

COMPETITIVE INTERACTIONS AMONG THREE EXOTIC PREDATORS OF THE HEMLOCK WOOLLY ADEGLID

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Abstract

The objective of this study was to evaluate competitive interactions among three exotic predators of the hemlock woolly adelgid (HWA) under simulated natural conditions in the laboratory. *Laricobius nigrinus* Fender (Coleoptera: Derodontidae) from western Canada and *Pseudoscymnus tsugae* Sasaji and McClure (Coleoptera: Coccinellidae) from Japan are two specialist predators being released into infested eastern hemlock stands in the United States for classical biological control of HWA (Salom et al. 2001). In addition, *Harmonia axyridis* Pallas (Coleoptera: Coccinellidae), an imported generalist predator of aphids, is found in increasing numbers in infested hemlock stands (Wallace and Hain 2000). Because these species may occur in the same ecosystem and competitive interactions can decrease the efficacy of biological control (Rosenheim et al. 1993), we examined conspecific and intraguild predation so that release strategies for *L. nigrinus* and *P. tsugae* may be optimized.

Laboratory studies were conducted using petri dish bioassays containing clipped, infested eastern hemlock twigs held in environmental chambers under two simulated environments corresponding to early and late spring in southwestern Virginia. The susceptibility of the eggs of each predator species to predation by conspecific and heterospecific larvae and adults was tested using no-choice and choice tests at a range of HWA densities. For the assays, the predator eggs were incorporated onto HWA infested foliage in their natural context and a single predator was then introduced for 48 h. The results showed that *L. nigrinus* eggs were highly susceptible to conspecific predation and intraguild predation by *H. axyridis*. Likewise, *P. tsugae* eggs were susceptible to intraguild predation by *L. nigrinus* and *H. axyridis*. However, predation of these two species was inversely HWA density dependent, primarily occurring when HWA density was either very low or absent. In contrast, *H. axyridis* eggs were only susceptible to conspecific

predation, and this occurred at high levels independent of HWA density.

Effects of competition among predators were analyzed by a series of tests comparing single predators alone to groups of three conspecifics or heterospecifics. Survival, feeding and reproduction were measured over a 6-day period with moderate HWA densities available throughout. Results showed that adults and larvae of each species survived as well alone as with conspecifics or heterospecifics. Larval feeding was additive regardless of the species combination. Adult feeding during the early spring simulation showed that *L. nigrinus* and *H. axyridis* had higher feeding rates than that of *P. tsugae*. In the late spring simulation, *H. axyridis* had the highest feeding rates followed by *L. nigrinus* and *P. tsugae*, which were similar. In terms of reproduction, *L. nigrinus* had the highest oviposition rates for both the early and late spring simulations. However, although *P. tsugae* and *H. axyridis* had very low oviposition rates during early spring, these increased dramatically in late spring. Oviposition was non-additive for *L. nigrinus* during both environmental simulations, but only during the late spring simulation for *H. axyridis*. Both *L. nigrinus* and *H. axyridis* demonstrated conspecific competitive interference. In contrast, *P. tsugae* oviposition was additive during both environment simulations.

It appears that eggs of *L. nigrinus* and *P. tsugae* are not chemically defended, but are preyed upon in the absence of sufficient HWA. Eggs of *H. axyridis* appear to be chemically defended, but suffer substantial conspecific predation. In terms of predator interactions, the results suggest that these three predator species may be more complementary than competitive. *L. nigrinus* appears to be an efficient predator in the colder conditions present in the early spring, while *P. tsugae* feeds more in warmer conditions as in late spring. *H. axyridis* has the potential to be a significant intraguild competitor, but in these

short-term studies with moderate HWA available, it did not cause significant mortality to *L. nigrinus* or *P. tsugae*, nor disrupt feeding or reproductive activities of these species. *L. nigrinus* and *H. axyridis* may regulate their population density through a combination of conspecific egg predation and decreasing oviposition in the presence of conspecifics.

Additional studies under way include using fabric branch enclosures to examine predators under more natural conditions in southwestern Virginia hemlock stands over 6 weeks during the overwintering and spring generations of HWA. Detailed video analysis of daily activity patterns are planned to better elucidate possible competitive interactions.

References

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