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Frontline

Forestry Research Applications

Canadian Forest Service – Great Lakes Forestry Centre

Technical Note No. 116

Detection tools for an invasive adelgid

INTRODUCTION

Eastern hemlock (*Tsuga canadensis* (L.) Carrière) is a medium-sized tree that can attain heights of 30 m or more and live for up to 600 years in eastern Canada. Historically, hemlock bark has been used as a commercial source of tannin. Currently, a minor amount of hemlock is cut by the forest industry in Ontario (an average of approximately 13,000 m^3 per year from 2009 to 2013) and used for coarse or dimensional lumber. The most important non-timber value of eastern hemlock, especially where it comprises 50% or more of the mature trees in a stand, is its foundational role in the ecosystem. Foundational species create biological conditions that define and structure an ecosystem. Because of their affinity for cool, moist sites, hemlocks cast a deep shade that provides a unique habitat upon which several animals depend. The alien invasive hemlock woolly adelgid (*Adelges tsugae* Annand) (HWA) threatens this ecologically valuable tree species.

A general overview of HWA biology and a synopsis of its arrival, establishment and spread in eastern North America are presented in *Frontline Technical Note No. 114.* There are two stages in the life cycle of HWA that will be important to remember in this document: the ovisacs and the crawlers (Fig. 1). Ovisacs are woolly masses, up to 5 mm in diameter, created by the secretion of waxy threads from glands along the dorsal surface of the HWA. Most ovisacs can be found on current and one-year-old twigs and each can contain many eggs. Crawlers are first instar nymphs hatched from eggs and the only actively dispersing stage of HWA. Two generations of ovisacs and crawlers are produced each year. The first generation, called sistens, can be found on hemlock from June to March. The second generation, called progrediens, can be found on hemlock from March to June. Crawlers, and in some cases egg masses, are spread to other host trees by wind, rain, animal activity or humans. Spread may range from a few centimetres to several kilometres per year. A tree with high densities of HWA experiences distinctive changes, with crowns becoming progressively thinner due to needle loss and bud dieback. In addition, the crown turns from a healthy green colour to a gray- yellowish-green colour (Fig. 2). HWA can kill 90% or more of the hemlocks in a stand. This mortality can happen in as little as 4 years but can take 10 years or more in the northern part of HWA's range.

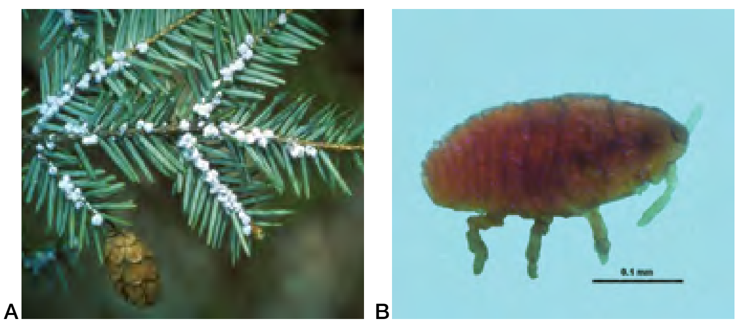

Figure 1. A) High density of HWA ovisacs of (sistens or progridiens) on 1-year-old hemlock twigs (Photo: Connecticut Agricultural Experiment Station Archive). B) Example of 1st instar HWA nymph (crawler) caught on sticky traps (Photo: Gene Jones).

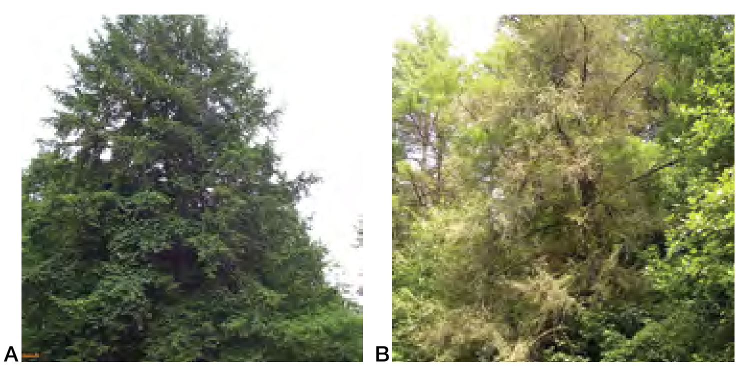

Figure 2. A) Green colour of healthy eastern hemlock (Photo: Tom McAvoy). B) Discoloured (gray to yellowish-green) hemlock infested by HWA (Photo: James Johnson).

HWA now infests all five American states (Maine, New Hampshire, Vermont, New York and Michigan) that share a border with eastern Canadian provinces. The Canadian Food Inspection Agency (CFIA) reported the detection of infested trees in Mississauga (2012) and in the Niagara Gorge from 2013 to 2015. In each case, the trees were removed (destroyed) within weeks of their discovery. However, the proximity of infestations in states bordering Canada means that these discoveries are unlikely to remain isolated occurrences: indeed, new arrivals are almost certain in the future. Thus, it is vital that an analysis be conducted to identify values-at-risk and likely pathways of HWA arrival into eastern Canada. Simultaneously, it will be important to possess tools that facilitate detection and delineation of new infestations.

HWA survey: advantages and limitations

Since 2007, the CFIA has used a ground-based detection survey modified from that of Costa and Onken (2006). This stand-based survey consists of examining foliage from the ground by visual assessment (naked eye, binoculars) along a pre-specified path in hemlock stands. Inspectors are asked to inspect two branches per tree until an infested tree is found or the maximum number (100) of negative trees has been examined, whichever occurs first. This level of sampling is sufficient to detect an infestation where 1-2% of the hemlock trees are infested (1-4 trees per hectare). The advantages of this survey are that very little equipment is required and it is relatively rapid, as several trees can be quickly examined visually within a relatively short time. However, this survey was not designed to be used as an HWA detection survey. Moreover, this survey is limited to foliage within 6 m of the ground. Detecting light HWA populations above this height is extremely difficult to accomplish and an infestation high in the crown of a tall tree may go unnoticed for several years. Meanwhile, the infestation can spread to neighbouring trees and stands.

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Current research efforts (in partnership with colleagues at Cornell University) are focussed on the development of tools to improve the detection and delimitation of HWA infestations. Two approaches to sampling populations are being developed, both of which offer the possibility of detecting HWA throughout the crown of a tree, irrespective of its height. Wool or Ball Sampling is an active technique that targets the ovisacs and has the surveyor deploy a launcher to take samples from high in the crown. Crawler Sampling is a passive sampling technique that involves setting up a sticky trap under a tree for HWA crawlers to land on.

Wool or ball sampling

This method consists of launching Velcro®-covered racquetballs with a sling shot (Hyperdog™ ball launcher) (Fig. 3) into tree crowns to snag HWA wool. Narrow strips of a fixed length of Velcro® (hook-side out) are glued onto each ball. Strips are spaced uniformly around each ball to ensure consistent flight. With this method it is possible to launch balls higher than 40 m and reach the tops of tall hemlocks.


A B

Figure 3. A) The Hyperdog™ ball launcher used in ball sampling with three Velcro®- covered racquet balls. B) Launching balls into the crown of hemlock (Photos: Jeffrey Fidgen).

Recommended Protocol: The first step is for surveyors to develop the proper search image for HWA wool, as occasionally, spider egg sacs or webbing from caterpillars caught on Velcro® can be confused with HWA wool. Adelgid wool is bright white, pliable and fluffy, and may contain a brownish-black nymph or an adult that may have orange-brown eggs and/ or light brown crawlers and cast nymphal skins with it (Fig. 4). Obtain samples of dead HWA ovisacs and compare them with spider eggs sacs or webbing from caterpillars. Apply both these to the Velcro® and learn to distinguish them from HWA wool.

Although wool sampling can be carried out at any time, it is most effective from late April to early July, when HWA wool is most conspicuous and abundant. We recommend surveyors target a different section of the middle and upper portion of the tree with each sample for good coverage of the crown. It is important that each ball sample contacts the outermost 40 cm of several branch tips as it ascends the edge of the crown, where HWA wool tends to be concentrated. A new ball should be used for sampling each tree or each group of trees with intermingled branches. It is important that balls used on HWA-infested trees are not used to sample another tree that may not be infested to prevent the spread of HWA. Between samples on a tree, balls may need to be cleaned of debris with a medium bristle tooth brush. After use, balls can be soaked in hot soapy water and any remaining debris removed with a medium bristle brush; allow balls to air dry before re-using.

Our research suggests that in most instances it will take less than 10 samples per tree to detect a low level of HWA infestation. We estimate that this level of wool sampling requires up to 12 min per tree to complete. Research is ongoing to evaluate the logistics and sensitivity of this sampling method at detecting even lower HWA populations. When wool suspected to be HWA is seen on the ball it should be gently removed and placed in 70% ethanol. Samples should be sent to a qualified laboratory for identification.

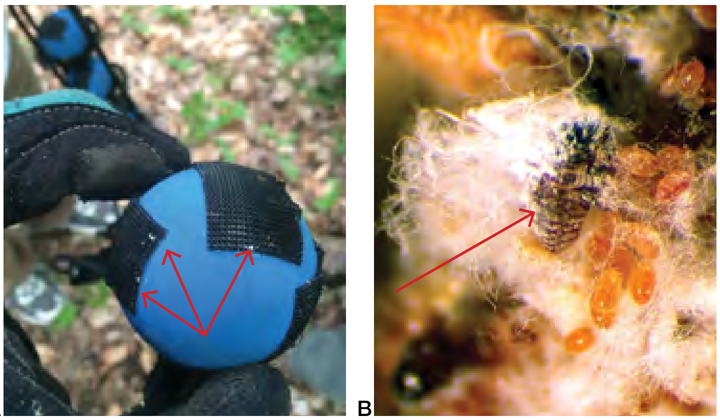

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Figure 4. A) Original prototype of the modified racquet ball showing several specks of HWA wool (red arrows) (Photo: Jeffrey Fidgen). B) Ovisac with wool pulled apart to show orange-brown eggs and brownish-black adult HWA (red arrow) (Photo: Michael Montgomery).

Crawler sampling

This passive method of sampling HWA uses sticky traps deployed horizontally about 130 cm above the forest floor. These traps are effective at intercepting crawlers dislodged from the canopy and can fill a much needed role in detection surveys and for delimitating an HWA infestation within a stand. Most crawlers disperse within an approximately 300-m (29-ha) radius from their point of origin. A single trap, therefore, has the potential to cost-effectively sample a much larger area than either visual surveying or wool sampling and is an effective way to sample in difficult terrain.

Recommended Protocol: We recommend that surveyors obtain samples of dead HWA crawlers and place them on sticky cards to help develop the proper search image when scanning traps to detect their presence and assess their abundance. Stakes, aluminum nails and sticky traps are the major components of crawler sampling. Install wooden stakes (2.5 × 2.5 × 200-cm long stakes work well) under the edge of the live crown of hemlock, where most ovisacs are likely to be located. Create a hole in the top of the stake by inserting an aluminum nail and then remove it. To set a trap, push a nail through the center of the sticky surface and then push the nail down into the hole in the stake with moderate finger pressure. This will facilitate later removal.

Traps should be installed just prior to the hatch of progrediens crawlers in mid-April and taken down just after sistens crawlers have settled in mid-July. Traps (25 × 25 cm or smaller) can be cut from brightly coloured, corrugated plastic sheets of 4-mm thickness or more. We prefer to use the commercially available green prism traps that are used for trapping the emerald ash borer (*Agrilus planipennis* Fairmaire) in Canada because they already contain the sticky coating needed to trap crawlers and crawlers are easily seen against the green colour of the trap (Fig. 5). Approximately six sticky traps can be cut from each prism trap. Any trap design that meets these criteria could be used to trap crawlers.

A B

Figure 5. A) Pair of 25 x 25 cm sticky traps attached to stakes, set up under a group of hemlock trees at the 2014 detection of *A. tsugae* in the Niagara Gorge, with close up (B) of nearest trap showing nail in centre (right) (Photos: Jeffrey Fidgen).

The number and placement of traps in a stand requires further investigation. However, based on previous research, we recommend starting with five traps per hectare. Because traps accumulate significant amounts of debris and non-target insects, it is recommended that they be collected and replaced with new traps preferably weekly but at least every 2 weeks. We placed each spent trap into a clear plastic Ziplock® bag to facilitate transportation, storage and examination. The bags should be stored in a freezer until they can be examined.

A dissecting microscope should be used to scan traps. We have found that an objective set at 6-7× with a 10× ocular (60-70× total magnification) is sufficient to see crawlers. We also recommend leaving traps inside the Ziplock® bag during examination. This will minimize odour and stickiness and if crawlers suspected to be HWA are found on the trap, their locations can be marked with a permanent marker on the bag's surface. Crawlers are distinctive but small: 0.3-mm long x 0.2-mm wide. Scanning of a trap by an experienced observer can take up to 20 min; although much less time is needed if several crawlers are on the trap. Scanning can stop after the first crawler is found if the purpose is solely for detection.

We are conducting research to determine the size, number and placement of traps in stands; their use in detection of residual and new HWA infestations; and the relationship between presence-absence or abundance of crawlers on traps and abundance of ovisacs in the canopy. It will also be important to establish the probability of detecting HWA crawlers with various trapping intensities relative to the level of infestation in a stand and to understand how often traps do not intercept crawlers when trees overhead harbour infestations (false negatives).

CONCLUSION

The current ground-based survey used for HWA detection in Canada is limited to hemlock foliage within 6 m of the ground: a significant portion of the crowns of trees that are 30-m tall remains un-surveyed. The ball sampling and sticky trapping techniques described here address this issue. Both techniques could easily be incorporated into any visual survey, in that the equipment needed is light-weight, portable, easy-to-use and requires minimal training. The use of these techniques could improve detection and delineation of new HWA introductions/arrivals in Canada and might prove useful for monitoring how its distribution changes over time. Additional research to optimize the use of these tools to improve the accuracy of these techniques and to develop stand level assessment protocols is currently underway. The Canadian Forest Service is the principal provider of scientific research and technology in support of the prevention and early detection of pests, such as HWA, that are injurious to the health of Canada's forests.

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	Print	Online
ISSN	1717-6980	1717-6980
Cat. No.	Fo123-1/116E	Fo123-1/116E-PDF
ISBN	978-0-660-04798-0	978-0-660-04799-7

Recycled paper

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