

Influence of Maternal Effects in Relation to Genetic Variance and Strength of Selection

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Introduction

Whenever parents provide parental care, they directly influence the offspring's phenotype. For instance, parents providing plenty and high quality parental care, accelerate offspring growth and improve offspring size. Such effects of parental care are called maternal effects.

In addition to directly influencing the offspring's phenotype, parents can indirectly impact the evolution of the offspring's phenotype. The genes coding for parental care are expressed in the parent, but they are also present in the offspring, as they are transmitted from the parent to the offspring like any other gene. As a consequence offspring traits such as body size that are influenced by parental care, are not only influenced by genes coding for body size, but also by genes coding for parental care, even though the genes for body size and parental care are not expressed in the same individual. Thus, genes for parental care can increase the genetic variance of offspring traits and impact the evolution of offspring traits.

The purpose of this research project was to investigate the relative importance of maternal effects for the evolution of the trait means when the magnitude of genetic variance and the strength of directional selection vary.

Methods

We simulated the evolution of the mean of a single trait in the presence of maternal effects using the equations given by Kirkpatrick and Lande (1989):

$$\Delta z(n) = z(n+1) - z(n) \\ = [C_{zz} + mP] \beta(n) + m \Delta z(n-1) - mP\beta(n-1)$$

whereas z is the mean of the trait, Δz is the change of the mean of the trait, n is the generation, m are the maternal effects and β is the selection gradient indicating the strength of directional selection. For C_{zz} and P we used the expressions given by Kirkpatrick and Lande (1989):

$$C_{zz} = 2G / (2 - m) \\ P = [(2 + m)G + (2 - m)E] / [(2 - m)(1 - m2)]$$

E is the environmental variation and is set to 1 in our simulations.

To evaluate the relative importance of maternal effects, genetic variance and directional selection for the evolution of trait means, we varied maternal effects from 0 to 1 (i.e. using only positive maternal effects). For genetic variance G , we used five different values representing very small, small, moderate, large, and very large variance (i.e., $G = 0.01$, $G = 0.1$, $G = 0.25$, $G = 0.5$, $G = 0.75$). For directional selection b , we used values representing weak, average, strong and very strong directional selection in field studies (i.e., $\beta = 0.01$, $\beta = 0.15$, $b = 0.5$, $\beta = 0.75$; Kingsolver et al. 2001).

We run the simulations using Maple 10.

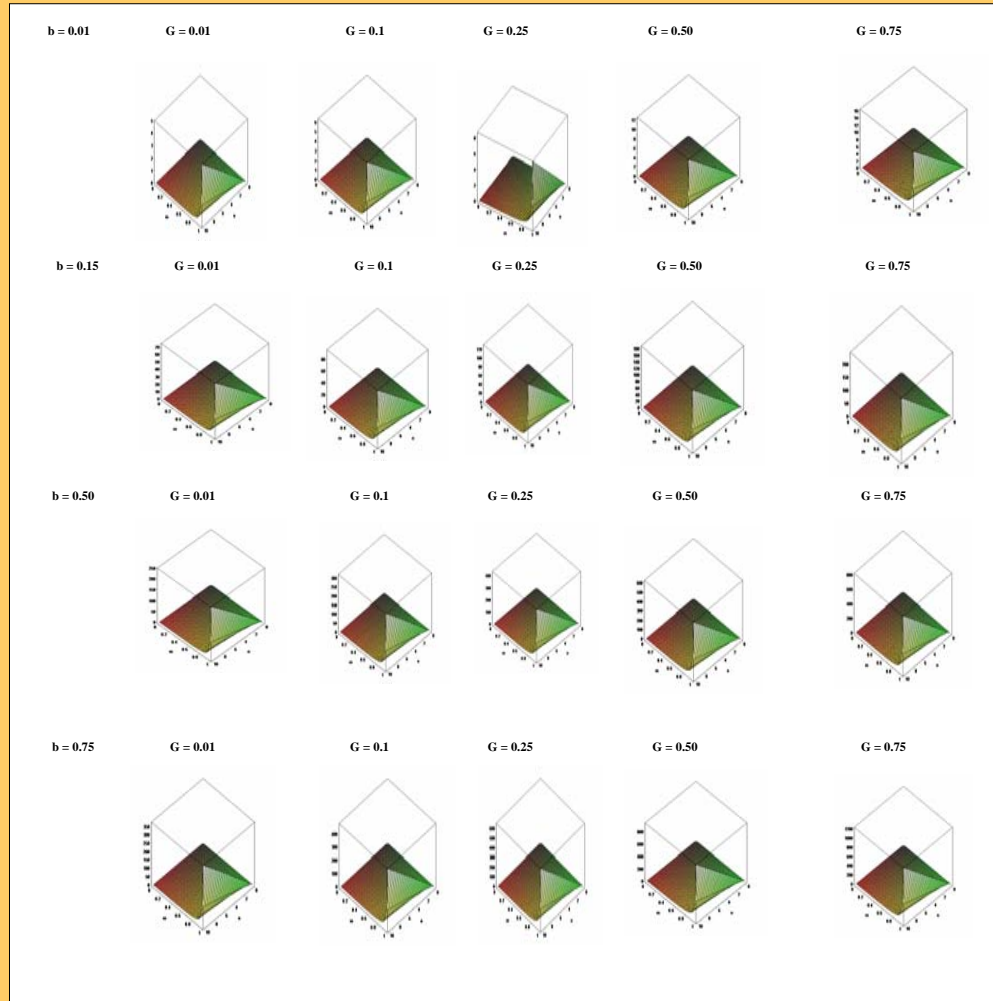


Fig 1. Evolution of mean of a single trait. m = Maternal Effect, β = Selection Gradient, n = Generation from 0 to 10, G = Genetic Variation

Results

The simulations show that the mean of a single trait increases with increasing genetic variance, selection gradient, and maternal effects (Figure 1). Large positive maternal effects cause a very large response of the trait mean to selection. Maternal effects seem to have a stronger impact on trait evolution than directional selection or genetic variance.

Conclusions

- Positive maternal effects accelerate trait evolution.
- Positive maternal effects seem to have stronger impacts on trait evolution than genetic variance or directional selection.

References

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