Fluctuating population dynamics promotes the evolution of phenotypic plasticity

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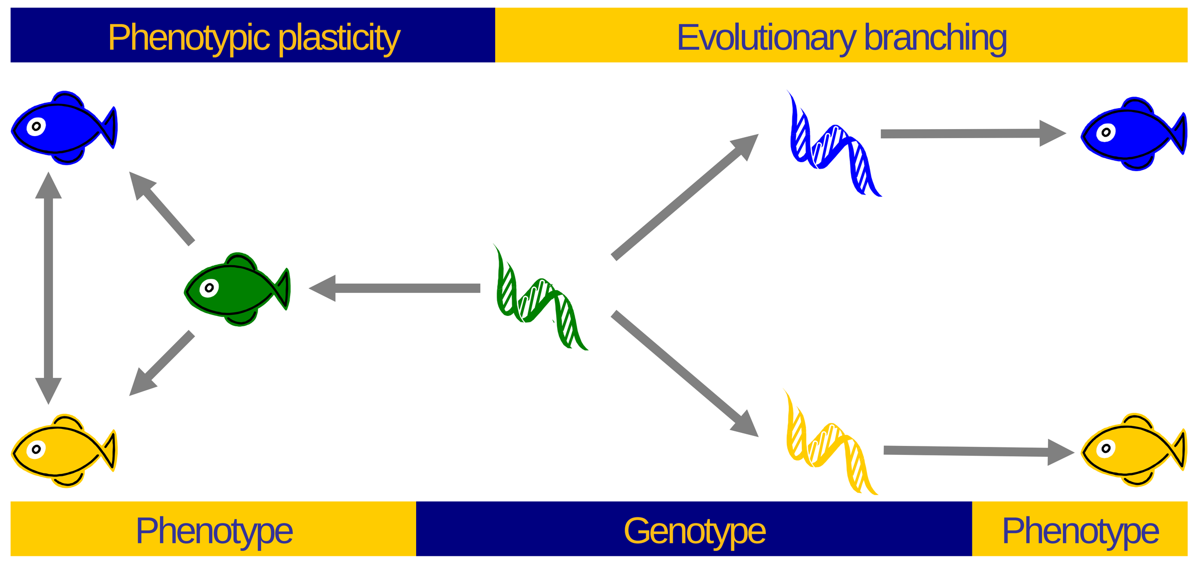
Introduction

An increasing number of studies are showing evidence in support of sympatric speciation. One basic question remains, however. When a population has undergone a branching in its phenotype, is this due to an evolutionary branching in the underlying genotype or due to phenotypic plasticity modifying a single genotype?

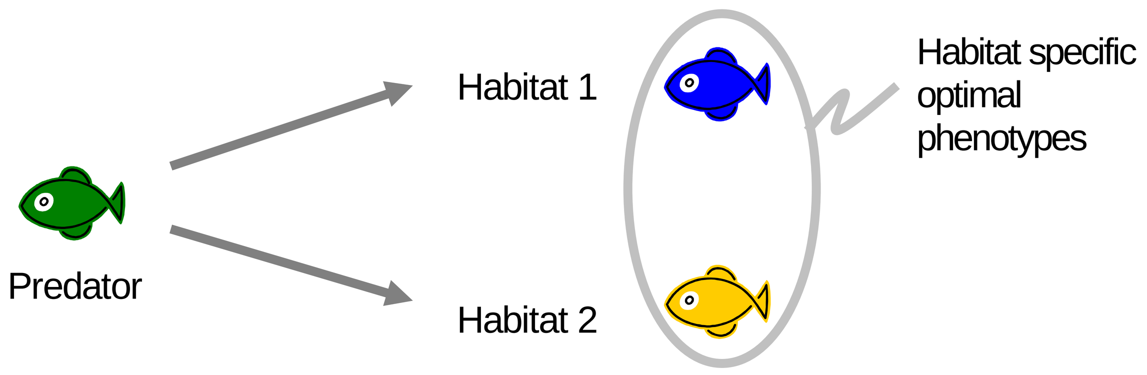


Are two distinct phenotypes (the blue and yellow fish) due to evolutionary branching or due to phenotypic plasticity?

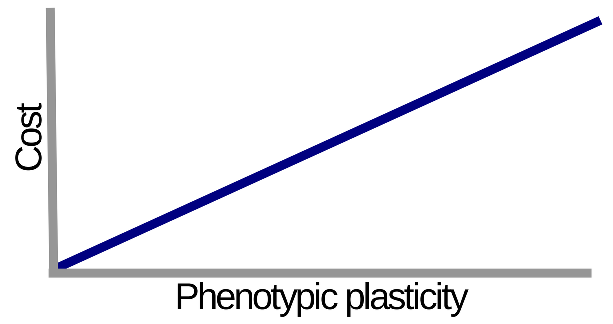
Thus, phenotypic plasticity has come to be viewed as a trait subject to selection, just like any other phenotypic character[1,2]. Here we present a model addressing the conditions under which a predator phenotype experiencing selection for two alternative optimal phenotypes gives rise to genetically based phenotypic branching or to phenotypic plasticity, allowing the corresponding genotype to give rise to two alternative, well-adapted phenotypes.

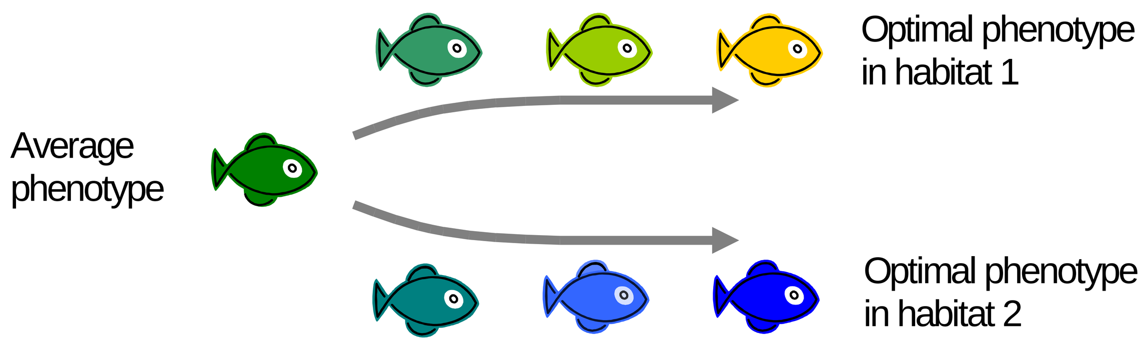
Theory

The model consists of one predator and two prey types inhabiting two different habitats (see poster *Adaptive evolution and then what?* for more details or ref. 3).



The predator can freely move between the habitats and selects one of them based on prey abundance and its predation efficiency. Each habitat requires a different optimal predator phenotype to obtain maximal predation efficiency. The further away the predator's phenotype is from the optimal phenotype in a given habitat, the lower the predation efficiency.

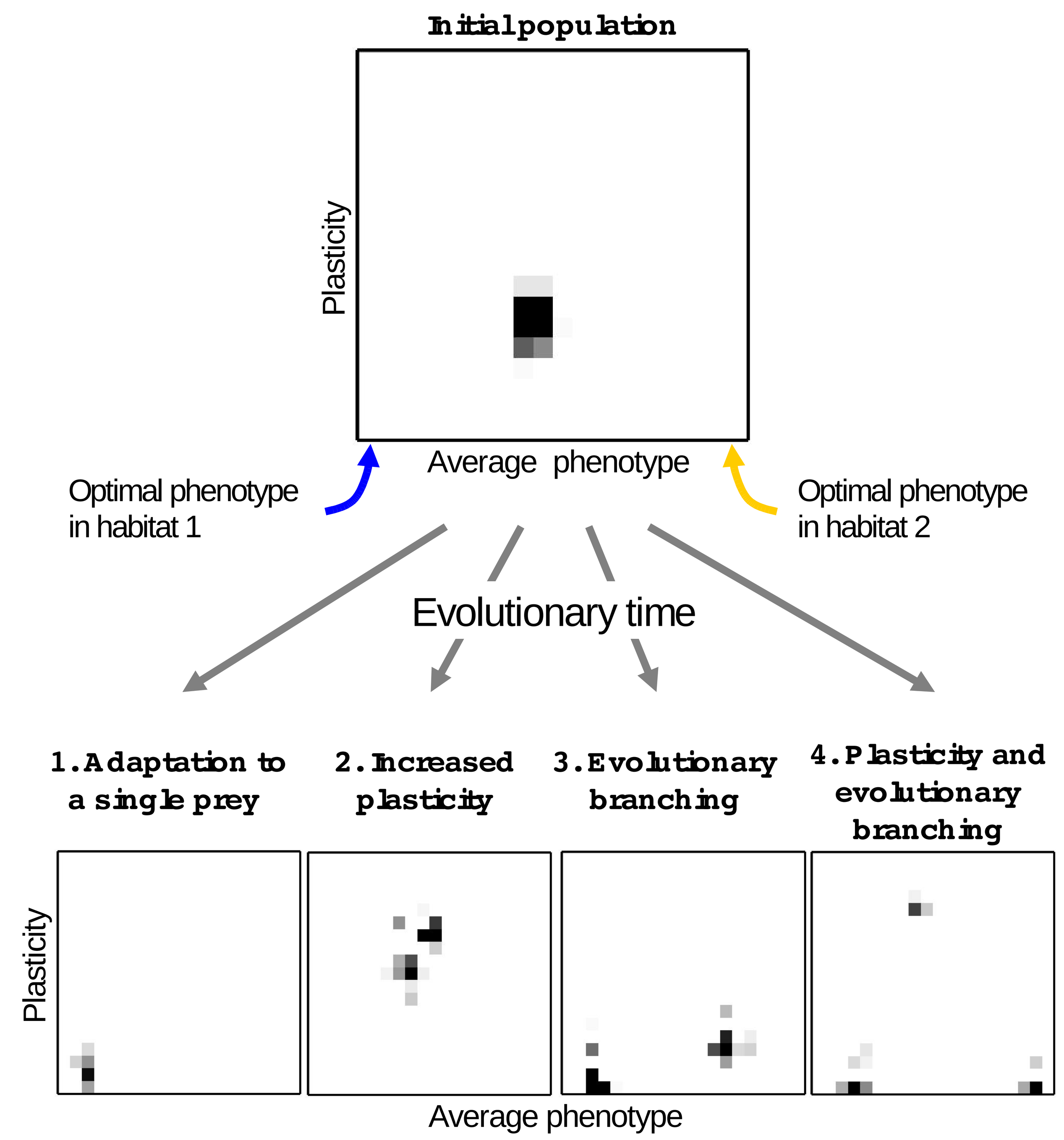




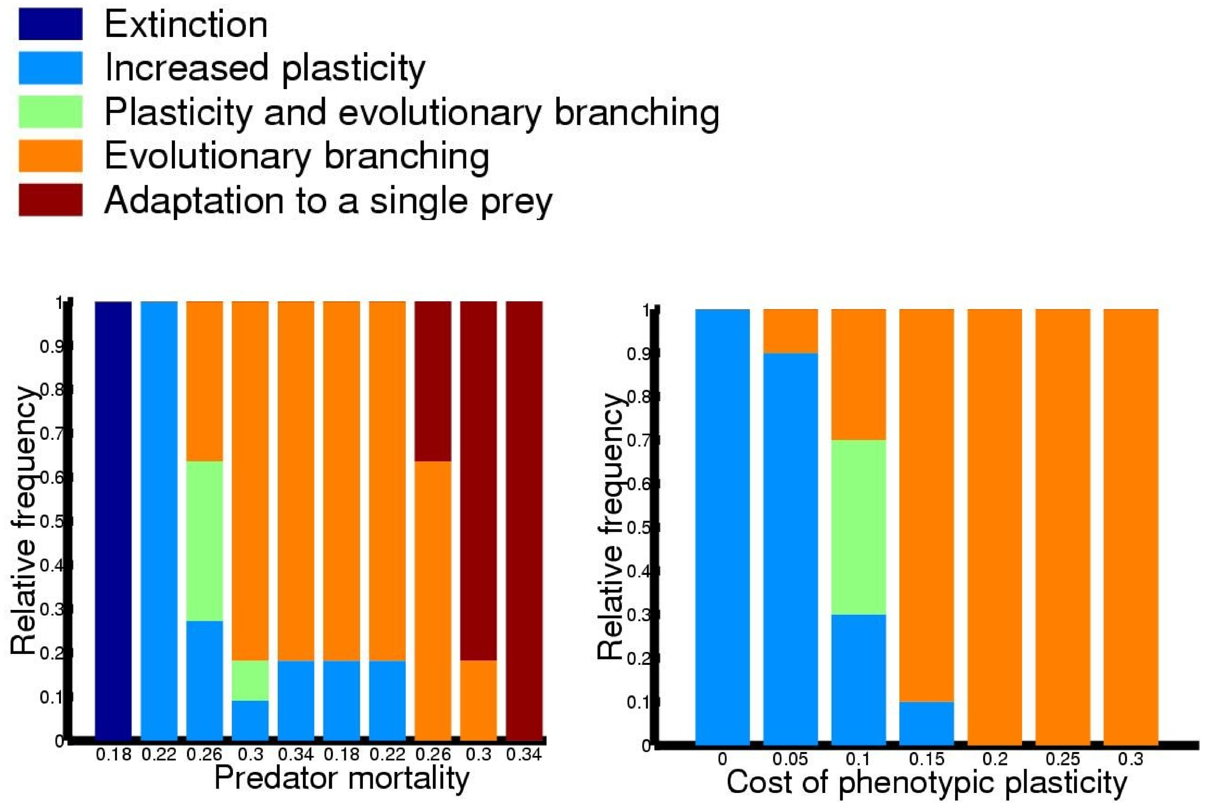
A predator can achieve the optimal phenotype in a specific habitat either by adapting its genotype to match the optimum, allowing it to efficiently utilize the specific resource but becoming unable to utilize the second prey type. Or selection can increase the phenotypic plasticity of the predator, enabling it to modify its phenotype to match either of the two prey types, thus being able to utilize both resource. It is assumed that phenotypic plasticity entails costs. Hence, there is a trade-off between the benefits of a high degree of phenotypic plasticity and the low cost associated with a low degree of plasticity.

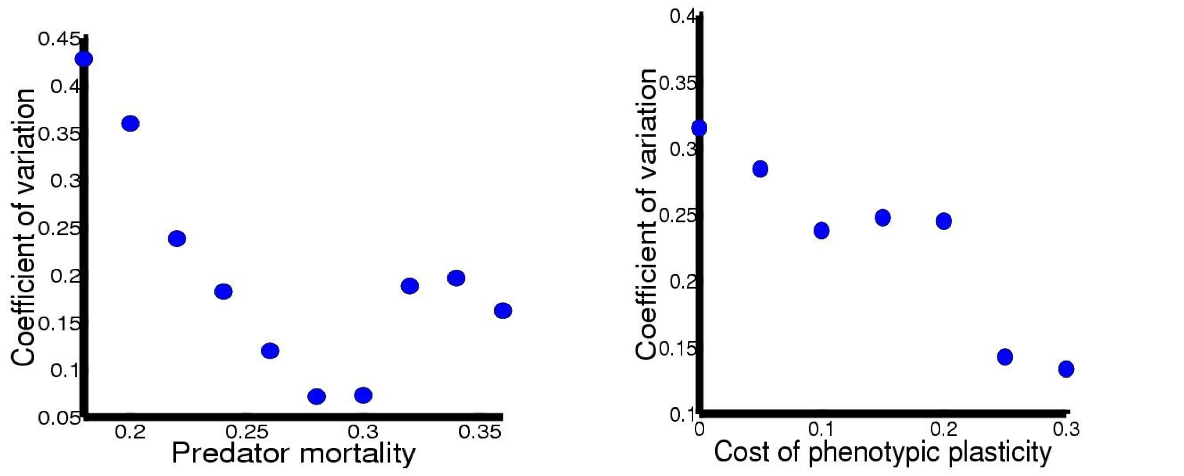
Results

We ran simulations for different parameter combinations to quantify the conditions under which different evolutionary dynamics unfolded.



The initial population had an average phenotype located between the two optimal phenotypes and a low amount of phenotypic plasticity. The possible outcomes of the evolutionary dynamics are: 1) the predator becomes perfectly adapted to the optimal phenotype in one of the two habitats, with virtually no phenotypic plasticity; 2) the predator evolves an increased phenotypic plasticity, allowing it to efficiently prey on both prey types; 3) the predator undergoes evolutionary branching, such that each of the emerging branches is well-adapted to one the two habitats but exhibits very little phenotypic plasticity; and 4) the predator diversifies into one generalist genotype with high plasticity and two specialists with low plasticity.





The main determinant of the evolutionary outcomes are the population fluctuations. As predator mortality (left panels) and cost of phenotypic plasticity (right panels) decrease, the fluctuations in population size (measured as the coefficient of variation during the first 500 time units) increase and the evolutionary response of the population progressively moves towards an increase in phenotypic plasticity rather than evolutionary branching.

Conclusions

- Adaptation for a fixed phenotype, either by evolutionary branching or adaptation to a single prey, is favored in relatively stable populations with small fluctuations.
- Increased population fluctuations promote the evolution of phenotypic plasticity.

References

1. Brönmark C. & Miner J.G.. 1992. Science 258:1348-1350.
2. Schlichting C.D. & Pigliucci M. 1998. Phenotypic Evolution: A Reaction Norm Perspective. Sinauer Associates.
3. Svanbäck R., Pineda-Krch M. & Doebeli M. Manuscript

Acknowledgements

The simulations were performed at the PIII/Linux Cluster at the Department of Physics and the IAM Linux Cluster at UBC. This work was supported by grants from the Swedish Research Council (VR) to RS and James S. McDonnell Foundation (USA), NSERC (Canada), and by the Pacific Institute for Mathematical Sciences to MD and MPK.

For further information

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