



Hemlock Woolly Adelgid Newsletter

Issue No. 2

August 1997

The Hemlock Woolly Adelgid Newsletter is a service of the USDA Forest Service, Northeastern Area in support of the HWA Working Group. This informal newsletter is intended to provide brief updates to those interested in activities associated with the hemlock woolly adelgid. For purposes of brevity, some of the articles submitted may have been edited. Readers are encouraged to contact the individual authors if more detailed information is desired. The HWA Newsletter will be prepared and distributed at least annually or as sufficient new information becomes available. Comments, questions and contributions for future newsletters are welcome and may be submitted to:

Brad Onken
USDA Forest Service
Forest Health Protection
180 Canfield Street
Morgantown, WV 26505-3101

or

Dennis Souto
USDA Forest Service
Forest Health Protection
271 Mast Road
P.O. Box 640
Durham, NH 03824-0640
Phone: (603) 868-7717
Email: dsouto@hpl.nena.org
Fax: (603) 868-7604

Phone: (304) 285-1546
Email: bonken@mserv.fsl.wvnet.edu
Fax: (304) 285-1505

The HWA Newsletter is also available under Entomology on the Forest Health Protection Home Page in Morgantown, WV at:
<http://troy2.fsl.wvnet.edu>

BIOLOGICAL CONTROL OF HWA

Exploration for Fungal Pathogens of HWA: A multi-state effort to locate insect-killing fungi associated with the hemlock woolly adelgid (HWA) was initiated in 1997. Plots for sampling various stages of HWA have been established in Massachusetts, Connecticut, New Jersey and Virginia. Helping with this research are Charlie Burnham (MA), David Orwig (CT), George Koeck (NJ), and Tim Tigner (VA). Twigs with moderate populations of HWA were sampled in early May and over 10,000 HWA carefully inspected for signs of fungal infection. Symptomatic adelgids were brought into the laboratory and isolations of microorganisms present made. Data on tree health and HWA population levels were recorded. The early May sampling was designed to (a) locate symptomatic crawlers, who potentially could have picked up fungal spores while seeking areas to settle down and feed, and (b) recover overwintering females that had retained infections from the previous year. Sampling will be repeated in early fall in hopes of obtaining more individuals that had become infected over the 1997 growing season.

To date, we have recovered entomopathogenic fungal isolates of *Beauveria*, *Verticillium* and *Paecilomyces* spp. Many isolates from HWA are presently being cultured and will be identified in the immediate future. All identifications will be verified by Dr. Richard A. Humber, USDA, ARS at Cornell. After the fall sampling, research will begin to determine pathogenicity levels of the isolates and their potential use in management of this pest.

Bruce L. Parker (802) 656-5440; Fax: (802) 658-7710; Email: bparker@zoo.uvm.edu

Establishing *Pseudoscymnus tsugae* Sasaji and McClure as a Biological Control Agent for Hemlock Woolly Adelgid, *Adelges tsugae* Annand - Kudos for Pseudos: Among the most widespread and effective predators of hemlock woolly adelgid, *Adelges tsugae* Annand, in Japan is a previously undescribed coccinellid of the genus, *Pseudoscymnus*. Dr. Mark McClure collected this beetle in 1992 throughout Honshu, Japan where it killed 86 to 99 percent of all adelgids. Drs. Hiroyuki Sasaji and Mark McClure have described and named this new beetle, *P. tsugae*.

Drs. McClure and Carole Cheah, assisted by Beth Beebe, Mary Klepacki and Rob Ballinger are working to implement a biological control program to save hemlock forests from the hemlock woolly adelgid. During the past three years more than 20,000 adults of *P. tsugae* have been reared at the Valley Laboratory in Windsor, Connecticut. The rearing effort was enhanced this spring with the completion of a temperature controlled insectary, together with more streamlined mass-rearing techniques. Our rearing success has spawned a cooperative venture with the New Jersey Department of Agriculture to establish a back-up colony of *P. tsugae*.

Beginning in 1995, more than 15,000 adult beetles have now been released in six hemlock forests in Connecticut and one in Virginia to evaluate *P. tsugae* as a biological control agent at the northern and southern ends of the infestation. The release of 2,430 beetles in late April 1997 in western Virginia was part of a collaborative effort with Dr. Tim Tigner, Virginia Department of Forestry, to investigate the ability of *P. tsugae* to affect densities of *A. tsugae* and balsam woolly adelgid, *Adelges piceae* (Ratzeburg) in the south.

In the field, *P. tsugae* has mated, reproduced and dispersed from release branches to adjacent branches and trees. It depressed adelgid densities by 70-100 percent at one site in Windsor where 1,100 adult beetles had been released five months earlier. At two other sites in Bloomfield and New Hartford where 1,450 beetles were released in spring 1996, live adults were recovered in May 1997. This demonstrated that *P. tsugae* was able to survive a relatively mild winter with little snow cover, in addition to a very severe winter the year before. It also suggested that adult beetles may be overwintering in the leaf litter on the forest floor.

Mark McClure (860) 683-4979 or email: mmcclure@caes.state.ct.us

Chinese Natural Enemies: Wenhua Lu (University of Rhode Island), Kristine Johnson (National Park Service), and Michael Montgomery (USDA-FS, NEFES) visited China this April to study and collect predators of hemlock woolly adelgid (HWA). They visited several sites near Lijiang in Kunming Province. This area has exceptional biological diversity. Two species of hemlock occur at 7,500-10,000 feet there. HWA is widespread but at low densities in the area. Fir and five-needle pine growing there also are infested with adelgids. Over 25 species of coccinellids have been collected from HWA infested hemlock; 12 of these appear to be previously undescribed species (description of six species is in press).

The two most common coccinellids are *Scymnus sinuanodulus* and *S. camptodromus* (nov. spp.). Both of these have been imported to the USDA-FS Quarantine Laboratory. *S. sinuanodulus* has been reared through one complete generation in the quarantine laboratory. Dr. Lu is overseeing the rearing and behavioral studies in the Quarantine Laboratory. She is assisted by Tim Johns and Julie Slowik. Currently (July), the F1 generation are adults that have mated. F2 progeny are expected by next spring. Feeding by this species seems restricted to adelgids.

Michael E. Montgomery (203) 230-4311 or email: mem1023@aol.com

FHTET Continues Support for Biocontrol: The USDA Forest Service Forest Health Technology Enterprise Team (FHTET) has been the principle leader in HWA biological control since 1993. Funds provided by the Enterprise Team to various cooperators to support activities in Fiscal Year 1997, together with \$15,000 provided by Finch-Pruyn and Company (Glens Falls, NY), and approximately \$55,000 provided by the USDI Biological Research Division of the U.S. Geological Survey, have totaled over \$271,000.

Dick Reardon (304) 285-1566 or email: rreardon@mserv.fsl.wvnet.edu

Teamwork on Predacious Ladybird Beetle: Recently the NJDA Phillip Alampi Beneficial Insect Laboratory received a starter colony of *Pseudoscymnus tsuga* from Mark McClure of the Connecticut Agriculture Experiment Station. The purpose of the starter colony was to establish a backup colony and investigate the development of mass rearing techniques for this coccinellid.

Bob Chianese or Dan Palmer (609) 530-4192 or email: agpchia.@ag.state.nj.us or agppalm.@ag.state.nj.us

Two for One: As previously mentioned, the Virginia Department of Forestry cooperated with the Connecticut Agricultural Experiment Station to introduce an exotic beetle predator, *Pseudoscymnus tsugae*, of the hemlock woolly adelgid into Virginia. We transplanted a few Fraser fir trees infested by the balsam woolly adelgid to the same site. Both species of adelgid are introduced and both are fed upon by the beetle predator. The balsam woolly adelgid is becoming a serious pest of Fraser fir Christmas trees. It might take two or more years of evaluation before we have a good basis for characterizing the effects of this introduction. Also, we cooperated with the University of Vermont in the search for fungi and other pathogens infecting HWA that might eventually be manipulated as part of an overall biological control program.

Tim Tigner (804) 977-1375 x3360 or email: tignert@hq.forestry.state.va.us

Southern Help: Matthew S. Wallace and Fred P. Hain, at North Carolina State University, are currently searching for potential natural enemies in the southern range of HWA. The objective for the 1997 field season was to determine the status of natural enemies of the hemlock woolly adelgid and the effect of these enemies, if present, on adelgid populations. This was done in two ways: (1) by sampling natural enemies in the lower and mid canopy of hemlock trees and (2) by conducting predator exclusion cage experiments to determine predation effects on adelgid survivorship. Our research plots were at Hanging Rock State Park, Stokes County, in northern North Carolina, and Jefferson National Forest, Lexington and Botetourt Counties in Southwestern Virginia. Preliminary results show moderate predation effects on HWA in the Virginia plots. In the future we hope to rear predators of HWA in preparation for possible augmentative release and to repeat our predator exclusion cage experiments.

Fred Hain (919) 515-3804; fax (919) 515-7273; or email: fred_hain@ncsu.edu

ECOSYSTEM IMPACTS

New Jersey Impact Plots: The Phillip Alampi Beneficial Insect Laboratory continued to monitor the study plots set up in 1988. The plots that have a series of years where the HWA population was heavy are the plots that have the lowest crown ratios, lowest crown densities and the highest transparencies. Hemlock stands that have had HWA the longest are the stands that have the poorest health in New Jersey.

As of 1996, the plots that have had a heavy HWA population in them the longest have the greatest mortality. In the lightly infested stands, overall stand mortality averages 5.3 percent while stands that have had a heavy HWA infestation (>30 adelgids/100 needles) since 1988, the mortality averages 53.4 percent and ranges upwards to 85.8 percent.

Other factors contributed to the death of the trees but the one that stands out consistently is the presence of a heavy HWA population. Heavily infested plots with the highest mortality are on a ridge or xeric sites. On comparable sites that are lightly infested, hemlock mortality is low.

Mark Mayer (609) 530-4192

Effects of Hemlock Woolly Adelgid (*Adelges tsugae* Annand) Infestation on Nutrient Cycling Rates in Eastern Hemlock (*Tsuga canadensis* (L.) Carr.) Forests: In this study, we are quantifying changes in forest ecosystem processes (namely N cycling and aboveground net primary productivity (ANPP)) induced by adelgid infestation, hemlock mortality, and seedling regeneration. As forest regeneration proceeds following adelgid-induced hemlock mortality, we predict that N cycling rates will accelerate.

In order to quantify these changes in nutrient cycling rates, in the spring of 1996 we worked with D. Orwig and D. Foster at the Harvard Forest to identify six formerly hemlock-dominated sites in Connecticut and at the Harvard Forest. These sites span a continuum from 0 percent to 100 percent hemlock mortality. Currently, we have completed a full year of N mineralization and ANPP measurements; additional measurement variables have included soil %C and %N, soil pH, and soil texture. Measurements of soil moisture, light availability, and soil temperature were also made in order to quantify microenvironmental changes due to hemlock mortality.

Preliminary data suggest that: 1) N mineralization and nitrification rates do accelerate with hemlock mortality; 2) the presence of earthworms may further accelerate nutrient cycling rates; and 3) there is great potential for nitrate leaching to ground- and stream water in heavily impacted stands. Future research will be focused in two directions: 1) quantifying the relationships between overstory composition, seedling regeneration, ANPP, and nutrient cycling rates; and 2) continued monitoring of ecosystem processes at additional infested and uninfested stands in collaboration with D. Orwig and D. Foster at the Harvard Forest (Petersham, MA).

Jennifer Jenkins (603) 862-2264 or email: jen.jenkins@unh.edu

Soil Water Chemistry Impacts: During the next two years, ecologists at the State University of New York - College of Environmental Science and Forestry (Syracuse, NY) will be monitoring the effects of overstory mortality and deer herbivory on soil water chemistry in hemlock stands. Tension lysimeters have been installed in four hemlock stands in the Catskill Mountains (southeast NY). Soil water samples are being collected monthly and analyzed for nitrogen (nitrate, ammonium, dissolved organic nitrogen), sulfate, phosphate, chloride, calcium, aluminum, potassium, magnesium, and sodium. After baseline data have been collected, deer exclosures will be installed around half of each of the four plots. Hemlock trees in two of the plots will be girdled, causing overstory mortality. Effects of overstory mortality and deer herbivory on soil water chemistry will be directly evaluated by comparing pretreatment and control data to post-treatment data. Potential effects of hemlock woolly adelgid infestation on soil water chemistry will also be indirectly evaluated.

Thad Yorks, Don Leopold, Dudley Raynal (315) 670-6760 or email: teyorks@mailbox.syr.edu or dendro@mailbox.syr.edu or djr@mailbox.syr.edu

Hemlock Health: Researchers at the Forest Service Center for Forest Health Research in Hamden, CT, and at the University of Connecticut have used remote sensing to classify the health condition of stands of eastern hemlock in the lower Connecticut River Basin, and have used ground truth data to confirm (with 82.1% accuracy) the classification of hemlock trees and stands into four levels of tree vigor. While there has been a general decline in hemlock health between 1985 and 1995 throughout much of this region, there have been substantially different patterns of change in specific locations in the study area. Some sites are showing of recovery, while others have been devastated.

Available data on elevation and soils were compared with our raster-based map of hemlock health, and several landscape features were found to have a statistically significant affect on the distribution of hemlock health. These features include aspect of slope, hydrology group (infiltration rate), depth to bedrock, soil order, drainage class (hydraulic conductivity), and surface texture. Forty-five research plots have been established within the region (Devil's Hopyard, Burnham Brook, Selden Neck, and Salmon River), and we are in the process of determining those specific biotic and abiotic factors that contribute to decline and to recovery.

Kathleen Shields (203) 230-4320 or email: kss4501@aol.com

Ecosystem Biodiversity: The National Park Service, the U.S. Geological Service's Biological Resources Division, and The Pennsylvania State University have begun year two of a study to ascertain landscape attributes of hemlock stands and to assess biological diversity of these stands at Delaware Water Gap National Recreation Area (DEWA) and Shenandoah National Park (SHEN). The study at DEWA will focus on aquatic ecosystems, while the SHEN study will focus on the terrestrial ecosystems. During year one of this project, Geographic Information System (GIS) methods were used to tabulate landscape attributes generated from a 1:24,000 digital elevation model (USGS topography). Topographic types included: 1) bench hemlock stands, 2) ravine hemlock stands, and 3) mid-slope hemlock stands. Landscape attributes used for classifying and clustering hemlock stands included: elevation, percent slope, aspect, and terrain shape. Hemlock stands in each topographic type were then paired with non-hemlock forest stands using multivariate distance based on similar landscape attributes. This paired approach will be used to compare the biodiversity of hemlock stands to non-hemlock forest stands with similar physical landscape attributes. In addition, landscape attributes of hemlock stands may be used to predict the susceptibility of hemlock stands to hemlock woolly adelgid infestations.

Aquatic marcorinvertebrate sampling was conducted at 28 hemlock and non-hemlock forest stands (14 pairs of stands) at DEWA during April 1997. Fish sampling will be conducted at DEWA during July 1997. At SHEN, biodiversity sampling of several terrestrial taxonomic groups (invertebrates, vertebrates, and plants) will be conducted during August 1997.

Kristi Sullivan (814) 863-1904 or email: kxy101@psu.edu

Forest Impacts: David Orwig and David Foster of Harvard Forest in Petersham, Massachusetts, continued their study on the effects of HWA on stand, landscape, and ecosystem dynamics in southern New England. They have obtained three years of funding from USDA to continue and expand the scope of our study. Within a 6000 km² transect extending through Connecticut from Long Island Sound to the Massachusetts border, they have mapped all hemlock stands >3 ha in size using black and white aerial photos and have incorporated this information into a GIS system with overlays of edaphic, topographic, and biological factors for a landscape analysis of hemlock distribution, extent of damage and mortality, and pattern of HWA spread. Stand-level analysis of vegetation, soil and

site factors, forest development, and history will be evaluated in a sub-set of these stands across the region to evaluate the initial environmental and regenerative response to varying degrees of hemlock mortality. In addition, they will be collaborating with Dr. John Aber and Jen Jenkins at the University of New Hampshire to examine the response of ecosystem processes including nitrogen mineralization and decomposition rates in forests impacted by HWA. This approach will allow them to assess the importance of local to landscape factors on both infestations/mortality and forest response.

The initial stand-level results will soon be published in the Journal of the Torrey Botanical Society ("Forest response to the introduced hemlock woolly adelgid in southern New England, USA", Orwig and Foster 1997).

David Orwig (508) 724-3302 x250 or email: orwig@fas.harvard.edu

OTHER ACTIVITIES OF INTEREST

West Virginia HWA News: The 1997 season is underway and we are conducting detection surveys in all counties where HWA has not been recorded. We plan to check at least two sites per county except in those counties adjacent to positive HWA counties, where we want to check as many sites as time permits. So far this season, we have two new county records; Jefferson and Berkeley County on June 4. Permanent plot data was collected the week of June 23-27. Study plots are located at Blackwater Falls State Park, Cathedral State Park and Greenland Gap.

Sherri Hutchinson (304) 558-2212 or via e-mail at hutchins@wvlc.wvnet.edu

USDA APHIS Offers Assistance on HWA Biocontrol: The Niles Plant Protection Center is a laboratory of the USDA Animal & Plant Health Inspection Service (APHIS), Plant Protection & Quarantine (PPQ) and located in Niles, Michigan. The Center staff includes degreed scientists, technical support personnel and biological aides, all with years of experience in conducting laboratory and field-based activities. Our specialty is planning and implementing multi-state biological control projects in cooperation with partners from federal and state agencies, universities and the private sector. In general terms, Niles Center staff can provide a number of support activities, as follows: Assist in design and implementation of biological control activities in the field and laboratory, rear and ship exotic natural enemies, develop survey and sample processing techniques, process survey samples and identify organisms, develop techniques for rearing, releasing and evaluating biocontrol organisms, design and fabricate field equipment, develop information for environmental assessments, obtain interstate shipment and release permits, promote communication between cooperating agencies, provide training, and conduct technology transfer. As reported in this HWA newsletter, the involved specialists are currently importing promising HWA natural enemies or evaluating those that are already in the country. As this effort continues, we could assist in several specific areas: 1) Assist with pre-release surveys, 2) provide rearing support for states or researchers that do not have production capabilities, 3) conduct biological studies and laboratory assessments of newly imported natural enemies, 4) obtain information for preparing environmental assessments and securing permits. We welcome your requests for cooperative activities and are prepared to assist where appropriate. Please contact us to discuss your ideas and needs. Learn more about the Niles Center by viewing our web page on the internet: <http://www.aphis.usda.gov/ppg/niles>.

David Prokrym (616) 683-3563 or via e-mail at [!a348bcniles@attmail.com](mailto:a348bcniles@attmail.com)

HWA Life History Model: Hemlock woolly adelgid (HWA) life stages were sampled continuously from 1994 to 1996 in eastern hemlock (*Tsuga canadensis*) stands in southwest Virginia. The objective was to compare life stage durations and mortality from observations previously made in Connecticut. A stage-frequency model was developed to help quantify these estimates. The models estimates followed the true data closely, justifying its use for other life stage parameter estimates. Timing and durations of the different life stages did not vary much between CT and VA. Through two years, a decline in sistens populations results from declining health of the hemlock hosts. Density-dependence was observed. Egg densities appear to be directly related to adult survival in sistens, yet inversely related to adult survival of progrediens. Fecundity for sistens and progrediens appear inversely related to adult survival. High mortality of 1994 sistens eggs was probably temperature related while high mortality of 1st instar sistens in 1994 and 1995 were likely a result of poor host tree conditions.

Scott Salom (540) 231-2794 or via e-mail at salom@vt.edu

PUBLICATIONS AND PAPERS

Publication: McClure, M.S., Salom, S.M., and K.S. Shields. 1996. Hemlock Woolly Adelgid. USDA Forest Service, FHTET-96-35. This publication contains information on the importance of hemlocks in eastern forest ecosystems, and hosts, life cycles, control and population trends of HWA. Great photos!

Dick Reardon (304) 285-1566 or email: rreardon@mserv.fsl.wvnet.edu

Paper: W.Blozan, 1997. Eastern hemlock in the Southern Appalachians: An overview and research opportunities. Topic presented at Fourth Conference: Ancient Eastern Old Growth Forests. Pattern, Process, Value, Management. Clarion University, Clarion, PA. This paper is loaded with facts about old growth eastern hemlocks and importance of preserving the undisturbed forest dynamics in these ecosystems.

Will Blozan (423) 436-1264