The effects of competition and ecological opportunity on adaptative diversification in *Pseudomonas fluorescens*

Susan F. Bailey and Rees Kassen, Department of Biology, University of Ottawa, Canada
(susan.bailey@uottawa.ca)

What drives adaptation and diversification?

The availability of multiple ecological opportunities may drive diversification through divergent evolution of multiple specialists, but in contrast, may slow rates of adaptation as selection pushes in multiple directions at once. Competition for those opportunities could further drive adaptive diversification (e.g. character displacement), but might also decrease diversity through competitive exclusion.

We tested the effects of these two possible drivers using replicate populations of *Pseudomonas fluorescens* SBW25 evolved over 1000 generations in a number of contrasting environments.

Varying ecological opportunity

Selection environments contained 1, 2, or 3 of the sugar resources: mannose (M), glucose (G), and xylose (X).

Varying competition

Selection environments with sugars MIXED together allowed competition for multiple opportunities to occur, while environments with sugars SEPARATED did not.

Results

**Fitness**

**Single-sugar populations:**

**Multi-sugar populations:**

![Fitness graph](image)

**Fig. 1.** Mean relative competitive fitness (ancestor fitness is 1) measured every 100 generations in each evolving population. Error bars show SE for 3 replicate populations.

**Phenotypic diversity**

Phenotype was characterized for 6 isolates from each of the 1-sugar and 3-sugar populations by estimating fitness in each of the 3 sugars making up the multi-sugar environments.

![Phenotypic diversity graph](image)

**Fig. 2.** Mean phenotypic diversity by generation. Diversity is measured as the mean euclidean distance in phenotype space between the 6 isolates of a population. Error bars show SE for 3 replicate populations.

**Conclusions**

Both ecological opportunity and competition for multiple resources affect the course of adaptive evolution in this system. Populations competing for multiple resources adapt more quickly than populations that do not compete (MIXED vs. SEPARATED, fig. 1). The presence of a particular opportunity (xylose) also speeds adaptation (fig. 1).

The presence of multiple opportunities may drive diversification (fig. 2), however the xylose-evolved populations are also quite diverse. Further analysis of the 2-sugar evolved populations may help clarify this.

Competition may drive diversification in the early stages of adaptation (fig. 2, compare MGX vs. M_G_X at generation 200).

Populations competing for multiple resources become more specialized than populations that do not compete (fig. 3). In fact, competition dramatically affects the phenotypic trajectory that an evolving population follows.

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