Electronic Supplementary Material

Blood flow to long bones indicates activity metabolism in mammals, reptiles and dinosaurs

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MATERIAL AND METHODS

Adult specimens were chosen to avoid ontogenetic changes to bone blood supply associated with growth and haematopoiesis [1]. Adulthood is represented by fusion of the epiphyseal plates in mammals [2], but is more difficult to recognise in reptilian long bones [3]. In this case larger femora were included preferentially to smaller ones and museum information also aided in determining the maturity of the specimens. Numerous foramina near the epiphyses of reptile bones were ignored and only those on the shafts measured, because the epiphyses have a separate blood supply and do not contribute flow to the shaft [2]. Both right and left femora were measured, and a maximum of four replicates were included for each species. However, due to limited availability of skeletons, this could not be fulfilled for all species. For those species with maximum replication, the average variation in femur volume was mean ±32%, and for foramina area variation was mean ± 37%.

Each dried and degreased femur was weighed and its length and volume measured. Maximum length was measured with callipers or a ruler to three significant figures or better. Volume was determined using displacement of granules (rice grains or 600 µm glass beads, depending on femur size). An appropriately sized cylinder was first filled with granules and levelled off at the rim, and the volume poured into a separate container. Some of the granules were replaced in the cylinder and the femur was placed on this bed to prevent it touching the wall of the cylinder and creating air pockets. The femur was then carefully covered with more granules and levelled again. The volume of the remaining granules was measured in a graduated cylinder and taken as femur volume. In all cases, the granules were not agitated in an attempt to maintain a consistent level of compaction. Repetitions indicated that this method provided a measurement error of around 10%. Volume could not be measured on some mounted specimens, so only length was measured.

Because of the great range in foramen size, it was necessary to measure foramen area with two techniques: digital photographs of the surface of small bones and vernier callipers for large ones. For smaller, disarticulated femora, a photograph was taken of the foramen through a camera attached to a stereo microscope. The scale of these photographs was calibrated with a photograph of a calliper set to a known distance at the same level of magnification. The precision ranged from about 0.001 mm for small bones to 0.1 mm for large ones. As many of the nutrient arteries enter the bone at an oblique angle, the femur was always positioned under the microscope to ensure the foramen appeared as circular as possible. Where bones were too large to fit under the microscope stand or were not able to be disarticulated, photographs were taken with a hand-held digital camera, and a calliper set to known distance was held across the opening of the foramen for scale. In all cases, the area of the foramen was determined where the opening appeared constant with depth (more or less uniformly dark), and the tapered entrance was ignored (Fig. 1). The photographs were analysed using Image J (www.nih.gov) to determine foramen area. Radius was calculated from area, assuming circularity. If more than one nutrient foramen was present, the areas were added together and a single radius calculated from the sum, under the simplifying assumption that, regardless of the pattern of circulation the artery and vein, the area of the combined entry and exit vessels is the same. This is an unavoidable problem, because the pattern of blood flow is not known in museum specimens.

Foramen size in a few mounted skeletons of mammals and dinosaur fossils was measured directly with vernier callipers from the diameters of the narrowest visible opening (Fig. 1). Area and Q_i were determined by the minor diameter only. Body masses for dinosaurs were estimated from femur length relationships for each taxonomic group, as it has been shown for carnivorous dinosaurs and mammals that body mass and femoral length are closely correlated [4]. Body masses (M_{new}) for new dinosaurs were calculated from femoral lengths (L_{new}), based on knowledge of masses (M_{known}) and lengths (L_{known}) from a complete specimen of either the same genus or family of the dinosaur femur under consideration, according to the relationship: $(M_{new}/L^3_{new}) = (M_{known}/L^3_{known})$. Known body mass and femur length estimates for selected dinosaur groups were taken from Henderson [5, 6] and Paul [7].

Data for metabolic rate of measured species were obtained from the literature. Where more than one value was available for each species, the mean was taken. Basal metabolic rate (BMR) and maximal metabolic rate (MMR) for mammals were taken at normal body temperatures of mammals. Both standard metabolic rate (called here BMR) and MMR for all reptiles were converted to a mammalian equivalent temperature of 38 °C using a Q_{10} of 2.4

[8]. This was done because data were usually taken at body temperatures different from preferred, activity or field body temperatures of the species, but such natural temperatures are not often available, and, in any case, it is unclear what temperature would be the most relevant for the present study. Correction to 38 °C is likely to overestimate values for some species, but using uncorrected data would certainly underestimate relevant values. The correction we applied actually results in a conservative conclusion, since it homogenises the data set and probably reduces the gap between reptiles and mammals.

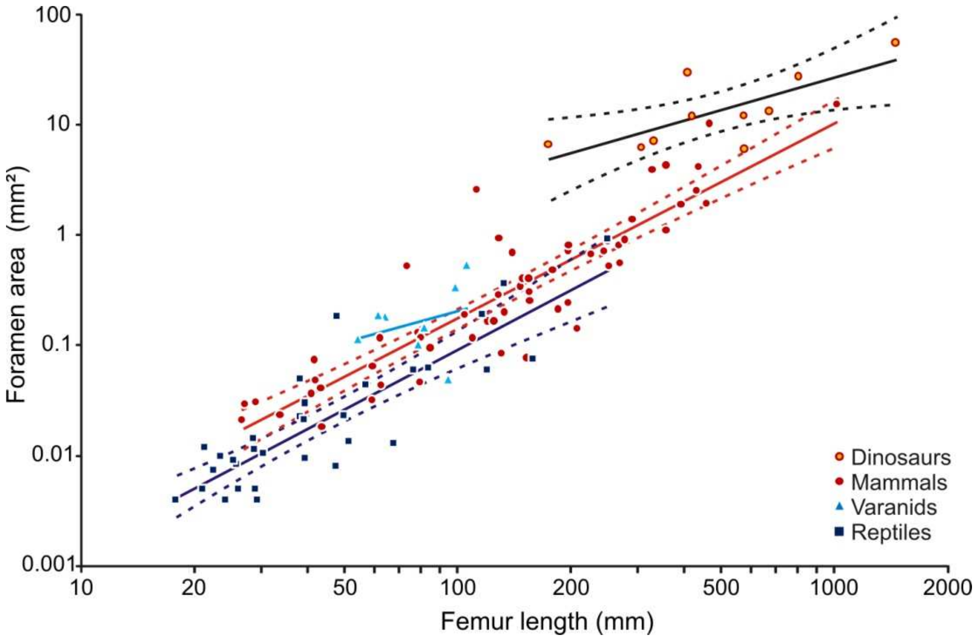
For all parameters, values for each animal replicate were obtained by averaging the left and right femur, and then replicate values were averaged to provide a single value for each species for analysis. Ordinary least squares regression was performed on log-transformed data relating foramina size and Q_i to the femur parameters (volume, mass and length), body size and metabolic rate. Confidence intervals (95%) of the regression mean were determined using JMPin (www.jmp.com) and plotted for the above variables. Separate regressions were fit to mammals, varanid lizards, other reptiles and dinosaurs. Varanids were separated from the remaining reptiles as they are known to have atypical metabolic rates [9], and when analysed separately were always statistically different from the remaining reptiles. As a result the term 'reptile' refers to all remaining reptiles, excluding varanids. Regression data were tested with ANCOVA [10] for significant differences in slope (*b*), and when no significant difference was found, elevation (*a*) was also tested [10]. When slopes were significantly different, the Johnson-Neyman test was used to show which data points differed [11]. Stepwise multiple regressions were performed for the relationships between foramina area and the femur parameters. Simple and multiple regressions were also performed for the relationship between Q_i and the metabolic variables, BMR, MMR and AAS. To eliminate the effects of body mass on the metabolic variables, each was plotted against body mass, and then the residuals were plotted against the residuals for body mass and foramen size. Both simple and multiple regressions were carried out in the software package statistiXL (www.statistixl.com). All tests were carried out with a P-value of 0.05, and all statistics displayed as mean ± 95% confidence intervals (CI).

To determine the physiological and morphological variables most strongly associated with inter-specific variation in Q_i in extant mammals, reptiles and varanids, the goodness of fit of the relationship between log Q_i and a candidate set of possible predictors was assessed on the basis of the small-sample (second order) version of Akaike's Information Criterion

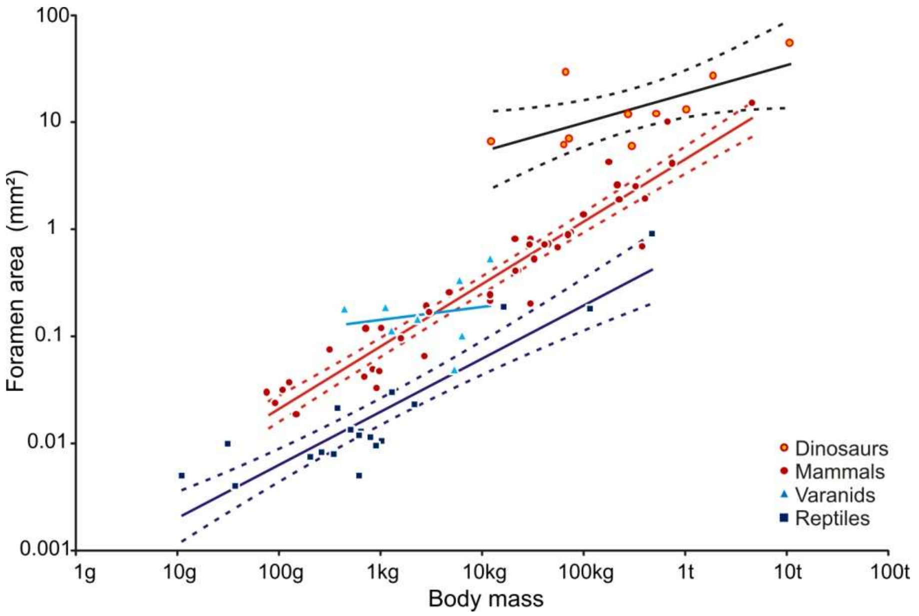
(AIC_c); [12] and the associated Akaike weight (w_i, the probability that a particular model is the best, given the data). The candidate set of seven *a priori* models included four single-predictor models that described variation in log Q_i on the basis of variation in log M_b, log BMR, log MMR, or log AAS, and three two-predictor models that included log M_b and one each of log BMR, log MMR and log AAS. The model with the lowest AIC_c is considered the best predictor of log Q_i, given the data. Values of AIC_c for all but the best model are expressed as the difference in AIC_c between a given model and the best model ($\Delta AIC_c = AIC_c$ – lowest AIC_c; ΔAIC_c for the best model is equal to zero). Models with values of ΔAIC_c less than 2 are considered well supported, those with ΔAIC_c of 4 - 7 have considerably less support, and those with ΔAIC_c greater than 10 have essentially no support [12]. The probability that any given model is actually the best fit out of those tested was measured by its Akaike weight (w_i), which is calculated as the relative-likelihood of the model compared to all others (the likelihood of the model divided by the sum of the likelihoods of all other models).

RESULTS

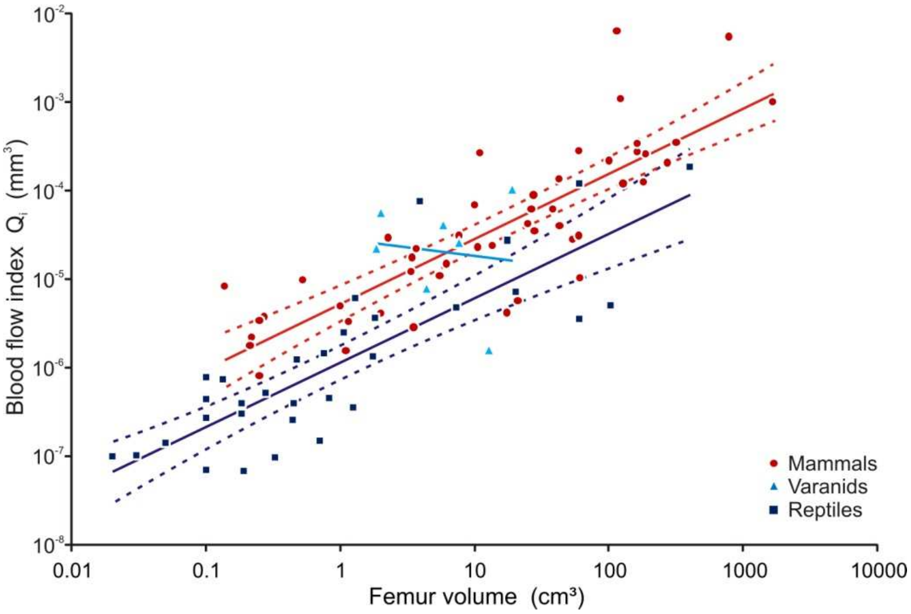
Foramen area is significantly correlated with femur length (Fig. S1) and femur mass (not shown; essentially identical to femur volume) in both mammals and reptiles, but not varanids (Table S1). Scaling exponents for the allometric equations are almost identical between reptiles and mammals, at around 1.8 for length and 0.5 for mass. Analysis of covariance reveals that mammals are always significantly higher in elevation than reptiles but never significantly different in slope (Table S1). Mammals and varanids are never significantly different in slope or elevation for any of the femur parameters. Reptiles are always significantly lower than varanids in elevation, yet never significantly different in slope. Foramen area of dinosaurs in relation to femur length is marginally not significantly different from mammals in slope, but was significantly higher (Fig. S1; Table S1). Foramen area in relation to body mass is significantly higher in mammals than in reptiles and in varanids compared to other reptiles, but little difference between mammals and varanids (Fig. S2; Table S2). Remarkably, foramen area of dinosaurs is significantly higher than in mammals, except for *Giraffatitan brancai*, which was not significantly different according to the Johnson-Neyman test (Table S2).



Supplementary Fig. S1: Relationship between foramen area (A) and femur length (L_F) in mammals (red, $A = 5.2 \times 10^{-5} L_F^{1.76}$), reptiles (dark blue, $A = 2.5 \times 10^{-5} L_F^{1.79}$), varanids (light blue, $A = 3.2 \times 10^{-3} L_F^{0.90}$), and dinosaurs (orange, $A = 3.5 \times 10^{-2} L_F^{0.96}$). 95% confidence intervals of the regression means are displayed. Regressions are compared in Table S1.



Supplementary Fig. S2: Relationship between femur foramen area (A) to body mass (M_b) in mammals (red, $A = 1.4 \times 10^{-3} M_b^{0.58}$), reptiles (dark blue, $A = 6.3 \times 10^{-4} M_b^{0.50}$), varanids (light blue, $A = 6.0 \times 10^{-2} M_b^{0.13}$), and dinosaurs (orange, $A = 0.43 M_b^{0.27}$). 95% confidence intervals of the regression means are displayed. Regressions are compared in Table S2.



Supplementary Fig. S3: Relationship between index to blood flow rate (Q_i) and femur volume (V_F) in mammals (red, $Q_i = 5.3 \text{x} 10^{-6} V_F^{0.74}$), reptiles (dark blue, $Q_i = 1.2 \text{x} 10^{-6} V_F^{0.73}$) and varanids (light blue, $Q_i = 2.9 \text{x} 10^{-5} V_F^{-0.2}$), plotted on log-log axes. 95% confidence intervals of the regression mean are displayed. Regressions are compared in Table S2.

Supplementary Table S1: Allometric relationships between foramen area (A, mm^2) with length (L_F, mm) and femur mass (M_F, g) in mammals, reptiles, varanids and dinosaurs. Equations are in the form $A = a X^b$, where *a* is the scaling factor and *b* is the exponent. Exponents are expressed as mean ± 95% CI. n = number of species. Analyses of covariance for these relationships are shown below each femur variable. Significant differences are **bold**.

GROUP	**Area v. Femur Length**				**Area v. Femur Mass**			
	$A = aL_F^b$				**$A = aM_F^b$**			
	n	Equation	r^2	*P*	n	Equation	r^2	*P*
Mammals	59	$A = 5.2\times10^{-5}L_F^{1.76 \pm 0.23}$	0.805	**<0.0001**	49	$A = 0.048M_F^{0.53 \pm 0.07}$	0.834	**<0.0001**
Reptiles	32	$A = 2.5\times10^{-5}L_F^{1.79 \pm 0.37}$	0.739	**<0.0001**	32	$A = 0.021M_F^{0.50 \pm 0.09}$	0.801	**<0.0001**
Varanids	8	$A = 3.2\times10^{-3}L_F^{0.90 \pm 2.91}$	0.088	0.4763	8	$A = 0.075M_F^{0.38 \pm 0.79}$	0.187	0.2848
Dinosaurs	10	$A = 0.34L_F^{0.96 \pm 0.74}$	0.532	**0.017**				

ANCOVA	**Slope**		**Elevation**					
	F	*P*	*F*	*P*	*F*	*P*	*F*	*P*
Mammal v. Reptile	0.010	0.921	11.7	**<0.001**	0.227	0.635	33.1	**<0.001**
Reptile v. Varanid	0.589	0.448	11.4	**0.002**	0.168	0.684	15.3	**<0.001**
Mammal v. Varanid	0.581	0.449	1.730	0.193	0.311	0.580	0.469	0.521
Dinosaur v. Mammal	3.79	0.056	32.2	**<0.001**				

Supplementary Table S2: Allometric relationships between blood flow index Q_i (cm^3) with femur volume (V_F, cm^3), and foramen area (A, mm^2) with body mass (M_b, g) in mammals, reptiles, varanids and dinosaurs. Equations are in the form $Y = a Xb$, where a is the scaling factor and b is the exponent. Exponents are expressed as mean ± 95% CI. n = number of species. Analyses of covariance for these relationships are shown below each variable. Significant differences are **bold**.

GROUP	**Flow v. Femur Volume** $Q_i = aV_F^b$				**Area v. Body Mass** $A = aM_b^b$			
	n	Equation	r^2	*P*	n	Equation	r^2	*P*
Mammals	39	$Q_i = 5.3x10^{-6}V_F^{0.74 \pm 0.14}$	0.706	**<0.0001**	44	$A = 1.45x10^{-3}M_b^{0.58\pm0.06}$	0.915	**<0.0001**
Reptiles	32	$Q_i = 1.2x10^{-6}V_F^{0.73 \pm 0.18}$	0.705	**<0.0001**	20	$A = 6.31x10^{-4}M_b^{0.50\pm0.11}$	0.834	**<0.0001**
Varanids	7	$Q_i = 2.9x10^{-5}V_F^{-0.2 \pm 1.8}$	0.016	0.789	8	$A = 0.06M_b^{0.13\pm0.65}$	0.037	0.649
Dinosaurs					10	$A = 0.43M_b^{0.27\pm.023}$	0.483	**0.026**
ANCOVA	**Slope**		**Elevation**		**Slope**		**Elevation**	
	F	*P*	*F*	*P*	*F*	*P*	*F*	*P*
Mammal v. Reptile	0.003	0.954	25.6	**<0.001**	2.06	0.156	82.8	**< 0.001**
Reptile v. Varanid	2.53	0.120	8.79	**0.005**	2.73	0.111	32.08	**< 0.001**
Mammal v. Varanid	2.83	0.099	0.015	0.902	5.85	**0.019**	#	#
Dinosaur v. Mammal					11.3	**<0.001**	*	*

Johnson-Neyman (J-N) test shows only smallest varanid lizard significantly above mammals.

* J-N test shows all dinosaur data are significantly higher than mammals, except *Giraffatitan brancai*, which is not significantly different.

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Appendix:

Individual specimens measured are identified by accession registration numbers for museums identified at the bottom of the table. Estimates of body mass and metabolic rates are derived from references provided below. Data for femur and foramen dimensions are means for the species and comprise right and left femora of all specimens.

APPENDIX					**Metabolic Rate**				**Femur**			**Foramen**		
Species	**Loc.**	**Reg. #**	**Body Mass**	**Ref.**	**BMR**	**Ref.**	**MMR**	**Ref.**	**Volume**	**Mass**	**Length**	**Area**	**Diameter**	**$Q_i = r^4/L$**
			g		**ml O_2 h^{-1}**		**ml O_2 h^{-1}**		**ml**	**g**	**mm**	**mm^2**	**mm**	**mm^3**
MAMMALS														
Monotremata														
Ornithorhynchus anatinus	SAM	M6298	693	29	194	29			2	3.54	43.22	0.0415	0.229529	4.08805E-06
Tachyglossus aculeatus	SAM	M22230	2725	29	431	29	3955.8	10	5.5	6.3	59.295	0.065	0.265737	1.08138E-05
Dasyuromorphia														
Antechinus minimus	SAM	M11942							0.2175	0.2325	26.67	0.021375	0.157455	2.16456E-06
	SAM	M11978												
	SAM	M22405												
	SAM	M23372												
Dasyuroides byrnei	SAM	M18284	92	29	72	29	1435.2	10	0.2125	0.245	33.6925	0.0235	0.184581	1.75547E-06
	SAM	M7519												
Thylacinus cynocephalus	SAM	M95							61	79.63	206.5	0.1425	0.424493	1.02424E-05
Peramelemorphia														
Isoodon obesulus	SAM	M13473	717	29	222	29	5731.8	10	2.275	2.7775	62.035	0.117625	0.369789	2.91277E-05
	SAM	M5230												
	SAM	M7265												
	SAM	M7266												
Perameles gunnii	SAM	M5227	837	29	420	29			1	0.62	41.8	0.049	0.294769	4.90365E-06
Diprotodontia														
Aepyprymnus rufescens	SAM	M15918	2820	27	1072	29			7.6875	10.02875	103.9613	0.190375	0.598972	3.06833E-05
	SAM	M18127												
	SAM	M20627												
	SAM	M9017												
Bettongia lesueur	SAM	M2135							3.675	4.575	78.0125	0.1305	0.437793	2.18546E-05
	SAM	M6045												
Bettongia penicillata	SAM	M11938	1018	29	561	29	11682	26	3.425	3.83125	79.61	0.117875	0.405743	1.73264E-05
	SAM	M13006												
	SAM	M18986												
	SAM	M22661												
Dendrolagus bennettianus	SAM	M5530							43	44.325	154.5	0.2465	0.559949	3.99897E-05
Dorcopsis luctuosa	SAM	M15178							21	17.505	130.25	0.085	0.328771	5.65112E-06

Hypsiprymnodon moschatus	SAM	M11940							1.15	1.45	62.4	0.044	0.235702	3.24565E-06
Lasiorhinus latifrons	SAM	M14039	29917	29	2992	29			28	36.76375	132.55	0.201	0.52217	3.46251E-05
	SAM	M2109												
	SAM	M22814												
	SAM	M5244												
Macropus agilis	SAM	M23314	12000	30					53.5	64.355	184.5	0.213	0.511888	2.81225E-05
Macropus greyi	SAM	M2120							27.5	29.29	145.975	0.343	0.656686	8.83586E-05
Macropus irma	SAM	M16489							26.5	42.35	154.5	0.305	0.6231	6.1048E-05
Macropus parryi	SAM	M14103	12000	5					59.5	76.69	195.5	0.243	0.556234	3.06032E-05
Macropus robustus	SAM	M1829a	29300	27	8100	9			60	63.1975	193.5	0.71675	0.95238	0.000281203
	SAM	M1829b												
	SAM	M1846												
	SAM	M5522												
Macropus rufus	SAM	M16383	32490	27	5861	6,9			180.625	157.4775	250.75	0.523	0.804733	0.000123214
	SAM	M5523												
	SAM	M6559												
	SAM	M6560												
Mucropus fuliginosus	SAM	M1988	30000	30					187.5	211.0188	267.125	0.812625	1.013924	0.000255186
	SAM	M21438												
	SAM	M21497												
	SAM	M2805												
Petaurus breviceps	SAM	M7307	127	29	90	29			0.27125	0.29375	40.75625	0.036875	0.212531	3.70267E-06
	SAM	M7308												
	SAM	M7314												
	SAM	M8664												
Phascolarctos cinereus	SAM	M21449	4765	29	1034	29			24.875	29.69125	155	0.255125	0.59702	4.15811E-05
	SAM	M21451												
	SAM	M22217												
	SAM	M23623												
Potorous tridactylus	SAM	M16233	976	29	416	29	7344	10	3.525	3.42	79.0275	0.04675	0.243785	2.8227E-06
	SAM	M7381												
Pseudocheirus peregrinus	SAM	M1684	916	29	431	29			1.1	1.47875	59.0375	0.032375	0.232818	1.53063E-06
	SAM	M20633												
	SAM	M21442												
	SAM	M24182												

Vombatus ursinus	SAM	M2112	22500	5					38.25	49.875	148.4125	0.405625	1.00501	6.09432E-05
	SAM	M22220												
	SAM	M58												
	SAM	M709												
Chiroptera														
Macroderma gigas	SAM	M3158	148	29	139	29			0.25	0.21	43.47	0.0185	0.15335	8.03273E-07
Carnivora														
Canis familiaris dingo	SAM	M5469							17.5	21.835	152	0.0775	0.312925	4.12517E-06
Felis catus	SAM	M21415	4600	7	2048	7			6.175	9.025	109.1	0.116875	0.37821	1.47526E-05
	SAM	M22271												
	SAM	M22785												
	SAM	M6564												
Panthera pardus	AM	S208	41400	5					100	94.5	244	0.719	0.956388	0.000215507
Ursus arctos	AM	M41108	233000	5					317.5	320	356.5	1.1035	1.185236	0.000346176
Ursus arctos isabellinus	AM	S479							127.5	128	268.5	0.5605	0.844623	0.000118709
Vulpes vulpes	SAM	M16206	4440	29	2442	29	50364	14	10	11.005	127.775	0.289	0.603721	6.87675E-05
Pinnipedia														
Arctocephalus fosteri	AM	M38115							11	14	73.25	0.524	0.995107	0.000263523
Arctocephalus pusillus doriferus	SAM	M15297	75000	30					122.5	90.28875	128.4125	0.939125	1.024448	0.001081466
	SAM	M22048												
	SAM	M22049												
	SAM	M22085												
Hydrurga leptonyx	SAM	M16338	380000	30					165	136.31	139.25	0.6935	0.939644	0.000349999
Lobodon carcinophagus	SAM	M10634	215000	30					115	138.725	111.72	2.591	1.809045	0.006276145
Proboscidea														
Elephas maximus	AM	display	4545400	12	409500	6					1010	15.1805	4.358905	0.024662322
Perissodactyla														
Equus asinus	SAM	M14139	177500	9	29288	9			785	620	356.5	4.277	2.320284	0.005429717
Equus caballus	AM	display	675000	3	65000	6	3360300	26			463.75	10.158	3.55839	0.024465289
	QM	JM5413												
Artiodactyla														
Alces alces	AM	S869	325000	27							429.5	2.516	1.788895	0.001498062
Bos taurus	QM	display	225000	3	46240	6	1453500	26			390	1.896	1.553511	0.000934957
Camelus dromedarius	QM	display	402000	30	40497	6,9			1655	1495	456.25	1.9335	1.564337	0.000863728
	SAM	M14440												

Capra hircus	SAM	M1124	45000	26	12660	8	806820	26	162.5	69.635	196	0.723	0.959452	0.000270227
Cervus eldii	AM	S1148									276.5	0.9065	1.073694	0.000302786
Dama dama	AM	P1683	70000	30							249.5	0.885	1.059788	0.000327054
	QM	display												
Gazella dorcas	AM	S685	21370	30							154	0.405	0.718082	0.000107955
Giraffa camelopardalis	AM	display	750000	30							435	4.138	2.294895	0.003994757
Lama glama	AM	S736	100000	20	26450	9					290	1.379	1.309923	0.00072342
Ovis aries	SAM	M4960	21150	24	10200	6	60822	26	162.5	90.07	196.5	0.807	1.013363	0.000336672
Sus scrofa	SAM	M4983	55300	5	8250	6	103896	26	272.5	270.8	225.5	0.6725	0.924633	0.000204517
Tapirus indicus	QM	display									327.5	3.8825	2.222953	0.004681093
Tetracerus quadricornis	AM	S1251							42.5	40.75	178	0.482	0.781581	0.000134445
	AM	S1301												
Rodentia														
Leporillus conditor	SAM	M12975	315	30					0.525	0.665	41.5025	0.074375	0.394898	9.64407E-06
	SAM	M12976												
	SAM	M21372												
	SAM	M21396												
Rattus lutreolus	SAM	M20630	109	29	63	29			0.25	0.185	28.955	0.031	0.198646	3.36448E-06
Ratus fuscipes greyii	SAM	M10397	76	29	84	29			0.1375	0.165	27.1075	0.02975	0.172308	8.24078E-06
	SAM	M10399												
	SAM	M10400												
	SAM	M10401												
Lagomorpha														
Lepus capensis	SAM	M22264	3030	5					13.5	11.985	119.5	0.167	0.461101	2.36509E-05
Lepus europaeus	SAM	M16992							10.5	12.16	124.55	0.167	0.461117	2.26901E-05
Oryctolagus cuniculus	SAM	M18984	1590	30	715	15	6750	15	3.35	4.34	84.29167	0.095	0.341464	1.2033E-05
	SAM	M19777												
	SAM	M9538												
REPTILES														
Crocodilia														
Crocodylus johnsoni	QM	J28895	16385	22					17.3125	20.325	115.875	0.19125	0.413818	2.67361E-05
	QM	J47916												
	QM	J58446												
	QM	J60590												

Crocodylus porosus	AM	unreg.	470000	16					397.5	594.5	249	0.917375	0.921707	0.000355442
	QM	display												
	QM	J24495												
	QM	J48126												
Testudines														
Caretta caretta	QM	J47984	13000	17					101.5	105.35	158	0.075	0.307098	5.00257E-06
	QM	J53275												
	QM	J57294												
Chelodina longicollis	SAM	R52621							1.8	2.115	56.705	0.044	0.235936	3.5477E-06
Chelodina rugosa	AM	R136148	2146	13					1.75	1.883333	49.65667	0.023333	0.166852	1.31107E-06
	AM	R136171												
	AM	R143558												
Chelonia mydas	AM	R137681	115000	23	18432	11	70963.2	11	3.875	4.05	47.6275	0.1835	0.478109	7.4523E-05
	AM	R171938												
Emydura krefftii	AM	R126260	1300	18					1.05	1.025	39.09	0.03	0.194451	2.41909E-06
Eretmochelys imbricata	AM	R2045							20.2	12.525	76.2225	0.06	0.26851	6.98597E-06
	QM	J57275												
Geochelone pardalis	AM	R104356							7.25	11.29	83.52	0.062	0.280634	4.70306E-06
Lepidochelys olivacea	QM	J85948							60	51.25	119	0.06	0.27199	3.45894E-06
Pelochelys cantori	QM	J14389							60	48.25	132.5	0.362	0.664333	0.000116205
Trionyx hurum	QM	J33571							1.275	1.025	37.9875	0.05025	0.277759	5.96478E-06
	QM	J49808												
Squamata														
Brachylophus vitiensis	AM	unreg.	345	19					0.7	0.69	47.27	0.008	0.100121	1.45712E-07
Chlamydosaurus kingii	QM	J21929	635	21					1.25	1.825	67.175	0.013	0.121077	3.52134E-07
	QM	J85989												
Corucia zebrata	AM	unreg.	1014	19					0.45	0.42	30.39	0.0105	0.11479	3.88704E-07
Ctenophorus cristatus	SAM	R20771							0.1	0.13	28.485	0.0145	0.135365	7.69685E-07
Ctenophorus nuchalis	SAM	R32287	37	21					0.02	0.02	17.77	0.004	0.070796	9.70599E-08
Ctenophorus vadnappa	SAM	R30054							0.05	0.04	20.98	0.005	0.078105	1.40238E-07
Egernia cunninghami	AM	unreg.	261	29	45	29			0.183333	0.208333	25.68667	0.008333	0.101125	2.9697E-07
	SAM	R35680												
	SAM	R55373												
Egernia kintorei	AM	unreg.							0.19	0.23	24.105	0.004	0.071365	6.72532E-08
Egernia major	AM	unreg.							0.75	0.825	37.975	0.0225	0.167968	1.43719E-06

Gemmatophora gilberti	SAM	R13927A							0.1	0.13	29.235	0.004	0.068933	6.94577E-08
Moloch horridus	SAM	R22514	31	19					0.1	0.1	23.295	0.01	0.112696	4.39058E-07
Nephrurus levis	SAM	R9948	11	19					0.03	0.05	26.075	0.005	0.079788	1.00845E-07
Physignathus lesueurii	SAM	R181	504	29	81	29			0.825	0.9625	51.1075	0.0135	0.128418	4.49613E-07
	SAM	R52619												
Pogona barbata	SAM	R52609	373	19					0.475	0.355	38.845	0.0215	0.165352	1.21173E-06
Pogona vitticeps	AM	R143847							0.4375	0.375	39.1475	0.0095	0.118481	2.52182E-07
	SAM	R26957	900	19										
Tiliqua multifasciata	AM	R102739	204	19					0.1	0.145	22.45	0.0075	0.097226	2.63887E-07
Tiliqua nigrolutea	AM	unreg.	800	19					0.275	0.335	28.69	0.0115	0.119561	5.09919E-07
Tiliqua occipitalis	AM	unreg.							0.183333	0.216667	25.265	0.009167	0.105608	3.87381E-07
	SAM	R55380												
	SAM	R55381												
Tiliqua rugosa	AM	R130833	609	29	96	29	421.3164	2	0.325	0.34	28.84	0.005	0.078947	9.59587E-08
	AM	R132482												
Tiliqua scincoides	AM	R106285							0.133333	0.156667	21.19167	0.012	0.122443	7.17646E-07
	SAM	R52618	493	29	77	29	250.2744	1						
	SAM	R55382												
	SAM	R55383												
Varanus giganteus	SAM	R33352	5333	19	317	29			12.75	11.73	94.315	0.049	0.343458	1.55427E-06
Varanus gouldii	AM	R21418	443	29	58	29	1254.197	25	5.825	5.7025	64.2075	0.1815	0.614725	3.99368E-05
	QM	J51147												
Varanus indicus	QM	J76294	1287	19					1.85	2.2	54.4	0.1135	0.461422	2.16658E-05
Varanus komodoensis	QM	unreg.	12000	5						21.9	105.5	0.536	0.956121	0.000281556
Varanus mertensi	QM	J46280	1121	19	92	29	1068.895	2	2	3.15	61.575	0.1875	0.574208	5.47876E-05
Varanus panoptes	AM	R100500	2317	19	212	29	3159.873	25	7.633333	9.475	81.5	0.145167	0.522531	2.52219E-05
	QM	J48943												
	QM	J85217												
Varanus spenceri	QM	J84416	6000	19					19	21.65	98.5	0.3355	0.827818	0.000100701
Varanus varius	QM	J16156							4.375	6.2125	78.5625	0.101625	0.329237	7.68629E-06
	QM	J47065	6343	19	450	29	5702.011	4						
	QM	J78194												
	QM	J81263												

DINOSAURS														
Sauropodomorpha														
Giraffatitan brancai	MB	MB.R.2699, right									1450	56.03192	8.345	0.237160932
	MB	MB.R.2916, right												
Plateosaurus longiceps	MB	MB.R.4402.44 right									575	5.980414	2.71	0.007048743
	MB	MB.R.4405.68 right												
Stegosauridae														
Kentrosaurus aethiopicus	MB	MB.R.3595 right									572.5	12.05635	3.9075	0.02620595
	MB	MB.R.3595 right												
	MB	MB.R.3576 left												
	MB	MB.R.3576 left												
Ceratopsidae														
Centrosaurus apertus	TM	TMP 1995.401.0030									800	27.33971	5.9	0.094666883
Styracosaurus albertensis	TM	TMP 89.97.01									670	13.20254	4.1	0.026359711
Pachyrhinosaurus lakustai	TM	TMP 88.55.71									417.5	11.88307	3.7	0.043613161
	TM	TMP 89.55.39												
Ornithopoda														
Unidentified hypsilophodontid	TM	TMP 1979.11.32									173	6.605199	2.9	0.025552059
Unidentified hadrosaur	TM	TMP 94.666.82									330	7.068583	3	0.015340909
Dysalotosaurus lettowvorbecki	MB	MB.R.2511 right									306	6.188702	2.74	0.015107283
	MB	MB.R.2508 left												
Theropoda														
Unidentified Ornithomimid	TM	TMP 91.36.569									406	29.82628	5.64	0.333527521
	TM	MP 99.55.337												
	TM	TMP 92.36.696												
	TM	TMP 1991.36.854												
	TM	TMP 1999.55.148												
	SAM = South Australian Museum, Adelaide													
	AM = Australian Museum, Sydney													
	QM = Queensland Museum, Brisbane													
	MB = Museum für Naturkunde, Berlin													
	TM = Royal Tyrell Museum, Drumheller													

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