

Both selection and gene flow are necessary to explain adaptive divergence: evidence from clinal variation in stream stickleback

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ABSTRACT

Questions: Does gene flow constrain adaptation in nature? Does spatial variation in selection make it difficult to detect the role of gene flow?

Data description: Variation in the adaptive morphology of threespine stickleback (*Gasterosteus aculeatus*) from multiple sites in each of three environments: Misty Lake, an inlet stream flowing into Misty Lake, and an outlet stream flowing out of Misty Lake. Variation among these same sites in habitat features that influence natural selection.

Search method: (A) Regressions of site means for morphological traits against distance from the lake. (B) Regressions of site means for morphological traits against site means for water flow. (C) Regression of residuals from (B) against distance from the lake.

Conclusion: Gene flow strongly constrains adaptation in the outlet, as evidenced by gradual shifts in morphology from the lake into the outlet, as well as gradual clines along the outlet. Gene flow does not constrain adaptation in the inlet, as evidenced by sharp shifts in morphology from the lake into the inlet, as well as the absence of clines along the inlet. Both selection and gene flow are required to explain adaptive variation within this system.

Keywords: constraints, dispersal, divergent selection, ecological speciation, hybrid zones, migration, parallel evolution.

INTRODUCTION

Natural selection drives the adaptive divergence of populations inhabiting different ecological environments (Endler, 1986; Schluter, 2000). The magnitude of this divergence, however, should be constrained by gene flow between the environments, as shown in numerous theoretical models (e.g. Haldane, 1948; Slatkin, 1973; García-Ramos and Kirkpatrick, 1997; Hendry *et al.*, 2001; Lenormand, 2002) and some empirical studies (e.g. King and Lawson, 1995; Hendry *et al.*, 2002; Saint-Laurent *et al.*, 2003; Hendry and Taylor, 2004; Nosil and Crespi, 2004). Despite this diverse support for each process, the relative importance of natural selection and gene flow to adaptive divergence in nature

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