Body size evolution in palaeognath birds is consistent with Neogene cooling-linked gigantism (Supplementary material)

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Table S1: Extinct crown and stem Palaeognathae included in this study. Species without an estimated mass were assigned a discrete weight category based on comparisons of preserved material to modern taxa. See main text for discussion of the age estimate for *Struthio brachydactylus*. Two taxa suggested to be ratites – a fragmentary distal tarsometatarsus (Tambussi et al., 1994) and an incomplete rostral section of a premaxilla (Cenizo, 2012) – are not included in this study. Although these taxa are large, their placement within Palaeognathae has been disputed (e.g. Mayr, 2009; Cenizo, 2012) and are therefore not included in this study.

Order	**Species**	**Mean Age (Mya)**	**log(mass)(kg)**	**Size Class**
Aepyornithiformes	*Aepyornis maximus*	1.29	5.78	gigantic
	Aepyornis medius	1.29	5.02	gigantic
	Aepyornis gracilis	1.29	4.84	gigantic
	Mullerornis hildebrandti	0.25	4.44	large
	Aepyornis grandis	1.29	4.43	large
	Mullerornis agilis	0.25	3.99	medium
	Mullerornis betsilei	0.25	3.84	medium
	Mullerornis rudis	0.25	-	medium
Apterygiformes	*Proapteryx micromeros*	17.50	0.76	small
Casuriiformes	*Dromaius ocypus*	3.96	-	large
	Emuarius guljaruba	23.50	3.93	medium
	Emuarius gidju	19.50	3.61	medium
Dinornithiformes	*Dinornis robustus*	1.00	5.27	gigantic
	Pachyornis elephantopus	1.50	4.82	gigantic
	Dinornis novaezealandiae	1.00	4.74	large
	Megalapteryx benhami	1.00	4.31	large

Order	Species	Mean Age (Mya)	log(mass)(kg)	Size Class
	Pachyornis geranoides	1.50	4.18	large
	Anomalopteryx didiformis	1.50	4.13	large
	Emeus crassus	0.50	4.12	large
	Megalapteryx didinus	1.00	4.00	large
	Eurapteryx curtus	1.00	3.77	medium
	Pachyornis australis	1.50	3.71	medium
	Euryapteryx curtus	0.80	3.68	medium
Lithornithiformes	*Paracathartes howardae*	53.90	1.36	small
	Lithornis celetius	59.25	1.07	small
	Lithornis vulturinus	52.20	0.92	small
	Lithornis promiscuus	56.30	0.90	small
	Lithornis plebius	56.30	0.41	small
	Calciavis grandei	51.66	0.15	small
	Pseudocrypturus cercanaxius	53.05	-0.03	small
	Fissuravis weigelti	57.50	-	small
	?Lithornis hookeri	51.90	-	small
Rheiformes	*Opistodactylus kirchneri*	7.90	3.73	medium
	Pterocnemia mesopotamica	11.50	3.44	medium
	Opistodactylus patagonicus	16.90	-	medium
	Opistodactylus horacioperezi	21.50	-	medium
Struthioniformes	*Struthio oldowayi*	1.90	5.53	gigantic
	Struthio transcaucasicus	3.09	5.39	gigantic
	Struthio dmanisensis	2.15	5.37	gigantic

Order	Species	Mean Age (Mya)	log(mass)(kg)	Size Class
	Struthio karatheodoris	8.10	5.20	gigantic
	Struthio linxiaensis	7.95	-	gigantic
	Struthio novorossicus	7.15	-	gigantic
	Struthio pannonicus	1.89	-	gigantic
	Struthio brachydactylus	12–16	4.56	large
	Struthio anderssoni	1.36	-	large
	Struthio asiaticus	2.50	-	large
	Struthio barbarus	2.50	-	large
	Struthio chersonensis	3.39	-	large
	Struthio coppensi	19.50	-	large
	Struthio daberasensis	3.50	-	large
	Struthio kakesiensis	5.35	-	large
	Struthio karingarabensis	5.35	-	large
	Struthio orlovi	10.30	-	large
	Struthio wimani	3.96	-	large
	Struthio/Namornis oshanai	15.50	-	large
Tinamiformes	*Crypturellus reai*	16.90	-0.60	small
	Santa cruz tinamou 1	17.00	-	small
	Santa cruz tinamou 2	17.00	-	small
Unknown	*Eremopezus eocaenus*	35.95	3.97	medium
	Remiornis heberti	57.50	2.62	medium
	Palaeotis weigelti	44.50	2.53	medium
	Diogenornis fragilis	57.35	2.37	medium
	Ratite indet.	35.05	-	medium

Table S2: Raw data used in this study to generate scaling equations. Fem = femur, tbt = tibiotarsus, tmt = tarsometatarsus, hum = humerus.

Species	Specimen weight (kg)	Dunning mean weight (kg)	fem length (mm)	tbt length (mm)	tmt length (mm)	hum length (mm)
Tinamus tao	1.6	84.3	123	80	87	-
Crypturellus undulatus	0.5	0.6	55	77	51	53
Tinamus tao	2.0	1.6	81	121	82	86
Crypturellus soui	0.2	0.2	45	62	38	40
Dromaius novaehollandiae	27.2	34.2	187	-	-	-
Struthio camelus	130.0	111	340	580	521	-
Apteryx owenii	1.2	1.2	74	110	61	-
Struthio camelus	66.3	111.0	243	-	-	-
Casuarius casuarius	36.6	44.0	204	358	-	98
Dromaius novaehollandiae	40.7	34.2	225	343	-	-
Struthio camelus	80.9	111.0	285	534	-	368
Struthio camelus	81.9	111.0	294	574	-	381
Rhea americana	18.9	23.0	190	321	-	265

Table S3: r^2 values from models describing the relationship between predicted body mass and observed body mass for extant Palaeognathae. 'Study' refers to the source of the respective equation used for mass prediction.

Study	**Femur**	**Tibiotarsus**	**Tarsometatarsus**
Current	0.90	0.94	0.87
Field et al. (2013)	0.51	0.58	0.46
Cubo and Casinos (1997)	0.49	0.55	0.44

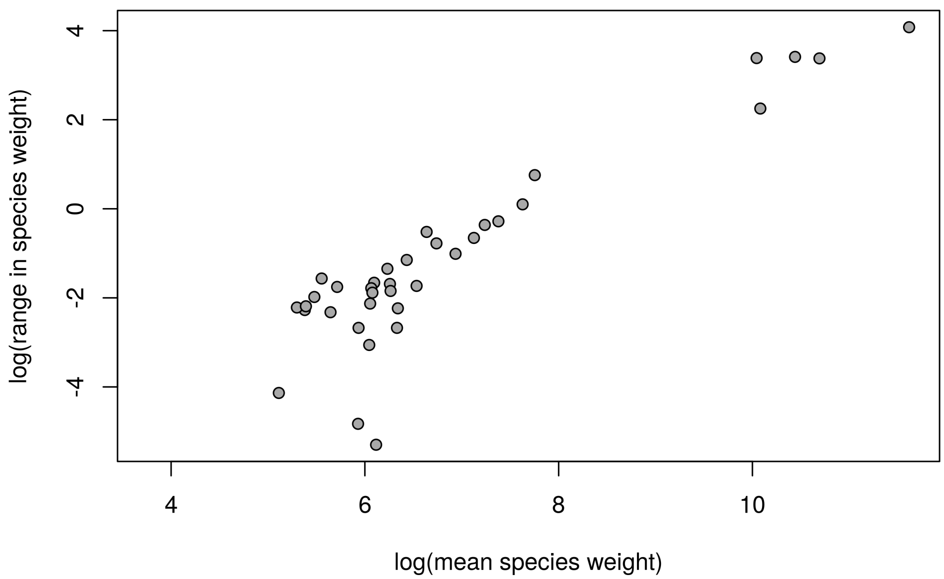

Figure S1: Range in palaeognath species mass plotted against mean species mass (n = 36). Data from Dunning (2007).

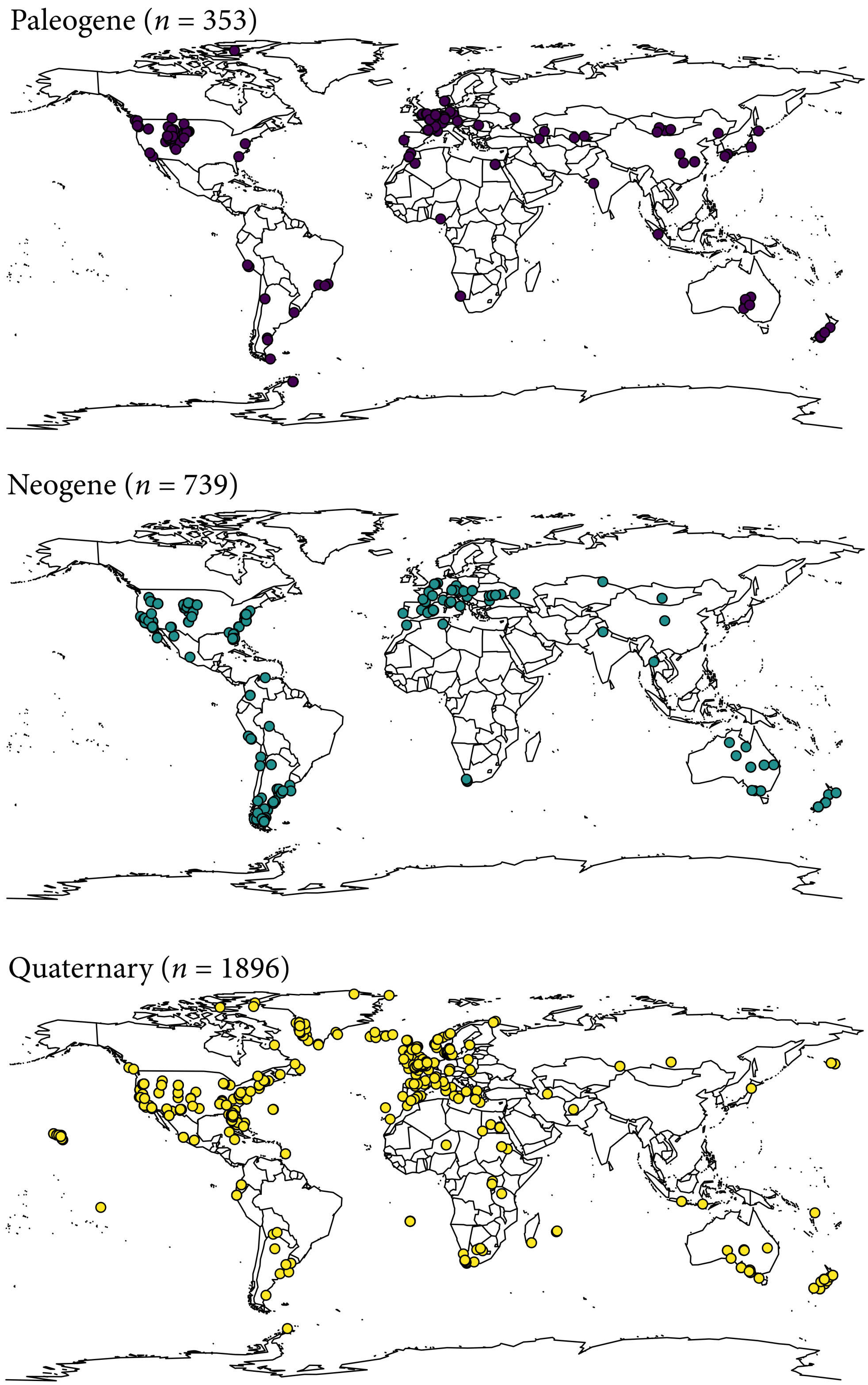

Figure S2: Number and geographic distribution of recorded avian specimens in the three Cenozoic periods.

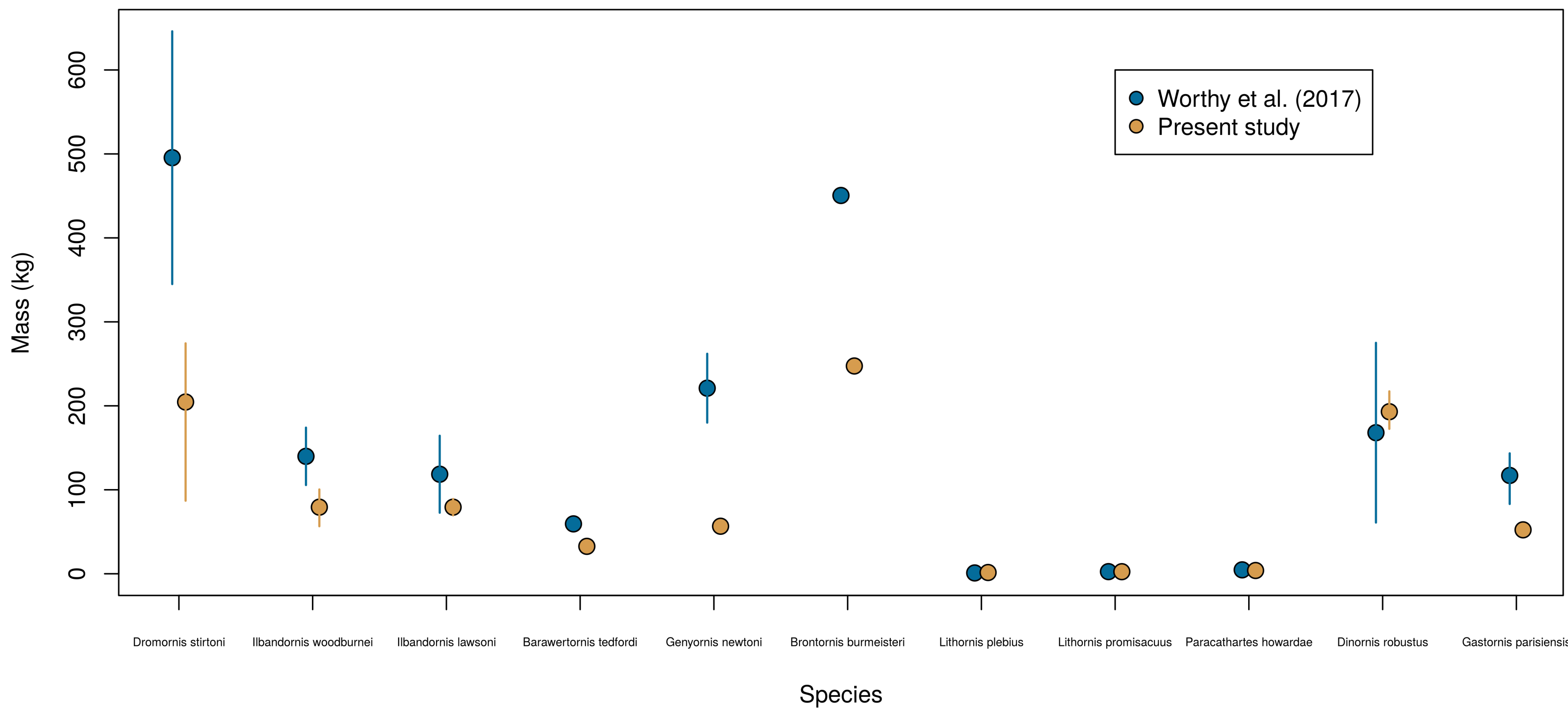

Figure S3: Comparison of weight estimates for a selection of species from Worthy et al. (2017) and the present study.

S1 Mass estimates for members of *Gastornis*, *Brontornis*, and *Diatryma*

The masses reported by Worthy et al. (2017) were calculated using femoral and tibiotarsus circumferences and the equations of Campbell and Marcus (1992), as well as taken from previous studies which used these same measurements (Handley et al., 2016). These equations led to the estimated mass of *Brontornis burmeisteri*, an undoubtedly large species, exceeding that of the largest elephant bird *Aepyornis maximus* despite skeletal estimates not being as large – Tambussi et al. (1999) reported the tibiotarsus length of *B. burmeisteri* to be 768mm compared to 810mm in *A. maximus* (Gatesy, 1991). We suggest that this discrepancy is due to the measurements not scaling appropriately with increasing body size, leading to an over-inflation of the masses of these taxa (Figure S3). This scaling disparity is possibly due to Gastornithiformes (the clade in which Gastornis is found, Worthy et al., 2017) being nested within the Galloanseres which lack any modern relatives of equivalent size. Our equations lead to the masses of these taxa; however, as no Galloanseres were included in the calculation of the equations used here this result should be viewed cautiously.

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