, A taxonomy of iguanodontians (dinosauria: Ornithopoda) from the lower Wealden Group (Cretaceous: Valanginian) of southern England. *Zootaxa* (2010).
47. D. B. Norman, On Asian ornithopods (Dinosauria: Ornithischia) A new species of iguanodontid dinosaur. *Zool. J. Linn. Soc.* (1998).
48. A. Prieto-Marquez, J. R. Wagner, Pararhabdodon isonensis and Tsintaosaurus spinorhinus: a new clade of lambeosaurine hadrosaurids from Eurasia. *Cretac. Res.* (2009).
49. G. Funston, Caenagnathids of the Dinosaur Park Formation (Campanian) of Alberta, Canada: anatomy, osteohistology, taxonomy, and evolution. *Vertebr. Anat. Morphol. Palaeontol.* (2020).
50. D. W. Krause, S. D. Sampson, M. T. Carrano, P. M. O'Connor, Overview of the history of discovery, taxonomy, phylogeny, and biogeography of majungasaurus crenatissimus (theropoda: Abelisauridae) from the late cretaceous of madagascar. *J. Vertebr. Paleontol.* (2007).
51. V. M. Arbour, Systematics, evolution, and biogeography of the ankylosaurid dinosaurs (Thesis). *Dep. Biol. Sci. Univ. Alberta* (2014).
52. R. T. Bakker, M. Williams, P. J. Currie, Nanotyrannus, a new genus of pygmy tyrannosaur, from the latest Cretaceous of Montana. *Hunteria* (1988).
53. P. J. Currie, Cranial anatomy of tyrannosaurid dinosaurs from the Late Cretaceous of Alberta, Canada. *Acta Palaeontol. Pol.* (2003).
54. S. L. Brusatte, T. D. Carr, T. E. Williamson, T. R. Holtz, D. W. E. Hone, S. A. Williams, Dentary groove morphology does not distinguish 'Nanotyrannus' as a

- valid taxon of tyrannosauroid dinosaur. Comment on: “Distribution of the dentary groove of theropod dinosaurs: Implications for theropod phylogeny and the validity of the genus *Nanotyrannu*. *Cretac. Res.* (2016).
55. T. D. Carr, A high-resolution growth series of *Tyrannosaurus rex* obtained from multiple lines of evidence. *PeerJ* (2020).
 56. T. D. Carr, T. E. Williamson, Diversity of late Maastrichtian Tyrannosauridae (Dinosauria: Theropoda) from western North America. *Zool. J. Linn. Soc.* (2004).
 57. T. R. Holtz Jr, *Dinosaurs: The Most Complete, Up-to-Date Encyclopedia for Dinosaur Lovers of All Ages (Updated Internet Supplement)* (Random House Books for Young Readers, 2007).
 58. A. Averianov, H. D. Sues, Morphometric analysis of the teeth and taxonomy of the enigmatic theropod *Richardoestesia* from the Upper Cretaceous of Uzbekistan. *J. Vertebr. Paleontol.* (2019).
 59. A. T. McDonald, A subadult specimen of *Rubeosaurus ovatus* (Dinosauria: Ceratopsidae), with observations on other ceratopsids from the two medicine formation. *PLoS One* (2011).
 60. J. A. Wilson, P. Upchurch, A revision of *titanosaurus lydekker* (dinosauria - sauropoda), the first dinosaur genus with a ‘gondwanan’ distribution. *J. Syst. Palaeontol.* (2003).
 61. J. B. Scannella, J. R. Horner, “*Nedoceratops*”: An example of a transitional morphology. *PLoS One* (2011).
 62. J. B. Scannella, J. R. Horner, *Torosaurus* Marsh, 1891, is *Triceratops* Marsh, 1889 (Ceratopsidae: Chasmosaurinae): Synonymy through ontogeny. *J. Vertebr.*

- Paleontol.* (2010).
63. L. Maiorino, A. A. Farke, T. Kotsakis, P. Piras, Is *Torosaurus* Triceratops? geometric morphometric evidence of late Maastrichtian ceratopsid dinosaurs. *PLoS One* (2013).
 64. N. R. Longrich, D. J. Field, *Torosaurus* is not triceratops: Ontogeny in chasmosaurine ceratopsids as a case study in dinosaur taxonomy. *PLoS One* (2012).
 65. H. Xing, J. C. Mallon, M. L. Currie, Supplementary cranial description of the types of *Edmontosaurus regalis* (Ornithischia: Hadrosauridae), with comments on the phylogenetics and biogeography of Hadrosaurinae. *PLoS One* (2017).
 66. T. A. Tumanova, V. R. Alifanov, First Record of Stegosaur (Ornithischia, Dinosauria) from the Aptian–Albian of Mongolia. *Paleontol. J.* (2018).
 67. R. D. Juárez Valieri, J. A. Haro, L. E. Fiorelli, J. O. Calvo, A new hadrosauroid (Dinosauria: Ornithopoda) from the Allen Formation (Late Cretaceous) of Patagonia, Argentina. *Rev. del Mus. Argentino Ciencias Nat. Nueva Ser.* (2010).
 68. P. Cruzado-Caballero, R. A. Coria, Revisiting the hadrosaurid (Dinosauria: Ornithopoda) diversity of the allen formation: A re-evaluation of *willinakaqe salitralensis* from salitral moreno, Río Negro Province, Argentina. *Ameghiniana* (2016).
 69. T. Sekiya, X. Jin, W. Zheng, M. Shibata, Y. Azuma, A new juvenile specimen of *Yunnanosaurus robustus* (Dinosauria: Sauropodomorpha) from Early to Middle Jurassic of Chuxiong Autonomous Prefecture, Yunnan Province, China. *Hist. Biol.* (2014).

70. A. Martinelli, A. Forasiepi, Late Cretaceous vertebrates from bajo de Santa Rosa (Allen Formation), Río Negro province, Argentina, with the description of a new sauropod dinosaur (Titanosauridae). *Rev. del Mus. Argentino Ciencias Nat.* (2004).
71. R. Molina-Pérez, A. Larramendi, *Dinosaur Facts and Figures: The Sauropods and Other Sauropodomorphs* (Princeton University Press, 2020).
72. L. Salgado, C. Azpilicueta, A new saltasaurine dinosaur (Sauropoda, Titanosauridae) from the Rio Negro Province (Allen Formation, Upper Cretaceous), Patagonia, Argentina. *Ameghiniana* (2000).
73. F. Seebacher, A new method to calculate allometric length-mass relationships of dinosaurs. *J. Vertebr. Paleontol.* (2001).
74. P. Cruzado-Caballero, J. Powell, Bonapartesaurus rionegrensis, a new hadrosaurine dinosaur from South America: implications for phylogenetic and biogeographic relations with North America. *J. Vertebr. Paleontol.* (2017).
75. R. A. Coria, B. G. Riga, S. Casadio, A new hadrosaurid (Dinosauria, ornithopoda) from allen formation, la pampa Province, Argentina. *Ameghiniana* (2012).
76. L. Salgado, R. A. Coria, C. M. Magalhaes Ribeiro, A. Garrido, R. Rogers, M. E. Simón, A. B. Arcucci, K. C. Rogers, A. P. Carabajal, S. Apesteguía, M. Fernández, R. A. García, M. Talevi, Upper Cretaceous dinosaur nesting sites of Río Negro (Salitral Ojo de Agua and Salinas de Trapalcó-Salitral de Santa Rosa), northern Patagonia, Argentina. *Cretac. Res.* (2007).
77. L. Salgado, R. A. Coria, The genus Aeolosaurus (Sauropoda, Titanosauridae) in the Allen Formation (Campanian-Maastrichtian) of Rio Negro Province, Argentina. *Ameghiniana* (1993).

78. J. Porfiri, J. Calvo, *Panamericansaurus schroederi* gen. nov. sp. nov. Un nuevo Sauropoda (Titanosauridae-Aeolosaurini) de la Provincia del Neuquén, Cretácico Superior de Patagonia, Argentina. *Brazilian Geogr. J. Geosci. Humanit. Res. Mediu.* **1** (2010).
79. R. A. Garcia, L. Salgado, The titanosaur sauropods from the late campanian-early maastrichtian allen formation of Salitral Moreno, Río Negro, Argentina. *Acta Palaeontol. Pol.* (2013).
80. G. V. Mazzetta, P. Christiansen, R. A. Fariña, Giants and bizarres: Body size of some Southern South American Cretaceous dinosaurs. *Hist. Biol.* (2004).
81. R. A. García, A giant tooth from the Late Cretaceous (middle Campanian-lower Maastrichtian) of Patagonia, Argentina: An enormous titanosaur or a large toothed titanosaur? *Cretac. Res.* (2013).
82. M. J. Benton, *Prehistoric Life* (Dorling Kindersley, Edinburgh, Scotland, 2012).
83. F. L. Agnolin, J. E. Powell, F. E. Novas, M. Kundrát, New alvarezsaurid (Dinosauria, Theropoda) from uppermost Cretaceous of north-western Patagonia with associated eggs. *Cretac. Res.* (2012).
84. F. E. Novas, D. Pol, J. I. Canale, J. D. Porfiri, J. O. Calvo, A bizarre Cretaceous theropod dinosaur from Patagonia and the evolution of Gondwanan dromaeosaurids. *Proc. R. Soc. B Biol. Sci.* (2009).
85. R. A. Coria, D. H. Tanke, K. Carpenter, in *Mesozoic Vertebrate Life* (2001).
86. R. Molina-Pérez, A. Larramendi, *Dinosaur Facts and Figures: The Theropods and Other Dinosauriformes* (Princeton University Press, 2020).
87. H. A. Leanza, S. Apesteguía, F. E. Novas, M. S. de la Fuente, Cretaceous

- terrestrial beds from the Neuquén Basin (Argentina) and their tetrapod assemblages. *Cretac. Res.* (2004).
88. R. A. Coria, L. S. Filippi, L. M. Chiappe, R. García, A. B. Arcucci, Overosaurusparadasorum gen. et sp. Nov., a new sauropod dinosaur (Titanosauria: Lithostrotia) from the Late Cretaceous of neuquén, Patagonia, Argentina. *Zootaxa* (2013).
 89. L. S. Filippi, A. C. Garrido, Pitekunsaurus macayai gen. et sp. nov., nuevo titanosaurio (Saurischia, Sauropoda) del Cretácico Superior de la Cuenca Neuquina, Argentina. *Ameghiniana* (2008).
 90. L. S. Filippi, R. A. García, A. C. Garrido, A new titanosaur sauropod dinosaur from the upper cretaceous of North Patagonia, Argentina. *Acta Palaeontol. Pol.* (2011).
 91. L. Salgado, R. A. Coria, Barrosasaurus casamiquelai gen. et sp. nov., a new titanosaur (Dinosauria, Sauropoda) from the anacleto formation (Late Cretaceous: Early campanian) of sierra barrosa (Neuquén, Argentina). *Zootaxa* (2009).
 92. G. Grellet-Tinner, V. Codrea, A. Folie, A. Higa, T. Smith, First evidence of reproductive adaptation to “Island effect” of a Dwarf Cretaceous Romanian titanosaur, with embryonic integument in Ovo. *PLoS One* (2012).
 93. P. C. Sereno, R. N. Martinez, J. A. Wilson, D. J. Varricchio, O. A. Alcober, H. C. E. Larsson, Evidence for avian intrathoracic air sacs in a new predatory dinosaur from Argentina. *PLoS One* (2008).
 94. P. Cruzado-Caballero, L. S. Filippi, A. H. Méndez, A. C. Garrido, I. Díaz-Martínez, First ornithopod remains from the Bajo de la Carpa Formation

- (Santonian, Upper Cretaceous), northern Patagonia, Argentina. *Cretac. Res.* (2018).
95. P. Cruzado-Caballero, A. H. Mendez, L. S. Filippi, R. D. Juárez Valieri, A. C. Garrido, Palaeobiodiversity of the Bajo de la Carpa Formation (Santonian, Upper Cretaceous) in the Cerro Overo-La Invernada area, northern Patagonia, Argentina. *VII Jornadas Int. sobre Paleontol. Dinosaur. y su Entorno. Libr. Resúmenes*, 53e55. *Sala los Infantes, Burgos* (2016).
 96. A. G. Martinelli, E. I. Vera, *Achillesaurus manazzonei*, a new alvarezsaurid theropod (Dinosauria) from the Late Cretaceous Bajo de la Carpa Formation, Río Negro Province, Argentina. *Zootaxa* (2007).
 97. J. D. Porfiri, R. D. Juárez Valieri, D. D. D. Santos, M. C. Lamanna, A new megaraptoran theropod dinosaur from the Upper Cretaceous Bajo de la Carpa Formation of northwestern Patagonia. *Cretac. Res.* (2018).
 98. M. D. Ezcurra, A. H. Méndez, First report of a derived abelisaurid theropod from the Bajo de la Carpa Formation (Late Cretaceous), Patagonia, Argentina. *Bull. Geosci.* (2009).
 99. N. R. Longrich, P. J. Currie, D. Zhi-Ming, A new oviraptorid (dinosauria: Theropoda) from the upper cretaceous of bayan mandahu, inner mongolia. *Palaeontology* (2010).
 100. T. Jerzykiewicz, D. A. Russell, Late Mesozoic stratigraphy and vertebrates of the Gobi Basin. *Cretac. Res.* (1991).
 101. V. M. Arbour, P. J. Currie, D. Badamgarav, The ankylosaurid dinosaurs of the Upper Cretaceous Baruungoyot and Nemegt formations of Mongolia. *Zool. J.*

- Linn. Soc.* (2014).
102. S. M. Kurzanov, a F. Banikov, A new sauropod from the Upper Cretaceous of Mongolia. *Paleontol. Zhurnal* (1983).
 103. V. R. Alifanov, R. Barsbold, *Ceratonykus oculatus* gen. et sp. nov., a new dinosaur (?Theropoda, Alvarezsauria) from the late cretaceous of Mongolia. *Paleontol. J.* (2009).
 104. D. B. Weishampel, P. Dodson, H. Osmólska, *The Dinosauria* (University of California Press, ed. 2nd, 2007).
 105. H. Osmólska, *Hulsanpes perlei* n.g. n.sp. (Deinonychosauria, Saurischia, Dinosauria) from the Upper Cretaceous Barun Goyot Formation of Mongolia. *Neues Jahrb. für Geol. und Paläontologie - Monatshefte* (1982).
 106. J. Nakajima, Y. Kobayashi, T. Chinzorig, T. Tanaka, R. Takasaki, K. Tsogtbaatar, P. J. Currie, A. R. Fiorillo, Dinosaur tracks at the Nemegt locality: Paleobiological and paleoenvironmental implications. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* (2018).
 107. B. Rinchen, T. Khishigjav, in *12th Symposium on Mesozoic Terrestrial Ecosystems* (2015).
 108. T. Maryńska, H. Osmólska, Protoceratopsidae (Dinosauria) of Asia. *Palaeontol. Pol.* (1975).
 109. M. Watabe, K. Tsogtbaatar, R. M. Sullivan, A new pachycephalosaurid from the Baynshire Formation (Cenomanian-late Santonian), Gobi Desert, Mongolia. *New Mex. Museum Nat. Hist. Sci. Bull.* (2011).
 110. A. O. Averianov, An ankylosaurid (Ornithischia: Ankylosauria) braincase from the

- Upper Cretaceous Bissekty formation of Uzbekistan. *Bull. l'Institut R. des Sci. Nat. Belgique, Sci. la Terre* (2002).
111. M. K. Brett-Surman, in *Mesozoic Vertebrate Life*, D. H. Tanke, K. Carpenter, Eds. (Indiana University Press, First., 2001).
 112. J. Van Itterbeeck, D. J. Horne, P. Bultynck, N. Vandenberghe, Stratigraphy and palaeoenvironment of the dinosaur-bearing Upper Cretaceous Iren Dabasu Formation, Inner Mongolia, People's Republic of China. *Cretac. Res.* (2005).
 113. K. Tsogtbaatar, D. B. Weishampel, D. C. Evans, M. Watabe, A new hadrosauroid (Dinosauria: Ornithopoda) from the Late Cretaceous Baynshire Formation of the Gobi Desert (Mongolia). *PLoS One* (2019).
 114. T. Tsuihiji, M. Watabe, R. Barsbold, K. Tsogtbaatar, A gigantic caenagnathid oviraptorosaurian (Dinosauria: Theropoda) from the Upper Cretaceous of the Gobi Desert, Mongolia. *Cretac. Res.* (2015).
 115. X. Xu, Q. Tan, J. Wang, X. Zhao, L. Tan, A gigantic bird-like dinosaur from the Late Cretaceous of China. *Nature* (2007).
 116. D. T. Ksepka, M. A. Norell, Erketu Ellisoni, a Long-necked Sauropod from Bor Guvé (Dornogov Aimag, Mongolia). *Am. Museum Novit.* (2006).
 117. A. Perle, M. A. Norell, J. M. Clark, A new maniraptoran theropod, *Achillobator giganticus* (Dromaeosauridae), from the Upper Cretaceous of Burkhan, Mongolia (Geology and Mineralogy Chair, National University of Mongolia, Ulan Bator, Mongolia, 1999).
 118. H. D. Sues, A. Averianov, A new basal hadrosauroid dinosaur from the Late Cretaceous of Uzbekistan and the early radiation of duck-billed dinosaurs. *Proc. R.*

Soc. B Biol. Sci. (2009).

119. H. D. Sues, A. Averianov, Ornithomimidae (Dinosauria: Theropoda) from the Bissekty Formation (Upper Cretaceous: Turonian) of Uzbekistan. *Cretac. Res.* (2016).
120. L. P. Tatarinov, L. A. Nessel. Dinosaurs of the Northern Eurasia: New Data about Assemblages, Ecology, and Palaeobiogeography. *Russ. J. Herpetol.* (1996).
121. A. Averianov, H. D. Sues, Review of Cretaceous sauropod dinosaurs from Central Asia. *Cretac. Res.* (2017).
122. P. J. Currie, S. J. Godfrey, L. Nessel, New caenagnathid (Dinosauria: Theropoda) specimens from the Upper Cretaceous of North America and Asia. *Can. J. Earth Sci.* (1993).
123. H. D. Sues, A. Averianov, Enigmatic teeth of small theropod dinosaurs from the Upper Cretaceous (Cenomanian-Turonian) of Uzbekistan. *Can. J. Earth Sci.* (2013).
124. S. M. Kurzanov, Brain-case structure in the carnosaur *Itemirus* n. gen. and some aspects of the cranial anatomy of dinosaurs. *Paleontol. Zhurnal* (1976).
125. S. L. Brusatte, A. Averianov, H. D. Sues, A. Muir, I. B. Butler, New tyrannosaur from the mid-Cretaceous of Uzbekistan clarifies evolution of giant body sizes and advanced senses in tyrant dinosaurs. *Proc. Natl. Acad. Sci. U. S. A.* (2016).
126. D. M. Martill, A review of the terrestrial vertebrate fossils of the Oxford Clay (Callovian-Oxfordian) of England. *Mercian Geol.* (1988).
127. R. Lydekker, On the Jaw of a New Carnivorous Dinosaur from the Oxford Clay of Peterborough. *Q. J. Geol. Soc. London* (1893).

128. J. W. Hulke, Note on some dinosaurian remains in the collection of A. Leeds, Esq., of Eyebury, Northamptonshire. *Q. J. Geol. Soc. London* (1887).
129. A. J. Charig, in *Aspects of Vertebrate History: Essays in Honor of Edwin Harris Colbert*, L. L. Jacobs, Ed. (Museum of Northern Arizona Press, Flagstaff, 1980).
130. J. B. Delair, The dinosaurs of Wiltshire. *Wiltsh. Archaeol. Nat. Hist. Mag.* 68 (1973), pp. 1–7.
131. Triassic reptiles from the Elgin area: Ornithosuchus and the origin of carnosaurs . *Philos. Trans. R. Soc. Lond. B. Biol. Sci.* (1964).
132. F. Von Huene, Carnivorous saurischia in Europe since the triassic. *Bull. Geol. Soc. Am.* (1923).
133. B. J. Chinnery, T. R. Lipka, J. I. Kirkland, M. J. Parrish, M. K. Brett-Surman, Neoceratopsian teeth from the Lower to Middle Cretaceous of North America. *New Mex. Museum Nat. Hist. Sci. Bull.* 14 *Low. Middle Cretac. Terr. Ecosyst.* (1998).
134. A. A. Farke, W. D. Maxwell, R. L. Cifelli, M. J. Wedel, A ceratopsian dinosaur from the lower cretaceous of Western North America, and the biogeography of Neoceratopsia. *PLoS One* (2014).
135. R. L. Cifelli, R. L. Nydam, J. D. Gardner, A. Weil, J. G. Eaton, J. I. Kirkland, S. K. Madsen, Medial Cretaceous vertebrates from the Cedar Mountain Formation, Emery County, Utah; the Mussentuchit local fauna. *Misc. Publ. Utah Geol. Surv.* (1999).
136. J. I. Kirkland, M. Suarez, C. Suarez, R. Hunt-Foster, The Lower Cretaceous in east-central Utah—The Cedar Mountain Formation and its bounding strata. *Geol.*

Intermt. West (2016).

137. K. Carpenter, J. I. Kirkland, D. L. Burge, J. Bird, Ankylosaurs (Dinosauria: Ornithischia) of the Cedar Mountain Formation, Utah and their stratigraphic distribution. *Vertebr. Paleontol. Utah* (1999).
138. K. Carpenter, Y. Ishida, Early and “middle” cretaceous iguanodonts in time and space. *J. Iber. Geol.* (2010).
139. J. R. Garrison, D. Brinkman, D. J. Nichols, P. Layer, D. Burge, D. Thayn, A multidisciplinary study of the Lower Cretaceous Cedar Mountain Formation, Mussentuchit Wash, Utah: a determination of the paleoenvironment and paleoecology of the Eolambia caroljonesa dinosaur quarry. *Cretac. Res.* (2007).
140. K. Carpenter, J. Bartlett, J. Bird, R. Barrick, Ankylosaurs from the Price River Quarries, Cedar Mountain Formation (Lower Cretaceous), east-central Utah. *J. Vertebr. Paleontol.* (2008).
141. R. D. Conkwright, Fact Sheet No. 15 Maryland’s State Dinosaur (*Astrodon johnstoni*). *Maryl. Geol. Surv. Div. Coast. Estuar. Geol.*, (available at www.mgs.md.gov/geology/fossils/maryland_state_dinosaur.html).
142. J. A. Frederickson, M. H. Engel, R. L. Cifelli, Niche Partitioning in Theropod Dinosaurs: Diet and Habitat Preference in Predators from the Uppermost Cedar Mountain Formation (Utah, U.S.A.). *Sci. Rep.* (2018).
143. L. E. Zanno, P. J. Makovicky, Neovenatorid theropods are apex predators in the Late Cretaceous of North America. *Nat. Commun.* (2013).
144. M. P. J. Oreska, M. T. Carrano, K. M. Dzikiewicz, Vertebrate paleontology of the cloverly formation (lower cretaceous), I: Faunal composition, biogeographic

- relationships, and sampling. *J. Vertebr. Paleontol.* (2013).
145. W. L. Parsons, K. M. Parsons, A new ankylosaur (Dinosauria: Ankylosauria) from the lower cretaceous cloverly formation of central Montana. *Can. J. Earth Sci.* (2009).
146. D. C. Woodruff, A new titanosauriform from the Early Cretaceous Cloverly Formation of Montana. *Cretac. Res.* (2012).
147. M. J. Wedel, R. L. Cifelli, R. K. Sanders, Osteology, paleobiology, and relationships of the sauropod dinosaur Sauroposeidon. *Acta Palaeontol. Pol.* (2000).
148. R. M. Sullivan, Revision of the dinosaur *Stegoceras lambe* (ornithischia, pachycephalosauridae). *J. Vertebr. Paleontol.* (2003).
149. D. A. Eberth, D. C. Evans, D. B. Brinkman, F. Therrien, D. H. Tanke, L. S. Russell, Dinosaur biostratigraphy of the Edmonton group (upper Cretaceous), Alberta, Canada: Evidence for climate influence. *Can. J. Earth Sci.* (2013).
150. J. C. Mallon, Competition structured a Late Cretaceous megaherbivorous dinosaur assemblage. *Sci. Rep.* (2019).
151. J. C. Mallon, D. C. Evans, M. J. Ryan, J. S. Anderson, Megaherbivorous dinosaur turnover in the Dinosaur Park Formation (upper Campanian) of Alberta, Canada. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* (2012).
152. N. R. Longrich, P. J. Currie, A microraptorine (Dinosauria-Dromaeosauridae) from the Late Cretaceous of North America. *Proc. Natl. Acad. Sci. U. S. A.* (2009).
153. D. W. Larson, P. J. Currie, Multivariate Analyses of Small Theropod Dinosaur Teeth and Implications for Paleoeological Turnover through Time. *PLoS One*

- (2013).
154. G. F. Funston, P. J. Currie, New material of *Chirostenotes pergracilis* (Theropoda, Oviraptorosauria) from the Campanian Dinosaur Park Formation of Alberta, Canada. *Hist. Biol.* (2020).
 155. G. F. Funston, W. S. Persons, G. J. Bradley, P. J. Currie, New material of the large-bodied caenagnathid *Caenagnathus collinsi* from the Dinosaur Park Formation of Alberta, Canada. *Cretac. Res.* (2015).
 156. V. M. Arbour, M. E. Burns, R. L. Sissons, A redescription of the ankylosaurid dinosaur *Dyoplosaurus acutosquameus* Parks, 1924 (Ornithischia: Ankylosauria) and a revision of the genus. *J. Vertebr. Paleontol.* (2009).
 157. Ł. Czepiński, Ontogeny and variation of a protoceratopsid dinosaur *Bagaceratops rozhdestvenskyi* from the Late Cretaceous of the Gobi Desert. *Hist. Biol.* (2019).
 158. C. Tsogtbaatar, Y. Kobayashi, T. Khishigjav, P. J. Currie, M. Watabe, B. Rinchen, First Ornithomimid (Theropoda, Ornithomimosauria) from the Upper Cretaceous Djadokhta Formation of Tögrögiin Shiree, Mongolia. *Sci. Rep.* (2017).
 159. L. M. Chiappe, M. A. Norell, J. M. Clark, in *Mesozoic birds: above the heads of dinosaurs* (2002), pp. 87–120.
 160. A. H. Turner, D. Pol, M. A. Norell, Anatomy of *Mahakala omnogovae* (Theropoda: Dromaeosauridae), Tögr ögiin Shiree, Mongolia. *Am. Museum Novit.* (2011).
 161. A. Cau, V. Beyrand, D. F. A. E. Voeten, V. Fernandez, P. Tafforeau, K. Stein, R. Barsbold, K. Tsogtbaatar, P. J. Currie, P. Godefroit, Synchrotron scanning reveals amphibious ecomorphology in a new clade of bird-like dinosaurs. *Nature* (2017).

162. M. H. Schweitzer, J. A. Watt, R. Avci, L. Knapp, L. Chiappe, M. Norell, M. Marshall, Beta-keratin specific immunological reactivity in feather-like structures of the Cretaceous Alvarezsaurid, *Shuvuuia deserti*. *J. Exp. Zool.* (1999).
163. P. J. Makovicky, M. A. Norell, J. M. Clark, T. B. Rowe, Osteology and Relationships of *Byronosaurus jaffei* (Theropoda: Troodontidae). *Am. Museum Novit.* (2003).
164. A. H. Turner, S. J. Nesbitt, M. A. Norell, A large alvarezsaurid from the Late Cretaceous of Mongolia. *Am. Museum Novit.* (2009).
165. M. A. Norell, J. M. Clark, A. H. Turner, P. J. Makovicky, R. Barsbold, T. Rowe, A new dromaeosaurid theropod from Ukhaa Tolgod (Ömnögovi, Mongolia). *Am. Museum Novit.* (2006).
166. J. M. Clark, M. A. Norell, R. Barsbold, Two new oviraptorids (theropoda: Oviraptorosauria), upper cretaceous djadokhta formation, ukhaa tolgod, Mongolia. *J. Vertebr. Paleontol.* (2001).
167. F. v. Huene, The fossil reptile order Saurischia, their development and history. *Monogr. zur Geol. und Palaeontol.* (1932).
168. P. R. Bell, F. Fanti, L. J. Hart, L. A. Milan, S. J. Craven, T. Brougham, E. Smith, Revised geology, age, and vertebrate diversity of the dinosaur-bearing Griman Creek Formation (Cenomanian), Lightning Ridge, New South Wales, Australia. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* (2019).
169. P. R. Bell, M. C. Herne, T. Brougham, E. T. Smith, Ornithomimid diversity in the Griman Creek Formation (Cenomanian), New South Wales, Australia. *PeerJ* (2018).

170. R. E. Molnar, in *Vertebrate Paleontology of Australasia*, P. Vickers-Rich, J. M. Monaghan, R. F. Baird, T. H. Rich, Eds. (Pioneer Design Studio in cooperation with the Monash University Publications Committee, 1991).
171. F. L. Agnolin, M. D. Ezcurra, D. F. Paisc, S. W. Salisbury, A reappraisal of the cretaceous non-avian dinosaur faunas from Australia and New Zealand: Evidence for their Gondwanan affinities. *J. Syst. Palaeontol.* (2010).
172. P. R. Bell, T. Brougham, M. C. Herne, T. Frauenfelder, E. T. Smith, *Fostoria dhimbangunmal*, gen. et sp. nov., a new iguanodontian (Dinosauria, Ornithopoda) from the mid-Cretaceous of Lightning Ridge, New South Wales, Australia. *J. Vertebr. Paleontol.* (2019).
173. R. E. Molnar, S. W. Salisbury, in *Thunder-lizards: The Sauropodomorph Dinosaurs* (2005).
174. T. Brougham, E. T. Smith, P. R. Bell, Noasaurids are a component of the Australian ‘mid’-Cretaceous theropod fauna. *Sci. Rep.* (2020).
175. T. Brougham, E. T. Smith, P. R. Bell, New theropod (Tetanurae: Avetheropoda) material from the ‘mid’-Cretaceous Griman Greek Formation at Lightning Ridge, New South Wales, Australia. *R. Soc. Open Sci.* (2019).
176. H. Mallison, The digital Plateosaurus II: An assessment of the range of motion of the limbs and vertebral column and of previous reconstructions using a digital skeletal mount. *Acta Palaeontol. Pol.* (2010).
177. N. D. Smith, D. Pol, Anatomy of a basal sauropodomorph dinosaur from the Early Jurassic Hanson Formation of Antarctica. *Acta Palaeontol. Pol.* (2007).
178. P. J. Makovicky, Antarctic Dinosaurs. *Encycl. Br.* (2012), (available at

www.britannica.com/topic/Antarctic-Dinosaurs-1812725).

179. W. R. Hammer, W. J. Hickerson, R. W. Slaughter, A dinosaur assemblage from the Transantarctic Mountains. *Antarct. J. Review*, 31–33 (1994).
180. C. L. Camp, A new type of small bipedal dinosaur from the Navajo Sandstone of Arizona. *Univ. Calif. Publ. Geol. Sci.* (1936).
181. N. D. Smith, P. J. Currie, W. R. Hammer, P. J. Makovicky, D. Pol, C. E. Raymond, S. International Symposium on Antarctic Earth, The dinosaurs of the Early Jurassic Hanson Formation of the central Transantarctic Mountains; phylogenetic review and synthesis. *Open-File Rep. - U. S. Geol. Surv.* (2007).
182. P. M. Galton, The species of the basal hypsilophodontid dinosaur *Thescelosaurus* Gilmore (Ornithischia: Ornithopoda) from the Late Cretaceous of North America. *Neues Jahrb. für Geol. und Paläontologie - Abhandlungen* (1995).
183. M. B. Goodwin, New occurrences of pachycephalosaurid dinosaurs from the Hell Creek Formation, Garfield County, Montana. *J. Vertebr. Paleontol.* **9** (1989).
184. D. J. Varricchio, in *Mesozoic Vertebrate Life* (2001).
185. G. F. Funston, P. J. Currie, M. E. Burns, New Elmsaurine Specimens from North America and Their Relationship to the Mongolian *Elmsaurus rarus*. *Acta Palaeontol. Pol.* (2016).
186. T. E. Williamson, T. D. Carr, A new genus of derived pachycephalosaurian from western North America. *J. Vertebr. Paleontol.* (2003).
187. C. A. Boyd, C. M. Brown, R. D. Scheetz, J. A. Clarke, Taxonomic revision of the basal neornithischian taxa *Thescelosaurus* and *Bugenasaura*. *J. Vertebr. Paleontol.* (2009).

188. C. J. Ott, in *Horns and Beaks: Ceratopsian and Ornithopod Dinosaurs* (2006).
189. T. W. Stanton, in *Proceedings of the Washington Academy of Sciences 11* (3) (1909), pp. 239–293.
190. M. B. Goodwin, E. A. Buchholtz, R. E. Johnson, Cranial anatomy and diagnosis of *Stygimoloch spinifer* (ornithischia: Pachycephalosauria) with comments on cranial display structures in agonistic behavior. *J. Vertebr. Paleontol.* (1998).
191. K. Carpenter, Redescription of *Ankylosaurus magniventris* Brown 1908 (Ankylosauridae) from the Upper Cretaceous of the Western Interior of North America. *Can. J. Earth Sci.* (2004).
192. M. Wosik, M. B. Goodwin, D. C. Evans, A nestling-sized skeleton of *Edmontosaurus* (Ornithischia, Hadrosauridae) from the Hell Creek Formation of northeastern Montana, U.S.A., with an analysis of ontogenetic limb allometry. *J. Vertebr. Paleontol.* (2017).
193. A. T. McDonald, C. E. Campbell, B. Thomas, A new specimen of the controversial chasmosaurine *Torosaurus latus* (Dinosauria: Ceratopsidae) from the upper cretaceous hell creek formation of Montana. *PLoS One* (2016).
194. D. A. Pearson, T. Schaefer, K. R. Johnson, D. J. Nichols, J. P. Hunter, Vertebrate biostratigraphy of the Hell Creek Formation in southwestern North Dakota and northwestern South Dakota. *Spec. Pap. Geol. Soc. Am.* (2002).
195. J. H. Hartman, K. R. Johnson, D. J. Nichols, The Hell Creek Formation and the Cretaceous-Tertiary Boundary in the Northern Great Plains: An Integrated Continental Record of the End of the Cretaceous. *Geol. Soc. Am. Spec. Pap.* **361** (2002).

196. J. T. Sankey, in *Vertebrate Microfossil Assemblages: Their Role in Paleoecology and Paleobiogeography*, J. T. Sankey, S. Baszio, Eds. (Indiana University Press, 2008).
197. L. E. Wilson, Comparative taphonomy and paleoecological reconstruction of two microvertebrate accumulations from the Late Cretaceous Hell Creek Formation (Maastrichtian), eastern Montana. *Palaios* (2008).
198. T. A. Gates, L. E. Zanno, P. J. Makovicky, Theropod teeth from the upper maastrichtian hell creek formation “sue” quarry: New morphotypes and faunal comparisons. *Acta Palaeontol. Pol.* (2015).
199. D. C. Evans, D. W. Larson, P. J. Currie, A new dromaeosaurid (Dinosauria: Theropoda) with Asian affinities from the latest Cretaceous of North America. *Naturwissenschaften* (2013).
200. M. Greenwald, The lower vertebrates of the Hell Creek Formation (upper Cretaceous), Harding County, South Dakota (Thesis). *South Dakota Sch. Mines Technol.*, 76 (1971).
201. M. C. Lamanna, H. D. Sues, E. R. Schachner, T. R. Lyson, A new large-bodied oviraptorosaurian theropod dinosaur from the Latest Cretaceous of Western North America. *PLoS One* (2014).
202. R. A. DePalma, D. A. Burnham, L. D. Martin, P. L. Larson, R. T. Bakker, The first giant raptor (Theropoda: dromaeosauridae) from the Hell Creek Formation. *Univ. Kansas Paleontol. Contrib.* **14**, 1–16 (2015).
203. D. A. Eberth, S. L. Kamo, High-precision U–PB CA–ID–TIMS dating and chronostratigraphy of the dinosaur-rich horseshoe canyon formation (Upper

- cretaceous, campanian–maastrichtian), red deer river valley, alberta, Canada. *Can. J. Earth Sci.* (2020).
204. W. Coombs, The Ankylosauridae (Dissertation). *Columbia Univ. New York*, 1–487 (1971).
 205. D. C. Evans, T. M. Cullen, D. W. Larson, A. Rego, A new species of troodontid theropod (Dinosauria: Maniraptora) from the horseshoe canyon formation (maastrichtian) of Alberta, Canada. *Can. J. Earth Sci.* (2017).
 206. E. Chung, Dinosaur’s Special Arm Muscles Likely Used to Flex Feathers in Mating Display. *CBC News* (2016), (available at www.cbc.ca/news/technology/apatoraptor-feathers-1.3536313).
 207. A. Sahni, The vertebrate fauna of the Judith River Formation, Montana. *Bull. Am Mus nat Hist* (1972).
 208. J. C. Mallon, C. J. Ott, P. L. Larson, E. M. Iuliano, D. C. Evans, *Spiclypeus shipporum* gen. et sp. nov., a boldly audacious new chasmosaurine ceratopsid (Dinosauria: Ornithischia) from the Judith River Formation (Upper Cretaceous: Campanian) of Montana, USA. *PLoS One* (2016).
 209. M. J. Ryan, D. C. Evans, P. J. Currie, M. A. Loewen, A new chasmosaurine from northern Laramidia expands frill disparity in ceratopsid dinosaurs. *Naturwissenschaften* (2014).
 210. M. J. Ryan, in *Geological Society of America Abstracts with Programs* (2006), p. 62.
 211. V. M. Arbour, D. C. Evans, A new ankylosaurine dinosaur from the judith river formation of montana, USA, based on an exceptional skeleton with soft tissue

- preservation. *R. Soc. Open Sci.* (2017).
212. C. A. Boyd, S. K. Drumheller, T. A. Gates, Crocodyliform Feeding Traces on Juvenile Ornithischian Dinosaurs from the Upper Cretaceous (Campanian) Kaiparowits Formation, Utah. *PLoS One* (2013).
 213. L. E. Zanno, M. A. Loewen, A. A. Farke, G. S. Kim, L. P. A. M. Claessens, C. T. McGarrity, in *At the Top of the Grand Staircase: The Late Cretaceous of Southern Utah* (2013).
 214. J. P. Wiersma, R. B. Irmis, A new southern Laramidian ankylosaurid, *Akainacephalus johnsoni* gen. et sp. nov., from the upper Campanian Kaiparowits Formation of southern Utah, USA. *PeerJ* (2018).
 215. S. D. Sampson, E. K. Lund, M. A. Loewen, A. A. Farke, K. E. Clayton, A remarkable short-snouted horned dinosaur from the Late Cretaceous (late Campanian) of southern Laramidia. *Proc. R. Soc. B Biol. Sci.* (2013).
 216. S. D. Sampson, M. A. Loewen, A. A. Farke, E. M. Roberts, C. A. Forster, J. A. Smith, A. L. Titus, New horned dinosaurs from Utah provide evidence for intracontinental dinosaur endemism. *PLoS One* (2010).
 217. T. A. Gates, S. D. Sampson, A new species of *Gryposaurus* (Dinosauria: Hadrosauridae) from the late Campanian Kaiparowits Formation, southern Utah, USA. *Zool. J. Linn. Soc.* (2007).
 218. T. E. Williamson, R. M. Sullivan, Reinterpretation of a *Parasaurolophus* skull from the Upper Cretaceous (Campanian) Kaiparowits Formation, Utah. *J. Vertebr. Paleontol.* **17**, 84A (1997).
 219. L. E. Zanno, D. J. Varricchio, P. M. O'Connor, A. L. Titus, M. J. Knell, A new

- troodontid theropod, *talos sampsoni* gen. et sp. nov., from the upper cretaceous western interior basin of North America. *PLoS One* (2011).
220. L. E. Zanno, S. D. Sampson, A new oviraptorosaur (Theropoda, Maniraptora) from the Late Cretaceous (Campanian) of Utah. *J. Vertebr. Paleontol.* (2005).
 221. T. D. Carr, T. E. Williamson, B. B. Britt, K. Stadtman, Evidence for high taxonomic and morphologic tyrannosauroid diversity in the Late Cretaceous (Late Campanian) of the American Southwest and a new short-skulled tyrannosaurid from the Kaiparowits formation of Utah. *Naturwissenschaften* (2011).
 222. R. S. Tykoski, Vertebrate paleontology in the Arizona Jurassic. *Mesa Southwest Museum Bull.* 11 (2005), pp. 72–93.
 223. J. M. Clark, D. E. Fastovsky, Vertebrate biostratigraphy of the Glen Canyon Group in northern Arizona. *Begin. age Dinosaur. faunal Chang. across Triassic-Jurassic Bound.* (1987).
 224. J. J. W. Sertich, M. A. Loewen, A new basal sauropodomorph dinosaur from the lower Jurassic Navajo sandstone of southern Utah. *PLoS One* (2010).
 225. T. B. Rowe, H. D. Sues, R. R. Reisz, Dispersal and diversity in the earliest North American sauropodomorph dinosaurs, with a description of a new Taxon. *Proc. R. Soc. B Biol. Sci.* (2011).
 226. K. Padian, Presence of the dinosaur *Scelidosaurus* indicates Jurassic age for the Kayenta Formation (Glen Canyon Group, northern Arizona). *Geology* (1989).
 227. R. Gay, in *Notes on Early Mesozoic Theropods* (2010), p. 44.
 228. T. Rowe, A new species of the theropod dinosaur *Syntarsus* from the early Jurassic Kayenta Formation of Arizona. *J. Vertebr. Paleontol.* (1989).

229. R. Gay, in *The Carnivorous Dinosaurs (Life of the Past*, K. Carpenter, Ed. (Indiana University Press, 2005), p. 392.
230. A. Averianov, P. Skutschas, A eutherian mammal from the early cretaceous of Russia and biostratigraphy of the asian early crataceous vertebrate assemblages. *Lethaia* (2000).
231. T. A. Gates, K. Tsogtbaatar, L. E. Zanno, T. Chinzorig, M. Watabe, A new iguanodontian (Dinosauria: Ornithopoda) from the Early Cretaceous of Mongolia. *PeerJ* (2018).
232. A. O. Averianov, H. D. Sues, A new Troodontid (Dinosauria: Theropoda) from the Cenomanian of Uzbekistan, with a review of Troodontid records from the territories of the former Soviet Union. *J. Vertebr. Paleontol.* (2007).
233. R. M. Sullivan, S. G. Lucas, D. R. Braman, Dinosaurs, pollen, and the Cretaceous-Tertiary boundary in the San Juan Basin, New Mexico. *New Mex. Geol. Soc. 56th F. Conf. Guid. Geol. Chama Basin* (2005).
234. R. M. Sullivan, in *New Mexico Geological Society 48th Field Conference Guidebook* (New Mexico Geological Society, Socorro, New Mexico, 1997).
235. V. M. Arbour, M. E. Burns, R. M. Sullivan, S. G. Lucas, A. K. Cantrell, J. Fry, T. L. Suazo, A new ankylosaurid dinosaur from the Upper Cretaceous (Kirtlandian) of New Mexico with implications for ankylosaurid diversity in the upper cretaceous of Western North America. *PLoS One* (2014).
236. N. R. Longrich, Titanoceratops ouranos, a giant horned dinosaur from the late Campanian of New Mexico. *Cretac. Res.* (2011).
237. D. W. Fowler, R. M. Sullivan, The first giant titanosaurian sauropod from the

- upper Cretaceous of North America. *Acta Palaeontol. Pol.* (2011).
238. S. G. Sullivan, R M, Lucas, Cretaceous vertebrates of New Mexico. *New Mex. Museum Nat. Hist. Sci. Bull.* (2015).
 239. T. E. Williamson, S. L. Brusatte, Small theropod teeth from the Late Cretaceous of the San Juan Basin, northwestern New Mexico and their implications for understanding latest Cretaceous dinosaur evolution. *PLoS One* (2014).
 240. D. C. Evans, D. W. Larson, T. M. Cullen, R. M. Sullivan, “Sauornitholestes” robustus is a troodontid (Dinosauria: Theropoda). *Can. J. Earth Sci.* (2014).
 241. T. D. Carr, T. E. Williamson, *Bistahieversor sealeyi*, gen. et sp. nov., a new tyrannosauroid from New Mexico and the origin of deep snouts in Tyrannosauroidea. *J. Vertebr. Paleontol.* (2010).
 242. P. M. Galton, Earliest record of an ankylosaurian dinosaur (Ornithischia: Thyreophora): Dermal armor from Lower Kota Formation (Lower Jurassic) of India. *Neues Jahrb. für Geol. und Paläontologie-Abhandlungen.* **291**, 205–219 (2019).
 243. R. E. Ulansky, in *Dinologia* (2014), p. 35.
 244. P. Yadagiri, A new sauropod *Kotasaurus yamanpalliensis* from Lower Jurassic Kota Formation of India. *Rec. Geol. Surv. India.* **11**, 102–127 (1988).
 245. S. L. Jain, T. S. Kutty, T. Roy-Chowdhury, S. Chatterjee, The sauropod dinosaur from the Lower Jurassic Kota Formation of India. *Proc. R. Soc. London A.* **188**, 221–228 (1975).
 246. C. From, T. H. E. Museum, O. F. Paleontology, J. a Wilson, P. C. Sereno, S. Srivastava, D. K. Bhatt, A. Khosla, A. Sahni, M. O. F. Paleontology, A new

- Abelisaurid (Dinosauria, Theropoda) from the Lameta Formation (Cretaceous, Maastrichtian) of India. *Contrib. from Museum Paleontol.* (2003).
247. J. A. Wilson, M. D. D’Emic, K. Curry Rogers, D. M. Mohabey, S. Sen, Reassessment of the Sauropod Dinosaur *Jainosaurus* (=“*Antarctosaurus*”) *septentrionalis* from the Upper Cretaceous of India. *Contrib. from Museum Paleontol. Univ. Michigan* (2009).
248. R. S. Loyal, D. M. Mohabey, A. Khosla, A. Sahni, Status and palaeobiology of the Late Cretaceous Indian theropods with description of a new theropod eggshell oogenus and oospecies, *Ellipsoolithus khedaensis*, from the Lameta Formation, District Kheda, Gujarat, Western India. *Gaia*, 379–387 (1998).
249. D. M. Mohabey, B. Samant, Cretaceous-Paleogene Transition of Reptilian Tetrapods across Deccan Volcanism in India. *Open J. Geol.* (2019).
250. D. Lambert, *The Wordsworth Book of Dinosaurs* (Wordsworth Editions Ltd, 1998).
251. G. S. Paul, *Predatory Dinosaurs of the World, a Complete Illustrated Guide* (Simon & Schuster, 1989).
252. F. E. Novas, S. Chatterjee, D. K. Rudra, P. M. Datta, in *New aspects of Mesozoic biodiversity* (Springer, Berlin, Heidelberg, 2010), pp. 45–62.
253. J. H. Ostrom, *Leptoceratops gracilis* from the “Lance” Formation of Wyoming. *J. Paleontol.* (1978).
254. B. Brown, E. M. Schlaikjer, A study of the troodont dinosaurs with the description of a new genus and four new species. *Bull. Am. Museum Nat. Hist.* (1943), pp. 115–150.

255. O. C. Marsh, Notice of new reptiles from the Laramie Formation. *Am. J. Sci.* (1892).
256. K. L. Derstler, The Dragons' Grave: an Edmontosaurus bonebed containing theropod egg shells and juveniles, Lance Formation (uppermost Cretaceous), Niobrara County, Wyoming. *J. Vertebr. Paleontol.* **15**, 26A (1995).
257. E. Tschopp, O. Mateus, R. B. J. Benson, A specimen-level phylogenetic analysis and taxonomic revision of Diplodocidae (Dinosauria, Sauropoda). *PeerJ* (2015).
258. K. Snyder, M. A. McLain, I. Snyder, A. V. Chadwick, in *Geological Society of America, Southeastern Section 67th Annual Meeting* (2018).
259. S. G. Dalman, New examples of tyrannosaurus rex from the lance formation of Wyoming, United States. *Bull. Peabody Museum Nat. Hist.* (2013).
260. K. Carpenter, Late Cretaceous dinosaurs from the Denver Basin, Colorado. *Rocky Mt. Geol.* (2002).
261. J. B. Hatcher, O. C. Marsh, R. S. Lull, The Ceratopsia. *Monogr. United States Geol. Surv.* **49**, 1–198 (1907).
262. M. T. Antunes, O. Mateus, Dinosaurs of Portugal. *Comptes Rendus - Palevol* (2003).
263. O. Mateus, S. C. R. Maidment, N. A. Christiansen, A new long-necked “sauropod-mimic” stegosaur and the evolution of the plated dinosaurs. *Proc. R. Soc. B Biol. Sci.* (2009).
264. C. Hendrickx, O. Mateus, Abelisauridae (Dinosauria: Theropoda) from the Late Jurassic of Portugal and dentition-based phylogeny as a contribution for the identification of isolated theropod teeth. *Zootaxa* (2014).

265. L. Mao, L. Xing, J. Zhang, T. Wang, D. Wang, Revisiting the world famous Lufeng Formation dinosaur fauna: new approaches to old problems. *Hist. Biol.* (2020).
266. H. L. You, Y. Azuma, T. Wang, Y. M. Wang, Z. M. Dong, The first well-preserved coelophysoid theropod dinosaur from Asia. *Zootaxa* (2014).
267. K. C. Rogers, C. A. Forster, The skull of *Rapetosaurus Krausei* (Sauropoda: Titanosauria) from the late cretaceous of Madagascar. *J. Vertebr. Paleontol.* (2004).
268. K. C. Rogers, J. A. Wilson, *Vahiny depereti*, gen. et sp. nov., a new titanosaur (Dinosauria, Sauropoda) from the Upper Cretaceous Maevarano Formation, Madagascar. *J. Vertebr. Paleontol.* (2014).
269. P. M. O'Connor, C. A. Forster, A late Cretaceous (Maastrichtian) Avifauna from the Maevarano Formation, Madagascar. *J. Vertebr. Paleontol.* (2010).
270. D. C. Evans, R. K. Schott, D. W. Larson, C. M. Brown, M. J. Ryan, The oldest North American pachycephalosaurid and the hidden diversity of small-bodied ornithischian dinosaurs. *Nat. Commun.* (2013).
271. M. J. Ryan, D. C. Evans, P. J. Currie, C. M. Brown, D. Brinkman, New leptoceratopsids from the Upper Cretaceous of Alberta, Canada. *Cretac. Res.* (2012).
272. D. W. Larson, The occurrences of vertebrate fossils in the Deadhorse Coulee Member of the Milk River Formation and their implications for provincialism and evolution in the Santonian (Late Cretaceous) of North America (Thesis). *Dep. Biol. Sci. Univ. Alberta* (2010).

273. C. E. Turner, F. Peterson, in *Vertebrate Palaeontology in Utah, Issue 1* (1999).
274. P. M. Sander, A. Christian, M. Clauss, R. Fechner, C. T. Gee, E. M. Griebeler, H. C. Gunga, J. Hummel, H. Mallison, S. F. Perry, H. Preuschoft, O. W. M. Rauhut, K. Remes, T. Tütken, O. Wings, U. Witzel, Biology of the sauropod dinosaurs: The evolution of gigantism. *Biol. Rev.* (2011).
275. J. Foster, *Jurassic West: The Dinosaurs of the Morrison Formation and Their World* (Indiana University Press, 2007).
276. D. D. Gillette, *Seismosaurus Halli*, gen. et sp. nov., a new sauropod dinosaur from the morrison formation (upper jurassic/lower cretaceous) of New Mexico, USA. *J. Vertebr. Paleontol.* (1991).
277. F. Therrien, D. M. Henderson, My theropod is bigger than yours...or not: Estimating body size from skull length in theropods. *J. Vertebr. Paleontol.* (2007).
278. D. J. Chure, M. A. Loewen, Cranial anatomy of *Allosaurus jimadseni*, a new species from the lower part of the Morrison Formation (Upper Jurassic) of Western North America. *PeerJ* (2020).
279. E. L. Nicholls, A. P. Russell, New specimen of *Struthiomimus altus* from Alberta, with comments on the classificatory characters of Upper Cretaceous Ornithomimids. *Can. J. Earth Sci.* (1981).
280. D. C. Evans, M. J. Ryan, Cranial anatomy of *Wendiceratops pinhornensis* gen. et sp. nov., a centrosaurine ceratopsid (Dinosauria: Ornithischia) from the Oldman Formation (Campanian), Alberta, Canada, and the evolution of ceratopsid nasal ornamentation. *PLoS One* (2015).
281. A. Boyle, *Wendiceratops: Horned Dinosaur Fossil Adds Hooks to Evolutionary*

- Tale. *NBC News* (2015).
282. K. Carpenter, Skeletal and derman armor reconstruction of *Euoplocephalus tutus* (Ornithischia: Ankylosauridae) from the Late Cretaceous Oldman Formation of Alberta. *Can. J. Earth Sci.* (1982).
 283. A. A. Farke, M. J. Ryan, P. M. Barrett, D. H. Tanke, D. R. Braman, M. A. Loewen, M. R. Graham, A new centrosaurine from the late cretaceous of Alberta, Canada, and the evolution of parietal ornamentation in horned dinosaurs. *Acta Palaeontol. Pol.* (2011).
 284. K. Chiba, M. J. Ryan, D. R. Braman, D. A. Eberth, E. E. Scott, C. M. Brown, Y. Kobayashi, D. C. Evans, Taphonomy of a monodominant *Centrosaurus apertus* (dinosauria: Ceratopsia) bonebed from the upper oldman formation of Southeastern Alberta. *Palaios* (2015).
 285. M. J. Ryan, A new basal Centrosaurine Ceratopsid from the Oldman Formation, Southeastern Alberta. *J. Paleontol.* (2007).
 286. J. Peng, D. Brinkman, A. P. Russell, *Vertebrate microsite assemblages (exclusive of mammals) from the Foremost and Oldman formations of the Judith River group (Campanian) of Southeastern Alberta : an illustrated guide* (2016).
 287. C. M. Brown, P. Druckenmiller, Basal ornithopod (Dinosauria: Ornithischia) teeth from the Prince Creek Formation (early Maastrichtian) of Alaska. *Can. J. Earth Sci.* (2011).
 288. J. F. Anderson, A. Hall-Martin, D. A. Russell, Long-bone circumference and weight in mammals, birds and dinosaurs. *J. Zool.* (1985).
 289. R. A. Gangloff, A. R. Fiorillo, D. W. Norton, The first Pachycephalosaurine

- (Dinosauria) from the Paleo-Arctic of Alaska and its paleogeographic implications. *J. Paleontol.* (2005).
290. J. M. Parrish, J. T. Parrish, J. H. Hutchinson, R. A. Spicer, Late Cretaceous vertebrate fossils from the North Slope of Alaska and implications for dinosaur ecology. *Palaios* (1987).
 291. R. S. Tykoski, A. R. Fiorillo, K. Chiba, New data and diagnosis for the Arctic ceratopsid dinosaur *Pachyrhinosaurus perotorum*. *J. Syst. Palaeontol.* (2019).
 292. R. Takasaki, A. R. Fiorillo, Y. Kobayashi, R. S. Tykoski, P. J. McCarthy, The First Definite Lambeosaurine Bone From the Liscomb Bonebed of the Upper Cretaceous Prince Creek Formation, Alaska, United States. *Sci. Rep.* (2019).
 293. A. R. Fiorillo, Microwear patterns on the teeth of northern high latitude hadrosaurs with comments on microwear patterns in hadrosaurs as a function of latitude and seasonal ecological constraints. *Palaeontol. Electron.* (2011).
 294. A. R. Fiorillo, R. S. Tykoski, A diminutive new tyrannosaur from the top of the world. *PLoS One* (2014).
 295. K. Li, C. Yang, F. Hu, Dinosaur assemblages from the Middle Jurassic Shaximiao Formation and Chuanjie Formation in the Sichuan-Yunnan Basin, China. *Vol. Jurassica* (2011).
 296. Z. Dong, On a Small Ornithopod (*Gongbusaurus wucaiwansensis*) from Kelamaili, Jungar Basin, Xinjiang, China. *Vertebr. Palasiat.* (1989).
 297. Y. Zhang, W. Chen, in *Transactions of the Continental Jurassic Symposium, Museum of Northern Arizona* (Flagstaff, 1996), pp. 97–107.
 298. Z.-M. Dong, S. Zhou, Y. Zhang, Dinosaurs from the Jurassic of Sichuan.

Palaeontol. Sin. (1983).

299. S. L. Brusatte, R. B. J. Benson, X. Xu, The evolution of large-bodied theropod dinosaurs during the mesozoic in asia. *J. Iber. Geol.* (2010).
300. O. Mateus, Late Jurassic dinosaurs from the Morrison Formation (USA), the Lourinhã and Alcobaça Formations (Portugal), and the Tendaguru beds (Tanzania): a comparison. *New Mex. Museum Nat. Hist. Sci. Bull.* (2006).
301. D. Schwarz, J. C. D. Kosch, G. Fritsch, T. Hildebrandt, Dentition and tooth replacement of *Dicraeosaurus hansemanni* (Dinosauria, Sauropoda, Diplodocoidea) from the Tendaguru Formation of Tanzania. *J. Vertebr. Paleontol.* (2015).
302. M. P. Taylor, A re-evaluation of *Brachiosaurus altithorax* Riggs 1903 (Dinosauria, Sauropoda) and its generic separation from *Giraffatitan brancai* (Janensch 1914). *J. Vertebr. Paleontol.* (2009).
303. O. W. M. Rauhut, Theropod dinosaurs from the Late Jurassic of Tendaguru (Tanzania). *Spec. Pap. Palaeontol.* (2011).
304. O. W. M. Rauhut, Post-cranial remains of “coelurosaurs” (Dinosauria, Theropoda) from the Late Jurassic of Tanzania. *Geol. Mag.* (2005).
305. K. Remes, Taxonomy of Late Jurassic diplodocid sauropods from Tendaguru (Tanzania). *Foss. Rec.* (2009).
306. P. D. Mannion, P. Upchurch, D. Schwarz, O. Wings, Taxonomic affinities of the putative titanosaurs from the Late Jurassic Tendaguru Formation of Tanzania: Phylogenetic and biogeographic implications for eusauropod dinosaur evolution. *Zool. J. Linn. Soc.* (2019).

307. E. Buffetaut, An early spinosaurid dinosaur from the Late Jurassic of Tendaguru (Tanzania) and the evolution of the spinosaurid dentition. *Oryctos* (2012).
308. M. L. Casanovas, X. Pereda Suberbiola, J. V. Santafé, D. B. Weishampel, A primitive euhadrosaurian dinosaur from the uppermost Cretaceous of the Ager syncline (southern Pyrenees, Catalonia). *Geol. en Mijnbouw/Netherlands J. Geosci.* (1999).
309. V. Riera, O. Oms, R. Gaete, À. Galobart, The end-Cretaceous dinosaur succession in Europe: The Tremp Basin record (Spain). *Palaeogeogr. Palaeoclimatol. Palaeoecol.* (2009).
310. H. K. Erben, J. Hoefs, K. H. Wedepohl, Paleobiological and isotopic studies of eggshells from a declining dinosaur species. *Paleobiology* (1979).
311. A. Torices, P. J. Currie, J. I. Canudo, X. Pereda-Suberbiola, Theropod dinosaurs from the upper cretaceous of the south pyrenees basin of Spain. *Acta Palaeontol. Pol.* (2015).
312. R. Allain, P. Taquet, A new genus of dromaeosauridae (dinosauria, theropoda) from the upper cretaceous of France. *J. Vertebr. Paleontol.* (2000).
313. J. Lü, L. Yi, S. L. Brusatte, L. Yang, H. Li, L. Chen, A new clade of asian late cretaceous long-snouted tyrannosaurids. *Nat. Commun.* (2014).
314. T. A. Gates, S. D. Sampson, L. E. Zanno, E. M. Roberts, J. G. Eaton, R. L. Nydam, J. H. Hutchison, J. A. Smith, M. A. Loewen, M. A. Getty, Biogeography of terrestrial and freshwater vertebrates from the late Cretaceous (Campanian) Western Interior of North America. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* (2010).

315. B. Chinnery, Description of *Prenoceratops pieganensis* gen. et sp. Nov. (Dinosauria: Neoceratopsia) from the two medicine formation of montana. *J. Vertebr. Paleontol.* (2004).
316. R. E. Barrick, W. J. Showers, A. G. Fischer, Comparison of thermoregulation of four ornithischian dinosaurs and a varanid lizard from the cretaceous two medicine formation: Evidence from oxygen isotopes. *Palaios* (1996).
317. B. J. Chinnery, J. R. Horner, A new neoceratopsian Dinosaur linking North American and Asian taxa. *J. Vertebr. Paleontol.* (2007).
318. S. D. Sampson, Two new horned dinosaurs from the upper cretaceous two medicine formation of montana; with a phylogenetic analysis of the centrosaurinae (ornithischia: Ceratopsidae). *J. Vertebr. Paleontol.* (1995).
319. J. P. Wilson, M. J. Ryan, D. C. Evans, A new, transitional centrosaurine ceratopsid from the Upper Cretaceous Two Medicine Formation of Montana and the evolution of the “Styracosaurus-line” dinosaurs. *R. Soc. Open Sci.* (2020).
320. P. Penkalski, A new ankylosaurid from the late cretaceous two medicine formation of Montana, USA. *Acta Palaeontol. Pol.* (2014).
321. A. T. McDonald, J. R. Horner, in *New Perspectives on Horned Dinosaurs: The Royal Tyrrell Museum Ceratopsian Symposium*, M. J. Ryan, B. J. Chinnery-Allgeier, D. A. Eberth, Eds. (Indiana University Press, 2010), pp. 156–168.
322. T. A. Gates, J. R. Horner, R. R. Hanna, C. R. Nelson, New unadorned hadrosaurine hadrosaurid (Dinosauria, Ornithopoda) from the campanian of North America. *J. Vertebr. Paleontol.* (2011).
323. D. J. Varricchio, Taphonomy of Jack’s Birthday Site, a diverse dinosaur bonebed

- from the Upper Cretaceous Two Medicine Formation of Montana. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* (1995).
324. D. A. Burnham, K. L. Derstler, P. J. Currie, R. T. Bakker, Z. Zhou, J. H. Ostrom, Remarkable New Birdlike Dinosaur (Theropoda: Maniraptora) from the Upper Cretaceous of Montana. *Univ. Kansas Paleontol. Contrib.* **13** (2000).
 325. N. R. Longrich, K. Barnes, S. Clark, L. Millar, Caenagnathidae from the upper Campanian Aguja Formation of west Texas, and a revision of the Caenagnathinae. *Bull. Peabody Museum Nat. Hist.* (2013).
 326. P. J. Currie, D. Trexler, E. B. Koppelhus, K. Wicks, N. Murphy, in *The Carnivorous Dinosaurs*, K. Carpenter, Ed. (Indiana University Press, 2005), pp. 313–324.
 327. R. J. Butler, The “fabrosaurid” ornithischian dinosaurs of the Upper Elliot Formation (Lower Jurassic) of South Africa and Lesotho. *Zool. J. Linn. Soc.* (2005).
 328. J. A. Hopson, On the generic separation of the ornithischian dinosaurs *Lycorhinus* and *Heterodontosaurus* from the Stromberg Series (Upper Triassic) of South Africa. *S. Afr. J. Sci.* (1975).
 329. P. C. Sereno, Taxonomy, morphology, masticatory function and phylogeny of heterodontosaurid dinosaurs. *Zookeys* (2012).
 330. B. W. McPhee, E. M. Bordy, L. Sciscio, J. N. Choiniere, The sauropodomorph biostratigraphy of the elliot formation of southern Africa: Tracking the evolution of sauropodomorpha across the triassic-jurassic boundary. *Acta Palaeontol. Pol.* (2017).

331. A. M. Yates, M. F. Bonnan, J. Neveling, A new basal sauropodomorph dinosaur from the Early Jurassic of South Africa. *J. Vertebr. Paleontol.* (2011).
332. P. M. Barrett, A new basal sauropodomorph dinosaur from the upper Elliot formation (Lower Jurassic) of South Africa. *J. Vertebr. Paleontol.* (2009).
333. C. P. De Fabrègues, R. Allain, New material and revision of *Melanorosaurus thabanensis*, a basal sauropodomorph from the Upper Triassic of Lesotho. *PeerJ* (2016).
334. A. M. Yates, M. F. Bonnan, J. Neveling, A. Chinsamy, M. G. Blackbeard, A new transitional sauropodomorph dinosaur from the Early Jurassic of South Africa and the evolution of sauropod feeding and quadrupedalism. *Proc. R. Soc. B Biol. Sci.* (2010).
335. B. W. McPhee, M. F. Bonnan, A. M. Yates, J. Neveling, J. N. Choiniere, A new basal sauropod from the pre-Toarcian Jurassic of South Africa: Evidence of niche-partitioning at the sauropodomorph-sauropod boundary? *Sci. Rep.* (2015).
336. D. Munyikwa, M. A. Raath, Further material of the ceratosaurian dinosaur *Syntarsus* from the Elliot Formation (early Jurassic) of South Africa. *Palaeontol. Africana* (1999).
337. A. M. Yates, A new theropod dinosaur from the Early Jurassic of South Africa and its implications for the early evolution of theropods. *Palaeontol. Africana*. **41**, 105–122 (2005).
338. W. T. Blows, A review of Lower and Middle Cretaceous dinosaurs of England. *New Mex. Museum Nat. Hist. Sci. Bull.* **14** (1998), pp. 29–38.
339. R. Allain, R. Vullo, J. Le Loeuff, J. F. Tournepiche, European ornithomimosaur

- (Dinosauria, Theropoda): an undetected record. *Geol. Acta an Int. earth Sci. J.* **12**, 127–135 (2014).
340. P. M. Barrett, S. C. R. Maidment, in *English Wealden Fossils*, D. J. Batten, Ed. (The Palaeontological Association, 2011), pp. 391–406.
341. J. Ruiz-Omeñaca, J. Canudo Sanagustín, “Pleurocoelus” valdensis Lydekker, 1889 (Saurischia, sauropoda) en el Cretácico Inferior (Barremiense) de la Península Ibérica. *Geogaceta* (2005).
342. D. B. Norman, On the history, osteology, and systematic position of the Wealden (Hastings group) dinosaur *Hypselosaurus fittoni* (Iguanodontia: Styracosterna). *Zool. J. Linn. Soc.* (2015).
343. K. Brooks, Dinosaur quarries of Hastings. *Hast. Dist. Geol. Soc. J.* **17**, 7–13 (2011).
344. D. F. Glut, *Dinosaurs: The Encyclopedia* (McFarland & Co, Jefferson, North Carolina, 1997).
345. P. Upchurch, P. D. Mannion, M. P. Taylor, The anatomy and phylogenetic relationships of “*Pelorosaurus*” becklesii (Neosauropoda, Macronaria) from the Early Cretaceous of England. *PLoS One* (2015).
346. M. P. Taylor, Xenoposeidon is the earliest known rebbachisaurid sauropod dinosaur. *PeerJ* (2018).
347. M. P. Taylor, D. Naish, An unusual new neosauropod dinosaur from the Lower Cretaceous Hastings Beds Group of East Sussex, England. *Palaeontology* (2007).
348. P. Upchurch, J. Martin, The anatomy and taxonomy of *Cetiosaurus* (saurischia, sauropoda) from the middle jurassic of England. *J. Vertebr. Paleontol.* (2003).

349. P. D. Mannion, A revision of the sauropod dinosaur genus “bothriospondylus” with a redescription of the type material of the middle jurassic form “b. madagascariensis.” *Palaeontology* (2010).
350. J. W. Hulke, Note (3rd) on (Ecumerotus, Hulke) ornuithopsis, H. G. Seeley, = Bothriospondylus magnus, owen, = Chondrosteosaurus Magnus, Owen. *Q. J. Geol. Soc. London* (1879).
351. D. Naish, S. C. Sweetman, A tiny maniraptoran dinosaur in the Lower Cretaceous Hastings Group: Evidence from a new vertebrate-bearing locality in south-east England. *Cretac. Res.* (2011).
352. P. Austen, D. Brockhurst, K. Honeysett, Vertebrate fauna from Ashdown brickworks, Bexhill, east Sussex. *Wealden News* 8 (2010), pp. 13–23.
353. M. W. Maisch, The nomenclatural status of the carnivorous dinosaur genus Altispinax v. Huene, 1923 (Saurischia, Theropoda) from the Lower Cretaceous of England. *Neues Jahrb. fur Geol. und Palaontologie - Abhandlungen* (2016).
354. J. I. Kirkland, D. Deblieux, New Basal Centrosaurine Ceratopsian Skulls from the Wahweap Formation (Middle Campanian), Grand Staircase Escalante Monument, Southern Utah. *Life Past New Perspect. Horned Dinosaur. R. Tyrrell Museum Ceratopsian Symp.* (2010).
355. J. G. Eaton, R. L. Cifelli, J. H. Hutchison, J. I. Kirkland, J. M. Parrish, Cretaceous vertebrate faunas from the Kaiparowits Plateau, south-central Utah. *Misc. Publ. Utah Geol. Surv.* (1999).
356. J. G. Eaton, H. Munk, M. A. Hardman, A new vertebrate fossil locality within the Wahweap Formation (Upper Cretaceous) of Bryce Canyon National Park and its

- bearing on the presence of the Kaiparowits Formation on the Paunsaugunt Plateau. *Natl. Park Serv. Geol. Resour. Div. Tech. Rep.* **3**, 36–40 (1998).
357. T. A. Gates, Z. Jinnah, C. Levitt, M. A. Getty, in *Hadrosaurs* (2014).
 358. A. L. Titus, J. G. Eaton, J. Sertich, Late Cretaceous stratigraphy and vertebrate faunas of the Markagunt, Paunsaugunt, and Kaiparowits plateaus, southern Utah. *Geol. Intermt. West* (2016).
 359. E. K. Lund, P. M. O'Connor, M. A. Loewen, Z. A. Jinnah, A New Centrosaurine Ceratopsid, *Machairoceratops cronusi* gen et sp. nov., from the Upper Sand Member of the Wahweap Formation (Middle Campanian), Southern Utah. *PLoS One* (2016).
 360. M. A. Loewen, R. B. Irmis, J. J. W. Sertich, P. J. Currie, S. D. Sampson, Tyrant dinosaur evolution tracks the rise and fall of late Cretaceous oceans. *PLoS One* (2013).
 361. G. Z. Peng, C. Shu, in *Proceedings of the Seventh Annual Meeting of the Chinese Society of Vertebrate Paleontology* (China Ocean Press, Beijing, 1999).
 362. G. Z. Peng, Y. Ye, Y. Gao, C. Shu, S. Jiang, A new camarasaurid from the Middle Jurassic, Xiashaximiao Formation in Dashanpu, China. *Jurassic Dinosaur Faunas Zigong*, 216–219 (2005).
 363. C. Tan, M. Xiao, H. Dai, X. F. Hu, N. Li, Q. Y. Ma, Z. Y. Wei, H. D. Yu, C. Xiong, G. Z. Peng, S. Jiang, X. X. Ren, H. L. You, A new species of *Omeisaurus* (Dinosauria: Sauropoda) from the Middle Jurassic of Yunyang, Chongqing, China. *Hist. Biol.* (2020).
 364. G. Yuhui, A new species of *Szechuanosaurus* from the Middle Jurassic of

- Dashanpu, Zigong, Sichuan. *Vertebr. Palasiat.* (1993).
365. P. M. Barrett, R. J. Butler, F. Knoll, Small-bodied ornithischian dinosaurs from the middle jurassic of sichuan, China. *J. Vertebr. Paleontol.* (2005).
366. Q. Ji, J. C. Lü, X. F. Wei, X. R. Wang, A new oviraptorosaur from the Yixian Formation of Jianchang, Western Liaoning Province, China. *Geol. Bull. China* (2012).
367. X. Xu, M. A. Norell, Non-avian dinosaur fossils from the Lower Cretaceous Jehol Group of western Liaoning, China. *Geol. J.* (2006).
368. X. Wang, H. You, Q. Meng, C. Gao, X. Cheng, J. Liu, Dongbeititan dongi, the first sauropod dinosaur from the Lower Cretaceous Jehol Group of western Liaoning Province, China. *Acta Geol. Sin. - English Ed.* (2007).
369. G. Han, L. M. Chiappe, S. A. Ji, M. Habib, A. H. Turner, A. Chinsamy, X. Liu, L. Han, A new raptorial dinosaur with exceptionally long feathering provides insights into dromaeosaurid flight performance. *Nat. Commun.* (2014).
370. J. Lü, S. L. Brusatte, A large, short-armed, winged dromaeosaurid (Dinosauria: Theropoda) from the Early Cretaceous of China and its implications for feather evolution. *Sci. Rep.* (2015).
371. H. Pu, Y. Kobayashi, J. Lü, L. Xu, Y. Wu, H. Chang, J. Zhang, S. Jia, An Unusual Basal Therizinosaur Dinosaur with an Ornithischian Dental Arrangement from Northeastern China. *PLoS One* (2013).
372. L. Xing, P. R. Bell, W. S. Persons, S. Ji, T. Miyashita, M. E. Burns, Q. Ji, P. J. Currie, Abdominal Contents from Two Large Early Cretaceous Compsognathids (Dinosauria: Theropoda) Demonstrate Feeding on Confuciusornithids and

- Dromaeosaurids. *PLoS One* (2012).
373. X. Xu, K. Wang, K. Zhang, Q. Ma, L. Xing, C. Sullivan, D. Hu, S. Cheng, S. Wang, A gigantic feathered dinosaur from the Lower Cretaceous of China. *Nature* (2012).
374. J. Liyong, C. Jun, P. Godefroit, in *Bernissart Dinosaurs and Early Cretaceous Terrestrial Ecosystems* (2012).
375. C. F. Zhou, K. Q. Gao, R. C. Fox, S. H. Chen, A new species of Psittacosaurus (Dinosauria: Ceratopsia) from the Early Cretaceous Yixian Formation, Liaoning, China. *Palaeoworld* (2006).
376. C. Z. Shen, B. Zhao, C. L. Gao, J. C. Lü, M. Kundrát, A New Troodontid Dinosaur (Liaoningvenator curriei gen. et sp. nov.) from the Early Cretaceous Yixian Formation in Western Liaoning Province. *Acta Geosci. Sin.* (2017).
377. C. Shen, J. Lü, C. Gao, M. Hoshino, K. Uesugi, M. Kundrát, Forearm bone histology of the small theropod Dalianosaurus liaoningensis (Paraves: Troodontidae) from the Yixian Formation, Liaoning, China. *Hist. Biol.* (2019).
378. C. Shen, J. LÜ, S. Liu, M. Kundrát, S. L. Brusatte, H. Gao, A New Troodontid Dinosaur from the Lower Cretaceous Yixian Formation of Liaoning Province, China. *Acta Geol. Sin.* (2017).
379. T. R. Holtz, in *Tyrannosaurus rex the Tyrant King* (2008).
380. J. O. Farlow, On the rareness of big, fierce animals: speculations about the body sizes, population densities, and geographic ranges of predatory mammals and large carnivorous dinosaurs. *Am. J. Sci.* (1993).
381. J. R. Horner, Steak Knives, Beady Eyes, and Tiny Little Arms (A Portrait of T.

- rex as a Scavenger) . *Paleontol. Soc. Spec. Publ.* (1994).
382. J. R. Horner, D. Lessem, *The Complete T. rex* (Simon & Schuster, New York, 1993).
 383. K. Carpenter, in *Tyrannosaurid Paleobiology* (2013).
 384. C. Carbone, S. T. Turvey, J. Bielby, Intra-guild competition and its implications for one of the biggest terrestrial predators, tyrannosaurus rex. *Proc. R. Soc. B Biol. Sci.* (2011).
 385. G. D. Ruxton, D. C. Houston, Could Tyrannosaurus rex have been a scavenger rather than a predator? An energetics approach. *Proc. R. Soc. B Biol. Sci.* (2003).
 386. J. O. Farlow, Speculations about the Carrion-Locating Ability of Tyrannosaurs. *Hist. Biol.* (1994).
 387. K. Chin, D. A. Eberth, M. H. Schweitzer, T. A. Rando, W. J. Sloboda, J. R. Horner, Remarkable preservation of undigested muscle tissue within a late cretaceous tyrannosaurid coprolite from Alberta, Canada. *Palaios* (2003).
 388. K. Chin, T. T. Tokaryk, G. M. Erickson, L. C. Calk, A king-sized theropod coprolite. *Nature* (1998).
 389. J. E. Peterson, K. N. Daus, Feeding traces attributable to juvenile Tyrannosaurus rex offer insight into ontogenetic dietary trends. *PeerJ* (2019).
 390. R. A. DePalma, D. A. Burnham, L. D. Martin, B. M. Rothschild, P. L. Larson, Physical evidence of predatory behavior in Tyrannosaurus rex. *Proc. Natl. Acad. Sci. U. S. A.* (2013).
 391. N. R. Longrich, J. R. Horner, G. M. Erickson, P. J. Currie, Cannibalism in Tyrannosaurus rex. *PLoS One* (2010).

392. P. M. Barrett, E. J. Rayfield, Ecological and evolutionary implications of dinosaur feeding behaviour. *Trends Ecol. Evol.* (2006).
393. E. J. Rayfield, Cranial mechanics and feeding in *Tyrannosaurus rex*. *Proc. R. Soc. B Biol. Sci.* (2004).
394. A. J. Rowe, E. Snively, Biomechanics of juvenile tyrannosaurid mandibles and their implications for bite force: Evolutionary biology. *Anat. Rec.* **305**, 373–392 (2022).
395. P. M. Gignac, G. M. Erickson, The Biomechanics behind Extreme Osteophagy in *Tyrannosaurus rex*. *Sci. Rep.* (2017).
396. G. M. Erickson, S. D. Van Kirk, J. Su, M. E. Levenston, W. E. Caler, D. R. Carter, Bite-force estimation for *Tyrannosaurus rex* from tooth-marked bones. *Nature* (1996).
397. K. T. Bates, P. L. Falkingham, Estimating maximum bite performance in *Tyrannosaurus rex* using multi-body dynamics. *Biol. Lett.* (2012).
398. J. R. Hutchinson, K. T. Bates, J. Molnar, V. Allen, P. J. Makovicky, A computational analysis of limb and body dimensions in *tyrannosaurus rex* with implications for locomotion, ontogeny, and growth. *PLoS One* (2011).
399. F. Therrien, D. K. Zelenitsky, J. T. Voris, K. Tanaka, Mandibular force profiles and tooth morphology in growth series of *albertosaurus sarcophagus* and *gorgosaurus libratus* (Tyrannosauridae: Albertosaurinae) provide evidence for an ontogenetic dietary shift in tyrannosaurids. *Can. J. Earth Sci.* (2021).
400. F. G. T. Radloff, J. T. Du Toit, Large predators and their prey in a southern African savanna: A predator's size determines its prey size range. *J. Anim. Ecol.*

(2004).

401. T. R. Holtz Jr, Theropod guild structure and the tyrannosaurid niche assimilation hypothesis: implications for predatory dinosaur macroecology and ontogeny in later Late Cretaceous Asiamerica. *Can. J. Earth Sci.* **58** (2021).
402. K. Schroeder, S. Kathleen Lyons, F. A. Smith, The influence of juvenile dinosaurs on community structure and diversity. *Science* (80-.). **371**, 941–944 (2021).
403. R. S. Scott, P. S. Ungar, T. S. Bergstrom, C. A. Brown, B. E. Childs, M. F. Teaford, A. Walker, Dental microwear texture analysis: technical considerations. *J. Hum. Evol.* (2006).
404. I. Calandra, G. Merceron, Dental microwear texture analysis in mammalian ecology. *Mamm. Rev.* (2016).
405. B. W. Schubert, P. S. Ungar, L. R. G. DeSantis, Carnassial microwear and dietary behaviour in large carnivorans. *J. Zool.* (2010).
406. L. R. G. DeSantis, Dental microwear textures: Reconstructing diets of fossil mammals. *Surf. Topogr. Metrol. Prop.* (2016).
407. L. R. G. DeSantis, B. W. Schubert, J. R. Scott, P. S. Ungar, Implications of Diet for the Extinction of Saber-Toothed Cats and American Lions. *PLoS One* (2012).
408. D. E. Winkler, E. Schulz-Kornas, T. M. Kaiser, T. Tütken, Dental microwear texture reflects dietary tendencies in extant Lepidosauria despite their limited use of oral food processing. *Proc. R. Soc. B Biol. Sci.* (2019).
409. F. M. Holwerda, B. L. Beatty, A. S. Schulp, Dental macro- And microwear in *Carinodens belgicus*, a small mosasaur from the type Maastrichtian. *Geol. en Mijnbouw/Netherlands J. Geosci.* (2013).

410. J. Bestwick, D. M. Unwin, M. A. Purnell, Dietary differences in archosaur and lepidosaur reptiles revealed by dental microwear textural analysis. *Sci. Rep.* (2019).
411. J. Bestwick, D. M. Unwin, R. J. Butler, M. A. Purnell, Dietary diversity and evolution of the earliest flying vertebrates revealed by dental microwear texture analysis. *Nat. Commun.* (2020).
412. H. Sakaki, D. E. Winkler, T. Kubo, R. Hirayama, H. Uno, S. Miyata, H. Endo, K. Sasaki, T. Takisawa, M. O. Kubo, Non-occlusal dental microwear texture analysis of a titanosauriform sauropod dinosaur from the Upper Cretaceous (Turonian) Tamagawa Formation, northeastern Japan. *Cretac. Res.* **136** (2022).
413. L. R. G. DeSantis, J. R. Scott, B. W. Schubert, S. L. Donohue, B. M. McCray, C. A. Van Stolk, A. A. Winburn, M. A. Greshko, M. C. O'Hara, Direct Comparisons of 2D and 3D Dental Microwear Proxies in Extant Herbivorous and Carnivorous Mammals. *PLoS One* (2013).
414. E. Snively, A. P. Russell, Craniocervical feeding dynamics of *Tyrannosaurus rex*. *Paleobiology* (2007).
415. K. Schwenk, in *Feeding: Form, Function, and Evolution in Tetrapod Vertebrates* (Academic Press, 2000), pp. 175–291.
416. C. Robinet, G. Merceron, A. M. Candela, L. Marivaux, Dental microwear texture analysis and diet in caviomorphs (Rodentia) from the Serra do Mar Atlantic forest (Brazil). *J. Mammal.* (2020).
417. J. R. Scott, Dental microwear texture analysis of extant African Bovidae. *Mammalia* (2012).

418. D. C. D'Amore, R. J. Blumensehine, Komodo monitor (*Varanus komodoensis*) feeding behavior and dental function reflected through tooth marks on bone surfaces, and the application to ziphodont paleobiology . *Paleobiology* (2009).
419. P. R. Bell, P. J. Currie, A tyrannosaur jaw bitten by a confamilial: Scavenging or fatal agonism? *Lethaia* (2010).
420. V. M. Lukasik, S. M. Alexander, Spatial and Temporal Variation of Coyote (*Canis latrans*) Diet in Calgary, Alberta. *Cities Environ.* (2011).
421. C. Delaney-Rivera, T. W. Plummer, J. A. Hodgson, F. Forrest, F. Hertel, J. S. Oliver, Pits and pitfalls: taxonomic variability and patterning in tooth mark dimensions. *J. Archaeol. Sci.* (2009).
422. I. Gade-Jørgensen, R. Stagegaard, Diet composition of wolves *Canis lupus* in east-central Finland. *Acta Theriol. (Warsz)*. (2000).
423. M. C. Metz, D. W. Smith, J. A. Vucetich, D. R. Stahler, R. O. Peterson, Seasonal patterns of predation for gray wolves in the multi-prey system of Yellowstone National Park. *J. Anim. Ecol.* (2012).
424. J. Yravedra Sainz de los Terreros, L. Lagos Abarzuza, F. Bárcena, A Taphonomic study of wild wolf (*Canis lupus*) Modification of horse bones in Northwestern Spain. *J. Taphon.* (2011).
425. A. Pole, I. J. Gordon, M. L. Gorman, M. MacAskill, Prey selection by African wild dogs (*Lycaon pictus*) in southern Zimbabwe. *J. Zool.* (2004).
426. G. B. Schaller, The Serengeti lion: A study of predator-prey relations. *Univ. Chicago, Chicago, Illinois, USA* (1976).
427. J. Yravedra, M. Andrés, M. Domínguez-Rodrigo, A taphonomic study of the

- African wild dog (*Lycaon pictus*). *Archaeol. Anthropol. Sci.* (2014).
428. A. N. Rice, Diet and Condition of American Alligators (*Alligator mississippiensis*) in Three Central Florida Lakes. *Wildl. Res.* (2004).
 429. C. S. Schneider, Alligator (*Alligator mississippiensis*) taphonomy: Analysis of gnawed and digested bone (Thesis). *Bost. Univ.* (2019).
 430. C. R. Shoop, C. A. Ruckdeschel, Alligators as predators on terrestrial mammals. *Am. Midl. Nat.* (1990).
 431. G. J. Soria-Ortiz, P. Charruau, V. H. Reynoso, Variation in diet of hatchlings, juveniles and sub-adults of *Caiman crocodilus chiapasius* in La Encrucijada, Chiapas, Mexico. *Rev. Mex. Biodivers.* (2020).
 432. S. K. Drumheller, J. H. Nestler, C. E. H. Farris, S. C. Farris, F. J. Mazzotti, *Crocodylus acutus* (American crocodile) bite marks on a nest data logger. *PeerJ* (2020).
 433. A. Villegas, J. J. Schmitter-Soto, Feeding habits of the american crocodile, *crocodylus acutus* (cuvier, 1807) (reptilia: crocodylidae) in the Southern Coast of Quintana Roo, México. *Acta Zool. Mex.* (2008).
 434. J. K. Njau, R. J. Blumenschine, A diagnosis of crocodile feeding traces on larger mammal bone, with fossil examples from the Plio-Pleistocene Olduvai Basin, Tanzania. *J. Hum. Evol.* (2006).
 435. U. D. V. Pienaar, Predator-prey relationships amongst the larger mammals of the Kruger National Park. *Koedoe* (1969).
 436. K. M. Wallace, A. J. Leslie, Diet of the Nile Crocodile (*Crocodylus niloticus*) in the Okavango Delta, Botswana. *J. Herpetol.* (2008).

437. M. C. Westaway, J. C. Thompson, W. B. Wood, J. Njau, Crocodile ecology and the taphonomy of early Australasian sites. *Environ. Archaeol.* (2011).
438. G. J. W. Webb, G. J. Hollis, S. C. Manolis, Feeding, Growth, and Food Conversion Rates of Wild Juvenile Saltwater Crocodiles (*Crocodylus porosus*). *J. Herpetol.* (1991).
439. R. Whitaker, D. Basu, The gharial (*Gavialis gangeticus*): a review. *J. Bombay Nat. Hist. Soc.* (1982).
440. L. L. Marker, J. R. Muntifering, A. J. Dickman, M. G. L. Mills, D. W. Macdonald, Quantifying prey preferences of free-ranging Namibian cheetahs. *African J. Wildl. Res.* (2003).
441. M. Domínguez-Rodrigo, J. Yravedra, E. Organista, A. Gidna, J. B. Fourvel, E. Baquedano, A new methodological approach to the taphonomic study of paleontological and archaeological faunal assemblages: A preliminary case study from Olduvai gorge (tanzania). *J. Archaeol. Sci.* (2015).
442. M. L. Allen, The ecology and behaviour of pumas (*Puma concolor*) in northern California, U.S.A. (Dissertation). *Victoria Univ. Wellingt.* (2014).
443. C. I. Montalvo, M. E. M. Pessino, V. H. González, Taphonomic analysis of remains of mammals eaten by pumas (*Puma concolor* Carnivora, Felidae) in central Argentina. *J. Archaeol. Sci.* (2007).
444. S. K. Bearder, Feeding habits of spotted hyaenas in a woodland habitat. *Afr. J. Ecol.* (1977).
445. P. Palmqvist, B. Martínez-Navarro, J. A. Pérez-Claros, V. Torregrosa, B. Figueirido, J. M. Jiménez-Arenas, M. Patrocínio Espigares, S. Ros-Montoya, M.

- De Renzi, The giant hyena *Pachycrocuta brevirostris*: Modelling the bone-cracking behavior of an extinct carnivore. *Quat. Int.* (2011).
446. J. Fraser, Diets of wild tuatara (*Sphenodon punctatus*) on Stephens Island (Thesis). *Univ. Otago* (1993).
447. T. C. S. Avila-Pires, Lizards of Brazilian Amazonia (Reptilia: Squamata). *Zool. Verh.* (1995).
448. K. L. Krysko, C. R. Gillette, R. M. Reichart, L. P. Nuñez, N. T. Coutu, J. A. Wasilewski, K. M. Enge, A. P. Borgia, Preliminary Dietary Analysis for the Non-indigenous Oustalet's Chameleon, *Furcifer oustaleti* (Mocquard 1894) (Squamata: Chamaeleonidae), in Southern Florida. *Reptil. Amphib.* (2012).
449. D. Wotherspoon, S. Burgin, Sex and ontogenetic dietary shift in *Pogona barbata*, the Australian eastern bearded dragon. *Aust. J. Zool.* (2016).
450. D. G. A. B. Oonincx, J. P. van Leeuwen, W. H. Hendriks, A. F. B. van der Poel, The diet of free-roaming Australian Central Bearded Dragons (*Pogona vitticeps*). *Zoo Biol.* (2015).
451. K. Çiçek, C. V. Tok, S. Hayretdal, D. Ayaz, Data on the food composition of European Glass Lizard, *Pseudopus apodus* (Pallas, 1775) (Squamata: Anguidae) from Çanakkale (Western Anatolia, Turkey). *Acta Zool. Bulg.* (2014).
452. J. H. Van Wyk, Seasonal variation in stomach contents and diet composition in the large girdled lizard, *Cordylus giganteus* (Reptilia: Cordylidae) in the Highveld grasslands of the northeastern Free State, South Africa. *African Zool.* (2000).
453. J. Koenig, R. Shine, G. Shea, The ecology of an Australian reptile icon: How do blue-tongued lizards (*Tiliqua scincoides*) survive in suburbia? *Wildl. Res.* (2001).

454. W. Beebe, Field Notes on the lizards of Kartabo, British Guiana, and Caripito, Venezuela. Part 2. Iguanidae. *Zool. Sci. Contrib. New York Zool. Soc.* (1944).
455. A. Parra-Romero, R. Galindo-Tarazona, J. F. González-Maya, I. M. Vela-Vargas, Not eating alone: Andean bear time patterns and potential social scavenging behaviors. *Therya* (2019).
456. B. Peyton, Ecology, Distribution, and Food Habits of Spectacled Bears, *Tremarctos ornatus*, in Peru. *J. Mammal.* (1980).
457. L. L. Irwin, F. M. Hammond, Managing black bear habitats for food items in Wyoming. *Wildl. Soc. Bull.* (1985).
458. B. N. McLellan, Implications of a high-energy and low-protein diet on the body composition, fitness, and competitive abilities of black (*ursus americanus*) and grizzly (*ursus arctos*) bears. *Can. J. Zool.* (2011).
459. M. Udoni, J. T. Pokines, T. L. Moore, Experimental Study of Black Bear (*Ursus americanus*) and Grizzly Bear (*U. arctos*) Tooth Marks and Other Gnawing Damage on Bone. *Forensic Anthropol.* **4** (2021).
460. J. Sethy, N. P. S. Chauhan, Dietary preference of Malayan sun bear *Helarctos malayanus* in Namdapha Tiger Reserve, Arunachal Pradesh, India. *Wildlife Biol.* (2018).
461. M. P. Galicia, G. W. Thiemann, M. G. Dyck, S. H. Ferguson, Characterization of polar bear (*Ursus maritimus*) diets in the Canadian High Arctic. *Polar Biol.* (2015).
462. M. Iversen, J. Aars, T. Haug, I. G. Alsos, C. Lydersen, L. Bachmann, K. M. Kovacs, The diet of polar bears (*Ursus maritimus*) from Svalbard, Norway,

- inferred from scat analysis. *Polar Biol.* (2013).
463. A. A. Kochnev, Autumn aggregations of polar bears on the Wrangel Island and their importance for the population. *Proc. Mar. Mamm. Holarct.*, 137–138 (2002).
464. C. Merbs, in *Forensic Taphonomy* (1996).
465. K. D. Rode, E. V. Regehr, D. C. Douglas, G. Durner, A. E. Derocher, G. W. Thiemann, S. M. Budge, Variation in the response of an Arctic top predator experiencing habitat loss: Feeding and reproductive ecology of two polar bear populations. *Glob. Chang. Biol.* (2014).
466. J. B. Losos, H. W. Greene, Ecological and evolutionary implications of diet in monitor lizards. *Biol. J. Linn. Soc.* (1988).
467. J. J. Bull, T. S. Jessop, M. Whiteley, Deathly Drool: Evolutionary and ecological basis of septic bacteria in Komodo dragon mouths. *PLoS One* (2010).
468. M. A. Imron, R. A. Satria, M. F. P. Ramlan, Komodo Dragon Predation on Crab-Eating Macaques at the Rinca Island's Visitor Centre, Indonesia. *Folia Primatol.* (2018).
469. C. Traeholt, Notes on the food and feeding behaviour of *Varanus bengalensis nebulosus* on Pulau Tioman, Malaysia. *Malayan Nat. J.* (1997).
470. E. R. Pianka, W. Auffenberg, Gray's Monitor Lizard. *Copeia* (1988).
471. K. M. Mijanur Rahman, I. I. Rakhimov, M. M. H. Khan, Activity budgets and dietary investigations of varanus salvator (Reptilia: Varanidae) in Karamjal ecotourism spot of Bangladesh Sundarbans mangrove forest. *Basic Appl. Herpetol.* (2017).
472. F. Guarino, Diet of a large carnivorous lizard, *Varanus varius*. *Wildl. Res.* (2001).

473. L. Koungoulos, P. Faulkner, B. Asmussen, Analysis of pit and score tooth-mark sizes from bones modified by Holocene Australian terrestrial fauna in relation to body size. *J. Archaeol. Sci. Reports* (2018).
474. L. R. G. Desantis, B. W. Schubert, E. Schmitt-linville, P. S. Ungar, S. L. Donohue, R. J. Haupt, Dental Microwear Textures of Carnivorans from the La Brea Tar Pits, California, and Potential Extinction Implications. *La Brea Beyond Paleontol. Asph. Biotas* (2015).
475. S. L. Donohue, L. R. G. DeSantis, B. W. Schubert, P. S. Ungar, Was the giant short-faced bear a hyper-scavenger? A new approach to the dietary study of ursids using dental microwear textures. *PLoS One* (2013).
476. E. B. Koppelhus, P. J. Currie, Eds., in *Dinosaur Provincial Park A Spectacular Ancient Ecosystem Revealed* (Indiana University Press, 2005), pp. 1–388.
477. J. O. Farlow, D. L. Brinkman, Wear Surfaces on the Teeth of Tyrannosaurs. *Paleontol. Soc. Spec. Publ.* (1994).
478. R. E. Molnar, Mechanical factors in the design of the skull of *Tyrannosaurus rex* (Osborne, 1905). *Gaia* (1998).
479. A. R. Jacobsen, *Predatory Behaviour of Carnivorous Dinosaurs: Ecological Interpretations Based on Tooth Marked Dinosaur Bones and Wear Patterns of Therapod Teeth*. (Steno Museum, University of Aarhus, 2003).
480. T. D. Carr, A taxonomic assessment of the type series of *albertosaurus* *sarcophagus* and the identity of *tyrannosauridae* (Dinosauria, Coelurosauria) in the *albertosaurus* bonebed from the horseshoe canyon formation (Campanian-Maastrichtian, Late Cretaceous). *Can. J. Earth Sci.* (2010).

481. P. J. Currie, J. H. Hurum, K. Sabath, Skull structure and evolution in tyrannosaurid dinosaurs. *Acta Palaeontol. Pol.* (2003).
482. R. Delcourt, A subadult maxilla of a tyrannosauridae from the two medicine formation, Montana, United States. *Pap. Avulsos Zool.* (2017).
483. W. S. Persons Iv, P. J. Currie, An approach to scoring cursorial limb proportions in carnivorous dinosaurs and an attempt to account for allometry. *Sci. Rep.* (2016).
484. J. R. Horner, K. Padian, Age and growth dynamics of *Tyrannosaurus rex*. *Proc. R. Soc. B Biol. Sci.* (2004).
485. Royal Tyrrell Museum of Paleontology Online Collection. *TMP1979.014.1056*, (available at <http://rtmp.emuseum.com/objects/93143/-?ctx=d6317a8d-fec9-493f-a5bf-1968402502d2&idx=0%0A>).
486. Royal Tyrrell Museum of Paleontology Online Collection. *TMP2014.008.0001*, (available at <http://rtmp.emuseum.com/objects/187708/-?ctx=5a894988-7a64-4d0b-b81f-1a0c26afa437&idx=107>).
487. Royal Tyrrell Museum of Paleontology Online Collection. *TMP2000.012.0011*, (available at <http://rtmp.emuseum.com/objects/114996/-?ctx=db1b438e-0468-465c-a90f-2f8407c12b31&idx=355>).
488. J. B. Smith, D. R. Vann, P. Dodson, Dental morphology and variation in theropod dinosaurs: Implications for the taxonomic identification of isolated teeth. *Anat. Rec. - Part A Discov. Mol. Cell. Evol. Biol.* (2005).
489. S. G. Dalman, S. G. Lucas, On the dentary in the Fukui Prefactural Dinosaur Museum of *Gorgosaurus libratus* (Theropoda: Tyrannosauridae) from the Dinosaur Park Formation (Upper Cretaceous) of Alberta, Canada. *Mem. Fukui Prefect.*

- Dinosaur Museum*. **16**, 17–27 (2017).
490. C. M. Brown, P. J. Currie, F. Therrien, Intraspecific facial bite marks in tyrannosaurids provide insight into sexual maturity and evolution of bird-like intersexual display. *Paleobiology* (2021).
491. P. J. Currie, E. B. Koppelhus, The significance of the theropod collections of the royal tyrrell museum of palaeontology to our understanding of late cretaceous theropod diversity. *Can. J. Earth Sci.* (2015).
492. T. M. Cullen, J. I. Canale, S. Apesteguía, N. D. Smith, D. Hu, P. J. Makovicky, Osteohistological analyses reveal diverse strategies of theropod dinosaur body-size evolution. *Proc. R. Soc. B Biol. Sci.* (2020).
493. A. Dinno, Nonparametric pairwise multiple comparisons in independent groups using Dunn’s test. *Stata J.* (2015).
494. W. P. Coombs, Theoretical Aspects of Cursorial Adaptations in Dinosaurs. *Q. Rev. Biol.* (1978).
495. S. G. Platt, T. R. Rainwater, S. Snider, A. Garel, T. A. Anderson, S. T. McMurry, Consumption of large mammals by *Crocodylus moreletii*: Field observations of necrophagy and interspecific kleptoparasitism. *Southwest. Nat.* (2007).
496. L. G. Frank, Social organization of the spotted hyaena *Crocuta crocuta*. II. Dominance and reproduction. *Anim. Behav.* (1986).
497. H. E. Watts, K. E. Holekamp, Interspecific competition influences reproduction in spotted hyenas. *J. Zool.* (2008).
498. A. Kane, K. Healy, G. D. Ruxton, A. L. Jackson, Body size as a driver of scavenging in theropod dinosaurs. *Am. Nat.* (2016).

499. J. R. Horner, M. B. Goodwin, N. Myhrvold, Dinosaur census reveals abundant Tyrannosaurus and rare ontogenetic stages in the upper cretaceous hell creek formation (Maastrichtian), Montana, USA. *PLoS One* (2011).
500. J. Happ, in *Tyrannosaurus rex the Tyrant King*, K. Carpenter, P. L. Larson, Eds. (Indiana University Press, 2008), pp. 355–368.
501. D. Hone, D. Tanke, Pre- and postmortem tyrannosaurid bite marks on the remains of daspletosaurus (tyrannosaurinae: Theropoda) from dinosaur provincial park, alberta, canada. *PeerJ* (2015).
502. P. L. Larson, K. Carpenter, *Tyrannosaurus rex, the tyrant king* (Indiana University Press, 2008).
503. R. L. Crabtree, J. W. Sheldon, The ecological role of coyotes on Yellowstone's Norther Range. *Yellowstone Sci.* (1999).
504. M. F. Delany, C. L. Abercrombie, American Alligator Food Habits in Northcentral Florida. *J. Wildl. Manage.* (1986).
505. Opportunistic predation and predation-related events on long-tailed macaque and proboscis monkey in Kinabatangan, Sabah, Malaysia. *J. Trop. Biol. Conserv.* (2012).
506. J. A. Parkinson, T. Plummer, A. Hartstone-Rose, Characterizing felid tooth marking and gross bone damage patterns using GIS image analysis: An experimental feeding study with large felids. *J. Hum. Evol.* (2015).
507. S. M. Gatesy, K. M. Middleton, Bipedalism, flight, and the evolution of theropod locomotor diversity. *J. Vertebr. Paleontol.* (1997).
508. A. Zeffer, L. C. Johansson, Å. Marmebro, Functional correlation between habitat

- use and leg morphology in birds (Aves). *Biol. J. Linn. Soc.* (2003).
509. M. Roeleke, L. Johannsen, C. C. Voigt, How bats escape the competitive exclusion principle-seasonal shift from intraspecific to interspecific competition drives space use in a bat ensemble. *Front. Ecol. Evol.* (2018).
 510. A. N. Naikatini, G. Keppel, G. Brodie, S. Kleindorfer, Interspecific Competition and Vertical Niche Partitioning in Fiji's Forest Birds. *Diversity*. **14**, 223 (2022).
 511. A. H. Turner, D. Pol, J. A. Clarke, G. M. Erickson, M. A. Norell, A basal dromaeosaurid and size evolution preceding avian flight. *Science* (80-.). (2007).
 512. F. A. Gianechini, M. D. Ercoli, I. Díaz-Martínez, Differential locomotor and predatory strategies of Gondwanan and derived Laurasian dromaeosaurids (Dinosauria, Theropoda, Paraves): Inferences from morphometric and comparative anatomical studies. *J. Anat.* (2020).
 513. D. W. Fowler, E. A. Freedman, J. B. Scannella, R. E. Kambic, The predatory ecology of *Deinonychus* and the origin of flapping in birds. *PLoS One* (2011).
 514. D. Pol, P. A. Goloboff, in *Bulletin of the American Museum of Natural History* (2020).
 515. S. L. Brusatte, G. T. Lloyd, S. C. Wang, M. A. Norell, Gradual assembly of avian body plan culminated in rapid rates of evolution across the dinosaur-bird transition. *Curr. Biol.* (2014).
 516. V. M. Arbour, L. E. Zanno, D. W. Larson, D. C. Evans, H. D. Sues, The furculae of the dromaeosaurid dinosaur *Dakotaraptor steini* are trionychid turtle entoplastra. *PeerJ* (2016).
 517. R. A. DePalma, Pers. comm. (2016).

518. N. E. Van Vranken, in *Geological Society of America Abstracts with Programs* (2016; doi: 10.1130/abs/2016SC-273479).
519. D. Madzia, A. Cau, Inferring “weak spots” in phylogenetic trees: Application to mosasauroid nomenclature. *PeerJ* (2017).
520. P. A. Goloboff, J. S. Farris, K. C. Nixon, TNT, a free program for phylogenetic analysis. *Cladistics* (2008).
521. J. B. Slowinski, Unordered versus ordered characters. *Syst. Biol.* (1993).
522. P. A. Goloboff, in *Techniques in Molecular Systematics and Evolution* (2002).
523. M. D. Abràmoff, P. J. Magalhães, S. J. Ram, Image processing with imageJ. *Biophotonics Int.* (2004).
524. R. M. Alexander, *Dynamics of dinosaurs and other extinct giants* (Columbia University Press, 1989).
525. J. O. Farlow, M. B. Smith, J. M. Robinson, Body mass, bone “strength indicator,” and cursorial potential of Tyrannosaurus Rex. *J. Vertebr. Paleontol.* (1995).
526. R. A. Thulborn, Speeds and gaits of dinosaurs. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* (1982).
527. K. Padian, P. E. Olsen, Ratite footprints and the stance and gait of Mesozoic theropods. *Dinosaur tracks traces* (1989).
528. S. M. Gatesy, M. Bäker, J. R. Hutchinson, Constraint-based exclusion of limb poses for reconstructing theropod dinosaur locomotion. *J. Vertebr. Paleontol.* (2009).
529. S. Hartman, M. Mortimer, W. R. Wahl, D. R. Lomax, J. Lippincott, D. M. Lovelace, A new paravian dinosaur from the Late Jurassic of North America

- supports a late acquisition of avian flight. *PeerJ* (2019).
530. E. Snively, H. O'Brien, D. M. Henderson, H. Mallison, L. A. Surring, M. E. Burns, T. R. Holtz, A. P. Russell, L. M. Witmer, P. J. Currie, S. A. Hartman, J. R. Cotton, Lower rotational inertia and larger leg muscles indicate more rapid turns in tyrannosaurids than in other large theropods. *PeerJ* (2019).
 531. X. Wang, M. Pittman, X. Zheng, T. G. Kaye, A. R. Falk, S. A. Hartman, X. Xu, Basal paravian functional anatomy illuminated by high-detail body outline. *Nat. Commun.* (2017).
 532. C. Hendrickx, O. Mateus, *Torvosaurus gurneyi* n. sp., the largest terrestrial predator from Europe, and a proposed terminology of the maxilla anatomy in nonavian theropods. *PLoS One* (2014).
 533. J. G. Meso, Z. Qin, M. Pittman, J. I. Canale, L. Salgado, V. Díez Díaz, Tail anatomy of the Alvarezsauria (Theropoda, Coelurosauria), and its functional and behavioural implications. *Cretac. Res.* (2021).
 534. H. Pontzer, V. Allen, J. R. Hutchinson, Biomechanics of running indicates endothermy in bipedal dinosaurs. *PLoS One* (2009).
 535. J. I. Kirkland, A large dromaeosaurid (Theropoda) from the Lower Cretaceous of Eastern Utah. *Hunteria*. **2**, 1–16 (1993).
 536. W. Auffenberg, *The behavioral ecology of the Komodo monitor* (University Presses of Florida, Gainesville, 1981).
 537. D. J. Varricchio, Gut contents from a Cretaceous tyrannosaurid: Implications for theropod dinosaur digestive tracts. *J. Paleontol.* (2001).
 538. W. E. Magnusson, E. Vieira Da Silva, A. P. Lima, Diets of Amazonian

- crocodilians. *J. Herpetol.* (1987).
539. P. W. Webb, Effect of body form and response threshold on the vulnerability of four species of teleost prey attacked by largemouth bass (*Micropterus salmoides*). *Can. J. Fish. Aquat. Sci.* (1986).
540. W. D. Matthew, B. Brown, The family Deinodontidae, with notice of a new genus from the Cretaceous of Alberta. *Bull. Am. Museum Nat. Hist.* **46** (1922).
541. D. M. Henderson, Skull and Tooth Morphology As Indicators of Niche Partitioning in Sympatric Morrison. *Gaia.* **15**, 219–226 (1998).
542. T. R. Holtz, Theropod guild structure and the tyrannosaurid niche assimilation hypothesis: implications for predatory dinosaur macroecology and ontogeny in later Late Cretaceous Asiamerica. *Can. J. Earth Sci.* (2021).
543. J. A. Frederickson, M. H. Engel, R. L. Cifelli, Ontogenetic dietary shifts in *Deinonychus antirrhopus* (Theropoda; Dromaeosauridae): Insights into the ecology and social behavior of raptorial dinosaurs through stable isotope analysis. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* (2020).
544. S. H. Hwang, M. A. Norell, Y. H. Qiang, Ji , Ji Shuán, Lü Junchang, G. Keqin, New Specimens of *Microraptor zhaoianus* (Theropoda: Dromaeosauridae) from Northeastern China. *Am. Museum Novit.* (2002).
545. A. J. De Ricqlès, K. Padian, J. R. Horner, E. T. Lamm, N. Myhrvold, Osteohistology of *confuciusornis sanctus* (Theropoda: Aves). *J. Vertebr. Paleontol.* (2003).
546. F. A. Gianechini, P. J. Makovicky, S. Apesteguía, The cranial osteology of *Buitreraptor gonzalezorum* Makovicky, Apesteguía, and Agnolín, 2005

- (Theropoda, Dromaeosauridae), from the Late Cretaceous of Patagonia, Argentina. *J. Vertebr. Paleontol.* (2017).
547. T. R. Lyson, N. R. Longrich, Spatial niche partitioning in dinosaurs from the latest cretaceous (Maastrichtian) of North America. *Proc. R. Soc. B Biol. Sci.* (2011).
 548. S. Creel, N. M. Creel, Limitation of African wild dogs by competition with larger carnivores. *Conserv. Biol.* (1996).
 549. M. G. Lockley, D. White, J. Kirkland, V. Santucci, Dinosaur tracks from the Cedar Mountain Formation (Lower Cretaceous), Arches National Park, Utah. *Ichnos* (2004).
 550. B. B. Britt, D. A. Eberth, R. D. Scheetz, B. W. Greenhalgh, K. L. Stadtman, Taphonomy of debris-flow hosted dinosaur bonebeds at Dalton Wells, Utah (Lower Cretaceous, Cedar Mountain Formation, USA). *Palaeogeogr. Palaeoclimatol. Palaeoecol.* (2009).
 551. C. Ciofi, J. Puswati, D. Winana, M. E. De Boer, G. Chelazzi, P. Sastrawan, Preliminary analysis of home range structure in the Komodo monitor, *Varanus komodoensis*. *Copeia* (2007).
 552. J. H. Fanshawe, C. D. Fitzgibbon, Factors influencing the hunting success of an African wild dog pack. *Anim. Behav.* (1993).
 553. R. D. Estes, J. Goddard, Prey Selection and Hunting Behavior of the African Wild Dog. *J. Wildl. Manage.* (1967).
 554. A. Perle, M. A. Norell, J. M. Clark, A new maniraptoran Theropod- *Achillobator giganticus* (Dromaeosauridae)- from the Upper Cretaceous of Burkhan, Mongolia. *Contrib. from Geol. Mineral. Chair, Natl. Museum Mong.* **101** (1999).

555. M. J. Motta, F. L. Agnolín, F. Brissón Egli, F. E. Novas, New theropod dinosaur from the Upper Cretaceous of Patagonia sheds light on the paravian radiation in Gondwana. *Sci. Nat.* (2020).
556. R. B. J. Benson, J. N. Choiniere, Rates of dinosaur limb evolution provide evidence for exceptional radiation in Mesozoic birds. *Proc. R. Soc. B Biol. Sci.* (2013).
557. S. L. Brusatte, M. Vremir, Z. Csiki-Sava, A. H. Turner, A. Watanabe, G. M. Erickson, M. A. Norell, The Osteology of Balaur bondoc, an Island-Dwelling Dromaeosaurid (Dinosauria: Theropoda) from the Late Cretaceous of Romania. *Bull. Am. Museum Nat. Hist.* (2013).
558. H. M. Kim, A. D. Gishlick, T. Tsuihiji., The first non-avian maniraptoran skeletal remains from the Lower Cretaceous of Korea. *Cretac. Res.* (2005).
559. R. Pei, M. A. Norell, D. E. Barta, G. S. Bever, M. Pittman, X. Xu, Osteology of a New Late Cretaceous Troodontid Specimen from Ukhaa Tolgod, Ömnögovi Aimag, Mongolia. *Am. Museum Novit.* (2017).
560. P. J. Currie, A. P. Carabajal, A new specimen of Austroraptor Cabazai Novas, Pol, Canale, Porfiri and Calvo, 2008 (Dinosauria, Theropoda Unenlagiidae) from the latest Cretaceous (Maastrichtian) of Río Negro, Argentina. *Ameghiniana* (2012).
561. F. E. Novas, F. Brissón Egli, F. L. Agnolin, F. A. Gianechini, I. Cerda, Postcranial osteology of a new specimen of Buitreraptor gonzalezorum (Theropoda, Unenlagiidae). *Cretac. Res.* (2018).
562. J. H. Ostrom, On a new specimen of the Lower Cretaceous theropod dinosaur Deinonychus antirrhopus. *Breviora.* **439**, 1–21 (1976).

563. T. Tsuihiji, R. Barsbold, M. Watabe, K. Tsogtbaatar, T. Chinzorig, Y. Fujiyama, S. Suzuki, An exquisitely preserved troodontid theropod with new information on the palatal structure from the Upper Cretaceous of Mongolia. *Naturwissenschaften* (2014).
564. X. Xu, M. A. Norell, A new troodontid dinosaur from China with avian-like sleeping posture. *Nature* (2004).
565. S. Burch, Osteological, myological, and phylogenetic trends of forelimb reduction in nonavian theropod dinosaurs (Thesis). *Grad. Sch. Stony Brook Univ.* (2015).
566. A. H. Turner, S. Montanari, M. A. Norell, A New Dromaeosaurid from the Late Cretaceous Khulsan Locality of Mongolia. *Am. Museum Novit.* (2021).
567. D. A. Russell, Zhi-Ming Dong, A nearly complete skeleton of a new troodontid dinosaur from the early Cretaceous of the Ordos Basin, Inner Mongolia, People's Republic of China. *Can. J. Earth Sci.* (1993).
568. X. Xu, X. Wang, A New Troodontid (Theropoda: Troodontidae) from the Lower Cretaceous Yixian Formation of Western Liaoning, China. *Acta Geol. Sin.* (2004).
569. X. Zheng, X. Xu, H. You, Q. Zhao, Z. Dong, A short-armed dromaeosaurid from the Jehol group of China with implications for early dromaeosaurid evolution. *Proc. R. Soc. B Biol. Sci.* (2010).
570. M. Wang, J. K. O'Connor, X. Xu, Z. Zhou, A new Jurassic scansoriopterygid and the loss of membranous wings in theropod dinosaurs. *Nature* (2019).
571. D. Hu, L. Hou, L. Zhang, X. Xu, A pre-Archaeopteryx troodontid theropod from China with long feathers on the metatarsus. *Nature* (2009).
572. G. Mayr, B. Pohl, S. Hartman, D. S. Peters, The tenth skeletal specimen of

- Archaeopteryx. *Zool. J. Linn. Soc.* (2007).
573. M. Wang, thesis, University of Chinese Academy of Sciences, Beijing (2014).
574. P. Godefroit, A. Cau, H. Dong-Yu, F. Escuillié, W. Wenhao, G. Dyke, A Jurassic avialan dinosaur from China resolves the early phylogenetic history of birds. *Nature* (2013).
575. D. Hu, J. A. Clarke, C. M. Eliason, R. Qiu, Q. Li, M. D. Shawkey, C. Zhao, L. D'Alba, J. Jiang, X. Xu, A bony-crested Jurassic dinosaur with evidence of iridescent plumage highlights complexity in early paravian evolution. *Nat. Commun.* (2018).
576. M. Wang, T. A. Stidham, Z. Zhou, A new clade of basal Early Cretaceous pygostylian birds and developmental plasticity of the avian shoulder girdle. *Proc. Natl. Acad. Sci. U. S. A.* (2018).
577. M. Wang, Z. Zhou, A new confuciusornithid (Aves: Pygostylia) from the Early Cretaceous increases the morphological disparity of the Confuciusornithidae. *Zool. J. Linn. Soc.* (2019).
578. P. Godefroit, H. Demuynck, G. Dyke, D. Hu, F. Escuillié, P. Claey's, Reduced plumage and flight ability of a new Jurassic paravian theropod from China. *Nat. Commun.* (2013).
579. F. Zhang, Z. Zhou, X. Xu, X. Wang, C. Sullivan, A bizarre Jurassic maniraptoran from China with elongate ribbon-like feathers. *Nature* (2008).
580. Y. H. Qiang, Ji , Ji Shuán, Lü Junchang, First avialan bird from China. *Geol. Bull. China* (2005).
581. B. P. Hedrick, P. L. Manning, E. R. Lynch, S. A. Cordero, P. Dodson, The

- geometry of taking flight: Limb morphometrics in Mesozoic theropods. *J. Morphol.* (2015).
582. U. Lefèvre, A. Cau, A. Cincotta, D. Hu, A. Chinsamy, F. Escuillié, P. Godefroit, A new Jurassic theropod from China documents a transitional step in the macrostructure of feathers. *Naturwissenschaften* (2017).
 583. X. Xu, X. L. Wang, X. C. Wu, A dromaeosaurid dinosaur with a filamentous integument from the Yixian Formation of China. *Nature* (1999).
 584. A. W. Poust, C. Gao, D. J. Varricchio, J. Wu, F. Zhang, A new microraptorine theropod from the Jehol Biota and growth in early dromaeosaurids. *Anat. Rec.* (2020).
 585. X. Xu, H. You, K. Du, F. Han, An Archaeopteryx-like theropod from China and the origin of Avialae. *Nature* (2011).
 586. Z. Zhou, F. Zhang, Two new ornithurine birds from the Early Cretaceous of western Liaoning, China. *Chinese Sci. Bull.* (2001).
 587. X. Xu, X. Zheng, C. Sullivan, X. Wang, L. Xing, Y. Wang, X. Zhang, J. K. O'Connor, F. Zhang, Y. Pan, A bizarre Jurassic maniraptoran theropod with preserved evidence of membranous wings. *Nature* (2015).
 588. X. Xu, Z.-C. Qin, A new tiny dromaeosaurid dinosaur from the Lower Cretaceous Jehol Group of western Liaoning and niche differentiation among the Jehol dromaeosaurids. *Vertebr. Palasiat.* **55**, 129–144 (2017).
 589. N. Ibrahim, P. C. Sereno, D. J. Varricchio, D. M. Martill, D. B. Dutheil, D. M. Unwin, L. Baidder, H. C. E. Larsson, S. Zouhri, A. Kaoukaya, Geology and paleontology of the upper cretaceous Kem Kem group of eastern Morocco.

Zookeys (2020).

590. R. S. Lull, The Cretaceous armored dinosaur, *Nodosaurus textilis* Marsh. *Am. J. Sci.* (1921).
591. R. A. Coria, B. G. Riga, S. Casadio, Un nuevo hadrosáurido (Dinosauria, Ornithopoda) de la formación Allen, Provincia de la Pampa, Argentina. *Ameghiniana* (2012).
592. J. E. Powell, in *Los Dinosaurios y Su Entorno Biotico, Actas del Segundo Curso de Paleontología in Cuenca* (1992).
593. A. Prieto-Márquez, Skeletal morphology of *Kritosaurus navajovius* (Dinosauria: Hadrosauridae) from the Late Cretaceous of the North American south-west, with an evaluation of the phylogenetic systematics and biogeography of Kritosaurini. *J. Syst. Palaeontol.* (2014).
594. G. Casal, *Aeolosaurus colhuehuapensis* sp. nov. (Sauropoda, Titanosauria) de la Formación Bajo Barreal, Cretácico superior de Argentina. *Rev. Bras. Paleontol.* (2007).
595. P. A. Gallina, A. Otero, Reassessment of *Laplatasaurus araukanicus* (Sauropoda: Titanosauria) from the Upper Cretaceous of patagonia, Argentina. *Ameghiniana* (2015).
596. J. A. Wilson, Redescription of the mongolian sauropod *nemegtosaurus mongoliensis* nowinski (Dinosauria: Saurischia) and comments on late cretaceous sauropod diversity. *J. Syst. Palaeontol.* (2005).
597. S. M. Kurzanov, An unusual theropod from the Upper Cretaceous of Mongolia. *Jt. Sov. Paleontol. Exped.* **15**, 39–49 (1981).

598. P. C. Sereno, L. Tan, S. L. Brusatte, H. J. Kriegstein, X. Zhao, K. Cloward, Tyrannosaurid skeletal design first evolved at small body size. *Science* (80-.). (2009).
599. B. J. Mader, R. L. Bradley, A redescription and revised diagnosis of the syntypes of the Mongolian tyrannosaur *Alectrosaurus Olseni*. *J. Vertebr. Paleontol.* (1989).
600. E. A. Maleev, Giant carnosaur of the family Tyrannosauridae. *Jt. Sov. Paleontol. Exped.* (1974).
601. P. J. Makovicky, M. A. Norell, *Yamaceratops dornogobiensis*, a new primitive ceratopsian (Dinosauria: Ornithischia) from the cretaceous of Mongolia. *Am. Museum Novit.* (2006).
602. T. Maryanska, H. Osmolska, Z. Kielan-Jaworowska, Pachycephalosauria, a new suborder of ornithischian dinosaurs. *Palaeontol. Pol.* (1974).
603. Y. Kobayashi, R. Barsbold, Reexamination of a primitive ornithomimosaur, *Garudimimus brevipes* Barsbold, 1981 (Dinosauria: Theropoda), from the Late Cretaceous of Mongolia. *Can. J. Earth Sci.* (2005).
604. D. Smith, P. Galton, Osteology of *Archaeornithomimus Asiaticus* (Upper Cretaceous, Iren Dabasu Formation, People's Republic of China). *J. Vertebr. Paleontol.* (1990).
605. B. P. Hedrick, L. E. Zanno, D. G. Wolfe, P. Dodson, The slothful claw: Osteology and taphonomy of *Nothronychus mckinleyi* and *N. graffami* (Dinosauria: Theropoda) and anatomical considerations for derived therizinosaurs. *PLoS One* (2015).
606. K. Carpenter, S. Hayashi, Y. Kobayashi, T. Maryńska, R. Barsbold, K. Sato, I.

- Obata, *Saichania chulsanensis* (Ornithischia, Ankylosauridae) from the Upper Cretaceous of Mongolia. *Palaeontogr. Abteilung A Palaeozoologie - Stratigr.* (2011).
607. X. Zhang, X. Xu, X. Zhao, P. Sereno, X. Kuang, L. Tan, A long-necked therizinosauroid dinosaur from the Upper Cretaceous Iren Dabasu Formation of Nei Mongol , People's Republic of China. *Vertebr. Palasiat.* (2001).
608. E. A. Maleev, Armored Dinosaurs of the Upper Cretaceous of Mongolia Family Ankylosauridae. *Tr. Paleontol. Instituta Akad. Nauk SSSR.* **62**, 51–91 (1956).
609. P. J. Currie, D. Badamgarav, E. B. Koppelhus, R. Sissons, M. K. Vickaryous, Hands, feet, and behaviour in *Pinacosaurus* (Dinosauria: Ankylosauridae). *Acta Palaeontol. Pol.* (2011).
610. C. W. Gilmore, On the dinosaurian fauna of the Iren Dabasu Formation. *Bull. Am. Museum Nat. Hist.* **67** (1933).
611. R. D. Martínez, O. Giménez, J. Rodríguez, M. Luna, M. C. Lamanna, An Articulated Specimen of the Basal Titanosaurian (Dinosauria: Sauropoda) *Epachthosaurus scuittoni* from the Early Late Cretaceous Bajo Barreal Formation of Chubut Province, Argentina. *J. Vertebr. Paleontol.* **24**, 107–120 (2004).
612. K. Curry Rogers, C. A. Forster, The last of the dinosaur titans: A new sauropod from Madagascar. *Nature* (2001).
613. J. I. Kirkland, B. B. Britt, C. H. Whittle, S. K. Madsen, D. L. Burge, A small coelurosaurian theropod from the Yellow Cat Member of the Cedar Mountain Formation (Lower Cretaceous, Barremian) of eastern Utah. *New Mex. Museum Nat. Hist. Sci. Bull.* (1998).

614. J. I. Kirkland, L. E. Zanno, S. D. Sampson, J. M. Clark, D. D. DeBlieux, A primitive therizinosauroid dinosaur from the Early Cretaceous of Utah. *Nature* (2005).
615. A. T. McDonald, J. I. Kirkland, D. D. DeBlieux, S. K. Madsen, J. Cavin, A. R. C. Milner, L. Panzarin, New basal iguanodonts from the cedar mountain formation of utah and the evolution of thumb-spiked dinosaurs. *PLoS One* (2010).
616. J. I. Kirkland, A Polacanthine Ankylosaur (Ornithischia:Dinosauria) from the Early Cretaceous (Barremian) of Eastern Utah. *New Mex. Museum Nat. Hist. Sci. Bull.* (1998).
617. D. B. Norman, *On the Ornithischian Dinosaur Iguanodon bernissartensis from the Lower Cretaceous of Bernissart (Belgium)* (Koninklijk Belgisch Instituut voor Natuurwetenschappen, 1980).
618. R. Royo-Torres, P. Upchurch, J. I. Kirkland, D. D. DeBlieux, J. R. Foster, A. Cobos, L. Alcalá, Descendants of the Jurassic turiasaurs from Iberia found refuge in the Early Cretaceous of western USA. *Sci. Rep.* (2017).
619. H. F. Osborn, C. C. Mook, Camarasaurus, Amphicoelias, and other sauropods of Cope. *Bull. Geol. Soc. Am.* (1919).
620. B. B. Britt, R. D. Scheetz, M. F. Whithing, R. D. Wilhite, *Moabosaurus utahensis*, n. gen., n. sp., a new sauropod from the Early Cretaceous (Aptian) of North America. *Contrib. from Museum Paleontol. Univ. Michigan* (2017).
621. V. Tidwell, K. Carpenter, W. Brooks, New sauropod from the Lower Cretaceous of Utah. *Oryctos* (1999).
622. S. Hartman, Skeletal Drawing. *Tyrannosaurus - Jane* (2014), (available at

<https://www.skeletaldrawing.com/theropods/tyrannosaurus-jane>).

- 623. C. A. Brochu, Osteology of tyrannosaurus rex: Insights from a nearly complete skeleton and high-resolution computed tomographic analysis of the skull. *J. Vertebr. Paleontol.* (2003).
- 624. R. D. Scheetz, Osteology of Orodromeus makelai and the phylogeny of basal ornithomimid dinosaurs. *Mont. State Univ. Coll. Lett. Sci.* (1999).
- 625. C. W. Gilmore, *On Troodon validus, an orthomimid dinosaur from the Belly River Cretaceous of Alberta, Canada* (University of Alberta Press, 1924).
- 626. C. W. Gilmore, Osteology of Thescelosaurus, an orthomimid dinosaur from the Lance formation of Wyoming. *Proc. United States Natl. Museum* (1915).
- 627. L. P. A. M. Claessens, M. A. Loewen, A redescription of Ornithomimus velox Marsh, 1890 (Dinosauria, Theropoda). *J. Vertebr. Paleontol.* (2016).
- 628. P. Christiansen, G. S. Paul, Limb bone scaling, limb proportions, and bone strength in neoceratopsian dinosaurs. *Gaia* (2001).