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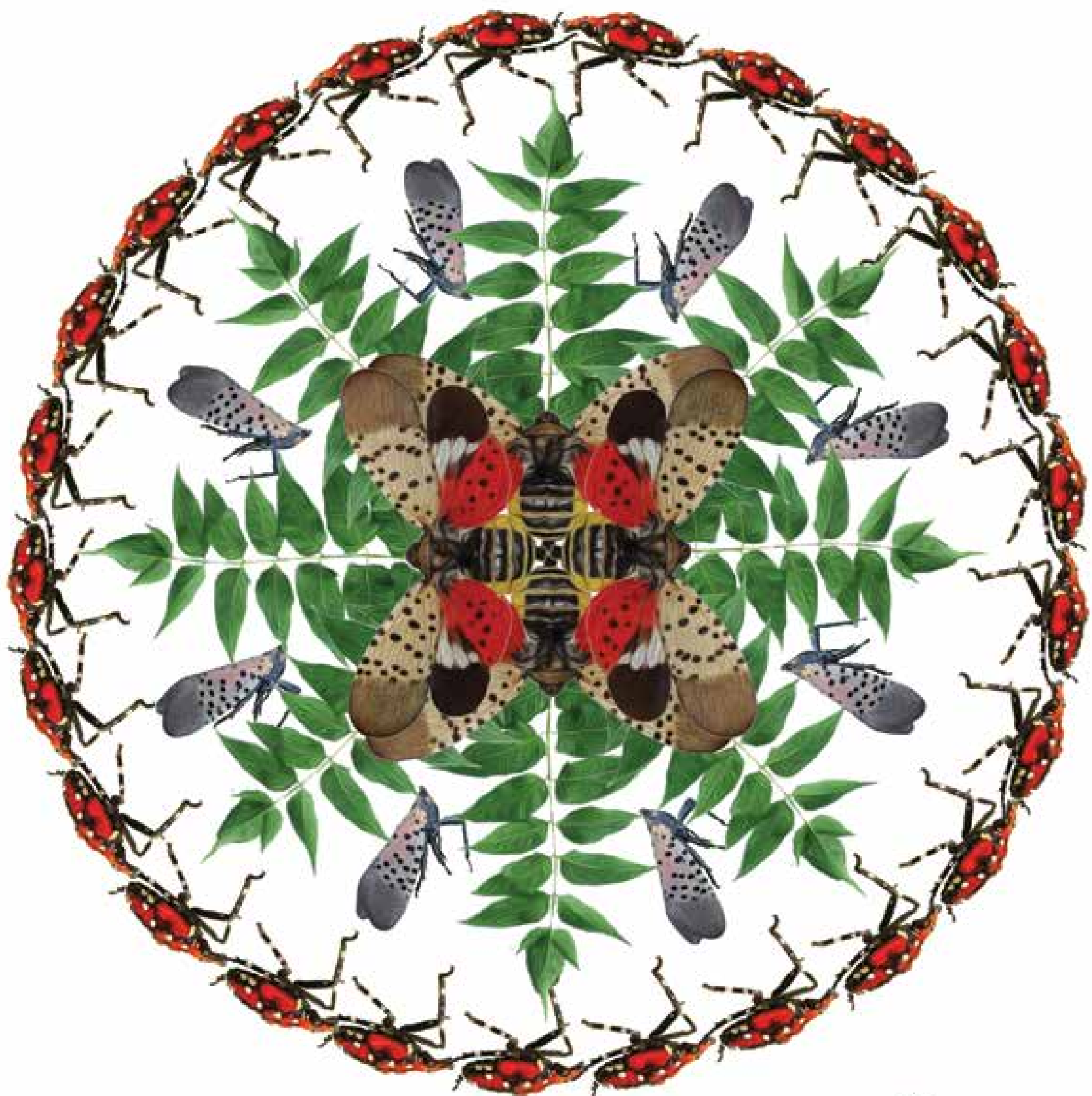

Spotted lantern fly, a new pest from Asia

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KAIROMONES AND TRAP TECHNOLOGY FOR THE SPOTTED LANTERNFLY, *LYCORMA DELICATULA* (HEMIPTERA: FULGORIDAE)

Miriam F. Cooperband[1], Kaitlin Cleary[1], Jacob Wickham[2], Sven Spichiger[3], John Baker[3], and Daniel Carrillo[4]

[1]Otis Laboratory, USDA-APHIS-PPQ-CPHST, 1398 W. Truck Rd.,Buzzards Bay, MA 02542
[2]Institute of Zoology, Chinese Academy of Sciences, 1 Beichen West Rd., Beijing, China 100101
[3]Pennsylvania Department of Agriculture, 2301 North Cameron St., Harrisburg, PA 17110
[4]Tropical Research and Education Center, University of Florida, 18905 SW 280 St. , Homestead, FL 33031

ABSTRACT

The spotted lanternfly (SLF) *Lycorma delicatula* (Hemiptera: Fulgoridae) is a newly invasive pest in eastern Pennsylvania where attempts are underway for its eradication. It is a univoltine phloem feeder whose primary host is tree-of-heaven *Ailanthus altissima*, but which has been found to feed on numerous other hosts including species of *Acer, Actinidia, Alnus, Aralia, Arctium, Betula, Cornus, Elaeagnus, Malus, Metaplexis, Morus, Phellodendron, Platanus, Populus, Prunus, Quercus, Rhus, Robinia, Rosa, Rubus, Salix, Styrax, Toona,* and *Vitis*. Recently, we also recorded large numbers feeding on Chinaberry *Melia azedarach* trees in Anhui province in China. They are invasive in Korea where they are a serious pest of grape, causing damage by feeding in large aggregations causing plants to wilt, and producing copious amounts of honeydew and sooty mold which ultimately blocks photosynthesis.

In order to assist in the eradication efforts, improved survey and detection tools are needed. At the start of this project in the spring of 2015, the best survey tool available was a brown sticky band made by a company in Korea. Bands are wrapped around tree trunks and SLF get captured as they walk across the surface as they migrate up the tree. Although these bands were able to capture 1st instar, 2nd instar, and 3rd instar nymphs, the 4th instar nymphs and the adults were able to avoid capture. In addition, no lures existed for SLF, although spearmint oil was reported as an attractant by Korean researchers. Therefore, our goal was to identify attractants and improve upon current detection tools. The goal of this project is the discovery of novel kairomones and the improvement of trapping technology for SLF. In support of this work, laboratory rearing capabilities and behavioral bioassays needed to be developed and conducted concurrently with host plant volatile collections and field trapping.

Observations on biology. Since the primary host of SLF is *A. altissima*, initial volatile collections and literature review focused on odors from *Ailanthus* and compared them to odors from grape. SLF were field collected in PA and brought to the Otis Laboratory insect containment facility where they were reared and used in behavioral bioassays. Nymphs were housed in cages with a choice of fresh cuttings of *Ailanthus* and a potted grape plant. Feeding by 1st and 2nd instars was observed on both host species, however, 3rd and 4th instars appeared to ignore the grape plant and fed only upon *Ailanthus* cuttings, and those that didn't have access to *Ailanthus* cuttings died. This suggested there might be an obligatory host shift to *Ailanthus* around the 3rd instar. Because of the possibility of different host preferences by different instars, we attempted behavioral bioassays and field testing of attractants for all stages. Additionally, in the end of August 2015 when we field-collected adults from aggregations on *Ailanthus* to use in laboratory bioassays, it was discovered that nearly all of the 400 adults collected from the aggregation were female. It was

later discovered that aggregations of males were on other species, and that the aggregations on *Ailanthus* gradually became more mixed in sex ratio over the mating season (see abstract by Michael Domingue, "Semiochemicals and mating behavior of adult spotted lanternfly"). For this reason, the adult stage was categorized into early (same-sex aggregations), mid (mating and mixed-sex aggregations), and late (oviposition), recognizing that adults at different stages of development are in different physiological states and would potentially respond differently to semiochemicals. Early adults seem to be feeding heavily on *Ailanthus* and would likely still be attracted to kairomones, whereas mid adults are finding mates and late adult females are ovipositing.

Host plant volatiles. Volatile collections were conducted in the summers of 2015 and 2016 on *Ailanthus*, wild grape, and Chinaberry and analyzed by gas chromatography coupled with mass spectrometry. In addition, literature was searched for volatiles for these three species and compared to our results. From these, several compounds of interest were selected based on abundance or unique presence in *Ailanthus*. Most compounds were available commercially, and one sesquiterpene (A) had to be synthesized.

Behavioral bioassays. Custom designed Y-shaped Teflon bioassay plates of two sizes were used to test nymphs and adults for attraction to compounds in the laboratory in the summers of 2015 and 2016. Lures for bioassays were made by placing 1 ul of compound in a 0.25 ml microtube and piercing a hole in the cap. These were placed upwind in one arm of the bioassay, and an empty microtube was placed in the other arm as a control. Seven odors were tested and of these, three (an alcohol, an ester, and a sesquiterpene) were found to be highly attractive in the Y-plate to one or more stages of SLF. The same compounds were also tested using 10 ul, but this reduced attraction. Spearmint oil was not significantly attractive.

Field studies in PA in 2015. Three field studies were attempted in PA in 2015. The first study targeted 1st and 2nd instars, and tested five odors on brown sticky bands from Korea, as well as blank brown sticky bands, and blank clear sticky bands (by Alpha Scents). Within each block, the seven treatments were deployed to *Ailanthus* trees that were within approximately 7 m from each other. Ten blocks of treatments were set up at 10 field sites within the quarantine zone. The five odors to be tested were formulated into lures by Alpha Scents and contained: 1) spearmint oil, 2) an acetate from *Ailanthus*, 3) an alcohol from *Ailanthus,* 4) a blend of the alcohol, acetate, and a sesquiterpene (B) from *Ailanthus* (ratio 2:1:1), a blend used for brown marmorated stink bug (BMSB). The study was replicated at ten field sites. The alcohol caught the most SLF (11.6 per trap), followed by the *Ailanthus* blend (8.2 per trap), the BMSB blend (6.6 per trap), no lure (4 per trap), the acetate (3.3 per trap), spearmint oil (3.1 per trap), and the clear band with no lure (1.5 per trap). However, there was a large amount of variation in the field and there were no significant differences.

The second field study was disrupted by eradication efforts. The third field study targeted adults, which we knew would not get caught on the brown sticky bands from Korea. Therefore, we tested two types of traps, the brown sticky bands from Korea and the purple prism sticky trap for emerald ash borer, wrapped around tree trunks. On both traps we tested five treatments: the alcohol from *Ailanthus,* the ester from *Ailanthus,* a blend of the alcohol and ester (1:1), and a commercially available sesquiterpene blend that contained small amounts of the attractive sesquiterpene (A), and blank controls. The purple prism traps caught more SLF adults than the brown sticky bands in all cases. The alcohol+ester and the ester alone caught the most SLF adults, followed by the alcohol, the sesquiterpene blend, and the control.

Field studies in China and PA in 2016. Twenty field studies were conducted on all SLF stages in three locations in China in the summer of 2016, a Chinaberry plantation at a southern site in Anhui province, and urban *Ailanthus* landscaping trees at two northern sites in Beijing. Five of these studies were also replicated in PA as well. Several of the same tests were conducted in two locations to improve results. Tests can be categorized as follows:

- Main attractants (alcohol, ester, sesquiterpene, control)
- Dose response to the ester (control, 1/2x, 1x, 2x)
- Blends of ester and alcohol (100:0, 75:25, 25:75, control)
- Trap technology (four tests)
- Attract and kill (two tests)

In 2016, lures were formulated in-house, and we conducted release rate studies to compare them to the Alpha Scents lures used in 2015. Results showed that the release rates of the in-house lures were much lower than those made by Alpha Scents in 2015. The sesquiterpene lure, which was not developed until 2016, released about 16 mg/d initially under lab conditions at 22 C and decreased to about 5 mg/d after two weeks. Although not significantly different, there was a trend that the sesquiterpene lure caught more SLF than the ester or the alcohol lures which released much less material than in 2015. When the dose was doubled by using two ester lures, the release rate exceeded that in 2015 and we caught significantly more SLF compared to the controls. Future work will focus on improving lure formulation for higher release rates.

Trap technology. Several types of sticky bands were tested and compared with the Korean brown sticky bands. A Chinese packing tape caught as many or more SLF than the Korean sticky bands, but did not fare as well or last as long in the sun and weather. An American company, Web-Cote, produced a light brown sticky band which was acquired late in the season and compared. This sticky band captured 30 times more adult SLF than the Korean sticky bands. Future work will be conducted to test it against other stages of SLF.

Phenology. Time to first emergence was recorded for the three field sites and is depicted in the figure below. At the southern-most site of Anhui, first emergence of 1st instar SLF preceded the Beijing site by about 3 weeks, and PA by about a month. By adulthood, the two China sites had converged but were still ahead of PA by several weeks.