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The Potential for Biological Control of Asian Longhorned Beetle in the U.S.

The Asian Longhorned Beetle (ALB) (*Anoplophora glabripennis*) is one of several in a group of high risk, non-indigenous species of wood boring beetles. These beetles have entered the U.S. in solid wood packing materials, such as crating, pallets or packing blocks—often constructed of raw wood, originating from Asia. At least two breeding populations of the ALB are currently known to exist within the U.S.: one in New York City and parts of Long Island, first identified in 1996; and the second in Chicago, Illinois, identified in 1998. In addition, ALB has been intercepted in a number of states, including Washington, Oregon, California, Texas, Alabama, Florida, Georgia, South Carolina, North Carolina, New Jersey, Pennsylvania, Massachusetts, Maine, Ohio, Indiana, Michigan and Wisconsin. The ALB is killing valuable street, park and residential trees, especially maples, and structural weakening of trees by the larvae also poses a physical danger to pedestrians and vehicles from falling limbs or trees during wind and/or ice storms.

ALB has a relatively broad host range, and has the potential to infest and kill many deciduous forest tree species in the eastern U.S., specifically maples, and particularly sugar maple. Its potential risk is further emphasized by the fact that maples comprise approximately 30% of all urban trees in eastern U.S. If ALB is allowed to move (via inadvertent transport or natural dispersal) from port cities and into the vast North American hardwood forests, the USDA predicts estimated annual losses to the U.S. economy of $138 billion. In China, its country of origin, ALB is a primary wood borer pest of many deciduous broadleaf tree species, particularly poplar and willow, as well as elm and maple. About 45% of the poplar plantations in China have been damaged by longhorned beetles. In five seriously infested provinces, ALB, together with the related species *A. nobilis*, has infested over 240 cities or counties, totaling 568,000 acres. Over 50,000,000 trees had been cut down from 1991 to 1993 in one province alone (Ningxia), resulting in losses of $US 37 million.

Although many control methods are under development for ALB in China, identification and

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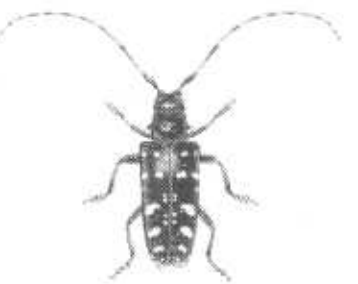
Have You Seen This Insect?



The adult beetle is about an inch long, shiny, black with bright white spots, and a pair of curved, black and white antennae that are even longer than the body. Emerging beetles leave round holes that are 3/8 inch or larger in the bark of infested trees.

If you suspect that you have found an Asian longhorned beetle, call your APHIS-PPQ State plant health director (see http://www.aphis.usda.gov/ppq/longhorn.html).

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removal of infested trees remains the only widely used method.

Current Eradication and Management Approaches for ALB in the U.S.

The USDA Animal and Plant Health Inspection Service (APHIS), together with various governmental agencies in New York and Illinois, are currently attempting to eradicate ALB in the respective areas, as well as to detect and intercept new introductions. Research efforts include developing: (1) detection methods for ALB; (2) control methods for ALB; (3) information on the dispersal potential of adult ALB, which will be used in establishing quarantine boundaries; and (4) host preference and susceptibility indices for ALB, which will help focus survey and detection efforts for ALB, as well as assist in the selection of tree species for re-planting impacted areas. Additional efforts include regulatory issues to reduce the potential for additional introductions and public awareness and education.

However, in the event that eradication is not successful, and considering the continuous threat of ALB re-establishment in these and other regions, management methods need to be developed. Among these management strategies are the use of biological control and/or natural control, host plant resistance, and selected silvicultural practices. While U.S. research efforts against ALB is just beginning, previously published information on the management of ALB and other *Anoplophora* species in Asia—as well as of other longhorned beetles worldwide—offers insight into the potential of various methods to manage ALB both here in the U.S. and in China.

Natural Enemies of ALB and Other Longhorned Beetles

There are many natural enemies of longhorned beetles in North America, including predators, parasitoids, and pathogens. Predators include a number of beetles, in some rather obscure groups such as the flat bark beetles, the cylindrical bark beetles, clerids and click beetles; a few flies, including robber flies; assassin and ambush bugs; thrips; and carpenter ants. In addition, a number of vertebrates, including birds, lizards, spiders, scorpions, toads, and small mammals, are recorded predators of longhorned beetles. Parasitoids include wasps in various families including braconids, ichneumonids, and numerous chalcids; and tachinid and sarcophagid flies. Nematodes and fungi have been reported as infecting larvae.

Of the natural enemies attacking longhorned beetles which share a common host with ALB, several parasitize either the egg or larval stage of longhorned beetles. Natural enemies known to attack ALB and/or beetles belonging to the same genus (*Anoplophora*) as ALB include the egg parasitoid *Aprostocetus fukutai* (Eulophidae), which parasitizes *A. chinensis* and *Apriona germarii*. However, no egg parasitoids have as yet been collected from ALB, nor *A. nobilis*. Several larval parasitoids have been identified, including *Ontsira* sp. (Braconidae), which parasitizes *A. chinensis* larvae, and *O. anoplophorae* , a gregarious larval ectoparasitoid of *A. malasiaca* on citrus.

More noteworthy, the cylindrical bark beetle *Dastarcus longulus* is a larval/pupal parasitoid of ALB, as well as several other related longhorned beetles in China. It has been found to parasitize and kill as much as 60% of ALB, and as many as 30 individuals of this parasitoid are capable of successfully completing their development on a single ALB larva or pupa, which usually kills the ALB within 10 days. In locations where *D. longulus* is established in relatively high numbers, ALB is said to be under natural control. Therefore, this natural enemy shows considerable promise in biological control of ALB and other *Anoplophora* species in China, and it is currently under investigation for future potential introductions into the U.S.

Although a number of invertebrate predators have been reported feeding on longhorned beetles world-wide, only five ant species have been reported as specific predators of *A. versteegii* in citrus in India. Several woodpeckers are known to contribute to the natural control of ALB in China, reportedly reducing populations by 30 to 80% in the field. Hanging bird nests in poplar plantations has been suggested to encourage them.

Pathogens represent an additional group of natural enemies worthy of investigation. The fungus *Beauveria bassiana* has been isolated from ALB larvae, and when injected as a liquor into insect holes, it has resulted in death of ALB. *B. brongniartii*, introduced from Japan, has also been shown to infect ALB, especially adults. In addition, *Paecilomyces farinosus* has been isolated from ALB larvae, while *Acremonium chrysogenum* and *Verticillium* sp. have been isolated from *A. nobilis*. *Metarhizium anisopliae* isolated from *Saperda populnea* larvae has been shown to infect *A. nobilis* and other related species. Entomopathogenic bacteria have been isolated from ALB larvae and pupae, and a baculovirus has been isolated from *A. nobilis* larvae. Finally, the entomopathogenic nematodes *Steinernema bibionis* and *S. feltiae*, when inserted into borer holes, have been reported to result in a minimum of 60% mortality of ALB. Strains of *Heterorhabatis* sp. and *S. feltiae* have also been evaluated for control of various poplar borers.

Exploration, collection and identification of natural enemies of ALB has been limited, and of those identified, few if any have received thorough evaluation, and none have as yet been developed completely for biological control of ALB. Therefore, sorely needed investigations of the natural enemies of ALB in China are currently in progress. Natural enemies, including the promising *D. longulus* mentioned above are being evaluated in greater detail. Exploration for new natural enemies of ALB is being conducted in key habitats such as wind-breaks, hedge-rows, plantations and natural forests that may harbor different complexes of natural enemies with differences in key performance traits, but also represent the different types of habitats which may be targeted in the U.S. Reciprocal investi-

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gations have only recently been initiated within the U.S., in which natural enemies found associated with ALB in known infestations are being collected and identified. Native natural enemies of longhorned beetles occurring in the U.S. will also be identified and evaluated as potential natural enemies for biological control of ALB in the U.S. and in China.

Potential for Biological Control

The challenges of managing ALB in the U.S. are many.

- As a newly-introduced exotic pest, natural controls have likely not had adequate time to develop the close associations generally considered necessary to be effective.
- While ALB has been reported to complete its development on trees belonging to at least 6 genera in the U.S. (maple, birch, poplar, willow, horsechestnut, and elm), approximately 80% of the trees removed thus far from U.S. infestations have been maples, primarily Norway, sugar and silver maple. Because maples comprise approximately 30% of all urban trees in eastern U.S., the abundance and predominance of maples in the eastern U.S. urban and forest landscapes, as well as the apparent preference of ALB for maples, collectively represent what is likely one of the most important challenges to managing ALB in the U.S.
- ALB is largely cryptic, hidden within the tree during approximately 90% of its life cycle. The remaining 10% is spent as a free-living adult, largely in the mid to upper canopy of trees. It is not only difficult to detect infested trees and free-living adults, but it may also be difficult to impose effective control measures to reduce population and damage levels within the protective environment of infested trees.
- The relatively long life span of free-living adult ALB and the inadvertent transport of infested cargo and firewood, also potentially contribute to the risk for spreading ALB in the U.S.

While these challenges are great, it is equally important to weigh these against those factors which should improve the potential for managing ALB in the U.S.

- Because exploration, identification and evaluation of natural enemies of ALB and related species in China and the Far East have been limited, China likely harbors an abundance of as yet undiscovered natural enemies. This may be particularly true in the forested areas in northeast China where ALB is said to be endemic as a result of natural control.
- Natural rates of ALB increase and spread appear to be relatively low, both of which tend to improve the potential success of natural enemy regulation of pest populations.
- While maples comprise a large proportion of the eastern urban landscape in the U.S., these landscapes differ greatly from the typical, largely monocultural, landscapes found in China where ALB is epidemic. Therefore, the tree species richness of the eastern U.S. landscapes should better sustain a rich natural enemy fauna, whether resulting from the development of new associations between native natural enemies and ALB, or from the introduction of exotic natural enemies from China. This species richness should also minimize the probability that ALB will develop mechanisms to overcome any naturally occurring tree defenses. However, one note of caution is that there appears to be a progressive shift in northeastern forests to an ever-decreasing diversity among maple species.

A successful biological control program for ALB in the U.S. and China will rely heavily upon the integration of several other essential components. In addition to the conservation of native natural enemies, as well as the introduction of exotic natural enemies, utilization of resistant hosts is paramount. Host defenses may either target adult ALB (non-preferred hosts), and/or target egg and larval ALB (hosts which are unsuitable for their growth and development). It should be emphasized that biological control and host plant resistance will likely focus on the egg and early larval stages of ALB, as they apparently represent the more vulnerable stages in its life cycle.

ALB on the Web: A Few Sites

http://willow.ncfes.umn.edu/asianbeetle_beetle.htm
http://www.aphis.usda.gov/oa/alb/lab/html
http://www.chicago-botanic.org/Asianbeetle.html
http://www.usia.gov/regional/ea/beetle/beetleqa.htm
http://www.aces.uiuc.edu/longhorned_beetle/
http://www.agr.state.il.us/beetle.html

Selection of tree species which are better able to withstand the more common stress factors, particularly those associated with the urban landscape (i.e. soil compaction and air pollution), should be encouraged. As in any pest management program, selection of plants or trees (species, cultivar or variety) which are best adapted to the particular site and environment under consideration is often the single most important decision that is made in managing an insect pest. This may be particularly true in landscapes, such as urban areas, where the implementation of control measures such as the application of insecticides is generally very difficult. In addition, silvicultural practices directed at improving tree health should strengthen the tree's ability to withstand ALB attack. Such practices include the modification of irrigation and fertilization methods, as well as the use of bait trees. Finally, the integration of methods resulting from the identification of weak links in the life history and behavior of ALB will play a major role in any management program. This may include the use of detection methods, as well as direct control methods (i.e. insecticides, bait trees). In conclusion, any one of these components, if exclusively utilized for management of ALB, will run the risk of jeopardizing any management program. Therefore, the integration of these methods will be essential for the management of ALB in the U.S.

— Michael T. Smith, USDA-ARS, Beneficial Insects Introduction Research Laboratory, Newark, DE

Adapted from: Smith, M.T., Gao Ruitong, Yang Zhong-qi, Li Guohong, Youqing Luo, Youju Jin, R. Xu, and Li Jianguang. Reveiw and analysis of the literature on Anoplophora glabripennis *(Motsch.) in China. (manuscript in preparation)*