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Rapid Communication

White Fringetree as a Novel Larval Host for Emerald Ash Borer

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ABSTRACT Emerald ash borer is an invasive Asian pest of ash species in North America. All North American species of ash tested so far are susceptible to it, but there are no published reports of this insect developing fully in non-ash hosts in the field in North America. I report here evidence that emerald ash borer can attack and complete development in white fringetree, *Chionanthus virginicus* L., a species native to the southeastern United States that is also planted ornamentally. Four of 20 mature ornamental white fringetrees examined in the Dayton, Ohio area showed external symptoms of emerald ash borer attack, including the presence of adult exit holes, canopy dieback, and bark splitting and other deformities. Removal of bark from one of these trees yielded evidence of at least three generations of usage by emerald ash borer larvae, several actively feeding live larvae, and a dead adult confirmed as emerald ash borer.

KEY WORDS Buprestidae, emerald ash borer, host range, Oleaceae, white fringetree

Introduction

The emerald ash borer, *Agrilus planipennis* (Fairmaire) (Buprestidae), is an invasive Asian pest of ash (*Fraxinus* spp.) species in North America. Since its discovery in 2002 in the Detroit, MI, area (Haack et al. 2002), this insect has had devastating effects on both wild and planted ash trees in the United States and Canada, killing millions of trees with current and future management efforts estimated at >10 billion dollars (Kovacs et al. 2010). All North American species of ash tested so far are susceptible to emerald ash borer (e.g., Rebek et al. 2008), but there are no published reports of this insect developing fully in non-ash hosts in the field in North America. I report here evidence that emerald ash borer can complete development in white fringetree, *Chionanthus virginicus* L. (Oleaceae).

White fringetree is a small multistemmed tree or large shrub of open forest understories and edges that reaches its greatest abundance in the southeastern United States (U.S. Department of Agriculture–The Natural Resources Conservation Service [USDA NRCS] 2014). It can be rare at the edges of its range; e.g., it is listed as Potentially Threatened in Ohio (Ohio Division of Natural Resources [ODNR] 2014), being restricted to only the southern-most counties (USDA NRCS 2014). It is planted occasionally as a horticultural specimen, primarily for its fragrant white flowers produced each spring, and a few cultivars exist (Niemiera 2010). White fringetree is in the same family as ash trees, and planted individuals and wild populations will come increasingly in contact with emerald ash borer as it spreads to the southeastern United States. Presuming resistance to emerald ash borer, white fringetree has been mentioned as a possible reservoir for ash-dependent insects as ash trees continue to decline in number (Powell Gardens 2014).

In the only investigation of the potential use of white fringetree by emerald ash borer, Haack et al. (2003) noted in a technical report that adult beetles would feed on leaves of this plant to a small degree in no-choice tests in the laboratory. No experimental demonstrations or natural observations of the suitability of this species for emerald ash borer larvae have been published, and this species is not listed as a host for any *Agrilus* species or any other species of buprestid wood borer (Paiero et al. 2012). During August, September, and October 2014, I visually examined 20 white fringetrees (each >5-cm dbh on at least one main stem) that were planted ornamentally for evidence of attack by buprestid woodborers. These trees were all grown in relatively open conditions and experienced some shade for part of the day. Eleven trees were examined in the Village of Yellow Springs, Greene County, OH, five trees were examined at Cox Arboretum in Dayton, Montgomery County, OH, and four trees were examined at Ferncliff Cemetery and Arboretum in Springfield, OH. All individuals examined in this study were recorded in planting records, inventories, or confirmed by homeowners to be white fringetree.

Of the 11 trees examined in Yellow Springs, 8 were located along a 300-m stretch of the Little Miami River Scenic Trail in Yellow Springs, Greene County, OH, and were planted by the Yellow Springs Tree Committee. The part of the trail considered in this part of the study is bordered on either side by the Glen Helen Nature Preserve and the campus of Antioch College. Both the nature preserve and the campus contain a large number of ash trees (primarily white ash, *Fraxinus*

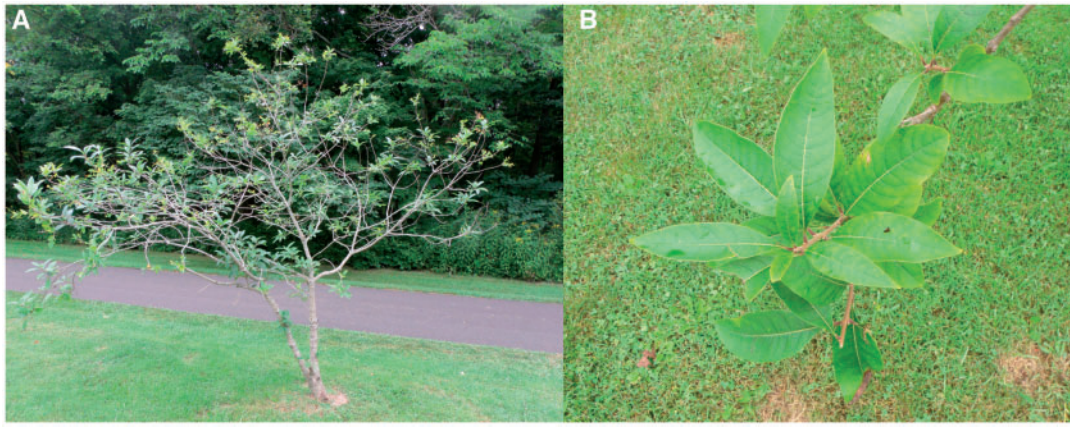

Fig. 1. White fringetree, *C. virginicus*, in an ornamental landscape along the Little Miami Scenic Trail in Yellow Springs, Greene County, OH. (A) Tree infested with emerald ash borer showing partial canopy dieback and epicormic sprouting. (B) Close-up of leaves of this tree.

Fig. 2. Evidence of the successful current and past use of white fringetree by emerald ash borer. (A) Adult exit hole characteristic of emerald ash borer detected on white fringetree. (B) One-year-old feeding gallery found under the exit hole. (C) Two-year-old feeding gallery found on the same tree, showing wound-healing response. (D) Current season gallery with live emerald ash borer larva found on the same tree.

americana L. and blue ash *Fraxinus quadrangulata* Michaux). Infestation of ash trees by emerald ash borer became visibly apparent for the first time in the village and nearby areas in 2012 (personal observation). On 17 August 2014, I found that one of the white fringetrees along the trail (Fig. 1; 39.802426, −83.886509) possessed a 3.18-mm-wide D-shaped exit hole characteristic of emerald ash borer (Fig. 2A) on one of its main stems, ∼1 m up from the base. This stem was 6 cm in diameter at breast height, 14 cm in diameter at the base

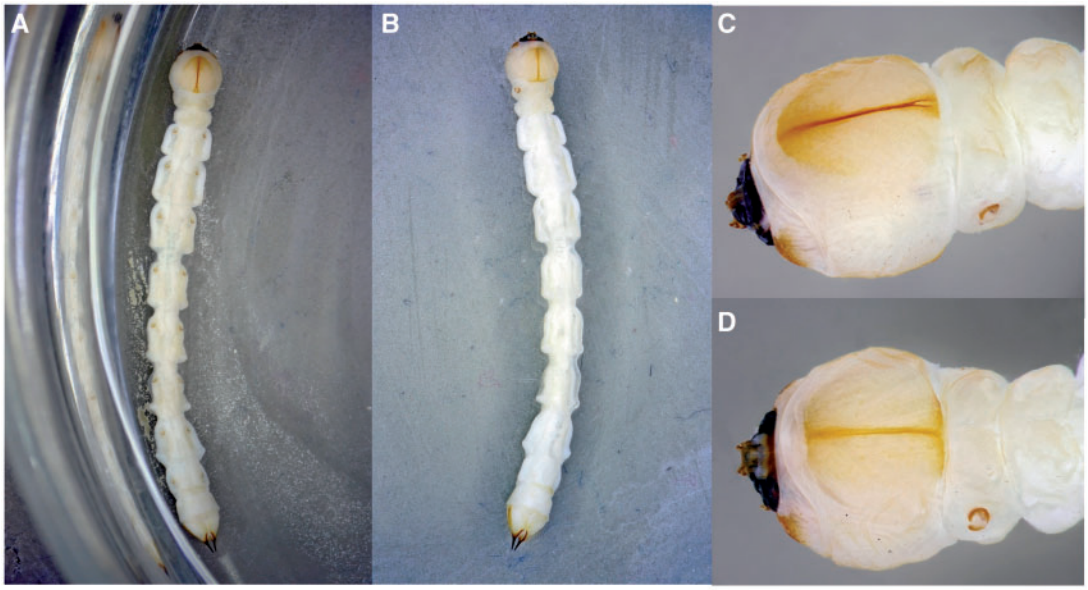

Fig. 3. Emerald ash borer larva recovered from white fringetree. (A) Dorsal habitus. (B) Ventral habitus. (C) Dorsal view of head. (D) Ventral view of head.

of the trunk, and approximately 15 years old according to ring counts. This tree was planted in 2004 according to records of the Yellow Springs Tree Committee (L. Kennedy, personal communication). Removal of the bark surrounding the exit hole revealed a serpentine feeding gallery characteristic of emerald ash borer (Fig. 2B), and the adult had apparently emerged at the start of the 2014 season. Removal of the bark in other locations on this stem revealed several full-sized galleries (Fig. 2C) that had apparently yielded adult beetles in 2013 (thus, ova were placed on the tree by 2012). These galleries were substantially calloused over and possessed well-healed exit holes evident on the inside of the bark that were not visible on the external surface of bark. While the infested tree possessed a vigorous wound-healing response around previous feeding galleries, the tree was showing signs of canopy dieback and epicormic sprouting (Fig. 1A) and would have likely been severely injured after the current season's feeding by larvae. It is worth noting that the infested tree displayed some basal trunk damage from lawn mowers. My initial observations of this tree were witnessed by Robert Gage and Dan Beverly, representatives of the Yellow Springs Tree Committee. This tree was cut down, removed from this site, and investigated further. Removal of additional sections of bark revealed several old galleries, as well as feeding galleries from the current season containing actively feeding larvae (Fig. 2D) near the base of the plant and on several of the main stems and branches. When examined under a dissecting scope, these larvae possessed major morphological characteristics that distinguish emerald ash borer larvae from larvae of other *Agrilis* species, such as trapezoidal abdominal segments and a bifurcated pronotal groove (Fig. 3, Chamorro et al. 2012). Pictures of the larvae were taken under magnification using a Nikon SMZ1000 (Nikon Instruments, Inc., Melville, NY) scope, processed with the program Zerene Stacker (V. 1.04, Zerene Systems, LLC., Richland, WA), with images produced using *pmax* and *dmap* methods combined into one image. These images and a physical specimen were examined first by Dr. James Zablotny, Insect Identifier with U.S. Department of Agriculture–The Animal and Plant Health Inspection Service–Plant Protection and Quarantine, and then by Dr. Lourdes Chamorro, Research Entomologist at the Systematic Entomology Laboratory of U.S. Department of Agriculture–Agricultural Research Service, and were declared to match certified emerald ash borer larval specimens (J. Zablotny and L. Chamorro, personal communication).

Six weeks after originally harvesting this tree, the cut stems were thoroughly examined for the presence of adult beetles trapped in the tree. Drying and cracking that had occurred over this period revealed evidence of a dead adult beetle trapped in a pupal chamber near a heavily calloused gallery (Fig. 4). This specimen was dug out of the chamber, photographed as above (Fig. 5), and the photographs and the specimen were sent first to Dr. Zablotny and then to Dr. Chamorro for examination. The specimen was determined by these individuals to be a male with external features and, most importantly, genitalia typical of emerald ash borer. On 13 October 2014, this specimen received final confirmation as *Agrilis planipennis* (Fairmaire) and its use of white fringetree declared a new host record (J. Zablotny and L. Chamorro, personal communication).

I investigated three other white fringetrees in the Village of Yellow Springs during August, two in private yards and one in the Kennedy Arboretum at Ellis Park. On 30 August 2014, I found that one of the trees in a private yard (39.799298; −83.896283) was also infested,

Fig. 4. Adult beetle trapped in a pupal chamber (within circle) on white fringetree.

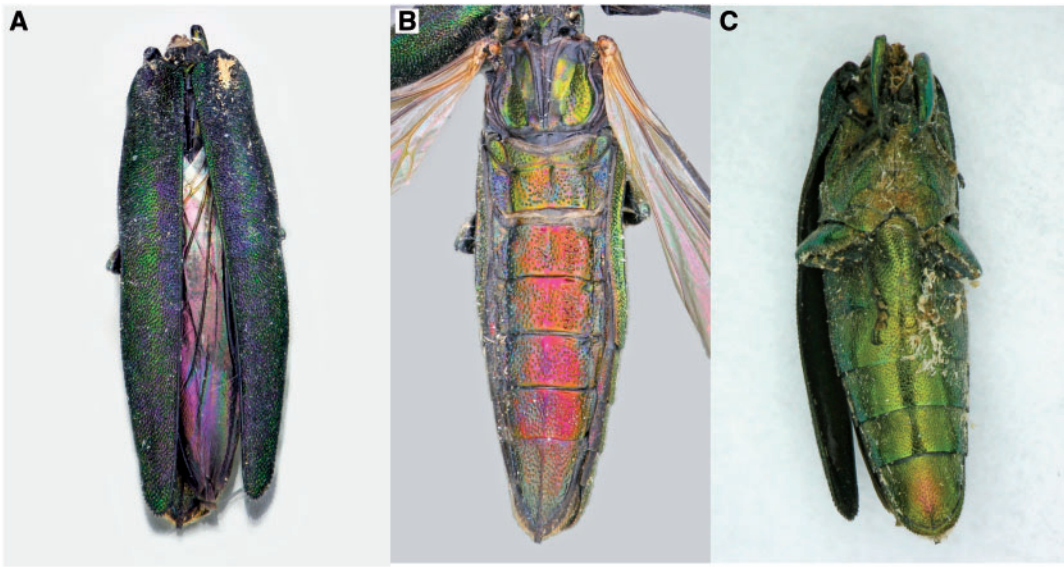

Fig. 5. Emerald ash borer adult (missing head) recovered from white fringetree. (A) Dorsal view, showing emerald and violet coloration. (B) View of dorsal surface of abdomen, showing metallic red light reflection, and raised carina on pygidium that extends beyond the abdomen. (C) Ventral view revealing emerald coloration.

showing visible exit holes consistent with emerald ash borer, and signs of canopy dieback, much like the first infested tree that was discovered. It was growing in a garden next to a private residence and showed no basal bark damage. I examined five white fringetrees at Cox Arboretum, a facility of the Five Rivers Metroparks in Dayton, Montgomery County, OH, on 20 September 2014. Like in the Village of Yellow Springs, ash trees in this area have been under attack by emerald ash borer for the past several years. One of the white fringetrees I examined along a walking path near a pond (39.654070; −84.225192) exhibited exit holes consistent with emerald ash borer, along with branch and canopy dieback, much like the others examined. It had no evidence of mechanical bark damage. Finally, I examined four white fringetrees growing at Ferncliff Cemetery

and Arboretum on 8 October 2014. One of these trees (39.940185; −83.827628) possessed a stem that was dying with a swelling encircling the base of this stem. Partial removal of the bark over the swelling revealed a current season's feeding gallery characteristic of emerald ash borer. This cemetery also harbored several ash trees in various states of emerald ash borer-induced canopy dieback. In total, 4 of the 20 mature white fringetrees I examined over this period showed symptoms of emerald ash borer attack. Removal of bark from one of these trees yielded evidence of three generations of usage by emerald ash borer, a dead adult, and live emerald ash borer larvae. Some of the other trees I examined may have contained feeding larvae for the first time in 2014 and whose damage was not yet apparent externally.

The ability of white fringetree to support the complete development of emerald ash borer has several ecological implications. First, questions have arisen about what emerald ash borer may do after the ash tree resource is exhausted, and this is evidence of the use of alternate host species, which may sustain the presence of emerald ash borer in North America. While ash trees are generally under heavy attack by emerald ash borer in the vicinity of the findings here, the ash tree resource is not yet exhausted in the region. For example, most white and green ash in the vicinity of the original finding are exhibiting moderate to severe dieback, but the numerous blue ash in areas such as the Glen Helen Nature Preserve show no evidence of emerald ash borer attack (personal observation), consistent with other reports (Tanis and McCullough 2012). Thus, emerald ash borer has been selecting some white fringetrees for oviposition, for the past several years in at least one case, even when ash trees were still widely available. The basal bark damage possessed by the first tree detected with an infestation may have made it particularly attractive to ovipositing adult females initially, as does mechanical girdling of ash tree trunks (McCullough et al. 2009). However, the three other infested trees examined showed no evidence of previous mechanical bark damage. If white fringetrees prove to be generally susceptible and suffer mortality because of emerald ash borer, then the existence of this species, which is already rare in parts of its range, may be threatened. Like the case for ash (Gandhi and Herms 2010), this would have indirect effects on other species wholly or partly dependent on white fringetree, such as the rustic sphinx moth [*Manduca rustica* (F.) (Lepidoptera, Sphingidae); Tuttle 2007].

Susceptibility of white fringetree to emerald ash borer has implications for horticulture and quarantine efforts as well. Sustaining existing trees in the ornamental landscape in the face of emerald ash borer will likely require pesticide treatment, such as those protocols recommended for ash trees (Herms et al. 2014). Because white fringetrees are small and are usually infrequently planted, this approach should be more feasible and less expensive than treatment of ash trees. Unlike ash trees, however, the flowers of white fringetree are bee-pollinated and the trees produce fleshy fruits that are eaten by birds; thus, systemic pesticide treatment of white fringetree carries additional ecological risks. Susceptibility of white fringetree to emerald ash borer will also influence decisions about planting this species in the landscape, which would ultimately affect decisions of nurseries to maintain this species in their inventories, as well as the inclusion of white fringetree in emerald ash borer quarantine regulations. Close relatives of white fringetree in North America include swamp privet (*Forestiera acuminata* Michaux), devilwood (*Osmanthus americanus* L.) and cultivated olive trees (*Olea europaea* L.). In fact, white fringetree is more closely related to these species than it is to *Fraxinus* species (Wallander and Albert 2000), so such species should now receive further scrutiny. The fate of the other white fringetrees that I examined in this study (which may have had undetected active galleries) along with additional planted individuals and those in wild populations will be followed to determine the full nature of the threat posed by emerald ash borer to this species.

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