Supporting Information for
Maternal effects do not resolve the paradox of stasis in birth weight in a wild mammal

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**1: Model of lifetime breeding success**

One of the most challenging aspects in modelling fitness, and particularly lifetime breeding success, is that it typically follows a non-Gaussian distribution. Some authors have therefore suggested that fitness should be analysed using more complex “generalised” linear models (de Villemereuil 2018, Bonnet et al. 2019). However, these models also rely on assumptions (e.g., strict mean-variance scaling relationship implied by the Poisson distribution), and violation of these distributional assumptions have unclear consequences for parameter estimates. On the contrary, we know that Gaussian models are robust to violations of distributional assumptions (Schielzeth et al. 2020), suggesting they may be more reliable to use than generalised linear models. As a result, we decided to analyse (relative) lifetime breeding success as a Gaussian response in models (b) and (d).

We also fitted a model for relative lifetime breeding success with sex-specific birth weight effects. However, birth weight affected the lifetime breeding success of females and males similarly (female slope : 0.22 [0.11; 0.36]; male slope: 0.25 [0.14; 0.37]). Therefore, for the sake of simplicity, we use in the main text a model including both sexes to estimate the linear selection gradient on birth weight (model (b)).

Finally, to predict the response to selection, we used the outputs of the models using relative lifetime breeding success, rather than annualised fitness components, as these provided a more straightforward estimate of the selection gradient (β).
2: Genetic and environmental covariance between birth weight, maternal performance, and fitness

A major assumption when measuring phenotypic selection is that the association between traits and fitness is causal. In particular, any environmental covariate that affects both a focal trait and fitness can lead to erroneously predict some evolutionary change in response to selection but cannot contribute to evolutionary change. Here, we investigated how such environmental covariance might explain the discrepancy between the observed and predicted response to selection presented in the main text. For this, we decomposed the phenotypic associations measured by models (a) to (d) into genetic and environmental components using bivariate models and relatedness information derived from the population pedigree.

First, we used a bivariate model between offspring birth weight and its juvenile survival to estimate the genetic and residual covariance between these two traits (thereby extending model (a)). We found positive covariances at both the genetic (cov_G(BW, JuvSurv) = 0.115 [0.02; 0.245]) and residual level (cov_R(BW, JuvSurv) = 0.20 [0.10; 0.28]). We did the same using a bivariate model with birth weight and lifetime breeding success as response variables (extending model (b)). We found a small positive genetic covariance between these two traits (cov_G(BW, LBS) = 0.044 [-0.10; 0.24]), with credible intervals widely overlapping zero. This result was consistent with the (absence of) observed change in breeding values for birth weight (Fig. 2). Indeed, according to the second theorem of selection, the evolutionary change should be equal to the genetic covariance of a trait with fitness (Robertson-Price identity; Robertson 1966 Anim. Prod. 8: 95:108, Price 1970 Evolution 45:853-861). These models included both sexes and accounted for the effect of sex as a fixed effect.

We then ran similar bivariate models to decompose the genetic and environmental associations between maternal performance for birth weight and a female’s fitness. We relied on the same variance partitioning approach as presented in the main text to define maternal effects for birth weight and we split maternal effects into genetic and environmental components. First, we used the mothers’ annual breeding success as a proxy of fitness and we modelled maternal genetic and maternal environmental effects for birth weight (extending model (c)). We found a positive genetic covariance between maternal effects for birth weight and mothers’ breeding success (cov_G(MatEff, ABS) = 0.045 [-0.047; 0.15]) and a small positive covariation at the maternal environmental level (cov_E(MatEff, ABS) = 0.0003 [-0.027; 0.08]), indicating that the phenotypic association between these two traits is mostly driven by genetic effects. This result makes sense because almost all the maternal effect variance captured by our variance partitioning approach is due to genetic effects (Gauzere et al. 2020 10.1111/evo.14000). Second, we used lifetime breeding success as a proxy of fitness. We used a model structure very similar to model (d) but this time we defined covariance terms at the maternal genetic and environmental levels. This model showed poor convergence, with the MCMC chains not mixing well, suggesting that we lacked sufficient information in our data to properly fit such a complex model structure. The fact that the maternal environmental variance is almost null might also explain the poor fit of this model. This poorly fitted model nonetheless suggested a small positive genetic covariance between maternal effects for birth weight and mothers’ LBS (cov_G(BW_Mat, LBS) = 0.25 [-0.17; 0.65]).

Overall, these results suggest that the phenotypic association between traits, maternal effects and fitness are not solely driven by environmental effects, which means that an evolutionary response to selection should be expected (but is not observed).
3: Linear mixed model results for each predictor tested in the model of birth weight, and models (a)-(d)

Table S1: Linear mixed model results for each predictor tested in the model of genetic change for birth weight. 'Region' defines the birth location (following Stopher et al. 2012, Gauzere et al. 2020) and is relative to the value for 'IA' (Intermediate Area). 'Repro' refers to the reproductive status of the female the year before and is relative to the value for 'WinterYeld'.

| Predictor     | post.mean | l-95% CI | u-95% CI | pMCMC  |
|---------------|-----------|----------|----------|--------|
| Intercept     | 6.095     | -17.670  | 26.360   | 0.5675 |
| Calf sex [male] | 0.315     | 0.242    | 0.382    | <0.001 *** |
| AgeHrs        | 0.016     | 0.015    | 0.017    | <0.001 *** |
| PopDens       | -0.004    | -0.008   | -0.001   | 0.0187 *  |
| Maternal age  | 0.458     | 0.391    | 0.535    | <0.001 *** |
| Maternal age^2 | -0.025    | -0.028   | -0.021   | <0.001 *** |
| Repro [Milk]  | 0.209     | 0.085    | 0.353    | 0.0085 ** |
| Repro [Naïve] | 0.229     | 0.073    | 0.408    | 0.0051 ** |
| Repro [SummerYeld] | 0.698    | 0.546    | 0.850    | <0.001 *** |
| Repro [TrueYeld] | 0.637    | 0.503    | 0.774    | <0.001 *** |
| Repro [Milk]  | 0.231     | -0.052   | 0.553    | 0.1376 |
| Region [MG]   | 0.703     | 0.475    | 0.968    | <0.001 *** |
| Region [NG]   | 0.280     | 0.068    | 0.505    | 0.0153 *  |
| Region [SG]   | 0.971     | 0.697    | 1.271    | <0.001 *** |
| Region [SI]   | 0.119     | -0.123   | 0.328    | 0.311  |
| Year          | -0.001    | -0.011   | 0.011    | 0.8751 |
Table S2: Linear mixed model results for each predictor tested in model (a) to (d).

**Model (a) of juvenile survival**

| Predictor               | post.mean | l-95% CI | u-95% CI | pMCMC  |
|-------------------------|-----------|----------|----------|--------|
| Intercept               | 1.080     | -0.253   | 2.617    | 0.142  |
| Calf sex [male]         | -0.366    | -0.479   | -0.244   | 0.001 *** |
| Birth weight            | 0.266     | 0.211    | 0.316    | 0.001 *** |
| Maternal age            | 0.125     | 0.002    | 0.259    | 0.054  . |
| Maternal age^2          | -0.008    | -0.014   | -0.001   | 0.01 *  |
| Region [LA]             | 0.732     | 0.484    | 0.951    | 0.001 *** |
| Region [MG]             | 0.885     | 0.677    | 1.078    | 0.001 *** |
| Region [NG]             | 0.207     | 0.028    | 0.377    | 0.032  * |
| Region [SG]             | 0.896     | 0.654    | 1.112    | 0.001 *** |
| Region [SI]             | 0.158     | -0.024   | 0.346    | 0.092  . |
| Birth date              | -0.018    | -0.023   | -0.012   | 0.001 *** |
| Repro [Milk]            | 0.331     | 0.099    | 0.541    | 0.004 ** |
| Repro [Naïve]           | 0.256     | -0.040   | 0.529    | 0.076  . |
| Repro [SummerYeld]      | 0.073     | -0.180   | 0.332    | 0.554  . |
| Repro [TrueYeld]        | 0.225     | 0.022    | 0.455    | 0.038  . |
| PopDens                 | -0.004    | -0.008   | 0.001    | 0.104  . |

**Model (b) of male annual breeding success**

| Predictor               | post.mean | l-95% CI | u-95% CI | pMCMC  |
|-------------------------|-----------|----------|----------|--------|
| Intercept               | -12.095   | -13.946  | -10.307  | <0.001 *** |
| Age                     | 1.969     | 1.702    | 2.202    | <0.001 *** |
| Age^2                   | -0.096    | -0.110   | -0.083   | <0.001 *** |
| Birth weight            | 0.195     | 0.062    | 0.325    | 0.002 ** |
| PopDens                 | 0.002     | -0.003   | 0.008    | 0.392  . |

**Model (b) of female annual breeding success**

| Predictor               | post.mean | l-95% CI | u-95% CI | pMCMC  |
|-------------------------|-----------|----------|----------|--------|
| Intercept               | -0.790    | -1.474   | -0.093   | 0.028  * |
| Age                     | 0.436     | 0.389    | 0.486    | <0.001 *** |
| Age^2                   | -0.022    | -0.025   | -0.019   | <0.001 *** |
| Birth weight            | 0.017     | -0.021   | 0.056    | 0.384  . |
| Region [LA]             | 0.110     | -0.063   | 0.302    | 0.242  . |
| Region [MG]             | -0.034    | -0.206   | 0.117    | 0.678  . |
| Region [NG]             | -0.215    | -0.347   | -0.045   | 0.002 ** |
| Region [SG]             | 0.100     | -0.061   | 0.251    | 0.216  . |
| Region [SI]             | -0.171    | -0.327   | -0.015   | 0.038  * |
| PopDens                 | -0.003    | -0.006   | -0.001   | 0.028  * |

**Model (b) of relative lifetime breeding success** (both sexes together)

| Predictor               | post.mean | l-95% CI | u-95% CI | pMCMC  |
|-------------------------|-----------|----------|----------|--------|
| Intercept               | 0.072     | -0.518   | 0.635    | 0.794  |
| Calf sex [male]         | -1.086    | -1.275   | -0.879   | <0.001 *** |
| Birth weight            | 0.237     | 0.148    | 0.322    | <0.001 *** |
### Bivariate model (c) of birth weight and female annual breeding success

|                  | post.mean | l-95% CI | u-95% CI | pMCMC      |
|------------------|-----------|----------|----------|------------|
| CaptWt:Intercept | 4.560     | 3.728    | 5.273    | <0.001 *** |
| FecA:Intercept   | 0.153     | -0.826   | 1.173    | 0.802      |
| CaptWt:Calf sex [male] | -0.329 | -0.400   | -0.258   | <0.001 *** |
| CaptWt:AgeHrs    | 0.016     | 0.015    | 0.017    | <0.001 *** |
| CaptWt:Maternal age | 0.450 | 0.381    | 0.526    | <0.001 *** |
| CaptWt:Maternal age^2 | -0.024 | -0.028   | -0.021   | <0.001 *** |
| CaptWt:Repro [Naïve] | 0.037 | -0.116   | 0.199    | 0.6406     |
| CaptWt:Repro [SummerYeld] | 0.512 | 0.381    | 0.632    | <0.001 *** |
| CaptWt:Repro [TrueYeld] | 0.449 | 0.336    | 0.554    | <0.001 *** |
| CaptWt:Repro [Winter Yeld] | -0.193 | -0.333   | -0.056   | 0.0102 *   |
| CaptWt:Region [LA] | 0.144     | -0.135   | 0.407    | 0.2889     |
| CaptWt:Region [MG] | 0.629     | 0.415    | 0.871    | <0.001 *** |
| CaptWt:Region [NG] | 0.137     | -0.057   | 0.362    | 0.2022     |
| CaptWt:Region [SG] | 0.857     | 0.618    | 1.099    | <0.001 *** |
| CaptWt:Region [SI] | 0.044     | -0.156   | 0.269    | 0.6746     |
| CaptWt:PopDens   | -0.002    | -0.005   | 0.001    | 0.2379     |
| FecA:Maternal age | 0.323     | 0.230    | 0.426    | <0.001 *** |
| FecA:Maternal age^2 | -0.019 | -0.024   | -0.013   | <0.001 *** |
| FecA:Region [LA] | 0.088     | -0.254   | 0.414    | 0.627      |
| FecA:Region [MG] | -0.508    | -0.796   | -0.218   | <0.001 *** |
| FecA:Region [NG] | -0.441    | -0.700   | -0.194   | 0.0017 **  |
| FecA:Region [SG] | -0.241    | -0.544   | 0.026    | 0.0901 .   |
| FecA:Region [SI] | -0.181    | -0.447   | 0.065    | 0.175      |
| FecA:PopDens     | -0.005    | -0.009   | 0.000    | 0.0476 *   |
Bivariate model (c) of birth weight and female annual survival

|                          | post.mean | l-95% CI | u-95% CI | pMCMC   |
|--------------------------|-----------|----------|----------|---------|
| CaptWt:Intercept         | 4.584     | 3.801    | 5.353    | <0.001  *** |
| SurvA:Intercept          | 5.601     | 1.348    | 10.761   | <0.001  *** |
| CaptWt:CaptWt:Male sex   | -0.327    | -0.398   | -0.256   | <0.001  *** |
| CaptWt:CaptWt:AgeHrs    | 0.016     | 0.015    | 0.017    | <0.001  *** |
| CaptWt:CaptWt:Maternal age | 0.448   | 0.377    | 0.524    | <0.001  *** |
| CaptWt:CaptWt:Maternal age^2 | -0.024 | -0.028   | -0.021   | <0.001  *** |
| CaptWt:CaptWt:Repro [Naïve] | 0.015 | -0.151   | 0.166    | 0.855    |
| CaptWt:CaptWt:Repro [SummerYeld] | 0.490 | 0.355    | 0.611    | <0.001  *** |
| CaptWt:CaptWt:Repro [TrueYeld] | 0.411 | 0.303    | 0.510    | <0.001  *** |
| CaptWt:CaptWt:Repro [Winter Yeld] | -0.201 | -0.353   | -0.063   | 0.005    ** |
| CaptWt:CaptWt:Region [LA] | 0.149     | -0.098   | 0.425    | 0.284    |
| CaptWt:CaptWt:Region [MG] | 0.620     | 0.412    | 0.849    | <0.001  *** |
| CaptWt:CaptWt:Region [NG] | 0.140     | -0.059   | 0.348    | 0.17     |
| CaptWt:CaptWt:Region [SG] | 0.842     | 0.602    | 1.054    | <0.001  *** |
| CaptWt:CaptWt:Region [SI] | 0.044     | -0.172   | 0.240    | 0.667    |
| CaptWt:SurvA:PopDens     | -0.002    | -0.005   | 0.001    | 0.245    |
| SurvA:SurvA:Maternal age | 0.137     | -0.130   | 0.375    | 0.267    |
| SurvA:SurvA:Maternal age^2 | -0.033  | -0.054   | -0.016   | <0.001  *** |
| SurvA:SurvA:PopDens      | -0.005    | -0.016   | 0.005    | 0.304    |
Bivariate model (d) of birth weight and female relative lifetime breeding success

|                          | post.mean | l-95% CI | u-95% CI | eff.samp | pMCMC |
|--------------------------|-----------|----------|----------|----------|-------|
| CaptWt:Intercept         | 4.493     | 3.584    | 5.459    | 1177     | <9e-04*** |
| LBS:Intercept            | 1.035     | 0.864    | 1.214    | 1177     | <9e-04*** |
| CaptWt:Calf sex [male]   | -0.331    | -0.415   | -0.247   | 1177     | <9e-04*** |
| CaptWt:AgeHrs           | 0.016     | 0.015    | 0.018    | 1177     | <9e-04*** |
| CaptWt:Maternal age      | 0.396     | 0.308    | 0.486    | 1249.4   | <9e-04*** |
| CaptWt:Maternal age^2    | -0.022    | -0.026   | -0.018   | 1177     | <9e-04*** |
| CaptWt:Repro [Naive]     | -0.039    | -0.223   | 0.144    | 1177     | 0.6882 |
| CaptWt:Repro [SummerYeld]| 0.462     | 0.328    | 0.613    | 1177     | <9e-04*** |
| CaptWt:Repro [TrueYeld]  | 0.449     | 0.334    | 0.577    | 1177     | <9e-04*** |
| CaptWt:Repro [Winter Yeld]| -0.210   | -0.365   | -0.048   | 971.7    | 0.0119 * |
| CaptWt:Region [LA]       | 0.064     | -0.272   | 0.379    | 1177     | 0.6933 |
| CaptWt:Region [MG]       | 0.593     | 0.341    | 0.865    | 1177     | <9e-04*** |
| CaptWt:Region [NG]       | 0.166     | -0.070   | 0.399    | 1177     | 0.1614 |
| CaptWt:Region [SG]       | 0.889     | 0.593    | 1.223    | 1177     | <9e-04*** |
| CaptWt:Region [SI]       | -0.054    | -0.312   | 0.173    | 1177     | 0.6525 |
| CaptWt:PopDens           | 0.000     | -0.005   | 0.004    | 1177     | 0.8343 |