NEW JERSEY DEPARTMENT OF AGRICULTURE

Funding PropoProject Status: New, not previously funded.

Project Number: NA-1998-01

Project Title: *Development of Efficient Rearing Techniques and Evaluation of*

Subject: Rearing of Hemlock Woolly Adelgid Predator, *P. tsugae*

Objective:

Develop an efficient, laboratory rearing procedures to expedite the release of sufficient numbers of *P. tsugae* for inoculation of hemlock woolly adelgid infestations throughout the East.

Project Description:

This project will have two primary phases. The first phase of the project will be to develop efficient rearing techniques to maximize production of *P. tsugae*. The second phase of this project will be to begin inoculating HWA-infested areas in an attempt to establish this predator beetle and reduce the impact of HWA.

FHP Lead Person: Brad Onken, Entomologist, FHP, Northeastern Area

Justification:

There is no effective chemical means of control of HWA in natural hemlock stands. Most research scientists and forest health protection specialists agree that biological control, the use of beneficial insects and pathogens, may be the only effective method to control HWA in natural hemlock stands. As such, the HWA Working Group identified biological control efforts as the highest priority. At present, *P tsugae,* has been approved for release and has been evaluated by the CT Agriculture Experiment Station for its potential use as a biological control agent. At this point, it's the rearing technology that needs to be refined for production and release to control HWA. Currently, it is both labor intensive and expensive. With over thirty years of insect rearing experience, the NJDA has a state-of-the-art insect rearing facility, that has mass produced over fifty different species of insects, and have released millions of beneficial insects throughout the northeast. The NJDA has the expertise and equipment to develop more efficient methods of production, making the program cost effective and resulting in more predators available for release over a larger area of the region.

Urgency:

The HWA is an exotic insect pest that currently threatens hemlock forests in 11 eastern states from North Carolina to Massachusetts. Hosts of the HWA include both eastern and Carolina hemlock (*Tsugae canadensis, T. caroliniana*). To date, approximately 25 percent of the 1.3 million hectares of host types has been infested (Rhea, 1996). In the past five years, HWA caused tree mortality and decline has been reported in NJ, PA, NY, CT, RI and VA. The HWA is currently the number one forest pest in many Northeastern states and recently has been identified at a workshop on exotic pests in the Southern Appalachian region as the number one exotic organism that poses the greatest threat to southern forests.

Hemlocks are a critical component of many unique ecosystems and occur on a diverse range of sites. Hemlock is an important cover species for ruffed grouse, turkey, and snowshoe hare and the foliage provides a suitable forage and habitat for deer, particularly in the winter (Quimby, 1996). Lapin (1994) discusses the importance of hemlock ecosystems to birds, fish, invertebrates, amphibians, reptiles, mammals, as well as Threatened and Endangered species and communities. Benzinger (1994) identified three bird species that appear to be obligates, including the black-throated green warbler, the solitary vireo, and the northern goshawk. Brook trout are found more commonly in streams associated with hemlock ecosystems because of the cooling effect of the hemlock canopy. Studies conducted at the Delaware Water Gap National Recreation Area in northeastern PA, demonstrated that summer stream temperatures were consistently 3-4° C. cooler at the lower end of a hemlock ravine than the upper end (Evans, et al., 1996).

Beyond the ecological values, hemlock trees and forests are very important aesthetically and for their recreational appeal. Numerous state and federal parks throughout the East are intrinsically associated with hemlock forests including such places as Cathedral State Park in WV, Delaware Water Gap National Recreation Area in PA/NJ, and Gillette Castle Park in CT. The eastern hemlock also happens to be the Pennsylvania State Tree.

As a timber species, the economic value of hemlock is quite variable but in PA, hemlock sawlog volume is twice the volume of white pine (Quimby, 1996).

Although chemicals are effective at controlling HWA in the landscape, protection of forest stands is not possible to achieve because drenching coverage is required and therefore impractical using aerial applications. Classical biological control is the only feasible method in forest settings.
Several state and federal parks including Sparta Glenn in NJ, Gillette Castle Park in CT and the Shenandoah National Park in VA have already experienced greater than 90 percent tree decline and mortality on their hemlock resource. Without a complement of biological control agents to control HWA populations, similar events are likely to occur throughout the range of eastern hemlock.

Link to National FHP Technology Development Priorities:

This project is directly linked to the overall strategy of the HWA Working Group. Although this Group has no national recognition, it is multi-regional and consists of research scientists, forest health specialists and resource managers from various state and federal agencies and universities. Furthermore, this proposal is directly linked to one of the four national priorities established by regional directors relevant to the control of non-indigenous forest pests.

Scope of Application:

The HWA is a multi-region problem and is currently affecting Region 8 and the Northeastern Area. The adelgid has the potential to infest the entire range of eastern and Carolina hemlock. Eastern hemlock occurs in an ornamental or forested situation in 21 states. Carolina hemlock is a rare species and only occurs in five states. The benefits from this project will be used throughout this range and begin in 1998.

Research Basis:

Dr. Mark McClure has been laboratory rearing *P. tsugae* since 1994 and initiated field releases in 1995 to expand his studies on the beetle predator. In his report to cooperators, at the meeting held in October 1997 at Windsor Locks, CT, he stated that current rearing methodology is labor intensive but that it is possible to improve rearing efficiency. Dr. McClure's observations at the release sites have confirmed the predators ability to overwinter under extremely cold conditions that occurred in the winter of 1995-96 as well as during a reasonably mild winter that occurred in 1996-97. He has confirmed establishment and documented dispersal. He has also observed a reduction in HWA populations as compared to the control trees which did not have *P tsugae* present. This insect holds great potential as a control against the spread of HWA. Dr. McClure and his staff have published 36 articles relating to HWA and these relevant works on *P. tsugae* are incorporated in the literature citations of this proposal.

Methods:

With a stock of over 600 *P. tsugae* beetles currently in place and eggs being laid, it will be possible to further develop and enhance the existing mass rearing technique. A selected number of male and female *P. tsugae* will be placed in rearing containers and placed in environmental growth chambers. The performance of the predators will be evaluated as we modify the conditions within certain containers. By separating small numbers of the beetles into individual containers, the chances of spreading contamination or developing a situation conducive to an epizootic are greatly reduced. During the October-January period of HWA development, we will be observing beetle behavior and their response to the various stages of the adelgid. An attempt will be made to determine if one stage of the adelgid is more conducive to promoting predator egg production than another. As beetle production, during the egg laying period of HWA, increases and more beetles become available, additional modifications in rearing technique can be evaluated in an effort to further increase efficiency. In addition to HWA infested hemlock sprigs, production containers will be supplied with various food supplements to determine if these additional nutritional sources effect longevity, performance, and/or reproductive capacity. The number of beetles visiting the supplements and the duration of time spent on the supplements will be one parameter used to evaluate beetle preference.

Since the NJDA has environmental chambers available for use, storage techniques will be evaluated. Various stages of both the host and predator will be exposed to distinctive temperature and photoperiod regimes in an effort to identify conditions which can be used to extend the life of the species, allow for stockpiling of the predator for spring release, allow for the stockpiling of host material for use when an increase in production is required, allow for more efficient use of available personnel and extend the active stage of HWA in an effort to lengthen the reproductive period of the predator.

In addition, it is known that *P. tsugae* will feed on other adelgid species. As these species become available in the field, a search for a species which is active throughout the summer will ensue. Since *P. tsugae* does not reproduce during the estivation period of HWA, an alternate host which is active during the this period may induce the predator to remain active and reproduce.

Host handling techniques is also a subject for scrutinization. Existing rearing methodology involves the use of field collected host material, and a considerable amount of time must be spent inspecting infested branches for native predators which, if not removed, will feed on the beetle population once introduced into the rearing cages. Since we have space available to maintain a large number of hemlock seedlings, an attempt to establish a laboratory host colony on hemlock seedlings is planned. A laboratory host colony will eliminate the need for field collected host material which will save time and the risk involved with their use.

P. tsugae and host material will be randomly collected in an effort to monitor predator sex ratios and eggs/ mass of HWA. Periodically, samples of dead beetles will be inspected for pathogens which may have been instrumental in causing the beetle's demise. In addition, since small numbers of predators will be contained in separate rearing containers it will be possible to monitor egg production, viability, longevity, effects of temperature, humidity and photoperiod variations on host and predator as well as other parameters which can be used to select the most efficient methods for production.

Measure of Success:

Year 1: •Determine optimal environmental conditions (temperature, humidity and photoperiod) necessary to maximize reproduction of *P. tsugae*.

•Determine if any particular life stage of HWA enhances fecundity of *P. tsugae.*

•Begin evaluation of various food supplements to determine if these additional nutritional sources effect longevity, performance, and/or reproductive capacity of *P. tsugae*.

•Begin predator/prey storage technique evaluation.

•Initiate a search and evaluate the suitability of other adelgid species as an alternate food source for *P. tsugae*.

•Establish a laboratory host colony on seedlings.

•Begin to release *P. tsugae* in at least one site in NJ and monitor its establishment and impacts.

Year 2: •Complete evaluation of food supplements.

•Complete evaluation of predator/prey storage technique.

•Complete alternate species of adelgid food source evaluation.

•Provide sufficient quantities of *P. tsugae* to other state and federal cooperators to begin establishment in other HWA infested areas.

•Provide evaluation results and optimum rearing methodology to other state and federal rearing facilities as requested.

Cooperators:

Dr. Mark McClure of the Connecticut Agriculture Experiment Station is credited for finding and evaluating this Japanese beetle predator as a biological control agent for the HWA. Dr. McClure will be available for consultation on an as-needed basis as we pursue this project.

George Koeck, a NJ State Forester, will assist in locating HWA and alternate host collection sites. Time involved will be minimal since these tasks can be accomplished in conjunction with assigned daily activities.

Dr. Scott Salom of Virginia Polytechnic Institute and State University, Department of Entomology, VA will be cooperating on exploring methods of limiting the duration of HWA aestivation periods. Dr. Salom will be available on an as-needed basis.

Products: This project will provide *Pseudoscymnus tsugae* to reduce the impacts of HWA on hemlock and refine existing rearing techniques and make available for use by other coccinelid rearing facilities.

Publications: Results will be reported through workshops and training sessions and the NJDA annual program report. A methods manual will be prepared on rearing, storage and handling procedures and made available to other rearing facilities and state cooperators interested in rearing this HWA predator.

Technology Transfer:

All technological advances made as a result of this project will be made available to any state, federal or private rearing facility that wishes to capitalize on our accomplishments. Much of the methodology rearing *P. tsugae* could also be applicable to other predator beetles being screened and evaluated for use as a biological control agent.

Project Duration: This project duration is two years.

Long Term Budget:

For the NJDA to maximize its efforts in developing rearing techniques, an additional full time hourly employee, supplies and technical support from the NJDA staff will be required. The funding required of FHP is **$25,000** for FY 98 and **$36,000** for FY 99.

The NJDA will provide the balance of funds in the amount of **$85,000** for the period beginning January 21, 1998 and ending September 30, 1998. An additional year, FY99, will be required for evaluation of rearing techniques at a cost to NJDA of **$90,000**. These costs are above and beyond the costs of equipment and operational expenses of which the NJDA will absorb.

FY 1998 Budget Request:

	Item	FHP	NJDA
Salary:	Biological Aid	--	$13,000
	Senior Lab Tech.	$19,000	$ 5,500
	Lab Technician	--	$10,500
	Principal Tech.	--	$31,500
	Research Scientist	--	$17,700
	Supervising Ent	$ 2,500	--
	Clerical	--	$ 6,800
Travel:	Attend Mtngs. & CMP charges	$ 500	--
Supplies:		$ 500	--
Indirect Cost -11.09%:		$ 2,495	--
Total FY 1998 Request:		**$24,995**	$85,000

STDP PRODUCTION FUNCTION

Project Number: NA-98-??

Project Cost: $236,000

Project Objective:

The objective of this project is to develop an efficient, cost effective laboratory rearing procedure which will expedite the production of *P. tsugae* for inoculation of hemlock woolly adelgid infestations throughout the Northeast.

At present, there are no significant HWA biological control agents or communities of agents established in this country. As is often the case with adaptive exotic insect pest species, the lack of natural enemies permits the pest to flourish until the food source is exhausted. To reduce the impact on our hemlock forests from HWA, the establishment of proven biological control agents such as *P. tsugae* is our only option.

Assumptions:

The primary benefits used in this economic analysis calculation is based on only timber values. Although eastern hemlock is not a premier timber species, the overall threat to the resource is high enough to justify this project. In reality, most of the value in our hemlock resource is not quantifiable at this time. These intangible values include: aesthetics, recreation, and the ecological impacts that involve both wildlife and plant communities.

- The development of a more efficient method of rearing *P. tsugae* will lead to an increase in production and more expedient releases on a larger scale.

- Probability of *P. tsugae* regulating HWA below tree-killing levels is 0.20.

- It is assumed that there is no salvage logging of HWA-killed trees.

- The entire range of eastern hemlock species will be impacted within 30 years.

- Estimated loss of hemlocks once infested is 50 percent.

- Adequate numbers of beetles can be reared to initiate establishment within the range of HWA.

Background data:

- Number of hemlock hectares is 1.3 million.
- Approximately 325,000 hectares (25 percent) are currently infested.
- Total cubic foot volume of hemlock is 12 billion.
- Total cubic feet of hemlock per hectare is 9230.7
- Stumpage value per MCF of hemlock is $46.87.

These values are extrapolated from FIA data.

Calculations:

Expenditures and Output Values:

EOV without project = (325,000 hectares)*(50% loss of trees)*(9.2 MCF/hectare)* ($46.87 per MCF) = $70,070,650 = discounted to $21,604,182

EOV with project = (325,000 hectares)*(50% loss of trees)*9.2 MCF/hectare)*($46.87 per MCF)*(1.2; 20% probability of success) = $84,084,780 discounted to $25,925,019

Benefit Attributable to Project:
$25,925,019 - $21,604,182 = $4,320,837

Benefit/Cost Ratio:
$4,320,837/$236,000 = 18.3

Benefit Attributable to STDP Funds:
18.3*$61,000 STDP costs = $1,116,300

PNV of Project:
$4,320,837 - $236,000 = $4,084,837

PNV of STDP:
$1,116,300 - $61,000 = $1,055,300

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