RECENT DEVELOPMENT AND ADVANCES IN SURVEY AND DETECTION TOOLS FOR EMERALD ASH BORER

Therese M. Poland[1], Deborah G. McCullough[2], Taylor Scarr[3], Joseph Francese[4], Damon Crook[4], Michael Domingue[5], Harold Thistle[6], Brian Strom[7], Laura Blackburn[8], Daniel A. Herms[9], Krista Ryall[10] and Patrick Tobin[11]

[1] USDA Forest Service, Northern Research Station, Lansing, MI 48910
[2] Departments of Entomology and Forestry, Michigan State University, East Lansing, MI
[3] Ontario Ministry of Natural Resources, Sault Ste. Marie, Ontario, Canada
[4] Otis Laboratory, USDA APHIS PPQ CPHST, Buzzards Bay, MA
[5] Department of Entomology, The Pennsylvania State University, University Park, PA,
[6] USDA Forest Service, Forest Health Technology Enterprise Team, Morgantown, WV
[7] USDA Forest Service, Southern Research Station, Pineville, LA
[8] USDA Forest Service, Northern Research Station, Morgantown, WV
[9] Department of Entomology, The Ohio State University, Wooster, OH
[10] Natural Resources Canada, Canadian Forest Service, Sault Ste. Marie, Ontario, Canada
[11] University of Washington, School of Environmental and Forest Sciences, Seattle, WA

ABSTRACT

The emerald ash borer (EAB, *Agrilus planipennis* Fairmaire) has killed hundreds of millions of ash trees since it was discovered near Detroit, Michigan and Windsor, Ontario in 2002 (www.emeraldashborer.info 2016) and continues to spread in North America. Canadian and U.S. federal, provincial, and state regulatory agencies have used artificial traps and lures in surveys to detect new infestations since 2008. Traps used in detection surveys have evolved over the years, and several different trap designs and lures have been tested in research studies. EAB is attracted to volatiles emitted by stressed ash trees including the green leaf volatile *cis*-3-hexenol (de Groot et al. 2008) and bark sesquiterpenes also found in Manuka and Phoebe oils (Crook et al. 2008). Attraction of males to *cis*-3-hexenol may enhanced by the female-produced pheromone *cis*-lactone (Silk et al. 2011, Ryall et al. 2012). EAB adults are also attracted to particular shades of green and purple (Francese et al. 2010, Crook et al. 2012).We compared different shades of green and purple prism traps to optimize color for EAB attraction. Light green prism traps (540 nm wavelength, 66% reflectance, Fig. 1A) were 6 to 10 times more attractive than dark purple prism traps (430-440 nm, 23% reflectance, Fig. 1B) when hung high in the canopy. Prism traps of a darker shade of "Sabic" green (540 nm, 49% reflectance, Sabic Polymershapes, Kalamazoo, MI, Fig. 1C) captured 2 times more EAB than the light green (540 nm, 66% reflectance) and 10 times more EAB than the dark purple traps. In 2011 and 2012, different trap designs were compared in large scale multi-state studies at sites with very low EAB populations. In 2011, the traps included dark purple prism traps, light "Sabic" purple prism traps (420nm, 21.7% and 670 nm, 13.6%, Sabic Polymershapes, Kalamazoo, MI, Fig. 1D) dark "Sabic" green prism traps, and dark "Sabic" green multiple funnel traps (Fig. 1E). All traps were baited with *cis*-3-hexenol and Manuka oil and hung in the ash canopy. Light purple prism traps captured significantly more EAB than the other traps, and their detection rate (i.e., proportion of traps that captured at least one EAB) was 85%. Detection rates for the other traps were 58% for green multiple

funnel traps, 66% for green prism traps, and 73% for dark purple prism traps. In 2012, the trap types included green multiple funnel traps and dark purple prism traps baited with either *cis*-3-hexenol plus Manuka oil or *cis*-3-hexenol plus *cis*-lactone. Although green multiple funnel traps tended to capture more EAB than the dark purple prism traps, variation was high and differences were not significant among trap types or lures. At sites with very low EAB populations, detection rates were similar among traps and ranged from 72 to 76%. We also tested green or purple multiple funnel traps treated with different lubricants including RainX, Fluon tinted the same color as the trap, untinted Fluon, or no treatment. Green multiple funnel traps treated with untinted Fluon captured significantly more EAB than green multiple funnel traps with the other treatments or purple multiple funnel traps with any treatment. There was no significant difference in the number of EAB captured in green multiple funnel traps treated with undiluted Fluon and Fluon diluted to 50% with water; however, trap catches were significantly reduced when Fluon was diluted to 25%.

In 2014, we compared different colored "double-decker" traps (Fig. 1F) consisting of two, three-sided prisms (60-cm tall × 40-cm wide on each side), made of corrugated plastic, mounted to the top and 120-cm from the top of a 2.4-m tall, 10-cm diameter PVC pipe slid over a T-post that was driven into the ground. Color and lure combinations included 1) dark purple top and bottom prisms both baited with *cis*-3-hexenol; 2) dark purple top prism baited with *cis*-3-hexenol and dark purple bottom prism baited with Manuka oil; 3) Sabic green top and light Sabic purple bottom prisms both baited with *cis*-3-hexenol; 4) Sabic green top prism baited with *cis*-3-hexenol and light Sabic purple bottom prism baited with Manuka oil; and 5) light Sabic purple top and bottom prisms both baited with *cis*-3-hexenol. Traps with green top prisms and light purple bottom prisms captured significantly more EAB than traps with dark purple prisms on the top and bottom, regardless of lure. Traps with light purple top and bottom prisms captured an intermediate number of EAB. For traps of the same color, there was no significant difference in attraction of EAB to traps baited with *cis*-3-hexenol on both prisms or with *cis*-3-hexenol on the top and Manuka oil on the bottom prism. The detection rate for traps with green tops and light purple bottoms was 90% for traps baited with *cis*-3-hexenol on both prisms, and 100% for traps baited with *cis*-3-hexenol on the top and Manuka oil on the bottom prism. Traps with dark purple top and bottom prisms had the lowest detection rates (60% and 70% for traps baited with *cis*-3-hexenol on both prisms or *cis*-3-hexenol on the top and Manuka oil on the bottom, respectively). The detection rate of traps with light purple top and bottom prisms baited with *cis*-3-hexenol on both prisms was 80%.

We also compared several different trap designs including 1) double-decker trap with dark purple top and bottom prisms baited with *cis*-3-hexenol on the top and Manuka oil on the bottom prism; 2) double-decker traps with Sabic green top prism and light Sabic purple bottom prism baited with *cis*-3-hexenol on both prisms; 3) Sabic green prism trap baited with *cis*-3-hexenol and hung in the ash canopy; 4) Sabic green funnel trap coated with Fluon, baited with *cis*-3-hexenol and hung in the ash canopy; and 5) Sabic green modified boll weevil traps baited with *cis*-3-hexenol and hung in the ash canopy. Standard boll weevil traps were modified by replacing the bottom portion with a 40-cm long green cylinder. At a site with very low EAB population density, significantly more EAB were captured in the double decker traps of either color than in the boll weevil traps which did not capture any EAB. The green prism traps and green funnel traps captured an intermediate number of EAB. All of the green and light purple double-decker traps captured at least one EAB, 80% of the dark purple double-decker traps, 60% of green canopy prism traps and 40% of green funnel traps captured at least one EAB.

We compared small light green prism traps slid over branches in the canopy of ash trees (Fig 1G). The traps were baited with *cis*-3-hexenol with or without *cis*-lactone and had a single dead EAB decoy placed in the center or no decoy. Traps baited with *cis*-3-hexenol, *cis*-lactone, and a decoy captured significantly

more EAB than traps without a decoy or *cis*-lactone.

Finally, we tested several different trap designs in a large multi-agency study replicated in sites with low to very low emerald ash borer densities in Ontario, Michigan, Ohio, and Pennsylvania. Traps included 1) double decker traps with Sabic green panel on top and light Sabic purple panel on the bottom both baited with *cis*-3-hexenol, 2) double decker traps with light Sabic purple top and bottom panels both baited with *cis*-3-hexenol, 3) Sabic green multiple funnel traps baited with *cis*-3-hexenol, 4) light Sabic purple prism traps baited with *cis*-3-hexenol; 5) dark Sabic green prism traps baited with *cis*-3-hexenol and *cis*-lactone; and 6) light Sylvar green prism traps baited with *cis*-3-hexenol and *cis*-lactone. In 2014, across all sites, we captured significantly fewer EAB in the light purple prism traps than in any other trap color or design. In 2015, preliminary results for Ontario and Michigan indicate that significantly more EAB were captured in the double-decker traps than in the light purple or light Sylvar green prism traps while dark

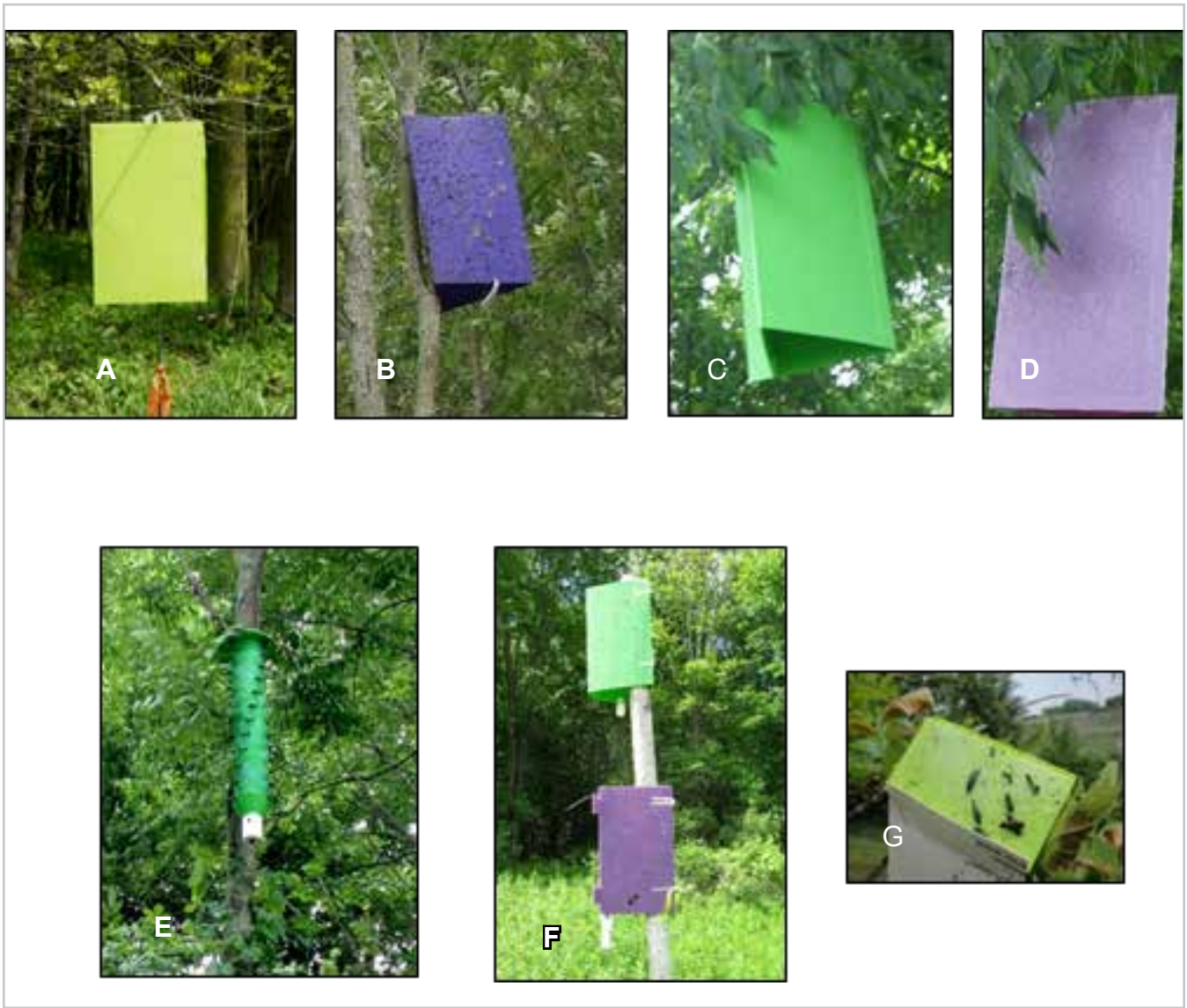

Figure 1. Traps used for capturing EAB. A. Light green prism trap; B. Dark purple prism trap; C. Dark "Sabic" green prism trap; D. Light "Sabic" purple prism trap; E. Dark "Sabic" green multiple funnel trap; F. Double-decker trap; G. Light green branch trap

Sabic green prism traps were intermediate. All double decker traps captured at least one EAB, 81% of the dark Sabic green prism traps and green funnel traps, 69% of light Sylvar green prism traps, and 63% of the light purple prism traps captured EAB.

Overall, double-decker traps, green prism traps, and green funnel traps are effective detection traps for EAB with 76 to 100% detection rates at sites with very low densities of EAB. Double-decker traps tended to have the highest detection rates and less variability than traps hung in the canopy where trap captures are influenced by infestation level of the trees bearing the traps or adjacent trees. The new darker Sabic green and lighter Sabic purple are more attractive to EAB than dark purple prisms. Traps baited with *cis*-3-hexenol alone were as attractive to EAB as traps with *cis*-3-hexenol plus Manuka oil lures. The pheromone *cis*-lactone increased attraction of EAB to small green branch traps baited with EAB decoys and *cis*-3-hexenol and placed over branches in the canopy of ash trees.

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