Anoplophora glabripennis (Motchulsky)

Coleoptera: Cerambycidae

Asian longhorned beetle, ALB

Host(s)	CAPS-Approved Survey Method
This species attacks a wide variety of broadleaf tree species. *Acer* spp. are most commonly attacked in New York (Haack et al., 1997). This revised host list, current to March 2011, is taken from USDA (2011) with some specific species hosts from EPPO (2000) and USDA (2010). **Preferred hosts in the United States:** *Acer* spp. (Maple), *Acer negundo* (Boxelder), *Acer platanoides* (Norway maple), *Acer pseudoplatanus* (Sycamore maple), *Acer rubrum* (Red maple), *Acer saccharum* (Sugar maple), *Acer saccharinum* (Silver maple), *Aesculus* spp. (Buckeye) *Aesculus hippocastanum* (Horse chestnut), *Betula* spp. (Birch), *Salix* spp. (Willow), and *Ulmus* spp. (Elm). **Occasional to rare hosts in the United States:** *Albizia* spp. (Albizia), *Albizia julibrissin* (Silk tree), *Cercidiphyllum* spp. (Katsura tree), *Fraxinus* spp. (Ash) *Fraxinus pennsylvanica* (Green ash), *Platanus* spp. (Sycamore), *Platanus acerifolia* (London plane tree), *Populus* spp. (Poplar), *Sorbus* spp. (Mountain ash), and *Sorbus aucuparia* (European mountain-ash). **Questionable United States records:** *Celtis* spp. (Hackberry), *Celtis occidentalis* (Common hackberry), *Hibiscus* spp. (Rosemallow). *Hibiscus syriacus* (Rose-of-Sharon), *Malus* spp. (Apple),	Visual survey. There are two main methods for surveying for *A. glabripennis*, inspections at the ground level and inspections within the crown of the tree. The latter is considered more effective than ground inspections.

Morus spp. (Mulberry), *Morus alba* (White mulberry), *Prunus* spp. (Plum), *Pyrus* spp. (Pear), *Quercus* spp. (Oak), *Quercus palustris* (Pin oak), *Robinia* spp. (Locust), *Robinia pseudoacacia* (Black locust), *Tilia* spp. (Basswood), and *Tilia cordata* (Little-leaf linden). **No United States record:** *Alnus* spp. (Alder), *Elaeagnus* spp. (Oleaster), *Elaeagnus angustifolia* (Russian olive), *Koelreuteria* spp. (Koelreuteria), *Koelreuteria paniculata* (Goldenrain tree), *Melia* spp. (Melia), and *Melia azedarach* (Chinaberry tree). **U.S. regulated genera:** *Acer* spp. (Maple), *Aesculus* spp. (Horse chestnut), *Albizia* spp. (Mimosa), *Betula* spp. (Birch), *Celtis* spp. (Hackberry), *Cercidiphyllum* spp. (Katsura), *Fraxinus* spp. (Ash), *Koelreuteria* spp. (Golden rain tree), *Platanus* spp. (Sycamore), *Populus* spp. (Poplar), *Salix* spp. (Willow), *Sorbus* spp. (Mountain ash), and *Ulmus* spp. (Elm) In China, *A. glabripennis* is considered a major pest of *Populus* spp. (poplars) (Hsiao, 1982) and their hybrids, including *P. nigra*, *P. deltoids*, *P. canadensis*, and *P. dakhuanensis* (EPPO, 2000). It is also considered a pest of *Salix* spp. (willows) in China as well (*S. babylonica*, *S. matsudana*) (EPPO, 2000).	

Reason for Inclusion in Manual

Anoplophora glabripennis is a PPQ Plant Program pest and is therefore a CAPS target.

Consult the Asian Longhorned Beetle Plant Pest Program website for detailed information regarding biology, survey protocols, and identification for ALB: http://www.aphis.usda.gov/plant_health/plant_pest_info/asian_lhb/index.shtml

Pest Description

Eggs:

"About 5–7 mm [approx. $^{3}/_{16}$ to $^{1}/_{4}$ in], off-white, oblong. The ends of the eggs are slightly concave (Peng & Liu, 1992). Just before hatching, eggs turn yellowish-brown" (EPPO, n.d.).

Larvae:

"The larva is a legless grub up to 50 mm [approx. 2 in] long when fully grown. It is creamy white in colour, with a chitinized brown mark on the prothorax" (EPPO, n.d.). A detailed description of the larva can be found in Cavey et al. (1998).

Pupae:

"The off-white [pupa is] 30–33 mm [approx. 1 $^{3}/_{16}$–1 $^{5}/_{16}$ in] in length with a width of 11 mm [approx. $^{7}/_{16}$ in]. The eighth segment of the abdomen has a protruding structure (Peng & Liu, 1992)" (USDA, 2008).

Adults:

"Typically cerambycid in shape, 25 mm (male) [approx. 1 in] to 35 mm (female) [approx. 1 $^{3}/_{8}$ in] long. Antennae 2.5 times body length in males; 1.3 times body length in females. The beetle is black with about 20 irregular white spots on the elytra. The antennae have 11 segments, each with a whitish blue base" (EPPO, n.d.).

A detailed description of the adult stage can be found in Lingafelter and Hoebeke (2002), while a detailed description of the larvae can be found in Cavey et al. (1998).

A. glabripennis adult on *Acer saccharinum* (silver maple) (Image courtesy of Melody Keena, USDA Forest Service, Bugwood.org).

Biology and Ecology

Maturation feeding occurs on twig bark after which mating occurs. Once mated, females chew an oviposition pit in which one egg is usually laid. Females can lay 25 to 40 eggs in their lifetimes. Females in New York have been observed laying eggs from July to early November (Haack et al., 1997). One generation occurs per year in the United States.

Eggs hatch in approximately two weeks. Larvae initially feed on the cambial layer of bark on both the branches and the trunk and then move into the woody tissue of the plant (EPPO, n.d.). Tunneling can occur in both the sapwood and heartwood and can be 10 to 30 cm (approx. 3 $^{15}/_{16}$ to 11 $^{13}/_{16}$ in) (Haack et al., 1997). Pupation occurs in the heartwood where the pupal chamber is packed with wood shavings. Adults create exit holes on leaving the host; the exit holes are approximately 10 mm (approx. $^{3}/_{8}$ in) in width and are located above the oviposition site (EPPO, n.d.).

Based on observations in Illinois and New Jersey, ALB populations do not have a propensity for dispersal/long-range movement when population levels are low and infestations are young/recent (Reardon, 2011, personal communication). However, ALB has been documented by many, including USDA-ARS, as capable of long-range dispersal (Reardon, 2011, personal communication). This species can attack both healthy and stressed trees. Over time, several generations can lead to the death of individual trees (EPPO, n.d.).

Countries of Origin

This species is native to China and Korea (USDA-CSREES, n.d.).

Current Distribution

This species is found in China, Japan, and Korea (EPPO, n.d.). It has been introduced into Austria, Canada, France, Germany, Poland, Italy, Switzerland, and the United States (EPPO, 2006; 2011). This species was first discovered in the United States in 1996 and then in Ontario, Canada in 2003 (Ric et al., 2007). This pest was considered eradicated from Ontario in 2013 after not being detected for five years. This pest was found again in late 2013 outside of the eradicated area in Mississauga, Ontario (CFIA, 2013).

Distribution in United States

ALB was first discovered in the United States in Brooklyn, New York, in August 1996. ALB was later detected in Chicago, Illinois, in July 1998. In October 2002, the beetle was found in Hudson County, New Jersey, and then in Middlesex and Union Counties, New Jersey, in August 2004. In August 2008, ALB was discovered in Worcester County, Massachusetts, and in July 2010, ALB was found in Suffolk County, Massachusetts. In June 2011, ALB was found in Clermont County, Ohio. *A. glabripennis* was declared eradicated from Chicago, Illinois in 1998 and Islip, New York in 2011 after the completion of control and regulatory activities and following confirmation surveys (Reardon, 2011, personal communication).

Hosts of this species are found throughout the United States, especially the eastern portion of the country. The latitudinal range in which *A. glabripennis* is considered a major pest in China (21°N to 43°N) covers an area in North America spanning from southern Mexico to the Great Lakes (Haack et al., 1997).

Peterson et al. (2003) used a model to predict the North American distribution for this pest based on climate. This prediction found that most of the United States was susceptible, especially the eastern portion of the country (Peterson et al., 2003).

Pathway

This species was introduced into the United States through infested woodpacking material. As such, most of the initial infestations were found in industrial parks and nearby urban areas. An infestation found in Austria in 2000 was traced back to wood-packing materials imported from China while infestations in Germany and France were found near areas where material was recently imported from China (Hérard et al., 2006). Due to introductions of such wood-boring pests as *A. glabripennis* and *Agrilus planipennis* (emerald ash borer), ISPM 15 has been published requiring that all wood-packing material used in international trade be either heat treated or fumigated.

This species has been intercepted at ports of entry at least 11 times with most instances occurring on material from China (AQAS, accessed July 21, 2011). Interceptions at ports of entry identified only as *Anoplophora* sp. have occurred at least 47 times (AQAS, accessed January 6, 2012).

Adults can spread actively through flying along natural corridors (distances greater than 400 yards) or passively through human-assisted means. Larvae can be moved through infested material like firewood (USDA, 2006). Larvae can be difficult to detect as they burrow deep into the wood (Nowak et al., 2001).

Due to the severity of this species, a U.S. Federal quarantine has been in effect since 1997 (USDA-APHIS, 1997). Several articles are regulated in infested areas to reduce the risk of human-assisted spread. Articles include the Asian longhorned beetle in any living stage of development, firewood from all hardwood species, and all host material that is living, dead, cut, or fallen. This includes nursery stock, logs, green lumber, stumps, roots, branches, and debris of half an inch or more in diameter (USDA, 2008; USDA-APHIS, 1997). For the most recent list of regulated articles quarantine areas see the Code of Federal Regulations: http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr;sid=753bccd91cdb45da8db45e3c89d2dc8e;rgn=div6;view=text;node=7%3A5.1.1.1.2.8;idno=7;cc=ecfr and the ALB Federal Orders page: http://www.aphis.usda.gov/plant_health/plant_pest_info/asian_lhb/spro.shtml.

Pathogens Vectored

This species is not known to vector any pathogens but damage caused by this species may lead to invasion by secondary pathogens.

Damage

External signs of *A. glabripennis* include:

Oviposition pit and exit holes (Image courtesy of Dennis Haugen, USDA Forest Service, Bugwood.org)

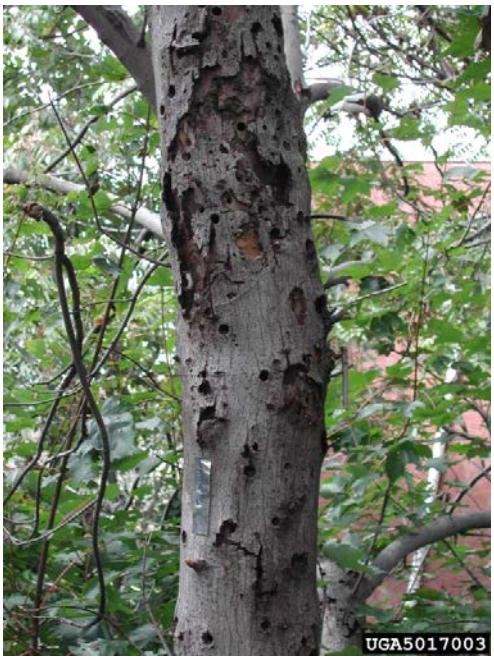
- Oviposition pits- "Often, but not always, the characteristic marks made by the mandibles are visible around the outer edges of the oviposition pit. Oviposition pits vary in shape from a nearly circular pit (15 mm [9/16 in] in diameter) to a narrow slit (about 1 mm in height)…The surface on which oviposition pits occur affects their visibility: pits on smooth bark are easier to detect than those on rough bark …The appearance of an oviposition pit changes with time. Typically, recently chewed oviposition pits (i.e., few hours to several weeks old) are reddish in colour…They become progressively darker as the season progresses because they oxidize over the season due to weathering… As the tree continues to grow, the appearance of the oviposition pit changes, and may be overgrown with new tissue. In some instances, the oviposition pit may be completely grown over, making it difficult to detect. Not all oviposition pits contain an egg" (Ric et al., 2007).
- Frass or shavings- "The frass can be seen protruding through cracks in the bark as it is pushed out of the feeding tunnels by larvae…This material can be seen on branches, at branch junctions…and on the ground at the base of infested trees… The presence of massive amounts of visible frass is rare…In most cases, only a small amount of frass is exposed because the bark is still intact…Also, frass deposited on branches and on the ground around the infested tree is most visible shortly after it is extruded from the tree" (Ric et al., 2007).

Frass exuded by *A. glabripennis* larva (Image courtesy of Kenneth R. Law, USDA APHIS PPQ, Bugwood.org).

- Hollow bark- "Feeding by young larvae on the outer sapwood eventually leads to the separation of the bark from the sapwood and creates a hollow area under the bark. These areas may appear as sunken or raised bark…Hollow areas can sometimes be seen through small cracks in the bark. This sign of injury can develop within the first year of attack if eggs have been laid in early summer, but in most instances it appears in the second year

following the attack. Unlike frass, this sign can be visible for several years" (Ric et al., 2007).

- Exposed feeding galleries- "Larvae feeding on the surface of the sapwood create depressed galleries of various sizes…This sign can be seen under field conditions only when the bark above the feeding gallery has fallen off the tree. This sign always occurs underneath an oviposition pit, therefore, it is impossible to detect the oviposition pit associated with the exposed feeding gallery…Callus tissue can be produced around exposed feeding galleries. Typically, this sign is visible only one to several years after larval feeding has occurred" (Ric et al., 2007).
- Exit/emergence holes- "An exit hole is made by an adult as it emerges from the pupal chamber located in the wood. Exit holes are circular and 6-14 mm [1/4 to 9/16 in] in diameter…Most exit holes are visible for several years, however, in some instances, callus tissue is produced around the hole. The growth of callus tissue around this type of injury can start soon after adult emergence, especially if it occurs in early summer, and can eventually enclose the exit hole completely" (Ric et al., 2007).
- Evidence of adult feeding- "Adult beetles feed on leaves, twigs, and petioles (leaf stems)…Adults feed on leaves by removing the primary and secondary leaf veins; the presence of jagged edges along the severed leaf tissue is characteristic…Adult beetles feed on twigs and petioles by stripping off the outer tissue of the twigs and petioles…Signs of beetles feeding on leaves and twigs can be found during inspection of the canopy prior to leaf fall. Feeding on petioles can cause leaves to be severed from their twigs and fall to the ground prematurely; signs of feeding on leaves and petioles can also be found while inspecting the ground beneath trees for leaves that have fallen from the tree during the summer. Signs of adult feeding on twigs



Extensive damage caused by *A. glabripennis*. Hollow bark, exposed feeding galleries, and exit holes can be seen in this image (Image courtesy of Pennsylvania Department of Conservation and Natural Resources - Forestry Archive, Bugwood.org).

Adult feeding damage (Image courtesy of Pennsylvania Department of Conservation and Natural Resources - Forestry Archive, Bugwood.org).

can be found after leaf drop in the fall and can be detected for several years after the damage was caused" (Ric et al., 2007).

Internal signs include:

- Feeding galleries in the outer sapwood- "This type of injury occurs underneath oviposition pits, begins at egg hatch and can only be revealed by carefully removing the bark. Larvae feeding on the surface of the sapwood create depressed galleries. This sign is not visible when the outer bark is still attached to the tree. Most of these galleries contain frass" (Ric et al., 2007).
- Tunneling through the wood- After feeding on the outer sapwood, larvae bore tunnels toward the heartwood…The entrance of the tunnel has a typical C-shape appearance…At maturity, a larva enlarges the tunnel creating a pupal chamber, where it transforms into a pupa…Once the development is completed, the pupa transforms into an adult and bores the remainder of the exit hole tunnel" (Ric et al., 2007).

Symptoms caused by *A. glabripennis* can include: oviposition stain (an oval-shaped bronze to brown stained area under the bark at the oviposition site), bark cracks or missing bark (due to larval feeding under the surface), foamy or frothy sap on oviposition pits, callus tissues around injuries, branch dieback, and tree death (Ric et al., 2007).

Extensive images of all of the signs and symptoms can be found in Ric et al. (2007).

It should be noted that many of the signs and symptoms can look similar to damage caused by other species besides *A. glabripennis*.

Survey

CAPS-Approved Method

The CAPS–approved method is visual inspection. If this species is found, it should be reported to the ALB Program (http://www.aphis.usda.gov/newsroom/hot_issues/alb/alb_report.shtml). Tests are currently being run on potential traps and lures for *A. glabripennis* but there is currently no approved trap or lure for this species.

There are two main methods for surveying for *A. glabripennis*: inspections at the ground level and inspections within the crown of the tree. The latter is considered more effective than ground inspections.

Ground inspections are the most rapid method of surveying and are good to use in heavily infested areas and with smaller diameter trees and shrubs. High contrast binoculars are essential when carrying out ground inspections. Before proceeding to within crown inspections, main stems and lower branches should be checked from the ground first.

When surveying within the crown, ladders, bucket trucks, or tree climbers can be used. This method is useful for examining all parts of the tree, including sections not visible from the ground. Ladders are useful when checking parts of the trunk that are too high for visual inspection. Bucket trucks are useful for checking large trees or parts of trees like branch

junctions. Tree climbers are the most practical way to inspect entire trees in woodlots. It is also considered the most thorough and effective survey method for detecting *A. glabripennis* on the bole and branches of large trees (Ric et al., 2007).

When surveying suitable hosts, make sure to record the location of the tree. The entire tree should be surveyed if possible. If a tree is found to be infested, it is removed.

Surveys conducted by the USDA "are organized into four levels to search for indications of beetle presence. The core area, known as Level 1, is composed of the area found within a 1/2 mile radius of an infested tree. Delimiting surveys, referred to as Level 2, are conducted at a range between a 1/2 mile and 1-1/2 miles from infested trees. Level 3 surveys include regulatory inspections of tree care companies and related wood-handling industries that conduct business in proximity to the regulated areas as well as inspection of ALB host trees in the vicinity of the establishment. Level 4 surveys consist of the inspection of selected locations up to 25 miles from known infested areas. The intensity and frequency of inspection in each survey level is set according to risk-based protocols" (USDA, 2006).

The following is found on the APHIS Plant Program website:

> **Intensive Core Survey (Level 1 Survey)**
> Annually, all host trees within a ½ mile radius of the initial find are surveyed visually. The initial survey is conducted by ground crews. Once visible damage is no longer evident from the ground, Bucket Trucks and Tree Climbers are used to complete the survey within the ½ mile radius. It is recommended that Tree Climbers be used whenever possible and Bucket Trucks be used when needed. If additional infestations are found, the ½ mile core area will be extended from the outermost find.
>
> **Delimiting Survey (Level 2 Survey)**
> All host trees within a minimum of 1-mile beyond the Intensive Core Survey Boundary are surveyed. Biennially, all host trees in the delimiting area are surveyed using ground crews, Bucket Trucks, or Tree Climbers.
>
> **High Risk Site Detection Survey (Level 3 Survey)**
> Using investigative work to identify potential high-risk sites where ALB infested materials may have been taken and utilizing interviews, databases, yellow pages, ads, or other potentially valuable sources of information the following sites are identified:
>
> 1. Tree services that conduct business within the infested or regulated area to determine locations where their vehicles are routinely parked and wood is disposed of or stored.
> 2. Municipal parks, tree wardens, foresters, or other municipal groups that may cut or trim trees.
> 3. In heavily infested areas, query local residents about any firewood they may have cut and given away or transported to other locations (cabins, camps, etc.).
> 4. Landfills or other places used for the disposal of recently cut wood and brush.
> 5. Utility companies.
> 6. Anyone else who may cut and transport wood.

At sites identified above, an annual ground-based visual survey for ALB is to be conducted of 50 to 100 potential host trees surrounding the site. Managers may choose to use Bucket Trucks and Tree Climbers based on the availability of resources. Only trees that are within 1.25 miles of the site are to be included.

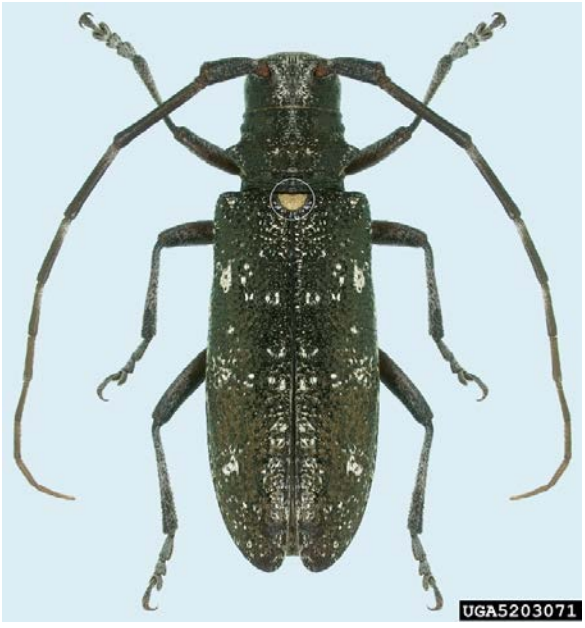
If ALB is found, the Intensive Core and Delimiting Survey Protocols will be used to determine the extent of the infestation.

Area Wide Detection Survey (Level 4 Survey)
All one-square mile areas within 25 miles of the epicenter of the current ALB infestation, but outside of the regulated area, shall be surveyed at least once every three years in the following manner. Two host trees at each of nine sites per square mile shall be inspected visually from the ground for evidence of ALB infestation. Sites shall be well distributed throughout the square mile block and separated by a minimum of 300 meters [328 yards]. Use a GPS unit, if available, to document locations and other data (see Survey Records section below). Where available, use Township-Range-Section to conveniently define survey blocks.

Generally, areas remain under quarantine until negative survey results have been reported for two consecutive years. If an area has had at least four years of surveys reporting negative data, it is no longer considered infested (USDA, 2006).

More information can be found in the newest version of the Asian Longhorned Beetle Cooperative Eradication Program Strategic Plan which can be found on the APHIS Program Pest webpage: http://www.aphis.usda.gov/plant_health/plant_pest_info/asian_lhb/index.shtml and the NPRG for *Anoplophora glabripennis*.

Time of year to survey
Inspections are easiest during winter months due to lack of leaves, but can be performed year round. Dry weather conditions are preferred as signs and symptoms are less likely to be obscured (Ric et al., 2007).



Monochamus scutellatus. The distinguishing characteristic for *M. scutellatus*, a white spot between the top of the elytra, is circled in yellow (Image courtesy of Natasha Wright, Florida Department of Agriculture and Consumer Services, Bugwood.org).

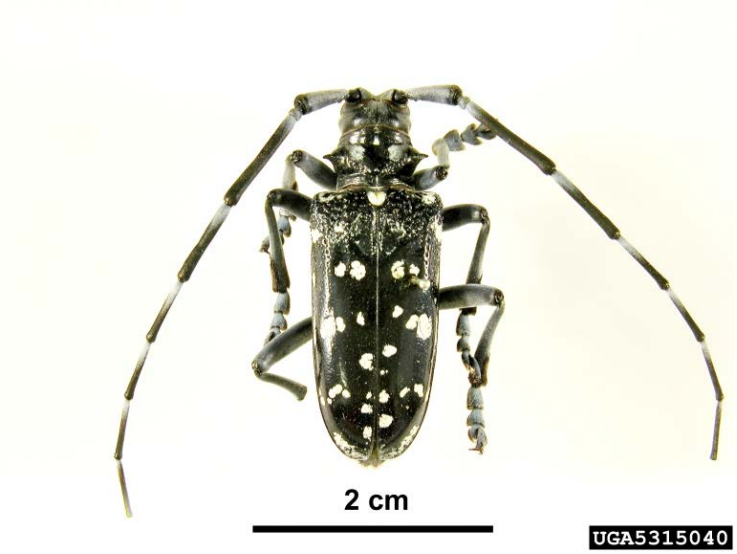
Identification

CAPS-Approved Method
Morphological. Identification should be determined by a taxonomist that has expertise in the Cerambycidae family.

Mistaken Identities

A. glabripennis is superficially similar to several longhorned beetles that are indigenous to North America, especially *Monochamus* beetles (Cavey, 2000). This species is most easily confused with *Monochamus scutellatus* (whitespotted sawyer). The main difference between these two species is the white spots on the beetle. Several guides exist to help differentiate these two species, including Hoebeke (n.d.) and Ric et al. (2007). *M. oregonensis* can be misidentified for *A. glabripennis* in the western part of the U.S. where this species is present. *M. oregonensis* also has the white dot between the tops of the elytra unlike *A. glabripennis* (UVM, n.d.).

A. glabripennis is also similar in appearance to the non-native species *Anoplophora chinensis* (citrus longhorned beetle) (Thomas, 2004). This species has previously been found in the United States but is not established. *A. chinensis* has rows of polished tubercles at the base of the elytra that are not found on *A. glabripennis*; these should be visible under 10x magnification (Thomas, 2004).



Anoplophora chinensis morph from Japan. (Image courtesy of Pest and Diseases Image Library, Bugwood.org).

Adults are also similar in appearance to other species in the *Anoplophora* genus, including *A. coeruleoantennata*, *A. freyi* (Lingafelter and Hoebeke, 2002) and *A. nobilis* (CABI, 2011) none of which are found in the United States as well as the indigenous cottonwood borer, *Plectrodera scalator* (Cavey, 2000). A revision of *Anoplophora* was completed by Lingafelter and Hoebeke (2002) and includes descriptions of species as well as a diagnosis section that can be used to differentiate the different species. A key to differentiate different adult *Anoplophora* species from China can be found in Gressitt (1951).

The larvae can be confused with *Monochamus* spp. (Cavey et al., 1998). Cavey et al. (1998) gives diagnostic differences between the two genera.

Resources and High Resolution Images

There are several resources that are available for this pest.

ID, hosts, images, symptoms, and survey

Ric, J., P. de Groot, B. Gasman, M. Orr, J. Doyle, M. T. Smith, L. Dumochel, T. Scarr, and J. J. Turgeon. 2007. Detecting Signs and Symptoms of Asian Longhorned Beetle Injury Training Guide. Her Majesty in Right of Canada.

Host tree identification aids

Audubon Society Field Guide to North American Trees. Eastern or Western Addition. Elbert Luther Little, Sonja Bullaty (Photographer), Angelo Lomeo (Photographer), June 1998.

A *First Guide to Trees*. Publisher: George A. Petrides, Roger Tory Peterson/ Paperback/Houghton Mifflin Company/ May 1998.

Tree Finder. A Manual for the Identification of Trees by their Leaves. May Theilgaard Watts/Paperback/ Publisher Nature Study Guild January 1998.

Simon & Schuster Guide to Trees. Mariella Pizzettii, Paola Lanzara, Stanley Schuler (Editor)/Paperback/ Simon & Schuster Trade/April 1978.

The Tree Identification Book. George W. D. Symonds, Stephen V. Chelminski (Photographer)/Paperback/ Morrow, William & Co./ December 1972.

Images

http://www.aphis.usda.gov/newsroom/hot_issues/alb/alb_links.shtml.

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