PROGRESS ON BIOLOGICAL CONTROL OF EMERALD ASH BORER

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ABSTRACT

The emerald ash borer (EAB), *Agrilus planipennis*, a buprestid native to northeastern Asia, was determined as the cause of ash tree (*Fraxinus* spp.) mortality in areas of southern Michigan and Ontario, Canada, in 2002. Infestations have been found since in Ohio, Indiana, Maryland, Virginia, Illinois, Pennsylvania, and West Virginia. Regulatory agencies have shifted from a tactic of eradication to one of management for this pest in North America. This change resulted in part from increasingly large infestations and limited capability to detect and control EAB. Classical biological control, the introduction and establishment of exotic natural enemies for sustained control of an invasive species, is being considered for management of EAB.

Considerable progress has been made since 2002 in developing an EAB biological control program. Natural enemy surveys of EAB in Michigan during 2003-2004 revealed less than 1% of immature EAB were parasitized and EAB eggs contained no parasitoids (Bauer and Liu, unpublished data). This level of parasitism was much lower than parasitism of EAB observed in China (Liu et al. 2007) and levels reported in the literature for a native species of *Agrilus* (Loerch and Cameron 1983). The lack of native natural enemies attacking EAB in the United States supports the need for biological control of EAB in North America.

In 2003, we began studying EAB and its natural enemies in ash stands in China. We found three hymenopteran parasitoids for possible use as EAB biocontrol agents in North America: a gregarious larval braconid ectoparasitoid, *Spathius agrili* (Liu and Liu 2002; Liu et al. 2003; Yang et al. 2005), a gregarious larval eulophid endoparasitoid, *Tetrastichus planipennisi* (Liu et al. 2003; Yang et al. 2006), and a solitary, parthenogenic encyrtid egg parasitoid, *Oobius agrili* (Zhang et al. 2005). Studies on the population biology of *O. agrili* and *T. planipennisi* parasitizing EAB attacking *F. pennsylvanica* planted in Jilin Province reveal the importance of natural enemies in maintaining EAB population densities below a tolerance threshold for this ash species, which is a common tree throughout eastern North America (Liu et al. 2007).

Oobius agrili was discovered in 2004 in Jilin Province, China (Zhang et al. 2005). In China, *O. agrili* is a solitary and parthenogenic egg parasitoid with at least two generations per year. This minute encyrtid wasp spends the winter and spring as a mature larva in EAB eggs, and adult emergence is synchronized with the EAB oviposition period during July and

August in the field. We developed laboratory rearing methods and recorded the life cycle of *O. agrili* parasitizing EAB eggs at 25° C (Bauer and Liu 2007). Using these methods, we performed no-choice assays with eggs of six *Agrilus* spp., two cerambycid beetles, and four lepidopterans. Overlap in physiological host range was found for three native *Agrilus* spp. with eggs of similar size to EAB. For these three species, paired choice assays revealed *O. agrili* strongly preferred to oviposit in EAB eggs laid on ash than in eggs of other *Agrilus* spp. on their respective host plants (Bauer and Liu 2007).

Tetrastichus planipennisi was discovered in 2003 in Jilin and Liaoning Provinces of China (Liu et al. 2003) and later in Heilongjiang Province (Yang et al. 2006). *Tetrastichus planipennisi* oviposits into the haemocoel of actively feeding third- and fourth-instar EAB larvae. In China, this tiny eulophid wasp completes at least four generations per year and overwinters as mature larvae inside the host gallery. After chewing a small emergence hole in the tree bark, adults emerge the following spring, with an average of 35 (range 5 to 122) adults emerging from a single host larva. We developed laboratory rearing methods and recorded the life cycle of *T. planipennisi* parasitizing EAB larvae at 25°C (Liu and Bauer 2007). Using no-choice assays, groups of female and male *T. planipennisi* were exposed to actively-feeding larvae of eight buprestid species, five cerambycid species, and a wood-boring sawfly, all implanted in small branches of their host plant. We also assayed larvae of a tenebrionid beetle and two lepidopteran species by implantation in small ash branches and sphingid larvae by exposure on host leaves. *Tetrastichus planipennisi* rejected all species except actively-feeding EAB larvae implanted in ash branches (Liu and Bauer 2007).

Spathius agrili was first reported in Tianjin, China (Liu and Liu 2002), where it is a prevalent parasitoid of EAB in stands of *F. velutina*, an ash species native to southwestern United States and parts of Mexico. In Tianjin, the emergence of *S. agrili* adults is well synchronized with the availability of third- and fourth-instar EAB larvae, its preferred host stages, and completes three generations per year (Yang et al. 2005). Females oviposit through the tree bark, paralyzing the larva and laying a clutch of eggs on the integument. At maturity, larvae of *S. agrili* spin a cocoon and pupate within the host gallery. No-choice laboratory assays of larval wood-boring insects from China and North America showed some overlap in the physiological host range of *S. agrili*, although successful parasitism was significantly lower in non-hosts than in EAB; no borers in genera other than *Agrilus* were attacked. Therefore, we evaluated the ecological host range of *S. agrili* using an olfactometer to determine the attractiveness of certain host plants. We found *S. agrili* was attracted to *F. pennsylvanica*, *F. velutina*, and a willow (*Salix babylonica*) only in Y-tube olfactometer tests. In nature, if parasitoids are not attracted to the host tree, they are unlikely to encounter and parasitize non-target larvae. In China, no *S. agrili* or *T. planipennisi* were reared from six species of field-collected *Agrilus* larvae (n = 2,074). Considering the combination of evidence from no-choice and olfactometer tests, the lack of *S. agrili* reared from other *Agrilus* spp. in China, and that native *Spathius* spp. were rarely reared from EAB in North America, we predict only incidental non-target parasitism (Gould et al. 2007).

Given the known risk of EAB to North American ash resources, the high potential benefit of these parasitoids in suppressing EAB populations, and the relatively low potential risk to native *Agrilus* spp., we submitted permit requests in January 2007 to USDA APHIS for release of each species in Michigan. After extensive review by federal and state scientists,

land managers, and university faculty members during a 60-day public comment period, it was agreed that the potential benefits outweighed the potential risks, and APHIS issued a finding of no significant impact (FONSI). Release permits were issued at the end of July, and field releases began in central and southeastern Michigan. In 2007, adult *O. agrili* (female n = 1406) were released in July and August at two sites in Ingham Co., Michigan; adult *T. planipennisi* (female n = 1360) were released from July through October at two sites in Ingham Co., Michigan; adult *S. agrili* (female n = 311) were released in August and September at one site each in Gratiot, Shiawasee, and Oakland counties, Michigan. We will evaluate the sites for establishment and dispersal of the parasitoids over the next five years or more. Additional research sites will be determined this winter for 2008 parasitoid releases.

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