Agrilus biguttatus

Scientific Name
Agrilus biguttatus (Fabricius)

Synonyms:
Buprestis biguttatus (=*biguttata*), Fabricius, 1777
Agrilus pannonicus Piller & Mitterpacher, 1783
Agrilus subfasciatus Ménétriés, 1832
Agrilus morosus Gory & Laporte, 1837

Figure 1. *Agrilus biguttatus* adult (Milan Zubrik, Forest Research Institute – Slovakia, bugwood.org)

Common Name(s)
Oak splendor beetle, two-spotted wood borer

Type of Pest
Bark beetle

Taxonomic Position
Class: Insecta, **Order:** Coleoptera, **Family:** Buprestidae

Reason for Inclusion
CAPS Target: AHP Prioritized Pest List – 2006 to 2012

Pest Description
Eggs: No description available.

Larvae: Larvae are cream-colored and legless with a relatively long and flat body (Moraal and Hilszczanski, 2000a). The pronotum is slightly wider than the rest of the body while the tail segment has two small black-brown horns on the end (Moraal and Hilszczanski, 2000a). The mean length of larvae from the current year is approximately 10 mm (approx. $^{3}/_{8}$ in), while older larvae (~1 ½ year) range from 25 to 43mm (approx. 1 to 1 $^{11}/_{16}$ in) (Moraal and Hilszczanski, 2000a).

Figure 2. Final stage larva of *Agrilus biguttatus* (Louis-Michel Nageleisen, Département de la Santé des Forêts, bugwood.org).

Pupae: No description available. Pupation occurs in individual cells from 10.4 to 14.8 by 3.0 to 4.5 mm (approx. $^{7}/_{16}$ by $^{1}/_{8}$ to $^{3}/_{16}$ in) in the outer bark (Vansteenkiste et al., 2004; Moraal and Hilszczanski, 2000b).

Adults: *Adult females:* "Length 10 ½ mm [approx. $^{7}/_{16}$ in]; breadth (across the shoulders of the elytra) 2 ½ mm [approx. $^{1}/_{8}$ in]... The front of the head flattened and with a central depression. ... The elytra long and narrow, at the base slightly broader than the thorax, and the sides sharply convergent from the middle to the apices; flattened over the disc, convex along the sides, and with two incurved basal hollows between the prominent long shoulders and the flattened scutellar area; the elytral surface more shagreened than rugulose in appearance, and with two small white-haired spots adsutural and towards the apex. Abdomen with six white-haired spots ventrally. Coloration bright metallic bronze green with localised suffusion of violet. The under-surface finely and more or less closely punctate with considerable confluence of the punctures on the thoracic parts."

Figure 3. Pupae of *Agrilus biguttatus* (Louis-Michel Nageleisen, Département de la Santé des Forêts, bugwood.org).

Adult males:
"...length is 11 ½ mm [7/16 in]. The anterior tibiae have a small sharp hook at the distal end on the inner side. The suffusion of violet on the elytra is more extensive than in the female metatype" (Staig, 1940).

For adult descriptions, see Staig (1940).

Figure 4. Left: Dorsal view of *Agrilus biguttatus*, Right: Side view of *Agrilus biguttatus* (Natasha Wright, FLDACS, bugwood.org).

Biology and Ecology

From May to July, females deposit small clusters of eggs (5 to 6) into bark crevices (Moraal and Hilszczanski, 2000b). Eggs take 1 to 2 weeks to hatch (Vansteenkiste et al., 2005).

After hatching, larvae burrow in the bark and begin feeding on inner bark, the cambial layer, and outer sapwood (Vansteenkiste et al., 2004). Galleries are zigzagged (Moraal and Hilszczanski, 2000a) and can intercross and measure from 0.5 to 5 mm (approx. $^{1}/_{16}$ to $^{3}/_{16}$ in) wide and up to 1.5 meters (4.9 ft) long (Vansteenkiste et al., 2004).

Younger larvae make longitudinal galleries while the older larvae produce irregular twisting, transverse galleries (which may lead to girdling of the tree) (Moraal and Hilszczanski, 2000b). Successful colonization depends on larvae density and rate of callus production. In northern Germany, hibernation occurs in the larval state and can repeat for up to two winters (Moraal and Hilszczanski, 2000a; Vansteenkiste et al., 2004). Larvae go through five instars to complete development (Moraal and Hilszczanski, 2000a; 2000b).

After 2 to 3 calendar years, pupation takes place from April to May in individual cells in the outer bark (Vansteenkiste et al., 2004; Moraal and Hilszczanski, 2000b).

Adults stay under the bark for approximately two weeks before emerging (Ciesla, 2003). In Belgium, emergence occurs from May to July through characteristic D-shaped exit holes (Vansteenkiste et al., 2004). The exit holes measure from 2.5 to 4 mm (approx. $^{1}/_{8}$ to $^{3}/_{16}$ in) by 2 to 3 mm (approx. $^{1}/_{16}$ to $^{1}/_{8}$ in) (Moraal and Hilszczanski, 2000b).

Many studies have found that *Agrilus biguttatus* will attack stressed or declining hosts (Moraal and Hilszczanski, 2000a; 2000b). Beetles prefer larger trees with a diameter at breast height (DBH) of 30 to 40 cm (approx. 11 $^{13}/_{16}$ to 15 $^{11}/_{16}$ in) that are over 80 years old and with thick bark (Moraal and Hilszczanski, 2000b). Adults feed on both the crowns of oaks and the parenchymal tissue of leaves (Moraal and Hilszczanski, 2000a). Attacks begin in south-facing, lower stem parts moving vertically in both directions (Vansteenkiste et al., 2004).

Figure 5. *Agrilus biguttatus* gallery in shape of zig-zag (final stage) and cambium necrosis (Louis-Michel Nageleisen, Département de la Santé des Forêts, bugwood.org).

Damage

Galleries produced by older larvae of *A. biguttatus* can lead to partial or complete girdling of the tree while larval activity can cause twig and branch dieback, thin crowns and epicormic branching (Moraal and Hilszczanski, 2000a). Other symptoms include frass-filled galleries in the cambium layer and D-shaped adult exit holes (Ciesla, 2003a; Moraal and Hilszczanski, 2000b; 2000a). Death of the tree occurs when attacked over several successive years or when infestations are heavy (Moraal and Hilszczanski, 2000b; 2000a).

Pest Importance

Agrilus biguttatus is a significant pest of oak forests in eastern and western Europe, Russian Asia, northern Africa, and the Middle East (Jacquiot, 1976; Gutowski and Lugowoj, 2000; Moraal and Hilszczanski, 2000b; 2000a; Hilszczanski and Kolk, 2001; Vansteenkiste et al., 2004). Over 20,000 ha (nearly 50,000 acres) of oak mortality has been attributed to this insect in the Voronej region of Russia alone. The insect also caused considerable damage in several regions of France between 1945 and 1949 following notably hot and dry summers (Jacquiot, 1976).

Figure 6. *Agrilus biguttatus* galleries in the shape of stairs (first stage) (Louis-Michel Nageleisen, Département de la Santé des Forêts, bugwood.org).

In Europe, *A. biguttatus* is an environmental concern (Key, 1991). In England, the insect will attack ancient oaks that are dominant features of landscapes. Losses of broad-leaved forest stemming from "coniferisation" and clear cutting infested trees are feared (Key, 1991). Dead trees are an integral part of an ecosystem, and removal of dead or dying trees to manage *A. biguttatus* would alter the function of the system.

Figure 7. D-shaped exit holes from *A. biguttatus* (C. Bystrowski).

The potential economic impact of *A. biguttatus* in the United States is difficult to predict because this species typically occurs in mixed populations with other pests of oak within its native range. The severity of damage varies depending on host availability, stand composition, and forest health, among other factors (Ciesla, 2003; Vansteenkiste et al., 2004). Establishment and spread by this insect could jeopardize valuable oak forests, domestic and foreign forest product industries, and the nursery trade. Significant economic losses may result from infestation of live tree hosts or feeding damage that may impact quality of timber, pulp and other forest products (Ciesla, 2003). Phloem feeding by this destructive insect can kill a tree or predispose it to further attack by secondary pests (Hartmann and Blank, 1992; Blank, 1997; Moraal and Hilszczanski, 2000a; 2000b; Ciesla, 2003; Vansteenkiste et al., 2004).

Control measures could be costly and ineffective given the elusive nature of *A. biguttatus*. Feeding larvae are generally well protected while tunneling inside the host (Ciesla, 2003; Vansteenkiste et al., 2004).

Concerns surrounding *A. biguttatus* are heightened by the invasion of a closely related species, emerald ash borer (*Agrilus planipennis*), that has killed thousands of ash trees in Michigan (Haack et al., 2002).

Risks associated with *A. biguttatus* have been evaluated previously. In the Exotic Forest Pest Information System (EXFOR), Ciesla (2003) considered the overall risk posed by the insect to be very high, but uncertainty in the rating was also high. The potential for establishment, spread, economic damage, and environmental damage were considered high (Ciesla, 2003).

Known Hosts

Major hosts

Quercus spp. (oak), *Quercus cerris* (European turkey oak), *Quercus ilex* (holly oak), *Quercus petraea* (durmast oak), *Quercus pubescens* (downy oak), *Quercus robur* (English oak), and *Quercus suber* (cork oak).

Other hosts

Castanea sativa (European chestnut), *Cytisus scoparius* (scotchbroom), *Fagus* spp. (beech) *Fagus sylvatica* (European beech), *Quercus pyrenaica* (Pyrenean oak), and *Quercus rubra* (northern red oak).

Infestations of *Populus* sp. are dubious and possibly based on a misidentification of *A. ater*.

(Jacquiot, 1976; Foster, 1987; Key, 1991; Hackett, 1995; Campobasso et al., 1999; Moraal and Hilszczanski, 2000a; 2000b; Ciesla, 2003; Vansteenkiste et al., 2004)

Pathogens or Associated Organisms Vectored

Agrilus biguttatus is not a known vector; however, it is considered to be a significant component in oak dieback. In Europe, “the insect may kill trees which are weakened by repeated insect defoliation, water stress and later winter frosts, before they are able to recover from temporary drawbacks for tree vitality…the larvae excavate galleries under the bark of weakened trees, which are killed through girdling” (Moraal and Hilszczanksi, 2000b). Damage due to this species may lead to invasion by secondary pests. *Armillaria* spp. may occur after trees are infested (Moraal and Hilszczanski, 2000a; 2000b).

Known Distribution

Agrilus biguttatus is found throughout much of eastern and western Europe, Russian Asia, northern Africa, and the Middle East.

Africa: Algeria and Morocco; **Asia:** Azerbaijan, Iran, Russia, and Turkey; **Europe:** Albania, Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, France, Germany, Greece, Hungary, Italy, Macedonia, Moldova, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, and the United Kingdom (Kuban et al., 2004; USDA-APHIS, 2010).

Pathway

Although this species has not been intercepted at U.S. ports of entry, the genus *Agrilus* has. *Agrilus* spp. interceptions at U.S. ports of entry have occurred 59 times; 29 times in dunnage and 4 times in crating (AQAS, 2004, queried September 4, 2014). This suggests that this genus most likely moves via international trade in wood products.

There is likely a strong pathway for *Agrilus* sp. into the United States. As of 2003, at least six exotic *Agrilus* sp. have become established in the United States (Ciesla, 2003).

If introduced into the United States, this species could move through human-mediated means, similar to *A. planipennis* (emerald ash borer). Adults of this species are also strong fliers and can travel several km on warm sunny days (Ciesla, 2003).

Potential Distribution within the United States

In Europe and Asia, *A. biguttatus* generally occurs in climates ranging from warm and dry to more temperate with adequate rainfall to support forest trees. The currently reported distribution of *A. biguttatus* suggests that the pest may be most closely associated with biomes characterized as: desert and xeric shrublands; Mediterranean scrub; temperate broadleaf and mixed forests; and temperate coniferous forests.

Survey

CAPS-Approved Method*:

There are no known attractants for *A. biguttatus*. There are three CAPS-approved survey methods:

1) Visual survey. The survey protocol outlined below must be followed in order to report negative data;
2) Visual + purple prism traps (no lure); or
3) *Cerceris* wasps.

1. Visual Survey

It is important to remember that this protocol is to be considered a minimal guide to conducting the survey. States may add additional efforts, risks, survey sites, etc. to provide more reliable results for reporting negative data specific to their State or area.

1.1 Sample Size

In order to maintain consistency when reporting negative data, a minimum of 10 sites should be surveyed per state. A minimum of 10 trees per site should be inspected.

1.2 Survey Design

At each site, two types of visual monitoring should be conducted. First, upon arriving at the site, a general stand-level overview should be conducted. This overview will determine if there are areas that stand out and require a more detailed inspection. These areas should be inspected first and if there are no areas as such, then random areas should be chosen for inspection.

A minimum of 10 trees will be required to be inspected per site. Select trees that are most likely to be attractive to *A. biguttatus*. For instance, *A. biguttatus* prefers larger trees with a diameter at breast height (DBH) of 30 to 40 cm (approx. 12 to 16 in), that are over 30 years old, and with thick bark. Select the oldest oak trees present in a stand—especially those oaks which have thick, corky bark (personal communication Zablotny, 2012). *Agrilus biguttatus* tends to frequent the trunk and large branches near the base of the canopy (personal communication Zablotny, 2012). Attacks begin in south-facing, lower stem parts and move vertically in both directions (Vansteenkiste et al., 2004).

Each site should be monitored at least one time during the season, generally May through August. The below survey methodology should be performed during the visual inspection.

1.3 Visual Inspection (What to do to each tree to consider it "surveyed"):

1. Stand level: Look for host trees that have the following signs of damage/ infestation:
   a. Thin crowns
   b. Epicormic shoots and branching
   c. Limb and tree mortality
   d. Twig and branch dieback
   e. Bark splits
   f. Excessive woodpecker damage
   g. Weeping sap from the trunk

2. Individual tree level: If any trees are found with the signs mentioned above, inspect the individual trees for further signs of damage. If no trees are found to have the above signs of damage, then survey 10 host trees at random. Look for the following signs of damage and insect life stages:
   a. Superficial inspection:
      - D-shaped adult exit holes from 3 to 4 mm ($^1/_8$ to $^3/_{16}$ in) in width.
      - Note: there are other native *Agrilus* species which infest oak and may also leave D-shaped exit holes, such as *Agrilus bilineatus* (Twolined chestnut borer) (personal communication Zablotny, 2012). The D-shaped exit holes of *A. bilineatus* are slightly larger than those of *A. biguttatus,* 5 mm ($^1/_5$ inch) for *Agrilus bilineatus,* compared to 3 to 4 mm ($^1/_8$ to $^3/_{16}$ in) for *A. biguttatus* (Haack and Acciavatti, 1992). The size of *A. biguttatus* exit holes is similar to those of *A. planipennis* (Emerald ash borer) in ash.

- Sweep foliage of smaller oaks in sunny areas around the trap and/or along the edge of tree lines. If no smaller oaks are available, sweep nearby foliage. Also, any recently downed oak trees would be ideal for inspection and/or sweeping. A minimum of five areas at each site should be swept. In each of the five areas, perform 10 sweeps with the net.

b. Under the bark (ONLY if D-shaped exit holes are present):
Note: Remove bark for thorough inspection ONLY if you observe other signs of infestation AND receive permission from the land owners.
   - Larvae under the bark.
   - Longitudinal galleries with some stair-stepping (made by younger larvae).
   - Irregular twisting, transverse galleries that measure from 0.5 to 5 mm ($^1/_{16}$ to $^3/_{16}$ in) wide and up to 1.5 meters (4.9 ft) long.
   - Pupae in the outer bark.
   - Frass-filled, transverse, winding larval galleries in the cambium layer.

1.4 Insect Specimen Collection

Collect any buprestid larvae, pupae, or adults that look similar to the target species, especially if D-shaped exit holes are present. Submit samples according to **Appendix B: How to Submit Bark Beetle Specimens for Identification from Wet Traps.**

2. Visual + Purple Prism Traps

Traps are an optional survey method that may be used in addition to visual surveys. Traps may be used to strengthen visual surveys or to rule out native *Agrilus s*pp. if there are signs of damage without insect life stages present. To use this method, the visual survey protocol should be followed in addition to placing purple prism traps. At this time, do not report negative data from purple prism traps without performing a visual survey. Trap trials are currently being conducted in the pest's native country of origin.

IPHIS Survey Supply Ordering System Product Name:

1) Prism Trap – Purple

This is also the recommended survey method for *Agrilus auroguttaus;* therefore, data can be reported for two targets from one survey method.

Method notes: when reporting data into NAPIS, use the NAPIS code 00581 - Trap;Prism;Purple (No Lure). **By using this code for *A. biguttatus,* you are stating that you have conducted both a visual survey (as described above) and have used a purple prism trap.**

Trap spacing: When trapping for exotic wood borers and bark beetles, separate traps with different lure combinations by at least 30 meters (98 feet).

Survey Site Selection:
Site selection should be identified by each respective State based on high risk factors. High risk sites to consider include: transit sites, ports, rail yards, destination sites,

warehouses, nurseries, pallet recyclers, landfills, green waste sites, urban parks, forests, cemeteries, etc.

Trap Placement:
Purple prism traps without a lure, should be placed within host trees (oak trees). Traps should be placed at each site as close as logistically possible to areas of risk such as dunnage piles, SWPM piles, and/or storage areas. Traps should be checked every two weeks.

Time of year to survey:
May through August.

3. *Cerceris* Wasps

Starting in the 2012 survey season, *Cerceris* wasps are an approved method for *A. biguttatus.* The solitary ground-nesting wasp, *Cerceris*, collects buprestid beetles from the nearby environment. By collecting the beetles from *Cerceris*, surveyors can detect the presence of *Agrilus* spp. in the nearby area. See the ***Cerceris* Wasps Survey Protocol** for further information.

Method notes: For the 2014 survey season and beyond, for *Cerceris* surveys, you will now need to ensure that the appropriate host species (Ash for *Agrilus planipennis* and Oak for the other three *Agrilus* targets) is within a 200 meter (650 foot) radius of the sampling site.

*For the most up-to-date methods for survey and identification, see Approved Methods on the CAPS Resource and Collaboration Site, at https://caps.ceris.purdue.edu/approved-methods.

Key Diagnostics/Identification

CAPS-Approved Method*:
Morphological. Pupae and adults may be identified by a taxonomist.

*For the most up-to-date methods for survey and identification, see Approved Methods on the CAPS Resource and Collaboration Site, at https://caps.ceris.purdue.edu/approved-methods.

Easily Confused Species

Many *Agrilus* species are similar in morphology and difficult to differentiate (Reißmann, 2010). However, *Agrilus biguttatus* is easier to tell apart due to the pubescent white spots found on the elytra; these spots are only found on two other exotic species: *Agrilus ater* and *Agrilus guerini* (Reißmann, 2010). Other species may be pubescent, but it does not form spots like the previous three species, instead the pubescence extends over a larger area, is sparse and can look more grey than white (Reißmann, 2010).

Agrilus biguttatus can be differentiated from both *A. ater* and *A. guerini* by looking at the tips of the elytra. In *A. guerini*, the tips of the elytra are long, divergent and sharp; in *A. ater*, the tips are divergent and sharp, but also short; in *A. biguttatus*, the tips are rounded (Reißmann, 2010). Both *A. ater* and *A. guerini* have three white scaly patches on their elytra while *A. biguttatus* only has one white scaly patch closer to the anterior part of the elytra (Reißmann, 2010).

A. biguttatus may be mistaken with the following species present in the United States: *Agrilus planipennis* (Emerald ash borer), *Agrilus cuprescens*, *Agrilus cyanescens*, *Agrilus derasofasciatus*, *Agrilus hypericici*, *Agrilus obsoletoguttatus*, *Agrilus pilosovittatus*, *and Agrilus sinuatus*. There are 171 *Agrilus* species documented in America north of Mexico.

This pest could be confused with other indigenous and exotic buprestid species in the United States (Ciesla, 2003): *A. planipennis*, *A. cuprescens* (=*aurichalceus*), *A. cyanescens*, *A. derasofasciatus*, *A. hyperici*, *A. pilosovittatus*, and *A. sinuatus* (Haack et al., 2002). A dubious host record in the literature reflects the potential difficulty with identification. According to Hellrigl (1978) *A. ater* may have been misidentified and mistaken for *A. biguttatus* on *Populus* sp. (see 'Known Hosts'). *Agrilus biguttatus* has not been reported on *Populus* elsewhere. Conspicuous life stages (pupa and adult) may be positively identified by close examination of morphological characters by a well-trained taxonomist.

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Revisions

September 2014

1) Updated datasheet format; merged Oak and EWB/BB datasheet.
2) Updated **Pest Description** section.
3) Updated **Pathogens or Associated Organisms Vectored** section.
4) Updated **Known Distribution** section.
5) Updated **Pathway** section.

6) Updated **Survey** section.