# EPPO Datasheet: *Agrilus anxius*

Last updated: 2020-07-03

## IDENTITY

**Preferred name:** *Agrilus anxius*
**Authority:** Gory
**Taxonomic position:** Animalia: Arthropoda: Hexapoda: Insecta: Coleoptera: Buprestidae
**Other scientific names:** *Agrilus gravis* LeConte, *Agrilus torpidus* LeConte
**Common names:** bronze birch borer
view more common names online...
**EPPO Categorization:** A1 list
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**EU Categorization:** A1 Quarantine pest (Annex II A)
**EPPO Code:** AGRLAX

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### Notes on taxonomy and nomenclature

The original 1841 description of *A. anxius* by H. L. Gory included a second species that was first described by Barter and Brown (1949) as *A. liragus* Barter & Brown, and later as the subspecies *A. granulatus liragus* Barter & Brown by Carlson and Knight (1969). The larval host plants of *A. liragus* (or *A. granulatus liragus*) include several species of *Populus,* whereas *A. anxius* is a specialist on *Betula*. Therefore, care must be taken when reading the literature on *A. anxius* prior to 1950 because it may include data for both *Agrilus* species. Although, if the host plant is given, readers can ascertain which *Agrilus* species is being discussed.

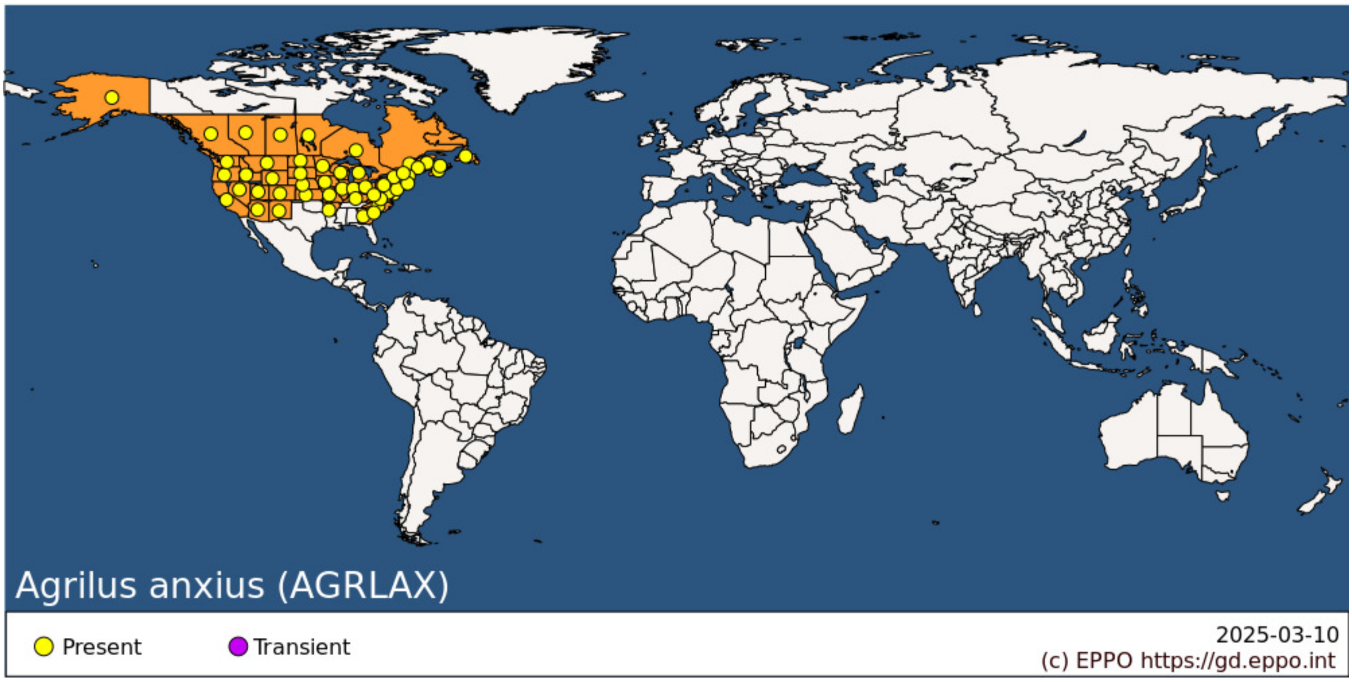
## HOSTS

The larval host plants of *A. anxius* are trees in the genus *Betula* (birch). In North America, primary hosts are *B. alleghaniensis, B. lenta, B. lutea, B. occidentalis, B. papyrifera,* and *B. populifolia* (Balch & Prebble, 1940; Ball & Simmons, 1980; Santamour, 1999; Nielsen *et al.*, 2011; Muilenburg & Herms, 2012). When planted in North America, several European and Asian birch species are readily infested and killed by *A. anxius* , including *B. maximowicziana, B. pendula, B. platyphylla* and *B. pubescens*, (Ball & Simmons, 1980; Miller *et al.*, 1991; Nielsen *et al.*, 2011; Muilenburg & Herms, 2012).

**Host list:** *Betula albosinensis, Betula alleghaniensis, Betula dahurica, Betula ermanii, Betula lenta, Betula maximowicziana, Betula nigra, Betula occidentalis, Betula papyrifera, Betula pendula, Betula platyphylla var. japonica, Betula platyphylla var. szechuanica, Betula platyphylla, Betula populifolia, Betula pubescens, Betula pumila, Betula utilis subsp. jacquemontii, Betula*

## GEOGRAPHICAL DISTRIBUTION

*Agrilus anxius* is native to much of the boreal and north temperate regions of North America where birch occurs (Bright, 1987; Muilenburg & Herms, 2012). Its current range has expanded into the Southern and Western United States as a result of widespread planting of birch species as ornamental trees (Duckles & Svihra, 1995; Muilenburg & Herms, 2012).




**North America:** Canada (Alberta, British Columbia, Manitoba, New Brunswick, Newfoundland, Nova Scotia, Ontario, Prince Edward Island, Québec, Saskatchewan), United States of America (Alaska, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, District of Columbia, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin, Wyoming)

## BIOLOGY

*A. anxius* usually completes its life cycle in one year but occasionally two years are required, depending on latitude, climatic conditions, and host condition (Balch & Prebble, 1940; Anderson, 1944; Nash *et al.*, 1951). In Ohio and Michigan, adult emergence usually begins at about 278 cumulative degree days (DD), using a base temperature of 10°C and a starting date of January 1 (Muilenburg & Herms, 2012). Adult emergence generally occurs over 10–12 weeks, with peak emergence occurring about 2–4 weeks after first emergence (Barter, 1957; Akers & Nielsen, 1984; Loerch & Cameron, 1984). Adult emergence typically begins in May in Kentucky (Mussey & Potter, 1997), May to June in Ohio and Michigan (Akers & Nielsen, 1984; Muilenburg & Herms, 2012), and late June to early July in New Brunswick, Canada (Balch & Prebble, 1940; Barter, 1957). Individual adults live for 2–5 weeks (Akers & Nielsen, 1990), which is typical of many *Agrilus* species (Chamorro *et al.*, 2015).

*A. anxius* adults consume foliage throughout their lifetime (Barter, 1957; Akers & Nielsen, 1990), which is common among *Agrilus* species (Chamorro et al., 2015). Adults typically feed for about one week to become sexually mature (Rutledge & Keena, 2019). Adults usually consume *Betula* and *Populus* foliage, but can survive and reproduce when fed foliage from other tree species under experimental conditions (Barter, 1957; Akers & Nielsen, 1990). Adults feed mostly along the leaf margin and cause negligible damage to trees (Barter, 1957; Muilenburg & Herms, 2012). No pheromone has yet been identified for *A. anxius* (Silk *et al.*, 2020). Mate location is primarily visual (Rutledge & Keena, 2019), with mating occurring on the trunk, branches, and foliage of birch trees. Adults typically pair for 7-11 minutes (Barter, 1957; Rutledge & Keena, 2012).

Females lay eggs singly or in clusters of up to 16 eggs, averaging 7 (Barter, 1957). Eggs are laid in bark crevices, cracks, and under loose layers of outer bark (Barter, 1957; Loerch & Cameron, 1984). Under laboratory conditions (approximately 25°C, 65% RH, and 16:8 L:D h photoperiod), females lived an average of 30 days and laid 55 eggs each (Rutledge & Keena, 2012). Eggs hatch in about 2 weeks (Barter, 1957).

Newly hatched larvae tunnel directly through the outer bark into the underlying inner bark (phloem) tissue. There are

4 larval instars (Loerch & Cameron, 1983a). Larvae construct galleries in the cambial region at the phloem-xylem interface, with total average gallery length varying between 41-85 cm based on host condition and birch species (Anderson, 1944). Larvae tunnel in the outer sapwood for short distances to molt (Barter, 1957). Larvae use their terminal processes (urogomphi) to pack frass tightly within their galleries (Carlson & Knight, 1969). Larval galleries disrupt downward transport in phloem tissue and upward transport in the outer ring of xylem (sapwood), which at high densities and usually over multiple years can girdle and kill trees (Barter, 1957). All larval instars can overwinter (Barter, 1957). However, only pre-pupal larvae (4th instars that have completed feeding and constructed pupal cells by autumn) that overwinter and experience freezing temperatures will pupate the following spring (Barter, 1957). Upon completion of larval development, 4th instars construct pupal cells in the outer sapwood, generally during late summer or autumn (Barter, 1957; Loerch & Cameron, 1984). Larvae that do not become final instars by autumn will overwinter in the cambial region, complete larval development the following summer, and then overwinter a second time before pupating.

Larvae construct individual pupal cells that are about half their body length and pass the winter inside in a U- or J-shaped position (Carlson & Knight, 1969). Pupation occurs in May-June in Michigan (Carlson & Knight, 1969) and (Pennsylvania (Loerch & Cameron, 1984).

Adults chew D-shaped exit holes as they emerge that are 3–5 mm wide (Muilenburg & Herms, 2012). Adult emergence usually occurs from May to the end of July (Barter, 1957; Akers & Nielsen, 1984). Newly emerged adults have nearly a 1:1 sex ratio (Barter, 1957).

*A. anxius* colonizes most *Betula* species and cultivars, although host resistance varies with *B. nigra* appearing to be nearly immune to colonization (Nielsen *et al.*, 2011). *A. anxius* is typically a secondary invader of North American birch species (e.g. *B. allegheniensis, B. lutea, B. papyrifera, B. populifolia* ) that have been stressed by drought, late spring frosts, old age, insect defoliation, soil compaction, and stem or root injury (Balch & Prebble, 1944; Anderson, 1944; Barter, 1957; Muilenburg & Herms, 2012; Haack & Petrice, 2019). European and Asian birch species that have been studied are much more susceptible than North American species to *A. anxius* (Miller *et al.*, 1991; Nielsen *et al.*, 2011). For example, in a 20-year common garden study in Ohio, USA, with a high number of replicates, bronze birch borer infestation caused complete mortality of Eurasian species (*B. maximowicziana, B. pendula, B. platyphylla* var. *szechuanica, B. pubescens*), but the majority of individuals (>75%) of North American species (*B. nigra, B. papyrifera, B. populifolia*) were still alive at the end of the study (Nielsen *et al.*, 2011). European and Asian birch species are highly susceptible to *A. anxius* colonization even when not stressed (Muilenburg & Herms, 2012). *A. anxius* infests birch trees of all sizes, with larvae being found in branches as small as 1 cm in diameter (Muilenburg & Herms, 2012).

In North America, *A. anxius* populations generally exist at endemic levels (Balch & Prebble, 1940). However, periodic outbreaks have been reported during the past century, usually being associated with widespread drought and defoliation (Balch & Prebble, 1940; Nash *et al.*, 1951; Houston, 1987; Muilenburg & Herms, 2012; Haack & Petrice, 2019).

## DETECTION AND IDENTIFICATION

### Signs and symptoms

Trees that have been infested or currently are infested with *A. anxius* will have one or more of the following signs or symptoms: D-shaped holes on the bark surface created by emerging adults, meandering or zig-zag larval galleries filled with frass at the phloem–xylem interface, or serpentine swellings or ridges visible through the outer bark where wound periderm (callus tissue) has grown over larval galleries (Anderson, 1944; Barter, 1957). Trees infested with *A. anxius* exhibit branch dieback, especially after multiple years of infestation, usually beginning with the upper crown branches (Ball & Simmons, 1980). Branch dieback is usually preceded by yellowing and thinning of the foliage.

### Trapping

When developing survey protocols for *A. anxius* it is important to recall that *A. anxius* infests North American birch species when they are stressed, whereas it will infest both stressed and healthy Eurasian birch. Therefore, girdling individual North American birch trees usually increases the tree's attractiveness to *A. anxius* adults (Rutledge, 2020; Silk *et al.*, 2020). The specific host compounds, or combination of compounds, that *A. anxius* adults use to locate stressed trees is still unknown (Silk *et al.*, 2020). *A. anxius* adults have been collected on both green and purple traps (Petrice *et al*., 2013; Rutledge, 2020; Silk *et al.*, 2020). In addition, ground-nesting solitary wasps in the genus *Cerceris*, which specialize in capturing buprestid adults, can be used as biosurveillance tools for many buprestids, including *A. anxius* (Kurczewski & Miller, 1984; Swink *et al*., 2013).

## Morphology

### *Eggs*

The eggs of *A. anxius* are creamy white when first laid, becoming more yellow as they mature (Barter, 1957). Eggs appear oval in shape, but flattened, and are 1.3 to 1.5 mm long and 0.8 to 1.0 mm wide (Barter, 1957; Carlson & Knight. 1969). Females coat the eggs after deposition with a whitish substance that likely helps cement the eggs to the bark and prevent desiccation (Barter, 1957).

### *Larva*

Larvae are creamy white with a brown head and urogomphi. The body is dorsoventrally flattened. The head is small and protracted into the enlarged prothorax. There are 10 abdominal segments, with the last terminating in two sclerotized tooth-like structures that are often called urogomphi, anal forceps, or terminal processes (Carlson & Knight, 1969; Loerch & Cameron, 1983a; Chamorro *et al*., 2015). Such terminal processes are characteristic of all known *Agrilus* larvae (Chamorro *et al*., 2015). *A. anxius* is recognized as having four larval instars (Loerch & Cameron, 1983a), although Barter (1957) reported five instars. Mature last-instar larvae measure 30-40 mm long (Barter, 1957; Carlson & Knight, 1969).

### *Pupa*

Pupation takes place inside the cells that were constructed in the outer sapwood by the mature larvae prior to overwintering. The larva first contracts its body to about half its former length and then molts to the pupal stage (Barter, 1957). Pupae are creamy white at first, but as pupation progress the eyes darken first, then the mouthparts, and lastly the elytra, until the entire pupa becomes bronze to black (Barter, 1957; Carlson & Knight, 1969). These colour changes are very similar to those seen for *A. planipennis* as described in Haack *et al*. (2015).

### *Adult*

Adults are narrow, subcylindrical with coppery-bronze metallic colouration. They are usually 6-11 mm long (Barter, 1957), but can vary between 5–13 mm (Paiero *et al.*, 2012). Males have a ventral groove on the first and second abdominal segments that is absent in females (Barter, 1957). Differences in aedeagus morphology are the most reliable characters to separate adult male *A. anxius* from the morphologically similar *A. liragus* (= *A. granulatus liragus*) (Barter & Brown, 1949; Carlson & Knight, 1969). Additionally, *A. anxius* has 22 chromosomes whereas *A. liragus* has 20 (Barter, 1957).

# PATHWAYS FOR MOVEMENT

There is no information about natural dispersion of *A. anxius* adults by flight. However, under laboratory conditions, the emerald ash borer (*Agrilus planipennis*), which is similar in size to *A. anxius*, can fly on average 1.3 km per day, with some individuals exceeding 7 km per day (Taylor *et al.*, 2010). Most *Agrilus* species, like many other bark- and wood-infesting insects, can be transported in live host plants or wood products such as logs, firewood, solid wood packaging, lumber, bark, and wood chips (Meurisse *et al.*, 2019). For example, during 1985-2000 there were 38 distinct interceptions of *Agrilus* species made at US ports of entry that originated from 11 countries, and of these 28 were from dunnage, 4 from crates, 5 from plants or plant parts, and 1 specimen was found loose in the ship hold (Haack *et al*., 2002; Haack, 2006). Importation of wood chips from North America to Europe is a potential pathway for movement *Agrilus* species and other pests , especially when the chips are relatively large in size, untreated and stored outdoors in close proximity to susceptible host trees (McCullough *et al.*, 2007; Kopinga *et al.*, 2010; Flø *et al.*, 2014).

## PEST SIGNIFICANCE

### Economic impact

In North America, *A. anxius* is considered the most serious pest of birch trees in both forest and amenity plantings (Barter, 1957; Ball & Simmons, 1980). In urban landscapes, *A. anxius* has caused widespread mortality of ornamental and street trees. In the northern hardwood and boreal forests of North America, periodic outbreaks of *A. anxius* have also led to widespread mortality of birch, causing negative impacts on forest tree composition and wildlife (Balch & Prebble, 1944; Nash *et al.*, 1951; Millers *et al.*, 1989; Haack & Petrice, 2019).

*Betula* species occur throughout most of Europe but are most common in the temperate and boreal forests of Northern Europe (Beck *et al.*, 2016). Moreover, birch are the most important commercial broadleaved species in Northern Europe, being used for pulpwood, fuel wood, lumber, plywood, and as amenity trees (Hynynen *et al.*, 2010; Beck *et al.*, 2016).

### Control

Control and detection of this type of wood-boring insect is difficult. There are several insecticides (e.g. azadiractin, bifenthrin, dicrotophos, dimethoate, dinotefuran, emamectin benzoate, imidacloprid, permethrin) that have been shown to control *Agrilus* species to varying degrees (Appleby *et al.*, 1973; Petrice & Haack, 2006; McKenzie *et al.*, 2010; Smitley *et al.*, 2010; McCullough *et al.*, 2011; Herms *et al.*, 2019). They may be used in nurseries and on ornamental birch trees. Depending on the label, they can be applied as soil drenches, soil injections, trunk injections, lower trunk sprays, or cover sprays on the trunk, branches and foliage (Herms *et al.*, 2019). The systemic insecticide emamectin benzoate, which is applied as a trunk injection, has demonstrated 2-year control against both *A. planipennis* larvae and leaf-feeding adults (McCullough *et al*., 2011; Herms *et al*., 2019).

Trees infested with buprestids can be cut down and then chipped or heat-treated to kill larvae and pupae within the host material (McCullough *et al.*, 2007). However, there are uncertainties about the maximum allowable size of wood chips to guarantee complete mortality of any larvae or pupae present (McCullough *et al.*, 2007; Kopinga *et al.*, 2010; Økland *et al.*, 2012). Additionally, the efficacy of heat-treatment in killing *Agrilus* larvae and pupae depends on the chamber temperature, the internal wood temperature, and duration of heat (Myers *et al.*, 2009; Goebel *et al.*, 2010; EPPO, 2020).

Several parasitoids of *A. anxius* have been documented in North America, including egg parasitoids in the families Aphelinidae and Encyrtidae, and larval parasitoids in the families Braconidae, Chalcididae, Eulophidae, Eurytomidae, and Ichneumonidae (Nash *et al.*, 1951; Barter, 1957; Loerch & Cameron, 1983b; Taylor *et al*., 2012; Triapitsyn *et al*., 2015). Although some natural enemies have caused more than 50% mortality to *A. anxius* eggs or larvae (Nash *et al.*, 1951; Barter, 1957; Loerch & Cameron, 1983b), there have been no studies on the role that these parasitoids play in the population dynamics of *A. anxius* in North America. With respect to entomopathogens, Kyei-Poku *et al.* (2011) reported a microsporidian infecting *A. anxius* in Ontario that varied greatly in incidence among populations.

### Phytosanitary risk

The wide geographic distribution of *A. anxius* in North America, from Alaska and Canada to parts of the Southern United States, indicates that *A. anxius* can tolerate a wide range of climatic conditions, and could probably establish throughout much of the EPPO region. Birch species exist throughout much of Europe and Asia, with some *Betula* species, such as *B. pendula* and *B. pubescens*, being very common in Northern Europe (Beck *et al.,* 2016). For example, in Nordic and Baltic countries, birch species comprise from 11–16% and 17–28%, respectively, of the total volume of growing stock (Hynynen *et al.*, 2010). Considering the high susceptibility of European *Betula* species to *A. anxius*, the introduction and establishment of this beetle would be likely to result in widespread mortality of *Betula* trees in forests, nurseries, and cities throughout Eurasia, with a similar effect to that of the introduction of the Asian buprestid *A. planipennis* on ash (*Fraxinus*) trees in North America (Poland & McCullough, 2006). As evidence of the growing concern that *A. anxius* could be introduced to Europe there are several recent efforts in Europe to develop contingency plans and survey methods for *A. anxius* prior to its possible arrival (EFSA *et al.*, 2020; Evans *et al.*, 2020; Petter *et al.*, 2020).

## PHYTOSANITARY MEASURES

Suggested phytosanitary measures are specified in the PRA performed by EPPO (EPPO, 2011); they are as follows. Plants for planting (except seeds) of *Betula* should originate from countries found free from the pest or be of small diameter (<2 cm for plants with stem, <1 cm for scions). Alternatively, they may be grown under insect-proof conditions. Wood chips should originate from countries found free from the pest or undergo heat treatment or fumigation. *Betula* wood with or without bark and furniture and other objects made of untreated birch wood should originate from countries found free from the pest, or undergo heat treatment or irradiation. Alternatively, outer sapwood should have been removed or wood commodities should be stored in the country of export for an appropriate period (1 year for wood chips, 2 years for wood). Importing during winter and processing some wood commodities (including woodchips) before the next flight period may be authorized under an import permit.

As a general approach, it has also been recommended that when importing plants for planting (except seeds) and wood commodities of *Betula* from countries where *A. anxius* occurs, precautions should have been taken to avoid any infestations while the consignments are transported through possibly infested areas (EPPO, 2017).

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