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Supplementary Material

Supplementary material for:

R. W. Taylor, M. M. Humphries, S. Boutin, J. C. Gorrell, D. W. Coltman, and A. G. McAdam. Selection on female behaviour fluctuates with offspring environment. *Journal of Evolutionary Biology*, 2014.

Data and code used in the analyses are available on github

<https://github.com/rwtaylor/2014-female-selection>

and archived on Zenodo

<http://dx.doi.org/10.5281/zenodo.10908>

Table S1

Behavior	Overall Repeatability	Repeatability Within Years	Repeatability Across Years
Aggression	0.39 (0.24 – 0.46)	0.23 (0.16 – 0.42)	0.50 (0.37 – 0.58)
Activity	0.48 (0.35 – 0.52)	0.33 (0.19 – 0.45)	0.54 (0.43 – 0.62)
Dociity	0.38 (0.33 – 0.40)	0.32 (0.24 – 0.37)	0.40 (0.36 – 0.42)

Table S1: Repeatability within and across years. Repeatabilities were estimated using linear mixed effects models with individual as a random effect. Repeatability across years was estimated after randomly sampling, for each individual, only one behavioural measure per year.

Table S2

Study Area	Year	N juveniles	N survive	Competition
KL	2003	79	10	7.90
KL	2004	64	21	3.05
KL	2005	140	42	3.33
KL	2006	102	16	6.38
KL	2007	103	24	4.29
KL	2008	107	12	8.92
KL	2009	84	17	4.94
KL	2010	138	34	4.06
SU	2003	70	15	4.67
SU	2004	65	16	4.06
SU	2005	109	35	3.11
SU	2006	90	7	11.62
SU	2007	87	21	4.14
SU	2008	67	1	67.00
SU	2009	39	5	7.80
SU	2010	90	29	3.10

Table S2: Variation in competition across years and study areas. N juveniles is the number of juveniles produced in the study area. N survive is the number of juveniles that recruited into the population by surviving overwinter to the next spring. Competition is the ratio of juveniles produced to juveniles recruited.

Table S3

	Chisq	Df	Pr..Chisq.
Year	38.1	7	< 0.0001
Grid	1.07	1	0.3
Activity	0.34	1	0.56
Aggression	0.34	1	0.56
Docility	0.98	1	0.32
Year x Activity	22.92	7	< 0.005
Year x Aggression	22.84	7	< 0.005
Year x Docility	10.33	7	0.17

Chisq	Df	Pr..Chisq.
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Table S3: Generalized linear mixed model results showing the interactions between year and the behavioural traits (BLUPs). Significance was calculated with Wald tests from an analysis of deviance. GLMMs were fitted with squirrel identity as a random effect and assumed a Poisson error distribution.

Table S4

Year	N	Aggression	Acitivity	Docility
2003	18	0.03 (-0.92 to 0.84)	0.45 (-0.17 to 1.32)	-0.08 (-0.26 to 0.06)
2004	26	-0.30 (-0.76 to 0.14)	0.03 (-0.32 to 0.67)	0.05 (-0.06 to 0.11)
2005	50	-0.18 (-0.45 to 0.10)	0.13 (-0.16 to 0.40)	0.03 (-0.02 to 0.07)
2006	48	0.39 (-0.04 to 0.79)	0.08 (-0.39 to 0.45)	-0.04 (-0.12 to 0.00)
2007	40	0.00 (-0.35 to 0.36)	0.11 (-0.22 to 0.42)	0.00 (-0.05 to 0.05)
2008	45	0.44 (-0.12 to 0.95)	-0.26 (-0.75 to 0.40)	-0.02 (-0.08 to 0.05)
2009	35	0.12 (-0.33 to 0.58)	-0.58 (-0.93 to -0.02)*	-0.06 (-0.11 to -0.01)*
2010	34	0.06 (-0.30 to 0.35)	0.03 (-0.26 to 0.30)	-0.05 (-0.08 to -0.02)*

Table S4: Non-standardized linear selection gradients () for female behavioural traits through annual reproductive success after accounting for behavioural measurement uncertainty (see methods for details). Posterior modes are given with the lower and upper bounds of the 0.95 highest posterior density interval. ## Table S5

Year	N	Aggression	Acitivity	Docility
2003	18	0.03 (-0.76 to 0.71)	0.79 (-0.24 to 1.38)	-0.38 (-1.12 to 0.31)
2004	26	-0.24 (-0.81 to 0.08)	0.02 (-0.36 to 0.62)	0.21 (-0.26 to 0.52)
2005	50	-0.19 (-0.47 to 0.07)	0.16 (-0.12 to 0.41)	0.10 (-0.09 to 0.34)
2006	48	0.39 (-0.04 to 0.72)	0.08 (-0.37 to 0.44)	-0.25 (-0.58 to -0.03)*
2007	40	-0.01 (-0.32 to 0.34)	0.09 (-0.23 to 0.42)	0.01 (-0.23 to 0.23)
2008	45	0.46 (-0.06 to 0.95)	-0.18 (-0.72 to 0.40)	-0.08 (-0.37 to 0.25)
2009	35	0.16 (-0.29 to 0.59)	-0.55 (-0.92 to 0.01)	-0.30 (-0.53 to -0.05)*
2010	34	-0.04 (-0.27 to 0.32)	0.04 (-0.25 to 0.30)	-0.23 (-0.35 to -0.10)*

Year	N	Aggression	Acitivity	Docility
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Table S5: SD-standardized linear selection gradients () for female behavioural traits through annual reproductive success after accounting for behavioural measurement uncertainty (see methods for details). Posterior modes are given with the lower and upper bounds of the 0.95 highest posterior density interval.

Table S6

Year	N	Mean_docility	Mean_stan_B
2003	18	17.29	-1.46
2004	26	17.31	0.95
2005	50	17.25	0.55
2006	48	16.77	-0.70
2007	40	16.77	0.05
2008	45	16.9	-0.27
2009	35	16.79	-0.97
2010	34	17.19	-0.87

Table S6: Mean-standardized linear selection gradients () for female docility through annual reproductive success after accounting for behavioural measurement uncertainty (see methods for details). Posterior modes are given with the lower and upper bounds of the 0.95 highest posterior density interval. Activity and aggression are synthetic behavioural measures, with means of zero and so can not be mean standardized.

Table S7

Year	Aggression	Activity	Docility
2003	-0.26 (-1.66 to 0.61)	0.90 (-0.25 to 1.76)	-0.11 (-0.36 to 0.10)
2004	-0.75 (-1.36 to -0.05)*	0.57 (-0.18 to 1.35)	0.07 (-0.13 to 0.24)
2005	-0.56 (-1.02 to -0.06)*	0.46 (-0.08 to 0.98)	0.05 (-0.04 to 0.16)
2006	0.98 (0.20 to 1.86)*	-0.33 (-1.11 to 0.48)	-0.10 (-0.22 to 0.04)
2007	-0.09 (-0.92 to 0.49)	0.19 (-0.53 to 0.88)	0.01 (-0.11 to 0.13)
2008	1.11 (-0.36 to 2.30)	-0.60 (-1.46 to 0.94)	-0.04 (-0.21 to 0.13)
2009	0.75 (-0.09 to 1.39)	-1.38 (-2.11 to -0.60)*	-0.12 (-0.23 to 0.00)*
2010	-0.03 (-0.74 to 0.67)	0.12 (-0.54 to 0.77)	-0.05 (-0.12 to 0.04)

Year	Aggression	Activity	Docility
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Table S7: Non-standardized linear selection gradients () \pm standard errors for female behavioural traits through annual reproductive success. Selection gradients were estimated from single realized BLUPs of behavioural traits. Significance was assessed using the `sim()` function in the R package `arm`.

Table S8

Year	Docility	mean
2003	-1.86	17.29
2004	1.25	17.31
2005	0.88	17.25
2006	-1.72	16.77
2007	0.12	16.77
2008	-0.63	16.9
2009	-2.04	16.79
2010	-0.79	17.19

Table S8: Mean-standardized linear selection gradients () \pm standard errors for female docility. Selection gradients were estimated from single realized BLUPs of behavioural traits. Significance was assessed using the `sim()` function in the R package `arm`. Activity and aggression are synthetic behavioural measures, with means of zero and so can not be mean standardized.

Table S9

	ARS	OWS	Fecundity
Intercept	-0.76 (-1.18, -0.42)*	-1.84 (-2.35, -1.42)*	1.34 (1.28, 1.41)*
Competition	-2.58 (-3.98, -1.72)*	-2.41 (-4.21, -1.27)*	-0.06 (-0.19, 0.09)
Aggression	0.45 (0.08, 0.82)*	0.59 (0.17, 1.13)*	-0.04 (-0.09, 0.02)
Activity	-0.17 (-0.53, 0.17)	-0.06 (-0.68, 0.24)	0.03 (-0.05, 0.06)
Docility	-0.29 (-0.55, -0.13)*	-0.29 (-0.54, -0.03)*	0.04 (0.00, 0.07)*
Aggression^2	-0.12 (-0.51, 0.15)	-0.28 (-0.70, 0.16)	0.02 (-0.05, 0.05)
Activity^2	0.00 (-0.36, 0.23)	-0.07 (-0.42, 0.31)	-0.02 (-0.07, 0.02)
Docility^2	-0.15 (-0.33, 0.04)	-0.20 (-0.41, 0.05)	0.01 (-0.03, 0.04)
Aggression x Competition	1.71 (0.48, 2.66)*	2.16 (0.55, 3.53)*	-0.03 (-0.16, 0.09)

	ARS	OWS	Fecundity
Activity x Competition	-0.72 (-1.77, 0.35)	-0.24 (-1.70, 1.10)	-0.03 (-0.15, 0.08)
Docility x Competition	-0.70 (-1.55, -0.26)*	-0.45 (-1.13, 0.49)	-0.04 (-0.14, 0.02)
Aggression x Activity	0.14 (-0.22, 0.67)	0.21 (-0.29, 0.84)	0.02 (-0.06, 0.08)
Aggression^2 x Competition	-0.27 (-1.36, 0.56)	-0.35 (-1.98, 0.70)	0.03 (-0.11, 0.14)
Activity^2 x Competition	-0.06 (-1.07, 0.68)	-0.11 (-1.32, 1.00)	0.00 (-0.11, 0.11)
Docility^2 x Competition	-0.51 (-1.05, 0.15)	-0.34 (-1.29, 0.19)	-0.02 (-0.11, 0.05)
Agg. x Act. x Competition	0.44 (-0.75, 1.92)	0.52 (-1.08, 2.57)	0.01 (-0.20, 0.16)

Table S9: Selection on female aggression and docility, through annual reproductive success, interacted significantly with juvenile offspring competition for vacant territories after accounting for behavioural measurement uncertainty. The generalized linear mixed model for annual reproductive success assumed a Poisson error distribution, while the model for offspring overwinter survival assumed a binomial error distribution weighted by fecundity. Random effects for identity and grid-year were included in both models to account for pseudoreplication. Presented are posterior modes of the distribution of coefficients from 1000 models of 1000 sets of individual random effects of each behavioural trait generated with MCMCglmm.

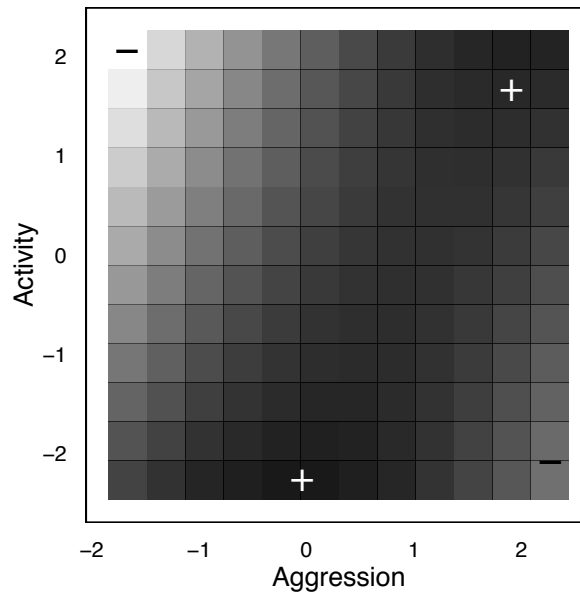
Table S10

	Est \pm se	Z	P
Intercept	1.362 \pm 0.091	14.937	< 0.001
Competition	-0.017 \pm 0.161	-0.106	0.92
Aggression	-0.058 \pm 0.049	-1.176	0.24
Activity	0.030 \pm 0.050	0.594	0.55
Docility	0.030 \pm 0.041	0.724	0.47
Aggression^2	0.036 \pm 0.053	0.672	0.50
Activity^2	-0.064 \pm 0.051	-1.248	0.21
Docility^2	0.005 \pm 0.026	0.209	0.83
Aggression x Competition	-0.067 \pm 0.117	-0.579	0.56
Activity x Competition	0.008 \pm 0.088	0.086	0.93
Docility x Competition	-0.116 \pm 0.087	-1.325	0.19
Aggression x Activity	0.024 \pm 0.075	0.319	0.75
Aggression^2 x Competition	0.153 \pm 0.149	1.029	0.30
Activity^2 x Competition	0.079 \pm 0.145	0.545	0.59

	Est \pm se	Z	P
Docility² x Competition	-0.067 \pm 0.055	-1.218	0.22
Agg. x Act. x Competition	-0.252 \pm 0.240	-1.051	0.29

Table S10: There was no evidence for selection on female behaviour through fecundity. Results from a generalized linear mixed model of fecundity with individual and grid-year as random effects. The model was fitted with a Poisson error distribution. This model ignores uncertainty around the BLUPs used for each individual's behavioural measure.

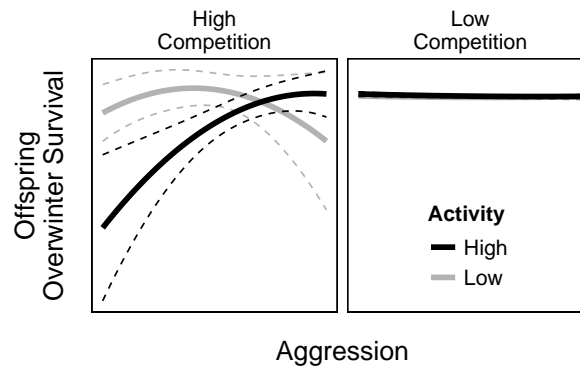
Figure S1



High activity females (black lines) were favoured when they were also aggressive in high competition environments (left panel). But, for low activity females, there was stabilizing selection for low to moderate levels of aggression through offspring overwinter survival ($b = -3.11 \pm 1.36$, $Z = -2.29$, $P = 0.02$). This positive correlational selection was not present in low competition environments (right panel). The interaction between aggression, activity and competition was significant for offspring overwinter survival ($b = 3.95 \pm 1.86$, $Z = 2.13$, $P = 0.03$). Predicted values from the model for offspring overwinter survival (Table 3) were plotted for the highest and lowest values of competition we measured. Dashed lines represent 95% confidence intervals around the predicted values.

Figure S2

The predicted relative fitness surface, as a function of female aggression and activity, was saddle shaped when competition among juveniles for vacant territories was high. Darker squares correspond to higher fitness. Fitness peaks (+) occurred for females with high aggression and activity, and for females with low-moderate



aggression and low activity. Predicted values from a linear model of relative fitness with the same predictors as the models in Table 3, were plotted for the highest levels of competition measured and mean docility.