Invasion of the Asian Longhorned Beetle *Anoplophora glabripennis* (Coleoptera: Cerambycidae): A Canadian Focus

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The Asian longhorned beetle (*Anoplophora glabripennis*) is a large, wood-boring invasive insect species native to China and Southeastern Asia that preys upon healthy hardwood trees, as well as trees under stress, by tunneling through their vascular system and depriving them of vital nutrients, leading eventually to their death. Since its discovery in the mid-1990s and early-2000s in the United States and Canada, respectively, government officials have been actively involved in preventing the further spread of this pest by screening cargo and surveying high-risk sites (Bell, 2004). Unfortunately, the only effective treatment to recover an Asian longhorned beetle-infested region is to cut down infested trees and destroy the wood. This has led to the removal of tens of thousands of infested urban trees in an effort to eradicate this exotic pest (Nowak *et al*., 2001). In fact, it has been predicted that if the *A. glabripennis* outbreak were to become widespread, it would significantly impact forests across North America, with an estimated death toll of 1.2 billion trees (Nowak *et al*., 2001).

A. glabripennis is believed to have been accidentally introduced from China to North America in untreated solid wood packing material, such as wooden crates, sometime during the early-1990s. It was first discovered to have colonized and infested trees in the United States along the coast of New York State, in 1996 (Peterson *et al*., 2004). In 1998, a growing population of *A. glabripennis* was detected in the Chicago, Illinois area (Nowak *et al*., 2001), and a third location infested with this species was identified in Jersey City, New Jersey, in 2002 (MacLeod *et al*., 2002). More recently, the Canadian Food Inspection Agency confirmed the presence of this exotic species in the Woodbridge area of Southern Ontario in 2003 – although probably present since at least 1998 (Bell, 2004). Since dispersal distances for beetles are relatively short – average of 106.3 metres (Wen *et al*., 1998) – it is believed that the infestations discovered in New York State and New Jersey spread from the same point of entry, whereas the infestations in Chicago and Woodbridge originated from separate points of entry. Spread by human activity can also accelerates dispersal, especially if packing material or firewood infested with eggs, larvae, and pupae are shipped without proper inspection or chemical treatment (Nowak *et al*., 2001). Unfortunately, estimates on the introduction date in Ontario predate the regulations enacted to prevent the movement of untreated wood from Hong Kong and China (Bell, 2004). Although various life stages of the beetle have been detected by alert workers in warehouses (Nowak *et al*., 2001), no other established *A. glabripennis* populations have been detected in the United States and Canada.

The number of annual generations of *A. glabripennis* varies with climate and latitude (EPPO, 1998). That is, the further North *A. glabripennis* is found, the longer it takes for a generation to develop. For instance, in Taiwan, one generation occurs per year, whereas in Northern China, a single generation takes two years to develop (MacLeod *et al*., 2002). Similarly, in Ontario, *A. glabripennis* has a one to two year life cycle. Adult beetles generally emerge in July and August, while some have been found as early as June 26th in New York (Nowak *et al*., 2001), and live for about a month to as late as mid-autumn (EPPO, 1998). In contrast, adult beetle emergence in Southern China begins in early spring, and in late June and July farther North (Nowak *et al*., 2001). This period also underlies when adult beetles are most active, especially during the heat of the day. The adults typically show a strong preference to lay eggs in the host-tree from which they emerged or fly relatively short distances to another host, where they feed on leaves, petiole, and the bark of young new shoots, when the population density becomes too high in their original host (MacLeod *et al*., 2002).

After mating, the Adult female *A. glabripennis* chews out oval or round grooves, known as ovipositing sites, into the main trunk, branches, and exposed tree roots, where eggs are laid a week after copulation (MacLeod *et al*., 2002). An adult can chew up to 35 to 90 individual depressions and lay up to 25 to 40 eggs per generation. The eggs, which are about 5 to 7mm long, are laid one by one under the bark, with each egg occupying a single oviposition slit (EPPO, 1998). The slits are typically cut on the Eastern side of the trunk or of branches greater than 5cm in diameter (MacLeod *et al*., 2002). Within a two-week period, larvae of *A. glabripennis* hatch from their oviposition niche and immediately bore into the wood, creating a visible scar on the surface of the bark. The larvae possess an off-white body colour and brown mandibles, with a segmented body that can reach a size of up to 60mm.

Early instar larvae feed in the phloem and the primary xylem layers of the branches and trunk and later enter the woody central part of the secondary xylem known as heartwood tissue (EPPO, 1998). Disruption of the cambium-phloem interface reduces nutrient and water transport within the tree, whereas the destruction of sapwood or heartwood tissue caused by later instar larvae, severely weakens the trees' structure and stability (Kreutzweiser *et al*., 2008). Generally, larvae of *A. glabripennis* feed in more than 24 species of hardwood trees (Nowak *et al*., 2001; MacLeod *et al*., 2002). In its native China and South Eastern Asia, including Taiwan, Korea, and parts of Japan, it prefers species of willows and species of cottonwood, whereas in the United States and Canada, species of maple are most commonly attacked (MacLeod *et al*., 2002). Other hardwoods species, including poplar, birch, horse chestnut, elm, and several new hosts have been documented in North America (Nowak *et al*., 2001).

Pupation of mature larvae takes place in chambers at the end of the feeding tunnel within the heartwood. The pupae hatch into adults over the winter months and chew their way out of the tree, leaving large circular holes, 10mm across, above the sites where the eggs were initially laid, accompanied by large amounts of sawdust-like wood shavings and animal waste, known as frass, packed into the chamber or around the base of the tree. In contrast to adult female *A. glabripennis*, male beetles are significantly smaller in size and can be seen anywhere on the tree as they rest or wander in search of a mate. Adult male *A. glabripennis* are typically 25 mm long, while adult females are 35 mm long. The antennas are 2.5 times the body length in males and 1.3 times the body length in females – giving rise to this beetle's common name – and have 11 segments, each with a whitish-blue base. The beetle is glossy black with about 20 irregularly-shaped white spots scattered along its wings (EPPO, 1998).

A. glabripennis is one of the most serious pests in China, causing substantial economic damage to poplars throughout the country (Macleod *et al*., 2002). Since larvae tunnel deep into the tree, killing this pest with biological or chemical pesticides remains a challenge. Like many exotic species, *A. glabripennis* has no known natural predators in North America that can control its spread. Recent studies, however, have shown a particular insecticide, known as imidaclorid, to be quite effective against beetles, especially when applied though soil and trunk injections (Wang *et al*., 2001). Insecticide treatment by soil injection under host trees has commenced in Ontario (Bell, 2004) and Chicago (Nowak *et al*., 2001). However, neurotoxic pesticides are harmful agents that are likely to cause unforeseen problems to indigenous species living on trees or within the soil and to waterways if used on trees alongside riparian zones. This measure only provides control, rather than eradication. Other control options currently being adopted include (Macleod *et al*., 2002): (i) Complete felling and destruction of infested trees to reduce population size and prevent spread; (ii) the use of chemical insecticides that prevent adults from laying eggs on the surface of the bark or sprays that kill adults directly; (iii) the use of trap trees to capture adult beetles and prevent them from laying eggs on specific surveyed trees; and (iv) planting trees that are more tolerant to *A. glabripennis* invasion.

Since more than 50 percent of Toronto's urban trees are maple, infested trees pose the threat of personal injury and property damage that can result from tree breakage where beetles have weakened stems and branches (Nowak *et al*., 2001). These trees and others threatened provide the city it aesthetic appeal, protection from the sun, fresh oxygen, and habitats for wildlife, such as birds and mammals. Thus, the removal of street and parkland trees in urbanized areas will likely cause a reduction in property value (Macleod *et al*., 2002). Furthermore, if *A. glabripennis* were to expand and go unchecked beyond current quarantined urban areas, the Canadian forest-based economy, which generates more than $30 billion in wood products annually, would inevitably falter and collapse. Similarly, the maple syrup industry, which generates another $213 million each year, would also be impacted. Broad-leaved deciduous trees are a vital component of healthy woodlands in Southern Canada. An uncontrolled population growth of *A. glabripennis* would not only affect tourism and recreation to which healthy forests support, but it would also overwhelm forest health and biodiversity. In Ontario, the number of trees removed after the first outbreak was 11000+ trees (Bell, 2004). Likewise, since the discovery of the infestations in 1996, damage from infestations in the United States has resulted in the removal of 30000+ trees and cost to State and Federal governments in excess of $269 million (Macleod *et al*., 2002).

Due to the Asian longhorned beetle's obscure lifestyle and tendency to lay a relatively low number of eggs on several different host species (Macleod *et al*., 2002), prospects for early detection and successful eradication of infested sites are reduced. However, if appropriate awareness is raised to the public, early detection of infestations by community members will likely decrease the spread of this invasive species. Henceforth, the full cooperation of the general public is required if eradication programs are to succeed.

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