

RA: *M.R. Wynkoop et al.*

DOI: 10.1163/15707563-bja10087

Animal Biology

Short Note

Plasma lactate dehydrogenase and pyruvate kinase activity changes with body mass and age across birds and mammals

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Supplementary material

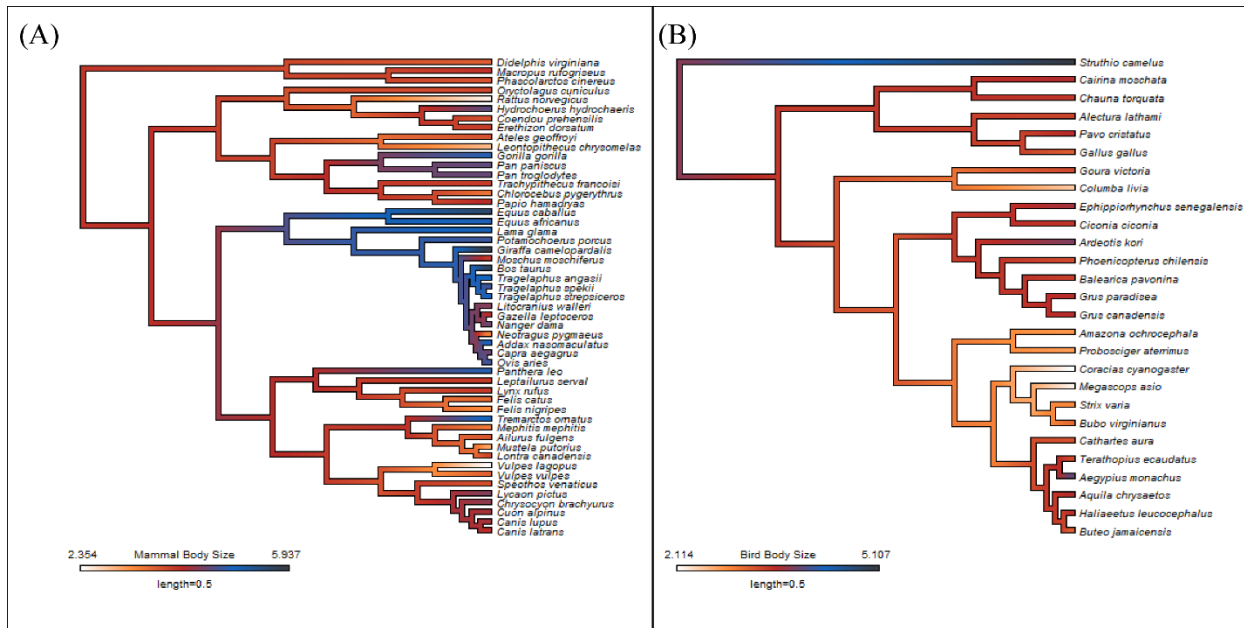


Figure S1. Phylogenetic trees for mammals (A) and birds (B) constructed from 1000 trees extracted from the supertree project (www.vertlife.org). Trait values for log-transformed body size are mapped onto the tree. Darker colors indicate larger body size of a given species.

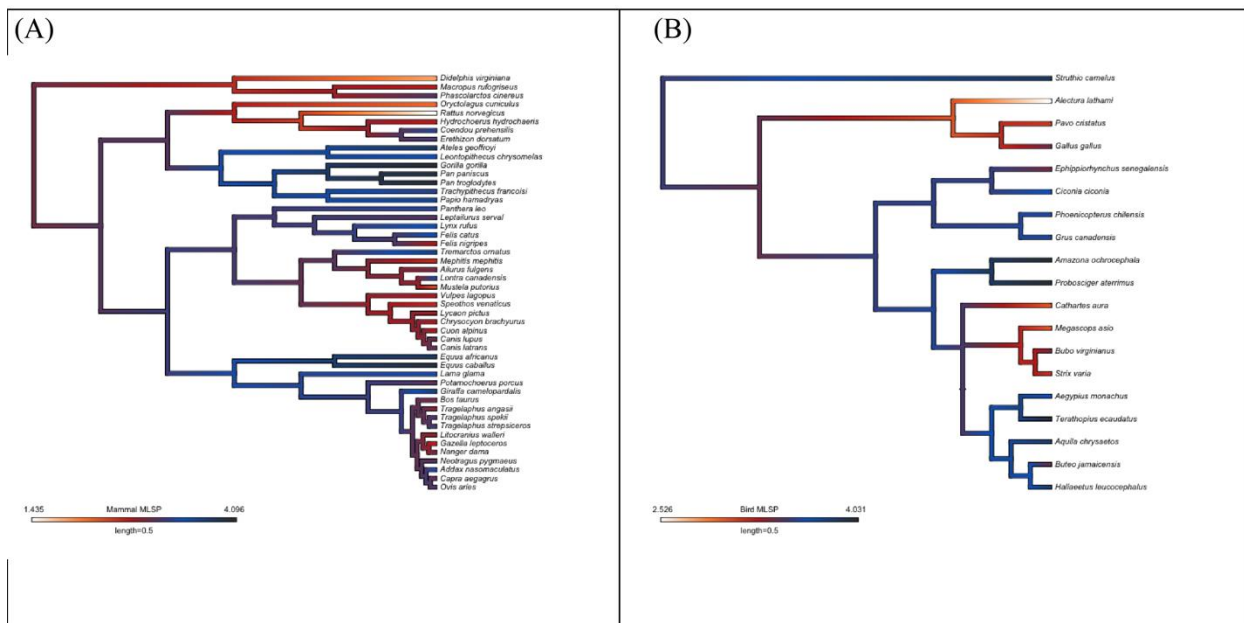


Figure S2. Phylogenetic trees for mammals (A) and birds (B) constructed from 1000 trees extracted from the supertree project (www.vertlife.org). Trait values for log-transformed maximum lifespan (MLSP) are mapped onto the tree. Darker colors indicate larger values for a given species.

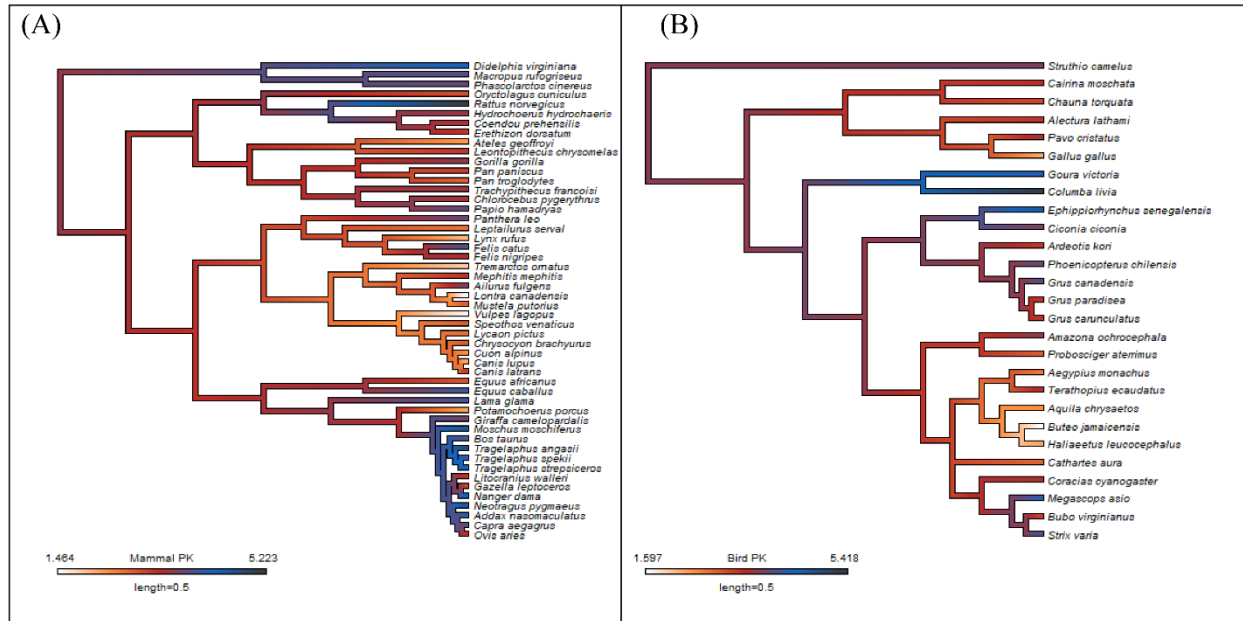


Figure S3. Phylogenetic trees for mammals (A) and birds (B) constructed from 1000 trees extracted from the supertree project (www.vertlife.org). Trait values for log-transformed pyruvate kinase (PK) are mapped onto the tree. Darker colors indicate higher PK values for a given species.

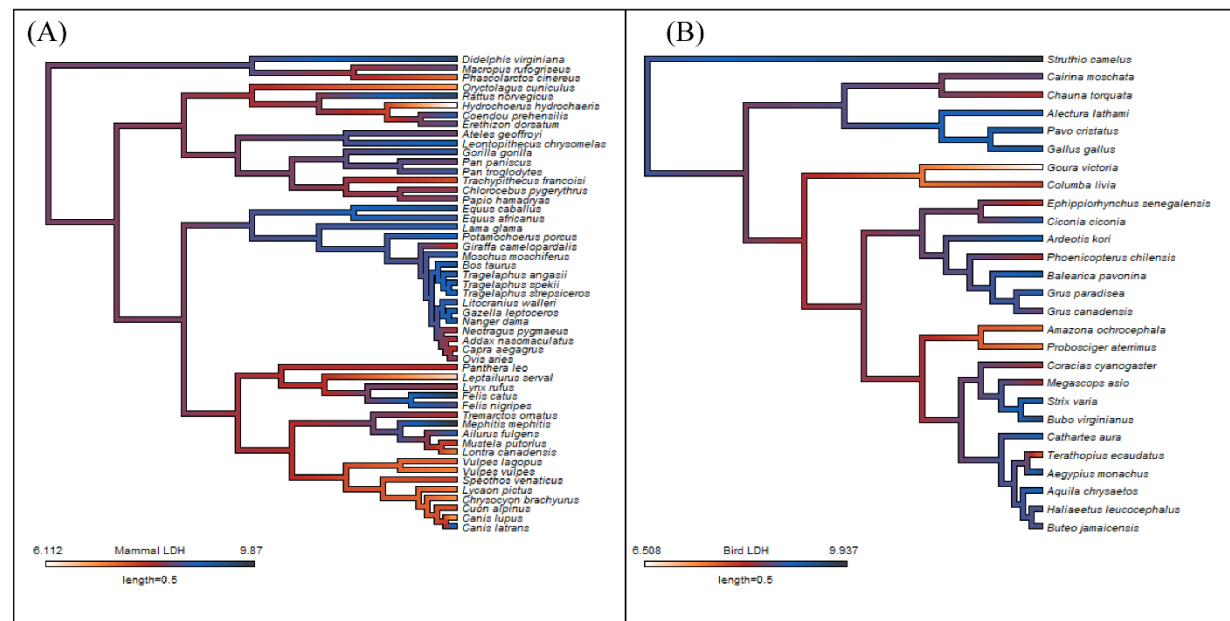


Figure S4. Phylogenetic trees for mammals (A) and birds (B) constructed from 1000 trees extracted from the supertree project (www.vertlife.org). Trait values for log-transformed lactate dehydrogenase (LDH) are mapped onto the tree. Darker colors indicate higher LDH values for a given species.

Table S1.

Species scientific and common name as well as sample sizes per individual.

Species	Common name	PK sample size	LDH sample size
Birds			
<i>Amazona ochrocephala</i>	Yellow-crowned Amazon parrot	1	1
<i>Haliaeetus leucocephalus</i>	Bald eagle	4	5
<i>Strix varia</i>	Barred owl	1	1
<i>Terathopus ecaudatus</i>	Bateleur eagle	1	1
<i>Coracias cyanogaster</i>	Blue-bellied roller	1	1
<i>Alectura lathami</i>	Brushturkey	1	1
<i>Phoenicopterus chilensis</i>	Chilean flamingo	9	7
<i>Aegypius monachus</i>	Cinereous vulture	1	1
<i>Pavo cristatus</i>	Common peafowl	2	2
<i>Gallus gallus</i>	Domestic rooster	1	1
<i>Megascops asio</i>	Eastern screech owl	2	2
<i>Aquila chrysaetos</i>	Golden eagle	1	1
<i>Bubo virginianus</i>	Great horned owl	2	2
<i>Ardeotis kori</i>	Kori bustard	1	1
<i>Cairina moschata</i>	Muscovy duck	1	1
<i>Struthio camelus</i>	Ostrich	3	3
<i>Probosciger aterrimus</i>	Palm cockatoo	1	1
<i>Buteo jamaicensis</i>	Red-tailed hawk	2	2
<i>Columba livia</i>	Rock pigeon	3	3
<i>Ephippiorhynchus senegalensis</i>	Saddle-billed stork	2	2
<i>Antigone canadensis</i>	Sandhill crane	1	1
<i>Chauna torquata</i>	Southern screamer	1	1
<i>Anthropoides paradiseus</i>	Stanley blue crane	1	1
<i>Cathartes aura</i>	Turkey vulture	1	1
<i>Goura victoria</i>	Victoria crowned pigeon	2	2
<i>Grus carunculata</i>	Wattled crane	1	0
<i>Balearica pavonina</i>	West-African crowned crane	0	1
<i>Ciconia ciconia</i>	White stork	2	2
Mammals			

<i>Addax nasomaculatus</i>	Addax	2	3
<i>Nanger dama</i>	Addra gazelle	1	1
<i>Panthera leo</i>	African lion	4	4
<i>Vulpes lagopus</i>	Arctic fox	2	2
<i>Felis nigripes</i>	Black-footed cat	2	2
<i>Lynx rufus</i>	Bobcat	3	3
<i>Pan paniscus</i>	Bonobo	2	2
<i>Hydrochoerus hydrochaeris</i>	Capybara	1	1
<i>Pan troglodytes</i>	Chimpanzee	4	4
<i>Felis catus</i>	Domestic cat	5	5
<i>Mustela putorius</i>	European polecat	1	1
<i>Equus asinus</i>	Donkey	4	4
<i>Oryctolagus cuniculus</i>	Flemish giant rabbit	1	1
<i>Trachypithecus francoisi</i>	Francois' langur	2	2
<i>Giraffa camelopardalis</i>	Giraffe	2	2
<i>Capra aegagrus</i>	Goat	8	8
<i>Leontopithecus chrysomelas</i>	Golden-headed lion tamarin	2	2
<i>Tragelaphus strepsiceros</i>	Greater kudu	2	3
<i>Papio hamadryas</i>	Hamadryas baboon	5	6
<i>Bos taurus</i>	Holstein cow	1	1
<i>Equus caballus</i>	Horse	2	2
<i>Ovis aries</i>	Jacob sheep	4	4
<i>Phascolarctos cinereus</i>	Koala	1	1
<i>Lama glama</i>	Llama	2	2
<i>Erethizon dorsatum</i>	North-American porcupine	1	1
<i>Lontra canadensis</i>	North-American river otter	3	3
<i>Tragelaphus angasii</i>	Nyala	1	1
<i>Coendou prehensilis</i>	Prehensile-tailed porcupine	2	1
<i>Vulpes vulpes</i>	Red fox	1	0
<i>Ailurus fulgens</i>	Red panda	4	5
<i>Potamochoerus porcus</i>	Red river hog	4	4
<i>Notamacropus rufogriseus</i>	Red-necked (Bennett's) wallaby	6	6
<i>Neotragus pygmaeus</i>	Royal antelope	1	1
<i>Leptailurus serval</i>	Serval	1	1

<i>Moschus moschiferus</i>	Siberian musk deer	1	1
<i>Tragelaphus spekii</i>	Sitatunga	4	4
<i>Gazella leptoceros</i>	Slender-horned gazelle	1	1
<i>Chlorocebus pygerythrus</i>	South-African vervet monkey	1	1
<i>Litocranius walleri</i>	Southern gerenuk	1	1
<i>Tremarctos ornatus</i>	Spectacled bear	1	1
<i>Rattus norvegicus</i>	Sprague–Dawley rat	1	1
<i>Mephitis mephitis</i>	Striped skunk	2	1
<i>Didelphis virginiana</i>	Virginia opossum	1	1
<i>Gorilla gorilla</i>	Western lowland gorilla	4	4
<i>Ateles geoffroyi</i>	Black-handed spider monkey	5	6
<i>Speothos venaticus</i>	Bushdog	1	1
<i>Canis lupus</i>	Gray wolf	1	1
<i>Chrysocyon brachyurus</i>	Maned wolf	6	6
<i>Lycaon pictus</i>	African wild dog	3	3
<i>Canis latrans</i>	Coyote	23	25
<i>Canis dingo hallstromi</i>	New Guinea singing dog	1	1
<i>Cuon alpinus</i>	Dhole	1	1

LDH, lactate dehydrogenase; PK, pyruvate kinase.

Table S2.

Demographic information per individual, including body mass, sex, age and MLSP.

Species	Body mass (kg)	Bird or mammal?	Sex	Age (years)	DOB	MLSP (years)	Age/MLSP
Yellow-crowned Amazon parrot	0.63	Bird	MI	39		56	0.696428571
Bald eagle	4.04	Bird	FI	18		48	0.375
Bald eagle	4.69	Bird	FI	7		48	0.145833333
Bald eagle	4.28	Bird	FI	7		48	0.145833333
Bald eagle	3.58	Bird	MI	7		48	0.145833333
Bald eagle	3.05	Bird	MI	15		48	0.3125
Barred owl	0.838	Bird	U	6		24	0.25
Bateleur eagle	2.42	Bird	F			55	
Blue-bellied roller	0.13	Bird	F	1			
Brushturkey	2.68	Bird	M	12		12.5	0.96
Chilean flamingo	2.6	Bird	FI	19		36.7	0.517711172

Chilean flamingo	2.95	Bird	MI	19		36.7	0.517711172
Chilean flamingo	1.9	Bird	M	46	1972	36.7	1.253405995
Chilean flamingo	2.95	Bird	M	37	1981	36.7	1.008174387
Chilean flamingo	1.9	Bird	F	37	1981	36.7	1.008174387
Chilean flamingo	2.45	Bird	F	23	1995	36.7	0.626702997
Chilean flamingo	2.55	Bird	M	12	2006	36.7	0.326975477
Chilean flamingo	3.25	Bird	M	31	1987	36.7	0.844686649
Chilean flamingo	2.45	Bird	F	31	1987	36.7	0.844686649
Cinereous vulture	9.84	Bird	F	29		39	0.743589744
Common peafowl	4.5	Bird	M	5	01/06/ 2013	23.2	0.215517241
Common peafowl	4	Bird	M	5	01/06/ 2013	23.2	0.215517241
Domestic rooster	1.7	Bird	MI	5		30	0.166666667
Eastern screech owl	0.151	Bird	F	12		20.7	0.579710145
Eastern screech owl	0.165	Bird	MI	3		20.7	0.144927536
Golden eagle	4.5	Bird	FI	12		48	0.25
Great horned owl	1.4	Bird	MI	7.5		29	0.25862069
Great horned owl	1.35	Bird	FI	8.5		29	0.293103448
Kori bustard	7.5	Bird	F	9	05/08/ 2009		
Muscovy duck	4.51	Bird	MI	10			
Ostrich	136.3	Bird	F	17	22/07/ 2001	50	0.34
Ostrich	128.2	Bird	F	17	22/07/ 2001	50	0.34
Ostrich	120	Bird	F	16	15/07/ 2002	50	0.32
Palm cockatoo	0.569	Bird	F	12	07/06/ 2006	56.3	0.213143872
Red-tailed hawk	1.74	Bird	FI	14.5		30.7	0.472312704
Red-tailed hawk	1.6	Bird	FI	7.5		30.7	0.244299674
Saddlebill stork	4.25	Bird	F	24	1994	30.2	0.794701987
Saddlebill stork	6.3	Bird	M	11	2007	30.2	0.364238411
Sandhill crane	4.34	Bird	M	10		36.6	0.273224044
Southern screamer	3.35	Bird	M	4	11/04/ 2014		

Stanley blue crane	4.32	Bird	F	8			
Turkey vulture	2.04	Bird	FI	13		20.8	0.625
Victoria crowned pigeon	2.94	Bird	M	14			
Victoria crowned pigeon	2.01	Bird	F	19			
Wattled crane	6.7	Bird	M	35	28/05/ 1983		
West African crowned crane	2.9	Bird	F	10			
White stork	3.06	Bird	F	25		39	0.641025641
White stork	3.86	Bird	M	20		39	0.512820513
Rock pigeon	0.301	Bird	n/a				
Rock pigeon	0.336	Bird	n/a				
Rock pigeon	0.265	Bird	n/a				
Addax	125	Mammal	F	13	21/05/ 2005	28	0.464285714
Addax	120	Mammal	F	8	16/06/ 2010	28	0.285714286
Addax	110	Mammal	F	2	17/05/ 2016	28	0.071428571
Addra gazelle	40	Mammal	F	3	12/04/ 2015	19.3	0.155440415
African lion	178	Mammal	F	8	31/08/ 2010	27	0.296296296
African lion	11.1	Mammal	M	1	14/11/ 2017	27	0.037037037
African lion	212.3	Mammal	M	1	18/12/ 2018	27	0.037037037
African lion	161.9	Mammal	F	8	31/08/ 2010	27	0.296296296
Arctic fox	5.9	Mammal	M	7	13/05/ 2011	16.3	0.429447853
Arctic fox	4.5	Mammal	F			16.3	
Black-footed cat	1.92	Mammal	M	8		15.6	0.512820513
Black-footed cat	1.67	Mammal	F	11		15.6	0.705128205
Bobcat	12.3	Mammal	MI	10		32.3	0.309597523

Bobcat	9.91	Mammal	FS	12		32.3	0.371517028
Bobcat	8.9	Mammal		13		32.3	0.40247678
Bonobo	37.5	Mammal	F	44	22/01/	55	0.8
					1974		
Bonobo	49.5	Mammal	M	27	23/12/	55	0.490909091
					1991		
Capybara	45.5	Mammal	F	10	01/01/	15.1	0.662251656
					2008		
Chimp	50	Mammal	F	35	24/12/	59.4	0.589225589
					1983		
Chimp	52.3	Mammal	F	22	16/12/	59.4	0.37037037
					1996		
Chimp	32.7	Mammal	F	6	16/01/	59.4	0.101010101
					2012		
Chimp	31	Mammal	F	7	17/04/	59.4	0.117845118
					2011		
Domestic cat	3.24	Mammal	F	4		30	0.133333333
Domestic cat	5.625	Mammal	M	3		30	0.1
Domestic cat	4.05	Mammal	M	5.5		30	0.183333333
Domestic cat	3.15	Mammal	F	4		39	0.102564103
Domestic cat	3.15	Mammal	F	1		30	0.033333333
Domestic ferret	1.075	Mammal	MN	5		11.1	0.45045045
Donkey	113.4	Mammal	M			47	
Donkey	58.96	Mammal	M	1	08/201	47	0.021276596
					17		
Donkey	88.9	Mammal	M	3	07/201	47	0.063829787
					5		
Miniature donkey	134	Mammal	FI	18.5		47	0.393617021
Flemish giant rabbit	7.5	Mammal	MN	4.5		9	0.5
Francois' langur	10.04	Mammal	F	16	02/09/	26.3	0.608365019
					2002		
Francois' langur	8.94	Mammal	F	6	03/11/	26.3	0.228136882
					2012		
Slender-horned gazelle	13.6	Mammal	F	7	28/04/	14.6	0.479452055
					2011		
Giraffe	700	Mammal	F	21	24/08/	39.5	0.53164557
					1997		

Giraffe	1067	Mammal	M	12		39.5	0.303797468
Goat	43	Mammal	M	8	20/05/2010	20.8	0.384615385
Goat	40	Mammal	F	11	17/08/2007	20.8	0.528846154
Goat	32.85	Mammal	F	5	24/04/2013	20.8	0.240384615
Goat	38	Mammal	F	5	24/04/2013	20.8	0.240384615
Goat	30.5	Mammal	F	4	24/04/2014	20.8	0.192307692
Goat	25	Mammal	F	2	27/04/2016	20.8	0.096153846
Pygmy goat	31.6	Mammal	FI	5.5		20.8	0.264423077
Pygmy goat	30	Mammal	F	12		20.8	0.576923077
Golden headed lion tamarin	0.78	Mammal	M	17	18/11/2001	31.6	0.537974684
Golden headed lion tamarin	0.79	Mammal	F	6	22/11/2012	31.6	0.189873418
Greater kudu	150	Mammal	F	2	07/09/2016	23.5	0.085106383
Greater kudu	130	Mammal	M	2	14/10/2016	23.5	0.085106383
Greater kudu	70	Mammal	M	1	11/10/2017	23.5	0.042553191
Hamadryas baboon	28	Mammal	M	20	20/10/1998	37.5	0.533333333
Hamadryas baboon	16.5	Mammal	F	14	13/09/2004	37.5	0.373333333
Hamadryas baboon	29.5	Mammal	M	13	08/10/2005	37.5	0.346666667
Hamadryas baboon	13	Mammal	F	8	01/10/2010	37.5	0.213333333
Hamadryas baboon	12	Mammal	M	5	21/05/2013	37.5	0.133333333
Hamadryas baboon	6	Mammal	M	3	25/09/2015	37.5	0.08

Holstein cow	635	Mammal	F	5		20	0.25
Horse	453.59	Mammal	M	10	2008	57	0.175438596
Horse	453.59	Mammal	M	12	2006	57	0.210526316
Jacob sheep	71.27	Mammal	MN	9		22.8	0.394736842
Jacob sheep	66.32	Mammal	MN	7		22.8	0.307017544
Jacob sheep	84.86	Mammal	MN	8		22.8	0.350877193
Jacob sheep	72.7	Mammal	MN	7.5		22.8	0.328947368
Koala	5.76	Mammal	F	10	24/03/ 2008	22.1	0.452488688
Llama	145	Mammal	F	17	13/05/ 2001	28.9	0.588235294
Llama	127.5	Mammal	F	8	01/07/ 2010	28.9	0.276816609
North-American porcupine	10.05	Mammal	FI	3		23.4	0.128205128
North-American river otter	8.6	Mammal	MI	13		27	0.481481481
North-American river otter	10.13	Mammal	M	9		27	0.333333333
North-American river otter	7	Mammal		9		27	0.333333333
North-American river otter	9.4	Mammal	M	12	01/03/ 2006	27	0.444444444
Nyala	118	Mammal	M	10	08/07/ 2008	18.5	0.540540541
Prehensile Tailed porcupine	5.9	Mammal	FS	8		26.6	0.30075188
Prehensile tailed porcupine	6.86	Mammal	MI	8.5		26.6	0.319548872
Red fox	4.7	Mammal	F	3	15/02/ 2015	21.3	0.14084507
Red panda	5.05	Mammal	FI	9.5		19	0.5
Red panda	5.45	Mammal	MI	3.5		19	0.184210526
Red panda	4.26	Mammal	F	4		19	0.210526316
Red panda	6.34	Mammal	F	4		19	0.210526316
Red panda	6.88	Mammal	F	5	16/02/ 2013	19	0.263157895

Red river hog	79	Mammal	F	11		22	0.5
Red river hog	63	Mammal	F	11		22	0.5
Red river hog	60	Mammal	F	14	18/10/2004	22	0.636363636
Red river hog	70	Mammal	M	18	06/05/2000	22	0.818181818
Royal antelope	2	Mammal	M			22	
Serval	10.07	Mammal	M	3	13/05/2015	22.4	0.133928571
Siberian musk deer	10	Mammal	M	2	03/06/2016		
Sitatunga	75	Mammal	F	6	16/04/2012	22.6	0.265486726
Sitatunga	50	Mammal	F	4	08/08/2014	22.6	0.17699115
Sitatunga	40	Mammal	F	4	08/10/2014	22.6	0.17699115
Sitatunga	75	Mammal	M	3	24/04/2015	22.6	0.132743363
South-African vervet monkey	3.06	Mammal	M	1	20/09/2018		
Southern gerenuk	27.6	Mammal	M	2	30/07/2016	17.3	0.115606936
Spectacled bear	128.9	Mammal	M	8	30/12/2010	39	0.205128205
Black-handed spider monkey	6.43	Mammal	F	28		47.1	0.59447983
Black-handed spider monkey	6.19	Mammal	F	21		47.1	0.445859873
Black-handed spider monkey	6.53	Mammal	M	20		47.1	0.42462845
Black-handed spider monkey	5.55	Mammal	M	32		47.1	0.67940552
Black-handed spider monkey	6.62	Mammal	F	16		47.1	0.33970276
Black-handed spider monkey	6.51	Mammal	F	19		47.1	0.403397028

Sprague–Dawley rat	0.28	Mammal	F	0.6		4.2	0.142857143
Striped skunk	2.63	Mammal	FS	4		13.9	0.287769784
Striped skunk	2.67	Mammal	MN	9.5		13.9	0.683453237
Virginia opossum	4.65	Mammal	MN	3		6.6	0.454545455
Red-necked (Bennett's) wallaby	15.2	Mammal	M	9	01/06/ 2009	15.2	0.592105263
Red-necked (Bennett's) wallaby	10.9	Mammal	F	9	01/10/ 2009	15.2	0.592105263
Red-necked (Bennett's) wallaby	16.35	Mammal	M	6	01/02/ 2012	15.2	0.394736842
Red-necked (Bennett's) wallaby	11.6	Mammal	F	4	30/09/ 2014	15.2	0.263157895
Red-necked (Bennett's) wallaby	11.3	Mammal	F	5	07/10/ 2013	15.2	0.328947368
Red-necked (Bennett's) wallaby	9.3	Mammal	F	2	07/09/ 2016	15.2	0.131578947
Western lowland gorilla	41	Mammal	M	6	31/08/ 2012	60.1	0.099833611
Western lowland gorilla	163	Mammal	M	35	26/10/ 1983	60.1	0.582362729
Western lowland gorilla	87.3	Mammal	M	9	27/07/ 2009	60.1	0.149750416
Western lowland gorilla	106.8	Mammal	F	44	16/08/ 1974	60.1	0.732113145
Bushdog	6.5	Mammal		10.25		14.1	0.726950355
Gray wolf	31	Mammal	F	3.4167		20.6	0.165859223
Maned wolf	23.129251 7	Mammal	F	2		16.8	0.119047619
Maned wolf	23.356009 07	Mammal	F	2		16.8	0.119047619
Maned wolf	16.780045 35	Mammal	F	7		16.8	0.416666667
Maned wolf	27.8	Mammal	F	6.916		16.8	0.411666667
Maned wolf	27.85	Mammal	M	6.66		16.8	0.396428571
Maned wolf	29.5	Mammal	F	8.416		16.8	0.500952381
African wild dog	30.4	Mammal	F	1.916		17	0.112705882
African wild dog	27.6	Mammal	M	1.916		17	0.112705882

African wild dog	30.4	Mammal	F	1.916	17	0.112705882
Coyote	13.3	Mammal	F	7	21.8	0.321100917
Coyote	16.2	Mammal	M	7	21.8	0.321100917
Coyote	16.1	Mammal	M	7	21.8	0.321100917
Coyote	12.9	Mammal	F	7	21.8	0.321100917
Coyote	16.5	Mammal	M	6	21.8	0.275229358
Coyote	17.3	Mammal	M	6	21.8	0.275229358
Coyote	12	Mammal	F	6	21.8	0.275229358
Coyote	16	Mammal	F	6	21.8	0.275229358
Coyote	16.3	Mammal	M	5	21.8	0.229357798
Coyote	14.2	Mammal	M	5	21.8	0.229357798
Coyote	14.6	Mammal	F	5	21.8	0.229357798
Coyote	14.5	Mammal	F	4	21.8	0.183486239
Coyote	18.3	Mammal	M	3	21.8	0.137614679
Coyote	14.7	Mammal	M	3	21.8	0.137614679
Coyote	16.1	Mammal	M	3	21.8	0.137614679
Coyote	11.4	Mammal	F	3	21.8	0.137614679
Coyote	12	Mammal	F	3	21.8	0.137614679
Coyote	17.1	Mammal	M	2	21.8	0.091743119
Coyote	16.4	Mammal	M	1	21.8	0.04587156
Coyote	16.1	Mammal	M	1	21.8	0.04587156
Coyote	13.8	Mammal	F	1	21.8	0.04587156
Coyote	12.8	Mammal	F	1	21.8	0.04587156
Coyote	9	Mammal	M	0.33	21.8	0.015137615
Coyote	9.08	Mammal	M	0.33	21.8	0.015137615
Coyote	8	Mammal	F	0.33	21.8	0.015137615
Coyote	11.8	Mammal	M	15.33	21.8	0.703211009
New Guinea singing dog	11.5	Mammal	M	6.333		
Dhole	17.69	Mammal		7	16.1	0.434782609

DOB, date of birth; MLSP, maximum lifespan. F, female; FI, female intact ; M, male; MI, male intact; MN, male neutered; FS, female spayed ; U, unavailable.