

HEMLOCK WOOLLY ADELGID PHENOLOGY AND PREDACIOUS BEETLE COMMUNITY ON JAPANESE HEMLOCKS

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ABSTRACT

Monthly samples of the hemlock woolly adelgid (HWA), *Adelges tsugae*, and predatory beetles were taken from *Tsuga sieboldii* near the border of Osaka and Kyoto prefectures. The beetles were collected by sweeping the canopy up to 5 meters height with nets. The phenology of HWA life stages were monitored by collecting branches and determining, under the microscope, the number of each stage of HWA present per cm twig length. The phenology of HWA on the hemlock appears to be similar to that observed in the eastern United States. Predacious beetles present included many generalist species, especially in the spring months. *Sasajiscymnus tsugae* was present in every month except January and February. A new species of *Laricobius* (Derodontidae) was present from November to May. The new *Laricobius* beetle would be a good compliment to *S. tsugae*, which was exported to the U.S. in 1994 from these study trees.

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KEYWORDS

Adelges tsugae, Japan, *Laricobius* new species, *Sasajiscymnus tsugae*, seasonal history

INTRODUCTION

Hemlock woolly adelgid (HWA), *Adelges tsugae* Annand (Hemiptera: Adelgidae), is an introduced pest in the eastern United States that can be lethal to the native hemlocks, *Tsuga canadensis* (L.) Carriere and *T. caroliniana* Engelman, growing there. HWA is innocuous in Japan, China, and western North America, where it is a native insect (Havill et al. 2006). Be-

cause HWA populations are not effectively regulated by natural enemies in the eastern U.S., classical biological control is considered the most promising option for controlling this pest in a forest setting (Cheah et al. 2004). Predators are the only natural enemies known to attack the family Adelgidae. Recently, Havill (2006), using DNA, pinpointed the origin of HWA in the eastern U.S. to a population in the central part (Kansai region) of Honshu Island, Japan. Because the Osaka Museum is interested in natural history information on insect fauna in the Kansai district and the USDA Forest Service desires information on HWA and its natural enemies in its native habitat, the two groups initiated a cooperative study in 2005.

METHODS

Tsuga sieboldii Carriere trees in a landscape setting at Nakahata, Takatsuki, Osaka Prefecture, were sampled every month for a year beginning in October. *Sasajiscymnus tsugae* (Sasaji and McClure) was collected and exported to the United States from one of these trees in 1994 (Sasaji and McClure 1997). The number and stage of HWA on the twig samples were determined using a microscope. During each visit, HWA-infested hemlock were collected and branches were swept using nets that could reach up to 5 meters into the canopy. Adult predacious beetles and insects in the net were sorted to type and counted. Occasional samples for predacious beetles on hemlock trees were taken at the Kobe Arboretum, Hyogo Prefecture; Koyasan, Wakayama Prefecture; Mt. Tsurugi, Tokushima Prefecture; Maji Village, Kochi Prefecture; and the lower slopes of Mt. Fuji.

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RESULTS AND DISCUSSION

HWA LIFE CYCLE

In July, almost all HWA were diapausing first instars on the new twigs. They began developing in September, and the adults, covered with wool, appeared in December. Most individuals were adults by February, and many eggs were found underneath the wool beginning in February. In spring, many crawlers hatched, dispersed, settled on twigs near their mothers, and developed rapidly. Eggs of the winter and spring generations were present from March to July. HWA phenology at Takatsuki seems to be similar to that in the eastern U.S., except that a few HWA may break diapause earlier in the fall and a few crawling stages were found during the winter (Figure 1).

PREDATORS

Twenty-seven predacious species in five families of Coleoptera were collected in sweep nets from Japanese hemlocks (Table 1). Although some immature insects were collected, the table includes only adults that could be identified. In addition to beetles, larvae of hoverflies such as *Heringia familiaris* Matsumura (Syrphidae) and green-lace wings (Chrysopidae) were observed from spring to summer. The months with the greatest diversity of predacious beetles were April-June, when HWA eggs were plentiful. Elaterids and cantharids were abundant

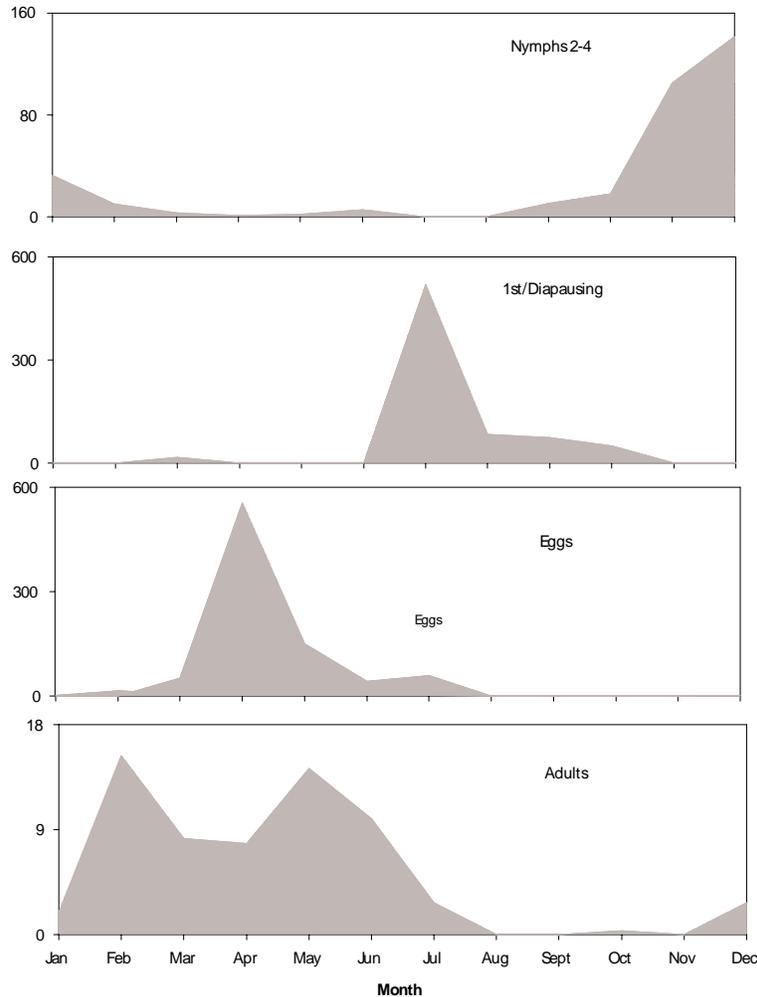


Figure 1. Phenology of *Adelges tsugae* life stages at Takatsuki, Japan

during this season. The cantharids are large and voracious, and one *Asiopodabrus* sp. individual consumed four sacs of eggs and adults and 17 settled nymphs overnight in the laboratory. The coccinellid, *S. tsugae*, was observed on the hemlocks for more months than any other beetle; the only months it was not collected were January and February. It seems to be the predator most likely responsible for the decline in number of the diapausing HWA nymphs during the summer. *Sasajiscymnus tsugae* was not found on other conifers near Takatsuki, and HWA is the only prey on hemlock on which we have seen it feeding. We have found *S. tsugae* only in the Kansai area (Osaka, Hyogo, Wakakusayama, and Wakayama prefectures) on *T. sieboldii* growing in landscape settings, but other scientists have collected it in other areas of Honshu Island on pine and in marsh grasses far from any hemlock. Adults of a derodontid beetle, *Laricobius* sp. nov., were present from November to May (the peak, in March). In Japan, the derodontid beetle is abundant and fairly widespread and seems to greatly reduce the overwintering HWA adults and the eggs laid by this generation.

Table 1. Predacious beetles collected in sweep nets from hemlock trees.

FAMILY/SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Elateridae												
<i>Ampedus carbunculus</i> (Lewis)					●							
<i>Cardiophorus niponicus</i>				●								
<i>Dalopius bizen</i> Kishii					●							
<i>Displatynychus adjutor</i> (Candeze)						●						
<i>Dolerosomus gracilis</i> (Candeze)				●	●							
<i>Kibunea eximia</i> (Lewis)					●							
<i>Melanotus annosus</i> Candeze						●						
<i>Melanotus correctus</i> Candeze					●							
<i>Spheniscosmomus cete cete</i> (Candeze)					●							
<i>Spheniscosmomus koikei</i> (Kishii et al)					●							
Cantharidae												
<i>Athemus vitellinus</i> (Kiesenwetter)					●							
<i>Athemus suturelles</i> (Motchulsky)					●							
<i>Micropodabrus longipes longipes</i>					●							
<i>Hatchiana heydeni</i> (Kiesenwetter)					●							
<i>Hatchiana sanoii</i> Imasaka					●							
<i>Asiopodabrus lictorius</i> (Lewis)					●							
<i>Asiopodabrus malthinoides</i>				●	●	●						
Derodontidae												
<i>Laricobius</i> sp. nov	●	●	●	●	●						●	●
Melyridae												
<i>Dasytes japonicus</i> Kiesenwetter					●							
<i>Laius hisstrio</i> Kiesenwetter						●	●					

Table 1 (cont.). Predacious beetles collected in sweep nets from hemlock trees.

FAMILY/SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Coccinellidae												
<i>Chilocorus kuwanae</i> Silvestri		●		●		●						
<i>Oenopia hirayamai</i> (Yuasa)	●											
<i>Phymatosternus lewisii</i> (Mulsant)		●										
<i>Sasajiscymnus tsugae</i> (Sasaji et al)			●	●	●	●	●	●	●	●	●	●
<i>Scymnus giganteus</i> H. Kamiya				●	●			●				
<i>Scymnus hoffmanii</i> Weise									●			
<i>Harmonia axyridis</i> (Pallas)			●	●					●	●	●	●

CONCLUSIONS

The Japanese *Laricobius* species appears to be an important natural enemy in the region that is the source of the HWA that is in the eastern United States. It seems to be a very promising candidate for biological control. More study of its life cycle and host-range in its endemic area coupled with host-range testing on potential non-target species in the U.S. is needed prior to its release. In addition to the *Laricobius* beetle and *S. tsugae*, many generalist species were collected from the hemlocks, and some of these are voracious on HWA. Based on initial observations, it appears that *Laricobius* is an important predator during the winter and early spring months, with generalists active in late spring and early summer, and only *S. tsugae* remains active on the tree during the summer months when HWA is in diapause. Thus, the Japanese *Laricobius* should be a good compliment to the Japanese *S. tsugae* already released for biological control of HWA in the eastern U.S.

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