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# Comparing free-ranging and captive populations reveals intra-specific variation in aging rates in large herbivores

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# ELECTRONIC APPENDIX

# Comparing free-ranging and captive populations reveals intra-specific variation in aging rates in large herbivores

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**Table A1**: List of all species (*n* = 22) included in the analysis. All variables are described in the methodology section of the paper.

| Species | | Diet | Data quality | Aging rate *GAM* (wild) | Aging rate *GAM* (zoo) | Aging rate *Gompertz* (wild) | Aging rate *Gompertz* (zoo) | Body mass (g) | Aging rate *GAM* (wild) | Aging rate *GAM* (zoo) | Aging rate *Gompertz* (wild) | Aging rate *Gompertz* (zoo) | Body mass (g) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Male | | | | | Female | | | | | |
| Impala | *Aepyceros melampus* | 60 | 1 | 0.0751 | 0.0064 | | | 55880 | 0.0784 | 0.0236 | | | 43660 | Spinage 1972; Silva & Downing 1995 |
| Moose | *Alces alces* | 2 | 0 | 0.0611 | 0.0478 | | | 323000 | 0.0834 | 0.0145 | | | 257500 | Ericson & Wallin 2001; Silva & Downing 1995 |
| Pronghorn | *Antilocapra americana* | 15 | 0 | 0.0839 | 0.0144 | 0.372 | 0.059 | 51500 | 0.0206 | 0.0036 | 0.240 | 0.111 | 41000 | Byers 1997; Silva & Downing 1995 |
| Gaur | *Bos gaurus* | 66 | 0 | 0.1684 | 0.0150 | | | 880000 | 0.0272 | 0.0035 | | | 590000 | Aresthani 2010; Weckerly 1998 |
| Wild goat | *Capra hircus* | 28 | 1 | 0.0591 | 0.0507 | | | 70100 | 0.0341 | 0.0251 | | | 42000 | Magomedov 2004; Silva & Downing 1995 |
| Alpine ibex | *Capra ibex* | 60 | 0 | 0.0534 | 0.0190 | 0.384 | 0.289 | 87400 | 0.0175 | 0.0353 | 0.407 | 0.131 | 53000 | Toigo 2007; Silva & Downing 1995 |
| Roe deer | *Capreolus capreolus* | 9 | 0 | 0.0537 | 0.0377 | 0.186 | 0.095 | 23580 | 0.0569 | 0.0555 | 0.214 | 0.196 | 23375 | Gaillard et al. 2004; Silva & Downing 1995 |
| Red deer | *Cervus elaphus* | 47 | 0 | 0.0698 | 0.0206 | | | 160300 | 0.0393 | 0.0250 | | | 98733 | Catchpole 2004; Silva & Downing 1995 |
| Sikadeer | *Cervus nippon* | 50 | 0 | 0.0730 | 0.0027 | | | 39450 | 0.0246 | 0.0038 | | | 27550 | McCullough 2009; Silva & Downing 1995 |
| Wildebeeste | *Connochaetes taurinus* | 90 | 1 | 0.0413 | 0.0288 | | | 210000 | 0.0879 | 0.0177 | | | 170500 | Atwell 1982; Silva & Downing 1995 |
| Topi | *Damaliscus lunatus* | 99 | 1 | 0.1800 | 0.0056 | | | 134000 | 0.1810 | 0.0258 | | | 122000 | Mertens 1985; Silva & Downing 1995 |
| Defassa Waterbuck | *Kobus ellipsiprymnus* | 80 | 1 | 0.1154 | 0.0158 | | | 231000 | 0.0301 | 0.0241 | | | 174000 | Spinage 1970; Weckerly 1998 |
| Lechwe | *Kobus leche* | 95 | 1 | 0.1142 | 0.0108 | | | 111750 | 0.1129 | 0.0108 | | | 86600 | Sayer & Van Lavieren 1975; Silva & Downing 1995 |
| Black-tailed deer | *Odocoileus hemionus* | 11 | 1 | 0.0460 | 0.0497 | | | 112500 | 0.0107 | 0.0191 | | | 55500 | Taber & Dasman 1957; Plard et al. 2011 |
| Mountain goat | *Oreamnos americanus* | 61 | 0 | 0.0469 | 0.0250 | 0094 | 0.300 | 75000 | 0.0426 | 0.0357 | 0.220 | 0.206 | 70000 | Festa-Bianchet & Côté 2009; Silva & Downing 1995 |
| Soay sheep | *Ovis aries* | 69 | 0 | 0.3679 | 0.0023 | 0.385 | 0.035 | 26000 | 0.0786 | 0.0114 | 0.280 | 0.169 | 20000 | Catchpole 1998; Weckerly 1998 |
| Bighorn sheep | *Ovis canadensis* | 67 | 0 | 0.0711 | 0.0206 | 0.257 | 0.181 | 100000 | 0.0467 | 0.0090 | 0.171 | 0.099 | 60000 | Loison 1999; Silva & Downing 1995 |
| Dall mountain sheep | *Ovis dalli* | 56 | 1 | 0.0796 | 0.0025 | | | 76000 | 0.0973 | 0.0296 | | | 48000 | Murie 1944; Weckerly 1998 |
| Reindeer | *Rangifer tarandus* | 36 | 1 | 0.0590 | 0.0423 | | | 106500 | 0.0590 | 0.0216 | | | 76000 | Reimers 1983, Leader-Williams 1988; Weckerly 1998 |
| Chamois | *Rupicapra rupicapra* | 74 | 1 | 0.0459 | 0.0008 | | | 40000 | 0.0440 | 0.0225 | | | 33500 | Bocci 2010; Silva & Downing 1995 |
| African buffalo | *Syncerus caffer* | 90 | 1 | 0.0394 | 0.0181 | | | 667000 | 0.0466 | 0.0140 | | | 534000 | Spinage 1972, Sinclair 1977, Mertens 1985, Silva & Downing 1995 |
| Greater kudu | *Tragelaphus strepsiceros* | 5 | 0 | 0.0566 | 0.0360 | 0.280 | 0.299 | 228000 | 0.0361 | 0.0360 | 0.377 | 0.176 | 157000 | Owen-Smith 1990; Silva & Downing 1995 |

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**Table A2**: Analysis of the influence of environment (captive versus wild), diet (percentage of grass in the diet), body mass (log-transformed), data quality (longitudinal versus cross-sectional) and sex (male versus female) on aging rate (*n* = 22 species). We compared models based on AIC and $w_i$ (see material and methods section). ΔAIC is the difference of corrected Akaike's criteria between the candidate model and the best model (in bold).

| Independent variables | Deviance | AIC | Δ AIC | Wi |
|---|---|---|---|---|
| species | 259.6 | 265.1 | 49.0 | 0.00 |
| species + environment | 214.1 | 222.1 | 6.0 | 0.04 |
| species + body mass | 258.8 | 266.8 | 50.7 | 0.00 |
| species + sex | 259.2 | 267.2 | 51.1 | 0.00 |
| species + diet | 259.4 | 267.4 | 51.3 | 0.00 |
| species + quality | 259.4 | 267.4 | 51.3 | 0.00 |
| species + environment * body mass | 212.4 | 224.4 | 8.3 | 0.01 |
| species + environment + body mass | 212.8 | 222.8 | 6.7 | 0.03 |
| species + environment * sex | 209.5 | 221.5 | 5.4 | 0.05 |
| species + environment + sex | 213.5 | 223.5 | 7.4 | 0.02 |
| **species + environment * diet** | **204.1** | **216.1** | **0.0** | **0.81** |
| species + environment + diet | 213.8 | 223.8 | 7.7 | 0.02 |
| species + environment * quality | 213.8 | 225.8 | 9.7 | 0.01 |
| species + environment + quality | 213.9 | 223.9 | 7.8 | 0.02 |
| species + body mass * sex | 257.5 | 269.5 | 53.4 | 0.00 |
| species + body mass + sex | 258.6 | 268.6 | 52.5 | 0.00 |
| species + body mass * diet | 258.4 | 270.4 | 54.3 | 0.00 |
| species + body mass + diet | 258.5 | 268.5 | 52.4 | 0.00 |
| species + body mass * quality | 258.7 | 270.7 | 54.6 | 0.00 |
| species + body mass + quality | 258.8 | 268.8 | 52.7 | 0.00 |
| species + sex * diet | 257.4 | 269.4 | 53.3 | 0.00 |
| species + sex + diet | 259.1 | 269.1 | 53.0 | 0.00 |
| species + sex * quality | 257.3 | 269.3 | 53.2 | 0.00 |
| species + sex + quality | 259.1 | 269.1 | 53.0 | 0.00 |
| species + diet * quality | 258.6 | 270.6 | 54.5 | 0.00 |
| species + diet + quality | 259.1 | 269.1 | 53.0 | 0.00 |

**Table A3**: Analysis of the influence of diet (percentage of grass in the diet), body mass (log-transformed) and data quality (longitudinal versus cross-sectional) on the difference in aging rate between wild and captive populations for females only (*n* = 22 species). We compared models based on AIC and $w_i$ (see methodology section). K represents the number of parameters in the model and λ the index of phylogenetic inertia. ΔAIC is the difference of corrected Akaike's criteria between the candidate model and the best model (in bold).

| Independent variables | k | λ | Deviance | AIC | Δ AIC | $w_i$ |
|---|---|---|---|---|---|---|
| Null | 3 | < 0.001 | 56.7 | 58.73 | 0.81 | 0.24 |
| Body Mass | 4 | < 0.002 | 55.98 | 61.08 | 3.16 | 0.07 |
| **Diet** | **4** | **< 0.003** | **52.82** | **57.92** | **0** | **0.35** |
| Quality | 4 | < 0.004 | 56.7 | 61.8 | 3.88 | 0.05 |
| Body Mass * Diet | 6 | < 0.005 | 51.74 | 63.16 | 5.24 | 0.03 |
| Body Mass + Diet | 5 | < 0.006 | 52.62 | 60.84 | 2.92 | 0.08 |
| Body mass * Quality | 6 | < 0.007 | 55.86 | 67.27 | 9.35 | 0.00 |
| Body mass + Quality | 5 | < 0.008 | 55.98 | 64.21 | 6.29 | 0.02 |
| Diet * Quality | 6 | < 0.009 | 50.48 | 61.9 | 3.98 | 0.05 |
| Diet + Quality | 5 | < 0.010 | 52.06 | 60.28 | 2.36 | 0.11 |

**Table A4**: Analysis of the influence of diet (percentage of grass in the diet), body mass (log-transformed) and data quality (longitudinal versus cross-sectional) on the difference in aging rate between wild and captive populations for males only (*n* = 22 species). We compared models based on AIC and $w_i$ (see methodology section). K represents the number of parameters in the model and λ the index of phylogenetic inertia. ΔAIC is the difference of corrected Akaike's criteria between the candidate model and the best model (in bold).

| Independent variables | k | λ | Deviance | AIC | Δ AIC | $w_i$ |
|---|---|---|---|---|---|---|
| Null | 3 | 0.08 | 78.02 | 80.05 | 6.31 | 0.02 |
| Body Mass | 4 | 0.10 | 75.3 | 80.39 | 6.65 | 0.02 |
| Diet | 4 | < 0.001 | 71.98 | 77.09 | 3.35 | 0.08 |
| Quality | 4 | 0.08 | 77.98 | 83.09 | 9.35 | 0.00 |
| Body Mass * Diet | 6 | < 0.001 | 62.48 | 73.89 | 0.15 | 0.40 |
| **Body Mass + Diet** | **5** | **0.08** | **65.54** | **73.77** | **0.00** | **0.43** |
| Body mass * Quality | 6 | < 0.001 | 74.82 | 86.23 | 12.49 | 0.00 |
| Body mass + Quality | 5 | < 0.001 | 71.18 | 79.42 | 5.68 | 0.03 |
| Diet * Quality | 6 | < 0.001 | 71.14 | 82.55 | 8.81 | 0.01 |
| Diet + Quality | 5 | < 0.001 | 71.20 | 79.42 | 5.68 | 0.03 |

**Table A5**: Analysis of the influence of environment (captive versus wild), diet (percentage of grass in the diet), body mass (log-transformed), data quality (longitudinal versus cross-sectional) and sex (male versus female) on aging rate (*n* = 21 species). Compared to Table S2, we excluded male *Ovis aries* from these models due to their particularly high aging rate. We compared models based on AIC and $w_i$ (see methodology section). ΔAIC is the difference of corrected Akaike's criteria between the candidate model and the best model (in bold).

| Independent variables | Deviance | AIC | Δ AIC | Wi |
|---|---|---|---|---|
| species | 243.6 | 249.6 | 46.9 | 0.00 |
| species + environment | 200 | 208 | 5.3 | 0.05 |
| species + body mass | 242.7 | 250.7 | 48 | 0.00 |
| species + sex | 243.2 | 251.2 | 48.5 | 0.00 |
| species + diet | 243.4 | 251.4 | 48.7 | 0.00 |
| species + quality | 243.4 | 251.4 | 48.7 | 0.00 |
| species + environment * body mass | 198.6 | 210.6 | 7.9 | 0.01 |
| species + environment + body mass | 198.6 | 208.6 | 5.9 | 0.04 |
| species + environment * sex | 196.9 | 208.9 | 6.2 | 0.03 |
| species + environment + sex | 199.4 | 209.4 | 6.7 | 0.03 |
| **species + environment * diet** | **190.7** | **202.7** | **0** | **0.77** |
| species + environment + diet | 199.8 | 209.8 | 7.1 | 0.02 |
| species + environment * quality | 199.2 | 211.2 | 8.5 | 0.01 |
| species + environment + quality | 199.8 | 209.8 | 7.1 | 0.02 |
| species + body mass * sex | 241.2 | 253.2 | 50.5 | 0.00 |
| species + body mass + sex | 242.5 | 252.5 | 49.8 | 0.00 |
| species + body mass * diet | 242.3 | 254.3 | 51.6 | 0.00 |
| species + body mass + diet | 242.3 | 252.3 | 49.6 | 0.00 |
| species + body mass * quality | 242.6 | 254.6 | 51.9 | 0.00 |
| species + body mass + quality | 242.6 | 252.6 | 49.9 | 0.00 |
| species + sex * diet | 241.1 | 253.1 | 50.4 | 0.00 |
| species + sex + diet | 243 | 253 | 50.3 | 0.00 |
| species + sex * quality | 240.9 | 252.9 | 50.2 | 0.00 |
| species + sex + quality | 243 | 253 | 50.3 | 0.00 |
| species + diet * quality | 242.4 | 254.4 | 51.7 | 0.00 |
| species + diet + quality | 243.1 | 253.1 | 50.4 | 0.00 |

**Table A6**: Analysis of the influence of environment (captive versus wild), diet (percentage of grass in the diet), body mass (log-transformed), and sex (male versus female) on aging rate estimated from Gompertz model (*n* = 7 species). We compared models based on AIC and $w_i$ (see methodology section). ΔAIC is the difference of corrected Akaike's criteria between the candidate model and the best model (in bold).

| Independent variables | Deviance | AIC | Δ AIC | $w_i$ |
|---|---|---|---|---|
| species | 103.7 | 109.7 | 17.3 | 0.00 |
| species + environment | 90.41 | 98.41 | 6.0 | 0.05 |
| species + body mass | 103.3 | 111.3 | 18.9 | 0.00 |
| species + sex | 100.8 | 108.8 | 16.4 | 0.00 |
| species + diet | 103.3 | 111.3 | 18.9 | 0.00 |
| species + environment * body mass | 89.68 | 101.7 | 9.3 | 0.01 |
| **species + environment * sex** | **80.37** | **92.37** | **0.0** | **0.93** |
| species + environment * diet | 88.03 | 100 | 7.6 | 0.02 |
| species + body mass * sex | 100.7 | 112.7 | 20.3 | 0.00 |
| species + body mass * diet | 101.6 | 113.6 | 21.2 | 0.00 |
| species + sex * diet | 100.3 | 112.3 | 19.9 | 0.00 |

**Table A7**: Analysis of the influence of diet (percentage of grass in the diet) and body mass (log-transformed) on the difference in aging rate estimated from Gompertz model between wild and captive populations for males only (*n* = 7 species). We compared models based on AIC and $w_i$ (see methodology section). K represents the number of parameters in the model and λ the index of phylogenetic inertia. ΔAIC is the difference of corrected Akaike's criteria between the candidate model and the best model (in bold).

| Independent variables | k | λ | Deviance | AIC | Δ AIC | Wi |
|---|---|---|---|---|---|---|
| **Null** | **3.00** | **<0.001** | **21.22** | **24.10** | **0.00** | **0.74** |
| Body Mass | 4.00 | <0.001 | 18.32 | 26.68 | 2.58 | 0.20 |
| Diet | 4.00 | <0.001 | 21.20 | 29.56 | 5.46 | 0.05 |
| Body Mass * Diet | 6.00 | <0.001 | 15.84 | 48.78 | 24.68 | 0.00 |
| Body Mass + Diet | 5.00 | <0.001 | 18.24 | 35.17 | 11.07 | 0.00 |

**Table A8**: Analysis of the influence of diet (percentage of grass in the diet) and body mass (log-transformed) on the difference in aging rate estimated from Gompertz model between wild and captive populations for females only (*n* = 7 species). We compared models based on AIC and $w_i$ (see methodology section). K represents the number of parameters in the model and λ the index of phylogenetic inertia. ΔAIC is the difference of corrected Akaike's criteria between the candidate model and the best model (in bold).

| Independent variables | k | λ | Deviance | AIC | Δ AIC | Wi |
|---|---|---|---|---|---|---|
| **Null** | **3** | **<0.001** | **5.38** | **8.26** | **0.00** | **0.83** |
| Body Mass | 4 | <0.001 | 3.79 | 12.15 | 3.89 | 0.12 |
| Diet | 4 | <0.001 | 5.38 | 13.74 | 5.48 | 0.05 |
| Body Mass * Diet | 6 | <0.001 | 3.60 | 36.53 | 28.27 | 0.00 |
| Body Mass + Diet | 5 | <0.001 | 3.76 | 20.68 | 12.42 | 0.00 |