Biological Control of Emerald Ash Borer (*Agrilus planipennis*)

The Pest: The emerald ash borer (EAB), an exotic invasive wood-boring beetle (Fig. 1) native to Asia, is threatening ash trees throughout North America. EAB was first detected in Michigan in 2002 although it likely arrived more than ten years earlier in solid wood packing materials. As of December 2008, EAB has been detected in ten states (Indiana, Illinois, Maryland, Michigan, Missouri, Ohio, Pennsylvania, Virginia, Wisconsin and West Virginia) and the Canadian provinces of Ontario and Quebec. EAB is well suited for climatic conditions on this continent. EAB larvae feed under the bark of ash trees (Fig. 2). cutting off the transport of nutrients, which results in tree death over a period of several years (Fig. 3). Forest inventories report 8 billion ash trees on U.S. timberlands, of which 693 million occur in Michigan. It is estimated that over 30 million of Michigan's ash trees have already succumbed to EAB. Clearly, the risk EAB poses to ash trees in North America is substantial. EAB is difficult to detect and control on an area-wide basis. Treatment options are limited and relatively few native natural enemies (parasitoids, predators and pathogens) attack EAB. As EAB spreads throughout North America, Federal and State agencies, land managers, and the public are seeking management tools that would reduce EAB population densities, slow its spread and reduce its impact on ash trees.


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Biological Control: Biological Control (or biocontrol) is the practice of importing and releasing host specific natural enemies from a pest's native range to control populations in the area of introduction. Biocontrol has been used for over 100 years in the U.S. and has successfully controlled invasive insect and weed pests such as gypsy moth, winter moth, ash whitefly, eucalyptus longhorned borer, purple loosestrife and Klamath weed. Because EAB is from northeastern Asia, U.S. and Chinese scientists have been searching for EAB and its natural enemies in that region since 2003. Numbers of EAB in Asia are very low as it is only a sporadic pest of ash because of resistant host plants, climatic conditions and natural enemies. Several EAB parasitoids (small stingless relatives of ants and wasps) were discovered in collaboration with scientists at the Chinese Academy of Forestry. USDA scientists are currently evaluating three parasitoids from China for biological control of EAB in the U.S. The biology of these EAB natural enemies is described below.


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Spathius agrili was found parasitizing up to 90 percent of EAB larvae in ash trees in China. Female *Spathius* parasitize EAB larvae by drilling through the bark (Fig. 4) and laying up to 20 eggs on its host. The hatching parasitoid larvae feed and develop on the EAB larva, resulting it its death. The cycle is repeated 3-4 times each summer and fall. *Spathuis* overwinter as pupae inside cocoons under the bark of ash trees and emerge as adults in the summer.


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Figure 1. Adult EAB (Tracy Ayer, USDA APHIS PPQ).
Figure 2. EAB larva (David Cappaert, Michigan State University, www.forestryimages.org).
Figure 3. Juli Gould and Ivich Fraser release *Spathius* in Genesee County, MI (Nicole Smith, USDA APHIS PPQ).
Figure 4. *Spathius agrili* ovipositing on EAB through ash bark (Dr. Yang Zhong-qi, Chinese Academy of Forestry).
Figure 5. *Spathius agrili* larvae consuming EAB host (Dr. Yang Zhong-qi).

Tetrastichus planipennisi is another parasitoid of EAB from China where it attacks and kills up to 50 percent of EAB larvae. The life cycle of *Tetrastichus* is similar to that of *Spathius*, however, the female parasitoid lays eggs inside EAB larvae where the parasitoid larvae grow, eventually killing their host. *Tetrastichus* completes at least four generations each year and one EAB larva can produce up to 127 *Tetrastichus* adults. They survive the winter as larvae inside their host or host gallery under the bark of ash trees.

Oobius agrili kills up to 60 percent of EAB eggs laid during the summer. Tiny female *Oobius* accomplish this by searching the bark of ash trees for EAB eggs, which are laid in bark crevices and between layers of bark. When *Oobius* finds an EAB egg, it injects its own egg inside where it will hatch, grow, and kill the host egg. An *Oobius* adult will emerge and repeat the cycle for at least two generations during the EAB egg-laying season. Each *Oobius* adult can parasitize up to 62 EAB eggs during its life time. *Oobius* spends the winter as larvae inside EAB eggs and emerge the following spring as adults.

Project Status: Laboratory methods for continuous rearing of these species of *Spathius, Tetrastichus,* and *Oobius* have been developed. The specificity of these parasitoids was studied extensively on native beetles and other insects. In laboratory no-choice assays, *Tetrastichus* rejected all non-EAB species as hosts attacking only actively-feeding EAB larvae in ash branches. Although *Spathius* and *Oobius* parasitized other species of wood borers in the genus *Agrilus*, parasitism rates were significantly lower than when parasitizing EAB. The preference of these parasitoids for EAB and ash habitats has been further confirmed through surveys in China and olfactometer tests.

An Environmental Assessment outlining the benefits of releasing these three parasitoids without posing a significant risk to native wood borers or their environs was prepared and published in the Federal Register for a 60-day comment period. Permit applications for field release of *Spathius, Tetrastichus* and *Oobius* were reviewed by international, national and state scientists and regulators, and permits were granted in July of 2007. Small numbers of each species were released in Michigan in the fall of 2007. Scientists have confirmed *Spathius* and *Oobius* successfully reproduced in Michigan field sites and survived the winter. Releases of the three species will continue while scientists further determine how these natural enemies can best be used to help suppress EAB populations. Scientists also continue to survey for and investigate the potential of additional EAB natural enemies that might be used in a biological control program. Most recently, two new species of *Spathius* were discovered in Korea and Russia respectively.

For more information:

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http://www.regulations.gov/fdmspublic/component/main?main=DocketDetail&d=APHIS-2007-0060
http://www.emeraldashborer.info/
http://www.aphis.usda.gov/plant_health/plant_pest_info/emerald_ash_b/background.shtml

Figure 6. *Tetrastichus planipennisi* adult parasitizing EAB larva (Dr. Houping Liu).
Figure 7. *Oobius agrili* adult parasitizing EAB egg (Dr. Houping Liu).