



Asian Longhorned Beetle

Anoplophora glabripennis Motschulsky (Coleoptera: Cerambycidae)

INTRODUCTION:

The Asian Longhorned Beetle (ALB) is an exotic wood boring beetle that entered the U.S. via solid wood packing materials originating in China and was first detected in Brooklyn, NY, in 1996. ALB is known to attack and successfully reproduce in 23 species of hardwood trees commonly found in North America, usually causing death within several years. In 1997 the Secretary of Agriculture declared an extraordinary emergency and enacted regulatory and control actions in an effort to eradicate the beetle. To date, over 66,000 infested trees have been destroyed at a cost approaching \$200 million.

ALB has the potential to destroy millions of acres of America's treasured hardwoods, ranging from national forests to backyard trees. ALB could kill a third of urban trees, with a compensatory value of nearly \$700 billion, and if it spreads to North American forests it could alter ecosystems across the continent. ALB could impact a number of commercial interests, causing many billions of dollars in losses to the lumber, maple syrup and fall foliage related tourism industries, all of which are dependent on healthy hardwood trees.



Adult ALB. Kenneth R. Law, USDA APHIS PPQ, Bugwood.org

DISTRIBUTION/SPREAD:

ALB is native to eastern China, Japan and Korea, where it is considered a major pest. Since its first detection in the U.S., there have been nearly 30 interceptions of ALB at shipping ports throughout the nation and ALB infested cargo in warehouses has been found and destroyed in at least 17 states ranging from California to South Carolina, Maine to Alabama, and Wisconsin to Texas. Infestations of ALB have become established at numerous locations within four North American cities or regions: various distinct areas of New York City (1996-2007); Chicago, IL (1998, 2001, 2008); New Jersey (2002, 2004, 2006); and Toronto, Canada (2003, 2007). Quarantines and control efforts were initiated in all locations in an effort to eradicate ALB. The most recent detection of ALB in July, 2008, infesting trees in an urban forest near a commercial business complex in Worcester, Massachusetts, raises concerns that new, stricter international import regulations enacted in 2001 may not be adequate to prevent new introductions.

Adult ALB are very strong flyers, easily covering distances greater than 400 yards (0.4 km), so natural dispersal accounts for much of their spread. ALB larvae, however, live deep inside trees during most of their life cycle, undetectable for a year or more, and can therefore be spread much longer distances by people moving infested firewood, timber or nursery stock. North America offers an abundance of host hardwood trees, so ALB can be expected to move readily through both landscapes and native forests. Research conducted in 2007 indicates ALB is tolerant of very cold temperatures, suggesting it is capable of moving further north than it is currently found.

HOST PLANTS:

In its native range in China, ALB causes widespread mortality of poplar, willow, elm and maple. Known host species of ALB in its introduced range in Europe, in which the beetle has successfully reproduced, include several species of maples (*A. platanoides*, *A. negundo*, *A. saccharinum*, *A. Pseudoplatnus*), Plane-tree (*Platanus* spp.), Fern leaved beech (*Fagus sylvatica* 'Asplenifolia'), birch (*Betula* spp.), Horsechestnut (*Aesculus hippocastanum*), poplars (*Populus* spp.), willow (*Salix* spp.) and ornamental fruit trees (*Prunus* spp.).

In North America, the data do not exist to identify the most suitable/best reproductive host of ALB, but ALB is known to attack, successfully complete development in, and emerge from 23 species of hardwood trees in the U.S. These include the following species: maple (*Acer*), including Norway maple (*A. platanoides*), Sugar maple (*A. saccharum*), Silver maple (*A.*

saccharinum), Red maple (*A. rubrum*), Boxelder or Manitoba (*A. negundo*), Black Maple (*A. nigrum*), Sycamore maple (*A. pseudoplatnus*), Japanese maple (*A. palmatum*), and Amur maple (*A. ginnala*); willow (*Salix*), including White willow (*S. alba*), Weeping willow (*S. babylonica*), Pussy willow (*S. discolor*), and Black willow (*S. nigra*); elm (*Ulmus*), including American elm (*U. americana*), Siberian elm (*U. pumila*), and Chinese elm (*U. parvifolia*); birch (*Betula*), including Water birch (*B. occidentalis*), White birch (*B. papyrifera*), and Gray birch (*B. populifolia*); *Aesculus*, including Horsechestnut (*A. hippocastanum*) and Ohio Buckeye (*A. glabra*); Mountain Ash (*Sorbus americana*); and London Plane-Tree (*Platanus acerifolia*).

The following species have been reported as susceptible to attack by ALB, although it is uncertain if ALB is able to successfully reproduce in these hosts in North America: poplar and aspens (*Populus*), Mimosa and silk tree (*Albizia*), Hackberry (*Celtis*), European mountain-ash (*Sorbus*), black locust (*Robinia*), Mulberry (*Morus*), Rose-of-Sharon (*Hibiscus*), and most ornamental fruit trees (*Malus*, *Prunus*, *Pyrus*).

Some species have been attacked by ALB but are known to be dead end hosts (reproduction is not successful) in North America. These include oaks (*Quercus* species), Linden (*Tilia* species) and Russian olive (*Elaeagnus* species).

Unlike most longhorned beetles found in the temperate zone, ALB not only feeds on stressed trees but also on healthy, full-grown trees; and unlike most wood-feeding insects of live hosts, ALB is polyphagous (feeds on a wide variety of host species). ALB can probably survive and reproduce in most sections of this country where suitable host trees exist. These traits make ALB more dangerous to North American forests than many other wood-feeding insects.

BIOLOGY and DAMAGE:

ALB differ from most longhorned beetle species, which have 2 to 4 year life cycles, in that they complete one generation every one or two years, making them capable of producing new adults annually. ALB most commonly overwinter in the larval stage deep inside the cambium and xylem of host trees, but may also overwinter as eggs or pupae. Mature larvae pupate just beneath the bark in the spring. Depending on the climate, adult ALB emergence begins in late May to early June, peaks in early to late July, and quickly declines in August, though adult activity may continue into late fall (October/November). Adult beetles are most active during daytime hours and live about 100 days, perishing before winter.

Newly emerged adults create dime-sized ($\frac{3}{8}$ - $\frac{1}{2}$ " or 9.5-12.7 mm), round exit holes in the bark that may first be noticed the second summer of infestation. Upon first emerging, ALB adults begin maturation feeding on their birth host trees, or may fly several hundred yards to seek new hosts. The beetles feed on leaves and leaf petioles, but prefer feeding on the outer layer of young twigs, striping the bark from twigs but avoiding the woody tissue beneath. After feeding for several days, the beetles mate along the trunks and branches of host trees.

After mating, female ALB chew individual, up to dime-sized, oval or round-shaped shallow depressions, or "oviposition notches", through the bark of trees into the cambial tissue. These oviposition scars may be the first sign, other than the adult beetle itself, of the presence of ALB. Females then lay one egg in each oviposition



All life cycle stages of ALB. Kenneth R. Law, USDA APHIS PPQ, Bugwood.org



Oviposition notches and an exit hole. Dennis Haugen, USDA Forest Service, Bugwood.org



Larva in frass-packed gallery. Steven Katovich, USDA Forest Service, Bugwood.org

notch, carefully plugging the hole up afterward with frass (digested wood) to protect and hide the young ALB. Females repeat this procedure until they lay an average of about 35 eggs (range: 25-90). Oviposition usually occurs first along the upper trunk and major branches where bark is smooth, but ALB females will also lay eggs on branches as small as 1-1½" diameter (2.5-4 cm) and, as the tree crown dies back, along the entire trunk and even on exposed roots.

Eggs hatch in about 11 days and the small, white, worm-like immature round-headed larvae tunnel into and begin feeding in the tree. Larvae are the most destructive stage, at first feeding on cambial tissues, then as they grow, boring deeper into the sapwood and heartwood damaging the nutrient and water transporting vessels. Galleries are initially horizontal, then turn upwards, and may reach lengths of 4-12 inches (10-30 cm). ALB larvae push frass out of their galleries through the oviposition site or through vent holes chewed through the bark. In the fall, larvae tunnel deep into the heartwood and feed on living tree tissue over the winter. In the spring and summer, mature larvae move back near the surface beneath the bark, and pupate there within the larval galleries. The new adults bore their way out of the tree, and begin the cycle again.



Black and white banded antennae. Michael Bohne, Bugwood.org



Adult feeding damage on twig (stripped bark). Dean Morewood, Health Canada, Bugwood.org



Adult feeding damage on leaf (holes clustered along a vein). Michael T. Smith, USDA-ARS, BIIRU, Newark, DE

IDENTIFICATION:

The Asian Longhorned Beetle is classified in the wood boring beetle family Cerambycidae, referred to as longhorned beetles (adults) and round-headed borers (larvae).

- Adult beetles are large, ¾-1½" long (20-40 mm), shiny black, with irregular white spots.
- Adult females are larger than adult males.
- Antennae are very long (1.5 to 2.5 times the body length) with black and white alternating bands.
- Eggs are the size/shape of a grain of rice: 1/5-1/3" long (5-7 mm).
- Larvae are cylindrical, segmented, roundheaded, and legless, with a white body and brown head, and breathing pores (spiracles) along the sides.
- Mature larvae are robust and reach 2" long (5 cm).
- Pupae are 1¼" long (~ 32 mm). See an image at: <http://tncweeds.ucdavis.edu/photos/anogl03.jpg>

WHAT TO LOOK FOR:

ALB will attack healthy or stressed, young or old, living or recently felled trees, ranging in size from nursery stock to trees large in diameter.

Symptoms of ALB infestation include:

- Wilted foliage, and eventually dieback of upper canopy.
- Adult feeding damage on leaves (moderate size holes in the foliage, often clustered around a vein), leaf stems, and bark of small twigs and branch tips (outer layers stripped, revealing woody tissues beneath).
- Shallow oval/round depressions (oviposition notches), up to ½" in diameter (13 mm), in bark.
- Round, nearly dime-sized, ¾-1½" diameter (9.5-13 mm) adult exit holes in the bark of infested trees.
- Frass from larvae feeding in the inner bark (cambium/phloem) is typically brown; may be stringy and wet, or coarse and dry; and may cling to the bark where it has been pushed out, or accumulate in branch crotches or at the base of the tree.

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- Frass from larvae feeding in the sapwood (xylem) is typically cream-colored; sliver-like; may be wet, but dries out quickly; and may cling to the bark, lodge within branch/trunk crotches, or pile up at the base of the tree.
- Bark staining and oozing sap from oviposition notches or exit holes may be present on the trunk, especially in spring.
- Galleries are individual; initially horizontal deep into the sapwood, then turn upwards; may reach lengths of 4-12" (10-30 cm).
- Broken branches and stems in heavily mined trees, especially after strong winds.
- Adult beetles may be found anywhere outdoors from infested trees to patio furniture, the sides of houses, etc.

MONITORING:

ALB is a regulated pest. Once an infestation is discovered, USDA APHIS and state officials establish quarantine boundaries around the infested area, and then conduct intensive surveys of all potential host trees on both public and private property within those boundaries.

The most common monitoring technique for ALB is visual inspections of host trees for ALB damage and active adults. Detection is challenging because most infestations begin near the top of a tree and are hidden by foliage much of the year. Various methods of inspection have been implemented and range in their efficiency and expense. These include ground surveys where the trunk is visually examined and upper parts of the tree are checked by inspectors standing below using binoculars, to using cherry pickers and tree climbers to survey the upper canopy.

Several research projects into alternative survey and detection methods are being investigated, including pheromone traps to lure the beetles; acoustic equipment to detect ALB chewing noises within a tree; a method recently developed by ARS scientists to analyze the unique genetic signature of the beetle's frass; and using a pyrethroid chemical to knock down adult, free-flying beetles from trees suspected of being infested.

MANAGEMENT:

Regulatory

Control of ALB is considered of the highest priority because the potential long term ecological and economic damage from this pest is so great. If ALB should spread beyond urban areas, eradication is unlikely. Therefore, the USDA APHIS appointed ALB Science Advisory Panel recommended on October 25, 1996, that the U.S. goal be complete eradication of ALB. Initially, all infested trees were cut down and chipped, stumps ground and all wood products incinerated. Quarantine measures did not permit home owners to cut down infested trees; only ALB certified tree-service personnel were allowed to do it. No one could use, dispose of or move any wood from a quarantined area without an inspection permit.

Some treatments exist to control ALB-infested cargo, but because the majority of the beetle's life is spent deep within the heartwood of host trees, using contact insecticides is not very useful. An Interim Rule enacted in 1998 took the more definitive step of requiring that all solid wood packing material from China be treated prior to shipment to the U.S., and that any infested containers detected would be sent back. In 2000, according to USDA officials, compliance was 98.4%.

Beginning in 2000, infested trees in quarantined areas of IL, NY and NJ were treated with a systemic pesticide. The treatments in IL and NJ were very successful, and after at least four years of negative surveys, in April 2008 both areas were declared eradicated of ALB. Unfortunately, ALB were reported in Chicago again in August 2008. It is not clear if this represents a new introduction of ALB or a previously undetected population from the original infestation. The more recently detected infestation in Massachusetts in 2008 appears to have gone undetected for at least five years. These two incidents have authorities concerned that as yet undiscovered ALB infestations may be more widespread in the U.S. than previously thought, and that current international import regulations may need to be revised.

Cultural Control

Because ALB attacks healthy hardwood tree species, the only cultural control of any value is replanting with non-host tree species after infested trees are removed.



Boring dust in branch crotch and multiple oviposition notches.
Robert A. Haack, USDA Forest Service, Bugwood.org

Mechanical/Physical Control

Infested trees can be removed and destroyed. Chipping wood products into pieces $\frac{5}{8}$ " (16 mm) or smaller in two dimensions eliminates all life stage of ALB. Research currently underway indicates microwave and heat treatments offer some promise for control of ALB in infested wood.

Biological Control

Natural enemies of native longhorned beetles abound in North America and may prey upon ALB as well. These include insect predators such as a number of beetles (flat bark beetles, cylindrical bark beetles, clerid beetles and click beetles), robber flies, assassin and ambush bugs, thrips, and carpenter ants. Vertebrate predators include birds (several woodpecker species in China reportedly reduce ALB populations by 30-80% in the field), lizards, spiders, scorpions, toads, and small mammals. Native wasps in various families (including braconids, ichneumonids, and numerous chalcidoids), and tachinid and sarcophagid flies are parasitoids of native longhorned beetles; recent research shows that at least two of the native braconid species and one ichneumonid species appear to parasitize ALB. To date, about 3 or 4 species of native natural enemies of native cerambycids have successfully parasitized ALB and produced offspring, providing the first concrete evidence of a native natural enemy successfully parasitizing ALB outside of Asia.



Damage in cross-section of trunk from galleries bored by larvae. Kenneth R. Law, USDA APHIS PPQ, Bugwood.org

The exploration, collection and identification of natural enemies of ALB are currently underway in China. Biological control agents known to attack

ALB or beetles belonging to the same genus as ALB include the egg parasitoid *Aprostocetus fukutai* Eulophidae (although no egg parasitoids have as yet been collected from ALB), and several larval parasitoids, including *Ontsira* spp. (Braconidae) and *O. anoplophorae*. Of great interest is a cylindrical bark beetle from China, *Dastarcus longulus*, which is a larval/pupal parasitoid of ALB. It has been reported to parasitize and kill as much as 60% of ALB in an infestation. This natural enemy shows considerable promise in biological control of ALB and is currently under investigation for future introductions into the U.S. A natural enemy of ALB from South Korea with a very narrow host range and very good host searching ability has also attracted the interest of U.S. researchers, who hope to work with this species in the near future.

Certain pathogens also show promise for control and merit further investigation. The fungus *Beauveria bassiana* has been isolated from ALB larvae, and *B. brongniartii*, introduced from Japan, has also been shown to infect ALB, especially adults. In addition, *Paecilomyces farinosus* has been isolated from ALB larvae. Entomopathogenic bacteria have been isolated from ALB larvae and pupae. Finally, the entomopathogenic nematodes *Steinernema bibionis* and *S. feltiae*, when inserted into borer holes, have been reported to cause 60% or greater mortality of ALB.

Chemical Control

In 2000, Chicago began tree trunk injection treatments with the systemic insecticide imidacloprid. When applied directly into the trunk of a tree or on the soil near the base of a tree, imidacloprid moves upward into the stems, twigs, and foliage where the beetles feed and lay eggs. Hundreds of thousands of host trees in IL, NY and NJ have been treated with imidacloprid since 2000 to prevent further ALB infestation. Although NY and NJ have not experienced the same success as in Illinois, aggressive treatments continue in anticipation of achieving eradication or preventing the spread of ALB.

Evaluations of the newer systemic neonicotinyl insecticides dinotefuran, thiamethoxam, clothianidin, acetamiprid, and thiacloprid have been conducted over the past several years. In every test, trees treated with any of the pesticides fared better than untreated trees, regardless of application method. Acetamiprid, thiacloprid and dinotefuran show particular promise as effective chemical control techniques to be added to the ALB eradication arsenal.

Additionally, the pyrethroid Lambda-Cyhalothrin (trade names Demand®CS and Scimitar®CS) is being investigated for its effectiveness in controlling adult ALB either as a spray applied directly to trees, or to fabric bands wrapped around branches in host trees. ALB adults hesitated to walk onto burlap, but more readily ventured onto denier bands (600 X 300 Denier, 7 mil. PVC backed polyester fabric; Source: American Home and Habitat, Inc.; Product # FPV600B; Contact: www.ahh.biz), which provided 100 percent mortality for 90 days when applied to bands at 450mg a.i./L and 600mg a.i./L. When applied as a spray on trees, Demand® proved to be highly effective at controlling adult ALB (90% to 99% 24-hour mortality over 29-67 day test periods in studies of both potted and landscape trees conducted in 2005 and 2006). Research continues on the use of this pyrethroid as a control for adult ALB.

LOOK-ALIKE INSECTS and DAMAGE:

A number of North American insects may be confused with ALB, chief among them the native Whitespotted pine sawyer (*Monochamus scutellatus* Say). The primary differences between ALB and the Whitespotted pine sawyer are that the latter attacks only conifers, is somewhat smaller, is bronzy-black rather than glossy-black, and the antennae are somewhat shorter and not distinctly black/white banded. Whitespotted pine sawyer larvae closely resemble ALB larvae, but are found only in conifers. ALB may also be mistaken for the Citrus Longhorned Beetle (CLB, *Anoplophora chinensis* Forster), an invasive pest from Asia eradicated in Washington State in 2006 after a 5-year effort.

An excellent website from the University of Vermont describing ALB look-alikes is available at:
<http://www.uvm.edu/albeetle/identification/index.html>.

If you capture a beetle you suspect is an ALB, place it in a jar and freeze it until it can be turned over to an authority.

How to Report a Possible Sighting/Infestation

In Maryland:

University of Maryland Cooperative Extension Exotic Pest Threats Website:
<http://hgic.umd.edu/faq/sendAQuestion.cfm>

Maryland Department of Agriculture: call 410-841-5920 to report suspect pests; visit http://www.mda.state.md.us/plants-pests/invasive_species.php for information.

Nationally: USDA-Animal and Plant Health Inspection Service (APHIS):
http://www.aphis.usda.gov/services/report_pest_disease/report_pest_disease.shtml

Adult ALB Actual Size:



Where to Get More Information:

UMD Cooperative Extension Exotic Pest Threats Website: <http://www.PestThreats.umd.edu/index.cfm>
USDA-Agricultural Research Service (ARS): <http://www.ars.usda.gov/pandp/people/people.htm?personid=5254>
http://www.ars.usda.gov/research/projects/projects.htm?ACCN_NO=409768&showpubs
USDA APHIS Beetle Busters Asian Longhorned Beetle website: <http://beetlebusters.aphis.usda.gov/history.html>
USDA Forest Service. 2004. APHIS Pest Alert NA-PR-01-99GEN, Asian Longhorned Beetle: http://www.na.fs.fed.us/spfo/pubs/pest_al/alb/alb04.htm
University of Massachusetts Asian Longhorned Beetle Fact Sheet: http://www.umassgreeninfo.org/fact_sheets/wood_attackers/asian_longhorned_beetle.html
University of Vermont Asian Longhorned Beetle website: <http://www.uvm.edu/albeetle/index.html>

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Selected References:

Becker, H. 2000. Asian Longhorned Beetle. USDA Agricultural Research Service magazine: <http://www.ars.usda.gov/is/AR/archive/jun00/asian0600.htm>

Campbell, F. 2004. Asian Longhorned Beetle Fact Sheet. The Nature Conservancy Global Invasive Species Team: <http://tncweeds.ucdavis.edu/products/gallery/anog11.html>

Haack, R. A., K. R. Law, V. C. Mastro, H. S. Ossenbruggen, B. J. Raimo. 1997. New York's Battle with the Asian Longhorned Beetle. Journal of Forestry, Vol. 95, No. 12: http://nrs.fs.fed.us/pubs/jrnl/1997/nc_1997_Haack_002.pdf

MuruetaGoiena, T. Introduced Species Summary Project: Asian Longhorned Beetle. Columbia University: http://www.columbia.edu/itc/cerc/danoff-burg/invasion_bio/inv_spp_summ/Anoplophora%20glabripennis.html#Benefits

Peabody, E. 2006. To Bag a Bad Beetle. USDA Agricultural Research Service magazine: <http://www.ars.usda.gov/is/pr/2006/060504.htm>

Smith, M. T., R. W. Fuester, J. M. Tropp, E. M. Aparicio, D. Tatman, J. Wildonger. 2006. Natural Enemies of Native Woodborers: Potential as Biological Control Agents for Asian Longhorned Beetle. Forest Health Technology Enterprise Team EAB and ALB Research and Development Review Meeting: http://www.emeraldashborer.info/files/EAB_ALB_2006.pdf

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