

## REPLACEMENT OF RESIDENT CRAYFISHES BY AN EXOTIC CRAYFISH: THE ROLES OF COMPETITION AND PREDATION

ANNA M. HILL<sup>1</sup> AND DAVID M. LODGE

*Department of Biological Sciences, University of Notre Dame, Notre Dame, Indiana 46556 USA*

**Abstract.** Exotic species are often a threat to native biodiversity. In northern Wisconsin lakes, the invading crayfish *Orconectes rusticus* is replacing *O. virilis*, the native, and *O. propinquus*, a previous invader. We tested the impacts of interspecific competition for food and of nonconsumptive effects of predation by largemouth bass, *Micropterus salmoides*, on growth and mortality of these three species. In competition experiments, *O. virilis* grew less, and *O. propinquus* suffered increased mortality in the presence of *O. rusticus* relative to single-species treatments. *Orconectes rusticus* was unaffected by the presence of congeners. In experiments testing nonconsumptive effects of predation, *O. virilis* growth declined substantially in the presence of largemouth bass, *O. rusticus* growth declined slightly, and *O. propinquus* growth was unaffected. Mortality of all three crayfishes increased in the presence of largemouth bass, with *O. virilis* experiencing the greatest and *O. rusticus* the least mortality.

To explore how competition, predation, and their interaction influence species replacements, we compared a fitness index (mortality/growth =  $\mu/g$ ) among species across biotic interaction domains: no interaction, intraspecific competition, interspecific competition, predation by fish, fish predation with competition, and predation risk with competition. In three of six domains, *O. virilis* and *O. propinquus* had somewhat similar  $\mu/g$ , but reversals in  $\mu/g$  rank between *O. virilis* and *O. propinquus* among domains occurred. These reversals are consistent with lack of unidirectionality of species replacements observed where *O. virilis* and *O. propinquus* distributions overlap. In all four interspecific interaction domains, *O. rusticus* had the lowest  $\mu/g$  (indicating greatest fitness), which is consistent with observed unidirectional replacement of *O. propinquus* and *O. virilis* by *O. rusticus*. Whereas some fish management strategies might reverse the replacement of *O. virilis* by *O. propinquus*, no realistic interaction domain is likely to reverse replacement of the native species by *O. rusticus*.

**Key words:** competition; crayfish; exotic; fitness; growth; invasion; mortality; nonconsumptive effects; *Orconectes*; predation risk; predation; survival.