

5.3 Impacts of North American Native and Introduced Natural Enemies on Population Dynamics of the Invasive Emerald Ash Borer

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The emerald ash borer (EAB), *Agrilus planipennis* Fairmaire (Coleoptera: Buprestidae), an invasive phloem-feeding beetle from Asia that attacks ash (*Fraxinus*) trees, was inadvertently introduced to North America during the 1990's. EAB was first detected in Michigan, USA and Ontario, Canada in 2002 and has since spread through much of eastern and central North America, where it has killed hundreds of millions of ash trees.

Five years after the discovery of EAB in North America, a classical biological control program began with the introduction of EAB parasitoid species from Asia (Bauer *et al.*, 2015). To date, several EAB biocontrol agents have been approved for release: two larval parasitoids, *Tetrastichus planipennisi* Yang (Hymenoptera: Eulophidae) and *Spathius agrili* Yang (Hymenoptera: Braconidae) and one egg parasitoid, *Oobius agrili* Zhang & Huang (Encyrtidae), from northeast China (Federal Register, 2007). More recently, a fourth EAB parasitoid, *Spathius galinae* Belokobylskij & Strazanac (Hymenoptera: Braconidae) from the Russian Far East, was also approved for release (Federal Register, 2015). Environmental releases of the three Chinese parasitoid species began in Michigan in 2007 and the Russian parasitoid in 2015, with small numbers of each species released initially. However, larger releases began in 2010 when the USDA APHIS mass-rearing facility was established in Brighton, Michigan (Bauer *et al.*, 2015; Duan *et al.*, 2015, 2017). By the summer of 2016, 24 EAB-infested states and two Canadian provinces had released one or more species of these biocontrol agents (MapBiocontrol, 2016).

In 2008, following the first releases of these biocontrol agents, we began studying the stage-specific mortality of immature EAB including that caused by the introduced biocontrol agents, native natural enemies, and other biotic factors. The study sites are located in six, southern Michigan hardwood forests near the epicenter of the EAB invasion, and the parasitoid introductions occurred near peak EAB densities prior to widespread ash tree mortality. The data were collected each year from 2008 to 2016, and partial life tables of EAB were constructed for each study site each year and analyzed to determine the role of North American native natural enemies and introduced biocontrol agents in suppressing populations of immature EAB life stages (Duan *et al.*, 2015).

Results of our study revealed that EAB populations were heavily attacked by woodpeckers, undetermined biotic factors (such as pathogens and/or host plant resistance), and a diverse group of native hymenopteran parasitoids (primarily species of *Atanycolus*

(Hymenoptera: Braconidae)) during the earlier phase of the study (2008- 2012), and then by *T. planipennisi*, one of the introduced biocontrol agents from China in the later phase of the study (2012-2016). Parasitism by both the North American native parasitoids and the introduced larval parasitoid contributed significantly to the reduction of net EAB population growth rates in our study sites from 2010 to 2016.

Life-table analyses of EAB populations further indicated that North American native, generalist natural enemies (primarily *Atanycolus* spp.) played a significant role in reduction of EAB population density during the outbreak phase of the invasion, when the introduced natural enemies were just being released and had not yet established large enough populations to provide significant suppression of the target pest. However, *T. planipennisi* established a self-sustaining population approximately 4-5 years following its release, spread to other infested areas, and provided significant suppression of EAB population growth in the aftermath of EAB invasion. Together, the North American native natural enemies and the introduced agent are providing significant biocontrol services against EAB, allowing ash seedlings, sapling, and young trees to fill forest gaps thereby facilitating the gradual recovery of forested ecosystems in southern Michigan.

References

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