The Killing Power of *Laricobius nigrinus* on hemlock woolly adelgid, *Adelges tsugae* Annand Populations.

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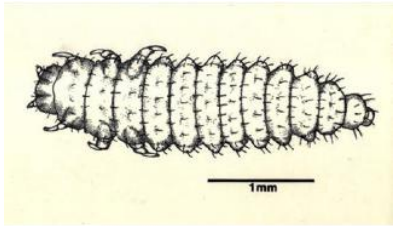
Hemlock woolly adelgid (HWA) Threshold Goal:**Once a hemlock has around 35% or so of needles infested – it grows normally! **

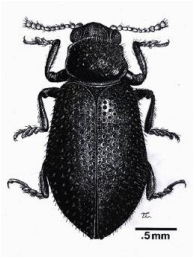
Background: The HWA is native to the Pacific Northwest of the USA, as well as the northern Pacific rim areas of China, Japan, and Taiwan. **A Japanese strain of the HWA was shipped into an arboretum in Richmond, Virginia during the 1950s or earlier, from HWA-infested Japanese weeping hemlocks (***Tsuga diversifola***) through the nursery trade.** Originally, the US Forest Service studied the HWA in Japan and China during the 1990s, and found that natural enemies, including winter and summer predatory beetles, hold the adelgid in check there. In 2006, DNA work was done on hemlock woolly adelgids from China, Japan, the East Coast, and the Pacific Northwest. The Pacific Northwest HWA was shown to be native to that region.

Native Winter- and Summer-active Predatory Beetles to Control HWA: Researchers found a native winter predatory beetle, *Laricobius nigrinus*, on western and mountain hemlocks, that emerges in October and feeds on the HWA during the winter & spring. This beetle is considered by most researchers to be a very effective predator of the HWA. The other predator to be found was the summer predatory ladybeetle, *Scymnus coniferarum*. Research is ongoing to make field releases of this beetle, since it was just approved for release in late 2012.



eats 235 HWA eggs/crawlers=

(needle duff) =



Laricobius nigrinus Larva Pupa Adult emerges mid-October

Every *Laricobius nigrinus* beetle represents between 220 – 250 HWA eggs eaten (ave. 235). *Critical for larva to have adequate needle duff to pupate in*. Larvae tunnel to the interface between needles and soil and pupate over the summer. If the hemlock does not have needle duff (rocky areas) then the summer predators dominate. We don't yet have effective summer predators yet as per our sampling. We find a very tiny amount of *Sasajiscymnus tsugae* on certain trees, not effective in our area.

Life History: Adult emerges in mid-October & eats 6 to 8 HWA per day (hemolymph (blood) feeder – vampire). Feeds until late April or so. Twenty weeks = 140 days; ½ are good weather (70 days X 7 HWA/day = 490 HWA prior to egg laying). Roughly 500 HWA killed; 250 HWA are killed prior to egg laying. Each female can lay between 200 and 400 eggs – 300 eggs average.

****300 times 235 eggs per larva = 70,500 eggs (HWA crawlers too) destroyed per ONE female! ****

Determining Predation rates for ***L. nigrinus*****: Optimum time is when redbud trees are in bloom**. Late March to Early April.

1. **Determine Average #Eggs/HWA Ovisac:** Dissect 30 to 50 ovisacs to get an average number of eggs per ovisac. This egg number is used to calculate how many ovisacs are destroyed by a single *L. nigrinus* larva & gives you your predation rate.
   a. Our average sistens egg count in the High Country is 23.6! Off the mountain the average is 100 or more. More HWA eggs per ovisac – trees die quicker. South needs help! 23.6 eggs per ovisac means the larva eats about a dozen ovisacs to complete development. Ovisacs with more than 100 eggs only need 2 to 3 ovisacs to complete development. At 23.6 eggs/ovisac - 1 egg per 12 ovisacs = 100% predation rate. At 100 eggs/ovisac – 1 egg per 2 to 3 ovisacs = 100%
2. **Count the number of Ln eggs/larva in the same ovisacs as encountered** – see Figures below.
3. **Multiply that number times 235 eggs eaten to get total eggs eaten**.
4. **Predation Rate is the # Eggs Eaten/Total # Eggs – see Table 1 and 2 below.**

Laricobius nigrinus egg (yellow) above a cluster of HWA eggs. (Photo: Mausel).

Table 1. Ovisac dissections at GGCC from 28 April '09 samples from second generation larvae. Four samples were taken on release trees. 235 HWA eggs must be consumed for a *L. nigrinus* larva to complete development. If there are 22.6 eggs/ovisac, each larva must consume 11 ovisacs or more. Based on our data, we were seeing collapsing HWA populations at the year old release sites.

Sample	**# L. nigrinus eggs/larvae**	**HWA Eggs Eaten (Ln x 235)**	**# Ovisacs**	**Total HWA Eggs**	**eggs/ovisac**	**Predation Rate Eaten/Total**
Walk bridge (#3 Green)	23	5405	130	2938	22.6	5405/2938 =184% 0 crawlers
105 Bushes (#6 Purple)	4	940	95	1862	19.6	940/1862 = 50.4 %
Crawford	13	3055	49	985	20.1	3055/985 = 310% 0 crawlers
#1 Green Lake	19	4465	159	3355	21.1	4465/3355= 133% 0 crawlers
Sums	**59**	**13865**	**433**	**9140**	**21.1**	**13865/9140=151%**

Table 2. HWA ovisac dissection and dispersal data from April 2010 *L. nigrinus* samples. Eight samples were taken from areas 500 yards or more from release sites. We dissected 664 ovisacs and found 41 *L. nigrinus* eggs or larvae. The **predation rate averaged 70.7%.** Each *L. nigrinus* larva eats 235 or more HWA eggs. We were seeing good dispersal to non-release trees, and predation rates on those trees were similar to those in Seattle after 3 years post beetle release.

Date	Site	#Ln	#Ln x 235 eggs eaten	#Ovisacs	# HWA eggs	Eggs/Ovisac	Predation Rate
7-Apr-10	#2Green	9	2115	125	2200	17.6	2115/2200=96.1%
14-Apr-10	Walkbridge#6	6	1410	67	1233	18.4	1410/1233=114%
17-Apr-10	Hole#10	2	470	39	488	12.5	470/488=96.30%
17-Apr-10	#4RedFlag	4	940	37	881	23.8	940/881=100.6%
30-Apr-10	105Bushes	5	1175	76	1778	23.4	1175/1778=66%
30-Apr	Walkbridge#6	3	705	70	1505	21.5	705/1505=46.8%
30-Apr-10	#2Green	8	1880	162	3694	22.8	1880/3694=50.9%
30-Apr-10	#1Lake	4	940	88	1848	21	940/1848=50.8%
Sum	**8 sites**	**41**	**9635**	**664**	**13627**	**20.5**	**9635/13627=70.7%**

Laricobius nigrinus larva inside HWA ovisac; a single larva consumes 220-250 eggs to complete development.

(Photo: Mausel)