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Monitoring the Field of Pest Management
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Biocontrol and IPM for the Asian Longhorned Beetle

A number of exotic organisms are now posing ecological and economic threats in the U.S. Some of these, such as the gypsy moth, the fire ant, and the Africanized honey bee have been with us for awhile. A relatively new addition is the Asian longhorned beetle, Anoplophora glabripennis. *This insect has potential for great economic damage in the U.S., as it kills a wide range of shade trees, leading to expensive replantings. A related species,* A. chinensis, *which kills ornamentals and citrus trees, has not yet appeared in the U.S. Solutions may come from improved monitoring in infested areas, better surveilance of imports, heat treatment of imported wood crating and pallets, and biological control.*

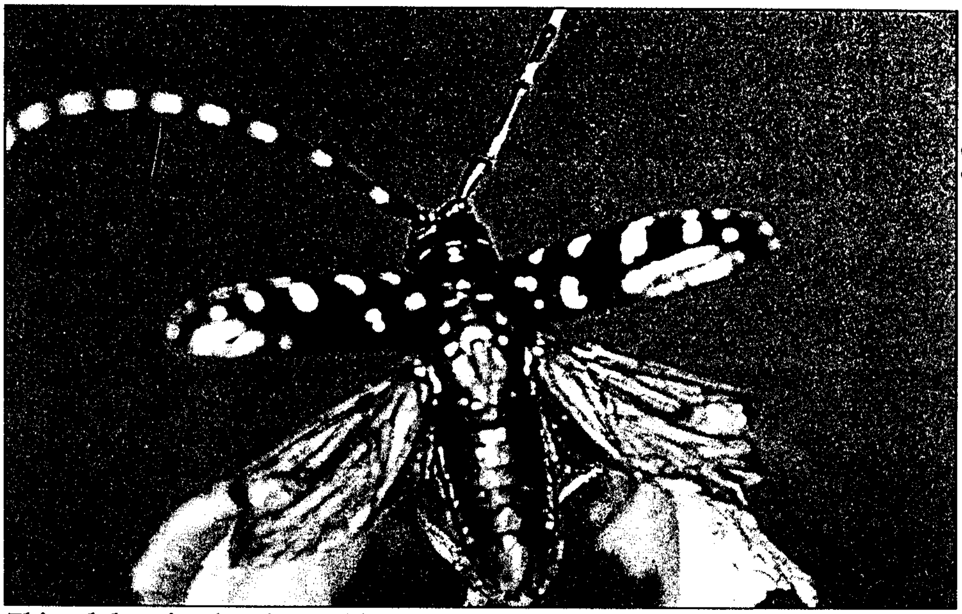

Photo courtesy of M.T. Smith and the USDA

This adult Asian longhorned beetle, *Anoplophora glabripennis*, prepares to fly toward a new host tree. The beetle disperses by flying and also is carried hidden in firewood and in international shipments containing raw wood.

By Michael T. Smith

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 beetle are currently known to exist within the U.S. One active population, which was first identified in 1996, is killing trees in New York City and parts of Long Island. The second population was found in Chicago, Illinois, in 1998 and led to the destruction of more than a thousand trees. In addition, the pest has been intercepted in shipments to 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 pest beetle is killing valuable street, park and residential trees, especially maples, *Acer* spp. 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. The pest beetle 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 maples.

Its potential risk is further emphasized by the fact that maples comprise approximately 30% of all urban trees in eastern U.S. If the pest beetle is allowed to spread by natural dispersal or incidental transport 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,

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Update

Photo courtesy of M.T. Smith and the USDA

This is a newly emerged adult beetle.

the Asian longhorned beetle is a primary wood borer pest of many deciduous broadleaf tree species, particularly poplar, *Populus* spp.; and willow, *Salix* spp.; as well as elm, *Ulmus* spp.; and maple. About 45% of the poplar plantations in China have been damaged by these beetles. In five seriously infested provinces, the pest beetle, together with the related species *A. nobilis*, has infested over 240 cities or counties, totaling 568,000 acres (230,000 ha). Over 50,000,000 trees had been cut down from 1991 to 1993 in Ningxia province alone, resulting in losses of $37 million (U.S.) Although many control methods are under development for the pest in China, identification and removal of infested trees remains the only widely used method.

Current Management

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:

- detection methods for ALB;
- control methods for ALB;
- information on the dispersal potential of adult ALB, which will be used in establishing quarantine boundaries; and
- 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 replanting 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 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 is just beginning, previously published information on the management of ALB and other *Anoplophora* species in Asia and elsewhere offers insight into the potential of various management methods both here in the U.S. and in China.

Natural Enemies

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 seen infecting larvae.

Parasitoids

Of the natural enemies attacking longhorned beetles, several parasitize either the egg or larval stage. Natural enemies known to attack the Asian longhorned beetle and/or beetles belonging to the same genus include the eulophid egg parasitoid, *Aprostocetus fukutai*, which parasitizes both *A. chinensis* and *Apriona germarii*. However, no egg parasitoids have as yet been collected from ALB or *A. nobilis*. Several larval parasitoids have been identified, including the braconid, *Ontsira* sp., 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 pest within 10 days. [Larvae of *D. longulus* may also be thought of as predators of larval *A. glabripennis*. The beneficial larvae consume the pest larvae, leaving nothing but an exoskeleton. An artificial diet has been developed for the beneficial, making insectary rearing possible (Ogura et al. 1999).] In locations where *D. longulus* is established in relatively high numbers, the Asian longhorned beetle is 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.

Predators Scarce

Although a number of invertebrate predators have been reported feeding on longhorned beetles worldwide, 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 birdnests in poplar plantations has been suggested to encourage them.

Pathogens

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.

Nematodes

Finally, the entomopathogenic nematodes *Steinernema bibionis* and *S. feltiae*, when inserted into

Box A. Biology and Improved Detection

Detection at the moment relies on visual detection of adult beetles and exit holes. The adult beetle is about an inch long (25.4 mm), shiny, black with bright white spots, and has 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 (9.5 mm) or larger in the bark of infested trees. The holes are so dramatic that affected homeowners in New York at first thought their trees had been attacked by drill-wielding vandals.

The current method of detection is to stand below trees and visually inspect with binoculars. With this method only about one-third of the infested trees can be detected. The author and Stephen A. Teale, an entomologist at State University of New York at Syracuse have been working on an acoustic detector. Beetles can be detected from a distance of 19-20 ft (6 m) by the chewing sounds they produce (Becker 2000).

Newly emerged adults feed on bark, then mate on twigs and branches. When the newly emerged beetles are mating, this is a good time to detect them. Though pheromones may be involved in the mating process, none have been isolated yet (see *IPMP* 22(3):10). Isolation of pheromones could lead to pheromone traps, which could make monitoring easier.

After mating, beetles disperse and females start laying eggs. Though the usual flight is about 50 yards (46 m), the beetle is capable of flying non-stop for more than 400 yards (366 m). Because they live more than 40 days, they can potentially travel 5 miles (8.3 km) or more during their lifetime. Mark- recapture studies show dispersals up to a mile (1.6 km) in one season (Haack et al. 1997; Smith et al. 2000).

Females chew through bark and lay a single egg, which is about one-quarter inch long (5-7mm). Each female can lay about 25-40 eggs from July to early November. According to Haack et al. (1997), "adults typically lay eggs first in the upper trunk and along major branches where the bark tends to be smooth. Small branches, 3 to 4 cm in diameter can be attacked. As the tree crown begins to die, adults lay eggs along the entire trunk and even on exposed roots" (Haack et al. 1997).

Eggs hatch in one or two weeks, and the larvae, which can grow to two inches (51 mm) in length, chew their way into sapwood and heartwood, often killing the tree. Hungry larvae excavate galleries where they pupate and become adults. New adults chew their way back out through the bark, leaving the distinctive exit holes (Haack et al. 1997).

If you suspect that you have found an Asian longhorned beetle, call your APHIS-PPQ State plant health director or your county agricultural commissioner.

borer holes, have been reported to result in a minimum of 60% mortality of ALB. Strains of *Heterorhabditis* 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.

Search for Natural Enemies

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 windbreaks, hedgerows, plantations and natural forests. These areas 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 investigations 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 the pest in the U.S. and in China.

Challenges and Potential for Management

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 for effectiveness. While ALB has been reported to complete its development on trees belonging to at least six genera in the U.S. (maple, birch, poplar, willow, horse chestnut, 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 the 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 the pest in the U.S.

Another challenge is that the Asian longhorned beetle is largely cryptic, and remains hidden within the tree during approximately 90% of its lifecycle. 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. (See Box A.)

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 the pest 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 management. 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.

Natural enemies may be particularly abundant in the forested areas of northeast China where the beetle is 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.

Diverse Plantings Important

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 the pest 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 the beetle, 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

Photo courtesy of M.T. Smith and the USDA

The author is shown listening for the noises of chewing beetle larvae. Acoustic detectors have potential for monitoring the beetle.

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.

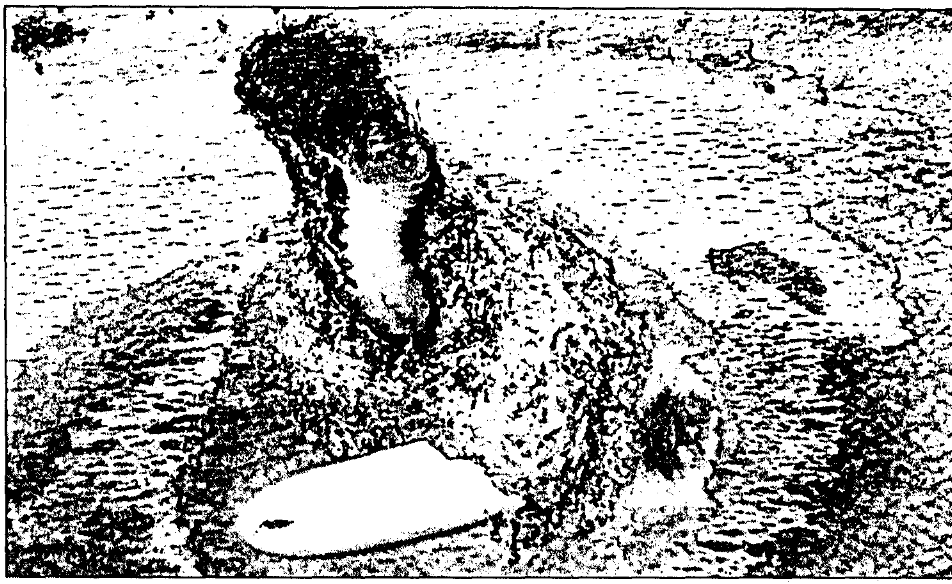
A successful biological control program for ALB in the U.S. and China will rely heavily upon the integration of several other essential components. Conservation of native natural enemies, introduction of exotic natural enemies, and utilization of resistant hosts is paramount. Resistant trees should either be repellent or unattractive to adult beetles, or they should not support growth and development of immature stages.

Egg and Larval Stages Vulnerable

Biological control and host plant resistance will likely focus on the egg and early larval stages of the pest, as they represent the more vulnerable stages of its lifecycle. Selection of tree species which can withstand compaction, air pollution, and other common stress factors associated with the urban landscape should be encouraged. As in any pest management program, selection of plants or trees which are best adapted to a particular site is often the most important decision. This fact may be particularly true in urban landscapes, where the implementation of control measures such as insecticide applications 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.

Conclusion

Identification of weak links in the life history and behavior of the Asian longhorned beetle will play a major role in developing components of an IPM program. This program may include better detection methods, biological control, resistant species, bait trees and insecticides. Any one of these components, if exclusively utilized for management of the pest beetle, could jeopardize the entire program if it failed. Therefore, an IPM approach involving several components will be essential for success.



A newly emerged larva is shown with an egg. Eggs and new larvae are hidden just beneath the bark.

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Dr. Michael T. Smith works at the United States Department of Agriculture, Agricultural Research Service, Beneficial Insects Introduction Research Laboratory, 501 S. Chapel St., Newark, DE 19713.

Relevant Websites

Chicago Botanic Garden's
http://www.chicago-botanic.org/Asianbeetle.html
Illinois Department of Agriculture:
http://www.agr.state.il.us/beetle.html
Purdue University:
http://www.ceris.purdue.edu/napis/pests/alb
USDA-APHIS:
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University of Minnesota: http://willow.ncfes.umn.edu/asianbeetle/beetle.htm
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