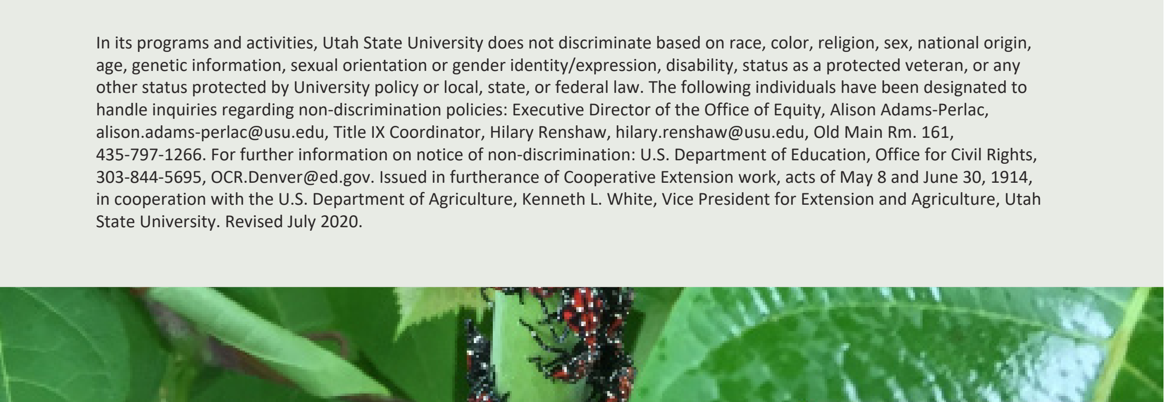



First Detector Guide to Invasive Insects

Biology, Identification & Monitoring

USDA
Extension
Utah State University



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Invasive Insects

Biology, Identification & Monitoring

CONTRIBUTING AUTHORS

Lori R. Spears,[1] Diane G. Alston,[1] Erin Brennan,[1] Cami Cannon,[1] Joey Caputo,[2] Ryan Davis,[1] Liz Hebertson,[3] Colleen Keyes,[4] Danielle Malesky,[3] Darren McAvoy,[1] Ann M. Mull,[1] Ricardo A. Ramirez,[1] Taryn M. Rodman,[1] and Kristopher Watson[2]

[1]Utah State University, [2]Utah Department of Agriculture and Food, [3]USDA Forest Service, [4]Utah Division of Forestry, Fire and State Lands

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UTAH FIRST DETECTOR PROGRAM

Invasive species are a leading and growing threat to our nation's agricultural and natural resources. Thousands of exotic species have been introduced into the U.S., and the estimated damage and management costs of invasive species exceed $138 billion per year. In response to this threat, the Utah Plant Pest Diagnostic Lab (UPPDL) and Utah State University (USU) Extension created the Utah First Detector Program to prepare citizen responders with the knowledge and skills necessary to identify invasive insects, collect and submit high quality samples to the UPPDL, and notify the appropriate authorities when necessary.

The UPPDL and USU Extension work closely with other federal and state agencies, such as the U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine (USDA APHIS PPQ) Program, USDA Forest Service, and Utah Department of Agriculture and Food (UDAF), to address invasive pest threats. The Utah First Detector Program is, in part, an extension of the Utah Cooperative Agricultural Pest Survey (CAPS) Program, which is part of the larger national CAPS program. For more information about the Utah CAPS program, visit http://utahpests.usu.edu/caps.

The target audience for the Utah First Detector Program includes Master Gardeners, Extension personnel, state agricultural inspectors, certified arborists, tree and lawncare professionals, forestry and natural resource professionals, conservationists, and others with an interest in pest detection and response.

PROGRAM GOAL

The primary goal of the Utah First Detector Program is to create a network of well-trained and committed citizen volunteers ("First Detectors") to assist with ongoing invasive pest detection and outreach efforts. The UPPDL, USU Extension, and their partners conduct workshops to train First Detectors to detect and identify invasive insects of concern. As part of this program, First Detectors will receive a printed copy of this guide and other reference materials needed to support invasive pest awareness initiatives.

ROLES & RESPONSIBILITIES

In order to become a First Detector, individuals must attend a First Detector training workshop, which is usually held in September (see https://utahpests.usu.edu/caps/get-involved for more information). In addition, First Detectors must be familiar with and agree to the following terms:

- *First Detectors never announce the arrival of a new pest.* All information regarding potentially new, invasive pests must be treated as confidential. First Detectors should immediately notify the UPPDL regarding suspected symptoms or collection of life stages. The UPPDL will then communicate that information to the appropriate agencies. This protocol is required to avoid premature and incorrect reports, as significant unintended consequences may result from hasty, inaccurate communications.
- *First Detectors do not have the authority to enter private property without permission.* If you do receive permission to enter private property, it is recommended that the property owner accompany you.
- *Being a First Detector is voluntary.* First Detectors will not be financially compensated or reimbursed for time and/or travel. However, continuing education units (CEUs) may be available for pesticide applicators and certified arborists. Master Gardeners may also be able to use First Detector volunteer hours toward Master Gardener service hours, but should first discuss this opportunity with their county Extension agent.

SUBMITTING SAMPLES

The UPPDL is a service of USU Extension and the Department of Biology at USU. The UPPDL is staffed with highly skilled and experienced professionals that provide rapid and accurate identification of pest-related problems. First Detectors may submit suspect samples (digital images and/or physical samples) directly to the UPPDL. If possible, send digital images to caps@usu.edu or utahpestlab@gmail.com for screening prior to submitting physical samples to the UPPDL.

Submitting Digital Images

Send high-resolution images as an email attachment to one of the labs listed on the next page. Images should be **in focus** and well-lighted, contain a ruler or other object for scale, and contain different parts/views of the insect and/or plant symptoms.

Submitting Physical Samples

Live insects can escape from containers; therefore, it is very important that you kill (do not squish) the insect before submitting it to the UPPDL. Place the insect into a spill-proof jar or vial containing rubbing alcohol (hand sanitizer or white vinegar are suitable alternatives). You can also freeze the insect before placing it into a sealable crush-proof container. If submitting plant material, handle it as if it contains a live pest (i.e., secure plant material so that an emerging pest could not escape). Wrap plant material in paper bags or newspaper. Secure samples using packing material to avoid breakage/damage. Samples containing plant material should be sent overnight.

Include with your submission, the date, collection location, email address, phone number, and physical address in case we have follow-up questions. Mail sample(s) to one of the labs listed below, and as soon as possible to prevent drying or deterioration of the insect or plant material.

Utah Plant Pest Diagnostic Laboratory
Utah State University
5305 Old Main Hill
Logan, UT 84322-5305
Phone: 435-797-2435
Email: caps@usu.edu or utahpestlab@gmail.com
Website: http://utahpests.usu.edu/uppdl/

Utah Department of Agriculture and Food
Plant Industry and Conservation Division
350 N. Redwood Road
Salt Lake City, UT 84114
Phone: 801-538-7184
Email: agriculture@utah.gov
Website: http://ag.utah.gov/plants-pests.html

Acknowledgments: Many thanks to Dawn Holzer and Alana Wild (both of USDA APHIS PPQ) for supporting and recognizing the need for this work. Funding was provided by USDA APHIS PPQ. The Utah First Detector Program is modeled after the Minnesota, Vermont, and North Dakota First Detector Programs.

Asian Longhorned Beetle

Anoplophora glabripennis Motschulsky

BACKGROUND

Asian longhorned beetle (ALB) (Coleoptera: Cerambycidae) is an invasive wood-boring pest that is a major threat to many hardwood tree species and to maple syrup production. It was first detected in the U.S. in New York during the 1980s, and probably arrived via infested wood packing material from China. The first major infestation of ALB in the U.S. was in Brooklyn in 1996. Soon after, infestations were found in other eastern locations, including Chicago and New England. ALB is currently only found in Massachusetts, New York, and Ohio, and is considered to have been successfully eradicated from New Jersey and Illinois.

Fig 1. Adult Asian longhorned beetle (ALB).

IDENTIFICATION

Adults are large, conspicuous beetles that are bullet-shaped, ¾ – 1 ½ inches in length (not including the very long black and white antennae), and have a glossy-smooth black body with irregular white spots (Figs 1 and 2). Some adults, although generally rare, have yellow spots and newly emerged adults may have a bluish tinge to their feet and antennae (Fig 2). The scutellum, or the triangular segment between the top of the wing covers, is black (a similar looking native insect has a white scutellum - see SIMILAR INSECTS section on page 7).

Fig 2. Some adults have a bluish tinge to the legs and antennae. Arrow points to black scutellum (triangular segment between the top of the wing covers).

Eggs are ¼ inch in length, roughly the size of a grain of rice (Fig 3). They are flat, creamy-white in color, and are laid individually in an aggregated pattern and in craters (oviposition pits) chewed into the bark by the adult female. Eggs can be found underneath the bark on the lower trunk, main branches, and lower crown.

Larvae are typical of roundheaded beetle larvae. They are cylindrical, ribbed, and light yellow or white (Fig 4). Larvae can reach up to 2 inches in length. Young larvae create galleries just under the bark, but tunnel into the heartwood of the tree as they mature.

Pupae are about 1 ½ inches in length and the same color as larvae, but have traits that resemble the adult (Fig 5). Pupae darken in color as they mature.

Fig 3. Eggs look like grains of rice.

Fig 4. Various stages of ALB larvae.

Fig 5. A pupa beginning to resemble an adult.

LIFE HISTORY

ALB has one generation per year (Fig 6). Adults emerge from host trees in late spring and can be found throughout the summer, until about the first frost. Adults feed on leaf veins (Fig 7) and bark of young twigs for 10 to 20 days before mating. A female may lay up to 90 eggs in her lifetime.

Eggs hatch within a couple of weeks and the newly emerging larvae feed on the cambium and sapwood, eventually tunneling deeper into the heartwood. ALB typically overwinters as a larva.

The following spring, larvae begin to chew their way toward the outside of the tree, where they pupate. Pupation lasts about 20 days, with adults emerging from trees during the late spring. Adults may remain on the tree they developed in, or fly short distances to infest new trees.

PLANT HOSTS

ALB infests more than 100 different tree species, making it especially threatening to forests and incredibly difficult to detect and eradicate. Maple is the preferred host, but there are many other trees it will attack, such

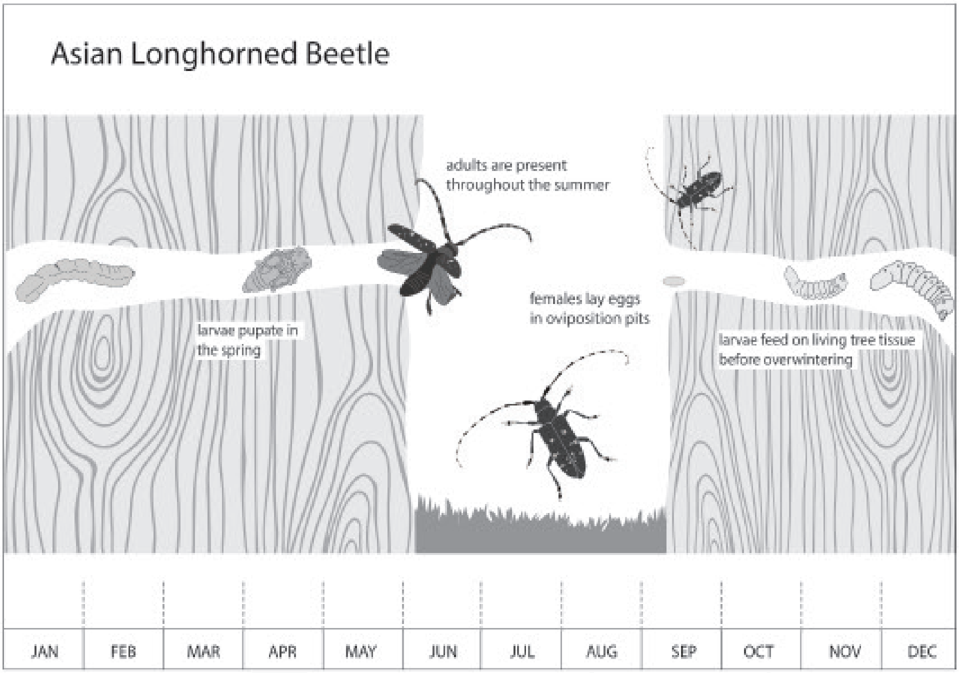

Fig 6. ALB has one generation per year.

as ash, birch, elm, poplar, willow, and sycamore. Some trees appear to not be at risk of ALB infestation, including oak and honeylocust. It is unknown if ALB infests conifers.

DAMAGE SYMPTOMS

Both adults and larvae feed on host trees, although the larvae cause the most damage. Adults will feed on leaf veins (Fig 7), and the females chew craters (oviposition pits) into tree bark, leaving mandibular (mouthpart) marks that can be seen around the edges of the pit (Figs 8-10). Craters are about ½ inch in diameter and vary in shape from circular to oval, depending on bark thickness. Freshly chewed pits are easier to see because the inner bark contrasts more sharply with the outer bark. ALB adult exit holes are perfectly round, nearly dime-sized (⅜ inch in diameter), and may ooze sap (Fig 11).

Larvae bore into and feed on the cambium and sapwood, creating large hollow chambers that can be seen in cross-sections of the trunk (Figs 12-14). Deposits of frass (sawdust-like insect waste) may collect at tree trunks and limb bases (Fig 15). Severe larval infestations lead to dead branches and can make tree limbs more likely to break during storms and cause damage to nearby structures. Larval feeding also disrupts the tree's ability to uptake water and nutrients, causing the tree to slowly die. Infested trees may be associated with drooping leaves and discolored foliage (Fig 16).

Fig 7. Adults tend to feed along the veins of leaves.

Fig 9. Oviposition pits and adult exit holes.

Fig 8. Heavily attacked tree showing fresh and old oviposition pits.

Fig 10. Recent oviposition wound. Note the chew marks that can be seen around the pit edges.

Fig 11. Adult exit holes are perfectly round.

Fig 12. Internal damage to tree trunk caused by ALB development within the tree.

Fig 13. Damage caused by larval feeding.

Fig 14. Larval galleries under the bark.

Fig 15. Frass from larval feeding will often collect at tree trunks and limb bases.

Fig 16. ALB can cause unseasonably discolored foliage.

WHAT CAN YOU DO?

Do not move or transport firewood. ALB can travel short distances on its own, but larvae and adults can survive within firewood and other wood materials.

Be aware of the signs and symptoms of an ALB infestation. First state detections of ALB have usually been made by a concerned citizen, not a professional entomologist. Report suspicious insects to the UPPDL.

Be aware of common and native insects that look like ALB. For more information about some of these insects, see the SIMILAR INSECTS section on the next page.

Keep trees healthy. Research suggests that healthy trees are less likely to become infested with pests. Trees should be properly watered and pruned, and fertilized when necessary. Keep at least a 4 foot diameter area around trees free of weeds and grass so that there is no competition for water or nutrients and so trunks are not damaged by lawnmowers. Your local USU Extension office can help with tree maintenance and planting information.

MONITORING

Pheromone-baited traps, including interceptor traps (Fig 17), have been used by survey personnel for monitoring ALB. However, ALB has been detected primarily by the public or through visual surveys. Therefore, there is a big push toward training volunteers to help with the surveying process (in areas where ALB has been detected) or to keep their eyes open for these pests (in areas where ALB has and has not been detected). Since initital infestations usually occur first in the upper parts of the tree canopy, trees are scanned with binoculars or inspected with bucket trucks. Initial detections of ALB in Utah, however, should focus on the identification of the adult beetle, as suspicious damage can be caused by insects that already occur in Utah.

Fig 17. Interceptor traps are used for detecting and monitoring ALB.

MANAGEMENT

When ALB infestations are found, APHIS and State officials establish quarantines, which help with beetle eradication by restricting the movement of ALB and ALB host materials (known as regulated articles). This minimizes the chance of ALB spreading to new locations. Unfortunately, control options beyond removing and chipping or burning infested trees (Fig 18) are limited.

Fig 18. Removal of an ALB infested tree.

Several of the known natural enemies (parasitoids and predators) in the native range of ALB affect insects that are native to the U.S., and therefore unlikely to be effective or approved for release in controlling ALB.

Some systemic insecticides have been used in the U.S. to control ALB, but they are known to have harmful impacts on some beneficial insect species. Currently, the most practical approach for controlling ALB is to detect and eradicate it before it spreads over large areas.

SIMILAR INSECTS

Other insects may be mistaken for ALB in Utah, including the white-spotted sawyer (*Monochamus scutellatus*) and banded ash borer (*Neoclytus caprea*). The white-spotted sawyer adult has a dull bronze-black body with variable white markings, faintly banded antennae, and white scutellum (i.e., a white segment located between the top of the wings) (Fig 19). The banded ash borer is a pest of ash, hickory, elm, linden, mesquite, and oak. Adults are black, and have yellow or cream-colored markings on their wings and antennae that are less than ½ the length of their body (Fig 20).

Fig 19. White-spotted sawyer. Arrow points to white scutellum.

Fig 20. Banded ash borer.

REFERENCES & ADDITIONAL RESOURCES

Haack, R.A., F. Herard, J. Sun, and J.J. Turgeon. 2010. Managing invasive populations of Asian longhorned beetle and citrus longhorned beetle: a worldwide perspective. Annual Review of Entomology 55: 521-546.

Hu, J., S. Angeli, S. Schuetz, Y. Luo, and A.E. Hajek. 2009. Ecology and management of exotic and endemic Asian longhorned beetle (*Anoplophora glabripennis*). Agricultural and Forest Entomology 11: 359-375.

Meng, P.S., K. Hoover, and M.A. Keena. 2015. Asian longhorned beetle (Coleoptera: Cerambycidae), an introduced pest of maple and other hardwood trees in North America and Europe. Journal of Integrated Pest Management 6: 1-13.

Asian Longhorned Beetle in Colorado - Identification of Insects and Damage of Similar Appearance, Colorado State University.

Asian Longhorned Beetle and Its Host Trees, U.S. Forest Service.

Efficient Irrigation of Trees and Shrubs, Utah State University Extension.

New Pheromone Traps Lure Asian Longhorned Beetles Out of Hiding, U.S. Forest Service.

Pest Alert: Asian Longhorned Beetle, USDA APHIS.

Post-Planting Tree Care, Utah State University Extension.

Questions and Answers: Asian Longhorned Beetle Control Treatments, USDA APHIS.

The Use of Volunteers in Exotic Pest Surveys, Cooperative Agricultural Pest Survey (CAPS) Program.

Using Traps to Detect Asian Longhorned Beetle, Penn State University.

Volunteer Guidelines: Asian Longhorned Beetle, Cooperative Agricultural Pest Survey (CAPS).

For more information on ALB, visit these websites: USDA Hungry Pests ALB page (http://www.hungrypests.com/the-threat/asian-longhorned-beetle.php), Don't Move Firewood ALB page (http://www.dontmovefirewood.org/gallery-of-pests/asian-long-horned-beetle.html), USDA ALB Informational Website (http://www.beetlebusters.info), and National Invasive Species Information Center ALB species profile (https://www.invasivespeciesinfo.gov/animals/asianbeetle.shtml).

PHOTO CREDITS

Figs 1, 7, 15. Pennsylvania Department of Conservation and Natural Resources - Forestry, Bugwood.org

Fig 2. Dutch government [CC0]

Figs 3, 5. Melody Keena, USDA Forest Service, Bugwood.org

Figs 4, 19. Steven Katovich, USDA Forest Service, Bugwood.org

Fig 6. Life cycle by Erin Brennan, Utah State University

Fig 8. Michael Bohne, Bugwood.org

Figs 9, 14, 16. Dennis Haugen, USDA Forest Service, Bugwood.org

Fig 10. Donald Owen, California Department of Forestry and Fire Protection, Bugwood.org

Fig 11. Daniel Herms, The Ohio State University, Bugwood.org

Figs 12, 18. Thomas B. Denholm, New Jersey Department of Agriculture, Bugwood.org

Fig 13. Joe Boggs, Ohio State University, Bugwood.org

Fig 17. University of Arkansas Forest Entomology Lab, University of Arkansas, Bugwood.org

Fig 20. David Cappaert, Bugwood.org

Balsam Woolly Adelgid

Adelges piceae Ratzeburg

BACKGROUND

Balsam woolly adelgid (BWA) (Hemiptera: Adelgidae) is a tiny sucking insect that is a serious pest of true firs in forests, landscapes, and Christmas tree production. In some areas of North America, BWA has completely removed true firs from forest stands. Originally from Europe, BWA was first detected in the U.S. in 1908. Through multiple introductions and spread, it now infests true firs over most of the country. In Utah, BWA was first observed killing subalpine fir in 2017 (Fig 1). It is now confirmed in Box Elder, Cache, Rich, Weber, Davis, Morgan, Salt Lake, Utah, and Summit counties.

Fig 1. A subalpine fir stand infested with balsam woolly adelgid (BWA).

IDENTIFICATION

Adults are small (less than 1/20 of an inch) and barely visible. They are dark purple to black, oblong, and wingless (Fig 2). Female adults produce a waxy protective covering called "wool." The wool or cottony mass covers both the female body and her eggs. Wool patches can be seen on host tree trunks and branches (Fig 3).

Fig 2. Ventral view of adult BWA.

Fig 3. White woolly masses of BWA on a fir trunk collar.

Immature life stages (eggs, crawlers, nymphs) are also very small and only barely visible to a trained eye using a hand lens or microscope.

LIFE HISTORY

In its native range, BWA alternates between spruce and fir; however, in North America, BWA remains on fir as its European spruce host is not present. BWA populations in North America are composed of females reproducing without mating (parthenogenesis); sexual reproduction requires the European spruce host.

Two generations are most common in the mountainous regions of western North America (Fig 4). In cold locations, a resting (immature) nymph, or neosistens, is the only stage that can survive winter temperatures. The overwintering neosistens begin movement in the spring. By early summer, most overwintering BWA have reached the adult stage. Each female produces 100-250 amber-colored eggs (first generation) during summer. Eggs hatch into reddish-brown crawlers in early summer; this is the only mobile life stage. Crawlers then move to new feeding sites on the same tree, or are dispersed longer distances by wind, animals, or humans (via firewood). Upon finding a new feeding site, the crawler inserts its feeding tube and begins sucking. Once the crawler begins feeding, it remains stationary and then transforms into a resting nymph. By late summer or early fall, adults and eggs covered in wool are present. By late fall, the (second generation) eggs have developed into crawlers, which then disperse to new feeding sites. By winter, crawlers have developed into overwintering neosistens.

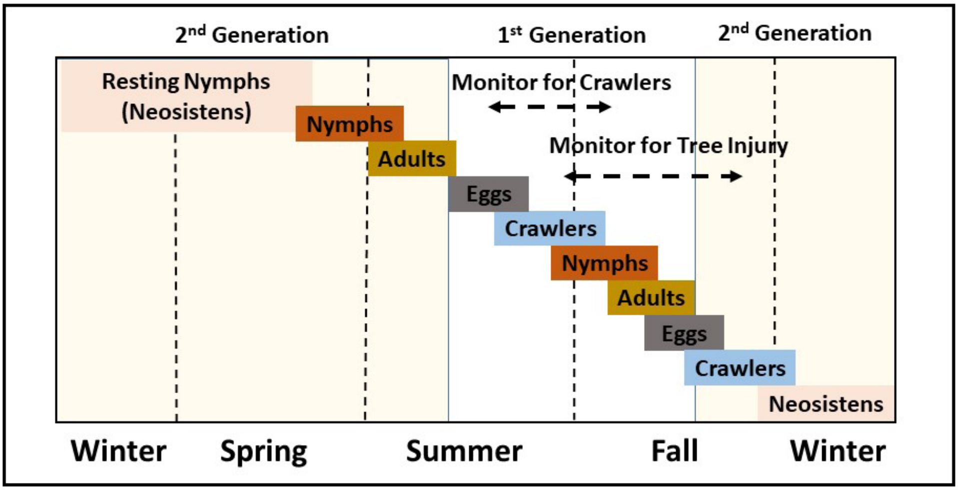

Fig 4. BWA has two generations per year. Adults and the "wool" covering are most visible in the fall.

PLANT HOSTS

BWA attacks all true fir species (*Abies*). In Utah, subalpine fir (*Abies lasiocarpa*) is a highly susceptible host tree; white fir (*A. concolor*) is a moderately susceptible host. Subalpine fir typically grows at elevations above 7,500 feet, and until now, has been one of the few forest tree species that has resisted large-scale pest infestations.

DAMAGE SYMPTOMS

Vigorous, mature host trees 4 inches or more in diameter seem to be most susceptible, but saplings and seedlings may also be affected. Common crown symptoms include:

- yellowing, then bronzing, of needles
- reddening and thinning of foliage from inside out
- white, waxy "wool" covering may be evident on tree trunk, near the tree base and on branches (Fig 3)
- abnormal swelling of branch nodes and buds called “gouting” in response to adelgid feeding (Fig 5)
- lower crown dieback leaving a green top and/or “top curl” (Fig 6)
- reduced cone production and poor stand regeneration
- reduced growth, poor form, and stunted trees and branches (Fig 7)
- dead leaders

Stem or trunk infestations tend to be more serious than crown infestations, and can result in wide, irregular growth rings and reddish, brittle wood called “rotholz.” Host responses to BWA feeding eventually cause decreased water flow to the crown, leading to tree death. Tree mortality typically occurs within 2 to 10 years of infestation; heavy infestations can kill trees in 2 to 3 years.

Fig 5. Abnormal swelling, or gouting, of fir branches caused by feeding injury from BWA.

Fig 6. Subalpine fir tree canopy decline; note dying lower branches and green top leader.

Fig 7. Young subalpine fir infested with BWA; note severely stunted growth.

MONITORING

BWA presence is difficult to detect until a tree is heavily infested and displays advanced symptoms (canopy decline, branch and node swelling).

In forests, common monitoring methods include aerial surveys to detect tree stand decline, followed by groundtruthing to identify specific BWA symptoms. Turnquist and Harris (2015) describe a systematic sampling method for signs and symptoms of BWA to estimate the extent of infestation in an area.

In older stands:

- Examine tree crowns, concentrating on the upper third, ideally using binoculars. Look for:
    - Thinning of foliage
    - Twig gouting
    - Stunted branch and leader growth
    - Dead leader
- Examine recently windblown branches or slash for the above symptoms.
- Examine the main stem for presence of white wool up to about 30 feet.
- Collect samples of all signs and symptoms for verification.

In young stands:

- Sample and examine branch nodes from two 2-to-11-year-old branches per tree, from two trees per site.

MANAGEMENT

Completely removing BWA from western ecosystems is unrealistic, as they are widespread and dispersed by the wind. At the forest scale, the most effective tactics to reduce BWA damage include:

- selectively removing heavily infested trees
- cutting and removal of infested trees in winter when crawlers are inactive
- consider prevailing winds when establishing cutting boundaries
- favor non-host tree species and genetically resistant strains or hybrids through selective harvest and planting

REFERENCES & ADDITIONAL RESOURCES

Alston, D., R. Davis, D. McAvoy, L. Spears, D. Malesky, L. Hebertson, and C. Keyes. 2018. Balsam woolly adelgid. Fact Sheet ENT-191-18. Utah State University Extension and Utah Plant Pest Diagnostic Laboratory.

BC Ministry of Agriculture. 2016. Balsam woolly adelgid in British Columbia. https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/animal-and-crops/plant-health/phu-balsamwoollyadelgid.pdf.

Ragenovich, I.R. and R.G. Mitchell. 2006. Balsam woolly adelgid. Forest Insect and Disease Leaflet 118. USDA Forest Service. https://www.na.fs.fed.us/pubs/fidls/bwa.pdf.

Sidebottom, J. 2009. Balsam Woolly Adelgid: Christmas Tree Notes. North Carolina State University - Extension. https://content.ces.ncsu.edu/balsam-woolly-adelgid.

Turnquist, R. and J.W.E. Harris. 2015. Balsam woolly adelgid. Forest Pest Leaflet Fo 29-6/1-11993-E. Pacific Forestry Centre, Natural Resources Canada. http://web.forestry.ubc.ca/fetch21/Z-PDF-pest-info-folder/3316-Balsam%20woolly%20adelgid.pdf.

PHOTO CREDITS

Figs 1, 3-7. Diane Alston, Utah State University

Fig 2. Gilles San Martin from Namur, Belgium [CC BY-SA 2.0 (https://creativecommons.org/licenses/by-sa/2.0)]

Brown Marmorated Stink Bug

Halyomorpha halys Stål

BACKGROUND

Brown marmorated stink bug (BMSB) (Hemiptera: Pentatomidae) is a pest of fruits, vegetables, nuts, and ornamentals. BMSB is also a nuisance pest that will invade homes and other buildings in large numbers during the fall and winter. Originally from Asia, BMSB was first found in the U.S. in Pennsylvania in 1996. BMSB has since expanded its range to more than 40 states. Its current distribution can be found at http://www.stopbmsb.org/where-is-bmsb/.

BMSB was first detected in Utah in 2012. Reproducing populations (adults and immature life stages) can be found in Utah, Salt Lake, Davis, Weber, and Box Elder counties, and a few adult bugs have been detected in Cache and Kane counties. In 2017, BMSB feeding damage was first reported on some fruits and vegetables in multiple counties.

Fig 1. Adult brown marmorated stink bug (BMSB).

IDENTIFICATION

Adults are shield-shaped; about ⅝ inch long; marbled brown with copper patches near the head; and have alternating dark and white bands on the antennae, legs, and along the abdominal edges; and rounded and smooth "shoulders" (Figs 1-3). Undersides are typically light gray, brown, or tan (Fig 4), but may include shades of red, orange, or green.

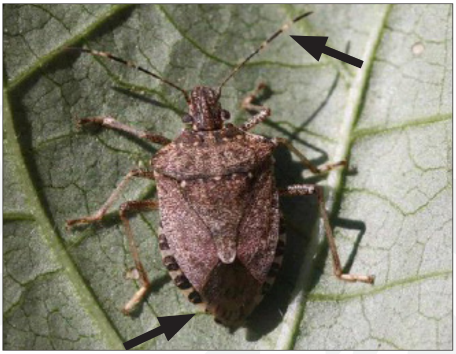

Fig 2. Arrows point to alternating dark and white bands on antennae and along abdominal edges.

Fig 3. Arrows point to the rounded and smooth shoulders.

Fig 4. The adult underside is typically light gray, brown, or tan.

Fig 5. Egg masses usually include 20 to 30 eggs.

Fig 6. Egg mass and 1st instar nymphs.

Fig 7. Mid-stage nymph.

Fig 8. Two adult BMSBs (left) and a late instar nymph (right).

Eggs are barrel-shaped, ¹⁄₁₆ inch wide, and translucent to white in color (Figs 5 and 6). As eggs mature, the black, triangular-shaped egg burster on the head of developing nymphs becomes visible. Eggs are typically laid on the underside of leaves and in masses of approximately 20 to 30 (average of 28).

Nymphs vary in color, depending on age. Newly hatched nymphs are tick-like in appearance, have orange-red backs with black stripes, and tend to huddle near the egg mass (Fig 6). As nymphs mature, they disperse from the egg mass, darken in color, develop wing pads (immature wings), and begin to look similar to adults in color and size (Figs 7 and 8). Nymphs range from ¹⁄₁₀ to ½ inch.

LIFE HISTORY

BMSB is typically associated with having one generation per year, but two generations are possible in Utah. Adults become active in the spring, and feed on nearly any green, growing plant for about 2 weeks before mating (Fig 9). A female may lay as many as 400 eggs in her lifetime. In northern Utah, BMSB egg masses have been detected from late May to September. Eggs hatch within a few days and the development time for each nymphal stage is about 1 week between molts, depending on temperature. Nymphs are first present in June and then reach peak numbers in July. Adult BMSB numbers peak in July and August. From October to November, the bugs move to protected sites where they mass together for the winter, including under the bark of standing trees, downed and dead trees, and inside buildings, especially in attics and walls. Adult aggregations may be seen on the outside of buildings, and in window seals, air vents, and cracks and crevices in concrete or buildings.

PLANT HOSTS

BMSB is a tree-loving bug, and has a very broad plant host range. Adults and nymphs will feed on vegetative and reproductive plant structures, including stems, leaves, fruits, seeds, nuts, pods, buds, and flowers. Plants that bear fruiting bodies (e.g., fruits and vegetables) are especially vulnerable to this pest. Stone and pome fruits, berries, and

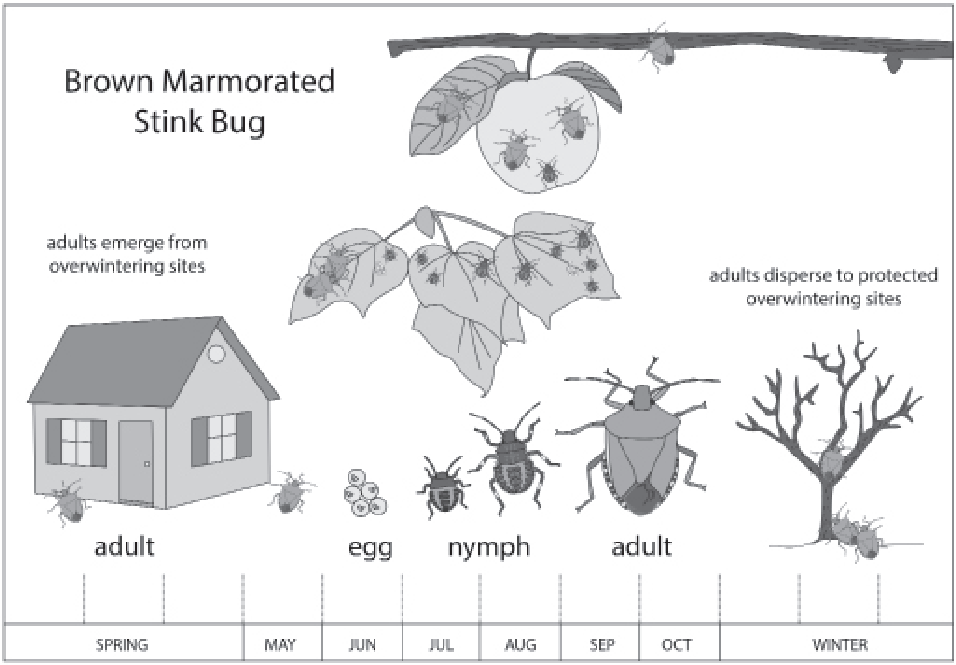

Fig 9. BMSB has one to two generations per year and overwinters in protected sites such as inside buildings and under tree bark.

vegetables, especially solanaceous fruits (tomatoes and peppers), legumes, and corn are preferred hosts. BMSB can also be found on many herbaceous and woody ornamental shrubs and trees, such as catalpa (Fig 10). Ornamental hosts in urbanized areas are important to building BMSB populations in the early summer before they move into agricultural crops. For a list of known host plants, see https://utahpests.usu.edu/caps/bmsb-host-plants (specific to Utah) and https://www.stopbmsb.org/where-is-bmsb/host-plants/ (nationwide list).

Fig 10. All life stages of BMSB have been found on catalpa trees in Utah.

DAMAGE SYMPTOMS

BMSB, like all stink bugs, has a piercing-sucking mouthpart (Fig 11). Mouthparts are used to puncture plant cells to obtain nutrients in the sap and inject salivary secretions that help break down the plant tissue. Feeding can cause necrotic (dark colored) lesions, pits, depressions, "cat-facing" (deformities), and gummosis (peach, nectarine, and apricot) on fruits; feeding in fruit flesh causes corky, discolored areas (Figs 12-14). BMSB feeding can even cause some fruit structures to abort. Damage may not appear until 2 weeks after feeding has occurred, and possibly later for fruit stored at cold temperatures. Further, sometimes there will be no visible external damage to the fruit; damage will only be seen underneath the skin.

Fig 11. Arrow points to the piercing-sucking mouthpart.

Fig 12. BMSB damage to peach; note the adult between the peaches.

Fig 13. BMSB damage to apple.

Fig 14. Interior corking injury.

Although it can be a major agricultural and domestic nuisance, BMSB does not bite, sting, spread mammalian diseases, or bore into or damage wooden structures. It is not directly harmful to people, pets, or buildings.

MONITORING

Monitoring techniques for BMSB include pheromone-baited sticky panel (Fig 15) or pyramid traps (Fig 16), beat sheets (Fig 17), and visual surveys. These methods are appropriate for both homeowners and commercial growers.

All traps should be paired with a lure. A few different types of commercial lures are available, but research in Utah has demonstrated that more stink bugs are captured with the Trécé Inc. dual lure, comprised of both a BMSB aggregation pheromone (murgantiol) and the synergist methyl decatrienoate (MDT) (Leskey et al. 2012). Traps should be checked at least once weekly from May to October, and the dual lure should be replaced at 12 week intervals. BMSB prefers edge habitats. Thus, monitoring should be focused around field and garden perimeters.

Beating sheets are helpful for dislodging BMSB directly from plants; however, note that BMSB will often move to the upper canopy of trees to feed. Visual monitoring should also include fruit inspections for damage, including internal injury (especially in peach and nectarine), since damage on the surface of some types of fruits may not be visible.

Fig 15. Sticky panel traps are comprised of a double-sided clear sticky panel (6″ x 9″, available from Trécé) mounted on a 5' wood stake. The sticky panels should be replaced every 4 weeks (or sooner if >50% of the surface area is covered by insects or debris).

Fig 16. Pyramid traps are typically black, stand 4', and consist of an inverted clear plastic container with an entry cone that is attached with a bungee cord. An example of a pyramid trap is available from AgBio, Inc. (Dead-Inn™ traps). To prevent escape and kill trapped bugs, add a small piece (6 in^2) of a long-lasting insecticide net (Vestergaard) or an insecticide-laced strip (Vaportape II [Hercon]).

Fig 17. Beat sheets are helpful for dislodging BMSB directly from plants.

MANAGEMENT

BMSB is a challenging insect to manage. Both nymphs and adults damage crops; adults are highly mobile, spread by hitchhiking or flying, and have a tough exoskeleton that is covered in a waxy, water-repellent cuticle that helps protect them from insecticide applications. Futher, BMSB can re-invade fields previously treated with insecticides and, over time, may develop resistance to insecticides. Therefore, it is imperative that you rotate chemicals from different mode of action groups to avoid resistant development.

Physical exclusion is one of the best methods to reduce BMSB adult aggregations in buildings and in the field. Exclusion can be accomplished by sealing cracks around windows, doors, and siding. Repair or replace damaged screen doors, screens, and windows in the winter to reduce access points for BMSB adults to enter. Simple attract-and-kill traps, which consist of a pan with soapy water and a light to shine on it, can be used to capture overwintering adults.

Some physical barriers in small acreage situations can be effective in deterring BMSB such as floating row covers, sticky bands around trunks and stems, or covering fruits with breathable bags or plants with netting.

Natural biological control has been observed in the U.S., but not enough to manage BMSB. Generalist predators (lacewings, mantids, earwigs, lady beetles, assassin bugs, minute pirate bugs, big-eyed bugs, and spiders) feed on BMSB egg masses and nymphs (Lara et al. 2016; Morrison et al. 2016). In addition, although researchers have found at least 12 native wasp

species that can parasitize egg masses of BMSB, native parasitoid wasps typically account for less than 11% mortality of eggs (Rice et al. 2014). The samurai wasp (*Trissolcus japonicus*) (Fig 18) co-evolved with BMSB in eastern Asia, where it is highly effective at parasitizing BMSB eggs. The wasp has been identified as the most promising agent for classical biological control of BMSB in the U.S.

Fig 18. The samurai wasp on a BMSB egg mass.

The samurai wasp has been found in several states, including Maryland, Virginia, Ohio, Michigan, Washington, Oregon, and California. It is speculated that the wasps arrived within stink bug egg masses on plant cargo shipped from Asia. Many of those wild populations became established, and these states are now able to release samurai wasps for control and research purposes, bypassing the lengthy procedures needed for introducing a new species.

In Utah, surveys for the samurai wasp and other natural enemies of BMSB are underway. To date, several native wasps have been observed parasitizing BMSB eggs: *Anastatus mirabilis, A. persalli, A. reduvii, Telenomus podisi, Trissolcus erugatus, Tr. euschisti, Tr. hullensis, Tr. parma, Tr. thyante, Tr. strabus,* and *Tr. utahensis*.

The samurai wasp has not yet been detected in Utah. Until the samurai wasp establishes in Utah on its own accord, state and federal regulations prevent its release. Once it is detected in Utah, however, researchers may then be allowed to redistribute it in areas with BMSB infestations.

The public can assist with detecting the samurai wasp in Utah. As a reminder, BMSB eggs are barrel-shaped, 1⁄16 inch wide, and translucent, white, or light green in color (Figs 5, 18). As eggs mature, dark triangular-shaped spots become visible (Fig 6). Eggs are typically laid on the underside of leaves in clusters of 20 to 30. If parasitized, however, BMSB eggs turn dark brown to black (Fig 19). If you find eggs that appear to be parasitized, carefully place the leaf with the egg mass into a sealed container, store the container at room temperature, and then send an email to caps@usu.edu.

Fig 19. A samurai wasp emerging from a BMSB egg; note that parasitized eggs are darker than unparasitized eggs as shown in Figs 5 and 18.

SIMILAR INSECTS

Rough stink bugs (*Brochymena* spp.) are commonly mistaken for BMSB in Utah. Adults can be distinguished from BMSB by having a heavily toothed shoulder and lack alternating dark and light bands on the antennae (Fig 20).

Brown stink bug adults (*Euschistus* spp.) are generally smaller than BMSB, have a small row of spines on the shoulders, and lack banding on the antennal segments (Fig 21).

Western conifer seed bugs, (*Leptoglossus occidentalis*), also known as leaf-footed bugs, are minor tree pests in the U.S. They are not stink bugs; however, they can be mistaken for BMSB as they have similar coloring. They are elongated (U-shaped) and have longer and thicker legs than BMSB and other stink bugs (Fig 22).

Squash bugs (*Anasa tristis*) are common garden pests and feed on summer and winter squash, melons, pumpkins, and cucumbers. Adults can reach a length of up to 1 inch, are dark brown in color, and have a more narrow body than stink bugs (Fig 23).

Fig 20. Rough stink bug.

Fig 21. Common brown stink bug.

Fig 22. Western conifer seed bug.

Fig 23. Squash bug laying eggs.

REFERENCES & ADDITIONAL RESOURCES

Aigner, J.D. and T.P. Kuhar. 2014. Using citizen scientists to evaluate light traps for catching brown marmorated stink bugs in homes in Virginia. Journal of Extension 52: 1-8.

Bergmann, E., K.M. Bernhard, G. Bernon, et al. 2013. Host plants of the brown marmorated stink bug in the U.S. Northeastern IPM Center Technical Bulletin.

Cannon C., D.G. Alston, L.R. Spears, C. Nischwitz, and C. Burfitt. 2016. Invasive fruit pest guide for Utah: insect and disease identification, monitoring, and management. Utah State University Extension and Utah Plant Pest Diagnostic Laboratory.

Hamilton G.C. 2009. Brown marmorated stink bug. American Entomologist 55: 19-20.

Holthouse M.C., D.G. Alston, L.R. Spears, and E. Petrizzo. 2017. Brown marmorated stink bug [*Halyomorpha halys* (Stål)]. Fact Sheet ENT-144-17. Utah State University Extension and Utah Plant Pest Diagnostic Laboratory.

Kuhar, T.P., K.L. Kamminga, J. Whalen et al. 2012. The pest potential of brown marmorated stink bug on vegetable crops. Plant Health Progress, doi: 10.1094/PHP-2012-0523-01-BR.

Lara, J., et al. 2016. Biological control program is being developed for brown marmorated stink bug. California Agriculture 70: 15-23.

Leskey, T.C., G.C. Hamilton, A.L. Nielsen et al. 2012. Pest status of the brown marmorated stink bug, *Halyomorpha halys* in the USA. Outlooks on Pest Management 23: 218-226.

Morrison, W.R., C.R. Mathews, and T.C. Leskey. 2016. Frequency, efficiency, and physical characteristics of predation by generalist predators of brown marmorated stink bug eggs. Biological Control 97: 120-130.

Rice, K.B., C.J. Bergh, and E.J. Bergmann et al. 2014. Biology, ecology, and management of brown marmorated stink bug. Journal of Integrated Pest Management 5: 1-13.

Schumm, Z.R., M.C. Holthouse, Y. Mizuno, D.G. Alston, and L.R. Spears. 2019. Parasitoid wasps of the invasive brown marmorated stink bug in Utah. Fact Sheet Ent-198-19. Utah State University Extension and Utah Plant Pest Diagnostic Laboratory.

Spears L., D. Alston, and M. Murray. 2018. Brown marmorated stink bug management for fruits and vegetables in Utah. Fact Sheet ENT-197-18. Utah State University Extension and Utah Plant Pest Diagnostic Laboratory.

For more information on BMSB, visit these websites: Stop BMSB (http://www.stopbmsb.org/) and National Invasive Species Information Center BMSB species profile (https://www.invasivespeciesinfo.gov/animals/stinkbug.shtml).

PHOTO CREDITS

Figs 1, 3. Susan Ellis, Bugwood.org

Figs 2, 22. Whitney Cranshaw, Colorado State University, Bugwood.org

Fig 4. Pennsylvania Department of Conservation and Natural Resources - Forestry, Bugwood.org

Fig 5. Jennifer Carr, University of Florida, Bugwood.org

Figs 6, 10, 15-17. Lori Spears, Utah State University

Figs 7, 8. Gary Bernon, USDA APHIS, Bugwood.org

Fig 9. Life cycle by Cami Cannon, Utah State University

Fig 11. U.S. Department of Agriculture [Public domain]

Fig 12. Marion Murray, Utah State University

Figs 13, 14. Christopher Bergh, Virginia Tech

Figs 18, 19. Oregon State University [CC BY-SA 2.0 (https://creativecommons.org/licenses/by-sa/2.0)]

Fig 20. Kansas Department of Agriculture, Bugwood.org

Fig 21. Russ Ottens, University of Georgia, Bugwood.org

Fig. 23. Gerald Holmes, California Polytechnic State University at San Luis Obispo, Bugwood.org

Emerald Ash Borer

Agrilus planipennis Fairmaire

BACKGROUND

Emerald ash borer (EAB) (Coleoptera: Buprestidae) is an wood-boring beetle that has caused the decline and mortality of tens of millions of ash trees (*Fraxinus* spp.) in the U.S. It is considered the most destructive forest pest to ever invade North America.

Originally from Asia and parts of Russia, EAB was first discovered in the U.S. in 2002 in southeastern Michigan. This insect most likely arrived to the U.S. as larvae or pupae embedded in ash pallets, crates, or packing material transported by airplanes or cargo ships. EAB is now known to occur in more than 30 eastern and midwestern states, and is rapidly expanding its range. As of May 2019, it has NOT YET been found in Utah, but an infestation has been found in neighboring Boulder, Colorado. Information on its most current distribution can be found at http://www.emeraldashborer.info.

Fig 1. Adult emerald ash borer (EAB).

IDENTIFICATION

EAB undergoes complete metamorphosis, which includes four distinct stages: adult, egg, larva, and pupa. The immature stage (larva) does not resemble the adult.

Adults are metallic green beetles with bronze heads, short saw-toothed antennae, flattened backs, rounded bellies, and iridescent purple-red abdominal segments beneath their wing covers. They are bullet-shaped, lack a defined waist, and are about ½ inch long and ⅛ inch wide (Figs 1-3).

Fig 2. Adults have purple-red abdomens hidden underneath the emerald green wing covers.

Fig 3. Adults are ½ inch long.

Eggs are oval to round, 1/16 inch in diameter, cream-colored when first deposited, and reddish-brown as they develop (Fig 4). Due to their small size, eggs are not easily observed.

Fig 4. Eggs are cream-colored (left) when first laid, but turn reddish-brown near maturity.

Larvae are cream-colored with 10 body segments and a flattened abdomen. They can reach a length of 1 inch when mature, are tapeworm-like in appearance (Fig 5), and have a pair of brown, pincer-like appendages on the last abdominal segment. Their brown head is mostly retracted, but the mouthparts are visible externally. The last instar larva (pre-pupa) will excavate a tiny chamber and curve back on itself (J-shaped) (Fig 6).

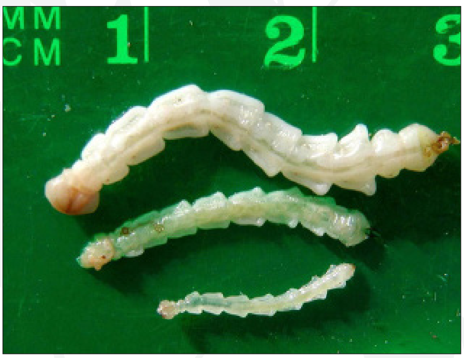

Fig 5. When mature, larvae can reach a length of 1 inch.

Fig 6. J-shaped larva.

Pupae have the characteristic shape of the adult, with short saw-toothed antennae and a blunt spine at the tip of the last abdominal segment. Newly developed pupae are white, but then take on the adult coloration as they develop (Figs 7 and 8).

Fig 7. Gradual maturation of pupae to the adult stage (from left to right).

Fig 8. Pupa in chamber.

LIFE HISTORY

EAB has a one year life cycle (Fig 9). Adults emerge from ash trees in the spring when degree-day (DD) accumulations reach 450 to 550 DD (using a base temperature of 50°F), which in Utah can occur as early as mid-April in southern Utah or mid-May in northern Utah. Peak emergence is at 900 to 1,100 DDs (mid-to late July). For more information on DDs in Utah, visit https://climate.usu.edu/traps/.

Adults will feed on ash leaves for 1 to 2 weeks before searching for mates. Mated females will lay eggs on bark or in bark crevices. Females can lay 60 to 90 eggs over the course of their lifetime. Eggs are laid individually or in groups, and hatch after 2 to 3 weeks. After eggs hatch, the newly developed larvae bore into the tree, feeding on the phloem and cambium layers, passing through four larval stages. EAB overwinters as a mature larva or pre-pupa in a tiny chamber excavated in the sapwood (Fig 8). They pupate in the spring and repeat the life cycle.

PLANT HOSTS

EAB attacks all North American ash (*Fraxinus*) species, including small, large, stressed, and even healthy trees. EAB was thought to specialize on ash, but was recently found infesting white fringe trees (*Chionanthus virginicus*) in Ohio and Illinois. This may indicate that EAB has a wider host range than originally thought or that it is adapting to utilize new hosts. Both ash and fringe trees are members of the olive family (Oleaceae).

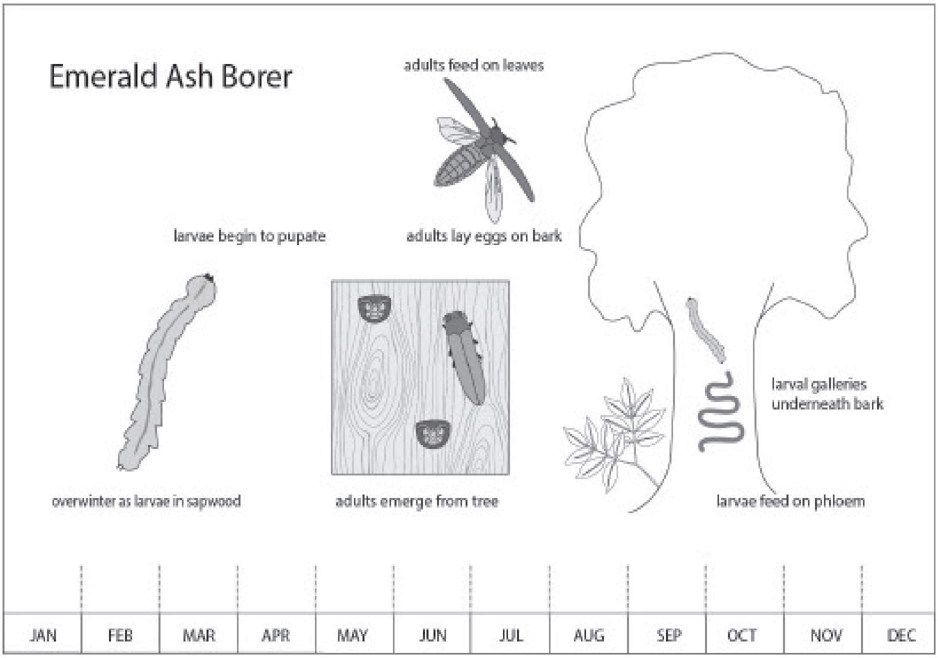

Fig 9. EAB has one generation per year and overwinters as larvae or pre-pupae under ash bark.

Utah has two native ash species that are susceptible to EAB - the small, shrubby singleleaf ash, *Fraxinus anomala*, that occurs sporadically in southern Utah, and velvet ash, *Fraxinus velutina*, in SW canyons. Yet, various planted ash species make up a substantial component of our urban forests. Ash comprises up to 30% of the urban canopy in many Utah communities, and all are susceptible to EAB attack.

DAMAGE SYMPTOMS

Larvae are the primary damaging life stage and are responsible for killing trees. They chew through bark into the phloem and sapwood, creating serpentine-shaped and excrement-filled galleries (Fig 10), which disrupt the flow of nutrients and water, starving the tree. Larval galleries curve at near right angles so that the tunnel length, as measured in a straight line from start to end point, is less than half of the actual total tunnel distance (note: any serpentine gallery in an ash tree should be suspect). Galleries are more common in the upper canopy in newly infested trees and increase in size as larvae feed and grow. Galleries, however, can be found lower on the trunk as the infestation progresses.

Larval infestations lead to bark splits, canopy dieback, epicormic branching (suckers) at the base of large, dead branches or the base of the tree, and increased woodpecker activity (Figs 11-14). Woodpeckers and other bark foraging birds feed on up to 85% of the EAB in an infested tree.

Adults leave D-shaped exit holes (⅛ inch wide) on tree branches and trunks when they emerge (Fig 15). Adults feed on ash foliage (Fig 16), but cause little damage overall to the tree. In Colorado, researchers have found that ash trees infested with EAB have leaves that are smaller and lighter in color compared to normal ash leaves.

When EAB densities are high, small trees can die within 1 to 2 years of becoming infested, whereas large trees are killed within 3 to 4 years. Unfortunately, EAB infestations are difficult to detect, especially during the early stages of invasion, and are nearly always fatal to the tree unless insecticides are used to protect trees.

Fig 10. Larval galleries curve at near right angles.

Fig 11. Bark splits.

Fig 12. Canopy dieback.

Fig 13. Epicormic suckers.

Fig 14. Woodpecker feeding damage on trunk and epicormic sprouts on ground.

Fig 15. Adults emerge from D-shaped exit holes.

Fig 16. Adult feeding on ash foliage.

WHAT CAN YOU DO?

Do not move or transport firewood. EAB can travel short distances on its own, but it is introduced to new, distant locations via infested firewood or other wood material containing living EAB. National quarantines of infested counties are in place to prevent the human-assisted spread of EAB and other invasive tree-killing pests, and many agencies, including Utah State University and their partners, have initiated campaigns to raise awareness about the dangers of moving firewood (Fig 17). For example, the Don't Move Firewood Campaign has played a major role in slowing the spread of invasive tree-killing pests.

Be aware of the signs and symptoms of an EAB infestation. If you think an insect looks suspicious or you see signs of damage, contact the UPPDL so that they can inspect the tree. The earlier we can detect EAB, the more management options will be available.

Know which trees could be infested. Learn to identify the trees in your community. For information on identifying ash, see IS MY TREE AN ASH section on page 37.

Be aware of established pests that can be confused with EAB. There are several insects that look like EAB or that tunnel in ash trees and cause similar damage. For more information, see the SIMILAR INSECTS section on pages 38-39.

Keep trees healthy. Healthy trees are less likely to become infested with EAB and other pests. Trees should be properly watered and pruned, and fertilized when necessary. Keep at least a 4 foot diameter area around trees free of weeds and grass so that there is no competition for water or nutrients and so trunks are not damaged by lawnmowers. Your local USU Extension office can help with tree maintenance and planting information.

Do not include ash in new plantings. Remove any ash that is not in optimal health or is in poor sites. The website Treebrowser.org can be used to select a variety of ash alternatives.

Fig 17. Watch for this billboard along I-15 in Utah. (Designed by Michael Wernert, USU Extension.)

MONITORING

There are a number of monitoring techniques state and federal survey personnel use for detecting EAB, including traps, branch sampling, girdled (trap) trees, and biosurveillance. Some of these may be suitable for homeowners.

Purple prism traps or Lindgren funnel traps (Figs 18 and 19) are used during statewide detection trapping programs, but are not available freely to the public. Traps are baited with a lure made of oils that mimic chemicals released by stressed ash so as to attract EAB. Traps are placed in trees during the spring and summer, and then taken down in the fall. Traps are for detection or monitoring purposes, and are not used to control EAB.

Fig 18. Purple prism trap.

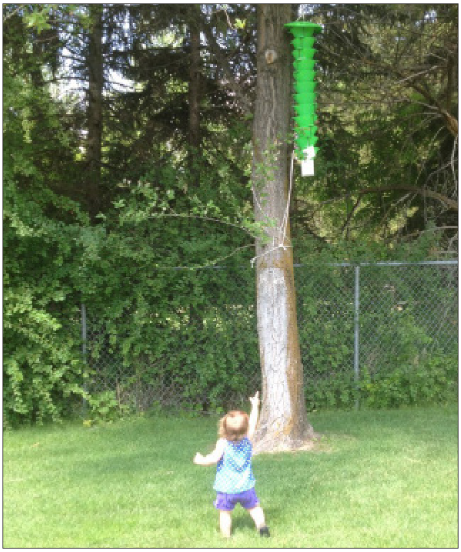

Fig 19. A budding entomologist pointing to a Lindgren funnel trap.

Branch sampling is recommended for both homeowners and survey personnel, and is most valuable in urban and other high-risk areas. Collect branches in the fall, after larvae can be more easily detected. Use the following steps to inspect branches:

1. Choose an ash tree that is 20 to 60 feet tall with a large, open canopy.
2. Collect two branches (1 to 4 inches in diameter) from the middle canopy. Remove branches using proper pruning safety procedures and precautions.
3. Remove lateral branches.
4. Use a drawknife to peel back the bark in thin strips (Fig 20).
5. Carefully examine the branches for EAB galleries and/or larvae.

Fig 20. Bark peeling with drawknife.

Girdled (trap) trees are considered effective EAB detection tools. Trees are girdled by removing the outer layer of bark and cambium layer around the entire circumference of the trunk (Fig 21). The tree is then forced into a state of stress and, therefore, highly attractive to EAB. In areas known to be infested with EAB, girdled trees are removed within a few weeks and destroyed, and a large number of EAB larvae are destroyed with it. This is known as a "population sink." In areas where EAB has not been detected, the tree is removed at the end of the season and remaining bark is stripped to check for EAB galleries and larvae.

Fig 21. Girdled tree.

Biosurveillance refers to the tracking and observation of native, stingless predatory wasps as they return to their nests with prey. *Cerceris fumipennis* (Fig 22) are predatory and solitary ground-nesting wasps that forage for beetles, including EAB, and then brings them to their nests.

Fig 22. *Cerceris fumipennis* entering a nest with two mating emerald ash borers.

MANAGEMENT

EAB has NOT been detected in Utah, so there is no current need for control of this insect. Insecticides (preventative or curative) should only be considered when EAB has been detected within 10 to 15 miles of your residence.

Insecticide treatment options include cover sprays, systemic soil drenches, trunk injections, and basal bark applications. Treatments may need to be repeated annually or biannually to protect trees during EAB invasions. Insecticides are not 100% effective due to the difficulty of managing insects under tree bark. Some chemicals

can kill larvae underneath the bark; however, 30-50% canopy decline is the "cutoff" for this to work. For more information, refer to the Multistate EAB Insecticide Fact Sheet.

USDA has also been working to develop biological control agents to help slow down EAB. Utah has already received the permits needed to release *Oobius agrili*, a tiny solitary egg parasitoid of EAB (Fig 23), when EAB arrives in the state.

Fig 23. *Oobius agrili* adult laying an egg within an EAB egg.

IS MY TREE AN ASH?

Some trees, such as box elder (*Acer negundo*) and black walnut (*Juglans nigra*), can be mistaken for ash trees. Characteristics for identifying ash trees include:

Opposite branching: Branches, buds, and leaflets are directly across from each other (Fig 24). Keep in mind that buds and limbs die, so not every branch will have an opposite mate.

Compound leaves: Ash leaves are compound with 5-11 leaflets (Fig 24). Leaflet margins may be smooth or toothed.

Bark: The bark of young ash trees is smooth, whereas mature trees have diamond-shaped ridges (Fig 25).

Seeds: Seeds are oar-shaped, typically occur in clusters, and hang on the tree until fall or early winter (Fig 26).

Fig 24. Ash leaf with 7 leaflets. Note that leaflets are directlly opposite of each other.

Fig 25. Mature ash bark.

Fig 26. Ash seeds.

SIMILAR INSECTS

There are several insects that look similar to EAB, and other types of insects that tunnel in ash trees. We highlight some of these "look-alike" insects below.

The honeylocust (*Agrilus difficilis*) and bronze birch (*A. anxius*) borers are related to EAB, but are pests of honeylocust and birch, respectively. They do not infest ash trees, but do cause similar D-shaped exit holes when they emerge from hosts. Honeylocust borers have black bodies with white or yellow spots alongside their abdomen (Fig 27). Bronze birch borers are mostly bronze (Fig 28).

Fig 27. Honeylocust borer.

Fig 28. Bronze birch borer.

The lilac ash borer (*Podosesia syringae*) is a clearwing moth that, as an adult, mimics a paper wasp. Larvae are caterpillar-like (Fig 29) (EAB larvae are tapeworm-like). Exit holes are irregularly round and about ¼ inch in diameter (Fig 30). When the adult emerges from pupation, the pupal skin extrudes from the adult exit hole (Fig 31). EAB leaves its pupal skin in a pupal chamber within the tree.

Fig 29. Lilac ash borer larva.

Fig 30. The lilac ash borer emerges from irregularly round exit holes.

Fig 31. Lilac ash borer pupal skin.

Ash bark beetle (*Hylesinus* spp.) adults are small (⅛ inch), oval beetles that have a variegated white and brown body and clubbed antennae (Fig 32). The larvae are legless, about ⅙ inch long when fully grown, and have white bodies and brown heads. Adult females construct transverse egg galleries (horizonal to wood grain), and larvae create longitudinal feeding tunnels (parallel to wood grain) (Fig 33). Exit holes are circular, about ⅛ inch in diameter, and are found in clusters or "shotgun" patterns (Fig 34).

Fig 32. Ash bark beetle.

Fig 33. Ash bark beetle galleries.

Fig 34. Ash bark beetle shotgun exit holes.

The banded ash borer (*Neoclytus caprea*) is a common ash borer in Utah. Adults are dark brown to black, and have a line of fine, white or yellowish hairs on their midsection and four bands across the wing covers (Fig 35). Adults are ½ to 1 inch long and emerge from oval exit holes that are about ¼ inch in diameter.

Fig 35. Banded ash borer and exit hole.

REFERENCES & ADDITIONAL RESOURCES

Cappaert, D., G. McCullough, T.M. Poland, and N.W. Siegert. 2005. Emerald ash borer in North America: a research and regulatory challenge. American Entomologist 51: 152-165.

McCullough, D.G., N.R. Schneeberger, and S.A. Katovich. 2008. Pest Alert: Emerald Ash Borer. United States Department of Agriculture, Forest Service, Northeastern Area State and Private Forestry. Newton Square, Pennsylvania. NA-PR-02-04.

Spears, L.R., R. Davis, and R.A. Ramirez. 2014. Emerald ash borer [*Agrilus planipennis* (Fairmaire)]. Fact Sheet ENT-171-14-PR. Utah State University Extension and Utah Plant Pest Diagnostic Laboratory.

Ash Tree Identification, Michigan State University.

Don't Be Fooled By Look-Alikes, Michigan State University.

Emerald Ash Borer Program Manual, USDA APHIS.

Emerald Ash Borer: The Green Menace, USDA APHIS.

Insecticide Options For Protecting Ash Trees from Emerald Ash Borer, North Central IPM Center Bulletin.

North Dakota Emerald Ash Borer First Detector Manual, North Dakota State University.

Minnesota Forest Pest First Detector Manual, University of Minnesota Extension, Minnesota Department of Agriculture, Minnesota Department of Natural Resources.

Signs and Symptoms of the Emerald Ash Borer, Michigan State University.

Vermont Forest Pest First Detectors, University of Vermont Extension.

For more information on EAB, visit these websites: USDA Hungry Pests EAB page, the Don't Move Firewood EAB page, and the EAB Information Network site.

PHOTO CREDITS

Figs 1, 2, 5, 6, 29, 32. David Cappaert, Bugwood.org

Fig 3. Eric R. Day, Virginia Polytechnic Institute and State University, Bugwood.org

Figs 4, 7, 15, 16. Debbie Miller, USDA Forest Service, Bugwood.org

Figs 8, 18, 20. Kenneth R. Law, USDA APHIS PPQ, Bugwood.org

Fig 9. Life cycle by Erin Brennan, Utah State University

Fig 10. Kelly Oten, North Carolina Forest Service, Bugwood.org

Fig 11. Michigan Department of Agriculture, Bugwood.org

Fig 12. Joseph OBrien, USDA Forest Service, Bugwood.org

Fig 13. Edward Czerwinski, Ontario Ministry of Natural Resources, Bugwood.org

Figs 14, 28, 30. Steven Katovich, USDA Forest Service, Bugwood.org

Fig 17. Billboard designed by Michael Wernert, Utah State University Extension

Fig 19. Ryan Davis, Utah State University

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Figs 25, 26. Paul Wray, Iowa State University, Bugwood.org

Fig 27. Kansas Department of Agriculture, Bugwood.org

Figs 31, 34, 35. Whitney Cranshaw, Colorado State University, Bugwood.org

Fig 33. James Solomon, USDA Forest Service, Bugwood.org

European Cherry Fruit Fly

Rhagoletis cerasi Linnaeus

BACKGROUND

European cherry fruit fly (ECFF) (Diptera: Tephritidae) is a new invasive insect to North America. It naturally occurs throughout most of continental Europe and central and western Asia, and is the most economically important pest of sweet cherries in Europe. ECFF was first detected in North America in Ontario in 2016, and first detected in the U.S. in New York in 2017. It is not known to occur in Utah; however, its predicted geographic range in the U.S. includes USDA plant hardiness zones 2 to 10, which spans most of the country, including Utah. Since adults fly only short distances, spread occurs primarily through movement of infested fruit. Indeed, ECFF has been intercepted more than 100 times at U.S. ports of entry (58 interceptions since 2000), with all interceptions occurring on *Prunus* spp. fruit found in passenger baggage.

Fig 1. European cherry fruit fly adult (ECFF).

Fig 2. Adults have four dark wing bands.

IDENTIFICATION

Adults are ⅛ to 3⁄16 inch long, slightly smaller than a house fly. The body is black with yellow markings on the head and thorax (midsection) (Fig 1). Wings are transparent with four characteristic bluish-black bands (Figs 1 and 2).

Eggs are white, oval-shaped, about 1⁄32 inch in length, and deposited under the skin of ripening fruit.

Larvae are creamy-white and translucent, legless, and shaped like a typical fruit fly larva: tapered at the head and rounded at the tail (Fig 3). Third (last) instar larvae can reach up to ¼ inch in length.

Pupae are pale yellowish-brown and ⅛ to 3⁄16 inch in length (Fig 4). Larvae pupate up to 2 inches deep in the soil under the host plant.

Fig 3. Arrows point to larvae in cherry fruit.

Fig 4. Pupae in the soil.

LIFE HISTORY

ECFF has one generation per year. It overwinters as a pupa in the soil underneath or near the host plant and emerges as the fruit ripens. Adults are most active from late May to early July when conditions are warm and dry, and can live up to 50 days, depending on temperatures. Mated females use their ovipositor to insert eggs into ripening fruit (i.e., fruit that are yellow to pink-yellow in color), but will continue to lay eggs until harvest. Females prefer to lay eggs in fruit that are in full sun, and usually lay only one egg per fruit. They can lay 30 to 200 eggs in their lifetime. Eggs hatch in 1 to 2 weeks. Larvae feed on fruit flesh for 4 to 6 weeks and progress through three larval stages. Mature larvae exit the fruit and drop to the ground to burrow into the soil and pupate.

PLANT HOSTS

Cherry (*Prunus* spp.) is the major host of the ECFF, including tart cherry (*P. cerasus*), sweet cherry (*P. avium*), black cherry (*P. serotina*), and mahaleb cherry (*P. mahaleb*). Honeysuckle (*Lonicera* spp.) is another major host. Minor hosts include barberry (*Berberis* spp.), dogwood (*Cornus* spp.), and snowberry (*Symphoricarpos* spp.).

DAMAGE SYMPTOMS

Injury to fruit is caused by oviposition (egg-laying) scars (Fig 5), but primary damage is caused by larval feeding, defecation, and tunneling in the fruit flesh. Infested fruit may soften prematurely, develop brown spots (Fig 6), wilt or shrivel, and fall off the tree. An exit hole may be visible as the single larva vacates the fruit. Feeding damage can result in fruit losses of up to 100% if left unmanaged.

MONITORING

A yellow sticky card baited with an ammonium acetate or carbonate lure (Fig 7) can be used to monitor for ECFF. Traps should be placed in the fruiting canopy of the tree, after bloom but before the fruit start to ripen and become susceptible. Adult captures are higher in traps placed in the sunny or southern part of the tree. Sweep nets can also be used to survey for ECFF in honeysuckle or other shorter growing hosts.

Fig 5. Oviposition (egg-laying) scar.

Fig 6. Damage to cherry fruits. Note the larval exit holes.

Fig 7. Yellow sticky card with an ammonium carbonate bait box.

MANAGEMENT

Cultural control options include early and complete harvest, removing dropped fruit from the orchard floor, removing wild and abandoned host trees, and placing exclusion netting (1.3 mm net) on trees. Additionally, covering the soil under the tree canopy with ground cover, weed barrier fabric, or mulches will help prevent larvae from burrowing into the soil or emerging adults from exiting the soil.

SIMILAR INSECTS

ECFF is a close relative of other *Rhagoletis* species in North America, including the western cherry fruit fly (WCFF, *R. indifferens*), which is the primary insect pest of sweet and tart cherries in Utah, and apple maggot (*R. pomonella*), which has also been caught in cherry orchards in Utah. The three species are distinguished by coloration and wing patterns (Figs 8-10). WCFF is about ⅕ inch long, slighter larger than the ECFF. It has a black body with white bands on the abdomen, and transparent wings with three dark bands, one of which forms a malformed letter "F." Apple maggot is about ¼ inch long, the largest of the three species and about the size of a common housefly. It has a black body, a prominent white spot on its lower thorax, white bands on the abdomen, and a bold "F" shaped mark on its wings.

Fig 8. Adult European cherry fruit fly (left) and wing banding pattern (right).

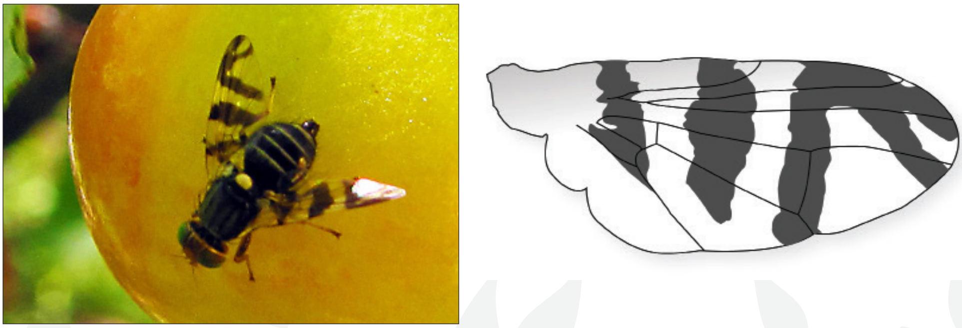

Fig 9. Adult western cherry fruit fly (left) and wing banding pattern (right).

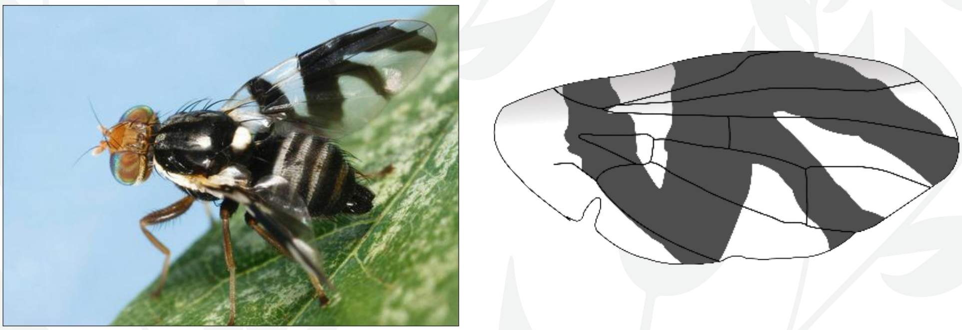

Fig 10. Adult apple maggot (left) and wing banding pattern (right).

REFERENCES AND FURTHER READING

Carroll, L.E., I.M. White, A. Freidberg, A.L. Norrbom, M.J. Dallwitz, and F.C. Thompson. 2002. *Rhagoletis cerasi* (Linnaeus). Pest fruit flies of the world. Version: 8th December 2006.

Canadian Food Inspection Agency (CFIA). 2016. *Rhagoletis cerasi* (European cherry fruit fly) – Fact Sheet.

Daniel, C. and J. Grunder. 2012. Integrated management of European cherry fruit fly *Rhagoletis cerasi* (L.): situation in Switzerland and Europe. Insects 3: 956-988.

Molet, T. 2011. CPHST Pest Datasheet for *Rhagoletis cerasi*. USDA-APHIS-PPQ-CPHST. Revised May 2016 and October 2016 by H. Moylett.

Noma, T., M. Colunga-Garcia, M. Brewer, J. Landis, and A. Gooch. 2010. European cherry fruit fly (*Rhagoletis cerasi*). Invasive Species Factsheets, Michigan State University.

Ozdem, A. and N. Kilincer. 2008. The biology of the European cherry fruit fly [*Rhagoletis cerasi* L. (Diptera: Techritidae)]. Acta Horticulture 795, 5th International Cherry Symposium. pp. 897-904.

Spears, L.R. and D.G. Alston. 2017. European cherry fruit fly (*Rhagoletis cerasi*). National Pest Alert. North Central IPM Center.

Spears, L.R. and D.G. Alston. 2018. European cherry fruit fly [*Rhagoletis cerasi* (Linnaeus)]. Fact Sheet ENT-201-18-PR. Utah State University Extension and Utah Plant Pest Diagnostic Laboratory.

USDA-APHIS. 2011. European cherry fruit fly. USDA – Stone Fruit Commodity-Based Pest Survey.

USDA-APHIS-PPQ. 2016. *Rhagoletis cerasi* (Linnaeus), European cherry fruit fly, Diptera: Tephritidae. Plant Epidemiology and Risk Analysis Laboratory, Center for Plant Health Science and Technology.

PHOTO CREDITS

Fig 1. Henri Koskinen, Shutterstock

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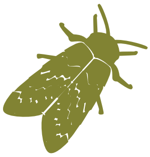
Figs 4-6. Rémi Coutin, OPIE

Fig 7. Diane Alston, Utah State University

Fig 8. Rémi Coutin, OPIE; Illustration by Cami Cannon, Utah State University

Fig 9. Marion Murray, Utah State University; Illustration by Cami Cannon, Utah State University

Fig 10. Joseph Berger, Bugwood.org; Illustration by Cami Cannon, Utah State University



GYPSY MOTH

Lymantria dispar Linnaeus

BACKGROUND

Gypsy moth (GM) (Lepidoptera: Erebidae) is a defoliating pest that is a serious threat to U.S. forests. There are two related subspecies of concern to the U.S., the European GM (*Lymantria dispar dispar*) and the Asian GM (*L. dispar asiatica*). The two subspecies can only be distinguished from each other by DNA tests. Both subspecies pose a threat to U.S. forests; however, the Asian GM poses a greater threat because it has a broader host range than the European GM, and the females can fly 20 to 25 miles per day (European GM females do not fly).

The European GM was first brought to the U.S. in 1869 to start a silkworm industry. It is now well-established in the eastern U.S., and has been detected in many other parts of the country, including Utah. The first detection of European GM in Utah occurred in 1988, and small populations have been detected periodically in Utah. The most recent detections occurred in 2007 (two moths) and 2016 (one moth). The Asian GM was first detected in the U.S. in 1991, and likely arrived on ships infested with egg masses traveling from Russia. In recent years, there have been several introductions of Asian GM to the U.S., including Washington and Oregon. The Asian GM has never been detected in Utah.

Fig 1. Adult male (left) and female (right) gypsy moths.

IDENTIFICATION

Adult males are grayish-brown with feathery antennae and have a wingspan of about 1 ½ inches. Adult females have creamy white wings with black wavy markings, thread-like antennae, and a wingspan of about 2 ½ inches (Fig 1). Both males and females have an inverted V-shape that points to a dot on the wings.

Eggs occur in conspicuous, velvety masses that are 1 to 2 inches long, tan in color, and firm to the touch (Figs 2-3). The eggs inside are black and pellet-like. Egg masses may contain between 100 to 1,000 individual eggs, and can be laid on various outdoor surfaces, including trees, houses, patio furniture, and vehicles.


Fig 2. Adult female with egg mass.


Fig 3. Egg masses can be found on many outdoor surfaces, including trees.

Larvae go through five to six growth stages. Young larvae are small (⅛ inch long), black caterpillars with long, black hairs and may have irregularly shaped yellow marks visible on the upper body surface. Older larvae are more easily identifiable. They have long, tan bristles, five pairs of blue spots followed by six pairs of red spots lining the back, and yellow spots along the sides of the body (Figs 4 and 5).

Mature larvae can reach 2 ½ inches in length. GM larvae do not produce silken tents or create extensive webbing.

Pupae are teardrop shaped, dark brown, about 2 inches in length, and have hardened shells covered in small hairs (Fig 5). They can be found in bark crevices or other cryptic locations.


Fig 4. Mature larva.

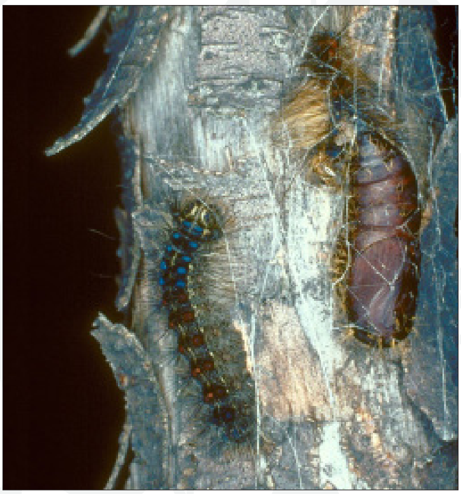


Fig 5. Mature larva (left) and pupa (right).

LIFE HISTORY

GM has one generation per year (Fig 6). The eggs are the overwintering stage, and will hatch during the spring (April). Young larvae climb to the tops of trees, where they feed during the day and dangle from silk strands until they are dispersed by wind. Mature larvae hide during the day at the base of trees or bark crevices, and then feed at night. Pupation takes place between July and August. Adults emerge from pupal cases 10 to 14 days later. Females will remain on the tree and release pheromones to attract mates. Egg masses are deposited by females in late July or August. GM populations go through cycles in which the populations increase for several years, then decline, and then increase again.

PLANT HOSTS

Larvae feed on the foliage of hundreds of tree species. The most preferred hosts include oak, aspen, apple, birch, and poplar, but they will also infest walnut, cherry, elm, hickory, honey locust, maple, and several western conifers. Asian GM larvae will feed on evergreen and deciduous trees, whereas European GM larvae feed primarily on deciduous trees. Least preferred hosts include ash, dogwood, and lilac, but some research suggests that GM can eventually adapt to unsuitable host plants.

DAMAGE SYMPTOMS

Larvae are the damaging life stage. They defoliate trees, leaving trees weakened, more susceptible to drought, diseases and other pests,

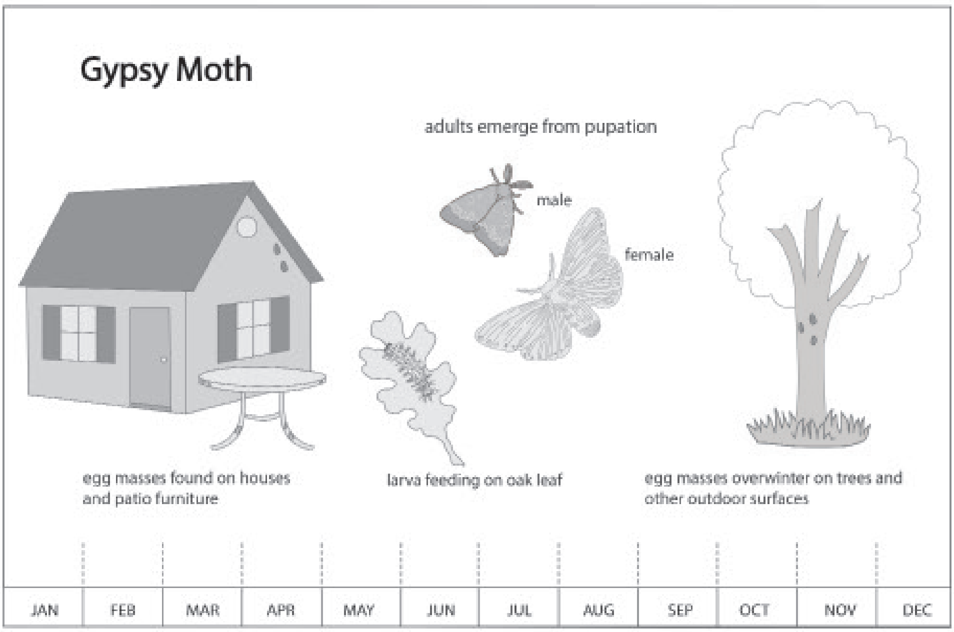


Fig 6. GM has one generation per year and overwinter as eggs on trees and other outdoor surfaces.

and can eventually kill trees and entire forests (Figs 7-10). GM larvae lower property values in infested urban areas, and their excrement, egg masses, and pupal casings can be a nuisance to homeowners (Fig 11).

Healthy trees can usually tolerate 1 to 2 years of GM attack; however, repeated infestations will weaken the tree to a point to which it cannot recover.

Fig 7. Larva feeding on oak leaf.

Fig 8. Larvae defoliate host trees.

Fig 9. GM is a defoliating insect.

Fig 10. Aerial view of GM damage.

Fig 11. GM larvae (on clay pot) can be a nuisance to homeowners.

WHAT CAN YOU DO?

Do not move or transport firewood. Like other forest pests, GM can spread to new areas on infested firewood and other wood materials. In general, do not transport firewood outside county boundaries.

Learn to identify all life stages of GM. Keep an eye open for GM life stages on and near your home, and keep your lawn and woodlot clean and free of hiding places (e.g., woodpiles, trash, unused equipment). Inspect buildings, fences, trees and shrubs, and rock gardens. Larvae and egg masses are more observable than adult moths.

Maintain tree health. In general, healthy trees are less susceptible to pests. Trees should be properly watered and pruned, and fertilized when necessary. Keep at least a 4 foot diameter area around trees free of weeds and grass so that there is no competition for water or nutrients and so trunks are not damaged by lawnmowers. Your local USU Extension office can help with tree maintenance and planting information.

MONITORING

There are a number of monitoring techniques state and federal survey personnel use for monitoring GM, including larval and adult trapping (Fig 12). These techniques, however, are more suitable for federal and state agencies that are involved in detection and delimiting surveys than for homeowners.

Fig 12. Trap used by survey personnel for detecting GM.

MANAGEMENT

GM has not been detected in Utah since 2016, so there is no need for control of this insect. Management efforts usually target the egg and larval stages, as early life stages are more susceptible to treatments.

One of the most common methods for controlling GM is aerial spraying of a bacteria-based pesticide called Btk, named after the bacterium, *Bacillus thuringiensis kurstaki*. Btk is harmful to moths and butterflies only during their caterpillar stage of development. Caterpillars eat vegetation sprayed with Btk, and then spores become activated in their stomachs, causing the caterpillars to die in 7 to 10 days.

GM is susceptible to attack by natural enemies, such as predators, pathogens (fungi and viruses), and parasitic wasps (parasitoids), such as *Aleiodes indiscretus* (Fig 13).

Fig 13. *Aleiodes indiscretus* wasp parasitizing a GM larva.

Other management options include mating disruption (pheromone that prevents male moths from finding mates), destroying egg masses with soapy or oily water, and placing sticky barrier bands on tree trunks (Fig 14). Barrier bands prevent caterpillars from crawling up trunks and into tree canopies. Note, however, that GM larvae can be dispersed by wind.

Fig 14. Barrier bands prevent GM larvae from crawling up tree trunks.

SIMILAR INSECTS

Some caterpillar defoliators that are common in Utah may be confused with GM caterpillars.

The western tent caterpillar (*Malacosoma californicum*) is a defoliator of broadleaf trees and shrubs throughout the western U.S. Adults are heavy bodied moths with wingspans of 1 to 2 inches, and vary in color from dark red-brown to yellow, tan, or gray (Fig 15). Egg masses are covered with a hardened, glossy material that is dark brown or pale gray (Fig 15). Young larvae are about ⅛ inch long and dark brown to black in color with white hairs (Fig 16). Mature larvae can reach 2 inches in length and are highly variable in color. They usually have a pale blue head and body, are speckled with black markings, have a mid-dorsal stripe edged by two bands that are black or yellowish orange and bordered with black, and are covered with orange-brown hairs with white tips (Fig 17). Caterpillars create and feed inside extensive silken tents.

Fig 15. Female western tent moth with egg mass.

Fig 16. Young western tent caterpillar larvae.

Fig 17. Mature western tent caterpillar larvae.

The fall webworm (*Hyphantria cunea*) is a common defoliator moth of ornamental and fruit trees in Utah. The adult moth has a wingspan of 1 to 2 inches and is primarily white in color, but can have black spots on the wings. Egg masses are white and contain several light yellow eggs. Young larvae are pale yellow with two rows of black marks along their bodies. Full grown larvae are about 1 inch long and have highly variable coloration (Fig 18). They are usually greenish with a broad, dusky stripe along the back, a yellowish stripe along the side, and are covered with long whitish hairs that originate from black and orange bumps. Larvae feed inside silken tents (Fig 19).

Fig 18. Fall webworm larvae are variable in color.

Fig 19. Fall webworm larvae are gregarious and feed inside silken tents.

REFERENCES & ADDITIONAL RESOURCES

Elkinton, J.S. and A.M. Liebhold. 1990. Population dynamics of gypsy moth in North America. Annual Review of Entomology 35: 571-596.

Herrick, O.W. and D.A. Gansner. 1987. Gypsy moth on a new frontier: forest tree defoliation and mortality. Northern Journal of Applied Forestry 4: 128-133.

Lazarević, J., V. Perić-Mataruga, B. Stojković, and N. Tucić. 2002. Adaptation of the gypsy moth to an unsuitable host plant. Entomologia Experimentalis et Applicata 102: 75-86.

Controlling Gypsy Moth Caterpillars with Barrier Bands, Maryland Cooperative Extension.

Fall Webworm, Utah State University Gypsy Moth in North America, U.S. Forest Service.

Gypsy Moth: A Destructive Forest Pest, Oregon Department of Agriculture and Oregon Invasive Species Council.

Gypsy Moth in Indiana, Purdue Extension.

Gypsy Moth, Penn State University.

Gypsy Moth: Slow the Spread Program, USDA APHIS.

Homeowner's Guide to Gypsy Moth Management, West Virginia University Extension Service.

Identifying and Managing Gypsy Moth Caterpillars, University of Wisconsin-Extension and Wisconsin Department of Natural Resources.

Pest Alert: Asian Gypsy Moth, USDA APHIS.

Western Tent Caterpillar, U.S. Forest Service.

For more information on GM, visit these websites: USDA Hungry Pests GM pages (http://www.hungrypests.com/the-threat/asian-gypsy-moth.php and http://www.hungrypests.com/the-threat/european-gypsy-moth.php) and Don't Move Firewood GM pages (http://www.dontmovefirewood.org/gallery-of-pests/asian-gypsy-moth.html-0 and http://www.dontmovefirewood.org/gallery-of-pests/european-gypsy-moth.html).

PHOTO CREDITS

Fig 1. John H. Ghent, USDA Forest Service, Bugwood.org

Figs 2, 19. Steven Katovich, USDA Forest Service, Bugwood.org

Fig 3. Daniela Lupastean, University of Suceava, Bugwood.org

Fig 4. Jon Yuschock, Bugwood.org

Fig 5. USDA Forest Service, USDA Forest Service, Bugwood.org

Fig 6. Life cycle by Erin Brennan, Utah State University

Fig 7. USDA APHIS PPQ , USDA APHIS PPQ, Bugwood.org

Figs 8, 9. Haruta Ovidiu, University of Oradea, Bugwood.org

Fig 10. Pennsylvania Department of Conservation and Natural Resources - Forestry, Bugwood.org

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Fig 18. Lacy L. Hyche, Auburn University, Bugwood.org

Japanese Beetle

Popillia japonica Newman

BACKGROUND

Japanese beetle (JB) (Coleoptera: Scarabaeidae) is an invasive insect that has an extensive plant host range. Plant damage is inflicted by both adults and larvae. Adults feed on the foliage of many plant species, while the larvae (white grubs) primarily feed on the roots of turf grass.

JB was first found in the U.S. in 1916 in a New Jersey nursery. It was likely introduced from Japan in shipments of ornamental plants. Since the 1970s, JB has been found throughout many western states, including Utah in 2006. An eradication program directed by the Utah Department of Agriculture and Food successfully eliminated JB from Utah. Recent monitoring traps have detected extremely low adult activity (e.g., in 2018, only three beetles were found in Utah).

Fig 1. Adult Japanese beetle (JB).

IDENTIFICATION

Adults are about ¼ inch wide and ½ inch long, oval shaped, and have a metallic green head and mid-section with copper-brown wing covers (Figs 1-3). They have five pairs of white hair tufts along the sides of the abdomen and another pair on the last abdominal segment (Fig 2). Their legs have prominent spines (Fig 3) and the underside of their body is metallic green and copper-brown.

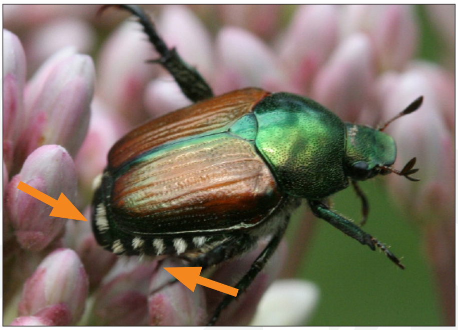

Fig 2. Arrows point to the five pairs of white tufts along the sides of the adult body and another pair on the last abdominal segment.

Fig 3. Arrow points to the prominent spines on the legs.

Eggs are about 1⁄16 inch in diameter, cylindrical when first deposited in the soil, but nearly round and 1⁄8 inch in diameter when mature (Fig 4).

Fig 4. Eggs are laid 2 to 3 inches in the soil.

Larvae, or "white grubs," are creamy white, and have a grayish-brown hind end and a yellow-brown head with dark mandibles (Fig 5). Larvae measure about 1⁄8 inch in length upon hatching, and 1 inch at maturity. Larvae have three pairs of underdeveloped legs and long brown hairs with short, blunt spines. They form a "C" shape when at rest. Many scarab beetle larvae, such as May/June beetles and chafers, look just like JB larvae. Suspect larvae should be submitted to the UPPDL for screening.

Fig 5. Larvae form a "C" shape when at rest.

LIFE HISTORY

JB has one generation per year (Fig 6). Most of the JB life cycle is spent underground, only emerging as adults to feed, mate, and lay eggs during the summer. Larvae are the overwintering life stage; most larvae overwinter as 3rd instars and burrow at a soil depth of 2 to 6 inches to spend the winter. The following spring, they feed, pupate, and then the adults emerge during June or July, feeding on a wide range of plants over a 6 to 8 week period. Mated females will fly to turf grass and burrow 2 to 3 inches underneath the soil to lay eggs. Each female can lay up to 60 individual eggs. Eggs hatch in July or August, and then the larvae feed on plant roots during the late summer and fall before overwintering.

PLANT HOSTS

JB attacks over 300 species of ornamental and crop plants. Adults chew on the leaves, flowers, fruit, and in some cases, stems of plants. Preferred hosts of adult JB include rose, maple, elm, grape, apple, stone fruits (cherry, plum, peach), blackberry, raspberry, asparagus, bean, and corn.

Larvae prefer fescues, perennial ryegrasses, Kentucky bluegrass, and bentgrass. The larvae also feed on roots of young ornamental trees and shrubs, and crops such as corn, peas, beans, tomatoes, and onions.

DAMAGE SYMPTOMS

Adults chew on the leaves, flowers, fruit, and in some cases, stems of plants. They are voracious feeders.

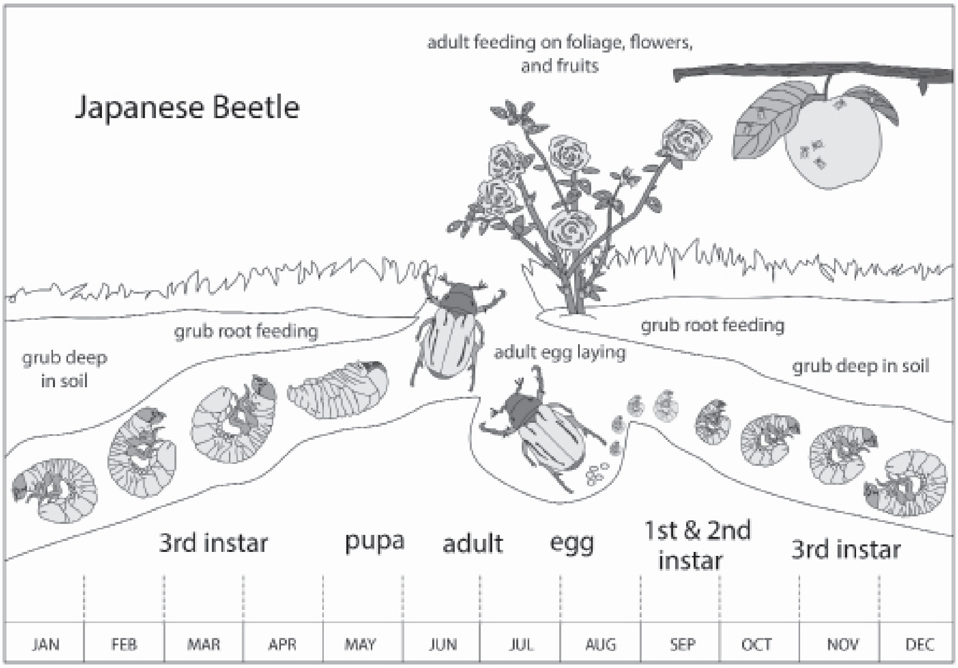

Fig 6. JB has one generation per year and overwinters as a larva in the soil.

Adults skeletonize leaves, chewing away softer tissue, and leaving the veins (Figs 7 and 8). They also chew holes in flower buds and petals, soft fruits, and corn silks (Figs 9-11). The adult beetles congregate (Fig 12) and can destroy crops in just a few days before moving on. They also wreak havoc on ornamental plants (Fig 13).

The larvae attack plants below ground and feed on the roots of grasses and some trees, shrubs, and vegetables. Large plantings of turf grasses (e.g., lawns and athletic fields) are especially attractive as egg-laying sites.

While damage to grasses is initially difficult to detect, it becomes apparent during late summer and early fall when grubs are more mature.

The compromised grass roots are inefficient in uptake of water and nutrients, and eventually turn leaves and stems yellow and brown. Severely injured turf will die. Feeding damage appears as patches of dead and dying plants mixed with healthy, unaffected grass (Fig 14). Turf with damaged roots is easily pulled back from the soil surface to reveal the grubs underneath (Fig 15). The damaged turf will also feel spongy and soft under-foot.

MONITORING

Effective monitoring is critical for determining when, where, and what JB can feed on. The techniques described below are appropriate for both homeowners, commercial growers, and survey personnel.


Fig 7. Adults skeletonize leaves.


Fig 8. Skeletonized leaf.


Fig 9. Adults chew holes in plants, including flowers.


Fig 10. Damage.


Fig 11. Adults feeding on corn.

Fig 12. Adults mass together to feed.

Fig 13. Damage.

Fig 14. Larval feeding causes patches of discolored turf. Other animals damage turf even further as they search for grubs to eat.

Fig 15. Turf can be pulled back to reveal larvae.

Scout for adults in the summer by inspecting susceptible plants, such as rose, apple, stone fruits, basswood/linden, crabapple, asparagus, and birch. JB prefer warm, sunny conditions, so monitoring should be done during the day and on the sunny side of the plant. Adults begin to feed at the top of plants, moving downward as the leaves are consumed.

Collect soil and root samples from damaged turf where JB is suspected to occur (Fig 16). Begin monitoring for larvae in the spring. Pull apart the roots and soil to look for mature larvae.

Examine turf grass for feeding injury and larvae. Turf grass that has been fed upon will be yellow to brown, and dying or dead. Leaves and crowns of grass plants will pull away easily from the roots. Grubs may be visible in the soil underneath damaged sod.

Another clue to the presence of white grubs in sod is predator digging activity, such as from birds, skunks, badgers, and other grub-eating predators. Inspect disturbed areas of turf for damage and grubs.

Fig 16. A soil corer can be used to collect soil and root samples.

MANAGEMENT

Control of JB can be difficult, as adults and larvae often occur on different host plants. Additionally, adults are highly mobile and can easily infest new areas.

Keep plants healthy by following recommended irrigation and fertilization schedules. Include a mix of plants that adult beetles avoid such as lilac, dogwood, and magnolia to discourage adult aggregations.

Mass-trapping is effective at reducing small and localized populations of JB. Place traps (Fig 17) near attractive plants of lower value. For example, an old or over-grown planting of roses will be highly attractive to JB, but can be “sacrificed” as a mass-trapping location.

Fig 17. Mass trapping can be an effective way to reduce JB infestations.

Removing JB by hand can be an effective method for small-scale, localized population reduction. Beetles can be easily removed by shaking plants or plant parts over a container filled with water and a few drops of dish soap. Dish soap helps facilitate the capture of the beetles by breaking the water tension, allowing beetles to sink into the water and drown rather than escape. Adults can also be hand-picked from small plants.

Encouraging beneficial insect populations in landscapes, gardens, and agricultural fields can help suppress pest insects, including JB. Ants and ground beetles are common predators of JB grubs. Avoid the use of broad-spectrum insecticides, and grow diverse flowering plants to provide nectar and pollen food resources to enhance populations of beneficial insects and natural enemies.

SIMILAR INSECTS

False Japanese beetles (*Strigoderma arbicola*), also known as sandhill chafers, rarely cause economic damage to crops. They are very similar to JB in size and body shape (Fig 18). The false JB, however, has wing covers that are dull in color compared to the shiny/metallic bronze wings covers of the true JB. The true JB has five distinct white tufts of hair along both sides of the abdomen, and one tuft on the hind end (Fig 2). The white tufts of hair on the false JB blend into one another and are not as distinct.

Hairy bear beetles (*Paracotalpa granicollis*) are also known as "little bear" beetles and feed on tree buds, blossoms, and leaves. They look very similar to JB, but can be distinguished by the prominent fuzz on their abdomen (Fig 19).

Bumble flower beetles (*Euphora inda*) feed on overripe, damaged, or dying fruit and vegetation, but are not considered pests of great concern. Larvae feed on dead and decaying plant matter. Adults are furry with yellowish brown hairs on the front of their backs and bellies, and have mottled gray and brown wing covers (Fig 20). They are about the size of a nickel (about ¾ inch in diameter). The common name of this beetle originated because adults often fly close to the ground and emit a loud buzzing sound similar to that of a bumble bee.

Fig 18. False Japanese beetle.

Fig 19. Hairy bear beetle.

Fig 20. Bumble flower beetle.

REFERENCES & ADDITIONAL RESOURCES

Kaufman, P. and M.L. Jameson. 2009. Biological observations and a new state record of *Paracotalpa granicollis* Haldeman (Coleoptera: Scarabaeidae: Rutelinae) in New Mexico. The Coleopterists Bulletin 63: 513-515.

Bumble Flower Beetle, Utah State University.

False Japanese Beetles, University of Minnesota Extension.

Japanese Beetle, Utah State University.

Japanese Beetles in the Urban Landscape, University of Kentucky.

Japanese Beetle Management in Minnesota, University of Minnesota Extension.

Managing the Japanese Beetle: A Homeowner's Handbook, USDA APHIS.

Managing Japanese Beetles in Fruit Crops, Michigan State University Extension.

PHOTO CREDITS

Figs 1, 10. Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org

Figs 2, 3, 5. David Cappaert, Bugwood.org

Fig 4. USDA Animal and Plant Health Inspection Service

Fig 6. Life cycle by Cami Cannon, Utah State University; adapted from drawings by J. Kalisch (University of Nebraska) and Joel Floyd (APHIS)

Fig 7. Daniel Herms, The Ohio State University, Bugwood.org

Figs 8, 13. Steven Katovich, USDA Forest Service, Bugwood.org

Fig 9. Dow Gardens, Dow Gardens, Bugwood.org

Fig 11. Daren Mueller, Iowa State University, Bugwood.org

Figs 12, 14. M.G. Klein, USDA Agricultural Research Service, Bugwood.org

Fig 15. Missouri Botanical Garden, missouribotanicalgarden.org

Fig 16. Lori Spears, Utah State University

Fig 17. Diane Alston, Utah State University

Fig 18. Whitney Cranshaw, Colorado State University, Bugwood.org

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Fig 20. Joseph Berger, Bugwood.org

Small Hive Beetle

Aethina tumida Murray

BACKGROUND

Small hive beetle (SHB) (Coleoptera: Nitidulidae) (Figs 1 and 2) is a pest of social bee colonies, including honey bees (*Apis mellifera*) and bumble bees (*Bombus* spp.). SHB will feed on pollen and honey, and kill bee brood and workers. SHB is native to sub-Saharan Africa where native African honey bee (*Apis mellifera scutellata*) behaviors, such as elevated aggression levels, can limit SHB infestations. SHB was first detected in the U.S. in South Carolina in 1996. SHB is now found throughout much of the U.S., with highest infestations occurring in the Southeast. It was first found in Utah in 2016, and is now confirmed in Washington, Millard, and Davis counties.

SHB is largely spread through packaged bees, beekeeping equipment, and bee products, but adults are strong fliers and can easily disperse to new hives. Their frass (insect poop) causes honey to discolor, ferment, and become frothy. Infested hives can appear slimy, drip fermented honey, and have a rotten orange odor that is repellent to bees and attractive to SHB. Under heavy infestations, bee colonies can quickly collapse. Queens stop laying eggs, and the heat generated by large numbers of SHB larvae can cause comb collapse and colony abandonment.

Fig 1. Arrow points to a cluster of small hive beetles in a honey bee hive.

Fig 2. SHB adults have clubbed antennae (left), but can be seen in the hive with their head and antennae tucked under their body (right).

IDENTIFICATION

Adults are small, ¼ inch long and ⅛ inch wide, flattened beetles that are oblong in shape, with clubbed antennae and shortened elytra (hard wing coverings) (Figs 1 and 2). Females are generally larger than males. Their color ranges from reddish-brown to dark brown (almost black) and darkens with age.

Eggs are 1/16 inch long, creamy white in color, and only 2/3 the size of honey bee eggs (Fig 3).

Larvae are 3/8 inch long, pearly white to beige in color, and have three pairs of legs near the head (Figs 3-5). They also have distinctive rows of body spines, and two large spines protruding from the rear.

Pupae are 1/4 inch long and creamy white to light brown in color, but darken with age.

Fig 3. SHB eggs (see arrow) and larvae clustered in the corner.

Fig 4. SHB larvae.

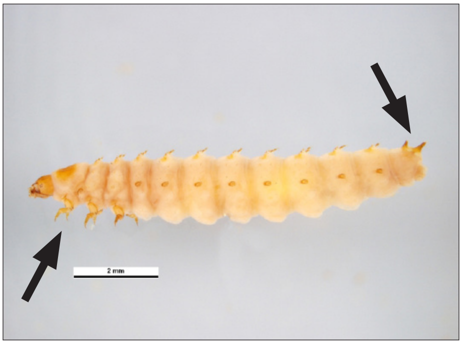


Fig 5. SHB larvae have three pairs of legs near the head, two large spines projecting from their rear (see arrows), and body spines.

LIFE HISTORY

SHB overwinters as adults and can be found amid the honey bee cluster where it is warm. During the spring, females lay eggs in clusters of 10 to 30 in cracks and crevices of the hive, under sealed brood cells, or in capped honey bee worker brood. A single female can lay up to 2,000 eggs in her lifetime. Eggs hatch in 2 to 6 days, and then the larvae feed for 3 to 14 days, tunneling through comb to eat bee eggs and brood, honey, and pollen. Tens of thousands of larvae may be present within a single hive, with up to 30 larvae per cell. When larvae reach their post-feeding stage ("wandering stage"), they become attracted to light. They congregate on the bottom board and in frame corners, eventually exiting colonies typically en masse at dusk, in search of suitable pupation substrates. They are capable of migrating more than 600 feet and can exist in this stage without feeding for up to 60 days. Pupation usually occurs within a 60 foot radius in the top 4 inches of the soil around the hive,

and lasts 2 to 12 weeks, depending on environmental conditions. Following pupation, adults leave the soil and invade bee colonies individually or in swarms and are attracted by the odors emitted by host colonies. They can fly up to 10 miles searching for new host colonies. Adults live an average of 4 to 6 months, but can survive up to 16 months. As many as six generations per year can occur under moderate environmental conditions.

MONITORING

Regular hive inspection is necessary for early detection. Ideally, hives should be inspected once or twice a month, especially during spring and summer. Use a flashlight to visually inspect hives. Adults actively seek dark areas of the hive and will scurry away from light when the hive is opened for inspection. When opening the hive, look for SHB adults running across the combs, crown boards, and the hive floor. Their heads may be tucked downward, so their clubbed antennae may not be readily visible (Figs 1 and 2). During warm weather, SHB adults will generally be on the hive floor; in cooler temperatures, look for them among the clustering bees. Also check cracks and crevices for egg clusters, and check combs and the bottom board for larvae (Figs 3-5). Alternatively, during sunny conditions, the top super of a hive can be placed on the hive lid for about 10 minutes. The sunlight will force the adults to the bottom of the super and onto the lid. When the super is lifted, the beetles can then be more easily observed.

Infested colonies may have fermented honey dripping from hive entrances, damaged and slimy combs, and dark, crusty traces that appear on the hive exterior from wandering larvae (Fig 6). Heavily infested colonies may smell like decaying oranges.

Fig 6. Damage to a honey bee hive.

MANAGEMENT

If SHB populations are large, a bee colony can collapse in less than 10 days. The most effective control method is prevention through ensuring that bee colonies are strong and healthy so that they can better defend themselves against SHB attack. Use the following tactics to safeguard your hives:

- Place hives in partial to full sun.
- Keep soil under hives dry.
- Combine, eliminate, or re-queen weak colonies.
- Clean hives and frames, and maintain in good condition to decrease beetle hiding sites.
- Avoid over-supering hives. Having

too many boxes gives beetles excessive space to move, hide, and lay eggs.

- Reduce stresses from other bee pests and diseases.
- Ensure that all colonies sent/received are free of SHB.
- Keep a high ratio of bees to comb to prevent SHB from hiding from patrolling bees. When splitting hives, have sufficient numbers of bees present in each split.
- If using a non-screen bottom board, regularly remove the accumulating debris to prevent SHB from pupating inside the hive.
- Maintain a clean extraction facility and equipment storage room with humidity levels <50%.
- Process honey within 1 to 2 days following removal from the colony, clean area afterward, and avoid leaving wax cappings and other bee products lying around. If you suspect a SHB infestation, prior to extracting honey, freeze honeycomb at 10°F for at least 12 hours to kill beetle life stages.
- Avoid using grease patties for mite control or adding protein patties for spring buildup. These are attractive to SHB and may increase chances of infestation.

Traps can be used to remove SHB from hives. Most traps work by drowning beetles in oil or soapy water. The traps that have been shown to be effective at controlling SHB include the commercially available Freeman Beetle Trap (Fig 7), West Trap, Beetle Blaster, and Hood Trap, as well as the homemade Sonny-Mel Trap (Zawislak 2014).

Fig 7. The Freeman Beetle Trap consists of a screened mesh bottom board and a plastic tray filled with cooking oil or soapy water and slid underneath the screened mesh. Guard bees pursue the beetles, which then fall into the liquid and die.

Entomopathogenic nematodes (EPNs) (e.g., *Steinernema carpocapsai, S. kraussei, S. riobrave,* and *Heterorhabditis indica*) can be an effective biological control strategy against wandering larvae and pupae. EPNs are commercially available and can be placed in the soil surrounding the hive where SHB pupates. However, applications should be made when temperatures are between 50°F to 68°F. Annual applications may be necessary since some EPNs may be unable to persist in Utah's climate.

SIMILAR INSECTS

The dusky sap beetle (*Carpophilus lugubris*) is a similar-looking beetle (Fig 8) and has been found in a few honey bee hives in Utah. However,

the dusky sap beetle is a scavenger, attracted to decaying fruit and vegetables, and is currently not known to impact honey bee colonies.

Fig 8. Dusky sap beetle, a SHB lookalike, on an overripe melon.

The SHB larva looks similar to the wax moth larva (*Galleria melonella*), but on close examination can be distinguished by their body spines and by only having three pairs of legs near the head (Fig 5). Wax moth larvae have an additional four pairs of less developed abdominal legs, lack body spines, and can grow to ¾ inch in length, double the size of SHB larvae (Fig 9). Further, wax moth larvae produce webbing in combs (Fig 10); SHB produces no webbing.

Fig 9. Wax moth larvae, unlike SHB larvae, have abdominal legs (see arrow) and lack rear and body spines.

Fig 10. Wax moth larvae produce webbing in the hive; SHB does not produce webbing.

REFERENCES AND FURTHER READING

Annand, N. 2011. Investigations on small hive beetle biology to develop better control options. M.S. thesis. Univ of Western Sydney. 146 pp.

Bernier, M., V. Fournier, and P. Giovenazzo. 2014. Pupal development of *Aethina tumida* (Coleoptera: Nitidulidae) in thermo-hygrometric soil conditions encountered in temperate climates. Journal of Economic Entomology 107: 531-537.

Buchholz, S., K. Merkel, S. Spiewok, J.S. Pettis, M. Duncan, R. Spooner-Hart, C. Ulrichs, W. Ritter, and P. Neumann. 2009. Alternative control of *Aethina tumida* Murray (Coleoptera: Nitidulidae) with lime and diatomaceous earth. Apidologie 40: 535-548.

Cuthbertson, A.G.S., J.J. Mathers, L.F. Blackburn, M.E. Powell, G. Marris, S. Pietravalle, M.A. Brown, and G.E. Budge. 2012. Screening commercially available entomopathogenic biocontrol agents for the control of *Aethina*

tumida (Coleoptera: Nitidulidae) in the UK. Insects 3: 719-726.

Cuthbertson, A.G.S., M.E. Wakefield, M.E. Powell, G. Marris, H. Anderson, G.E. Budge, J.J. Mathers, L.F. Blackburn, and M.A. Brown. 2013. The small hive beetle *Aethina tumida*: A review of its biology and control measures. Current Zoology 59: 644-65.

Elzen, P.J., J.R. Baxter, D. Westervelt, C. Randall, K.S. Delaplane, L. Cutts, and W.T. Wilson. 1999. Field control and biology studies of a new pest species, *Aethina tumida* Murray (Coleoptera, Nitidulidae), attacking European honey bees in the Western Hemisphere. Apidologie 30: 361–366.

National Bee Unit. 2017. The small hive beetle: a serious threat to European apiculture. Animal and Plant Health Agency.

Neuman, P., J.S. Pettis, and M.O. Schafer. 2016. Quo vadis *Aethina tumida*? Biology and control of small hive beetles. Apidologie 47: 427-466.

Sheridan, A., H. Fulton, and J. Zawislak. 2012. Small hive beetle management in Mississippi. Mississippi State Univ.

Spears, L.R. and A.M.M. Mull. 2018. Small hive beetle [*Aethina tumida* (Murray)]. Fact Sheet ENT-192-18-PR. Utah State University Extension and Utah Plant Pest Diagnostic Laboratory.

Zawislak, J. 2014. Managing small hive beetles. Univ of Arkansas, Div of Agriculture.

PHOTO CREDITS

Figs 1, 3, 6. Jessica Louque, Smithers Viscient, Bugwood.org

Fig 2. Garry Fry, National Bee Unit, Food and Environmental Research Agency, UK, nationalbeeunit.com (left image); Natasha Wright, Florida Department of Agriculture and Consumer Services, Bugwood.org (right image)

Fig 4. James D. Ellis, University of Florida, Bugwood.org

Fig 5. Pest and Diseases Image Library, Bugwood.org

Fig 7. DML. http://www.honeybees-by-the-sea.com/freeman1.htm

Fig 8. Whitney Cranshaw, Colorado State University, Bugwood.org

Fig 9. Susan Ellis, USDA APHIS PPQ, Bugwood.org

Fig 10. Juan Campá, MGAP, Bugwood.org

Spotted Lanternfly

Lycorma delicatula White

BACKGROUND

Spotted lanternfly (SLF) (Hemiptera: Fulgoridae) (Figs 1 and 2) is a new invasive planthopper to North America. It is native to China, Vietnam, and India, and has spread to Japan and South Korea where it is causing considerable damage to some fruits. SLF was first detected in the U.S. in Pennsylvania in 2014 and is thought to have first arrived to the country on imported landscaping stone. As of May 2019, SLF has also been reported in Delaware, New York, Virginia, New Jersey, Connecticut, and Maryland. It is not known to occur in Utah. SLF is a quarantine pest and can restrict interstate movement of regulated articles (e.g., fruit, lumber, firewood); however, it can easily spread to new areas by the unintentional movement of life stages on infested plant material and manmade objects. SLF is a nuisance pest and can congregate in large numbers in and around homes and structures (Fig 3).

Fig 1. Spotted lanternfly adult.

Fig 2. Adults have gray forewings with black spots; and red, white, and black hindwings.

Fig 3. SLF often feed in large numbers.

IDENTIFICATION

Adults are about 1 inch long. The forewings are gray with black spots, and black blocks outlined in gray are arranged along the wing tip. The upper sides of the hindwings are black and white, and the lower sides are red with black spots (Figs 1 and 2). Their legs are black and their abdomen is yellow with broad black bands on the top and bottom surfaces.

Females lay one to two egg masses; each mass contains 30 to 50 eggs and is covered by a waxy substance roughly 1 inch long. Newly laid egg masses are white in color but turn brownish-gray and mud-like as they age (Figs 4 and 5). Beneath the waxy cover, the eggs are seed-like and deposited in 4 to 7 parallel rows.

Fig 4. Female adult with a newly laid egg mass.

Fig 5. Eggs are laid in vertical parallel rows (see arrow); egg masses turn brownish-gray and appear mud-like as they mature.

Nymphs (immature life stage) are wingless and undergo four instars. The first three instars are black with white spots; the last instar is black and red with white spots (Fig 6). Fully-winged adults develop after the fourth instar.

Fig 6. Nymphs undergo four instars (molts). The first three instars are black with white spots (top); the fourth instar is black and red with white spots (bottom).

LIFE HISTORY

SLF has one generation per year, and overwinters as eggs. Eggs hatch from late April to early summer. Nymphs then begin crawling and feeding on a wide range of host plants. Adults are present by mid-summer (mid to late July) and prefer to feed on tree-of-heaven, but can also be found on other hosts (see the PLANT HOSTS section on the next page). Eggs are laid from September to the onset of winter (late November to early December). Each female can produce one to two egg masses (30 to 100 individual eggs). Adults die with a hard frost.

PLANT HOSTS

SLF are broad generalists that feed on more than 70 plant species including grape, fruit trees (apple, peach, cherry, apricot, and plum), and hardwood/ornamental trees (e.g., maple, willow, birch, ash, walnut, poplar, sycamore, aspen, oak, linden, pine, lilac, serviceberry, and dogwood). Adults show a strong preference for tree-of-heaven, an invasive plant from China that is widely established in the U.S.

DAMAGE SYMPTOMS

SLF uses a piercing-sucking mouthpart to feed on phloem from stems, leaves, and bark. It does not feed directly on fruit. Branches highly infested with SLF (Fig 7) may lose vigor, wilt, and die. Extensive feeding results in weeping wounds that leave trails of sap along the bark. As it feeds, SLF secretes sugary excrement (honeydew) that, along with sap from oozing wounds, promotes the growth of fungi, such as sooty mold (Fig 8). Sooty mold (a gray and black fungus) develops around the base of trees and branch crotches, and can coat leaf and fruit surfaces, therefore interfering with photosynthesis and ultimately negatively affecting plant growth and crop yield. Further, the honeydew can attract unwanted insects, such as ants and wasps, and coat items underneath the affected tree(s) (e.g., porches and vehicles) with the sticky residue.

MONITORING

SLF can be monitored with visual inspection. Nymphs and adults gather in large numbers on host plants

Fig 7. Apple (top) and grape (bottom) highly infested with adult SLF.

Fig 8. SLF feeding can result in weeping wounds and sooty mold growth (gray and black fungus on lower tree trunk).

and are easy to find at dusk or night when they move up and down tree trunks. During the day, they tend to congregate in the canopy or at the base of the host plant if there is adequate cover. Begin monitoring for nymphs toward late April or early May, and then continue monitoring for adults through the summer and fall. In addition, keep an eye out for the mud-like egg cases from September through April. Eggs are laid on any smooth surface, such as tree bark, landscaping stone, outdoor furniture, vehicles, railway cars, telephone poles, and fence posts. Sticky tree bands are another useful monitoring tool. Sticky bands should be placed about 4 feet above the base of host trees, with the sticky portion of the band facing outward (Fig 9). Push pins can be used to help secure the band to the tree. Bands should be checked and replaced every 2 weeks. Research shows that brown sticky traps are more attractive to nymphs and adults than blue or yellow sticky traps, and current field trials are assessing the combined efficacy of brown sticky bands and a methyl salicylate lure.

Fig 9. Place brown sticky bands around known host trees to monitor for SLF.

MANAGEMENT

Egg masses can be scraped off a substrate by using a credit card, putty knife, or similar tool. Using a downward motion, scrape the egg mass into a vial containing rubbing alcohol or hand sanitizer and tightly seal (Fig 10).

Fig 10. Scrape SLF egg masses into a container filled with rubbing alcohol or hand sanitizer and tightly seal.

In addition, consider removing tree-of-heaven if it is present on your property. In Pennsylvania, it is recommended to remove female tree-of-heaven, while leaving a few male “trap” trees for targeted insecticide sprays. Male trap trees are preferred over female trees because females produce seeds which can repopulate the property. Further, an herbicide application may need to accompany tree-of-heaven removal, as small pieces of remaining root can generate new shoots.

SIMILAR INSECTS

Other insects may be mistaken for SLF in Utah, including the ornate tiger moth (*Apantesis ornata*) (Fig 11), box elder bug (*Boisea trivettata*) (Fig 12),

small milkweed bug (*Lygaeus kalmii*) (Fig 13), red fire bug (*Pyrrhocoris apterus*) (Fig 14), and nymphs of various stink bug species, including brown marmorated stink bug (*Halyomorpha halys*, pages 17-27).

Fig 11. Ornate tiger moth.

Fig 12. Box elder bug (adult and nymphs).

Fig 13. Small milkweed bug.

Fig 14. Red fire bug (adult and nymphs).

REFERENCES AND FURTHER READING

Biddinger, D. and H. Leach. 2018. Updated insecticide recommendations for spotted lanternfly on grape. Penn State University Extension.

Dara, S.K. 2014. Spotted lanternfly (*Lycorma delicatula*) is a new invasive pest in the United States. Agriculture and Natural Resources, University of California (UCANR).

Guédot, C. 2016. Spotted lanternfly. Univ. of Wisconsin Extension.

Han, J.M., H.J. Kim, E.J. Lim, S.H. Lee, Y.J. Kwon, and S.W. Cho. 2008. *Lycorma delicatula* (Hemiptera: Auchenorrhyncha: Fulgoridae: Aphaeninae) finally, but suddenly arrived in Korea. Entomol. Res. 38: 281-286.

Krawczyk, G., D. Biddinger, and H.L. Leach. 2018. Spotted lanternfly management for homeowners. Penn State University Extension.

Moylett, H. and T. Molet. 2018. CPHST pest datasheet for *Lycorma delicatula.* USDA-APHIS-PPQ-CPHST.

Park, J.D., M.Y. Kim, S.G. Lee, S.C. Shin, J. Kim and I.K. Park. 2009. Biological characteristics of *Lycorma delicatula* and the control effects of some insecticides. Korean J. Appl. Entomol. 48: 53-57.

Pennsylvania Department of Agriculture. 2017. Guidelines for the control of spotted lanternfly. Penn Dept. of Agriculture.

Shin, Y.-H., S.-R. Moon, C.-M. Yoon, K.-S. Ahn, and G.-H. Kim. 2010. Insecticidal activity of 26 insecticides against eggs and nymphs of *Lycorma delicatula* (Hemiptera: Fulgoridae). Korean J. Pest. Sci., 14: 157-163.

Simisky, T. 2018. Spotted lanternfly. Univ. of Massachusetts at Amherst Extension.

Spears, L.R. and A.M.M Mull. 2019. Spotted lanternfly [*Lycorma delicatula* (White)]. Fact Sheet ENT-207-19-PR. Utah State University Extension and Utah Plant Pest Diagnostic Laboratory.

Swackhamer, E. 2018. Spotted lanternfly management: placing sticky bands on trees. Penn State University Extension.

Swackhamer, E., D. Jackson, and Gover, A. Spotted Lanternfly IPM Management Calendar. Penn State University Extension.

USDA Forest Service. 2014. Field guide for managing tree-of-heaven in the southwest. TP-R3-16-09.

Yoon, C., S.R. Moon, J.W. Jeong, Y.H. Shin, S.R. Cho, K.S. Ahn, J.O. Yang, and G.H. Kim. 2001. Repellency of lavender oil and linalool against spot clothing wax cicada, *Lycorma delicatula* (Hemiptera: Fulgoridae) and their electrophysiological responses. J. Asia Pac. Entomol. 14: 411-416.

PHOTO CREDITS

Figs 1, 4, 5, 7 (left), 8. Emelie Swackhamer, Penn State University, Bugwood.org

Fig 2. Pennsylvania Department of Agriculture, Bugwood.org

Figs 3, 6, 7 (right), 9. Lawrence Barringer, Pennsylvania Department of Agriculture, Bugwood.org

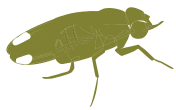
Fig 10. Pennsylvania Department of Agriculture, in https://extension.psu.edu/spottedlanternfly-management-for-homeowners

Fig 11. Donald Hobern from Copenhagen, Denmark [CC BY 2.0 (https://creativecommons.org/licenses/by/2.0)]

Fig 12. William M Ciesla, Forest Health Mgt International, Bugwood.org

Fig 13. Joseph Berger, Bugwood.org

Fig 14. KoS [Public domain]



Spotted Wing Drosophila

Drosophila suzukii Matsumura

BACKGROUND

Spotted wing drosophila (SWD), (Diptera: Drosophilidae) (Fig 1), is an invasive fly native to Russia and parts of Asia. It infests soft fruits and differs from related species by laying eggs in healthy, developing fruit, but will also infest overripe and damaged fruit. Because adult females will lay eggs in maturing fruit, larvae can be unknowingly present in fruit that is harvested for market (Fig 2).

Fig 2. SWD larva (see arrow) in raspberry.

SWD was first recorded in the continental U.S. (California) in 2008, and first detected in Utah in 2010. It is currently established in Rich, Cache, Box Elder, Weber, Davis, and Utah counties. Despite SWD being in Utah for nearly a decade, it has not yet caused economic injury in any fruit crop that we know of. It is thought that Utah's hot, dry climate delays primary development of SWD until late summer to early fall when temperature conditions are more ideal for this pest. At this time, late-season maturing, soft fruits are at greatest risk for SWD infestation.

Fig 1. Adult male (left) and female (right) SWD.

IDENTIFICATION

Adults are about $\frac{1}{12}$ to $\frac{1}{7}$ inch long. They have a pale brown body with unbroken lateral bands on the upper abdomen, red eyes, and short featherlike antennae (Fig 1). SWD is named for a dark spot on each wing of the male fly. Many flies have spots on their wings, but small flies with only one spot per wing should be considered suspect. Males also have two dark bands ("sex combs") on each lower foreleg (Fig 3). Females do not have a spot on each wing, but can be distinguished from other drosophilids by a large, saw-like ovipositor (egg-laying device) located on the tip of the abdomen (Fig 4).

Eggs are less than $\frac{1}{32}$ inch long (Fig 5). They are white to creamy translucent in color and cylindrical in shape. There are two thin respiratory filaments on one end. The filaments may protrude from fruits with eggs present (Fig 5).

Larvae are about $1/16$ to $1/6$ inch long. They are cream-colored maggots with black mouthparts. Mature larvae can be distinguished from other fruit fly larvae (e.g., cherry fruit fly) by having a smaller body that is tapered at both ends, and shallow fruit feeding (Fig 6).

Pupa are $1/10$ inch long, and brown and cylindrical with two breathing tubes extending on one end (Fig 7).

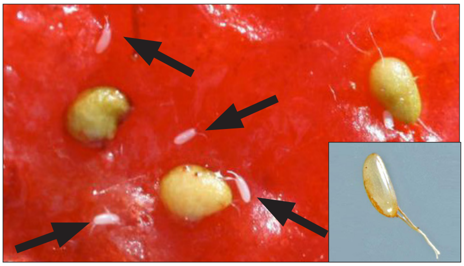


Fig 5. main image: SWD eggs in strawberry fruit (arrows point to eggs; large yellow spots are strawberry seeds); inset: close up of SWD egg.

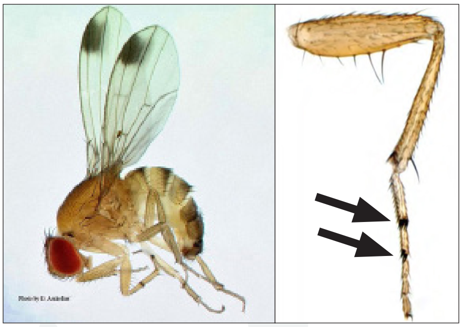


Fig 3. Adult male SWD (left); note spots on wings, and "sex combs" on forelegs (right. Arrows point to sex combs.

Fig 6. SWD larva on cherry fruit; note breathing holes cut through the skin.

Fig 4. Adult female SWD; note the lack of spots on wings and ovipositor (egg laying device on tip of abdomen) with dark serrated teeth for cutting into fruit (see inset).

Fig 7. SWD pupa protruding from a cherry fruit with breathing tubes extended.

LIFE HISTORY

Adults and pupae are the overwintering life stages; however, adults are the only life stage that has been detected in Utah to-date. Because adults have been detected in the same locations in subsequent years, this suggests that SWD is overwintering, reproducing, and completing full generations in Utah. In Utah, trap captures of adults peak from late September to early November.

Adult flies increase activity in the spring as temperatures warm (Fig 8). They are most active between 68°F to 77°F, and prefer hours of dawn and dusk. Degree-day (DD) models estimate that adult emergence begins at 270 DD (lower development threshold 50°F) (late April to early May) in northern Utah; however, low populations are difficult to detect and few adults have been detected in traps before August. The adult lifespan can vary from 8 days to 9 weeks depending on environmental conditions and time of year.

PLANT HOSTS

SWD hosts include tree fruits, berries, soft-skinned vegetables, and ornamental and wild fruits. Soft-skinned fruits (e.g., cherry and raspberry) are most vulnerable to SWD attack as they near maturity; firmer-skinned fruits (e.g., apple and grape) become more attractive to SWD when they are overripe or damaged. SWD is a late season pest in Utah, so fruits that are harvested early in the season are less susceptible to SWD.

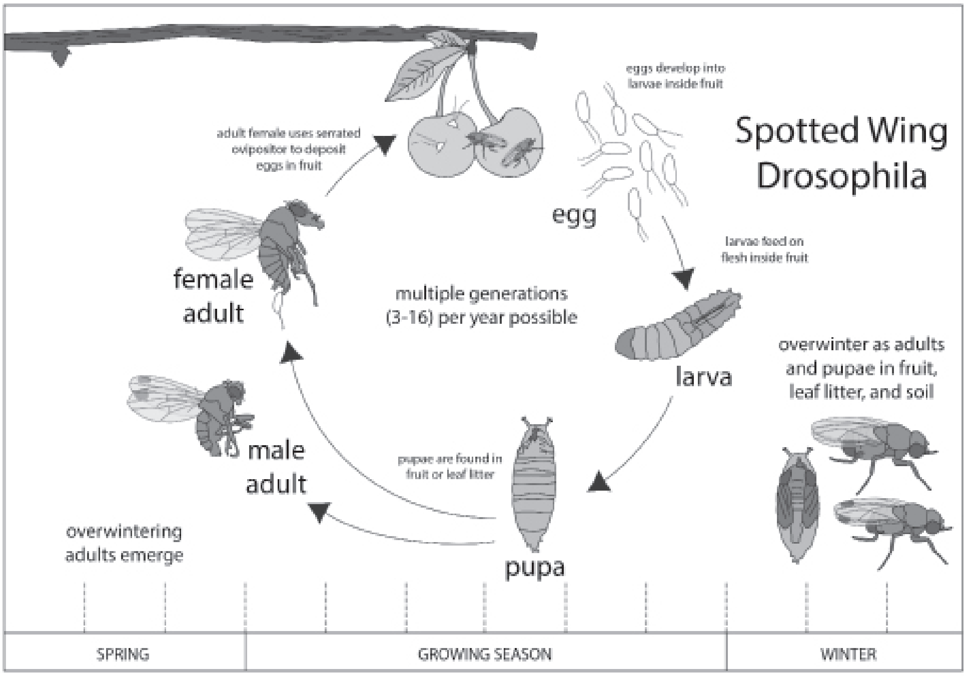


Fig 8. SWD has multiple generations per year and overwinters as adults or pupae.

DAMAGE SYMPTOMS

Adult females cause injury to fruit via egg-laying. Egg-laying (oviposition) scars are pin-prick holes in the fruit skin that may become sunken (Fig 9). SWD eggs have two small hair-like filaments that may be seen protruding through the fruit skin.

Primary damage is caused by larval feeding and tunneling in the fruit flesh. After 5 to 7 days of larval feeding, the fruit skin begins to show damage symptoms. Larval feeding will cause the fruit to become soft, wrinkled, and spotted (Fig 10). As larvae increase in size, they cut breathing holes through the fruit skin (Fig 6).

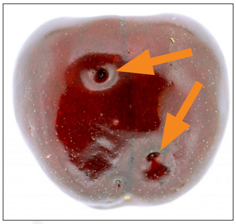


Fig 9. Damage to cherry fruit. Arrows point to oviposition scars that have become sunken and enlarged.

Fig 10. Advanced SWD damage in cherry fruits. Note SWD pupae adhering to the skin of some fruits.

MONITORING

Adult flies can be monitored using bait traps, and larval infestations of fruit can be determined by visually inspecting fruit. Commercial monitoring traps are available for purchase, but simple traps can be made from a 16 to 32 oz clear plastic cup and lid. Drill, punch, or melt holes into the sides of the cup or the cup lid. Holes should be big enough for SWD to enter, but small enough (¼ or 3⁄16 inch drill bit size) to exclude larger insects. Leave a portion of the circumference around the cup without holes to allow for easy pouring of the liquid trap bait and trapped insects when replacing the bait. Use a string or wire hanger threaded through holes punched in the cup sides to hang the trap at fruit level in a tree or from a stake. Traps should be placed in cool and shady areas of the field or orchard (Fig 11). Begin monitoring before the earliest fruit begins to ripen.

The most common liquid baits used in SWD traps are apple cider vinegar (ACV) or sugar-water-yeast mixtures (2 tsp active dry baker's yeast, 4 tsp white sugar, 12 oz (1½ C) warm water—good for two to three traps). Both baits are effective; their preference has varied among studies and locations. Adding 1 to 2 drops of unscented dish soap to liquid bait mixtures will break the surface tension and improve the trapping efficiency of the bait. Liquid baits should be replaced at least weekly. Continue to monitor traps through harvest of susceptible fruits.

Adding a synthetic, commercially available dry lure with your chosen trap and trap bait may provide an

early warning in susceptible crops and increase SWD captures. Commercial lures last 1 to 2 months in the field (1 month in hot climates).

Fig 11. SWD trap with apple cider vinegar bait and commercial lure. Note that there are holes (not shown) drilled into the cup lid for fly entry.

Check traps weekly and keep records of SWD activity in each trap at each weekly check. In the field, carefully decant the liquid bait and captured flies from the trap into a storage container. Refill the trap with fresh bait solution. Do not combine new with old bait, or dump old bait on the ground near monitoring sites.

Transport the trap bait containers indoors and then pour the bait solution through a fine mesh strainer and wash the insect specimens by carefully "dipping" the strainer into another water-filled container (Fig 12). Use a hand lens or magnifying glass to examine the floating insects. If you need a closer look at a fly, use forceps to remove it and place it in a different dish. If identification help is needed, samples can be sent to the Utah Plant Pest Diagnostic Lab at Utah State University. For greater details about processing the liquid bait to find SWD adults, consult the USU Extension fact sheet on Monitoring for Spotted Wing Drosophila in Utah.

Fig 12. Liquid bait is poured through a fine mesh strainer and dipped in fresh water for rinsing and better visualization of the flies.

MANAGEMENT

Non-chemical control methods are reliant on effective SWD monitoring, and can be used by homeowner and commercial fruit growers, but are generally more feasible for use on a smaller scale.

Sanitize: Maintain a clean orchard by eliminating fallen and infested fruit remaining on trees or plants after harvest. Dispose of infested fruit in a plastic sealable bag in the trash, or solarize the fruit under clear plastic in the sunshine. Composting or burying fruit is not effective in killing SWD.

Netting: Fine netting placed over susceptible plants may keep SWD adults from attacking fruit. Netting should be applied after flowering to allow for pollination, but before fruit begins to ripen and SWD activity is detected in traps. Mesh size should be 0.98 mm or smaller.

Early and Timely Harvest: SWD are attracted to ripe, ripening, and over-ripe fruit; thus, early and timely harvest reduces the exposure of susceptible fruits to SWD. Harvest fruit as early as possible and continue to pick fruit as it ripens. Select early maturing cultivars to avoid exposure to late-season SWD when populations tend to increase.

Chilling: After harvest, chill fruit immediately to 34°F to 38°F, or to just above the fruit freezing point, for 12 to 72 hours. This will stop development and kill many eggs and older larvae.

Open Crop Canopies and Manage Irrigation: SWD prefer humid shady sites. Minimize overhead irrigation and repair leaks in the irrigation system. Maintain good air flow and open tree canopies to reduce humidity and shade in the crop canopy.

Traps: Trapping is not an effective method to reduce SWD populations; however, it is important for determining the presence of SWD, assessing if treatment is required, and optimal timing of insecticide applications, if needed.

Chemical control is not recommended unless SWD is caught in monitoring traps or fruit infestation is detected. Consult the USU SWD fact sheet (Spears et al. 2017) for more information about insecticides that are effective for controlling SWD.

REFERENCES AND FURTHER READING

Cannon C., D.G. Alston, L.R. Spears, C. Nischwitz, and C. Burfitt. 2016. Invasive fruit pest guide for Utah: insect and disease identification, monitoring, and management. Utah State University Extension and Utah Plant Pest Diagnostic Laboratory.

Spears L.R., C. Cannon D.G. Alston, R.S. Davis, C. Stanley-Stahr, and R.A. Ramirez. 2017. Spotted Wing Drosophila [*Drosophila suzukii*]. Fact Sheet ENT-187-17. Utah State University Extension and Utah Plant Pest Diagnostic Laboratory.

Monitoring for Spotted Wing Drosophila in Utah, USU Extension.

Spotted Wing Drosophila, Oregon State University.

MyPest Page Degree-Day/Phenology Models, Oregon State University.

Spotted Wing Drosophila in Home Fruit Plantings: Insecticide Options, Oregon State University.

Spotted Wing Drosophila, Washington State University.

Spotted Wing Drosophila, Michigan State University.

PHOTO CREDITS

Fig 1. Shane F. McEvey, Australian Museum [CC BY 4.0 (https://creativecommons.org/licenses/by/4.0)]

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Fig 3. G. Arakelian (left); Martin Hauser, California Department of Food and Agriculture (right)

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Fig 5. main image: Hannah Burrack, North Carolina State University, Bugwood.org; inset: Brigitte Rozema & Howard Thistlewood, Agriculture & Agri-Food Canada, Pacific Agri-Food Research centre, Summerland

Figs 6, 7. Elizabeth Beers, Washington State University

Fig 8. Illustration by Cami Cannon, Utah State University

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Fig 10. Peter Shearer, Oregon State University

Fig 11. Lori Spears, Utah State University

Fig 12. Cory Stanley-Stahr, formerly Utah State University

Velvet Longhorned Beetle

Trichoferus campestris Faldermann

BACKGROUND

Velvet longhorned beetle (VLB), (Coleoptera: Cerambycidae), is a wood-boring pest that infests fruit, forest, and landscaping trees, as well as green (timber) and dry wood (lumbar). VLB is native to Asia and Russia. It was first detected in North America in Quebec in 2002, and in the U.S. in Rhode Island in 2006. It has been detected/intercepted in a few other states, mostly in the Midwestern and Eastern U.S., but also in Utah (since 2010). In Utah, VLB is currently found in some orchards, ornamental landscapes, and along natural waterways in Utah, Salt Lake, Davis, and Tooele counties. VLB spreads to new areas through infested wood packing material used for imported commodities such as machinery, building supplies, glass, tools, and tiles.

Fig 1. Adult velvet longhorned beetle (VLB).

Fig 2. Adults vary in color from dark brown to brownish orange.

IDENTIFICATION

Adults all have an elongated body that is about ½ to ¾ inch long. They have long parallel wing covers (elytra) and vary in color from dark brown to brownish orange, with the legs and antennae usually being lighter in color than the body (Fig 1). Antennae are segmented and about ¾ the length of the body (Figs 1 and 2). The name "velvet" comes from the fine hairs that are irregularly distributed and form light colored "patches" along the body and wing covers (Fig 3).

Eggs are white, oval in shape, and approximately 1⁄16 inch long.

Larvae are about ½ to 1 inch long, and yellow to white in color with a brown head, segmented body, and short poorly developed legs (Fig 4).

Pupae are about ¾ inch long, and have a white to cream colored body (Fig 5).

Fig 3. Close up of fine hairs on body of VLB.

Fig 4. Larvae are about ½ to 1 inch in length.

Fig 5. Pupae are about ¾ inch in length.

PLANT HOSTS

VLB has been known to infest apple, cherry, mulberry, peach, and a number of hardwood, ornamental, and conifer timber tree species. Many tree species may also serve as dry wood hosts for VLB. It is unknown if VLB prefers stressed or healthy trees; however, it does seem to be more attracted to medium to large sized trees. Nursery trees are susceptible hosts and may act as a reservoir for the pest to spread to new areas.

DAMAGE SYMPTOMS

Symptoms include round exit holes (about ⅜ inch in diameter) on the trunk and main branches (Fig 6); a thinning, wilted or yellowing canopy (Fig 7); frass (insect excrement) deposits at the base of the tree; peeling bark; tunnels made by large larvae; and epicormic shoots (shoots that grow from dormant buds beneath the bark, trunk, stem, or branch of a plant). Larval tunneling may weaken the trees, so that branches are more likely to break off during high wind. A VLB infestation can impact fruit yield, tree longevity, and wood marketability.

Fig 6. Adult exit holes are round about about ⅜ inch in diameter.

Fig 7. Heavy damage from VLB can cause thinning, wilting, or yellowing canopy.

LIFE HISTORY

From May to August, adults emerge from trees through ⅜ inch round diameter exit holes, which they create by chewing through the wood (Figs 6 and 8). Adults fly at night; peak flight and mating occur from June to early August. Females lay their eggs on the trunks and large branches of healthy, stressed, dying, and cut trees. Larvae hatch and burrow into the tree bark forming galleries (tunnels) in the cambium, sapwood, and heartwood, increasing in size as they mature. Galleries range in size from 2 to 6 inches wide. Larvae are the overwintering and damaging life stage; they can take 2 or more years to complete their development. Pupation

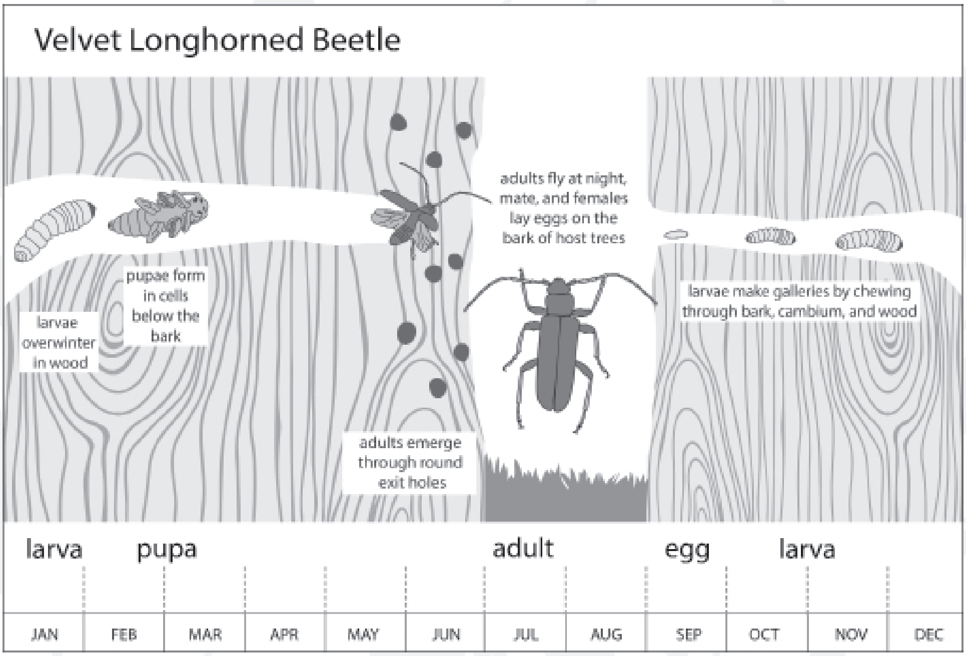

Fig 8. Larvae are the overwintering life stage, and remain in host trees for 2 or more years to complete their development.

occurs in the late winter to spring with a final molt to the adult stage in spring to summer.

MONITORING

The best time of year to monitor for VLB is during peak flight from late June to early August. In Utah, high numbers of VLB have been detected in riparian habitats near golf courses and near cull piles of discarded plant materials in commercial fruit production areas. Monitoring in Utah has been successful with Lindgren funnel or cross vane panel traps baited with an ethanol lure. In addition, Fluon® or Teflon™ should be applied to the surfaces of panel traps to prevent the beetles from escaping the trap. An insecticide vapor strip or ethylene (toxic to mammals) or propylene (nontoxic) glycol should be used in combination with traps to kill trapped insects. Other monitoring methods include visual inspection for adult exit holes and tree injury symptoms (as described previously), and black light and (infrared light) trapping (using either commercially or homemade manufactured black light traps).

Fig 9. Cross vane panel traps are used for monitoring VLB.

MANAGEMENT

VLB is one of many pests that can be transported to new areas on firewood; therefore, be sure to collect or buy firewood within 25 to 50 miles of where you will be using it to prevent inadvertently moving VLB to non-infested areas. Prevention is a key component in managing VLB. Early detection and proper identification can be accomplished through the monitoring methods described above, and will greatly increase the success of VLB prevention. Unfortunately, VLB can be difficult to control because most of its life cycle is spent within the host tree, where it is protected from foliar insecticides and natural enemies.

Biological Control: Natural enemies of longhorned beetles in the U.S. include predators, parasitoids, and pathogens. Predators include flat bark beetles, cylindrical bark beetles, clerid beetles, click beetles, robber flies, assassin and ambush bugs, thrips, carpenter ants, birds, lizards, spiders, scorpions, toads, and small mammals. Parasitoids include braconid, ichneumonid, and chalcid wasps; and tachinid and sarcophagid flies. Nematodes and fungi have been observed as pathogens of longhorned beetle larvae (Smith 1999).

REFERENCES AND FURTHER READING

Cannon, C., D.G. Alston, L.R. Spears, C. Nischwitz, and C. Burfitt. 2016. Invasive fruit pest guide for Utah: insect and disease identification, monitoring, and management. Utah State University Extension and Utah Plant Pest

Diagnostic Laboratory.

Grebennikov, V.V., B.D. Gill, and R. Vigneault. 2010. *Trichoferus campestris* (Faldermann) (Coleoptera: Cerambycidae), An Asian wood-boring beetle recorded in North America. The Coleopterists Bulletin 64: 13-20.

Rodman, T.M., L.R. Spears, D.G. Alston, C. Cannon, K. Watson, and J. Caputo. 2019. Velvet longhorned beetle, *Trichoferus campestris* (Faldermann). Fact Sheet ENT-208-19-PR. Utah State University Extension and Utah Plant Pest Diagnostic Laboratory.

Rose, R., J. Ryan, D. Lance, P. Baldauf, J. Gittleman, C. McFarland, J. Burch, P. Douglass, D. Hoffman, and R. Santos. 2014. Asian longhorned beetle response guidelines. USDA APHIS PPQ, Asian Longhorned Beetle Eradication Program.

Smith, M.T. 1999. The potential for biological control of Asian longhorned beetle in the U.S. Midwest Biological Control News 6: 1-7.

USDA APHIS PPQ. N.D. *Trichoferus campestris* (Faldermann). Exotic Wood Borer / Bark Beetle Survey Reference. CPHST Pest Datasheet.

Watson, K., C.A. Pratt, and J. Caputo. 2015. Total records of velvet longhorned beetle *Trichoferus campestris* Faldermann (Coleoptera, Cerambycidae) from Utah. Utah Department of Agriculture and Food, Plant Industry and Conservation Division.

PHOTO CREDITS

Fig 1. Boris Loboda, http://ukrbin.com/show_image.php?imageid=28517

Fig 2. Hanna Royals, USDA APHIS PPQ CPHST ITP, Bugwood.org

Fig 3. Steven Valley, Oregon Department of Agriculture, Bugwood.org

Figs 4-7. UDAF Entomology Staff Members

Fig 8. Cami Cannon, Utah State University

Fig 9. USDA, National Plant Board

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