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SURVEY FOR POTENTIAL PREDATORS OF THE ELONGATE
HEMLOCK SCALE IN TENNESSEE AND NORTH CAROLINA

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The elongate hemlock scale, *Fiorinia externa* Ferris (Hemiptera: Diaspididae) (EHS), is an invasive insect from Japan (Takagi 1963) that feeds on the needles of eastern hemlock, *Tsuga canadensis* (L.) Carriere. This diaspidid often co-exists with the exotic hemlock woolly adelgid, *Adelges tsugae* Annand (Hemiptera: Adelgidae), throughout the northern United States (McClure 2002), where they cause extensive damage to eastern hemlock and threaten to disrupt forest composition. EHS invaded eastern hemlocks in the southern Appalachian range and has become well established in western North Carolina and eastern Tennessee. Heavily-infested trees were discovered in Mar 2004 in two urban areas located at Tyson Park and Lynnhurst Cemetery, Knoxville, TN (Buck et al. 2005; Lambdin et al. 2005), where little is known about the natural enemies of this introduced pest. Several species of predators including *Atractotomus magnicornis buenoi* (Mercet) and *Phytocorus* sp. (Heteroptera: Miridae), *Conwentzia pineticola* Enderlin (Neuroptera: Coniopterygidae), and *Chilocorus stigma* (Say) and *C. kuwanae* Silvestri (Coleoptera: Coccinellidae) have been recorded to feed on EHS in other areas of the United States (Davidson & McComb 1958; McClure 1977). In addition, the parasitoid *Encarsia citrina* (Craw) (Hymenoptera: Aphelinidae) has been reported to be an important mortality factor of EHS (McClure 1978, 1979, 2002). To better understand the population dynamics of EHS, a survey was designed to identify its potential predators in eastern Tennessee and western North Carolina.

Populations of potential predators were sampled with beat sheets and branch extractions of eastern hemlock at 2 urban and 2 forest sites. Urban sites were located at Lynnhurst Cemetery (Knoxville, TN) and at Biltmore Estate (Asheville, NC). Forest sites were located at Bays Mountain Park (Kingsport, TN) and at Biltmore Estate (Asheville, NC). All sites were sampled from Sep 15, 2004 to Apr 28, 2006 except at the Bays Mountain Park site, which was sampled from Aug 29, 2005 to Apr 10, 2006. Each urban or forest site was arranged into 5 blocks with 3 trees sampled monthly per block for predators.

Predators were collected with a beat sheet (75 cm × 75 cm) by striking one branch 3 times from each of the 4 cardinal directions per tree. The beat sheet was scanned for predators, and when dis-

covered, they were placed into a glass vial (6 dram), labeled (date, site, block, tree, and direction) and transported to the laboratory for processing. Data (date, site, tree number, species, number of specimens per species, location and developmental stage of the predators collected) recorded from the 4,380 beat sheet samples were subjected to Kruskal-Wallis Test with SPSS 14.0 for Windows. We extracted 2 branch samples (30 cm) from each of 5 trees per block, and placed them into separate, labeled "Ziploc" bags to observe predators and the impact of their feeding upon the scale insect in the laboratory. Data recorded included the date of collection, site, number of EHS from 100 needles per sample, and the number and location of EHS damaged by predators. Predator damage (defined as any injury or mutilation to the scale test or body) was determined from EHS specimens taken from 3,600 branch samples throughout the study period.

Six predaceous species (*C. stigma*, *Conwentzia* nr. *pineticola* Enderlein, *Harmonia axyridis* Pallas, *Rhyzobius lophanthae* (Blaisdell), *Scymnillus horni* (Gordon), and *Scymnus lowei* Mulsant) were collected and identified from EHS-infested eastern hemlock. A total of 504 specimens consisting of 347 adults and 157 larvae was obtained from beat sheet sampling. Experiments are underway to assess the ability of these field-collected predators to feed on EHS. The only other scale insect species encountered was the native hemlock scale, *Abgrallaspis ithacae* (Ferris) (Hemiptera: Diaspididae), comprising less than 0.02% of the scale insect fauna at the sites. Two of the coccinellid species (*S. horni* and *R. lophanthae*) represent new state records for Tennessee, while collections of *S. lowei* represent new county records for eastern Tennessee. Except for *S. horni*, the remaining predators were previously collected and identified in North Carolina (Kathleen Kidd, personal comm.). The native species *S. horni* is common to the forests of the eastern United States (Robert Gordon, personal comm.). The coccinellids *C. stigma*, *R. lophanthae*, and *S. horni* are primary predators of scale insects, while *S. lowei*, *H. axyridis*, and *Coniopterix* sp. appear to be more generalist predators feeding primarily on aphids, scale insects, and mites.

Lowest numbers of specimens were collected for the species *S. lowei*, *Conwentzia* sp., and

H. axyridis. Percent damage to EHS field-collected samples was 9.8% for Biltmore Estate urban, 9.7% for Biltmore Estate forest, 6.2% for Lynnhurst Cemetery urban, and 4.7% for Bays Mountain Park forest sites, respectively. Although predators were found at urban and forest sites, the number of species and species combinations differed per site.

More predator specimens for each species were found in urban areas ($n = 55$, $df = 3$, $H < 0.05$) with *R. lophanthae*, *C. stigma*, and *S. horni* comprising the dominant species. *Scymnillus horni* was the only species found at the Bays Mountain Park site, and *S. lowei* was only found at the Lynnhurst Cemetery site. Although more specimens of *S. horni* were found on the south side of the tree and higher numbers of *R. lophanthae* were found on the north side of the tree, no differences ($n = 80$, $df = 3$, $H > 0.05$) for direction were noted for direction preference among the species.

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SUMMARY

Six predators from EHS-infested eastern hemlocks were collected in eastern Tennessee and western North Carolina. *Rhyzobius lophanthae* and *S. horni* are known to feed on scale insects as their primary food source, and both represent new state records for Tennessee. The most dominant species collected were *S. horni*, *R. lophanthae*, and *C. stigma*, respectively.

The natural predator abundance does appear sufficient to significantly reduce the heavy populations of EHS now present on eastern hemlocks within the region. However, augmentation of their numbers along with the use of the parasitoid *E. citrina* or other more host specific parasitoids offer the potential of suppressing pest populations in both forests and urban landscapes.

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