One beetle too many: The emerald ash-borer, *Agrilus planipennis* (Coleoptera: Buprestidae), threatens *Fraxinus* trees in Europe

Brigitta Wessels-Berk[1] & Ernst-Jan Scholte[1,2]
[1]Dutch Plant Protection Service, PO Box 9102, 6707 EA Wageningen, The Netherlands, E-mail: b.f.wessels-berk@minlnv.nl; [2]National Institute for Public Health and the Environment (RIVM), PO Box 1, 3720 BA Bilthoven, the Netherlands

The emerald ash-borer, *Agrilus planipennis* constitutes a major risk to ash (*Fraxinus*) trees in Europe. This beetle, originating from Eastern Asia, has become a pest in northern America, killing over 20 million *Fraxinus* trees. The larvae destroy ash trees by boring serpentine tunnels in the phloem, just beneath the bark, cutting off food. No control method exists other than destroying the larvae by cutting and chipping host trees. The potential impact if this beetle invades Europe will be huge.

Keywords: Agrilus planipennis, *Fraxinus*, phytosanitary risk, Europe

The emerald ash-borer, *Agrilus planipennis*, has the dubious honour to be one of the most feared beetles on earth (Fig. 1). It has the highest quarantaine status (IAI), and National Plant Protection Organizations (NPPO's) around the world continuously inspect their indigenous *Fraxinus* trees and imported wood products on the presence of this beetle because its presence usually results in the destruction of *Fraxinus* trees (Nomura 2002).

Agrilus planipennis belongs to the family of the Buprestidae, also called jewel beetles or metallic wood-boring beetles. Buprestidae are relatively small, elon-

Figure 1. Habitus and close-up of emerald ash borer, *Agrilus planipennis*. Source: www.padil.gov.au

gated beetles. Adult beetles measure between 3 and 100 mm, although most species are smaller than 20mm, with bright, iridescent colours. The larvae of all species of this genus bore tunnels in plant material, including leafs, logs, stems, and roots. *A. planipennis* measures approximately 7.5-15 mm and its larvae (1.5-3 cm, white colour) bore into wood. Females lay eggs on the bark of a host tree (*Fraxinus*) in May-June. One female lays about 65-90 eggs during her lifetime. Eggs hatch and the larvae bore to the phloem area just behind the bark, where they tunnel serpentine tunnels. The development through four larval stages takes approximately 1-2 years in temperate zones. Fourth instar larvae excavate chambers either in the bark or slightly in the sapwood, where they become prepupa in September-October. Most of the population overwinters in this stage, although some individuals overwinter as earlier-instar larvae. In these chambers, they moult into pupae during spring, and emerge as adults in May/June. The adults live approximately 2-3 weeks, during which they disperse no more than several kilometres (Nomura 2002)

Host plants of *A. planipennis* are almost exclusively *Fraxinus* trees: in northern America they include *F. americana*, *F. chinensis*, *F. japonica*, *F. lanuginose*, and *F. nigra*, but the species was also found in *Ulmus davidiana* var. japonica, *Ulmus propinqua*, *Juglans mandshurica* var. *sieboldiana*, and *Pterocarya rhoifolia,* and in Europe *F. excelsior*, *F. pennsylvanica,* and possibly *F. angustifolia* (Lyons *et al.* 2007, Volkovich 2007).

The original distribution of *A. planipennis* includes Mongolia, central, eastern, and north-eastern China, Taiwan, both Koreas and Japan (EPPO 2006). In July 2002 the species was found in Northern America: specimens were identified in south-eastern Michigan, USA, but evidence suggests that it may have been established in the state five years earlier (Haack *et al.* 2002). It is currently present in seven US states (CEAP 2008), including Michigan (2002), Ohio (2003), Indiana (2004), Illinois (2006), Maryland (2006), Pennsylvania (2007), and in Ontario, Canada. It is believed that the species entered the USA at Detroit, in dunnage from cargo ships. In Europe, the species was found in Moscow, Russia in 2005, and seems to be spreading (Volkovich 2007). The pathway of this introduction is not known. The species has not been found in other areas of Europe.

The species damages infested trees because the larvae bore serpentine tunnels in the cambial layer and the inner bark (phloem), disrupting, or even completely cutting off the nutrient flow from the leaves to the roots. Nomura (2002) states that, 'during the early stage of an infestation, when *A. planipennis* population is low, the initial damage is low. However, after 2 to 3 years of continuous infestation, the population builds up, and eventually the tree's nutrient and water transport system is disrupted, culminating in wilting and eventual tree mortality. *A. planipennis* will kill apparently healthy trees during high beetle population levels which are probably triggered by a few years of hot and dry climatic conditions. *A. planipennis* can cause severe damage to ash stands over 8 years

of age that are not crown-closed, with good sun light penetration, and that are comprised of trees with bark fractures. After 1 to 2 years of infestation, the bark often falls off in pieces from damaged trees thereby exposing the tunnel-ridden sapwood. In the most severe cases, entire stands may be destroyed'.

In its natural area, *A. planipennis* population dynamics are balanced due to natural enemies: parasitoids, predators, and entomopathogenic fungi. In a search for natural enemies in China, only two species were found: a *Spathius* sp. (Braconidae), and a *Tetrastychus* nov. sp. (Eulophidae), but with relatively high infection levels, ranging between 0 and 50%, with averages of 6.3 and 6.6% respectively (Liu *et al.* 2003). In Northern America, natural enemies were found as well, but infection levels were always lower than 1% (Bauer *et al.* 2004). Apparently, the absence of most of these natural enemies in the 'new' areas has an enormous impact on the populationdynamics, allowing build-up of *A. planipennis* populations to such high levels as to become a true pest. As a result, more than 20 million *Fraxinus* trees were killed by this species in southern Michigan. In the Moscow area, where *A. planipennis* was first found in 2005, many *Fraxinus* trees in city squares or along railway tracks declining or dying. In some places, 70-80% of the *Fraxinus* trees have lost most of their foliage (EPPO 2007).

Other symptoms that may indicate an *A. planipennis* infestation and may be seen from the outside, include crown dieback/chlorosis, epicormic shoots, increased woodpecker and squirrel feeding, bark deformities, foliage feeding, and exit holes. The exit holes are D-shaped of 3.5-4.1 mm in diameter. A clear sign of *Agrilus* sp. infestation that can not be seen from the outside, is the presence of typically serpentine shaped larval galleries, mostly filled with frass. They can easily be found by peeling away the bark (Lyons *et al.* 2007, Moraal and Wessels-Berk 2007). It should be noted, however, that once signs and symptoms become apparent, trees are often severely infested and infestation may have spread to surrounding areas where infestation signs are not apparent yet. Based on the infestation symptoms, examination techniques applied by inspectors should include visual inspection, crown survey, and bark peeling.

Control of larvae is difficult. Only systemic chemical insecticides can reach the well-hidden larvae. This can be done by tree-injection, soil drenching, or soil injections with imidacloprid (Smitley & McCullough 2004). Adults can be killed by using trunk and foliage spraying with cyfluthrin. Ongoing studies suggest that biological control using the entomopathogenic fungus *Beauveria bassiana* sprayed on tree trunks is another option for control of adults, causing up to 50% infection rates. Currently, the most effective way to control and try to eradicate an outbreak of *A. planipennis* is by cutting down and chipping infested trees in the infested and surrounding area. In northern America, domestic phytosanitary measures have been imposed to restrict the movement of ash trees, firewood, branches, and logs from infested to non-infested areas (Haack *et al.* 2002, EPPO 2005)

Having witnessed the spread and damage by *A. planipennis* in the USA, the fact that indigenous *Fraxinus* trees (*F. excelsior*, *F. angustifolia*, *F. ornus*) and imported *F. pennsylvanica* are very common in Europe (Pliura & Heuertz 2003), and the fact that the species has already entered eastern Europe, it is clear why this species poses a serious phytosanitary risk for Europe. Since *Fraxinus excelsior* is very common in the Netherlands, it is recommended that the Dutch NPPO develops a contingency plan for this species.

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