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THE ROLE OF BIOCONTROL OF EMERALD ASH BORER

IN PROTECTING ASH REGENERATION AFTER INVASION

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The Forest Health Technology Enterprise Team (FHTET) was created in 1995 by the Deputy Chief for State and Private Forestry, USDA Forest Service, to develop and deliver technologies to protect and improve the health of American forests.

FHTET became Forest Health Assessment and Applied Sciences Team (FHAAST) in 2016. This booklet was published by FHAAST as part of the technology transfer series.

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KEY FINDINGS

THE GOAL OF THE EAB BIOCONTROL PROGRAM IS TO PROTECT ASH REGENERATION AND RESTORE CANOPY COVER OVER TIME

- Long-term monitoring in Michigan and several northeastern states has documented increasing parasitism and reduced EAB attack rates.
- Ash regeneration is currently benefiting from releases of introduced parasitoids, which now cause 20-80% parasitism of EAB larvae in ash saplings (1-2 inch dia.) and young trees (5-8 inch dia.).
- *Spathius galinae*, the most recently released EAB biocontrol agent, appears to be establishing in the northeast United States and Michigan, based on 2017 recoveries. Only 5% of ash are too big for *S. galinae* to attack EAB larvae through the bark of the main trunk. We believe that *S. galinae*, where released and established, will begin protecting most large ash trees over the next five years and may provide continuity of protection for young ash trees as they mature, allowing ash regeneration in EAB-damaged forests.

Emerald ash borer, *Agrilus planipennis* (Photo: Pennsylvania Department of Conservation and Natural Resources – Forestry Archive)

BACKGROUND INFORMATION

Emerald ash borer (EAB) is an invasive Asian beetle that is destroying ash in forests over much of eastern North America because of the high susceptibility of our native ash and a lack of effective natural enemies (**Fig. 1**). To increase mortality of EAB larvae and eggs, the USDA (FS, ARS, APHIS) is carrying out a biological control program based on importation of parasitoids from the beetle's native range in northeastern China and the Russian Far East. Four such parasitoids have been approved for release since 2007 (**Figs. 2-5**), and these species are being reared at the USDA APHIS EAB Biocontrol Facility in Brighton, Michigan, for release in the United States. Three of these natural enemies are now established at various locations and are helping lower EAB densities.

Detailed information on EAB, biocontrol, release site selection, and how to request parasitoids is in the "EAB Biocontrol Release and Recovery Guidelines," available at www.MapBiocontrol.org.

Fig. 1. Typical damage to native ash trees caused by an infestation of the invasive Asian beetle, Emerald Ash Borer (Photo: USDA FS)

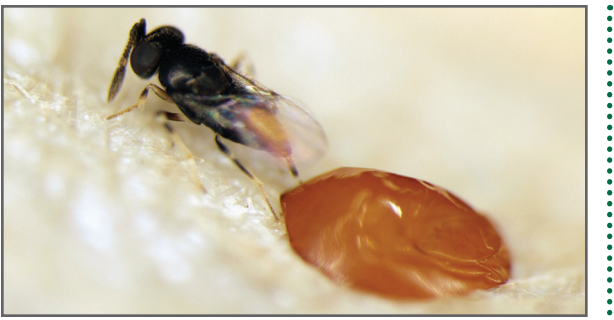


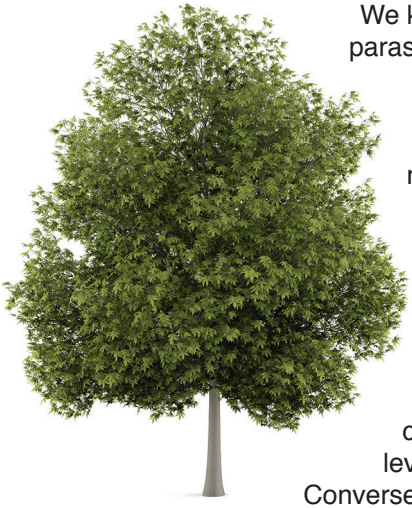
Fig. 2. Egg parasitoid ***Oobius agrili*** (Photo: USDA ARS)

Fig. 3. Larval parasitoid ***Tetrastichus planipennisi*** (Photo: USDA ARS)

Fig. 4. Larval parasitoid ***Spathius agrili*** (Photo: USDA ARS)

Fig. 5. Larval parasitoid ***Spathius galinae*** (Photo: USDA ARS)

How Will Asian Parasitoids Help Protect Ash?



We know that in Asia, parasitoids cause high mortality of EAB, while in North America our native parasitoids only sometimes do so. While North American ash are less resistant than Asian ash, American ash can tolerate some level of EAB attack. Conversely, woodpeckers, which are scarce in northeastern Asia, are common in North America and kill about 30-50% of surviving large EAB larvae. The goal of the EAB biocontrol program is to lower survival of EAB eggs and larvae by establishing more effective Asian parasitoids. The combination of these introduced parasitoids, together with moderate levels of tree resistance, high woodpecker predation, and some attack by native parasitoids, will reduce EAB densities and lower the number of attacks per tree to levels that ash trees can survive. This lower attack rate is already happening at Michigan study sites and is allowing ash saplings (1-2 inch dia.) and young ash (5-8 inch dia.) to survive and produce seed for ash regeneration. We have made considerable progress over the last ten years documenting the impacts of these factors, as described below. Moreover, in the aftermath of EAB in southeast Michigan forests where *T. planipennisi* is protecting young ash, recruitment and growth of native hardwoods are favored over invasive species.

What Gains Has the EAB Biocontrol Program Made?

- **Release of four EAB parasitoids from Asia.**
  - *Oobius agrili*, egg parasitoid from China, released since 2007
  - *Tetrastichus planipennisi*, internal larval parasitoid from China, since 2007
  - *Spathius agrili*, external larval parasitoid from China, since 2007
  - *Spathius galinae*, external larval parasitoid from Russia, since 2015

- **Establishment of two parasitoid species confirmed, third likely.** *Oobius agrili* and *T. planipennisi* are established in various areas and are being widely released. *Spathius galinae* is increasingly encountered during field surveys, but it is too early to confirm establishment.

- ***Oobius agrili*** causes up to 22% parasitism of EAB eggs at monitored Michigan study sites and is spreading slowly.

- ***Tetrastichus planipennisi*** is now widely established in the infested parts of North America and is spreading rapidly, causing ~20% parasitism in young ash trees (**Fig. 6**) and 50-80% parasitism in ash saplings (**Fig. 7**).

- **90% Reduction in EAB attacks on surviving trees.** In Michigan, EAB attack on surviving ash (larvae per m^2 of phloem area) is now <10% of the peak in 2009 (**Fig. 8**).

- **Avoidance of plant invasions.** In southern Michigan, where forests are recovering from the loss of ash overstory trees, native hardwoods are favored over invasive plants where ash seedlings, saplings, and young trees are protected by *T. planipennisi.*

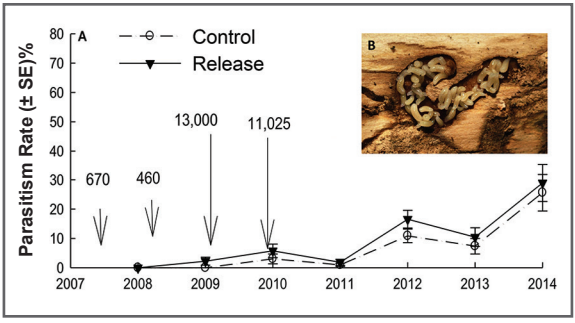


Fig. 6. (A). EAB larval parasitism by the introduced parasitoid *Tetrastichus planipennisi* in young ash trees (5-8 inch dia.) at release and non-release control plots, after parasitoid releases in monitored Michigan study sites starting in 2007 (arrows show number of adult parasitoids released by year) (Duan et al. 2015. J. Appl. Ecol. 52:1246-1254); **(B).** *T. planipennisi* larvae developed inside the parasitized EAB larva (Inset photo: USDA ARS)

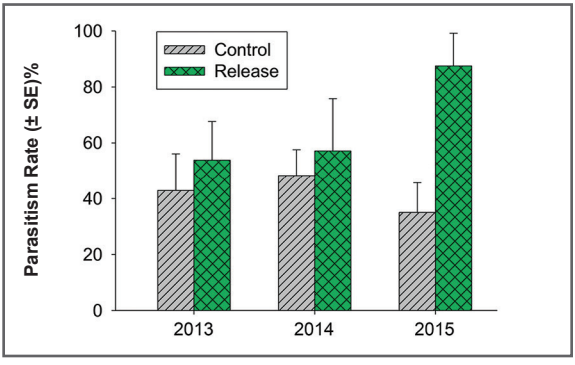


Fig. 7. EAB larval parasitism by *Tetrastichus planipennisi* in ash saplings (1-2 inch dia.) from 2013-2015 at the monitored Michigan study sites (Duan et al. 2017. For. Ecol. Manag. 394:64-72)

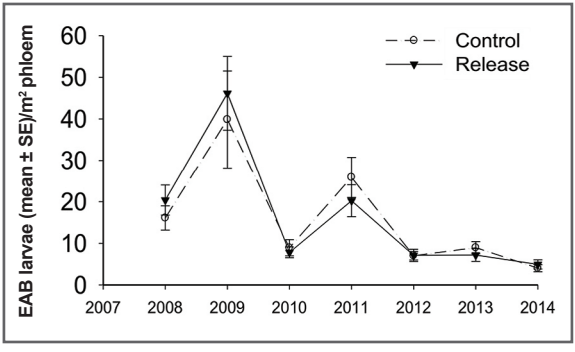


Fig. 8. EAB larval densities declined in the surviving ash trees at Michigan study sites after death of the larger ash trees (2008-2009). The parasitoids, released from 2007-2010, became established in the surviving ash and EAB parasitism increased from 2012-2014 (see Fig. 6) (Duan et al. 2015. J. Appl. Ecol. 52:1246-1254)

What is Likely to Happen in the Next Few Years?

Based on (1) our work during the past 10 years in Michigan and 3-6 years in the northeastern United States, (2) the likely imminent spread of EAB to the South and West, and (3) the species of ash in those not-yet-invaded areas, we expect

- **That** the newest larval parasitoid, *S. galinae*, recovered in 2017 in 11 of our 12 lifetable study plots in Michigan, Connecticut, Massachusetts, and New York, will establish and spread quickly in the northeastern and north central United States.

- **That** small ash (1 to 8 inch dia.), now and in the near future, will be protected by *O. agrili* and *T. planipennisi*, allowing ash regeneration in the northeastern and central United States.

- **That** within 5-10 years, as current young ash reach mid-size (9-15 inch dia.), *S. galinae* may be abundant and able to protect these trees as they enter the mid-size cohort, allowing ash regeneration (**Fig. 9**) and regrowth to continue.

Fig. 9. Ash seedlings grow quickly after EAB kills the overstory ash trees, thereby favoring the regeneration and recruitment of native hardwoods over invasive species. (Photo: USDA FS, also used on booklet front cover)

What Do We Need for the Not-Yet-Invaded Regions in the South and West?

- **New regions may need different parasitoids.** States just now being invaded in the South (Louisiana and nearby states) or likely to be invaded soon in the West (California through Oregon) and Southwest (Arizona and nearby states) may need DIFFERENT ASIAN PARASITOIDS (due to climatic differences between these states and northeastern China or the Russian Far East, the source of the parasitoids we are now releasing). Efforts to find and collect EAB parasitoids in southern and western China are needed now.

- **South.** In 2017, work began in southern China (at about the latitude of mid-Florida) in a newly located natural ash stand in an area potentially matching Louisiana.

- **West.** In 2017, a new EAB population was found in western China in an area with a climate similar to that of the Interior Great Basin (Utah and surrounding states). This EAB population needs to be sampled for parasitoids.

- **Southwest.** Several rare species of ash are native to Arizona and surrounding southwestern states. Conservation and restoration plans should be developed before EAB invades the region as these native ash species have small distributions and are expected to suffer high mortality from EAB.

Booklet back cover image: Young ash trees and saplings shown here are protected by introduced EAB parasitoids, especially by the larval parasitoid *Tetrastichus planipennisi*, which attack about 20% of large EAB larvae in young trees (5-8 inch dia.) and 50-85% in saplings (1-2 inch dia.) (Photo: USDA FS)

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