Waging War on a Voracious Pest

In Fenton, Michigan, APHIS entomologists Ivich Fraser (left) and Juli Gould release *Spathius agrili,* a parasitic wasp that attacks the emerald ash borer. Logs attached to the tree are used for monitoring purposes.

NICHOLE SMITH (D2150-1)

Efforts To Contain the Emerald Ash Borer

While driving to Michigan to study an infestation of emerald ash borer (EAB) beetles in June 2009, Agricultural Research Service entomologists John Vandenberg and Michael Griggs stopped to check out some defoliated ash trees along a highway in western New York State. What the two scientists discovered, in the town of Randolph, was New York's first infestation of a pest from Asia that has killed tens of millions of ash trees in at least 15 states and two Canadian provinces.

The emerald ash borer is a voracious beetle with stealthy habits. First detected near Detroit, Michigan, in 2002, it is metallic green and about a half-inch long. It will attack a wide variety of ash trees, wiping out huge swaths of wooded tracts and trees that shade many suburban neighborhoods. It poses more than an ecological threat, too. Ash trees are used to make furniture, tool handles, baseball bats, and other wood products.

The beetle spends much of its early life feeding under the bark of the ash tree, so that by the time it is detected, it is usually too late to save an infested tree. Ash borer beetle larvae feed on the phloem tissue of the tree, which weakens the tree and eventually kills it. One sign of infestation is damage from woodpeckers that feed on borer larvae.

"The ash borer is a really hard pest to detect in its early stages and really hard to study because of how it spends most of its life cycle," says Vandenberg.

A Variety of Control Strategies

Vandenberg and Griggs, both with ARS's Robert W. Holley Center for Agriculture and Health in Ithaca, New York, and Jian Duan, an entomologist at the ARS Beneficial Insects Introduction Research Unit in Newark, Delaware, are working with Leah Bauer, an entomologist with the

STEPHEN AUSMUS (D2138-6)

Emerald ash borer, *Agrilus planipennis.*

U.S. Department of Agriculture's Forest Service, and other federal and state partners on long-term efforts to control the spread of the EAB. Strategies include evaluating use of a fungal pathogen and three species of nonstinging parasitic wasps imported as biocontrol agents from the beetle's native lands, northeast Asia. Other ARS researchers are exploring whether pheromones can be used to keep the pest in check and developing cryopreservation techniques as a way of ensuring a future supply of ash trees. Partners along with the Forest Service include scientists from USDA's Animal and Plant Health Inspection Service (APHIS); Cornell University; the State University of New York's College of Environmental Science and Forestry; and foresters and scientists in New York, Maryland, Michigan, and Massachusetts and a number of other states.

APHIS plays an essential role in the effort. The agency joined with the Forest Service to conduct extensive studies that now make it possible to release nonstinging wasps in infested areas. APHIS also operates a facility in Brighton, Michigan, where large numbers of wasps are reared for field releases. "Before these natural enemies could be released, we conducted host-specificity testing to see if they would attack other wood-boring insects. We found that they preferred the emerald ash borer," says Juli Gould, an APHIS entomologist.

The beetle can be spread when people transport infested firewood and nursery stock, and infested trees are often found along highways. After the discovery by Vandenberg and Griggs in New York, a follow-up survey turned up a pattern of infestation that prompted state and federal quarantines restricting the movement of firewood, lumber, and logs from ash trees growing in the area. Many of the nearby properties are wooded, with up to 80 percent of their acreage covered by ash trees. "If you have an ash tree that is really important to you, you can inject insecticide into it once every year or two and that may save it. But that's really expensive, and it's not practical to do that for a forest of infested trees," Vandenberg says.

Crews in New York have been "girdling" ash trees by removing a 6-inch-wide rim of bark from around the tree to expose the wood. The girdled trees become attractive to the beetles, so that they leave other trees alone. The girdled trees are removed the following winter and spring, which prevents a new crop of EAB adults from emerging and dispersing, according to Bauer, the Forest Service entomologist.

Vandenberg is helping with control efforts in New York, girdling trees in Randolph and setting up sticky traps near them to study the extent of the infestation.

STEPHEN AUSMUS (D2137-14)

Entomologist Jian Duan (left) and technician Jeff Wildonger dissect EAB-infested ash logs to confirm that the borers have been parasitized by *Tetrastichus planipennisi,* a wasp from China.

STEPHEN AUSMUS (D2141-2)

A brood of *Tetrastichus planipennisi* pupae that developed on an EAB larva inside an ash log.

Scientists and technicians have girdled 17 clusters of ash trees in and around Randolph and 120 single girdled trees, known as "sentinel trees," within about 5 miles of the epicenter. The trees will be cut down and carved up into sections to assess the level of infestation, Vandenberg says. But newly discovered infestations in other parts of New York and other states pose a challenge for regulators and researchers alike.

Emerging from the trunk of an ash tree, an emerald ash borer is infected with *Beauveria bassiana,* an insect-pathogenic fungus that may prove to be a valuable biocontrol for this pest.

HOUPING LIU (D2146-1)

STEPHEN AUSMUS (D2140-19)

The parasitic wasp *Tetrastichus planipennisi* is native to China and is showing promise as a biocontrol in the United States for emerald ash borer.

Wasp Watch

Duan is working with Bauer and Gould to try to determine how well the three wasp species that are natural EAB enemies, *Oobius agrili*, *Tetrastichus planipennisi,* and *Spathius agrili,* will survive the winter in different northeastern areas and whether any one of them is more effective than the others. "This is a new habitat for them, and we don't know how late in the year they remain active," Duan says.

The researchers attached cages containing the wasps to green ash trees infested with EAB larvae between August and October in areas of Michigan and Maryland to assess the wasps' abilities to parasitize the ash borer and survive in those areas. The results are promising, says Duan. "We found that they successfully overwintered and survived in Michigan, and if they can survive the winter in Michigan, they most likely would successfully overwinter in New York and Pennsylvania," he says.

Duan is also assessing the potential use of several species of wasps native to North America. In collaboration with other researchers, he identified optimal rearing techniques for one of the parasitic wasps *(T. planipennisi)* to help ensure a sufficient supply. The rearing-techniques research was published in the *Journal of Economic Entomology.*

Wasps have been released in Michigan, Illinois, Indiana, Ohio, West Virginia, and Maryland, and releases are planned in several other states. Generally, scientists and technicians will release 1,200 individuals of each species at each release site, 600 at a time. In many states, there have been multiple release sites. "We also have long-term monitoring plots to look at the impact in all these states," Gould says.

Recently, Duan published a preliminary assessment of the establishment and impact of those newly released parasitoids on EAB populations in three natural forest stands in Michigan. Findings, published in the journal *Environmental Entomology,* showed that at least one of the wasps *(T. planipennisi)* had become established in three release sites in Michigan and that it was the most abundant species of the parasitoid wasps attacking EAB larvae a year after release.

Vandenberg is also testing use of an insect-pathogenic fungus, *Beauveria bassiana,* as a biocontrol agent along with the wasps. The fungus is the active ingredient in BotaniGard, a commercially available insecticide labeled for use against a variety of insects. The researchers think the fungus could be applied to infested trees as a first step before the wasps are released. Preliminary results show that it kills the beetles but leaves the wasps unharmed, says Vandenberg, but those studies are ongoing.

Using Chemical Attractants

Since 2007, ARS entomologist Allard Cossé has worked with a multidisciplinary team of scientists from ARS, APHIS, and the Forest Service to identify naturally occurring chemicals that the ash borer and its parasitoids simply cannot resist. Early success came with the identification by APHIS and Forest Service colleagues of several compounds emitted from the bark and leaves of girdled ash trees. These compounds, which are sensed by the antennae of adult ash borers, led to the development of traps baited with manuka oil—a less expensive proxy. These traps are now used to detect infestations of ash borer and support the establishment of new quarantine areas to contain the pest.

Cossé and colleagues have also discovered components of the ash borer's chemical attractant, or pheromone, and synthesized it for use in traps—either alone or combined with attractants derived from ash trees. Their target, macrocyclic lactone, is a compound that adult female ash borers emit while feeding. This compound's role as a sex attractant for adult male borers has recently been determined in large-scale field tests in Canada and the United States, adds Cossé, who is with ARS's National Center for Agricultural Utilization Research (NCAUR) in Peoria, Illinois.

His collaborators include, among others, Gould, Damon Crook, Victor Mastro, Jonathan Lelito, and Ivich Fraser—all with APHIS's Plant Protection and Quarantine program; Bruce Zilkowski and Richard Petroski, with ARS-NCAUR; Peter Silk and Krista Ryall, with the Canadian Forest Service; Ashot Khrimian, with ARS's Invasive Insect Biocontrol and Behavior Laboratory in Beltsville, Maryland; along with Bauer and Therese Poland, who are both with the Forest Service's Northern Research Station.

A key tool has been the electro-antennogram, a device that records the strengths of electrical signals generated by the EAB's antennae when connected to electrodes and exposed to different odors the pest encounters in nature. The device, coupled with gas chromatography analysis and wind tunnel experiments, has also proved invaluable in finding and developing attractants to help monitor ash borers.

Now these tools have been harnessed to identify attractants for the three parasitic wasps being released to control the pest. So far, the researchers have developed an experimental pheromone formulation for one of the three wasp species, namely *S. agrili.* Cossé reports the formulation is a blend of five compounds produced by male *S. agrili,* and it attracts other males as well as females. Efforts are now under way to develop pheromones for the other two species and then to blend them with ash tree attractants for added effect.

The researchers have made rapid progress, but their efforts are a race against the clock, given the rate that the pest is spreading. "If we can slow down the spread

LOUELA CASTRILLO (D2145-1)

ARS entomologist John Vandenberg sprays a formulation of spores of the fungus *Beauveria bassiana* on an ash tree at a test site in Michigan.

of the emerald ash borer and establish populations of natural enemies, it's possible we can create a kind of equilibrium whereby fewer trees are lost to the pest," says Cossé.

Ensuring Ash's Future

As added insurance, a team of ARS researchers in Ames, Iowa, and Fort Collins, Colorado, has devised a procedure for putting ash tree budwood material into a "deep freeze" for future use.

Using cryopreservation techniques that have been very effective for apple and sour cherry, horticulturist Mark Widrlechner and plant physiologist Gayle Volk showed that dormant budwood can be safely stored in liquid nitrogen vapor for prolonged periods and later thawed for use in propagating elite clones or cultivars.

Seed-storage methods can safeguard much of the diversity in North America's ash populations. "But there are selected ash cultivars with superior form and stress tolerance that never produce seeds—or that may have special characteristics useful in fighting EAB," says Widrlechner, with ARS's North Central Regional Plant Introduction Station in Ames. "For these trees, having a reliable method to preserve and propagate them in the future would be extremely valuable."—By **Dennis O'Brien** and **Jan Suszkiw,** ARS.

This research is part of Crop Protection and Quarantine, an ARS national program (#304) described at www.nps.ars.usda.gov.

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Native to China, the parasitic wasp *Spathius agrili* is being used as a biocontrol for emerald ash borer.

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