Evaluating Threat Level, Infestation Behavior, Economic Impact and Potential Measures for Control of Ambrosia Beetles in NY Apple Orchards
Final Report 2016

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Preventive Treatments against *Xylosandrus germanus* (Black Stem Borer)

In two Wayne Co. sites with known orchard infestations of black stem borer (BSB), Furber and Fowler, trials were set up using potted Rome Beauty nursery apple trees inside wooded areas directly adjacent to the orchard planting. The potted trees were flooded to stress them into producing ethanol, so as to attract beetles and promote new attacks. Additionally, individual ethanol lures were attached to each tree to increase their attractiveness to the beetles. On May 10, just as the adult flight was starting, trunks of the potted trees were sprayed with one of four candidate insecticides using a Solo backpack sprayer: Lorsban Advanced (chlorpyrifos, Dow AgroSciences), 1.5 qt/100 gal; Cobalt (chlorpyrifos+lambda-cyhalothrin, Dow AgroSciences), 1.3 qt/100 gal; Perm-Up (permethrin, UPI), 10 fl oz/100 gal; or Danitol (fenpropathrin, Valent), 16 fl oz/100 gal; plus a Check (unsprayed). Trees were arranged in circular 5-tree groupings in the wooded areas, which were replicated 10 times at each site. Another identical set of 10 replicate tree groupings was also deployed at each site, with a dispenser of a commercial repellent, BeetleBlock (verbenone, ChemTica) hung ~1 m high on a pole placed in the center of each of the 5-tree groupings.

Verbenone, a natural terpene compound found in many plants such as pine trees, is used in the control of bark beetles such as mountain pine beetle and Southern pine bark beetle. It is produced, probably as a defensive mechanism, when the number of insects in an infested tree approaches the maximum that the tree can support, and acts as repellent to other beetles. Because it has demonstrated efficacy in related groups of bark boring beetles, as well as this species, we proposed that it might offer a higher degree of prevention than using insecticide sprays alone. Half of the treated replicates were evaluated for infestations on July 6, after the end of the first adult flight of the season, and the remaining replicates were evaluated near the end of the season, on August 19. Infestations were quantified and assessed by destructive sampling and dissection in the lab, to determine the following classes of infestation in the test trees: # of attack sites/tree, # of trees containing empty galleries, # of trees containing live adults, dead adults, and brood.

Results of the preliminary evaluation (Table 1) showed no statistical differences among the insecticide-alone or insecticide-plus-verbenone treatments in the following categories of infestation: number of attack sites per tree (both sites); number of trees with empty galleries only (Fowler); number of trees with live adults or dead adults (Furber); and number of trees with brood (Fowler). Among the variables with some statistical differences: at the Furber site, significantly fewer Danitol-treated trees (with or without verbenone) had empty gallery-only infestation sites than did the Check trees and Perm-Up trees without verbenone. At Fowler, fewer live adults were taken from Danitol-plus-verbenone trees than from those treated with Perm-Up-plus-verbenone. Also, the Lorsban-plus-verbenone trees at the Fowler site had a statistically higher level of dead adults than the Checks. At Furber, the following trees had statistically fewer trees with brood than did the Lorsban-plus-verbenone trees: Danitol-plus-verbenone, and both Cobalt and Danitol without verbenone. In no case did the combination of verbenone repellent plus insecticide sprays appear to improve the control of BSB over the insecticides alone; levels of infestations were just as likely to be higher with the addition of verbenone as lower. Although statistical separation among treatments was not uniformly seen in these results, there was a trend (in 8 out of 10 comparisons) for the Danitol treatments to have among the lowest numerical values in the different infestation categories overall.

The final evaluation of these treatments (Table 1) revealed similar trends. The number of attack sites per tree generally increased over levels seen in the July evaluation, with a small number of statistical differences being found. At the Furber site, Lorsban-plus-verbenone was the only treatment significantly lower than any of the others (in this case, Perm-Up-plus-verbenone and Danitol-plus-verbenone). At the Fowler site, the Perm-Up treatment had significantly fewer attack sites than the Perm-Up-plus-verbenone; all other treatments were statisically comparable. Once again, there were no cases where the addition of verbenone improved control.

In the other categories of infestation, the final evaluation showed statistical differences in the following treatments: empty galleries - Danitol had the lowest incidence at Furber, and Perm-Up was significantly different than the other treatments at Fowler. For dead adults - at Furber, Cobalt-plus-verbenone had the lowest levels and Perm-Up-plus-verbenone the highest levels (perhaps a more indicative measure of efficacy?); at Fowler, Lorsban-plus-verbenone was lowest, Lorsban alone and Perm-Up-plus-verbenone were highest. For sites containing brood, Fowler had the highest numbers in the untreated Check, and the lowest in the verbenone-only plots; there were no treatment differences at Furber. There were also no treatment differences in sites with live adults at either Furber or Fowler.

Many of the infestation category readings had a high level of variability, so results showing statistical differences were not always the lowest mean values.

Trapping Trials to Determine Occurrence and Timing of *Xylosandrus germanus* (Black Stem Borer) Ambrosia Beetles in NY Orchards, 2016

In 2016, traps were placed at a total of 43 orchards to determine the occurrence and timing of BSB. Traps consisted of inverted 1.75-L plastic juice bottles, which had 6 x 10-cm rectangles cut out of each of the sides and were baited in the upper portion of the traps with pouch-style dispensers loaded with 10 ml of 95% ethanol; water with a small amount of dish detergent was placed in the cap was used as a capture medium. The traps were suspended from 1.2-m tall metal garden hangers at a 1-m height; at each site, two traps were placed on an edge of the planting adjacent to a hedgerow, and two additional traps were located in the orchard interiors, ~20–30 m from the orchard edge and in proximity to previously attacked trees, to verify their attractiveness. Traps were checked 1–2 times per week starting in mid-April, before maximum temperatures of 20°C began to occur, and through the summer. Beetles trapped were collected, sorted and identified.

Traps were placed in the following counties at the designated number of farms in each county: Lake-W (Niagara, 4; Orleans, 12, set out on 18 Apr); Lake-E (Wayne, 8; Ontario, 1, set out on 13–19 Apr); and ENY (Clinton, 5; Essex, 1; Saratoga, 1; Washington, 1, set out on 28 Apr; and Columbia, 2; Dutchess, 2; Ulster, 5, set out on 19 Apr). Traps were checked weekly until 30 Aug (Lake-W), 20 Sep (Lake-E), and 30 Sep (ENY), and captures recorded as previously described.

Results

Beetle activity began at a continuous but low level on 19 Apr statewide, although sustained captures did not occur until 15–17 May (corresponding to 50–65 and 48–109 $DD_{10°C}$ among trap sites in the Lake Ontario and ENY regions, respectively) (Figs. 1 & 2). The first flight, which peaked in the Lake Ontario counties on 31 May and 1 Jun in ENY, subsided by 13–15 Jun statewide. Trends similar to 2015 in the ratios of orchard edge to interior trap captures were seen in the respective regions, with a range of 1.5–28X as many edge captures in the Lake Ontario counties (significantly different on 24 and 31 May, 16 and 30 Aug in Lake-W; and 22 Jun–27 Jul, 24 Aug and 1 Sep in Lake-E). Ratios of 0.5–4 edge:interior captures in ENY were obtained, but differences were not significantly different on any date.

Acknowledgements

We wish to thank Todd Furber and J.D. Fowler for allowing us to conduct these trials on their farms; Wafler Nursery for providing the trees and facilities for potting them; John Vandenberg, Louela Castrillo, Michael Griggs and Rebecca Howes, USDA-Ithaca, for their advice and assistance in potting trees, setting up the trials, and providing technical supplies and support for conducting the research. This work was supported by funds from the USDA Hatch Program, NY Apple Research & Development Program, Dow AgroSciences (Alejandro Calixto), Valent Biosciences (Gary Kirfman), and UPI (United Phosphorus) (Tony Estes).

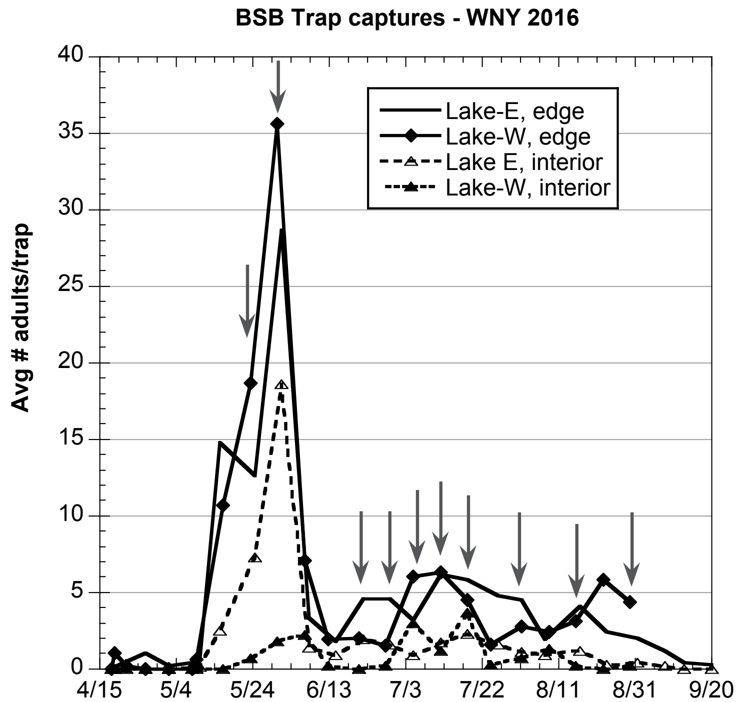

Fig. 1. Trap captures of BSB in the Lake Ontario region, 2016. Arrows designate dates at which captures at the orchard edge were significantly higher than in the interior.

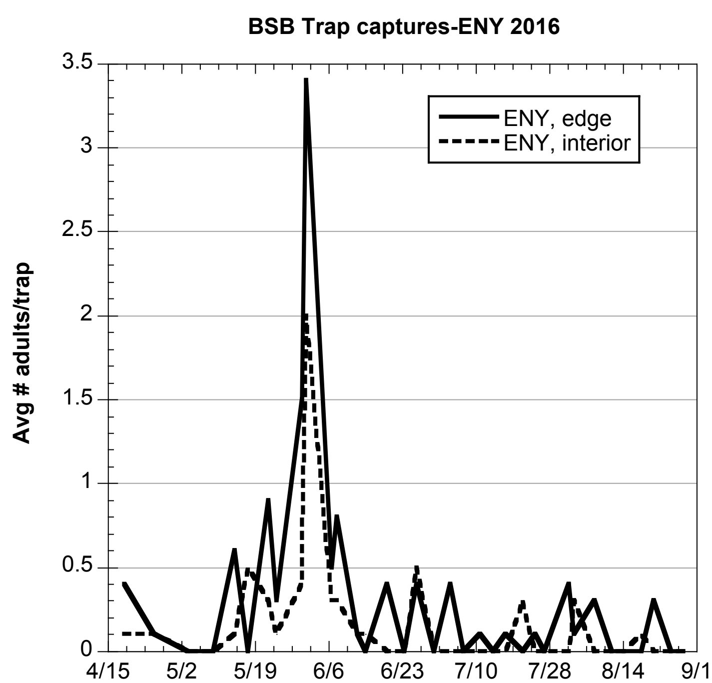

Fig. 2. Trap captures of BSB in Eastern New York counties, 2016.

Table 1. Mean number of trees with different categories of infestation by black stem borer after May 10 insecticide trunk applications and a verbenone repellent; preliminary evaluation, July 6; final evaluation, August 19, 2016.

Furber	Mean # Attack Sites		Mean # of Sites Containing: Empty Galleries		Live Adults		Dead Adults		Brood	
Treatment	Prelim	Final	Prelim	Final	Prelim	Final	Prelim	Final	Prelim	Final
Check-no verb	13.0 a	17.0 ab	1.6 a	4.4 ab	0.0 a	2.6 a	4.0 a	1.8 ab	2.4 ab	1.4 a
Check-verb	11.6 a	11.0 ab	0.6 ab	3.8 abc	0.4 a	1.8 a	4.4 a	1.2 ab	2.0 ab	1.2 a
Cobalt-no verb	7.0 a	13.4 ab	1.0 ab	4.8 ab	0.2 a	1.8 a	1.6 a	1.6 ab	1.2 b	1.0 a
Cobalt-verb	7.6 a	8.6 ab	1.4 ab	2.4 abc	0.0 a	1.0 a	2.8 a	0.6 b	2.4 ab	0.6 a
Danitol-no verb	9.0 a	5.8 ab	0.0 b	1.0 c	0.0 a	1.0 a	3.6 a	2.2 ab	1.2 b	0.2 a
Danitol-verb	5.4 a	17.4 a	0.0 b	6.0 a	0.4 a	2.8 a	1.0 a	1.4 ab	0.6 b	1.4 a
Lorsban-no verb	8.6 a	13.6 ab	0.6 ab	2.4 bc	0.6 a	2.8 a	3.4 a	4.6 ab	1.2 b	1.6 a
Lorsban-verb	11.4 a	10.6 b	0.4 ab	3.8 abc	0.0 a	1.6 a	4.2 a	0.8 ab	4.6 a	0.2 a
Perm-Up-no verb	14.4 a	17.2 ab	1.6 a	3.4 ab	0.2 a	1.6 a	3.4 a	3.0 ab	1.8 ab	2.4 a
Perm-Up-verb	11.0 a	22.8 a	0.8 ab	7.2 a	0.4 a	3.0 a	2.4 a	3.8 a	2.2 ab	0.6 a

Fowler	Mean # Attack Sites		Mean # of Sites Containing: Empty Galleries		Live Adults		Dead Adults		Brood	
Treatment	Prelim	Final	Prelim	Final	Prelim	Final	Prelim	Final	Prelim	Final
Check-no verb	6.2 a	18.0 ab	1.8 a	2.4 ab	1.0 ab	4.4 a	0.4 b	2.6 ab	0.4 a	1.2 a
Check-verb	4.6 a	11.4 ab	1.2 a	2.2 ab	0.8 ab	0.2 a	0.6 ab	2.6 ab	1.0 a	0.0 b
Cobalt-no verb	6.2 a	10.8 ab	0.2 a	4.2 a	1.0 ab	0.4 a	1.8 ab	2.0 ab	1.2 a	0.4 ab
Cobalt-verb	6.6 a	6.4 ab	1.6 a	2.0 ab	1.0 ab	1.0 a	0.8 ab	0.8 bc	1.4 a	0.4 ab
Danitol-no verb	9.6 a	14.8 ab	3.0 a	3.4 ab	1.0 ab	1.6 a	1.2 ab	1.4 abc	2.0 a	1.0 ab
Danitol-verb	5.4 a	11.8 ab	1.4 a	3.6 ab	0.2 b	1.4 a	1.2 ab	1.0 abc	0.6 a	0.2 ab
Lorsban-no verb	9.6 a	17.0 ab	0.4 a	6.0 a	0.8 ab	1.6 a	2.2 ab	3.4 a	1.6 a	0.4 ab
Lorsban-verb	11.6 a	7.2 ab	1.0 a	2.0 ab	1.2 ab	1.4 a	2.8 a	0.2 c	2.4 a	0.4 ab
Perm-Up-no verb	10.8 a	7.2 b	2.0 a	3.0 b	1.4 ab	0.8 a	1.8 ab	1.0 bc	2.4 a	0.2 ab
Perm-Up-verb	11.8 a	17.0 a	0.0 a	4.8 ab	2.6 a	1.2 a	1.2 ab	3.2 a	1.4 a	0.6 ab

Means within a column followed by the same letter are not significantly different (Student's t Test, $P<0.05$).
Data was transformed log ($x + 0.1$) prior to analysis.