MANAGEMENT TACTICS FOR EMERALD ASH BORER: CHEMICAL AND BIOLOGICAL CONTROL

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ABSTRACT

Emerald ash borer (EAB) (*Agrilus planipennis*), an invasive buprestid native to northeast Asia, has killed tens of millions of ash (*Fraxinus*) trees in infested areas of eastern North America. EAB apparently arrived in infested solid wood packaging materials from China in the early 1990s near Detroit, MI, but was not identified as the cause of local ash mortality until 2002. At that time, very little was known about its biology, and there was no information on how to manage it. Since then, much progress has been made in evaluating control tactics for EAB including the use of insecticides and biological control.

Insecticides. Many research groups are involved in conducting studies to evaluate various insecticide products and application techniques for controlling EAB including cover sprays, soil applications, bark-penetrating trunk sprays, and stem injection with systemic insecticides. Several recent studies were highlighted. Overall, the studies found that emamectin benzoate (TREE-äge™) provided excellent control of EAB for at least 2 to 3 years, and neonicotinoid insecticides (imidacloprid and dinotefuran) could protect most ash trees but must be applied annually. In one study, mortality of EAB adults fed on leaves from trees treated with emamectin benzoate (0.4 g ai/inch d.b.h.) was 100 percent in the first year and more than 90 percent in the second year following a single treatment. Larval density in emamectin benzoate-treated trees was reduced by >99 percent in both the first and second year after treatment compared to larval density in untreated control trees (McCullough et al. in press). In another study, trees were treated with four different doses (0.1, 0.2, 0.4, or 0.8 g ai/inch d.b.h.) of emamectin benzoate in 2006, and canopy decline and exit-hole density were monitored for 4 years. The three lowest doses provided excellent control for 3 years (< 10 percent canopy decline and < 2 exit holes per m^2 compared to 53 percent canopy decline and ~20 exit holes per m^2 on untreated control trees). The highest dose provided excellent control for 4 years (5 percent canopy decline and 0.5 exit holes per m^2 compared to 96 percent canopy decline and ~25 exit holes per m^2 on untreated control trees) (Herms et al. 2010). For the neonicotinoid insecticides, imidacloprid (Merit 2F™ 1.4 g ai/inch d.b.h. or Xytect™ 1.4 or 2.8 g ai/inch d.b.h.) soil drenches applied annually in spring or fall from 2006 to 2009 provided good protection of large trees (~10 percent canopy decline in trees treated with the high dose of Xytect™, 20 to 40 percent decline in trees treated with the low dose of Merit 2F™ or Xytect™, and >90 percent decline in untreated control trees) even under high EAB pressure, particularly when applied at the high rate (Herms et al. in press). Dinotefuran (Safari™ 1.7 g ai/inch d.b.h.) and imidacloprid (Macho™ 1.7 g ai/inch d.b.h.) applied with or without PentraBark™ as bark-penetrating trunk sprays and imidacloprid (Imicide™ 0.15 g ai/inch d.b.h.) applied with Mauget capsules as a trunk injection, reduced EAB density by 30 to 60 percent

compared to untreated controls after two consecutive years of treatment. There was no reduction in larval density in the second year after a single treatment (McCullough et al. in press).

Biological Control. Since 2002, much progress has been made toward developing a biological control program for EAB. Explorations in China yielded three parasitoid species: *Tetrastichus planipennisi* (gregarious larval endoparasitoid, Eulophidae), *Spathius agrili* (gregarious larval ectoparasitoid, Braconidae), and *Oobius agrili* (solitary egg parasitoid, Encyrtidae) (Liu et al. 2003, Yang et al. 2005, Zhang et al. 2005). By 2007, research findings on parasitoid biology (Liu et al. 2007), laboratory rearing, host specificity (Yang et al. 2008), and risk assessment were completed and submitted to USDA APHIS, along with requests for permits to release the three EAB parasitoids from China in Michigan. An environmental assessment was compiled and posted on the Federal Register by APHIS for public comment (Federal Register 2007). After review by researchers, land managers, and the public, APHIS issued a finding of no significant impact (Federal Register 2007) and granted release permits for the three parasitoid species in Michigan in late July 2007 (Bauer et al. 2008).

This allowed researchers to begin studying the three EAB biocontrol agents at field sites in Lower Michigan in 2007. The objectives were to assess parasitoid reproduction and overwintering. That summer and fall, *O. agrili* and *T. planipennisi* were each released at two different sites in Ingham County, and *S. agrili* was released at one site each in Gratiot, Oakland, and Saginaw Counties. During the winter and early spring of 2008, *O. agrili* was recovered from one Ingham County site and *S. agrili* was recovered from the Oakland County site, confirming field reproduction and overwintering in Michigan. In 2008, additional research sites were established in Michigan, Indiana, and Ohio for long-term monitoring of parasitoid establishment and efficacy. Also in 2008, a replicated multi-year cohort life table study in Ingham County was initiated to determine stage-specific mortality of EAB by each parasitoid species and other factors. In 2008 and 2009, *O. agrili* was recovered at low prevalence (<1 percent parasitism) from EAB eggs sampled at the three replicated release plots; none were detected in the non-release control plots. In 2009, *T. planipennisi* was recovered from ~10 percent of EAB larvae at the three life table release sites. At two of those sites, *T. planipennisi* was also recovered ~ 800 m from the release epicenters (Bauer et al. in press).

In 2009, new EAB biocontrol study sites were established in Michigan, Illinois, and Maryland. At these and previously established sites, parasitoid reproduction, phenology, overwintering, establishment, spread, and prevalence were monitored. This monitoring was done mainly by sampling and dissecting ash trees, although emergence traps stapled to tree trunks, and sentinel logs were also tested as detection tools. At selected sites, data were collected to evaluate the impact or efficacy of biocontrol by comparing changes in ash condition and EAB densities in parasitoid-release vs. non-release control plots (Bauer et al. in press).

Recent advances have also been made in rearing methods for the three EAB biological control agents. Laboratory conditions for diapause induction in *O. agrili* were determined. When in diapause, *O. agrili* can be stored in the refrigerator for more than 10 months. This allows for mass production and year-round stockpiling of *O. agrili* until needed for the relatively narrow release window during EAB's egg-laying period. For *S. agrili*, parasitism and progeny production were enhanced by allowing group mating vs. single pair mating and by the presence of ash foliage (with or without EAB feeding) (Gould et al. in press). For *T. planipennisi*, parasitism of EAB larvae was enhanced in ash logs vs. ash sticks (Ulyshen et al. 2010, Duan et al. in press). The advances in rearing techniques, along with the completion in 2009 of the EAB Biological Control Production Facility in Brighton, MI, will provide EAB parasitoids for implementation of the USDA Emerald Ash Borer Biological Control Program (USDA 2010).

Development of this classical biological control for EAB was supported by research showing that parasitism by native natural enemies did not exceed 1 percent (Bauer et al. 2005). In 2007 and 2008 at two sites in Oakland County, however, an unknown *Atanycolus* sp. (Hymenoptera: Braconidae) was discovered parasitizing 9 to 71 percent of EAB larvae (Cappaert et al. 2009). *Atanycolus* are solitary larval ectoparasitoids reported from many *Agrilus* species. This *Atanycolus* species was recently described as *A. cappaerti* Marsh and Strazanac (Marsh et al. 2009), and its biology and parasitism of EAB and native *Agrilus* hosts were investigated in the field (Cappaert et al. 2009, Tluczek et al. in press). In the future, this species may prove useful as a fourth parasitoid species for EAB biocontrol.

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