Supplementary Note 1. Body mass of KNM-NP 59050, KNM-RU 7290 and *Oreopithecus*.

The exact body mass estimates used here are given in grams in Supplementary Table 1.

KNM-NP 59050

The M^1 crown of KNM-NP 59050 is fully formed and can be used to estimate adult body mass of the specimen. Based on M^1 crown area (mesiodistal length x buccolingual width) and published regression formulae[55,56] body mass estimates were obtained of between 14 and 18 Kg (Table). These values appear large for KNM-NP 59050. It is most similar in cranial dimensions to *Symphalangus syndactylus* infants of the same developmental age (Extended Data Table 1), and this species has an adult body mass of about 11 Kg (ref. 45). As previously reported for proconsulines[57], *Nyanzapithecus alesi* could thus be megadont, a phenomenon likely related to the prominent cingula enlarging molar crown size. To study the endocranial volume and semicircular canal size of KNM-NP 59050 we therefore consider a range of body masses. Although most similar to *Symphalangus* infants, some cranial dimension of the specimen are intermediate between *Nomascus* and *Symphalangus* infants (Extended Data Table 1b: maximum cranial length and maxillo-alveolar length). As the smallest body mass we therefore use the mean of the latter two species or 9.4 Kg (ref. 45). As the largest value we use 17.9 Kg, based on the M^1 area (Table). As the main body mass estimate we use 11.3 Kg, based on the similarities in cranial dimensions to *Symphalangus* infants.

Body mass (BM) estimates based on M^1 and M^2 crown area, using regressions reported in refs 55 and 56 for samples of extant primates. Estimates with 95% confidence intervals (95% CI) are given in Kg. *Samples which do not include great apes.

	Source	**Extant sample used**	**KNM-NP 59050** BM	**KNM-NP 59050** 95% CI	**KNM-RU 7290** BM	**KNM-RU 7290** 95% CI
M^1	Egi et al[56]	anthropoids*	17.9	16.4-19.3	22.1	20.7-23.6
	Egi et al[56]	primates*	14.5	13.2-15.8	17.9	16.6-19.2
	Gingerich et al[55]	primates	13.9	12.3-15.7	16.9	14.8-19.3
M^2	Egi et al[56]	anthropoids*	-	-	20.0	18.6-21.4
	Egi et al[56]	primates*	-	-	17.7	16.5-18.9
	Gingerich et al[55]	primates	-	-	17.9	15.6-20.4

KNM-RU 7290

Ekembo heseloni is known to be megadont[57]. Indeed, for KNM-RU 7290 body mass estimates based on M^1 and M^2 area range from 17 to 22 Kg (Table), but orbital height suggest a body mass of about 14 Kg (ref. 58). In the comparisons of endocranial volume and semicircular canal size of this specimen we use the estimate derived from orbital height (Extended Data Fig. 7a,b; SupplementaryTable 1), which appears to be most consistent with the largest values obtained based on postcranial elements of *E. heseloni*[57]. In comparisons of adult specimens we use ratios, scaling cranial dimensions against M^1 crown area (Methods; Extended Data Fig. 4, 5). To explore if the megadontia of *E. heseloni* substantially affects the ratio values of KNM-RU 7290 an alternative, reduced M^1 area of 58.5 mm^2 was used, in addition to the measured area of 76.0 mm^2. This reduced M^1 area was calculated to match the 14 Kg suggested by orbital height of KNM-RU 7290.

Oreopithecus bambolii

The body mass of male *Oreopithecus* has been estimated to be 32 Kg, based on postcranial elements[59]. Males are estimated to be about 40% larger than females (T. Harrison, pers. comm), suggesting a body mass estimate for females of 23 Kg. The endocranial volume used here[60] was estimated from the foramen magnum area of a smaller individual, and the female body mass value was used in Extended Data Fig. 7a. The BA208 specimen whose semicircular canal size was analysed is of unknown sex[61], thus the male-female body mass range is shown in Extended Data Fig. 7b.

Supplementary Table 1 | Comparative semicircular canal measurements. Given are the sample size (n), height/width proportions of the anterior (ASCh/w) and lateral (LSCh/w) canal arcs, relative arc size of the lateral canal (LSC-R%), and where used in Extended Data Figure 7, the body mass[26,44,45] (BM in g) and mean radius of curvature (SC-R in mm). See Methods for more details.

Taxon	Source	n	ASCh/w	LSCh/w	LSC-R%	BM	SC-R
Aotus trivirgatus	Ref. 42	2	92	79	30	-	-
Cebus apella	Ref. 42	4	93	77	29	-	-
Saimiri sciureus	Ref. 42	3	96	76	31	-	-
Cercopithecus cephus	Ref. 42	1	81	102	33	4290	2.2
Cercopithecus diana	Ref. 42	1	86	88	34	5200	2.4
Cercopithecus mitis	Ref. 42	1	81	86	33	7930	2.5
Cercopithecus nictitans	Ref. 42	2	81	97	34	5100	2.3
Macaca fascicularis	Ref. 42	3	87	91	32	5465	2.4
Macaca mulatta	Ref. 42	1	81	96	33	4475	2.3
Macaca nigra	Ref. 42	2	91	97	32	9286	2.6
Macaca sylvanus	Ref. 42	1	94	83	31	7680	2.5
Semnopithecus entellus	Ref. 42	2	93	92	32	13550	2.6
Trachypithecus obscurus	Ref. 42	1	84	97	30	31600	2.8
Trachypithecus vetellus	Ref. 42	2	91	96	32	14533	2.5
Nomascus sp	This study	3	76	94	30	7535	2.6
Hoolock hoolock	This study	1	80	98	31	6875	2.6
Hylobates agilis	This study	4	75	91	32	5850	2.4
Hylobates muelleri	This study	10	76	91	33	5530	2.5
Hylobates lar	This study	2	85	100	30	5620	2.7
Symphalangus syndactylus	This study	6	77	94	32	11300	2.5
Pan troglodytes	This study	30	67	93	31	44967	2.5
Pan paniscus	This study	6	73	82	31	39100	2.6
Gorilla beringei	This study	7	67	96	34	120950	2.8
Gorilla gorilla	This study	39	64	96	34	126550	2.9
Pongo abelli	This study	8	66	86	30	56750	2.7
Pongo pygmaeus	This study	16	62	82	30	57150	2.6
Aegyptopithecus zeuxis CGM85785; DPC5401, 6642	Ref. 43	3	91	79	29	4649	1.9
Victoriapithecus macinnesi KNM-MB 29100	Ref. 43	1	93	92	31	6000	2.2
Saadanius hijazensis SGS-UM 2009-002	Ref. 43	1	100	91	29	20000	2.3
Ekembo heseloni KNM-RU 2046al	Ref. 43	1	85	93	32	13933	2.4
Hispanopithecus laietanus CLl 17000	Ref. 43	1	74	91	29	34000	2.3
Rudapithecus brancoi RUD 77, 200	Ref. 43	2	73	98	29	26850	2.3
Oreopithcus bambolii BA208	Ref. 43	1	73	82	28	27429 (22857-32000)	2.6
Nyanzapthecus alesi KNM-NP 59050	This study	1	66	81	28	11300 (9418-17900)	2.1

Supplementary Table 2 | GPS Coordinates of stratigraphic sections and localities shown in Extended Data Fig. 2a. All GPS coordinates based on the WGS84 datum.

CSF 2015-1	Base section	2° 58.151’N	35° 52.052’E
	Top section	2° 57.995’N	35° 51.861’E
CSF 2015-2	Base section	2° 57.546’N	35° 52.270’E
	Top section	2° 57.995’N	35° 51.861’E
CSF 2015-3	Base section	2° 58.192’N	35° 52.070’E
	Top section	2° 58.531’N	35° 51.859’E
KNM-NP 59050	cranium	2° 58.129’N	35° 52.046’E
Dating sample	15-NPD-03	2° 57.584’N	35° 52.337’E

Supplementary Table 3 | Scanning parameters used for KNM-NP 59050. The fossil was scanned on beamline ID 19 of the European Synchrotron Radiation Facility (ESRF) in Grenoble, France. Four different voxel sizes were used, and the associated scanning parameters are given here.

	complete cranium	**teeth, ear region**	**Long period lines in teeth**	**enamel microstructure**
Voxel size	28.06 µm	12.86 µm	3.44 µm	0.72 µm
Average energy	126.2 keV	140.8 keV	100.8 keV	60.2 keV
Filters	Al 5.6 mm Cu 6 mm	Al 5.6 mm Cu 12 mm	Al 5.6 mm Cu 2.8 mm	Al 2.8 mm Cu 0.35 mm Au 0.14 mm
Propagation distance	13000 mm	13000 mm	3000 mm	300 mm
Sensor	FReLoN 2K CCD	sCMOS PCO edge 5.5	FreLoN 2K CCD	sCMOS PCO edge 5.5
Scintillator	LuAG:Ce 750 µm	LuAG:Ce 500 µm	GGG:Eu 100 µm	GGG:Eu 50 µm
Insertion device	W150	W150	W150	U32 / U32
ID Gap	40 mm	42 mm	40 mm	14.3 / 14.3 mm
Projection number	4998	9974	6000	8000
Scan geometry	360°, half-acquisition, double scan	360°, half-acquisition, double scan	360°, half-acquisition, double scan	360°, half-acquisition
Exposure time	0.3 s	0.05 s	0.25 s	0.1 s
Time per scan	26.5 min	10.3 min	26.6 min	15.1 min
Number of scans	24	15	51	36
Total time	10.6 h	2.6 h	22.6 h	9.1h
Reconstruction	phase retrieval	phase retrieval	edge detection	edge detection

References

55. Gingerich, P. D., Smith, B. H. and Rosenberg, K. Allometric scaling in the dentition of primates and prediction of body weight from tooth size in fossils. *Am. J. Phys. Anthrop.* **58**, 81-100 (1982).
56. Egi, N., Takai, M., Shigehara, N., & Tsubamoto, T. Body mass estimates for Eocene eosimiid and amphipithecid primates using prosimian and anthropoid scaling models. *Int. J. Primatol.* **25**, 211-236 (2004).
57. Rafferty, K. L., Walker, A., Ruff, C. B., Rose, M. D., & Andrews, P. J. Postcranial estimates of body weight in *Proconsul*, with a note on a distal tibia of P. major from Napak, Uganda. *Am. J. Phys. Anthrop.* **97**, 391-402 (1995).
58. Begun, D. R. & Kordos, L. in *The evolution of thought. Evolutionary origins of great ape intelligence*. (eds. Russon, A. E. & Begun D. R.) 260-279 (Cambridge University Press, 2004).
59. Jungers, W. L. Body size and morphometric affinities of the appendicular skeleton in Oreopithecus bambolii (IGF 11778). *J. Hum. Evol.* **16**, 445-456 (1987).
60. Manser, J, & Harrison, T. Estimates of cranial capacity and encephalization in *Proconsul* and *Turkanapithecus*. *Am. J. Phys. Anthropol*. **28**, 189 (1999).
61. Rook, L., Bondioli, L., Casali, F., Rossi, M., Köhler, M., Solá, S. M., & Macchiarelli, R. The bony labyrinth of *Oreopithecus bambolii*. *J. Hum. Evol*. **46**, 347-354 (2004).