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SENSITIVITY OF SPOTTED LANTERNFLY TO INSECTICIDES AND USE OF SENTINEL TRAPS ON THE INFESTATION PERIPHERY

Phil Lewis

USDA APHIS PPQ; Otis Methods Laboratory 1398 W. Truck Rd., Buzzards Bay, MA 02542

ABSTRACT

The infestation of spotted lanternfly (*Lycorma delicatula*) has continued to spread since it was first detected in late 2014 in eastern Berks County (southeastern Pennsylvania). This invasive pest is now established in over a dozen counties in southeastern Pennsylvania, as well as multiple counties in New Jersey, Delaware, Virginia and Maryland that border or are associated with the Pennsylvania infestation. There is great potential for this insect to spread beyond its current boundaries and recent finds in new municipalities are for the most part located adjacent to existing quarantine boundaries. The strategy to eliminate this pest is multifaceted and includes establishment and enforcement of quarantines, intensive surveys using tree sticky bands and traps, outreach and extension activities, and chemical control.

Tree of heaven (*Ailanthus altissima*) is a key host where all life stages of the insect are present but where adults are observed to congregate in large numbers. A standard control approach has been implemented that involves clearing most *Ailanthus* from a property while retaining several trees that are then treated with insecticide as trap trees. Treatment is conducted via a simple bark spray application in May or June to the lower portion of the tree trunk using a systemic insecticide (dinotefuran). Treatments applied at the highest labeled rate were effective against nymphs and when the adult stage begins maturation feeding on *Ailanthus* in August and September.

Observations of these trees during the summer verify that the treatments are quite effective, with dead lanternfly nymphs and adults readily found beneath treated trees (Figure 1). There is a concern, however, about proper timing and longevity of the treatments considering EPA label restrictions of one application per year and that adults are active between mid-July and a hard frost (December or later in Pennsylvania, depending on the year). Tree foliar residues of dinotefuran can be readily detected using a commercially available ELISA kit. Foliage samples were collected throughout the growing season over multiple years and dinotefuran residue present in leaves following bark spray treatments have been quantified.

Data from multiple studies over a four year period show that expected residues ranged from 7 to 13 ppm (average 10 ppm) following bark spray applications. Trees treated in early May maintained stable residue values into September, while an early April treatment had residue values drop by about half from August to September, when one-third of the study trees had residue values below 1 ppm. There was carry-over of residue from prior-year treatments, but values were low and ranged between 1-2 ppm.

Trunk injection of systemic insecticides is another method of applying pesticides to growing trees, although it requires the use of both specialized equipment and formulations. Such a formulation is available for dinotefuran and it achieves a similar level of control while resulting in a 7-fold decrease in the amount of insecticide applied per tree as compared to a dinotefuran bark spray application (2.7 g of active ingredient versus 19 g). Although less product is used with a trunk injection application,

residue values in foliage were 5 to 10 times higher as compared to a bark spray treatment. Residue values declined steadily between June and September, but averaged 100 ppm in June and declined steadily to a little over 50 ppm by the end of the four month period.

Spotted lanternfly (SLF) susceptibility to several systemic insecticides and two treatment methods was made over a two year period by using tarps to monitor adults falling out of the tree canopy. Sets of trees were treated via trunk injection with dinotefuran, imidacloprid (Dinocide & Imicide 10% formulations; JJ Mauget) and emamectin benzoate (Tree-age; Arborjet) and compared to the standard bark spray treatment application of dinotefuran. Injection treatments were applied at 2 mL of formulated product per diameter inch of tree using Arborjet's Quikjet Air device.

The emamectin product was only tested the first year as mortality on most sample dates was not different from the control group. However, adult SLF are susceptible to both dinotefuran and imidacloprid applied as either an injectable formulation or as a bark spray. In the first year there were about 28,000 dead SLF adults collected from 12 tarps while populations increased almost 10-fold the following year with over 252,000 SLF adults tallied from under 17 study trees. Mortality data were highly variable over time (Figure 2) and also varied greatly by individual tree, with some trees attracting and killing a disproportionate number of SLF. A single tree in the first year accounted for over a third of the catch and three of the most productive trees the following year made up over half of the total. It is of interest to note that the three most productive trees the first year were again among the most productive the following year. The attractiveness of SLF to certain *Ailanthus* trees over others within a landscape is being investigated.

A second use of these trap trees is that they can serve as toxic sentinels and be serve as an SLF monitoring tool for areas and states that are on the periphery of an infestation. SLF is a very active and mobile insect and is highly attracted to *Ailanthus*, especially at the adult stage, so an attract and kill method is a good means of detecting low population levels in an area versus an occasional visual inspection. Key transportation routes, railways, truck stops, rest areas and DOT facilities are all ideal locations in which to set up these sentinel trap trees. Additional areas of concern (vineyards) can also be readily monitored using this method.

Once a suitable area is identified to establish a sentinel *Ailanthus* tree, it is treated with a bark spray application and a 25-gallon water ring is positioned at the base of the tree. Trees should range in size between 4 and 10 inches in diameter (Figure 3). The ring can be checked for SLF lifestages every 3 to 4 weeks. State and federal partners from six states are currently deploying sentinel trap trees.

After two years of experience with sentinel trap trees, results demonstrate that they are most useful when deployed on *Ailanthus* outside of known infested areas. These traps can be effective as a means to investigate isolated incidents or for detecting SLF range expansion. Compared to an intense survey activity like sticky bands that must be checked and replaced often, sentinel trap trees can greatly reduce the amount of time and personnel needed by an agency as they manage and prepare for an SLF infestation.

Figure 1. Adult mortality is evident from this picture of a treated tree in August. Wing-flaring of adults indicates pesticide poisoning.

Figure 2. Average SLF adult mortality by date over a 6 week period.

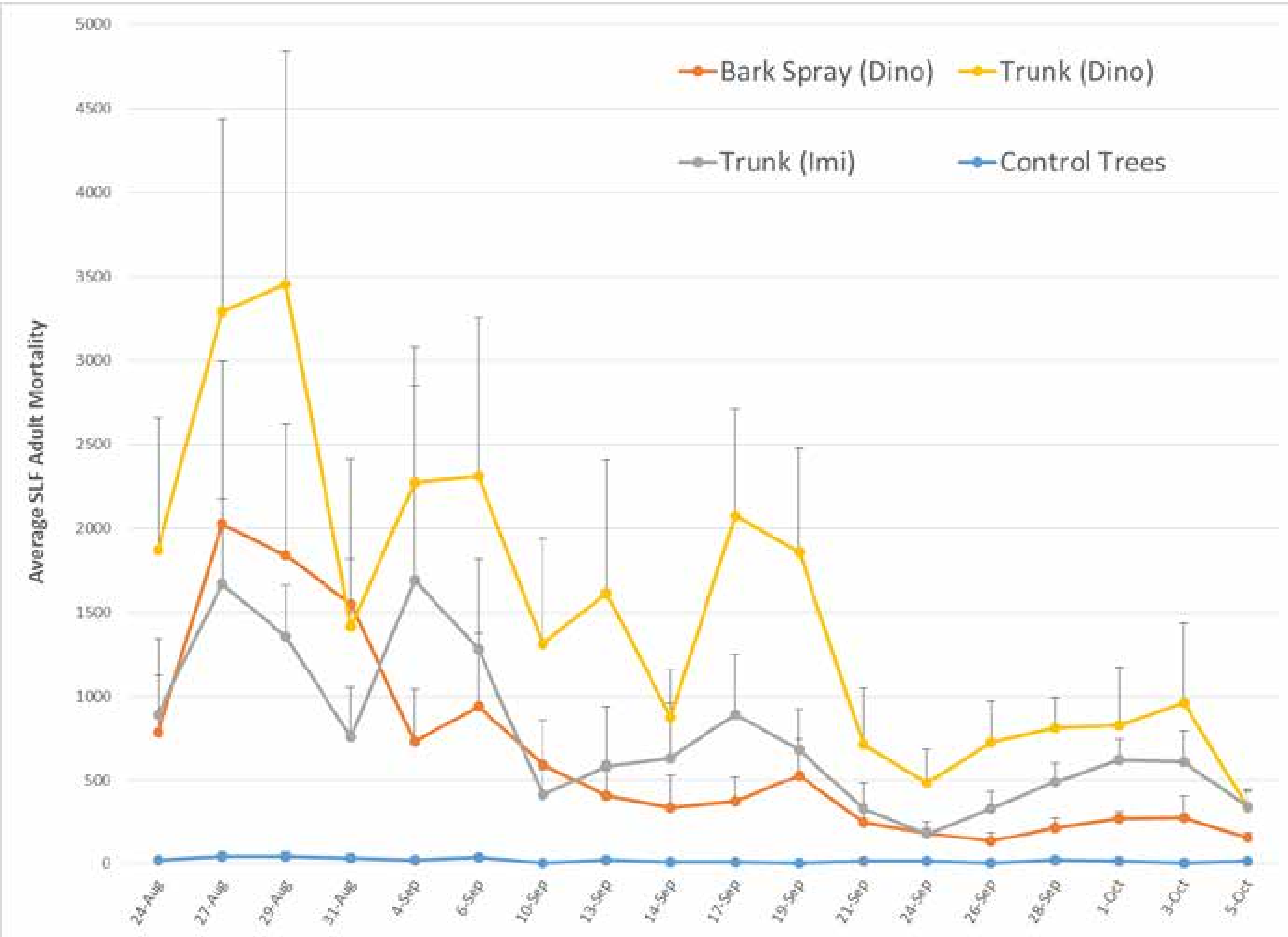

Figure 3. Sprayed tree with collection ring. Spray dries in about a ½ hour.

DEVELOPMENT OF BIOLOGICAL CONTROL METHODS AGAINST THE INVASIVE SPOTTED LANTERNFLY

Juli Gould[1], Hannah Broadley[2] and Kim Hoelmer[2]

[1]USDA APHIS PPQ Science and Technology, 1398 West Truck Road, Buzzards Bay, MA 02542
[2]USDA ARS NEA BIIR, 501 South Chapel Street, Newark, E 19713

ABSTRACT

Eradication and containment of the spotted lanternfly (SLF), *Lycorma delicatula* (White), has been considerably challenging, and this devastating exotic pest has now spread to five states. Because eradication is unlikely, scientists are pursuing management strategies such as biological control. USDA scientists have been collaborating with researchers at the Chinese Academy of Forestry since 2015 to search for natural enemies of SLF throughout China. Exploratory surveys were conducted in 27 provinces in China, where scientists collected SLF egg masses and nymphs. SLF was found to be widely distributed throughout China, being recovered in 21 of the 27 provinces surveyed. To date, we have recovered one egg parasitoid, *Anastatus orientalis* Yang & Choi (Hymenoptera: Eupelmidae) and one nymphal parasitoid, *Dryinus sinicus* Olmi (Hymenoptera: Dryinidae).

Anastatus orientalis was discovered parasitizing SLF eggs in northern China in 2011 (as part of exploration for natural enemies of SLF in Korea). This parasitoid was reported to parasitized 20% of egg masses and 40% of the eggs within these masses during one of its purported two generations per year. It has established in Korea, although information on its effectiveness there is lacking. Parasitized egg masses were shipped from China to the USDA-APHIS quarantine laboratory in Massachusetts, and we have been conducting biological studies to better understand how to rear and utilize this potential biocontrol agent. Research has concentrated on parasitoid life-history (life-cycle, sex ratio, longevity and fecundity), behavior (superparasitism, competition, attractants), and optimizing rearing (oviposition, development, storage, and how to initiate and break diapause).

Researchers in China have reported that *A. orientalis* has two periods of emergence from SLF egg masses (May and September). It was hypothesized that female wasps oviposit into fresh SLF egg masses in the fall, adults emerge in the spring, and emerging adults parasitize as yet un-emerged SLF eggs. Field data from China suggested this might not be the case. Our collaborators collected egg masses in April and the emerging adults were allowed to oviposit on those masses. A month later, when the eggs were dissected, many eggs contained developing parasitoid larvae, as anticipated. However, a sample collected in the field in late July revealed very few parasitoid larvae; they had all emerged prior to collection. There are no SLF eggs available for oviposition in July in China, so it is likely they were using at least one host other than SLF for reproduction. We designed a study to elucidate the particulars of the *A. orientalis* life-cycle. One hundred egg masses were collected in Beijing in early March and shipped to the APHIS quarantine facility in Massachusetts. Fifty egg masses were placed in a growth chamber that mimicked the temperature and day length of Beijing, China, and the remaining egg masses were reared under conditions that mimicked Pottstown, Pennsylvania. Emerging wasps were collected daily and provided new egg masses to parasitize. Under Beijing conditions, *A. orientalis* adults started emerging in early July, which would explain our field observations. This population went on to have a third generation in the fall, when SLF

egg masses would be available in the field. Pennsylvania temperatures are generally cooler than those in Beijing, and emergence of adults in both May and July was slightly later than that observed in China. However, there was no fall generation of *A. orientalis* under Pennsylvania conditions. While SLF is moving south to where conditions would more closely resemble those found in Beijing, the extra summer generation is still problematic. We compared the climate throughout China to those in Pennsylvania and have identified locations where parasitoid populations might be better synchronized with SLF. In one of those locations, Yantai (Shandong Province), some egg parasitoids did not emerge in the spring like *A. orientalis* and might be a species with a one-year life-cycle. We plan to collect egg masses from Yantai and investigate a possible new species.

If *A. orientalis* has a summer generation, which our evidence suggests it does, then it will need to attack at least one host other than SLF. We conducted host specificity testing, prioritizing large, univoltine planthoppers that are closely related to SLF and overwinter as eggs. To date we have seen reproduction in seven of the 18 species tested (39%). This includes one Fulgoridae (*Poblicia fulginosa*), four Pentatomidae (*Euschistis servus, Chinavia hilaris, Podisus maculiventris,* and *Halyomorpha halys*) one Coreidae (*Anasa armigera*), and one Saturniidae (*Antheraea* sp.). We also observed oviposition on another Pentatomid (*Thanta custator*) and a Bombycidae (*Bombyx mori*), although as of this writing it is too early to know if progeny will be produced. All of the species produced males, but female adults emerged from only three of the non-target hosts. These females were smaller than females emerging from SLF, however, they were able to produce progeny when provided SLF eggs. Future research on SLF egg parasitoids will include 1) collection of egg masses in Yantai to determine if there is another species/biotype, 2) confirm a July generation of *A. orientalis* in China, 3) collect non-target species related to SLF in China to determine if they are attacked by *A. orientalis*, 4) conduct choice tests for species that *A. orientalis* attacked in no choice tests, and 5) conduct life-table studies in South Korea to determine if *A. orientalis* is contributing to the decline of SLF populations in that country.

We have conducted less research on the nymphal parasitoid *Dryinus sinicus* because we collected it later (2018), it is univoltine, and rearing its host, second instar SLF nymphs, is challenging. Female wasps have raptorial forelegs that they use for gasping SLF nymphs, which they temporarily parasitize during oviposition. Parasitoid larvae develop on the outside of the SLF nymph in a protective sac called a thalacium. A conservative estimate of parasitism levels is 20-40%. We currently have this species in colony, where it is overwintering as pupae in cocoons, and this spring we will be concentrating on developing effective methods to rear this species.

In conclusion, we have discovered and are studying two potential biocontrol agents and hope to discover more in China. There is still much research to be done, however, before a biocontrol program against the SLF can be implemented.