

Insects and Their Life Cycle: Steps to Take to Assess Threats

Alicia M Bray and Jason B Oliver

Alicia M Bray is Post-Doctoral Research Associate, Otis L Floyd Nursery Research Center, Tennessee State University, McMinnville, TN 37110; Tel: 931-815-5160; email: abray@tnstate.edu.

Jason B Oliver is Research Associate Professor, Otis L Floyd Nursery Research Center, Tennessee State University, McMinnville, TN 37110; Tel: 931-668-3572; email: joliver@tnstate.edu.

Bray AM, Oliver JB. 2013. Insects and their life cycle: steps to take to assess threats. In: Haase DL, Pinto JR, Wilkinson KM, technical coordinators. National Proceedings: Forest and Conservation Nursery Associations—2012. Fort Collins (CO): USDA Forest Service, Rocky Mountain Research Station. Proceedings RMRS-P-69. 17-19. Available at: http://www.fs.fed.us/rm/pubs/rmrs_p069.html

Abstract: This paper provides a brief overview of the importance of wood-boring insects to the forest nursery industry. Descriptions of the major insect groups are provided with special attention to the life stages that are most problematic within each group. Steps are provided to guide individuals to mitigate potential threats if a new insect is detected causing damage to trees.

Keywords: forest pest, Buprestidae, Cerambycidae, Scolytinae

Introduction

There are more insect species in the world than all other animals combined. Although there are thousands of insects accidentally introduced each year, very few become established in the introduced range and many that do establish have no significant impact. Most insects (99%) are of minor importance to humans beings; they are food for other insects and animals, scavengers, and so on. Beneficial insects are the next largest category comprising predators, parasitoids, pollinators and sources of human products (silk, dyes, honey, etc.). Humans have intentionally introduced some beneficial insects into ecosystems if the benefits out-weighted the cost of introduction. The final category of insects, destructive insects, is the smallest category. These insects receive the most attention due to the impact they have on humans, animals, and the environment. The remainder of this paper will focus on destructive insects of forest and nursery systems.

Types of Insect Pests and the Conditions that Favor Them

Within insects, beetles are the most diverse insect group. Wood-boring beetles, such as metallic borers (Buprestidae), long-horned borers (Cerambycidae), and bark and ambrosia beetles (Scolytinae), are very problematic to the forest ecosystem and the nursery industry. Bark and ambrosia beetles are extremely problematic being implicated in as much as 60% of insect-related forest mortality (Anderson 1960). Wood-boring beetles are becoming an increasing problem due to the number of non-indigenous borers introduced into the U.S. by international trade (Haack 2006; Aukema and others 2010).

A variety of environmental and biological conditions can cause an explosion of destructive forest and nursery pest populations. Environmental conditions may increase the availability of stressed trees to attack (e.g., drought, flood), and conducive temperatures or moisture may create favorable conditions for insect populations to thrive. A couple of biological conditions that may allow an increase in destructive forest-nursery pest populations could include the reduction of natural enemies that feed on the pest, or the pest switching hosts to one that has reduced defenses in a new environment.

Forest/nursery insect pests can be divided into four broad categories:

- 1) Defoliating forest pests, such as the gypsy moth, forest tent caterpillar and eastern tent caterpillar are damaging to large number of trees when populations exponentially increase.
- 2) Piercing-sucking forest pests, such as the hemlock wooly adelgid, have killed thousands of hemlock trees throughout the eastern U.S.
- 3) Terminal feeders, such as the pales weevil and pine tip moths, are problematic to younger trees by affecting the growth form of the tree.
- 4) Finally, borer pests are becoming increasingly problematic due to the cryptic nature of their life history and the damage they cause to vascular tissues in trees.

Knowledge on the life cycle of the borer pest group plays a critical role in the ability to mitigate their effects. The larvae of borers are the most destructive life stage to trees because they feed under the bark and reduce the tree's ability to transport water and nutrients. Unfortunately, borer larvae are not easily visible during pest scouting and are therefore difficult to detect, so most efforts in beetle detection are focused on the adults. Adults are most often detected when they fly to new host trees or during their search for mates. Many borer traps exploit host plant or mate-associated lures to attract the adults.

What to Do Once a Pest Problem is Detected

Once a pest problem is detected, there are several steps one should follow to determine which species is causing the damage and how to control or reduce the damage. Steps given here are written for an insect problem; however, these steps would be similar if the problem was caused by a fungus, bacteria, or virus.

Detect and Identify Pest

The first step should be identification of the pest. Collection of adults and/or larvae should be accomplished and sent to the state entomologist, extension agent, pest diagnostic center, or university entomologist (if available) for identification.

Gather Information on Biology and Life Cycle

If it is a new pest, research will need to be conducted to understand the biology of the insect, including determination of the host range, number of generations and offspring per year, sex ratio of offspring, and identification of potential native biological control organisms. Once insect identification is confirmed, available knowledge on the pest should be obtained to determine if control strategies have already been developed.

Assess Impact and Develop Monitoring and Control Strategies

A critical assessment of the economic impact should also be conducted in addition to the biological information obtained. Unfortunately, in our current economic climate of decreasing budgets, the decision to control or eradicate a forest nursery pest will most likely be based on the economic and environmental benefits of control relative to the financial cost of developing and implementing a control program. During evaluation of the biology of the insect, control strategies should be assessed to facilitate any eradication or control program. Control strategies may include chemical control, semiochemical control (host or insect produced volatiles), host plant resistance, cultural control, and biological control (native or exotic predators and parasitoids). Other control methods may include generating sterile males of the pest population, exclusion, or legal methods (e.g., quarantines).

Emerald Ash Borer Case Study

The emerald ash borer provides a good example of the steps taken when a new pest is detected in forest and urban trees.

Detect and Identify Pest

Emerald ash borer (EAB) was first detected in Michigan and Windsor Ontario in the summer of 2002. Since its detection, it is now the most destructive introduced forest insect pest in recent U.S. history, causing the death of millions of ash trees (*Fraxinus* spp.) to date in the mid-west and eastern U.S. (USDA 2010). Specimens were first reared from ash in May 2002 in southeastern Michigan by an extension agent and sent to several experts in identification of metallic wood-boring beetles. These experts were able to determine the beetles were in the genus *Agrilus*, but the specific species was undetermined at that time. Digital images and specimens were sent to an expert in Asian *Agrilus* species, Dr. Eduard Jendek in Slovakia, who was able to make a positive identification of *A. planipennis* in July 2002.

Gather Information on Biology and Life Cycle

Research on the general biology of EAB was already underway, while it was being identified (Haack 2002). It is thought to have arrived in packing material from Asia in the early 1990's (Siegert and others 2007). Females are capable of laying 60-90 eggs with larvae boring under the bark and feeding on the phloem. All known native ash species in the U.S. are susceptible to EAB attack and several can be killed within as little as 2 years (Haack and others 2004; Anulewicz and others 2008).

Assess Impact and Develop Monitoring and Control Strategies

Due to the potential devastation of EAB in the U.S., legal control was established by implementing federal and state quarantines in hopes to limit the spread of EAB throughout the U.S. A number of new methods to detect the beetle at new locations have been developed (e.g., girdled trees, traps) and these have become an important part of the quarantine program. Effective chemical control strategies currently are targeting the destructive larval stage of EAB. Examples of chemical control are tree injections of Tree-äge (active

ingredient emamectin benzoate) providing multiple years of ash tree protection or basal drench treatments of imidacloprid providing single year protection (Hermes and others 2009; Smitley and others 2010). Biological control has been developed by identifying parasitoids from EAB's native range in Asia (*Spathius agrili*, *Tetrastichus planipennisi*, and *Oobius agrili*) and releasing them into the introduced range in the U.S. (Bauer and others 2007). A native predator, *Cerceris fumipennis* (Careless and others 2009) and a native parasitoid, *Atanycolus hicoriae* (Cappert and McCullough 2008) have also been identified to attack EAB. Work on semiochemical control and host plant resistance is ongoing.

Summary

Once a pest problem is detected, there are several steps one should follow to determine which species is causing the damage and how to control or reduce the damage. These steps include: 1) detect and identify the pest; 2) gather information on pest biology and life cycle; and 3) assess the impact and develop monitoring and control strategies.

The emerald ash borer case study is a good example of the steps to take when a new pest is detected in forest and urban trees. Beetle identification was accomplished within a couple months of detection using an international group of experts. The biology of the beetle has been determined in the introduced range, including host range and reproductive potential. Monitoring strategies have been developed and control strategies have been identified utilizing chemical control as well as biological control. The long-term survival of ash trees in North America is yet to be determined; however, current control strategies against EAB and continued research to develop other control methods will be critical to ensure ash remains in our environment. Lessons learned from successes and failures in detecting, identifying, assessing and mitigating new insect pests can be applied to other pest problems in forests and forest nurseries.

References

- Anderson RF. 1960. Forest and shade tree entomology. John Wiley & Sons, Inc. New York, NY. 428 p.
- Anulewicz AC, McMullough DG, Cappaert DL, Poland TM. 2008. Host range of the emerald ash borer (*Agrilus planipennis* Fairmaire) (Coleoptera: Buprestidae) in North America: results of multiple-choice field experiments. *Environmental Entomology* 37:230-241.
- Aukema JE, McCullough DG, Von Holle B, Liebhold AM, Britton K, Frankel SJ. 2010. Historical accumulation of nonindigenous forest pests in the continental United States. *BioScience* 60:886-897.
- Bauer LS, Liu H, Gould JR, Reardon RC. 2007. Progress on biological control of the emerald ash borer in North America. *Bio-control News and Information* 28:49N-66N.
- Careless PD, Marshall SA, Gill BD, Appleton E, Favrin R, Kimoto T. 2009. *Cerceris fumipennis* – A biosurveillance tool for emerald ash borer. Canadian Food Inspection Agency. 16 p.
- Haack RA. 2006. Exotic bark- and wood-boring Coleoptera in the United States: recent establishments and interceptions. *Canadian Journal of Forest Resources* 36:269-288.
- Haack RA, Jendek E, Liu H, Marchant KR, Petrice TR, Poland TM, Ye H. 2002. The emerald ash borer: a new exotic pest in North America. *Newsletter of the Michigan Entomological Society* 47:1-5.
- Haack RA, Petrice TR, Miller DL, Bauer LS, Schiff N. 2004. Host range of emerald ash borer. In: Mastro V, Reardon R, compilers. *Proceedings of the emerald ash borer research and development review meeting*. Morgantown (WV): USDA Forest Service, Forest Health Technology Enterprise Team. FHTET 2004-02. 38 p.
- Hermes DA, McMullough DG, Smitley DR, Sadof CS, Williamson RC, Nixon PL. 2009. Insecticide options for protecting ash trees from emerald ash borer. *North Central IPM Center Bulletin*. 12 p.
- Siegert NW, McCullough DG, Liebhold AM, Telewski FW. 2007. Resurrected from the ashes: a historical reconstruction of emerald ash borer dynamics through dendrochronological analysis. In: Mastro V, Lance D, Reardon R, Parra G, compilers. *Emerald ash borer and Asian longhorned beetle research and development review meeting* Morgantown, WV: U.S. Forest Service, Forest Health Technology Enterprise Team: FHTET 2007-04. p 18-19.
- Smitley DR, Docola JJ, Cox DL. 2010. Multiple-year protection of ash trees from emerald ash borer with a single trunk injection of emamectin benzoate, and single-year protection with an imidacloprid basal drench. *Arboriculture & Urban Forestry* 36:206-211.
- USDA Forest Service. 2010. Integrated program strategy for reducing the adverse impacts of emerald ash borer throughout the northeastern area. USDA Forest Service, Northeastern Area State and Private Forestry – Forest Health and Economics. Lexington, KY: ASMR. p. 962-980.