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First records and reproductions of the Asian longhorned beetle *Anoplophora glabripennis* (Motschulsky) (Coleoptera, Cerambycidae) in Switzerland

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The Asian longhorned beetle *Anoplophora glabripennis* (Motschulsky, 1853) is an invasive, tree-killing species native to East Asia, which was introduced to North America in 1996 and to Europe in 2001. In 2011, the first findings of 4 living adult beetles as well as numerous egg depositions in maples (*Acer pseudoplatanus*) were documented in a village in Canton Freiburg. In 2012, a mass infestation, mostly of maples, was detected in the city of Winterthur (Canton Zurich). Approximately 150 adult beetles, numerous larvae and new ovipositions were recorded on around 120 infested trees. In both years, several additional incidences of dead beetles and living larvae were detected on pallets with Chinese granite curbstones at Rhine ports near Basel and some inland construction sites. The Winterthur population probably represented the third generation after the first infestation, which most likely occurred six years ago, and the unnoticed emergence of two generations two and four years later. Control measures include the felling of infested trees and meticulously checking for infestation signs on nearby potential host trees, assisted by trained sniffer dogs. The species most frequently mistaken for *A. glabripennis*, because they look alike, are presented.

Keywords: *Anoplophora glabripennis*, Cerambycidae, new records, quarantine pest, Switzerland

INTRODUCTION

The Asian longhorned beetle (ALB) *Anoplophora glabripennis* (Motschulsky, 1853) is indigenous to China, both Koreas and Taiwan. In China it is known as a widespread insect living on broadleaf trees. There, ALB frequently occurs on poplar species (*Populus* spp.), often in pure afforested stands. ALB did not appear as a serious pest until large-scale plantations of susceptible poplars were initiated in the 1980s (Haack *et al.* 2010).

In the 1990s, ALB was repeatedly introduced to North America, where it spread in urban areas in the northeastern part of the USA, in Chicago, and in the region of Toronto in Canada. In most cases, interceptions occurred when living ALB larvae were shipped in wooden packaging material. Since 2001, ALB has been detected in various European countries (EPPO 2012a). The first interception was recorded in Austria (Dauber & Mitter 2001). The European and Mediterranean Plant Protection Organization EPPO lists ALB as an A1 quarantine organism (EPPO 2012b), and countries are obliged by law to conduct surveys and introduce control measures. A recent comprehensive overview of the biology and pest status worldwide can be found in Haack *et al.* (2010).

In Switzerland, the first incidences of living and dead ALB beetles, larvae, and egg depositions were recorded in 2011 and 2012. They are documented here in detail.

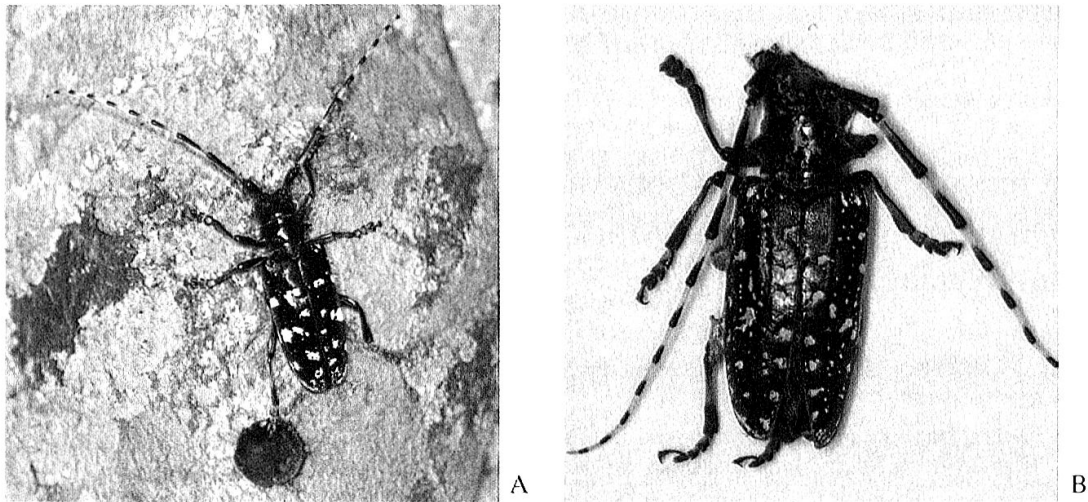


Fig. 1: Adult *A. glabripennis* with the usual large, white spots, near an exit hole (A; location Winterthur ZH), and a rare form with more numerous, yellowish spots (squashed specimen) (B; location Frutigen BE).

MORPHOLOGY AND BIOLOGY OF *A. GLABRIPENNIS*

Anoplophora glabripennis is a large cerambycid species from the subfamily Lamiinae. Its body length typically ranges from 20 to 35 mm, with the males somewhat smaller than the females. Males have antennae that attain more than twice their body length, while the female antennae are just slightly longer than their body. The pronotum carries two distinct lateral spines. The basic color of the stout body is shiny black, with the elytra usually showing a variable pattern of between 10 and 20 white spots, exact number and color can, however, vary considerably (Lingafelter & Hoebeke 2002; Fig. 1). The conspicuous antennae are banded black and blue/white, while the legs and tarsi are black with a blue pubescence. Unlike the very similar congener *Anoplophora chinensis* (Forster, 1771), of which two individuals were recorded in Switzerland six years ago (Wermelinger 2006), the elytral base of *A. glabripennis* is quite smooth rather than granulated as in *A. chinensis*.

A detailed description of the species and a key to *Anoplophora* (Hope, 1839) are provided in Lingafelter & Hoebeke (2002).

The oblong flat eggs are off-white and 5–7 mm in size (Fig. 2A). The larvae are legless. This is an important characteristic to distinguish them from other similar cerambycid larvae (see below). The ALB larvae grow up to 5 cm in length and have a pinnacle-like pattern on the prothoracic plate (Fig. 2B).

For oviposition, the female chews a funnel-like pit or a slit into the bark of its host tree. There it inserts its ovipositor and slides it between the phloem and the sapwood before injecting an egg a few millimeters from the basis of the funnel. Females usually produce around 30–60 eggs each, but sometimes even up to 200 eggs (Smith *et al.* 2002, Keena 2006). After 1–2 weeks, the larvae hatch and start feeding in the phloem. In the third instar, they penetrate into the sap- and heartwood and excavate an oval-shaped gallery of up to 30 cm in length. They pass through a large number of instars (usually around 9 to 14). In the laboratory, the number was found to vary within a range of even 5 to 21, depending on temperature and body weight (Keena & Moore 2010). Eventually, the larvae pupate near the bark surface at the end of the gallery, separated from the remaining gallery by wood shavings.

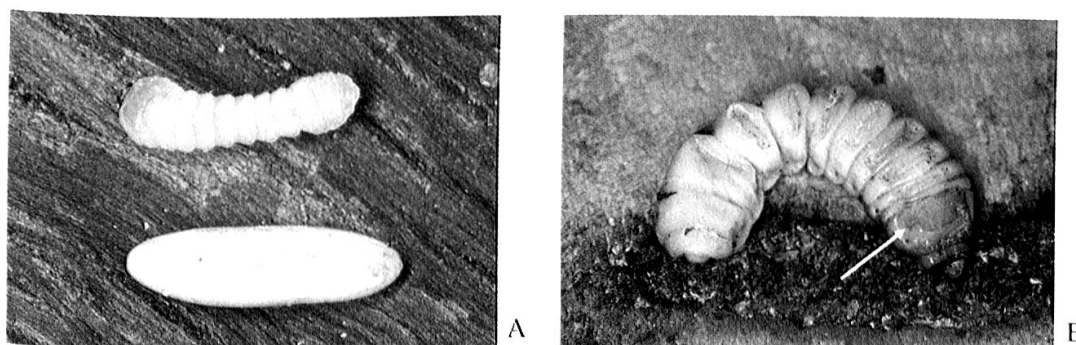


Fig. 2: Egg (5 mm) and neonate larva (A) and late-instar larva (B) of *Anoplophora glabripennis*. Its prothoracic plate (arrow) distinguishes it from *Saperda* spp.

After a 2–3 week pupation time, the adult beetles emerge from the tree by chewing perfectly circular holes 1 cm in diameter, on average. In Central Europe, the complete cycle usually takes two years, but it may be shortened to 1.5 years after heat years. Upon emergence, the beetles perform maturation feeding on the green bark of twigs or on leaves. They do not readily fly and often look for feeding and oviposition sites by just crawling around within the crown of their birth tree. Thus, trees that are large and suitable enough may be colonized by several subsequent generations. They only take flight on warm, sunny days within a radius of up to 250–500 meters. During the entire adult lifespan of 1–2 months, the range may extend up to 1–3 km (Smith *et al.* 2001). The flight activity of ALB covers the entire vegetation period from May to October. Females are attracted by a combination of male pheromones and host tree volatiles, while males respond primarily to host tree volatiles (Nehme *et al.* 2010).

The Asian longhorned beetle colonizes a very large range of broadleaf host trees (Haack *et al.* 2010; see section on «Importance» in this paper). The favorite host is maple, but host preferences seem to vary between continents (Benker & Bögel 2008). ALB preferably attacks the upper parts of the trunks and branches of both, young and old, healthy and weakened trees. In contrast to *A. chinensis* it does not breed in roots. Young larvae need a living tree to develop under the bark, but once penetrated into the wood, they can survive and pupate also in dead trees and in sawn timber (MacLeod *et al.* 2002).

INFESTATION SYMPTOMS

The most obvious symptoms are the large circular exit holes, which indicate that adults have successfully developed. Other signs of the presence of adult beetles are peeled-off bark on twigs from maturation feeding, and oviposition pits or slits in the bark of trunks and branches, often accompanied by sap oozing. Oviposition sites are frequently found on the sunny side of the trunks. These symptoms may be difficult to detect from the ground if the bark surface is covered with lichen, moss or even ivy.

ALB larvae may expel brown or white frass during their development, which can aggregate at the base of trees or in crotches between branches. A less specific symptom is the sparse foliation of infested trees. At a later stage in large trees, the crown may die back and branches break due to the larvae tunneling in the wood and subsequent fungus infections.

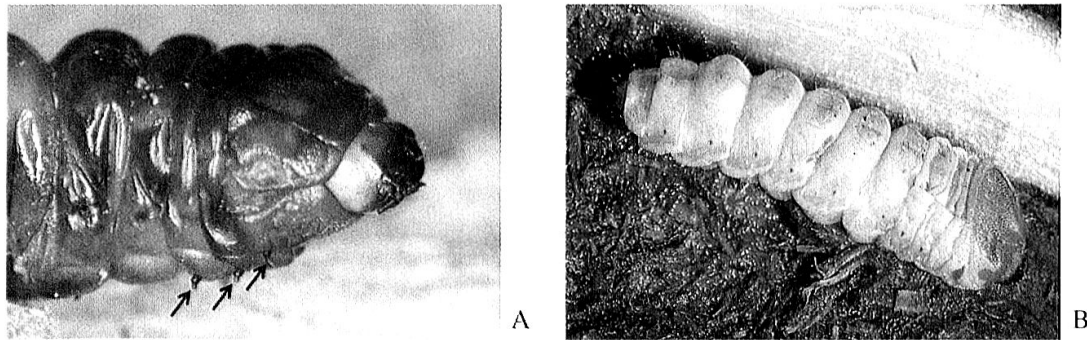


Fig. 3: Larvae of *Aromia moschata* (A) and *Saperda carcharias* (B). Arrows indicate the legs (photo on right: G. Csóka).

POSSIBLE CONFUSIONS

The Swiss Forest Protection Service at WSL was consulted around 160 times after the large infestation in Winterthur (see below). In most cases, native species were confused with ALB, the most frequent ones are specified below. Similar-looking adult beetles can be found in many places in association with other host trees and other habitat types. The species that looked most alike and that were most often mistaken were *Monochamus sartor* (Fabricius, 1787) and *M. sutor* (Linnaeus, 1758), which both develop in conifers. *Monochamus* spp. have dull, coarse elytra and a yellow scutellum, while ALB has shiny, smooth elytra and a black scutellum. The ALB finding from Frutigen (see below) with numerous yellowish spots did indeed look like a *Monochamus* species at first sight (Fig. 1B). Other mistaken cerambycid beetles were *Saperda carcharias* (Linnaeus, 1758) and *Aromia moschata* (Linnaeus, 1758), but these are easily distinguishable because of their color and the lack of white spots. In addition, several findings of the red-listed *Rosalia alpina* (Linnaeus, 1758) have been reported in this context.

Larvae are much more difficult to identify, especially for lay people. Larvae were usually collected from broadleaf trees that are also potential hosts for ALB, mainly willow (*Salix* spp.) and poplar, and that were suspected to have been attacked by ALB. In willow, *A. moschata* larvae were most often found, occasionally together with ALB larvae. Since these two species belong to different subfamilies, *A. moschata* larvae can be clearly discriminated from *A. glabripennis* by the presence of tiny thoracic legs (Fig. 3A). Larvae in poplar may be *S. carcharias*, which have a punctured prothoracic plate rather than a pinnacle-formed one (Figs. 2B, 3B). Likewise in poplar, the caterpillars of the clearwing moth *Sesia apiformis* (Clerck, 1759) (Sesiidae) have distinct thoracic as well as prolegs, and a head capsule markedly larger than that of ALB. In addition, two cossid moth larvae, i.e. *Cossus cossus* (Linnaeus, 1758) and *Zeuzera pyrina* (Linnaeus, 1761) (Cossidae) have been frequently reported because they are abundant and share many host species with ALB. However, their striking colors and prolegs make them easily discernable.

IMPORTANCE AS A QUARANTINE PEST

In Europe and North America, ALB is clearly a primary pest, i.e. it also attacks healthy trees. After a few years, a colonized host tree, or at least some parts of its crown, will die due to the larval galleries and subsequent infection with fungal

pathogens. Host trees include a wide range of broadleaf species. In the region of its origin, this polyphagous beetle has become most detrimental in poplar and maple plantations. In the countries of introduction, the favorite host trees so far have been maple, horse chestnut (*Aesculus*), poplar, birch (*Betula*), willow, sycamore (*Platanus*), black locust (*Robinia*), elm (*Ulmus*), stone fruit (*Prunus*), and ash (*Fraxinus*) (Haack *et al.* 2010).

Larvae can develop in branches as thin as 3 cm in diameter, and exceptionally even in smaller ones. Larvae can survive in sawn boards 1.5 cm thick, so long as they are not injured during sawing. Thus, adults can emerge later from untreated wooden products like transport pallets.

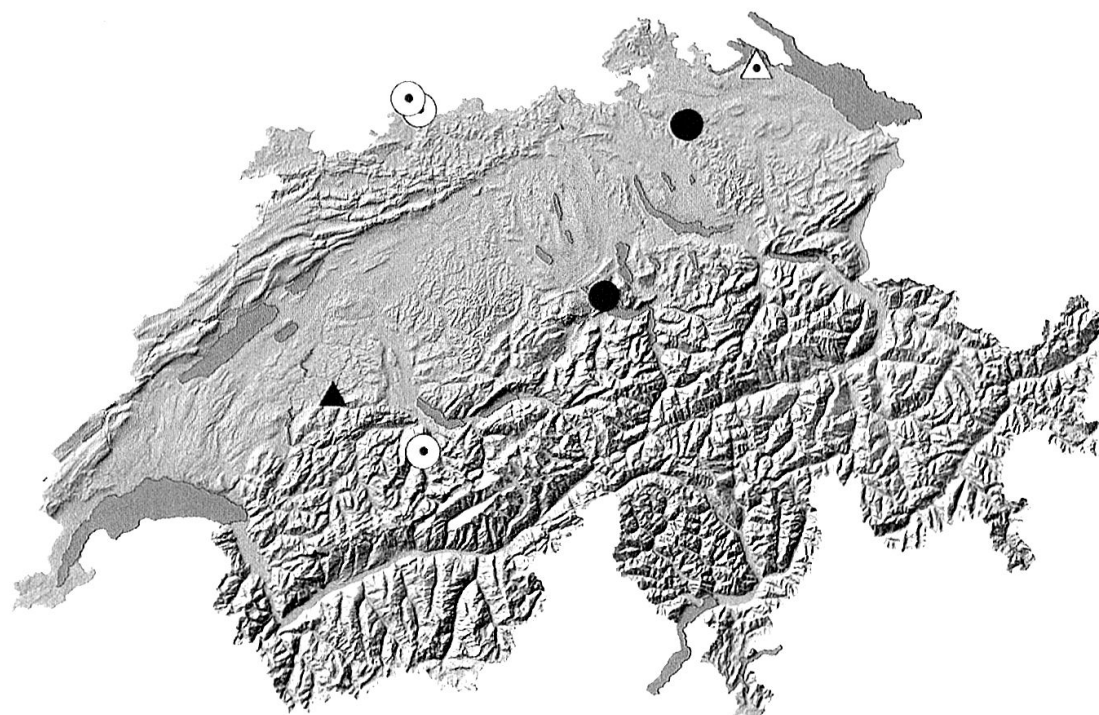
Until now, ALB has mostly occurred in urban or industrial areas where infested wood packaging material is stored. In Europe, infestations or detections of larvae in imported packaging material or imported trees have also been documented in Austria, Belgium, Denmark, France, Germany, Italy, Netherlands, Poland and United Kingdom (EPPO 2012a). Host trees are often ornamental trees in alleys, parks or gardens. Dead branches in the crown of dying trees could pose a risk for people and vehicles if they fall, and the trees will lose their ornamental value. In North America, control measures cost millions of dollars. The tasks of surveying, removing and later replacing of the trees are enormous, if the infestation is not detected early and measures are not taken in time.

As long as ALB has not spread into the forest, a complete eradication of a smaller infestation spot is feasible. Outside its natural range in East Asia, ALB has not yet been found in large forested areas. Complying with the European regulation, the goal of the plant protection authorities must be to eradicate this invasive pest.

INCIDENCE OF *A. GLABRIPENNIS* IN SWITZERLAND

The distribution of the first observations of ALB is presented in Fig 4. All cases occurred in inhabited or industrial areas. Forests have not yet been affected, even though some forest edges are close to the infestation spots. More information about the exact localities with ALB records is given in Tab. 1.

The first observation of ALB in Switzerland was made by a private individual in a garden in Brünisried, Canton Freiburg, in August 2011 (Engesser *et al.* 2012). After some wrong alleys, we received a picture of a captured beetle, which could be identified as *A. glabripennis*. On-site inspections yielded a total of four living adults, including an ovipositing female, and signs of maturation feeding on small twigs were detected in some maple crowns. A survey by the cantonal and communal plant protection authorities was initiated, with the support a bit later of trained sniffer dogs from Austria. Seven maples with egg depositions at different heights were found within a radius of a few dozen meters. Five infested *Acer pseudoplatanus* grew in a hedgerow, together with non-colonized hazelnuts. The most infested tree close by was about 12 meters high with several dozen oviposition sites. The tree was cut down and most of the larvae had hatched by the time it was removed from the site a couple of weeks later. The source of the infestation could not be identified as there were no exit holes on the trees, nearby transport pallets or firewood. There were also no recent construction activities with imported Chinese granite or other products on transport pallets from East Asia.



- ▲ Living beetles and infested trees in 2011
- △ Dead beetles in wooden packaging material in 2011
- Living beetles and/or infested trees in 2012
- Living larvae or dead beetles in wooden packaging material in 2012

Fig. 4: Incidence of *Anoplophora glabripennis* in Switzerland.

The second record in 2011 was from the village of Salenstein, Canton Thurgau, where empty larval galleries and dead beetles were found in pallets with Chinese granite stones on a construction site. The pallets were delivered in late fall from interim storage at the port of Weil am Rhein in Germany, only a few hundred meters north of the Swiss-German border near Basel. At this port, flying ALB were observed in summer 2011 and an infested sycamore tree was found in 2012 (LTZ 2012). Thus, the pallets were presumably brought to Switzerland after the emergence of the beetles. Surveys in 2012 in Salenstein did not reveal any infested trees.

An outstanding outbreak of ALB was detected in Winterthur in July 2012. It probably started 6 years ago, when a new road was built and Chinese granite was stored on wooden pallets at the construction site, just at the intersection with the most pronounced subsequent ALB infestation (M. Hochstrasser, pers. comm.). The presence of ALB was detected on around 55 trees in an alley of 64 maples after some crown dieback. Several of the infested trees had both old and new exit holes, which indicated that they had been infested by at least two generations. The compulsory felling of one particular tree – probably the most attractive one – revealed 40 live adults in its crown. On an adjacent abandoned industrial area with many young, naturally regenerated trees, more infestations were found. ALB, sometimes together with *A. moschata*, seemed to colonize mainly young willows. Even an attack on *Buddleja* sp. was reported and confirmed by sniffer dogs (St. Rütten, pers.

Tab. 1: Incidence of *Anoplophora glabripennis* in Switzerland and affected host tree species.

year	locality, canton	infested substrate	number of beetles	living larvae
2011	Brünisried (FR)	7 <i>Acer pseudoplatanus</i>	4 living, 1 dead	yes
2011	Salenstein (TG)	imported pallets	4 dead	no
2012	Birsfelden (BL)	imported pallets	0	yes
2012	Basel (BS)	imported pallets	1 dead	yes
2012	Winterthur (ZH)	60 <i>Acer pseudoplatanus</i> 1 <i>Acer platanoides</i> 8 <i>Acer campestre</i> 1 <i>Populus</i> sp. 50 <i>Salix</i> sp. (mainly <i>S. caprea</i>) 1 <i>Buddleja</i> sp.	150 living	yes
2012	Weggis (LU)	none	1 living	no
2012	Frutigen (BE)	imported pallets	2 dead	no

comm.). In total, approximately 150 living adult beetles were recorded in Winterthur during maturation feeding and egg deposition. In 2012, ovipositions were identified at a distance of up to 350 meters away from the initial infestation spot at the intersection.

At the end of July 2012, one living male ALB was found near the village of Weggis (Canton Lucerne). However, no infested trees or wood packaging material was found, and this beetle's origin remains unclear.

In addition to these, three cases with living beetles, larvae and dead beetles were detected in wooden packaging material from China in several places in Switzerland, mainly in ports around Basel, where Chinese stone products arrive by ship.

MEASURES

After the first records of ALB in Switzerland, the Swiss Federal Plant Protection Service (SPPS) and the cantonal plant and forest protection services immediately started control and surveying measures, according to international conventions on quarantine pests. All known infested trees and pallets were eliminated by chipping and/or burning. Within infested areas, not only colonized trees were felled, but also a number of exposed trees without symptoms. In Winterthur, all 64 maples in the alley were cut, and on the abandoned industrial area, all potential host trees and shrubs were preventively removed.

The SPPS disposed control and surveying activities in infestation areas, as well as in defined focus and buffer zones. The activities involved surveyors on the ground, assisted by sniffer dog teams and tree climbers for selected crowns. In addition, inspections of imported wooden packaging material were intensified. Packaging wood from overseas is supposed to be heat-treated according to the ISPM-15 standard, but obviously a certain amount of the shipped pallets had not been correctly treated.

Guidelines for managing ALB are in preparation. Appropriate measures and recommendations can be based on the EPPO and on experience from neighboring countries (Schröder 2008, Hoyer-Tomiczek 2009). Several examples from other countries suggest that the pest can be eradicated if meticulous survey and control measures are introduced.

ZUSAMMENFASSUNG

Der Asiatische Laubholzbockkäfer (ALB) ist ein invasiver Primärschädling aus Ostasien. Er befällt eine breite Palette von Laubgehölzen und kann diese zum Absterben bringen. International ist der ALB als Quarantäneschädling eingestuft und es besteht eine Melde- und Bekämpfungspflicht. Im Jahr 1996 wurde der Käfer nach Nordamerika verschleppt, 2001 tauchte er erstmals in Europa auf.

In der Schweiz wurde 2011 ein erster Befall registriert. In Brünisried (FR) wurden vier adulte Käfer und sieben befallene Bergahorne mit zahlreichen Eiablagestellen entdeckt. Die Herkunft der Käfer ist unbekannt. Im Juli 2012 wurde in der Stadt Winterthur (ZH) ein grosser Befallsherd registriert. Eine Allee aus Bergahornen war befallen, daneben mehrere jüngere Laubbäume auf einer Brachlandfläche. Insgesamt wurden rund 120 befallene Bäume mit Larven und/oder Eiablagen gefunden sowie etwa 150 adulte Käfer in den Kronen oder an den Stämmen. Vermutlich befand sich die Winterthurer Population bereits in ihrer dritten Generation seit der Einschleppung in Holzpaletten mit chinesischem Granit. Auch bei anderen Importen wurden jeweils lebende Larven in Paletten gefunden, so beispielsweise in Hafenanlagen im Raum Basel.

Zur Bekämpfung werden befallene Bäume gefällt und vernichtet. Erfahrungen aus dem Ausland zeigen, dass die Tilgung eines Befallsherdes bei konsequentem Vorgehen möglich ist. Zur Überwachung werden unter anderem auch Baumkletterer und speziell ausgebildete Spürhunde eingesetzt.

In der Praxis wurden die adulten Käfer häufig mit *Monochamus* spp. und die Larven mit *Aromia moschata* verwechselt. Die Verwechslungsmöglichkeiten werden erläutert.

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