Project Status: New, not previously funded.

Project Number: R8-98-01

Project Title: Evaluating the potential of native or established predators as biological control agents for hemlock woolly adelgid in eastern hemlock forests.

Subject: Exotic pests, Biological Control, Hemlock Woolly Adelgid, ”Adelges• ”tsugae• (Homoptera: Adelgidae), Eastern defoliators

Project Objectives:

1. Evaluate effectiveness, feeding preferences, feeding rates, and fecundity of ”Laricobius• ”nigrinus•, ”L•. ”rubidius•, ”L•. ”erichsonii• and ”Aphidecta• ”obliterata• on
hemlock woolly adelgid (HWA).

2. Determine synchrony of ”Laricobius• and ”Aphidecta• life stages with HWA.

3. Determine temperature and photoperiod conditions necessary to break aestival diapause of HWA that will allow for continuous rearing of the adelgids and their predators.

Project Description:

The project has two major facets:

1. Evaluate native or established beetle species for potential as biological control agents of HWA. ”Laricobius• spp. (Coleoptera: Derodontidae) are predators specific to ”Adelges• spp. Three species are currently established in North America, two are native and one introduced for the balsam woolly adelgid, ”Adelges• ”piceae•. Additionally, ”Aphidecta• ”obliterata• (Coleoptera: Coccinellidae), introduced for control of balsam woolly adelgid is also established in North America. These candidate predators will be evaluated for their potential as biological control agents for the hemlock woolly adelgid.

2. Develop a continuous rearing procedure for HWA that is not constrained by the 4 month long aestival diapause of 1st instar sistens nymphs. We have identified a temperature and photoperiod that allows 25 percent of the adelgids to continue development without going into diapause. This will be further investigated to obtain the highest percentage possible.

FHP Person Who Will Lead The Project: James R. Rhea, FHP, Asheville, NC.

Justification:

Natural enemies imported from Asia show promise as predators of HWA. We hypothesize that additional adelgid predators, either native or already established in North America, can result in greater reduction of HWA populations than any one species alone. It is possible that one or more of the species we propose to evaluate will be determined to be an effective biological control agent. Their strategic release may help reduce the devastating impact of the HWA.

Continuous rearing has proven difficult because of the 4 month aestival diapause of 1st instar sistens. This makes the intensive effort of rearing predators even more difficult. Thus, being able to break diapause in HWA sistens will improve the operational or augmentative aspect of any biological control product obtained.

Urgency:

The only practical option available for suppressing HWA populations in hemlock stands is the use of biological control agents. Without these efforts, hemlock stands will continue to die off and the insect will continue to spread unchecked throughout the range of eastern hemlock.

Link To National FHP Technology:

Development of strategies to reduce the impact of exotic pests is a high priority for the USDA Forest Service. In 1996, The Southern Appalachian Biological Control Initiative rated HWA as the No. 1 exotic pest threatening the southern Appalachians.

Scope of Application:

Predators determined to be effective enough to be considered for release should be available for use throughout the range of HWA (currently 25 percent of geographic range of eastern hemlock). Rearing of non-diapausing HWA will allow for continuous rearing of at least some of the predator candidates.

Research Basis:

Biological control appears to have strong potential for controlling hemlock woolly adelgid (HWA), ”Adelges• ”tsugae• Annand, populations in the eastern USA (HWA Working Group Strategic Planning Meeting, 1996). While most efforts have focused on importation and evaluation of exotic predators from Japan (Cheah and McClure 1996) and China (Mike Montgomery personal communication), some native or established predators of Homoptera may be suitable for control of the HWA (Montgomery and Lyons 1996). We intend to evaluate the potential of four species of Coleoptera (Derodontidae and Coccinellidae) predators as biological

control agents of the HWA. Three derondontid beetles to be evaluated are: (a) ”Laricobius• ”nigrinus•, found only on HWA in western hemlock forests (Lee Humble, personal communication); (b) a related species, ”L•. ”rubidius•, a predator of white pine adelgid; and (c) ”L•. ”erichsonii•, an introduced predator of the balsam woolly adelgid. Of these species, ”L•. ”nigrinus• may have the best potential as a biological control agent, because it appears to be well synchronized to the HWA life cycle and is specific to the host (Lee Humble personal communication). One Coccinellid beetle to be evaluated is ”Aphidecta• ”obliterata•, an introduced predator of BWA, occasionally found feeding on HWA in British Columbia (Humble 1994).

The lab at Virginia Tech University has been studying the effect of temperature and photoperiod on life stage development and initiation and duration of diapause of the HWA. After one season of testing, we have determined that HWA develops best under relatively cool temperatures 22¼oC. This is consistent with field observations that this insect appears to thrive under cool temperatures (McClure 1987, Gray and Salom 1996). They have also identified that 25 percent of the 1st instar sistens continue development without going into aestival diapause at 12¼oC and a 12:12 (L:D) photoperiod. At 17¼oC and the same photoperiod, no HWA avoided diapause, but its duration was reduced by 25 percent. In a concurrent test using the same temperatures under a 16:8 (L:D) photoperiod, the insects did not break diapause after 5 months. This suggests that both photoperiod and temperature play a role in inhibiting the occurrence and reducing the duration of aestival diapause in HWA.

Methods:
Two sets of evaluations will be conducted. The first set involves the quarantine evaluation of ”L•. ”nigrinus• and ”A•. ”obliterata•. We will travel to Victoria, British Columbia, and with the help of Dr. Lee Humble, will collect live ”A•. ”obliterata• and ”L•. ”nigrinus• and bring them back to Virginia Tech in early and possibly late spring, 1998 and 1999. Shipping permits have already been obtained. In addition there will be a laboratory evaluation of ”L•. ”rubidius• and ”L•. ”erichsonii•. Collections for these latter two species will be made in Virginia and North Carolina in late winter - early spring, 1998. Colonies of all species will be reared and laboratory evaluations of the two imported species will be conducted in the quarantine facility at Tech in 1998 and 1999. A consistent source of HWA is assured with our recent establishment of a sapling stage plantation plus hundreds of potted hemlock seedlings, all infested with HWA. Feeding rates, fecundity, host searching abilities, competition, and exclusion studies will be the principal focus of lab experiments. Compatibility of species that show the most promise in reducing HWA populations will be determined.

Upon completion of the quarantine evaluation of the two imported species, petition to APHIS for field release will be made of either species that show potential. The other species will be evaluated in infested hemlock stands.

Following these studies, candidate biological control agents should be available for limited release in hemlock stands infested with HWA. Success at this level would eventually lead to a more widespread release of the predator, after rearing of sufficient numbers can be attained.

In the second set of evaluations, 12 hemlock seedlings, containing HWA progredien adults will be placed in each environmental chamber maintained at one of three L:D photoperiods (8:16, 10:14, and 12:12) and three constant temperatures (12, 14, and 16 C). Thus, with a factorial approach, there will be 9 treatments. As soon as sistens begin settling at the base of the needles, developmental stage and mortality will be determined by destructively sampling the seedlings. Every 3.5 days a seedling from each treatment will be chosen randomly. Shoot tips will be cut from the seedling and examined under a microscope. Sampling for each seedling will be terminated after 100 live adelgids are observed. The level of infestation and the number of seedlings available will allow us to follow the adelgids through two sistens and one progrediens generation. The temperatures and photoperiods can be modified for the second sistens generation by fine tuning the environmental settings around the optimum temperature/photoperiod combination from the first sistens generation. These data will be summarized as frequency distributions since we can not follow individual adelgids through their life cycle. The environmental conditions which produce the lowest percentage of sistens going into diapause and the lowest level of mortality will be incorporated into a continuous rearing program that can be used for continuous rearing of predators.

Measure of Success:

The region should consider the project a success if: (1) at least one candidate predator from those evaluated becomes available for release, and (2) if we are able to bypass aestival diapause of HWA sistens and develop continuous rearing procedures that allow for continuous production of predators.

Cooperators:

Scott M. Salom and Loke T. Kok (Virginia Tech), Philip Eggborn (Virginia Dept. of Agric. and Consumer Services), Tim Tigner (Virginia Dept. of Forestry), and Lee Humble (Forestry Canada).

Products:

Predator(s) may be available for limited releases by the year 2000, and perhaps full scale releases 1 or 2 years later. A continuous rearing procedure could be ready by the end of 1999.

Publication:

Results will be reported in scientific journals and perhaps technical proceedings in the interim. The natural enemy evaluations may be published in either Entomophaga or Biological Control. The diapause study will likely be published in Environmental Entomology.

Technology Transfer:

Any insects available for release will be made available to state agricultural agencies and USDA Forest Service personnel for eventual release in the forest. The Virginia Department Of Agriculture and Consumer Services and Virginia Department of Forestry will assist us in evaluating the impact of the natural enemies. Rearing procedure can be described in detail in a Research Note produced by the USDA Forest Service.

Project Duration:

3 Years (1998-2000)

Long Term Budget Including FY 98:

Items	FY 1998		FY 1999		FY 2000	
	FHP	VA Tech	FHP	VA Tech	FHP	VA Tech
Salary	15,080	12,500	19,683	12,500	21,310	12,500
Equipment	9,000	9,000	4,500		0	
Materials & Supplies	6,420		6,300		7,500	
Subcontract	1,000		1,000		1,000	
Travel	3,500		3,500		4,000	
Indirect @14%	”	4,900		4,898		4,733•
Total	35,000	26,400	34,983	17,398	33,810	17,233

STDP Production Function

Project Number: R8-98-xx

Project Cost: $164,824

Project Objective:

This project will evaluate the feeding preference, feeding rates, synchrony, and fecundity of 4 native (naturalized) predator insects of hemlock woolly adelgid. The project will also develop continuous rearing methodologies for hemlock woolly adelgid. This will aid in the rearing of predators capable of significantly impacting adelgid populations. With this information mass rearing of one or more of these predators can begin.

Assumptions:

For the purposes of this analysis the value of eastern hemlock as a timber species will be utilized. This value is only a small part of the overall importance of eastern hemlock to the forests and landscapes of the eastern United States. Eastern hemlock has numerous values that are not quantifiable. These values include aesthetics, recreational, ornamental, and ecological.

The development of continuous rearing methods for hemlock woolly adelgid will increase the capacity to rear populations of predators for release.

The potential success of one or more of the predators being investigated at limiting adelgid impacts in a significant manner is 20 percent.

The entire range of eastern hemlock will be infested within 30 years.

Estimated loss of hemlocks once infested is conservatively 50 percent.

The mass rearing of one or more of the predator insects is possible and populations can be established within areas impacted by hemlock woolly adelgid.

Background Data:

Number of hemlock hectares is 1.3 million.

Approximately 325,000 hectares(25%) are currently infested.

Total cubic foot volume of hemlocks is 12 billion.

_Total cubic feet of hemlock per hectare is 9230.7

Stumpage value per MCF of hemlocks is $46.87

Data extrapolated from USDA-FSD-FIA reports

Calculations:

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

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

Benefit Attributed to Project:

25,925,019-21,604,182 = $4,320,837

Benefit/Cost Ratio:

4,320,837/164,824 = 26.2

Benefit Attributed to STDP Funds:
ÜŒ26.2*$103,793STDP costs = 2,719,376

PNV of Project:

$4,320,837 - $164,824 = 4,156,013

PNV of STDP:

$4,320,837 - $103,793 = $2,615,583

Literature, Citations, Attachments, etc.:

Cheah, C.A. and M.S. McClure. 1996. Exotic natural enemies of ”Adelges• ”tsugae• and their prospect for biological control. pp. 103-112. In Salom, S., T. Tigner, and R. Reardon (eds.). Proc. First Hemlock Woolly Adelgid Review. For. Health Tech. Enterp. Team Public. 96-10.

Gray, D.R. and S.M. Salom. 1996. Biology of hemlock woolly adelgid in the southern Appalachians. pp. 26-35. In Salom, S., T. Tigner, and R. Reardon (eds.). Proc. First Hemlock Woolly Adelgid Review. For. Health Tech. Enterp. Team Public. 96-10.

Humble, L.H. 1994. Recovery of additional exotic predators of balsam woolly adelgid, ”Adelges• ”piceae• (Ratzeburg) (Homoptera: Adelgidae), in British Columbia. Can. Ent. 126:1101-1103.

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