

REPRODUCTIVE STRATEGIES OF SCYMNUS LADYBEETLE PREDATORS OF HWA

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Abstract

Hemlock woolly adelgid, *Adelges tsugae* Annand (Homoptera:Adelgidae) is an introduced Asian pest of native Eastern and Carolina hemlocks, *Tsuga canadensis* Carriere and *Tsuga caroliniana* Engelman, in eastern North America. Current efforts to manage the spread of *A. tsugae* have focused on developing biological control programs based on the release of predators from Japan, China and Canada. While species from Japan and Canada have been released, a history of colony and production difficulties have delayed field release trials for *Scymnus* species from China. Colonies of two Chinese ladybeetle species, *Scymnus* (*Neopullus*) *sinuanodulus* Yu & Yao and *Scymnus* (*Neopullus*) *ningshanensis* Yu & Yao (Coccinellidae:Tribe Scymnini) have been maintained in Connecticut since 1996 and 1998, respectively, but have experienced mass mortality in recent years. In October 2002, improved colony maintenance and production procedures were revised significantly as a result of a new cooperative project between the USDA Forest Service and the Connecticut Agricultural Experiment Station. Some of the challenges facing the development of improved mass rearing technology for *S. sinuanodulus* and *S. ningshanensis* are presented here: biased sex ratios & adult parasitism, and a possible interpretation provided in terms of reproductive strategy.

Insect sex ratios are generally balanced, with exceptions in some orders. Female biased sex ratios in larger coccinellids are known to be distorted by maternally transmitted cytoplasmic male-killing bacteria of the genus *Wolbachia*. Biased sex ratios can also arise from differential larval survival and inbreeding. There are few

published studies on sex ratios of Scymnini species. Sex ratios of F1 progeny reared in early spring 2002 were extremely skewed towards females in *S. ningshanensis* (11:1) and in *S. sinuanodulus*, by 2.2:1. After colonies of *S. sinuanodulus* and *S. ningshanensis* were stabilized in 2003, overall sex ratios of the F1 2003 generation produced in the spring and summer were still biased towards females, but much less so than in 2002, when the colonies experienced highly stressed conditions (2.4:1 for *S. ningshanensis* and 1.9:1 for *S. sinuanodulus*).

Parasitized male adults were discovered in fall 2002 field collections of *S. sinuanodulus* adults from China. Each of two cadavers contained one parasite larva. This is the first record of adult parasitism in *S. sinuanodulus*. Examination of F1 2002 summer cadavers recorded 16.8% of males and 14% of females with the same displaced elytra and sunken abdomens, suggesting previous contamination by parasites. In winter 2003, under quarantine conditions, an unidentified adult parasite was found to have successfully emerged from a parasitized male *S. sinuanodulus*, which had died in July 2003. In China, native Chinese hemlocks are a minor component of highly diverse forests which support a large diversity of coccinellid species on low, scattered densities of *A. tsugae*. The native abundance of *S. sinuanodulus* may be the result of an adaptive reproductive strategy, reflected in a biased sex ratio, that favors the production of females when there is abundant intra- and interspecific competition for limited prey resources and natural population regulation by parasites.