

Effect of population density on relationship between pre- and postcopulatory sexual traits

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Abstract

Sexual selection theory states that the premating (ornaments and armaments) sexual traits should trade off with the postmating (testes and ejaculates) sexual traits, assuming that growing and maintaining these traits is expensive and that total reproductive investments are limited. Male–male competition and sperm competition are predicted to affect how males allocate their finite resources to these traits. Here, we studied relative expenditure on pre- and postmating sexual traits among 82 species for three mammalian orders with varying population density using comparative phylogenetic analysis. The results showed that population density affected sexual size dimorphism (SSD) in both Artiodactyla and Carnivora, but not in Primates. However, relative testis mass and sperm size were not affected by population density. Moreover, we did not find associations between the SSD and testis mass or sperm size in three taxonomic groups. The interspecific relationships between pre- and postcopulatory sexual traits did not change with increased population density. Our findings suggest that population density did not affect variation in the relationship between pre- and postcopulatory sexual traits for these three mammalian orders.

Keywords

Artiodactyla; carnivore; male–male competition; primate; sexual size dimorphism; sexual selection; sperm competition; testis mass; ungulate

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Supplementary material

Table S1.

Order, species, body mass (kg) in males and females, sexual size dimorphism (SSD), sperm length (μm), testes mass (g) and population density (ind. km^{-2}) in mammals.

Taxonomic order	Species	Male mass (kg)	Female mass (kg)	SSD	Sperm length (μm)	Testes mass (g)	Pop density (ind. km^{-2})	References
Artiodactyla	<i>Aepyceros melampus</i>	57.00	43.00	1.33	46.15	120.00	13.36	1, 2
Artiodactyla	<i>Alcelaphus buselaphus</i>	177.00	165.00	1.07	58.15	107.00	3.65	1–3
Artiodactyla	<i>Alces alces</i>	633.00	500.00	1.27	62.50	106.00	0.40	1–3
Artiodactyla	<i>Antidorcas marsupialis</i>	33.70	27.90	1.21	57.84	71.00	10.69	1–3
Artiodactyla	<i>Antilocapra americana</i>	54.00	45.40	1.19		76.00	0.88	1, 2
Artiodactyla	<i>Axis porcinus</i>	43.00	32.00	1.34	67.43	49.45	16.50	1–3
Artiodactyla	<i>Bison bison</i>	700.00	425.00	1.65	70.06	523.60	0.30	1–3
Artiodactyla	<i>Capreolus capreolus</i>	24.75	23.00	1.08		43.00	8.11	1, 2, 4
Artiodactyla	<i>Cervus elaphus</i>	340.00	255.00	1.33	63.01	218.00	4.19	1–4
Artiodactyla	<i>Gazella dorcas</i>	15.62	13.30	1.17	64.40	31.46	2.30	1, 3–5
Artiodactyla	<i>Giraffa camelopardalis</i>	1100.00	700.00	1.57	47.77	1074.00	1.23	1–3
Artiodactyla	<i>Hemitragus jemlahicus</i>	63.00	31.00	2.03		26.70	3.04	1, 2, 4
Artiodactyla	<i>Kobus ellipsiprymnus</i>	240.00	180.00	1.33	61.61	73.65	2.46	1–3
Artiodactyla	<i>Muntiacus muntjak</i>	19.00	20.00	0.95	58.16	6.50	3.12	1, 3, 5
Artiodactyla	<i>Neotragus moschatus</i>	4.80	5.10	0.94	70.54	58.90	17.32	1, 3
Artiodactyla	<i>Odocoileus virginianus</i>	82.00	49.50	1.66	52.00	85.50	14.96	1–3
Artiodactyla	<i>Rangifer tarandus</i>	103.00	71.00	1.45	56.50	132.00	2.55	1–3
Artiodactyla	<i>Tragelaphus angasii</i>	138.00	72.00	1.92	63.13	38.30	126.94	1–3
Artiodactyla	<i>Tragelaphus eurycerus</i>	300.00	240.00	1.25	60.69	52.85	0.40	1–3
Artiodactyla	<i>Tragelaphus strepsiceros</i>	259.00	171.00	1.51	69.47	92.00	1.06	1–3

Taxonomic order	Species	Male mass (kg)	Female mass (kg)	SSD	Sperm length (µm)	Testes mass (g)	Pop density (ind. km ⁻²)	References
Carnivora	<i>Acinonyx jubatus</i>	43.70	38.00	1.15	52.51	15.51	0.01	1, 3, 5
Carnivora	<i>Ailuropoda melanoleuca</i>	111.70	96.80	1.15	50.23	330.00	0.18	1, 3, 5
Carnivora	<i>Callorhinus ursinus</i>	192.00	42.00	4.57	54.10	63.60	18.00	1–3
Carnivora	<i>Canis adustus</i>	9.47	8.32	1.14		13.30	0.74	1, 4, 6
Carnivora	<i>Canis latrans</i>	12.19	10.53	1.16		15.40	0.28	1, 4, 6
Carnivora	<i>Canis lupus</i>	41.93	35.63	1.18		27.38	0.01	1, 4, 6
Carnivora	<i>Canis mesomelas</i>	8.05	7.27	1.11	55.09	22.26	0.74	1, 3, 6
Carnivora	<i>Crocuta crocuta</i>	45.00	67.04	0.67		9.85	0.12	1, 4, 5
Carnivora	<i>Cuon alpinus</i>	17.50	11.50	1.52		6.35	0.55	1, 4, 6
Carnivora	<i>Felis catus</i>	3.10	3.23	0.96	59.35	2.34	0.95	3, 5
Carnivora	<i>Gulo gulo</i>	14.18	9.41	1.51		17.00	0.01	1, 2, 4
Carnivora	<i>Lutra lutra</i>	10.10	7.00	1.44	70.22	4.05	0.85	1–3
Carnivora	<i>Martes pennanti</i>	4.60	2.50	1.84		7.76	0.21	1, 2, 4
Carnivora	<i>Meles meles</i>	11.60	10.10	1.15	80.00	14.40	2.67	1–3
Carnivora	<i>Mephitis mephitis</i>	2.81	2.00	1.41		5.05	8.33	1, 2, 4
Carnivora	<i>Mustela erminea</i>	0.32	0.21	1.51		2.64	6.25	1, 2, 4
Carnivora	<i>Mustela frenata</i>	0.30	0.15	1.94		1.88	0.76	1, 2, 4
Carnivora	<i>Mustela nivalis</i>	0.12	0.06	1.95		0.43	12.89	1, 2, 4
Carnivora	<i>Mustela putorius</i>	1.11	0.69	1.61	73.73	3.14	0.47	1–4
Carnivora	<i>Nasua nasua</i>	4.40	3.45	1.28	78.34	4.84	15.42	1, 3, 5
Carnivora	<i>Nyctereutes procyonoides</i>	6.10	6.05	1.01	62.90	5.64	12.02	1, 3, 4
Carnivora	<i>Panthera tigris</i>	340.50	133.50	2.55	53.63	24.40	0.03	1, 3, 5
carnivora	<i>Taxidea taxus</i>	9.28	7.15	1.30		35.56	2.07	1, 2, 4
Carnivora	<i>Ursus arctos</i>	180.90	1820.00	0.10	70.35	68.60	0.02	1, 3, 5

Taxonomic order	Species	Male mass (kg)	Female mass (kg)	SSD	Sperm length (µm)	Testes mass (g)	Pop density (ind. km ⁻²)	References
Carnivora	<i>Vulpes vulpes</i>	6.20	5.11	1.21	64.00	9.00	1.10	1, 3, 6
Primates	<i>Aotus trivirgatus</i>	0.92	0.95	0.97		1.20	24.37	1, 2, 4
Primates	<i>Ateles geoffroyi</i>	7.78	7.29	1.07		13.40	19.06	1–3, 5
Primates	<i>Ateles paniscus</i>	9.11	8.44	1.08	65.10	64.23	8.00	1, 2, 4
Primates	<i>Callithrix jacchus</i>	0.26	0.24	1.08	52.10	1.30	508.18	1, 2, 7
Primates	<i>Cebus apella</i>	3.05	2.39	1.28	84.30	9.10	23.77	1–3
Primates	<i>Cercopithecus ascanius</i>	9.2	6.40	1.44		3.00	105.79	1, 2, 4
Primates	<i>Chlorocebus aethiops</i>	5.29	2.98	1.78	91.52	20.60	85.30	1, 3, 5
Primates	<i>Colobus guereza</i>	10.7	9.00	1.19		10.70	99.20	1, 2, 4
Primates	<i>Erythrocebus patas</i>	10	5.60	1.79	92.80	7.20	0.26	1–3
Primates	<i>Galago senegalensis</i>	0.23	0.20	1.15	80.80	1.66	89.77	1, 3, 5
Primates	<i>Gorilla gorilla</i>	160	93.00	1.72	61.17	23.20	0.59	1–3
Primates	<i>Hylobates lar</i>	5.7	5.30	1.08	63.30	5.50	6.60	1–3
Primates	<i>Lagothrix lagotricha</i>	8.34	5.75	1.45		11.20	10.72	1, 2, 4
Primates	<i>Lemur catta</i>	2.9	2.50	1.16	79.70	17.80	215.00	1–3
Primates	<i>Leontopithecus rosalia</i>	0.61	0.58	1.05		1.48	4.07	1, 2, 4
Primates	<i>Loris tardigradus</i>	0.22	0.18	1.22		1.80	72.29	1, 2, 4
Primates	<i>Macaca arctoides</i>	12.2	8.40	1.45	77.61	48.20	1.09	1, 3, 5
Primates	<i>Macaca fascicularis</i>	5.9	4.10	1.44	73.63	35.20	49.99	1, 2, 4
Primates	<i>Macaca mulatta</i>	6.2	3.00	2.07	74.10	46.20	11.10	1–4
Primates	<i>Macaca nemestrina</i>	10	7.00	1.43	89.70	66.70	18.92	1–4
Primates	<i>Macaca silenus</i>	6.8	5.00	1.36	32.90	42.00	1.01	1–3
Primates	<i>Mandrillus sphinx</i>	31.6	12.90	2.45	55.70	58.86	21.40	1–3
Primates	<i>Microcebus murinus</i>	0.09	0.08	1.02	75.20	2.49	461.00	1–4

Taxonomic order	Species	Male mass (kg)	Female mass (kg)	SSD	Sperm length (μm)	Testes mass (g)	Pop density (ind. km^{-2})	References
Primates	<i>Nasalis larvatus</i>	20.4	9.98	2.04		11.80	8.99	1, 2, 4, 5
Primates	<i>Nycticebus coucang</i>	1.3	1.20	1.08	91.00	1.20	20.00	1–3, 5
Primates	<i>Otolemur crassicaudatus</i>	1.19	1.11	1.07	60.30	13.32	87.99	1, 3, 5
Primates	<i>Pan paniscus</i>	39	31.00	1.26	68.10	135.20	2.00	1–3
Primates	<i>Pan troglodytes</i>	49	41.00	1.20	57.36	118.80	1.63	1–3
Primates	<i>Papio anubis</i>	26	13.00	2.00	80.10	78.42	10.80	1–3
Primates	<i>Papio hamadryas</i>	18.3	9.40	1.95	77.20	72.30	2.10	1–3
Primates	<i>Pongo pygmaeus</i>	69	37.00	1.86	66.58	35.30	2.00	1–3
Primates	<i>Pygathrix nemaeus</i>	11	8.44	1.30	39.30	8.40	1.55	1, 3, 5
Primates	<i>Saguinus midas</i>	0.59	0.43	1.36		1.83	10.98	1, 2, 4
Primates	<i>Saguinus oedipus</i>	0.41	0.43	0.96	54.80	1.48	45.52	1, 2, 4
Primates	<i>Saimiri sciureus</i>	0.85	0.68	1.26	69.24	3.17	36.09	1–3
Primates	<i>Theropithecus gelada</i>	19	11.70	1.62	88.20	21.50	51.42	1–3
Primates	<i>Varecia variegata</i>	3.6	3.10	1.16		2.63	27.83	1, 2, 4

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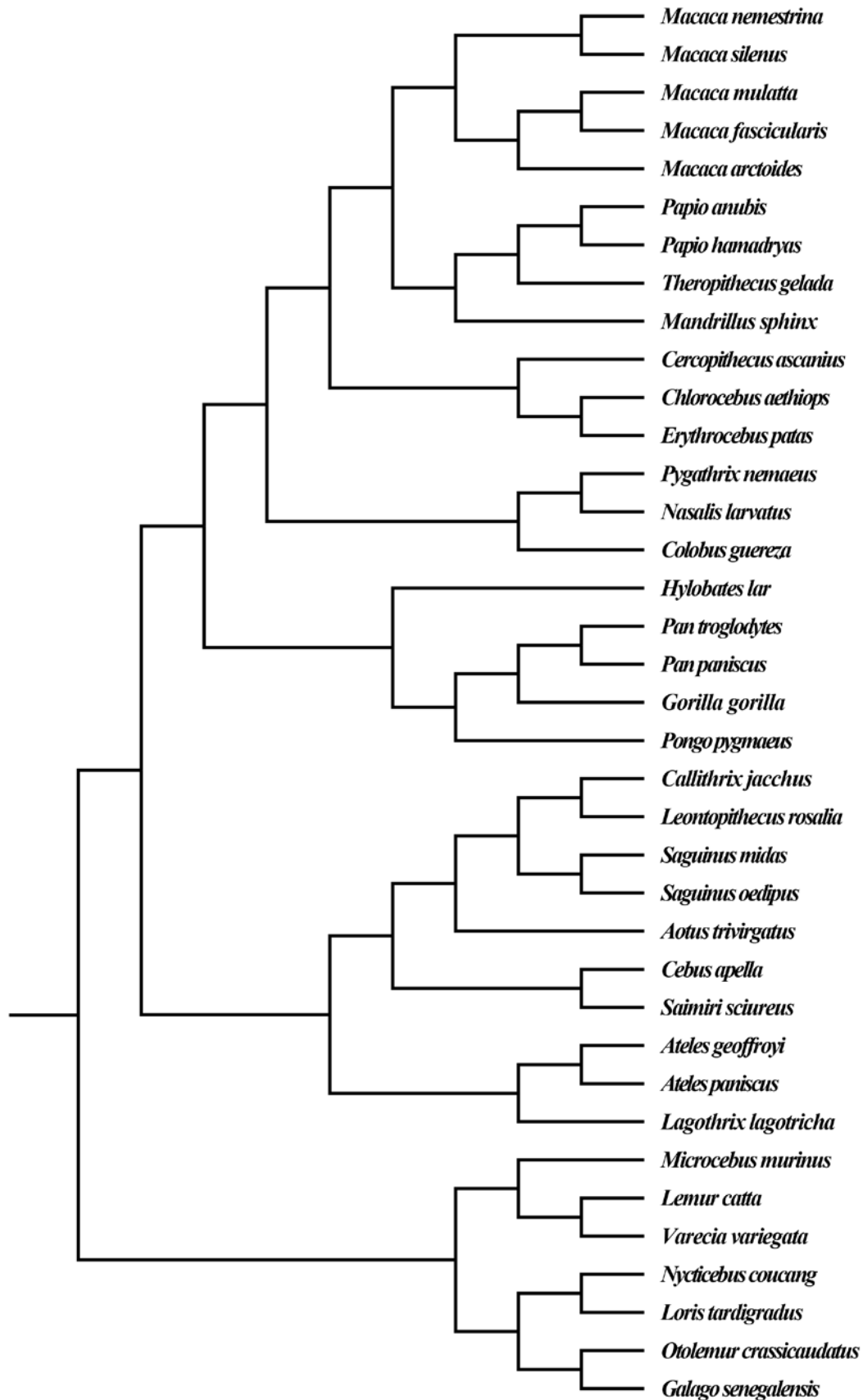


Figure S1. Phylogenetic tree of the 37 primate species used in the comparative analysis, based on the phylogeny of Perelman et al. (2011).

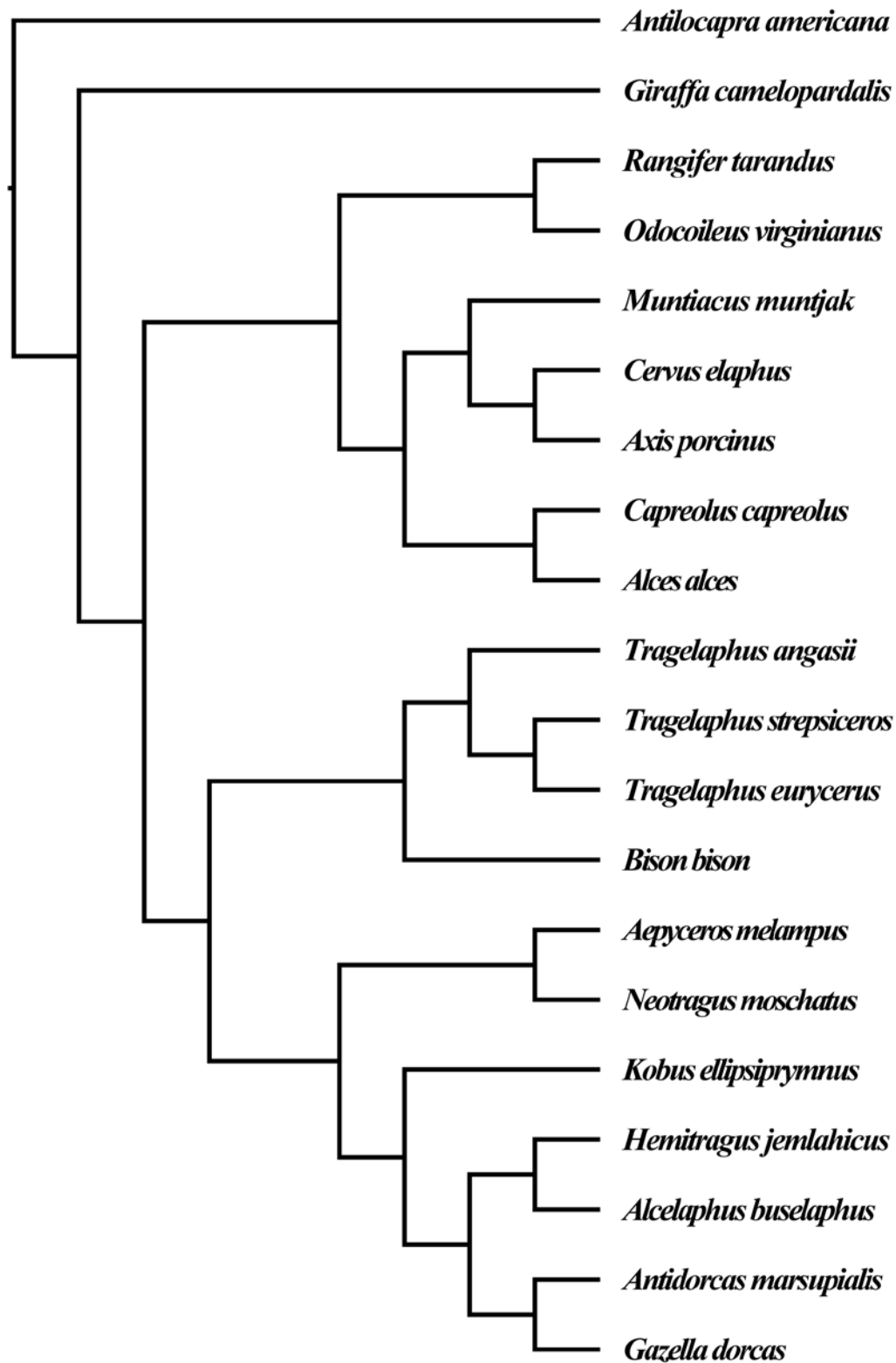


Figure S2. The phylogenetic tree of the 25 species of Artiodactyla used in the comparative analysis from the phylogeny of Agnarsson & May-Collado (2008).

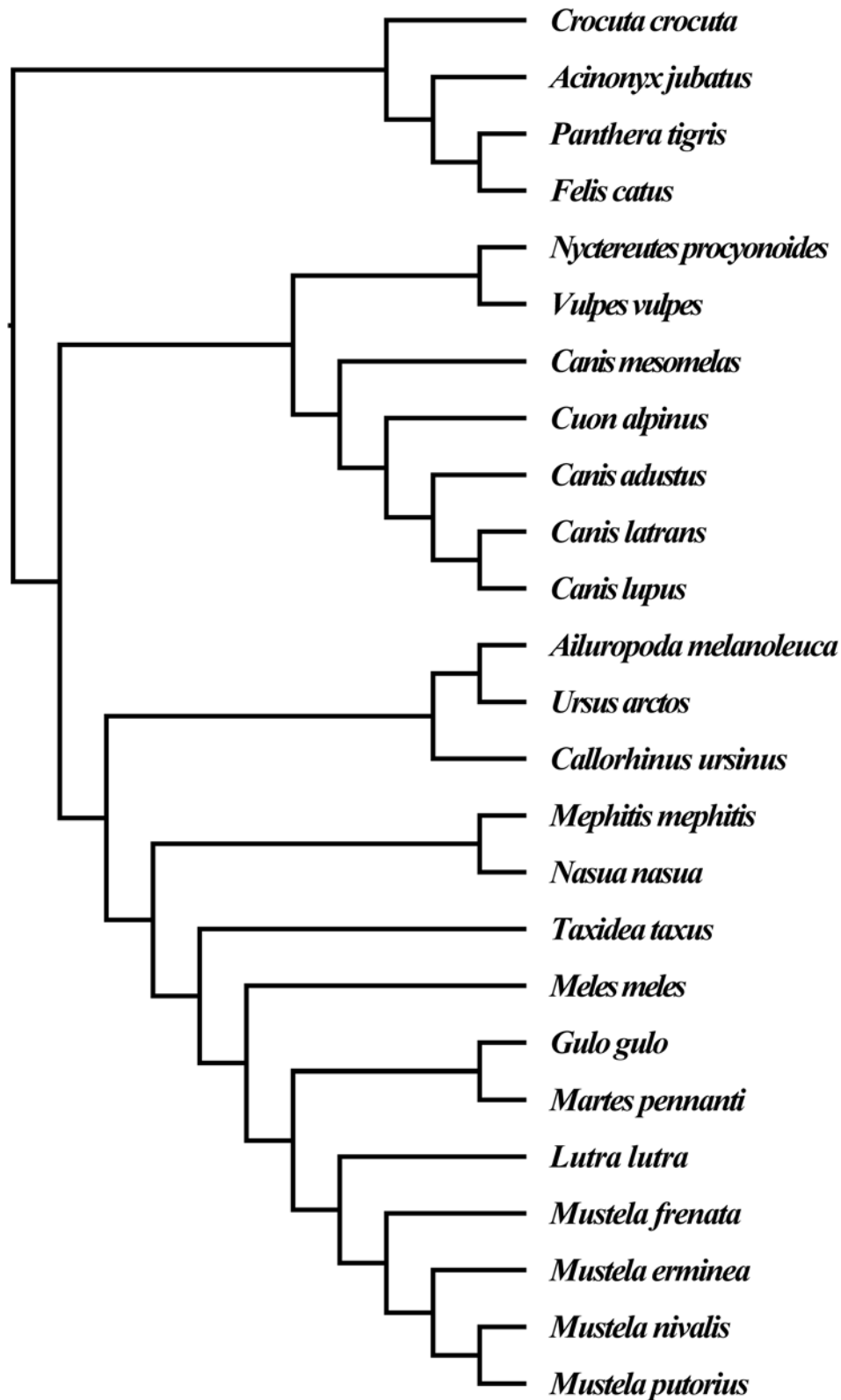


Figure S3. The phylogenetic tree of the 20 species of Carnivora used in the comparative analysis from the phylogeny of Agnarsson et al. (2010).

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