Supporting Information

Alberts et al. 10.1073/pnas.1311857110

SI Materials and Methods

Mortality Models Compared with Previously Published Studies. The female mortality models presented in the current analysis differ from those reported in the earlier analysis (1), because in the current analysis we included only those individual females that had experienced at least one live birth in both the fertility cessation and the mortality models (compare Table 2 in ref. 1 with Table 2 in the present paper). Changes were relatively small in magnitude compared with differences that have been reported between populations of chimpanzees and between populations of humans (2).

Limitations on Human Comparison. We restricted our mortality and fertility cessation datasets to the same individuals in the nonhuman primate analyses, which allowed us to ask about reproductive versus general senescence in the same sets of individuals, an approach we believe to be particularly powerful. This design was not possible for our analysis of the !Kung data because data for mortality and fertility cessation on the same individuals were not available. However, because the human pattern of accelerated reproductive senescence relative to mortality is well known (see refs. 2–11), the !Kung data provide a valuable heuristic comparison for our nonhuman primate analyses.

1. Bronikowski AM, et al. (2011) Aging in the natural world: Comparative data reveal similar mortality patterns across primates. *Science* 331(6022):1325–1328.
2. Hawkes K, Smith KR, Robson SL (2009) Mortality and fertility rates in humans and chimpanzees: How within-species variation complicates cross-species comparisons. *Am J Hum Biol* 21(4):578–586.
3. Levitis DA, Burger O, Lackey LB (2013) The human post-fertile lifespan in comparative evolutionary context. *Evol Anthropol* 22(2):66–79.
4. Hawkes K, Smith KR (2010) Do women stop early? Similarities in fertility decline in humans and chimpanzees. *Ann N Y Acad Sci* 1204:43–53.
5. Cohen AA (2004) Female post-reproductive lifespan: A general mammalian trait. *Biol Rev Camb Philos Soc* 79(4):733–750.
6. Fedigan LM, Pavelka MSM (2011) Menopause: Interspecific comparisons of reproductive termination in female primates. *Primates in Perspective*, eds Campbell C, Fuentes A, MacKinnon K, Bearder S, Stumpf R (Oxford Univ Press, Oxford, UK), 2nd ed, pp 488–498.
7. Kirkwood TBL, Shanley DP (2010) The connections between general and reproductive senescence and the evolutionary basis of menopause. *Ann N Y Acad Sci* 1204:21–29.
8. Hill K, Hurtado AM (1991) The evolution of premature reproductive senescence and menopause in human females: An evaluation of the "grandmother" hypothesis. *Hum Nat* 2:313–350.
9. Emery Thompson M, et al. (2007) Aging and fertility patterns in wild chimpanzees provide insights into the evolution of menopause. *Curr Biol* 17(24):2150–2156.
10. Lancaster JB, King BJ (1985) An evolutionary perspective on menopause. *In Her Prime: A New View of Middle-Aged Women*, eds Brown JK, Kerns V (Bergin and Garvey, MA), pp 13–20.
11. Peccei JS (1995) The origin and evolution of menopause: The altriciality-lifespan hypothesis. *Ethol Sociobiol* 16(5):425–449.

Table S1. Summary of nonhuman primate study populations

Common name	Species	Family	Country	Average annual rainfall (mm)*	Lifestyle	Start year†	Sample size‡	Predominant dispersing sex	Mean age at first dispersal (y)
Sifaka	*Propithecus verreauxi*	Indriidae	Madagascar	578	Arboreal	1984	116	M	4–5
Muriquis	*Brachyteles hypoxanthus*	Atelidae	Brazil	1,180	Arboreal	1983	69	F	6–7
Capuchins	*Cebus capucinus*	Cebidae	Costa Rica	1,736	Arboreal	1983	45	M§	4–5
Baboons	*Papio cynocephalus*	Cercopithecidae	Kenya	347	Semiterrestrial	1971	211	M	7–8
Blue monkeys	*Cercopithecus mitis*	Cercopithecidae	Kenya	1.962	Arboreal	1979	113	M	7–8
Chimpanzees	*Pan troglodytes*	Hominidae	Tanzania	1.330	Semiterrestrial	1963	60	F	12–13
Gorillas	*Gorilla beringei*	Hominidae	Rwanda	1.358	Terrestrial	1967		M	15–16
							71	F	7–8

Further details about and references for study sites are in Bronikowski et al. (1). This table is modified from ref. 1.
*Average annual rainfall for each study, representative of the study years. Rainfall data for gorillas were collected by the Rwandan Government Meteorological Office at a location several kilometers from the field site and at a lower elevation. Rainfall data for other studies were collected at the study site.
†Year study was established. Latest census date for all populations in these analyses was between June 30, 2011 and October 12, 2011.
‡We restricted the analysis to individual females in each study species who survived until at least the average age of first birth, and experienced at least one live birth; this excluded any females that had not given birth by the time of the analysis, regardless of their age. Males (M) were excluded from the analysis.
§Twelve percent of female (F) capuchins disperse. The average age interval of dispersing capuchin females is 6–7 y.

1. Bronikowski AM, et al. (2011) Aging in the natural world: Comparative data reveal similar mortality patterns across primates. *Science* 331(6022):1325–1328.

Table S2. Summary of !Kung data

Dataset	Source	Details	Sample size
Fertility cessation data	T-Space at University of Toronto Libraries: Basic Women's Interviews (1) doi: hdl.handle.net/1807/18002	Each row contains information for one individual woman; the relevant columns for this analysis were ID number, year of birth, year of death, year of birth of last child, age at last pregnancy, pregnant at end of study, error in estimate, status of menopause.	141
Mortality data	Table 4.5 in ref 2.	Includes mortality data for both males and females; data for females were not separable from data for males.	133

1. Howell N (2009) Basic Women's interviews. Available at http://hdl.handle.net/1807/18002.
2. Howell N (1979) *Demography of the Dobe !Kung* (Academic, New York).

Table S3. Definitions of terms

Term	Definition
Mean interbirth interval (IBI)	Mean duration of the interval between live births in a population; defined separately for each species/population.
Fertility cessation	Cessation of fertility from all causes, including cessation caused by the death of the female and cessation caused by fertility completion.
Fertility completion	Cessation of fertility caused by reproductive senescence. Fertility completion occurred when a female lived longer than (Mean IBI + 2SD) after her last live birth without giving birth again (where mean IBI was specific to her species and population). See also ref. 1.
Modal age of an event	Age at which events (in our case either death, fertility completion, or fertility cessation) are centered. Modal age (m) is calculated based on Gompertz parameters *a* and *b* (see Table 2) as follows: $m = (1/b)\ \ln(b/a) + \text{initial adult age}$.
Postreproductive representation	Proportion of all adult-years in a population that are lived by postfertile individuals (2, 3).

1. Caro TM, et al. (1995) Termination of reproduction in nonhuman and human female primates. *Int J Primatol* 16(2):205–220.
2. Levitis DA, Burger O, Lackey LB (2013) The human post-fertile lifespan in comparative evolutionary context. *Evol Anthropol* 22(2):66–79.
3. Levitis DA, Lackey LB (2011) A measure for describing and comparing post-reproductive lifespan as a population trait. *Methods Ecol Evol* 2(5):446–453.

Table S4. Fertility completion rates compared with mortality rates

Species	Model parameter	χ^2 values: Comparison of model parameters for fertility completion vs. model parameters for mortality	Statistically significant difference?
Sifaka	*a*	9.32	Yes
	b	5.42	Yes
	Whole model	10.69	Yes
Baboons	*a*	32.3	Yes
	b	13.5	Yes
	Whole model	45.5	Yes
Blue monkeys	*a*	3.96	Yes
	b	2.06	No
	Whole model	4.50	Yes

Comparisons of Gompertz *a*, Gompertz *b*, and whole models, for the fertility completion models and the mortality models for the three nonhuman primate species for which we could fit models.

Table S5. Ninetieth percentiles of the distributions of age (in years) at death and at last live birth (species listed in order of the 90th percentile for age at death)

Species	90th percentile for age at death	90th percentile for fertility cessation
Baboons	19.8	18.4
Capuchins	21.5	20.4
Sifaka	24.6	22.1
Blue monkeys	26.1	23.4
Muriquis	30.0	27.8
Gorillas	38.3	33.5
Chimpanzees	40.6	38.0
Humans (!Kung)	74.5	43.0

Table S6. Fertility completion and mortality: Model comparisons for Gompertz vs. other models

Species	Process	Gompertz (G)	Gompertz–Makeham (GM)	Logistic	Logistic-Makeham	Best
Sifaka	Fertility completion	−43.567	−43.567	−42.923	−42.923	G
Baboons	Fertility completion	−20.244	−20.244	−20.213	−20.213	G
Blue monkeys	Fertility completion	−40.706	−40.706	−40.618	−40.409	G
Human (!Kung)	Fertility completion	−285.956	−283.575	−285.956	−283.575	GM
[1]Sifaka	Mortality	−236.69	−236.69	−235.99	−235.73	G
Muriquis	Mortality	−45.80	−44.33	−45.80	−44.33	G
Capuchins	Mortality	−50.36	−50.36	−49.36	−49.30	G
Baboons	Mortality	−411.96	−411.96	−411.83	−411.83	G
Blue monkeys	Mortality	−191.28	−191.28	−191.28	−191.28	G
Chimpanzees	Mortality	−122.75	−122.75	−121.65	−121.65	G
Gorillas	Mortality	−77.44	−77.43	−77.44	−77.43	G
Human (!Kung)	Mortality	−161.469	−161.469	−161.469	−161.469	G

Model comparison via maximum likelihood performed in program WinModest (1).

1. Pletcher SD (1999) Model fitting and hypothesis testing for age-specific mortality data. *J Evol Biol* 12(3):430–439.