Mass Release and Recovery of *Cybocephalus nipponicus* (Coleoptera: Cybocephalidae) on Elongate Hemlock Scale, *Fiorinia externa.*

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Abstract

From 2000 to 2008, 339,050 *Cybocephalus nipponicus* were released into Elongate Hemlock Scale infested hemlock sites throughout NJ. In 2008 *C. nipponicus* was recovered at 58.5% of the hemlock sites surveyed in compared to just 20% of the sites surveyed in 2006 (the data from 2007 is not complete). *C. nipponicus* is definitely expanding its range throughout the state and increasing its population in NJ hemlock stands.

Introduction

The elongate hemlock scale (*Fiorinia externa* Ferris) (EHS) (Homoptera: Diaspididae) is a serious pest of eastern hemlock, *Tsuga canadensis* (L.) Carriere and was first discovered in New York City in 1908 (Sasscer 1912). It is found from Massachusetts to Virginia and west to Ohio (Kosztarab 1996). The EHS can kill hemlock trees over time and works synergistically with the hemlock woolly adelgid (HWA), *Adelges tsugae* (Homoptera: Adelgidae) to accelerate the decline of hemlock (McClure 2002). It has also been found to kill hemlocks after a heavy HWA infestation has passed through an area and then declined leaving trees with high *Fiorina* scale populations (Danoff-Burg and Bird 2002). The elongate hemlock scale has one generation per year in the northeastern United States (McClure 1978) and there are few North American biological control agents that are effective. *Aspidiophagus citrinus* Craw (Hymenoptera: Aphelinidae) and *Chilocorus kuwanae* Sylvestri (Coleoptera: Coccinellidae) were shown to be effective biological control agents in Japan and are present in the United States but their life cycles are asynchronous with *F. externa* in the US reducing their effectiveness (McClure 1986, 2002). In New Jersey, the coccinellid, *Chilocorus stigma* (Say) fills the same ecological niche as *C. kuwanae* but it is not as effective in suppressing the scale populations in most instances. *C. kuwanae* has been released and established in New Jersey but has never been recovered on hemlock by Phillip Alampi Beneficial Insect Laboratory staff. All *Chilocorus* species found on hemlock have been *C. stigma*. In New Jersey approximately 90% of the hemlock stands have been seriously impacted by the HWA and most of them also have an EHS infestation (Mayer et. al. 2002).

Since 1986, the Phillip Alampi Beneficial Insect Laboratory (PABIL) has been working with a predatory beetle, *Cybocephalus nipponicus* Enrody-Younga, (Coleoptera: Cybocephalidae) (Figure 1), a tiny exotic predatory beetle from China/Korea which has been effectively used as a biological control agent on the euonymus scale, *Unaspis euonymi* (Comstock) (Homoptera: Diaspididae). *C. nipponicus* is a predator on armored scales in the family Diaspididae and also feeds on San Jose scale, *Diaspidiotus perniciosus* (Comstock) and juniper scale *Carulaspis juniperi* (Bouche). The beetles were initially shipped to the PABIL from the USDA/APHIS/PPQ Laboratory in Niles, Michigan and were released on scale-infested euonymus plants. In 1994, the PABIL initiated a mass-rearing program in New Jersey that allowed the lab to substantially increase the numbers of *C. nipponicus* released and the number of release sites. All of the PABIL's rearing stock originated from Chinese collections while the beetles that were shipped to the PABIL for direct field release were of Korean origin.

In 1999, two occurrences heightened the laboratory's interest in *C. nipponicus* as a possible predator of the EHS. The first was that *C. nipponicus* was recovered from hemlock sites at Washington Crossing State Park and at the Freer Nature Preserve in Colts Neck, New

Jersey while field staff were surveying for the introduced predator of the hemlock woolly adelgid, *Sasajiscymnus tsugae*. The beetles were not released in those stands but were released on euonymus scale at three sites nearby the Freer Preserve in Monmouth County in 1996/1997 and in 1995 at one site near Washington Crossing SP. All of the release sites were within one mile of the hemlock stands. The recovery was originally thought to be a coincidence but the collection of the beetles on EHS in succeeding years at the Freer Preserve in Monmouth County and at other sites gave us an indication that the beetle may be dispersing onto and feeding on the EHS.

The second event was an inundative release of 300-400 *C. nipponicus* on the young scale-infested hemlock trees in the exterior hoop/shade-house/cold frame at the laboratory. The beetles rapidly reduced the *EHS* population and gave a strong indication that the beetles would feed on the EHS.

The genus *Cybocephalus* has recently been revised in North America by Smith and Cave (2006) resulting in the placement of the genus in its own family, the Cybocephalidae. Cybocephalus used to be in the Nitidulidae but there are sufficient morphological and behavioral differences to warrant the change in families. *Cybocephalus nipponicus* is now the official taxonomic name of the species and it is no longer *Cybocephalus sp. nr. nipponicus.*

Figure 1. *Cybocephalus nipponicus* male, female and larva

Materials and Methods

For release, the beetles were packed in Fonda® 8 oz. containers with excelsior, 500 beetles per container (Figure 2). At the release site the lid was removed and the containers and lids were placed into the branches of the tree. After five minutes, any remaining beetles in the containers were gently brushed out onto the infested branches using a soft, 1-inch camel hair paintbrush. Collections of *C. nipponicus* were made concurrently while surveying for the two HWA predators, *Sasajiscymnus tsugae* and *Scymnus sinuanodulus* by beating branches with a whiffle ball bat below which was placed a one meter square beating sheet (Figure 3). Any *C. nipponicus* recovered in the years after release were collected and brought up to the PABIL to confirm identification.

Figure 2. *C. nipponicus* dorsal view of male and release container

Figure 3. Sampling for *C. nipponicus*

From 2000 to 2008, 339,050 *C. nipponicus* were released into EHS infested hemlock sites throughout NJ (Table 1). Release sites where data were collected were found to have statistically significant fewer scales than the controls after inundative releases (Mayer et. al. 2005).

Table 1. Releases of *C. nipponicus* on Elongate Hemlock Scale in NJ

YEAR	Number	No. of Sites
2000	10,000	3
2001	3,750	1
2002	72,300	13
2003	41,500	5
2004	55,000	2
2005	74,500	28
2006	74,000	16
2007	9,000	5
2008	11,000	8
TOTAL	**339,050**	**81**

Unfortunately, due to budgetary, personnel and time constraints, no scale counts have been undertaken since 2005.

Results and Discussion

C. nipponicus has been established throughout New Jersey on euonymus by the PABIL and it has been observed feeding on juniper scale, *Carulaspis juniperi* Boche, pine needle scale, *Chionaspis pinifoliae* (Fitch) and San Jose scale, *Quadraspidiotus perniciosus* (Comstock). Smith and Cave (2006) list 14 species of armored scales that are fed upon by *C. nipponicus.*

The PABIL rears *C. nipponicus* on San Jose scale infested butternut squash and has released a total of 1,024,080 beetles in New Jersey since 1986. The beetle is found on almost every scale infested euonymus plant that is checked and is distributed throughout New Jersey (Matadha et. al. 2003). Van Driesche et. al. (1998) observed that *C. nipponicus* dispersed from the original release sites in New England.

C. nipponicus has considerably reduced euonymus scale, *U. euonymi* populations in landscapes in New Jersey reducing damage to the plants (Mayer et. al. 1995, Hudson et. al. 2001). The beetles tend to remain on the plants until the food source is exhausted, then disperse and return when the scale population has increased.

Since 1999 *C. nipponicus* has been increasingly found on hemlock, although in low numbers. Every year the number of recovery sites increase and this is expected to persist in the future (Figure 4). Unfortunately the data for 2007 are lost but in 2008, surveys were done at 43 of the 77 sites where HWA beneficials have been released, and *C. nipponicus* was recovered at 28 of them, which was twice the number of recoveries made in 2006.

Figure 4. *Cybocephalus nipponicus* Recoveries 1999-2008

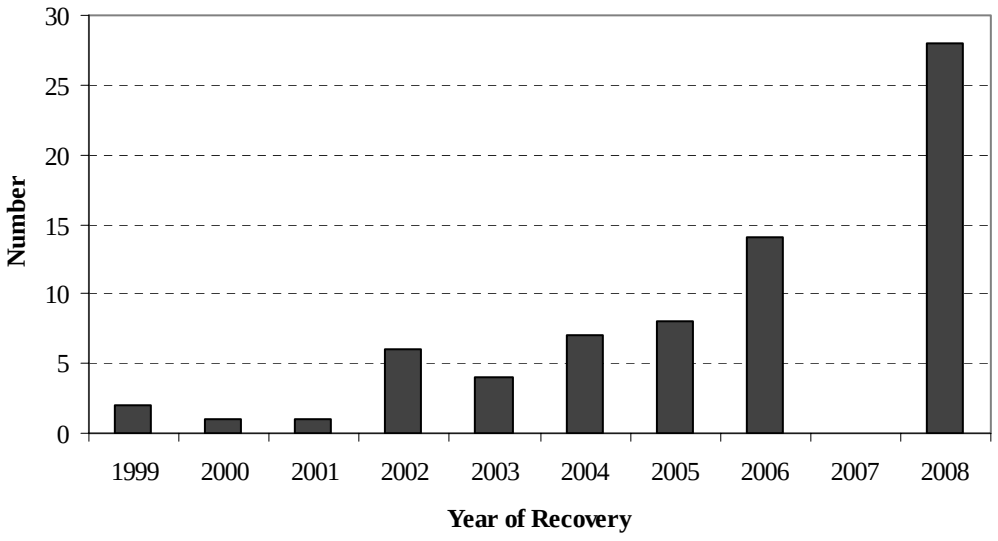
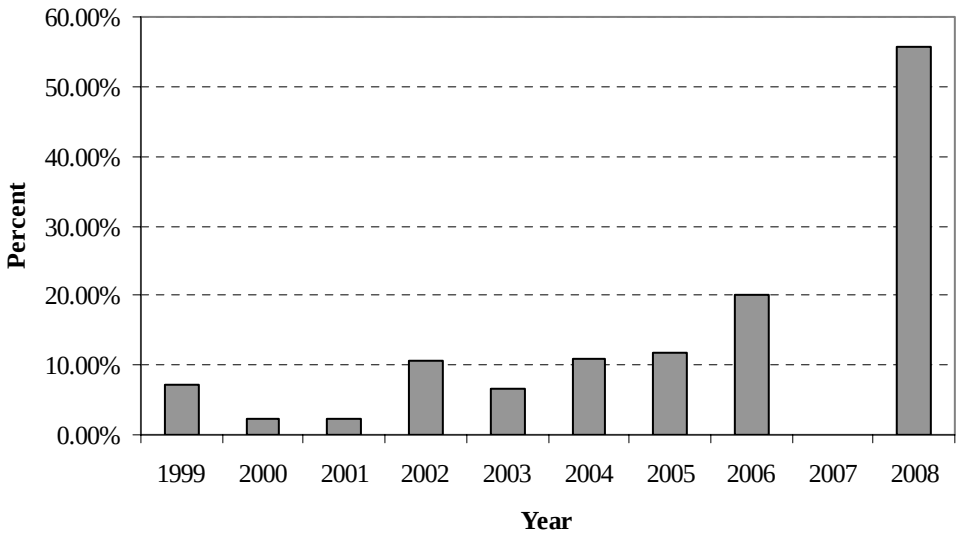


Figure 5 is more impressive when one calculates the percentage of surveyed hemlock sites with *C. nipponicus* recoveries. *C. nipponicus* was recovered at 58.5% of the sites surveyed in 2008 compared to just 20% of the sites surveyed in 2006. The overall recovery percentage of the sites has virtually tripled. *C. nipponicus* is definitely expanding its range throughout the state and increasing its population in hemlock stands.

Figure 5. *Cybocephalus nipponicus* Recoveries at % of Sites Surveyed



The objective of the project was to establish the beetles in EHS infested hemlock stands throughout New Jersey and it appears that the beetles are found in the majority of the sites.

Unquestionably, the beetles will feed upon and develop on EHS. There is the potential, then, for *C. nipponicus* to be a biological control agent but it stills remains to be seen whether *C. nipponicus* can be an effective control agent. *C. stigma*, a native coccinellid also feeds on the EHS, but it does not reach population levels sufficient to impact the scale, probably due to the dispersal of the insect as an adult. On beech scale, *Cryptococcus fagisuga*, *C. stigma* fed on the scale in all stages but readily dispersed in the adult stage (Mayer and Allen, 1983). *Chilocorus kuwanae*, an introduced coccinellid, may also have some potential, but PABIL personnel have never recovered it from EHS. *C. nipponicus* may be like *C. stigma*, where it feeds on the EHS but it may not attain sufficient numbers to control the scale. It will be some time before the full impact of the beetle can be demonstrated.

There is another species of *Cybocephalus* in the eastern United States, *Cybocephalus nigritulus* and it has been recovered from Pennsylvania, Massachusetts, and Rhode Island although there are no records from New Jersey or New York (Smith and Cave 2006). There are some antennal and male genitalia differences but the easiest way to differentiate between the species is to use male characters. The head and prothorax of male *C. nipponicus* are bicolored while male *C. nigritulus* are completely black (Smith and Cave 2006). None of the specimens recovered by the Phillip Alampi Beneficial Insect

Laboratory were determined to be *C. nigritulus.* Smith and Cave (2006) also have not recorded *C. nigritulus* as feeding on EHS.

Conclusion

Since 2000, the Phillip Alampi Beneficial Insect Laboratory has been making inundative trial releases of *C. nipponicus* onto *Fiorinia externa*. The beetles have established at 58.5% of the surveyed hemlock sites. *C. nipponicus* is expanding its range and population in the State of New Jersey.

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