SUPPLEMENTARY INFORMATION

Sex differences in adult lifespan and aging rates of mortality across wild mammals

Jean-François Lemaître[1*‡], Victor Ronget[1‡], Morgane Tidière[1], Dominique Allainé[1], Vérane Berger[2], Aurélie Cohas[1], Fernando Colchero[3,4], Dalia Conde[3,5], Michael Garratt[6], András Liker[7], Gabriel A.B. Marais[1], Alexander Scheuerlein[8], Tamás Székely[9,10], Jean-Michel Gaillard[1]

[1] Univ Lyon, Université Lyon 1, CNRS, Laboratoire de Biométrie et Biologie Évolutive UMR 5558, F-69622, Villeurbanne, France.
[2] Department of Biology, University of Turku, Turku, Finland.
[3] Interdisciplinary Center on Population Dynamics, CPop, University of Southern Denmark, Odense, Denmark
[4] Department of Mathematics and Computer Science (IMADA), University of Southern Denmark, Odense, Denmark.
[5] Species 360 Conservation Science Alliance, Bloomington, MN, 55425, USA
[6] School of Biomedical Sciences, Department of Anatomy, University of Otago, New Zealand.
[7] MTA-PE Evolutionary Ecology Research Group, Department of Limnology, University of Pannonia, Pf. 158, H-8201 Veszprém, Hungary.
[8] Max Planck Institute for Demographic Research, Rostock 18057, Germany.
[9] Milner Centre for Evolution, Department of Biology and Biochemistry, University of Bath, Bath BA2 7AY, UK.
[10] Department of Evolutionary Zoology and Human Biology, University of Debrecen, Debrecen H-4032, Hungary.

‡ Equal contribution
* *Author for correspondence*: jean-francois.lemaitre@univ-lyon1.fr (ORCID: 0000-0001-9898-2353)

www.pnas.org/cgi/doi/10.1073/pnas.1911999117

Rate of aging relative to adult lifespan. Median adult lifespan and rates of aging were negatively associated across mammals (phylogenetic regression: slope = -0.38 ± 0.16, $p < 0.001$, $R^2 = 0.56$, see statistical analyses for method and models used for all the regressions and the Fig. S2). Short-lived species age thus faster than long-lived species, as well established in the aging literature (1, 2). To obtain measures of aging rates independent of adult lifespan (hereafter called *relative* aging rate), we also computed the aging rate relative to adult lifespan as the residuals of the phylogenetically corrected relationship between the parameter b_1 (see methods, Eq. (1)) and adult lifespan (both log-transformed) as follows

$$Relative\ aging\ rate = \log(\text{rate of aging}) - (-0.38) \times \log(adult\ lifespan) - 0.55 \qquad (5)$$

To account for the negative association between adult lifespan and aging rate, we performed a similar analysis to *absolute* aging rate (see Methods) using the relative aging rate and we found similar results. There were no consistent differences between males and females in aging rates. The Null model was ranked first (Table S5), revealing that none of the sexual size dimorphism, hunting status and data quality influenced the magnitude of sex differences in relative aging rates. There was also no effect of mating or social system (mean difference $_{\text{monogamous vs. polygynous}}$ = -0.08 [-0.53; 0.36], mean difference $_{\text{monogamous vs. promiscuous}}$ = -0.01 [-0.49; 0.41], mean difference $_{\text{cooperative vs. non-cooperative breeder}}$ = -0.18 [-0.58; 0.21]).

Relationship between male and female adult lifespan. To assess whether sex differences in adult lifespan were the same in fast or slow life histories, we first ran a Bayesian hierarchical analysis (see Materials and Methods) for all species by regressing male adult lifespan against female adult lifespan. Same sex differences in median adult lifespan between slow and fast life histories should lead to a slope close to 1. However, the estimated slope was lower than 1 (slope = 0.87 [0.81; 0.94], Fig S3), showing that sex differences in adult lifespan in favour of females increase with female adult lifespan (i.e. longer-lived species).

References

1. Jones OR, et al. (2008) Senescence rates are determined by ranking on the fast–slow life-history continuum. *Ecology Letters* 11(7):664–673.

2. Ricklefs RE (2010) Life-history connections to rates of aging in terrestrial vertebrates. *Proceedings of the National Academy of Sciences* 107(22):10314–10319.

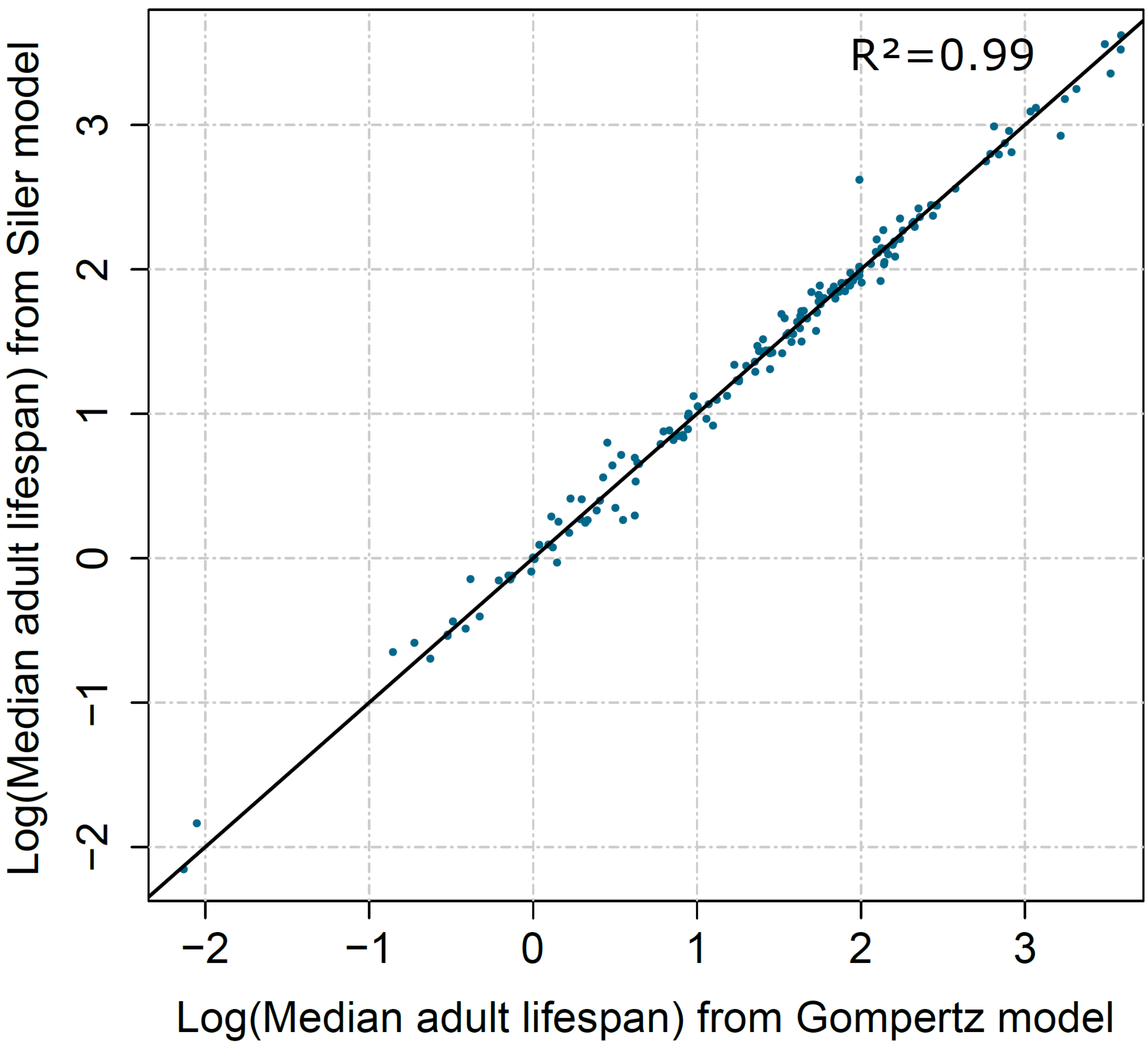

Fig. S1.

Relationship between median adult lifespan estimated using a Gompertz model and median adult lifespan estimated using a Siler model (only 'longitudinal' and 'transversal-dx' data were included in this analysis).

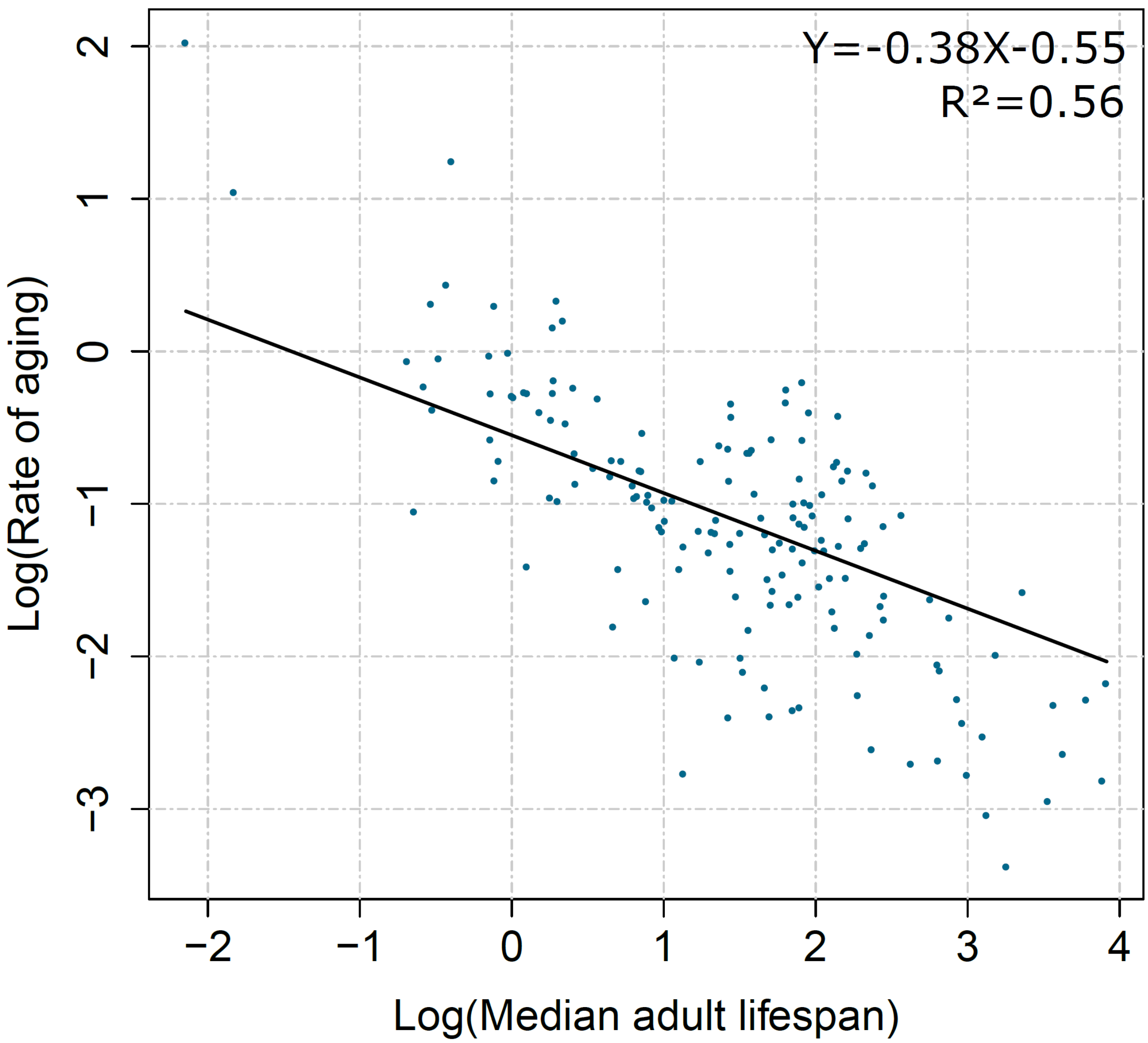

Fig. S2.

Relationship between rate of aging and median adult lifespan on a log-log scale.

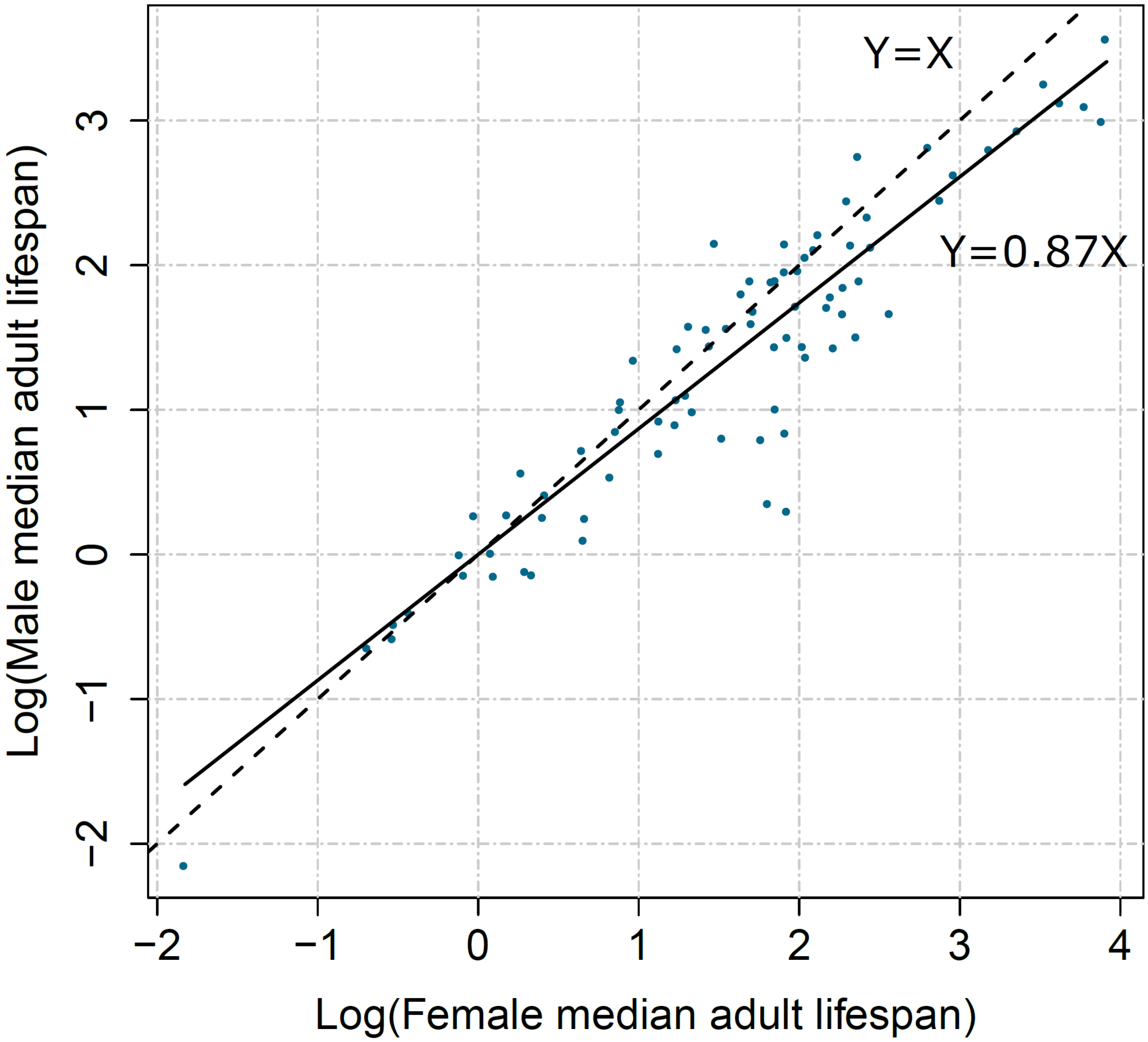

Fig. S3.

Allometric relationship between male and female median adult lifespan. The best regression line is in black. The dash line represents isometry (i.e. slope of 1).

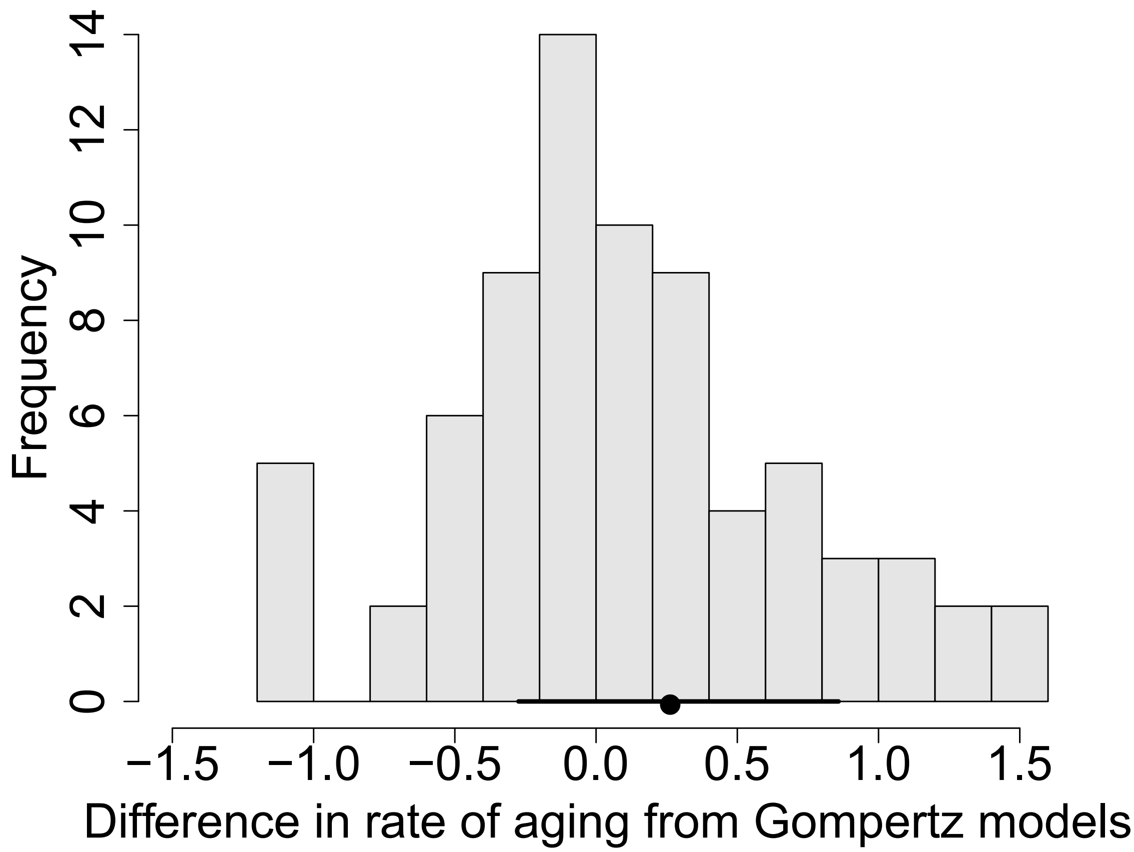

Fig. S4.

Frequency distribution of the magnitude of sex differences in rate of aging estimated from species-specific Gompertz models across mammals in the wild (a). The black dot corresponds to the overall effect for non-human mammals and is associated with its 95 % credibility interval. Compared to Figure 2 that displays the picture obtained from species-specific Siler models, seven species (*Mandrillus sphinx*, *Mirounga leonina*, *Muscardinus avellanarius*, *Mustela erminea*, *Myotis lucifugus*, *Spermophilus beldingi*, *Tamias striatus*) have been removed because their estimates of the Gompertz rate of aging were negative, making impossible any computation of sex-differences in aging rates.

Table S1. Ranking of the different models for the analysis of sex differences in adult lifespan using Deviance Information Criterion. The selected model is in bold (SSD: sexual size dimorphism). Only the five models with the highest support are presented.

Models	DIC	ΔDIC
Hunted+Quality+SSD	**118.8**	**0**
Hunted+Quality (Null model)	119.0	0.11
Hunted+Quality+SSD+ Sex-biased detection	119.8	0.97
Hunted+Quality+Sex-biased detection	120.0	1.21
Hunted+Quality+SSD+Hunted*SSD	120.5	1.63

Table S2. Ranking of the different models for the analysis of the sex differences in rate of aging using Deviance Information Criterion. Selected model is in bold (SSD: sexual size dimorphism). Only the five models with the highest support are presented.

Models	DIC	ΔDIC
Hunted + Quality (Null model)	**89.5**	**0**
Hunted + Quality + Hunted*Quality	89.5	0
Hunted + Quality + Sex-biased detection	90.4	0.9
Hunted + Quality + Sex-biased detection + Hunted*Quality	90.4	0.9
Hunted + Quality + SSD	90.8	1.3

Table S3. Mean of the posterior distribution of sex differences in median adult lifespan from the null model (a) and the model with the highest support (b). Each parameter is associated with the lower and upper limits of 95% credibility interval.

a: Null Model

Parameter	Mean	Lower CI	Upper CI
Sex difference (Intercept)	-0.171	-0.376	0.036

b: Model with highest support based on DIC

Parameters	Mean	Lower CI	Upper CI
Intercept	-0.165	-0.372	-0.071
Hunted (Yes)	-0.142	-0.335	0.041
Data quality (transversal)	0.121	-0.027	0.269
SSD	-0.226	-0.490	0.042

Table S4. Mean of the posterior distribution of sex differences in *relative* aging rate from the null model. The mean sex difference is associated with the lower and upper limits of 95% credibility interval.

Parameter	Mean	Lower CI	Upper CI
Sex difference (intercept)	0.191	-0.144	0.545

Table S5. Ranking of the different models of the sex difference in *relative* aging rate using Deviance Information Criterion. The selected model is in bold (SSD: sexual size dimorphism, Sex-bias in individual detection). Only the five models with the highest support are presented.

Models	DIC	ΔDIC
Hunted + Quality (Null model)	**89.4**	**0**
Hunted + Quality + Hunted*Quality	89.4	0
Hunted + Quality + Hunted*Quality + Sex-biased detection	90.2	0.8
Hunted + Quality + Sex-biased detection	90.4	1
Hunted + Quality + SSD	90.7	1.3

Supplementary data S1. Full list of mammalian populations with age- and sex-specific mortality data recovered during our literature survey. The column yes/no indicates whether the population is considered or not in our analyses. When the population was not retained, we provide a justification.

Supplementary data S2. Body mass (male and female, in grams), age at first reproduction (in years) and mating system (monogamous, polygynous or promiscuous) and associated references for each population used in the analyses.

Supplementary data S3. Data on sample size, type of studies (longitudinal, transversal_lx or transversal_dx), social system (cooperative breeder: CB or non-cooperative breeder: NCB), hunting status (yes / no), parameters of the Siler model (a0_Siler, a1_Siler, c_Siler, b0_Siler, b1_Siler), parameters of the Gompertz model for males (a_Gompertz, b_Gompertz), adult lifespan_80, mean adult lifespan, adult lifespan_50 and lifespan_max per sex and for each mammalian population used in the analyses. The full definition of each variable is provided in the Material and Methods section.

Supplementary data S4. Data on possible sex-specific bias in detection rate for each mammalian population included in our analysis.