EPPO Study on the risk of bark and ambrosia beetles associated with imported non-coniferous wood

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EXECUTIVE SUMMARY

Bark and ambrosia beetle species (Coleoptera: Scolytinae and Platypodinae) have attracted a lot of attention in the past decades following numerous introductions worldwide, many being in relation to international trade. In some cases, massive damage has been noted. Following recent introductions into the EPPO region of new non-indigenous species of bark and ambrosia beetles, concerns were expressed about the risks posed with trade of non-coniferous wood. It was considered that, unlike for conifer wood, the current regulations in place in many EPPO member countries are not appropriate to limit such risk. The *EPPO Study on the risk of bark and ambrosia beetles associated with imported non-coniferous wood* was carried out in 2018-2019. This Study was conducted by an Expert Working Group (EWG) including experts on ambrosia and bark beetles, experts on pest risk analysis and risk managers. The objective of the Study was to highlight factors that are important in relation to the potential risks of successful entry, establishment, spread and impact of bark and ambrosia beetles. Biological and other risk factors were identified and were illustrated with examples from 26 bark and ambrosia beetle species or groups of species known to be invasive or posing a threat to plant health. These representative species are classified into three categories based on known damage and level of uncertainty. Based on the information assembled and consideration of the risk factors, horizontal phytosanitary measures are proposed for wood commodities, irrespective of the host plant species and the origin, i.e. for all genera of non-coniferous woody plants and from all origins. The rationale for such recommendation is provided. The study includes case studies and pest information sheets for the 26 representative species or groups of species selected by the EWG. Finally, in addition to the evaluation of the risk factors, information is also provided on non-coniferous woody plants in the EPPO region, as well as non-coniferous wood commodities and trade of such commodities.

INTRODUCTION

Why this EPPO Study?

Bark and ambrosia beetles (Coleoptera: Scolytinae and Platypodinae) have attracted a lot of attention in the past decades following numerous introductions worldwide and, in some cases, massive damage. Many bark and ambrosia beetle species are known to have spread worldwide in relation to international trade. Recently new non-indigenous species of bark and ambrosia beetles have been introduced into Europe, which were not listed specifically as quarantine pests. It was also noted that ambrosia beetles are regularly intercepted in wood packaging material. These species are probably also associated with other types of wood but have never been detected on it. ISPM 15 (FAO, 2019) defines action to be taken on wood packaging material but it does not cover wood commodities and regulation for non-coniferous wood in many EPPO member countries is currently not considered sufficient to cover such risks.

This issue was discussed at the joint meeting of the Panel on Phytosanitary Measures and the Panel on Quarantine Pests for Forestry (Paris, 2017-03-22) which expressed concerns about recent introductions. Both Panels concluded that it would be worth identifying phytosanitary measures that may be appropriate to reduce the risk of further introduction of bark beetle and ambrosia beetle species in non-coniferous wood.

During the joint Panel meeting it was agreed to launch a study to identify representative bark and ambrosia beetle species that are associated with non-coniferous wood, not present in the EPPO region or present but not widely distributed, for which horizontal measures to cover the risk of all similar pests may be developed.

An Expert Working Group (EWG) was convened with the following tasks:

- Describe the pest subfamilies covered.
- Identify the different commodities to be covered, including the tree species or genera.
- Identify representative species of bark and ambrosia beetles associated with non-coniferous wood preferably absent from the EPPO region or present but not widely distributed that can present a potential risk (if possible, other significant pathways than wood commodities should also be identified). Ideally, species should be from different parts of the world and covering all tree species/genera identified above.
- Discuss if horizontal measures can be identified (taking into account existing measures i.e. existing PRAs, PM 8 Standards for non-coniferous wood, current regulations) and how these should be defined and justified (including specific requirements for the establishment of PFA).

General elements on bark and ambrosia beetles

Bark and ambrosia beetles are defined as follows in Hulcr *et al.* (2015) (details under the text boxes added as relevant for the study):

Ambrosia beetle

A species in either of the weevil subfamilies Scolytinae or Platypodinae* that is obligately associated with nutritional fungal symbionts. Obligate symbiosis with fungi is present in at least 11 independent scolytine and platypodine groups. Ambrosia beetles are therefore not monophyletic, and the name is not a taxonomic designation.

Bark beetle

'Bark beetle' is both a taxonomic and ecological designation. In the taxonomic sense, bark beetles are all species in the weevil subfamily Scolytinae, including species that do not consume bark. In the ecological sense, bark beetles are species of Scolytinae whose larvae and adults live in and consume phloem of trees and other woody plants[#]

*The Specification for the EPPO Study originally mentioned only Scolytinae. However, it was proposed that Platypodinae may also be covered in order to fully assess ambrosia beetles. Both sub-families belong to the family Curculionidae.

Bark beetles are not obligatory associated with fungal symbionts (see 1.4).

There are more than 6000 species of Scolytinae described to date, where the majority are tropical or subtropical species. About 2100 species of Scolytinae are ambrosia beetles (J. Hulcr, calculated from Hulcr *et al.*, 2015), the remaining species are mostly bark beetles. The second subfamily Platypodinae includes around 1400 additional ambrosia beetle species (Jordal, 2015). Complete reviews of the biology and ecology of Scolytinae and Platypodinae can be found in numerous recent publications, such as Vega *et al.* (2015) for bark beetles, or Hulcr and Stelinski (2017) for ambrosia beetles.

Within the Scolytinae, a group of ambrosia beetles which has attracted attention in recent decades due to numerous invasions and damage is the tribe Xyleborini (in recent classification of Scolytinae under Curculionidae), which contains ca. 1300 described species. They are generally considered particularly suited for the invasion of new habitats and fulfil several essential risk factors (see 1). Many species detailed in this study are Xyleborini, from the genera *Euwallacea*, *Xyleborus*, *Xyleborinus*, *Cnestus* and *Xylosandrus*.

Consideration of bark and ambrosia beetles by EPPO

The 'traditional' EPPO approach of horizon-scanning and PRA has identified several non-coniferous bark and ambrosia beetles presenting a potential risk, which have been either recommended for regulation or added to the EPPO Alert List. *Pseudopityophthorus minutissimus* and *P. pruinosus* were added to the EPPO A1 List in 1987 (as vectors of *Ceratocystis fagacearum*) and are regulated in the EU and Turkey accordingly (EPPO, 2018). Both are absent from the EPPO region. Three other species, with a limited distribution in the EPPO region, have since been recommended for regulation by EPPO (*Megaplatypus mutatus*, *Euwallacea fornicatus* and *Pityophthorus juglandis*), but are not yet specifically regulated by EPPO countries (EPPO, 2018). Some general measures, such as surveillance or inspection, have been applied in certain countries (e.g. some EU countries). Trapping at points of import, entry and destination, and other environments has also received attention in recent years and has led to the detection of species (e.g. Rassati *et al.*, 2015).

Several other species have been added to the EPPO Alert List over time**,** 'to draw the attention of EPPO member countries to certain pests possibly presenting a risk to them and achieve early warning'. Of the species currently on the Alert List, *Xylosandrus compactus* and *X. crassiusculus* were listed in response to their introduction into the EPPO region, whereas *Xyleborus glabratus* is still absent. Finally, *Scolytus schevyrewi* and *Platypus quercivorus* (associated with *Raffaelea quercivora*), were previously added to the Alert List and deleted (the latter twice). All those species were identified by the EWG as presenting a potential risk and are detailed in this study. Finally, the EPPO Reporting Service has also published information on certain species, but this mainly occurs when a species has been introduced and raised some concerns.

Some of the difficulties associated with identifying bark and ambrosia beetle species presenting a potential risk

- Information is often lacking to identify and assess potential risks associated with bark or ambrosia beetles, for example whether live trees are attacked in the native range, which species are host plants, associated fungi, suitability of climate for establishment.
- For some regions little literature is available or translation is required (many publications on bark and ambrosia beetles exist in Chinese and Japanese).
- Bark and ambrosia beetles do not always cause damage and very few of the species introduced in Europe or the USA have been reported to cause widespread damage (Kirkendall and Faccoli, 2010, Haack and Rabaglia, 2013). However, massive and unforeseen damage has been expressed in some cases and examples are provided in this study.
- Information available (bark or ambrosia beetles not known to cause damage in their area of origin) does not necessarily reflect what could happen in case of introduction as many species emerge as damaging only in specific circumstances when introduced outside of their native range. Several catalogues of Scolytinae and Platypodinae (e.g. Wood and Bright, 1992), give information on distribution or host range, but damage is mentioned only if the host is important or introduction and impact have occurred.

Conducting PRAs on each species identified may be possible, but in most cases, it would lead to uncertainties:

1. Which are the pathways, and can the bark or ambrosia beetle species enter? Data on trade of wood (recognized pathway) is mostly unavailable at the species and genus level, and it would be difficult to assess if there is a trade for many host wood commodities. However, knowing whether a particular wood is traded may not be that relevant for the many polyphagous species that are prone to finding new hosts when introduced to new locations.
2. Can tropical and subtropical species adapt to climatic conditions in the EPPO region? Establishment in the Mediterranean area may be possible, especially when referring to cases of successful establishment in recent years. However, the assessment of establishment in temperate and cooler areas would be subject to more uncertainty. Even if establishment occurred, potential impacts would also be uncertain.

3. Would the species have an impact in the EPPO region? The known hosts may not be major for the EPPO region (especially tropical or subtropical species), which influences the assessment of establishment, spread and potential damage. However, the ability to attack new host species when introduced to new locations is common, and the possible host range and extent of damage cannot be predicted.

Approach followed for this study

The objective of this study is to highlight factors that are important in relation to the potential risks of successful entry, establishment, spread and impact of bark and ambrosia beetles. The EWG followed a horizontal approach across species.

EWG members were asked to propose bark and ambrosia beetle species that they considered present a potential risk. Various sources were used, such as expert knowledge, literature, NPPO risk registers, EPPO lists, interception data, etc. The EWG then selected species for which sufficient data was available to illustrate risk factors. Several species, known to have been introduced in other parts of the world, have never caused economic damage (*Hypothenemus eruditus*, *Monarthrum mali*, *Xyleborinus artestriatus* and *X. octiesdentatus*). The EWG noted that such species could still be interesting to illustrate pathways or risk factors, and the possibility that they may become more damaging could not be excluded.

Many species selected in this Study are native or introduced to North America, or introduced into the EPPO region; detailed information is available, and if impact occurred, extensive research has been conducted.

The EWG analysed the main characteristics of bark and ambrosia beetles that contribute to the phytosanitary risk. These are presented in Section 1 and illustrated with examples that are documented in case studies and in pest information sheets. Horizontal measures were then considered, which are reported in Section 2.

Information on individual species was assembled mostly at the start of 2018, and no data was updated after September 2018 (including research results resulting in changes of names, taxonomy, additional knowledge on the species, etc.).

SECTION 1. RISK FACTORS

This section reviews the factors that influence whether a bark or ambrosia beetle presents a potential risk of entry, establishment, spread and impact for the EPPO region. The risks relate both to biological factors and other factors. Risk factors are detailed below and some examples of bark and ambrosia beetle species are given. The factors are ranked as major, medium or minor. Important aspects of the risk are outlined in the text and summarized in Table 4 to visualize known risks for the species studied. Examples are developed in case studies (Annex 1) and Pest information sheets (Annex 2).

1. Biological factors

1.1 Mating strategy (major factor)

The reproduction strategy is a major factor for entry and establishment success.

Many Scolytinae are inbreeders, which means that they mate with their siblings in the galleries where they developed (sib-mating). Consequently, nearly all females leaving the tree are already mated. For this reason, they do not need to find a male to produce a new generation after they have left their host, thus facilitating entry (transfer to a host) and establishment. The largest clade of inbreeding species includes the tribe Xyleborini (ambrosia beetles) and some genera of the tribe Dryocoetini (bark beetles). All members of the Xyleborini have this reproduction strategy. Many examples in this study are inbreeders, including species in the Xyleborini genera *Ambrosiodmus*, *Cnestus*, *Euwallacea*, *Xyleborinus*, *Xyleborus*, *Xylosandrus*, as well as *Hypothenemus eruditus*. Out of 83 species of Scolytinae that are known to have established in a new continent (Europe or the EPPO region, USA or Canada, New-Zealand – see also 2.2), 57 are inbreeding (pers. comm., J.C. Grégoire, Université libre de Bruxelles, 2018). This proportion (68%) is largely higher than the proportion of inbreeding species in the world (ca. 27% recalculated after Kirkendall *et al.*, 2015). Furthermore, among the supposedly outbreeding species that crossed a geographic barrier, *Orthotomicus erosus* (Mendel 1983) and *Tomicus piniperda* (Janin and Lieutier 1988) show a proportion of females already mated upon emergence, or mated during maturation feeding on twigs or during overwintering at the base of trees previous to colonising a new host. As with the inbreeding species stricto sensu, these early mated females could be capable to found alone a new colony.

In addition, many inbreeders are also haplodiploid, which enables unfertilised females to produce haploid males parthenogenetically, with which they can then mate, i.e. with their “sons” (Jordal *et al.*, 2001, citing others). This facilitates colonization as females do not necessarily have to be fertilized before dispersal and finding a host. For example, *X. crassiusculus* is haplodiploid.

Conclusion. Inbreeding is favourable in particular for entry and establishment. One single female fertilized by a brother or a son, and surviving the transport, may remain undetected, leave the commodity, find a host tree and start a new colony, which is sufficient to establish a population.

In Table 4, Inbreeding indicates beetles that reproduce through inbreeding

1.2 Host condition (major factor)

Most bark and ambrosia beetles live in dying or trees that recently died and are associated with non-pathogenic fungi but a few among them can attack live trees (Raffa *et al.*, 2015 for bark beetles, Hulcr *et al.*, 2017 for ambrosia beetles). Some species that attack weakened or recently dead trees at low population densities can shift to living, apparently healthy hosts at higher population densities. Bark beetles infest live trees more often than ambrosia beetles (Haack and Rabaglia, 2013).

- *Healthy trees*

Healthy non-coniferous trees are normally unsuitable to attacks by bark and ambrosia beetles. However, some species have been recorded to attack and eventually kill live, apparently healthy non-coniferous trees, in particular several bark and ambrosia beetle-fungus complexes. This represents a minority of species to date. However, the concept of attacks on ‘healthy’ trees is often debated in the literature as trees that seem healthy may have been previously exposed to some stress (see below for examples).

- *Stressed trees*

Bark beetles and ambrosia beetles that attack live trees mostly attack stressed trees. Stress may arise from various factors. Those mentioned in the literature include flooding, drought, mechanical damage (including windbreak and snowbreak), freezing, ozone exposure (Ranger *et al.*, 2010), graft incompatibility, unsuitability for particular site conditions, excessive or improperly timed nutrients supply (Hulcr and Stelinski, 2017), disease (Ploetz *et al.*, 2013), other insect pests. The two strongest predictors of ambrosia beetle damage in nurseries and urban trees in the USA are flooding (including excessive irrigation) and late frost (Hulcr and Stelinski, 2017). Under normal circumstances, trees would be sufficiently resilient to recover. However, as ambrosia beetle pressure has increased in recent years and aggressive species of ambrosia beetles are now present throughout the area, stresses on the hosts can trigger fatal attacks (Hulcr and Stelinski, 2017). Monospecific, similarly aged high density stands, such as nurseries, orchards, young forest plantations, are prone to attacks on stressed trees (Hulcr and Stelinski, 2017; Ploetz *et al.*, 2013). For many reasons urban trees are also prone to stress (Brune, 2016). Some beetles, such as *Euwallacea* and *Xylosandrus*, preferentially attack trees in non-natural, environmentally stressful settings, such as urban environments and orchards in both invaded and native ranges (Hulcr and Stelinski, 2017). With climate change, tree stress is likely to increase in the EPPO region in the future (Brune, 2016 citing others).

Finding information on whether a species attacks live trees (whether stressed or healthy) is not always easy. It is usually well documented mostly when a species has moved into areas where damage has been observed and publications are available (e.g. North America). Many destructive introduced ambrosia beetles were shown only retrospectively to be capable of colonizing and damaging live trees in their native range, with the help of associated pathogenic fungi, when field studies were conducted (Hulcr *et al.*, 2017). In some cases, the fungus has proved more virulent on a new host in an invaded area (e.g. *Raffaelea lauricola* and *Xyleborus glabratus*).

All bark and ambrosia beetles considered in this study have some association with live trees. *Megaplatypus mutatus* is a primary pest and attacks only live standing trees (and not declining trees or cut wood). Species such as *Austroplatypus incompertus*, *Euwallacea fornicatus sensu lato*, *E. interjectus*, *Pityophthorus juglandis*, *Platypus apicalis*, *P. gracilis*, *P. koryoensis*, *P. quercivorus*, *P. subgranosus*, *Xyleborus glabratus*, *Xylosandrus crassiusculus*, *X. compactus* have also been recorded on apparently healthy trees, while others such as *Ambrosiodmus rubricollis*, *Euwallacea validus*, *Euplatypus parallelus*, *Cnestus mutilatus*, *Scolytus schevyrewi* are recorded to attack mostly stressed trees.

Hulcr *et al.* (2017) suggest that screening of the ambrosia beetle-fungus associations that colonize live tree tissues in their native habitats could help identify future tree-killing pests. Sanguansub *et al.* (2002) used attacks on freshly cut wood to identify species presenting a risk of attacking living trees, and identified some species presenting a risk of attacking live trees (such as *Platypus quercivorus*, *Xyleborus seiryorensis*, *X. laetus*, *X. ganshoensis*, *Crossotarsus simplex*). This study develops in detail a few selected examples, but other species are reported attacking live trees, either in their range of origin or in newly colonised areas, such as:

- ✓ *Euwallacea destruens*: mortality in plantations in Asia - Hulcr and Stelinski, 2017;
- ✓ *E. similis* (=*E. denticulus*): reported to attack *Ceratonia siliqua* (USA, Israel) (O'Donnell *et al.*, 2016 citing others);
- ✓ *Dendroplatypus impar* (South-East Asia) and *Corthylus columbianus* (USA): attack vigorous trees, seldom killing hosts (Kamata *et al.*, 2002)
- ✓ *Trachyostus ghanaensis* and *Doliopygus dubius*: attack 'healthy' trees in Ghana (Wagner *et al.*, 2008);
- ✓ *C. externedentatus* (on weakened trees) and *Notoplatypus elongatus, Platypus tuberculosus, Trachyostus aterriumus* (on 'healthy' living trees) (Bickerstaff, 2017);
- ✓ *Anisandrus apicalis:* new pest of kiwi in Guizhou, China (Li *et al.*, 2016);
- ✓ *Anisandrus maiche:* Asian species first found in the USA in 2005 and in Ukraine in 2007 in forests and plantations (incl. *Populus tremula* and *Quercus robur*) (with no damage at that date) (EPPO, 2013).
- ✓ *Ambrosiophilus atratus* (pest of fruit trees in the Korean Republic - Choo *et al.*, 1983).

- *Dying, freshly cut or fallen trees*

Some species are recorded as attacking only dying or dead standing trees in their native range or even in some invaded areas, but may start being recorded on live trees when introduced in another new area. Such species are difficult to identify from a literature study before a different behaviour is observed in another site.

Many species are known to attack cut and windblown trees, and may not be considered as pests unless they decrease the quality of the wood. Some species, such as *Monarthrum mali* and *Xylosandrus crassiusculus* attacking live trees, have also been recorded attacking timber. Freshly cut or fallen trees can be a material on which beetles can increase in numbers and then move to attacking live trees. For example, *Phloeotribus liminaris* emerging from logging slash caused a significant outbreak on (stressed) *Prunus serotina* in Wisconsin.

Conclusion. The ability to colonize live trees (whether stressed or apparently healthy) is key to the risk of entry (transfer to a host), establishment and impact presented by bark and ambrosia beetles. The ability to live in cut wood would be an advantage for entry (association with wood commodities).

In Table 4, Live trees indicates beetles specifically known to attack live trees (whether stressed or apparently healthy)

1.3 Host specificity (major factor)

- *Polyphagy*

Bark and ambrosia beetles tend to have a preference for either coniferous or non-coniferous hosts. Nevertheless, some species, even if attacking mostly non-coniferous trees, are occasionally found attacking coniferous species.

Many bark beetles have a narrow host range, from mono- to oligophagous (hosts within one genus versus one family). Ambrosia beetles are often less constrained in their host range than phloem-feeding bark beetles, and some are known to colonize many tree species (Raffa *et al.*, 2015). The high level of polyphagy of ambrosia beetles is linked to the fact that they only need to find a suitable habitat/substrate to grow their fungal associates (Seybold *et al.* 2016, citing others).

Polyphagy is an advantage for entry, establishment (higher probability of finding a suitable host) and impact. Out of 19 bark and ambrosia beetles reported as introduced into Europe, 15 were polyphagous (breeding in several to many families of woody plants) (Kirkendall and Faccoli, 2010). However, it is sometimes difficult to ascertain from the literature whether the recorded hosts are breeding hosts or not. The EWG used the term polyphagy in relation to the number of host families recorded for the bark and ambrosia beetle species.

There is no direct relation between polyphagy and impact: some of the less polyphagous ambrosia beetles had a large impact where introduced (e.g. *X. glabratus* in the USA). The level of polyphagy of species in terms of families attacked is summarized in Table 4, with *Euwallacea fornicatus sensu lato*, *Hypothenemus eruditus*, *Xylosandrus compactus* and *X. crassiusculus* attacking plants in at least 50-60 families.

- *New hosts*

The known host range of a species is important, but it can change, either in the native distribution or when introduced into a new area. Consequently, evaluating the possible wood commodities to be regulated based only on known hosts to protect non-coniferous species from bark and ambrosia beetles presents high uncertainties and does not fully cover the risk of entry and establishment. Most bark and ambrosia beetles considered in this study have been recorded on new hosts when introduced into new areas. In addition, some species, which are not known to have been introduced to new areas yet, are part of this study because of concerns that they would attack other hosts, especially those closely related to their known hosts, if they reached the EPPO region (e.g. *Gnathotrupes* spp. of *Nothofagus* is currently limited to that genus, but it is not known if it could attack Fagaceae).

Encounters with new hosts do not always result in damage, but are an important component of the potential impact, i.e. whether a bark or ambrosia beetle will be able to utilize a new susceptible host. Striking example of encounters with new very susceptible hosts, leading to extensive damage, are:

- ✓ In the USA, *Xyleborus glabratus*, which caused the death of over 300 million *Persea borbonia*, a North American species, since the early 2000s.
- ✓ In Japan, *Platypus quercivorus* caused massive damage when it spread, presumably as a result of climate change, to more temperate areas where it encountered the very susceptible new host *Q. crispula*. There has also been one record on *Q. robur*, a species that is widespread and economically and environmentally invaluable in the EPPO region.
- ✓ In China, an *Acanthotomicus* sp.[1] thought to be native to the region started to extensively attack a North American species, *Liquidambar styraciflua*, used in China for ornamental purposes.
- ✓ In the USA, *Pityophthorus juglandis* encountering the very susceptible *Juglans nigra*, which resulted in substantial mortality.

Conclusion. Polyphagy is an advantage for entry, establishment and impact, and some species have also demonstrated an ability to attack new host species when introduced to new locations.

In Table 4, Polyphagous indicates beetles recorded in several host families
New hosts indicates beetles known to have passed onto new hosts species

1.4 Associated fungi (major factor)

Ambrosia beetles are always associated with fungal symbionts (Hulcr and Stelinski, 2017), and may also carry other fungi. Bark beetles are also associated with fungi, with relationships ranging from casual associations or more consistent but not obligate associations to coevolved nutritional mutualism (Ploetz *et al.*, 2013).

Hulcr and Stelinski (2017) present a table summarizing knowledge of the associations between ambrosia beetle genera and ambrosia fungi. Compared to phloem-feeding bark beetles, fungus-farming by ambrosia beetles provides more nutrition faster and allows for the colonization of much broader host diversity, which in turn would be favourable to establishment. Bark beetle fungal associations have been reviewed for example by Paine *et al.* (1997) and further discussed by Six and Wingfield (2011). The fungi would travel along the pathways with their beetle vector. The fungus may also be transported alone with host material, but transfer to a living new host would require an effective vector to pick it up (such as for *Seiridium cardinale* transfer by native *Phloeosinus* spp. - Graniti, 1998; Webber and Gibbs, 1989).

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[1] This species was known as *Acanthotomicus* sp. at the time of the Study (and this name is used throughout), but has more recently recognized as a new species, *Acanthotomicus suncei* (Gao and Cognato, 2018).

There can be a high level of specificity between the fungal symbionts and beetles, with vertical transmission (from one generation to the next). However, lateral transmission from one beetle species to another also occurs in bark and ambrosia beetles, and this includes fungal symbionts that are plant pathogens (Raffa *et al.*, 2015). In addition to one or a few symbionts, ambrosia beetles also carry other associated fungi, which were shown to vary depending on beetle lineages, and numbers of associated fungi larger than previously known were found in several species (Kostovcik *et al.*, 2015). The knowledge on fungal associations of bark and ambrosia beetles is still incomplete, although huge progress is continuously made in particular using molecular techniques. In particular, studies have shown variations in associations:

- *Raffaelea lauricola*, the symbiont of *Xyleborus glabratus*, has been found in or on nine other ambrosia beetle species in the USA since *X. glabratus* was introduced (although the nature of these associations is not known to date).
- Two *Euwallacea* sp. were found farming two closely-related *Fusarium* species (O'Donnell *et al.*, 2015). The authors mentioned the possibility of host-switch between *Euwallacea* and members of the ambrosia *Fusarium* clade, which may bring together more aggressive and virulent combinations of these mutualists.
- *Raffaelea quercivora*, the symbiont of *Platypus quercivorus*, was found associated with *Cyclorhipidion ohnoi* and *Crossotarsus emancipatus* in Taiwan, fungal species that are only known to colonize completely dead wood (Simmons *et al.*, 2016).
- *Sporothrix nothofagi*, a highly pathogenic fungus killing *Nothofagus* in New Zealand, is associated with three Platypodinae: *Platypus apicalis*, *P. gracilis* and *Treptoplatypus caviceps*.
- From the data reported in the review by Kirisits (2004) of the fungal associations with European Scolytinae, it can be demonstrated that many fungus species are shared by different beetle species. *Ophiostoma piceae,* was identified in 22 bark beetle species, *Ceratocystiopsis minuta* in 14 species, *O. piceaperdum* in 13 species, etc. 33 fungus species out of 86 (48.4%) were reported with one single bark-beetle species. Conversely, one bark-beetle species, *Ips typographus*, was reported as associated with 33 fungal species, *Hylurgops palliatus* was associated with 26 species, etc. Only one bark-beetle species out of 27 (3.7%) was found associated with one single fungus species.
- Out of 30 fungus species associated with ambrosia beetles and considered in the same study, 26 (87%) were each associated with one beetle species; two fungal species were each associated with three beetle species, and two fungi were each associated two beetles. Conversely, out of nine ambrosia-beetle species considered, four were associated with only one beetle species, *Trypodendron lineatum* had 12, and *T. domesticum* had eight associates.

The symbiotic fungi in bark and ambrosia beetles are key to the potential impact of species. This is especially the case if the fungus has proved pathogenic on some hosts, and generally the association of a pathogenic fungus with a bark or ambrosia beetle will increase the risk. For example, the fungus *Sporothrix nothofagi* (associated with *Platypus apicalis*, *Platypus gracilis*, *Treptoplatypus caviceps*) is responsible for *Nothofagus* death in New Zealand (Ploetz *et al.*, 2013). Unfortunately, this may not be identified until the fungus occurs in a new invasion area or on a new host, which leads to unexpected impact. This was the case for *Raffaelea lauricola* (associated with *Xyleborus glabratus*) on *Persea borbonia* in the USA and *Geosmithia morbida* associated with *Pityophthorus juglandis* when they passed from *Juglans major* to *Juglans nigra* in the USA. In both cases, attacks on new hosts resulted in extensive tree mortality. Ambrosia beetles may also play a role in the transmission of non-symbiotic pathogenic fungi (e.g. *Euwallacea interjectus*/*Ceratocystis ficicola*, *E. validus*/*Verticillium nonalfalfae*, *Platypus subgranosus*/*Chalara australis*, *Euplatypus parallelus*/*Fusarium* wilt fungi). In addition, association with certain fungal genera (e.g. *Ceratocystis* spp.) may indicate a possible risk, while in other genera (e.g. *Fusarium* spp.) some species are pathogenic and others are not, which makes it more difficult to predict a potential risk.

Where maturation feeding occurs on external tissues of the tree (e.g. terminal shoots), it allows the inoculation of pathogenic fungi to healthy trees. This favours establishment as the pathogen weakens the tree and makes it more susceptible for bark beetle reproduction, and increases impact. This is known for bark beetles such as *Scolytus multistriatus* and *S. schevyrewi* for *Ophiostoma novo-ulmi*, and *Pityophthorus juglandis* for *Geosmithia morbida*. There is no evidence that this happens for ambrosia beetles.

Finally, a beetle vectoring a pathogenic fungus may not lead to substantial damage if it does not find a susceptible host. For example, *Scolytus schevyrewi*, Asian vector of Dutch elm disease (*Ophiostoma novo-ulmi),* turned out to be no better or a potentially less effective vector on North American elm species than *S. multistriatus* (Jacobi *et al.*, 2013).

Conclusion. Fungus-farming is favourable to establishment. In addition the association of a pathogenic fungus with a bark or ambrosia beetle increases the potential impact. Among species carrying pathogenic fungi, those inoculating the pathogen through maturation feeding have an advantage for establishment and impact.

In Table 4, Fung. farm. indicates fungus-farming species
Pathog. indicates beetles known to be associated with a pathogenic fungus
Mat. feed. indicates beetles with known maturation feeding.

1.5 Climatic requirements (major factor)

Bark and ambrosia beetles occur in a large variety of climates. Species known to occur in areas climatically similar to those occurring in the EPPO region are very likely to establish. Furthermore, many bark and ambrosia beetles originate from tropical or subtropical areas, however many of them are known to have established under new climatic conditions in particular in South-East USA and the Mediterranean Basin. Some species established in South-East USA are now also found further North. No example of spread to the northern part of the EPPO region was found in this study, but some introductions are probably too recent to judge. In addition, this might change in the future as a result of global warming.
The present study includes examples of tropical or subtropical species established in the Mediterranean Basin. This climatic tolerance might be explained by bark and ambrosia beetles being protected in the tree during most of their life cycle and consequently being less exposed to adverse climatic conditions (e.g. low temperature and humidity).

- *Temperature*

Temperatures influence development and growth of bark and ambrosia beetle species, and therefore voltinism, abundance and geographical range, and are important for establishment and spread. In addition, beetles need suitable conditions when they emerge from the trees and fly to new hosts and temperature is known to be an important factor for dispersal. Although the trees protect beetles to a certain extent from extreme ambient temperatures, the temperature inside the tree may still reach levels causing injury or death. For example, it was predicted that the minimum winter temperatures of −6.2°C or lower for 12 h would be a limiting factor for *Xyleborus glabratus* in the USA (Formby *et al.*, 2018).

From data on fungi in trees, temperature is also expected to impact fungal development (e.g. Deprez-Loustau *et al.*, 2007, Boddy *et al.*, 2014; Grosdidier *et al.*, 2018).

- *Humidity*

Humidity is a key factor for the development of fungi on which ambrosia beetles are feeding. However, humidity in the tree is usually higher than in the ambient air, being more suitable for the fungi. Positive correlations have been observed between ambrosia beetle population levels and rainfall (Beaver, 1979). Wherever fungus farming is possible (mostly in regions with higher humidity), ambrosia beetles tend to be more abundant than bark beetles.

How far a beetle can establish in cooler or drier conditions, is generally not known (e.g. to temperate areas or dry Mediterranean areas for tropical species), except if this has already occurred. Analyses of interception frequency of non-indigenous Scolytinae (citing Brockerhoff *et al.*, 2006) suggest that the great majority of introduced ambrosia beetle species do not establish. Many species are likely to fail to establish because of unsuitable climate. Considering that the large majority of the ambrosia beetle species recently introduced into Europe and the USA are of South-East Asian origin, a larger number of establishments may occur with climate changes, e.g. with warmer and wetter climate (Marini *et al.*, 2011 citing others). In addition, not all species cause damage, and sub-optimal climatic conditions may be one reason. Nevertheless, there are known cases of tropical or subtropical species that have established and caused damage in other areas, such as *Xylosandrus crassiusculus*, *X. compactus*, *Xyleborus bispinatus*, *Ambrosiodmus rubricollis*, *Euwallacea fornicatus sensu lato*.

Conclusion. The climatic conditions under which a bark or ambrosia beetle occurs are important for the potential risk (especially establishment and spread). However, tropical/subtropical species are known to

have established in cooler climatic conditions or may expand their range in the introduced area under global warming.

In Table 4, Climate indicates beetles known to originate from climates represented in the EPPO region, or to have moved from subtropical/tropical climates to cooler climates.

1.6 Mass attacks (medium factor)

Although most, if not all, bark and ambrosia beetles infesting non-coniferous wood can establish at low population densities (down to one single female in sib-mating species) on recently dead, weakened or apparently healthy hosts, mass-attack, based on aggregation pheromones, facilitates the establishment of some bark or ambrosia beetles as it allows to overcome the defences of living trees. Based on the biology of the species studied, it was considered that mass-attack for establishment would occur at least for *Acanthotomicus* sp., *Monarthrum mali*, *Pityophthorus juglandis* and *Platypus quercivorus*. However, the establishment of species hypothetically depending on obligatory mass-attack would be difficult, because mass-attack implies a much higher Allee threshold than that needed by solitary colonisers. These latter have displayed high success in entry and establishment.

Once the species is established and the epidemic threshold is reached, aggregation pheromones facilitate mass attacks on live trees, which result in higher impact. Such mass attacks are known for *Acanthotomicus* sp., *Pityophthorus juglandis*, *Platypus apicalis*, *P. gracilis*, *P. quercivorus* and *P. koryoensis*, or *Xylosandrus crassiusculus*.

Mass-accumulation on dead material may influence impact but was not considered by the EWG to be a species-specific trait and a risk factor.

Conclusion: the need for mass-attacks can be unfavourable to establishment, but mass attacks once the species is established and the epidemic threshold is reached can result in higher impact.

In Table 4, Aggreg. pherom. indicates species that use an aggregation pheromone

1.7 Dispersal capacity (major factor)

- *Natural dispersal*

All bark and ambrosia beetles have some flight capacity, for at least one of the sexes, but the flight biology and capacity varies widely among species. Generally, most active dispersal flights are limited to few hundred metres, although bark and ambrosia beetles have the capacity to fly over longer distances, particularly downwind (many references, such as cited in Raffa *et al.*, 2015). Recent studies in the landscape in New Zealand found two non-native pine bark beetles (*Hylurgus ligniperda* and *Hylastes ater*) more than 25 km from the nearest host patch (Chase *et al.*, 2017). The flight distance depends on environmental conditions (such as presence of hosts, population pressure, wind). Natural spread by flight may be hindered at the limits of the climatic range as the conditions would not be appropriate for flying. Precise data is often lacking on the flight capacity of individual species. Among the species in this study, *Platypus quercivorus* is recorded as having a good flight capacity (in experiments in a flight mill, some individuals flew over 25 km), *Cnestus mutilatus* is in the process of a rapid range expansion in South-East USA, and some natural spread is known for many others such as *Pityophthorus juglandis* or *Xyleborus glabratus* (although individuals of the latter are reported as 'poor flyers'). The size of the pioneer population will influence dispersal capacity (because there will be more individuals dispersing long distances among the members of a larger population).

- *Human-assisted dispersal*

Even where there is known natural dispersal capacity, the main factor for establishing new infestations of bark and ambrosia beetles is movement of wood. Both bark and ambrosia beetles are in wood commodities and are not easily detected (see 2.4). Various wood commodities are moved over long distances, including high value wood such as walnut or ash, or low value wood such as firewood.

The human-assisted spread of ambrosia beetles is potentially greater than that of bark beetles because they are in the xylem, their entry holes can easily pass unnoticed, and they can survive in wood without bark. However, non-coniferous wood is generally not subject to regulations requiring debarking, and the risk of the transmission of bark beetles is probably not lower than that of ambrosia beetles.

Conclusion. The capacity to disperse, either natural or human-assisted, increases the risk of entry, establishment (finding a host far from the entry point) and spread for all bark and ambrosia beetles.

1.8 Voltinism and sister broods (medium factor)

Voltinism relates to the number of generations per year (multivoltine versus univoltine), which may be separate or overlapping. Overlapping generations also occur in the case of sister broods (subsequent ovipositions by the same female in different galleries), which is known for bark beetles. The number of generations increases both the risk of spread and impact through higher population density. The risk factor relates to those species that are able to respond to warmer temperatures by producing more generations leading to higher populations, such as *Pityophthorus juglandis*, *Xyleborus glabratus*, *Xylosandrus crassiusculus* or *X. compactus*. Fahrner and Aukema (2018) identified voltinism as the major factor influencing spread in introduced insects.

Conclusion. Voltinism and sister broods increase both the risk of spread and impact through higher population density.

In Table 4, Multiv. indicates beetles with more than one generation.

1.9 Diapause and natural enemies (minor factors)

- *Diapause*

Diapause would present an additional risk factor as it would allow the survival of individuals for long periods. However, more evidence of diapause for bark and ambrosia beetles is needed, and especially in relation to consequences for entry and establishment. This is therefore not used as a risk factor.

- *Natural enemies*

Natural enemies may have a role in limiting the impact of individual species. For example, *Dendroctonus micans* in the UK and France was contained by a predator native to the range of introduction, *Rhizophagus grandis*. However, this appears to be a rare case of biological control of a bark beetle. In most cases, little information is available on native, generalist natural enemies. This is therefore not used as a risk factor.

2. Other factors

2.1 Association with wood commodities (major factor)

Association with non-coniferous wood pathways (see Annex 3 [– on non-coniferous] and 4 [– on commodities]) is an essential component of the risk of entry in this study. Non-coniferous woody species as covered in this study are analysed in Annex 3.

Bark and wood-boring Scolytinae and Platypodinae spend most of their life cycle inside the tree. Ambrosia beetles bore galleries in the xylem of branches, trunks, stumps or roots (depending on species). They use the wood of their host to raise in their galleries their fungal associates on which adults and larvae feed. Bark beetles feed on a variety of tree tissues, from bark, to phloem, sapwood and xylem.

Because of physical or chemical properties, the wood of some non-coniferous species/genera is not likely to carry bark and ambrosia beetles (e.g. holly - *Ilex aquifolium* - Southwood, 1961).

Bark and ambrosia beetles are known to be associated with wood commodities in trade, and are commonly intercepted (e.g. Cola, 1971, 1973; Marchant, 1976; Brockerhoff *et al.*, 2006; Haack and Rabaglia, 2013, etc.). There have been many interceptions of bark and ambrosia beetles on various wood commodities in the EU (see Annex 5). In New Zealand for the period 1950-2000, about 73% of Scolytinae interceptions were made in wood packaging material (including dunnage), 21% in sawn timber or logs, and 6% in other material. Firewood (including as round wood) has also been identified as a risk for bark and ambrosia beetle movement (USDA-APHIS, 2010; Dodds *et al.*, 2017, Haack *et al.*, 2010). Bark and ambrosia beetles can be associated with wood commodities as listed in the table below (details on commodities are given in Annex 4).

Table 1. Association of bark and ambrosia beetles with wood commodities

Wood commodity	**Association of ambrosia beetles**	**Association of bark beetles**
Round wood with bark (including firewood and harvesting wood residues (when in the form of top of trees, branches, twigs etc.))	Yes	Yes
Round wood without bark (including debarked or bark-free)	Yes	Yes, some stages may be present in the xylem
Sawn wood	Yes	Yes, some stages may be present in the xylem
Wood chips, hogwood[2], processing wood residues (except sawdust and shavings)	Yes	Yes
Isolated bark	No	Yes
Wood packaging material *(excluded from this study, covered by ISPM 15)*	Yes	Yes
Sawdust and shavings, processed wood material, post-consumer scrap wood, furniture and other objects	No	No

Because of their association with bark and wood, bark and wood-boring Scolytinae and Platypodinae may also be associated with some non-wood pathways, including plants for planting (see below). Amongst species known to live in trunks or branches, some are known to attack large diameter material (which would make wood an obvious pathway, and plants for planting less likely) and some attack twigs (i.e. the reverse). However, it is not always possible to find in the literature whether a species attacks large or small trees or parts of trees.

All species in this study have some association with wood commodities, although there are uncertainties for some commodities and for species preferably attacking small diameter material (see below). Two specific issues are:

- ✓ Species that preferentially attack twigs or small diameter material (such as *Xylosandrus compactus*, rarely found in material > 6 cm diameter) are less likely to be associated with wood commodities produced mainly from trunks. However, commodities such as firewood (as round wood) may contain material of smaller diameter. In addition, some individuals may attack larger diameter material, for example in case of high population levels and outbreaks, and some wood commodities may also contain small diameter material or whole trees (EPPO, 2015a). Information is not available on the composition of commodities, also considering the diversity of non-coniferous wood that may be traded.
- ✓ Given the small size of bark and ambrosia beetles (adult body size ranges from less than 1 to 9 mm for the species in this study), association with commodities such as wood chips, hogwood and processing wood residues remains a potentially important risk, even if some individuals would be destroyed during processing, or would have lower likelihood of survival and transfer into a new area. Ambrosia beetles, which are associated with moisture-requiring fungi, may be more sensitive. However, the risk would depend on the freshness and humidity in the material, the size of particles etc. In this respect, processing wood residues (off-cuts, but not sawdust or shavings) may present a higher risk than wood chips or hogwood (especially when fresh and with bark) because they are bigger. However, such material can be further processed into chips or hogwood which will reduce the pest risk.

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[2] 'Wood with or without bark in the form of pieces of varying particle size and shape, produced by crushing with blunt tools such as rollers, hammers, or flails' (definition proposed in EPPO, 2015a)

Wood packaging material not treated according to ISPM 15 has been listed as a possible pathway in the pest information sheets for all species, given the large number of interceptions and introductions presumably linked to this pathway.

Other (non-wood) pathways are not specifically covered in this study but are indicated where relevant in the pest information sheets of individual species. A potential association with plants for planting (and possibly cut branches) was identified, with variable levels of uncertainty, for bark and ambrosia beetle species in this study. In addition, some species of Scolytinae and Platypodinae may feed and breed on various plant parts other than wood, such as seeds (*Conophthorus* sp. on conifer cones, *Coccotrypes dactyliperda* and *Dactylotrypes longicollis* on palm seeds), fresh or dry fleshy plant tissues (including stems of herbaceous plants, leaf petioles etc.) (Kirkendall *et al.*, 2015). Of 58 Scolytinae species known to be established in the continental USA as of 2010, Haack and Rabaglia (2013) categorized 25 as ambrosia beetles, 13 as bark beetles, 19 as seed and twig feeders, and one as a root feeder of herbaceous plants.

Conclusion. All bark and ambrosia beetles in this study have some association with wood commodities, thus increasing the risk of entry.

In Table 4, Wood comm. indicates the association with wood commodities

2.2 Known introductions (major factor)

Association with commodities in trade does not always results in establishment in new areas. Nevertheless, many species have already moved to new areas, either within their native continent or others, through natural or human-assisted spread. Imported wood commodities are often suspected to have been a possible pathway for introduction.

A total of 83 exotic bark and ambrosia beetle species (counting only Scolytinae, not Platypodinae)[3] have been recorded to have established in the USA or Canada (pers. comm., J.C. Grégoire, Université libre de Bruxelles, 2018; including references from Atkinson *et al.* 1990; Cognato *et al.* 2011, 2013, 2015; Gomez *et al.*, 2018; Haack 2001; 2006; Lee *et al.*, 2009; Okins and Thomas 2010; Rabaglia *et al.* 2009, 2010; Rabaglia and Okins 2011; Smith and Cognato, 2015; Seybold *et al.*, 2016; Hoebeke *et al.* 2018), New Zealand (Brockerhoff *et al.* 2006), Europe or other countries of the EPPO region (EPPO 2013; Faccoli *et al.* 2016; Gaaliche *et al.*, 2018; Garonna *et al.* 2012; Kirkendall and Faccoli 2010; Mendel *et al.*, 2012; Montecchio and Faccoli 2014; O'Donnell *et al.*, 2016). Information may not be complete, in particular for the whole EPPO region or for New Zealand. Out of the 83, 50 (ca. 60%) attack only non-coniferous hosts, 19 (ca. 23%) attack both coniferous and non-coniferous plants, and 12 (ca. 15%) attack only conifers, and the hosts of 2 (2%) are unknown. Hence, taking the overlap into account, 69 (83%) species can attack non-coniferous plants, and 31 (37%) species can attack coniferous species.

Most species used as example in this study are known to have moved to new areas, and about half are present with a limited distribution in the EPPO region.

The most recent publication in the EPPO region to date relates to *Hypocryphalus scabricollis*, reported causing severe damage on *Ficus carica* in Tunisia (Gaaliche *et al.*, 2018). It had previously been reported in Malta (1991 - Mifsud & Knížek 2009) and Italy (Faccoli *et al.*, 2016), also on *F. carica*.

Conclusion. The past introduction history documents a risk of entry and establishment.

In Table 4, Introd. indicates beetles known to have been introduced into new areas

2.3 Trade of wood commodities (major factor)

Introductions of bark and ambrosia beetles are related to traded commodities (see above). The existence of a trade is an essential factor for the risk of entry. There is no complete picture of all wood commodities traded into the whole EPPO region, although limited data is available for some genera and areas (e.g. *Quercus* for

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[3] This figure is based on a draft table providing details of species, which is under finalization and is planned to be published separately in a scientific article.

the EU in Eurostat). However, a huge diversity of non-coniferous species is known to be used for wood. For example, the 'working list of commercial timber tree species' lists 1575 non-coniferous species (see Annex 5).

FAOStat provides some data on import of wood commodities for most EPPO countries, although it does not detail wood by tree species or genera. Data is available for 'industrial non-coniferous tropical round wood', 'industrial non-coniferous non-tropical round wood' (both excluding firewood), 'non-coniferous sawn wood', 'wood chips and particles'. These commodities correspond partly to EPPO terms for wood commodities. Annex 5 provides definitions for the commodities in FAOStat, their correspondence with EPPO terms, and an analysis of FAOStat data. It is noted that trade data is not available for some commodities as defined in EPPO. Data for 2015 show imports to the EPPO region from all continents, with special features highlighted below.

Table 2. Summary of analysis of FAOStat data (imports into EPPO countries) in 2015 (see Annex 5)

Commodity (as per FAO Stat)	
'Industrial non-coniferous non-tropical roundwood' (excluding firewood)	Total import volume: over 1 020 000 m^3 from 63 countries. North America (esp. USA) and Asia (esp. China) represented over 75% and 17% of total imports, respectively.
'Industrial non-coniferous tropical roundwood' (excluding firewood)	Total import volume: over 190 000 m^3 from 38 countries. Africa represented over 90% of total imports.
'Sawn wood, non-coniferous'	Total import volume: over 1 304 000 m^3 from 72 countries. Africa, Asia (esp. Malaysia), North America (esp. USA) and South America (esp. Brazil) represented over 99% of total imports.
'Wood chips and particles (coniferous and non-coniferous)'	Total import volume: over 4.1 million m^3 from 27 countries. North America (esp. USA) and South America (esp. Brazil) accounted for over 99% of imports (about 55 and 44 % respectively)

Conclusion. There is a trade of non-coniferous wood commodities into the EPPO region, which creates a risk of entry. The commodities imported from outside the EPPO region come from a large diversity of origins in the northern and southern hemispheres.

2.4 Detection and identification in commodities and in trees (major factor)

Bark and ambrosia beetles are generally small and cryptic, and some may travel successfully in small numbers, which makes them difficult to detect. Nevertheless, Scolytinae often respond to attractants which may facilitate detection (e.g. pheromones, kairomones). Commonly used attractants such as ethanol allow a large range of bark and ambrosia beetles to be detected (Miller *et al.*, 2009; Steininger *et al.*, 2015). Detection success rates can be improved for a particular species by using a specific pheromone. Improved detection of wood boring beetles using commonly used attractants or multilure blends, including in the environment and at entry points, is being extensively studied (e.g. Rassati *et al.*, 2014 & 2015; Steininger *et al.*, 2015).

- *Size*

Scolytinae beetle bodies vary in size from ca. 0.5 mm to a little over a centimeter in length, with most species in the range 1 to 4 mm long (Kirkendall *et al.*, 2015). Adult body size for species (Scolytinae or Platypodinae) in this study range from less than 1 mm to 9 mm. Larger species may be easier to detect and may also be destroyed during the processing of wood, but they are still small insects.

- *Crypticity*

Bark and ambrosia beetle spend most of their life cycle within the inner bark (phloem and cambium) for bark beetles or the xylem for ambrosia beetles. Entry or exit holes are very small. Frass or sawdust is a sign of beetle presence, however, frass or sawdust may not always be noticed or may be washed away. Many species live in tree parts (e.g. crown, branches, top stems, roots) that are difficult to inspect.

- *Abundance*

In a new area, bark and ambrosia beetles can remain at low levels for several years before populations reach a level where spread starts occurring (e.g. following abiotic disturbances such as drought or storm), and populations are noticed. Most species of bark and ambrosia beetles are commonly not detected until damage is expressed, or until specific surveys are performed. Damage generally appears after some years following introduction after populations build-up. There are many examples in the literature. In the EPPO region, *Dryocoetes himalayensis*, found on *Juglans* and *Pyrus* in its Asian range, was first found in Europe in the 1970s, but its hosts in Europe were unknown until the first damage was recorded on *J. regia* in the Czech Republic in 2016 (Foit *et al.*, 2017). When no damage was observed following introduction of a species into a new area, it is difficult to assess whether this is due to the fact that they were introduced recently or to other factors.

- *Identification*

Identification of bark and ambrosia beetles is difficult and requires either specialized taxonomic expertise or access to gene sequencing. Kirkendall and Faccoli (2010) note that there is a lack of good illustrations and keys, which hinders identification, particularly for species coming from Asia and Oceania. Finally, taxonomic expertise to identify new species may be lacking in some EPPO countries.

Conclusion*. *Bark and ambrosia beetles are difficult to detect and identify, thus increasing the risk of entry and establishment.

2.5 Difficulty of eradication and containment (major factor)

Eradication of bark and ambrosia beetles is very difficult in nearly all circumstances. The eradication of *X. crassiusculus* in The Dalles, Oregon, is considered as the first success of eradication of an ambrosia beetle in North America (LaBonte, 2010).

Most species of bark and ambrosia beetles are commonly detected long after establishment (see above) and eradication is thus extremely difficult to achieve as population density has increased. In addition, there are few measures that are effective due to the cryptic life cycle (i.e. only removal and destruction of trees; mass-trapping is not effective). When detected, the species may already have started spreading naturally or through human-assisted pathways. This is especially the case when they are introduced into natural environments, even more if those are not managed or in areas that are less subject to pest surveillance. As for eradication, containment is extremely difficult, especially if the species is present in natural environments and is polyphagous. A good example of containment is the biological control of *Dendroctonus micans* by a specific predatory beetle, *Rhizophagus grandis*, which proved successful in the republic of Georgia, Turkey, France and the United Kingdom.

Conclusion. Eradication of bark and ambrosia beetles is very difficult in nearly all circumstances, increasing the risk of spread and impact.

2.6 Suitable habitats (colonization of new habitats and natural range of plant species) (major factor)

Although there is a wide diversity of non-coniferous woody plants in the EPPO region (see Annex 3), some areas present a wider natural range of species, such as the Mediterranean area, especially exposed to introductions of the predominantly tropical and subtropical bark and ambrosia beetles (see above *Climatic requirements*).

- *Diversity of woody species in the area of entry*

Areas where the diversity of trees is highest are more favourable for entry and establishment because non-indigenous beetles are more likely to find a suitable host. Details are provided in Annex 3 on this heterogeneity in the EPPO region. Regions with a high tree diversity are more vulnerable to exotic pest establishment (Liebhold *et al.* 2013). Conversely forest landscape heterogeneity may slow the spread (Rigot *et al.*, 2014) because suitable habitats may be less connected.

- *Proximity of forest and crops*

Habitat shifts between forest and orchards have been noted as a triggering factor of local outbreaks (e.g. *Xylosandrus crassiusculus* in Ghana and the USA; *Ambrosiodmus rubricollis* in Italy in an abandoned peach orchard; *Euwallacea fornicatus sensu lato* from avocado to forests). This has been noted in particular in young trees, stressed by planting. The proximity of forests and orchards increases the risk of attacks on new hosts.

- *Urban trees as gateways*

There is usually more diversity of woody species in the cities due to the presence of parks, botanical gardens, street trees, private gardens, which increases the probability for the beetles of finding a suitable host. Cities are considered as heat-islands with an average temperature of 2-3 degrees warmer than surrounding areas and may thus be more suitable for the establishment of warm-adapted species. Woody plants are also usually more stressed by air pollution, drought and soil compaction in urban environments, which make them more vulnerable to beetle attacks (Brune, 2016; EPPO, 2015b). Finally, large ports and airports, which are important entry points, are located close to cities and movements of potentially infested commodities linked to population density are particularly important in and around cities, and will favour human assisted spread (EPPO, 2015b). Newly established bark or ambrosia beetles could then spread to surrounding environments, including forests.

Conclusion. The existence of suitable habitat(s) increases the risk of entry, establishment, spread and impact.

2.7 Management practices (medium factor)

Good management practices can reduce susceptibility to infestation by bark and ambrosia beetles. They would protect plants from attacks by secondary pests. For example, thinning of plantations can increase vigour of individual trees (Fettig *et al.*, 2007). Conversely overwatering or underwatering of young trees in orchards can reduce resilience to attack (Ranger *et al.*, 2013, 2016).

2.8 Known damage (major factor)

- *Economic impact*

Damage by bark and ambrosia beetles can lead to degradation of the wood value, tree decline and sometimes tree death. Bark beetles can kill trees by themselves, but are also associated with destructive diseases. Tree decline and mortality would have major negative impacts on forests, as well as plantations and other productions such as fruit trees, nurseries and ornamental trees. Replacement of dead trees would incur costs, for example to replace urban trees. Structural damage is caused through gallery formation, and degradation of quality through staining (by the fungus) of freshly cut trees. Mechanical damage may also weaken the host physiologically and makes it more susceptible to other harmful biotic or abiotic environmental factors. Finally, exports of wood commodities from a country where a bark or ambrosia beetle has established may be negatively affected.

Table 3. Examples of known economic impacts (all species mentioned may also cause other impacts)

Reduction in wood value	*Xylosandrus crassiusculus*, *Phloeotribus liminaris*, *Platypus quercivorus*, *P. apicalis*, *P. gracilis*, *Monarthrum mali*, *Megaplatypus mutatus*, *Euplatypus parallelus*, *Austroplatypus incompertus*, *Platypus subgranosus* *Trachyostus ghanaensis* (FAO, 2007 citing Wagner, Atuahene and Cobbinah, 1991)
Death of mature trees	*Platypus apicalis*, *P. gracilis*, *P. subgranosus*, *P. quercivorus*, *P. koryoensis*, *Gnathotrupes* spp. of *Nothofagus*, *Euwallacea fornicatus sensu lato*, *Megaplatypus mutatus*, *Scolytus schevyrewi*
Death of young trees (nurseries, plantations, ornamentals, fruit trees)	*Cnestus mutilatus*, *Xylosandrus crassiusculus*, *X. compactus*, *Hypothenemus eruditus*, *Acanthotomicus* sp. on *Liquidambar styraciflua*
Damage in fruit orchards	*Euwallacea fornicatus sensu lato* (incl. *Persea americana*, *Punica granatum* etc.), *Xylosandrus compactus* (coffee), *Pityophthorus juglandis* (*Juglans*), *Ambrosiodmus rubricollis*? (peach), *Xyleborus bispinatus*? (fig), *Monarthrum mali* (incl. *Malus*), *Megaplatypus mutatus* (incl.

	Malus, *Corylus*, others), *Xylosandrus crassiusculus* (*Castanea sativa*, *Mangifera indica*, *Vitis*), *Ambrosiodmus rubricollis*? (stone fruit), *Phloeotribus liminaris*? (peach), *Euplatypus parallelus* (*Mangifera indica, Anacardium occidentale).* *Ambrosiophilus atratus* (Choo *et al.*, 1983)

Impacts for which there is an uncertainty are marked with '?'

- *Environmental impact*

Bark and ambrosia beetles may have an impact on non-coniferous plants in the wild, especially in areas where these are important, such as sensitive environments or mountains. Tree mortality may lead to soil erosion. *X. compactus* is causing environmental damage in the Mediterranean maquis in Italy, and attacked rare native species in Hawaii and La Réunion. Changes to ecosystems may also occur due to death of trees, and other species associated with host plants may be affected. Dutch elm disease caused the disappearance of elm trees from the landscape and from the forests all over Europe (Ghelardini *et al.*, 2017; Santini and Faccoli, 2014). Environmental damage or concerns mentioned in relation to extensive tree mortality due to *Platypus quercivorus* and *R. quercivora* in Japan, relate to preventing forest regeneration, deterioration of biodiversity, soil erosion, changes of forest composition. *Xyleborus glabratus* has altered the composition of forests and threatens North American Lauraceae species. The coniferous species *Dendroctonus ponderosae* and *Ips typographus* have caused such damage that forests have become net emitters of carbon (Kurz *et al.*, 2008; Seidl *et al.*, 2008 and 2014).

- *Social impact*

Social impact may be high in areas of infestation in forests, plantations or orchards because of job losses. This was the case for *Dendroctonus rufipennis* due to a processing unit closing because of losses of wood production (Grégoire *et al.*, 2015). Losses of jobs had also been anticipated to occur when *Pityophthorus juglandis* would reach the main area of *Juglans nigra* production in Eastern USA (although this may not have happened to date). Changes in the landscape may affect tourism. The recreational value of parks and amenity will also be affected, e.g. because risk of tree breakage may increase. Social damage also occurs, due to loss of amenity and garden trees (e.g. *P. juglandis* in the USA). *Euwallacea fornicatus sensu lato* caused the death of large number of ornamental trees in California and Israel. Finally damage may occur in botanical tree collections, such as occurred with *P. juglandis* in the USA, or *Platypus quercivorus* in Kyoto National Garden (Japan).

Knowledge on existing damage is useful to identify a risk. However, there are often uncertainties in terms of the hosts that will be attacked in a new invaded area, and their susceptibility; consequently, damage cannot be fully predicted. In addition, the expression of damage in a new area would take time, until populations reach a certain level, and they may not be expressed in the first place of introduction. It is therefore difficult to rule out that a new situation could arise in a new place, except possibly for bark and ambrosia beetles that have moved extensively worldwide for a long time, and do not present any other specific factor (but they are probably already widely present in the EPPO region).

Conclusion. Bark and ambrosia beetles may cause high economic, environmental or social impact. Known high impact is an indicator of potential risk.

In Table 4, Kill trees indicates beetles known to be capable of killing trees of some hosts
Decreased value indicates beetles recorded to have decreased the value of wood commodities or the
quality of crops (e.g. orchards) (but never recorded to kill the trees) for some hosts.

Table 4. Rating of risk factors for the 26 representative species and groups of species

Legend: s.l. = *sensu lato*; Y = Yes; N = No; N? = doubt on the answer; Empty cell: no information available.

Type of beetle and risk factors	**Key element of risk factor**	*Acanthotomicus suncei* Cognato	*Ambrosiodmus rubricollis* (Eichhoff)	*Austroplatypus incompertus* (Schedl)	*Cnestus mutilatus* (Blandford)	*Euplatypus parallelus* (Fabricius)	*Euwallacea fornicatus s.l.* (Eichhoff)	*Euwallacea interjectus* (Blandford)	*Euwallacea validus* (Eichhoff)	*Gnathotrupes* spp. of *Nothofagus*	*Hypothenemus eruditus* (Westwood)	*Megaplatypus mutatus* (Chapuis)	*Monarthrum mali* (Fitch)	*Phloeotribus liminaris* (Harris)	*Pityophthorus juglandis* Blackman	*Platypus apicalis* White	*Platypus gracilis* Broun	*Platypus koryoensis* (Murayama)	*Platypus quercivorus* (Murayama)	*Platypus subgranosus* Schedl	*Scolytus schevyrewi* Semenov	*Xyleborinus artestriatus* (Eichhoff)	*Xyleborinus octiesdentatus* (Murayama)	*Xyleborus bispinatus* Eichhoff	*Xyleborus glabratus* Eichhoff	*Xylosandrus compactus* (Eichhoff)	*Xylosandrus crassiusculus* (Motschulsky)
Bark / ambrosia	a = ambrosia beetle, b = bark beetle	b	a	a	a	a	A	a	a	a	b	a	a	b	b	a	a	a	a	a	b	a	a	a	a	a	a
Mating strategy	Reproduction through inbreeding	N	Y	N	Y	N	Y	Y	Y	N	Y	N	N	N	N	N	N	N	N	N	N	Y	Y	Y	Y	Y	Y
Host condition	Recorded as attacking live trees (stressed or apparently healthy)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Host specificity	Polyphagous; recorded from multiple host families	N	Y	N	Y	Y	Y	Y	Y	N	Y	Y	Y	N	N	Y	Y	N	Y	Y	N	Y	Y	Y	Y	Y	Y
	No. of host families (indicative); based on pest information sheets, taking account of all host families. '+' indicates when this is probably higher	1	20+	1	20+	30+	60+	18+	13+	1	50+	30+	14+	1	1	5+	5+	1	15+	5+	2	9+	4+	10+	5+	60+	50+
	Known to have colonised new host species	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
Associated fungi	Fungus-farming species	N	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	N	N	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
	Known to be associated with pathogenic fungus	N	N	N	N	Y	Y	Y	Y	N	Y	N	N	N	Y	Y	Y	N	Y	Y	Y	N	N	Y	Y	Y	Y
	Known maturation feeding	N	N	N	N	N	N	N	N	N	N	N	N	Y	Y	N	N	N	N	N	Y	N	N	N	N	N	N
Climatic requirements	Originates from climates represented in the EPPO region, or has moved from subtropical/tropical to cooler climates	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Type of beetle and risk factors	**Key element of risk factor**	*Acanthotomicus suncei* Cognato	*Ambrosiodmus rubricollis* (Eichhoff)	*Austroplatypus incompertus* (Schedl)	*Cnestus mutilatus* (Blandford)	*Euplatypus parallelus* (Fabricius)	*Euwallacea fornicatus s.l.* (Eichhoff)	*Euwallacea interjectus* (Blandford)	*Euwallacea validus* (Eichhoff)	*Gnathotrupes* spp. of *Nothofagus*	*Hypothenemus eruditus* (Westwood)	*Megaplatypus mutatus* (Chapuis)	*Monarthrum mali* (Fitch)	*Phloeotribus liminaris* (Harris)	*Pityophthorus juglandis* Blackman	*Platypus apicalis* White	*Platypus gracilis* Broun	*Platypus koryoensis* (Murayama)	*Platypus quercivorus* (Murayama)	*Platypus subgranosus* Schedl	*Scolytus schevyrewi* Semenov	*Xyleborinus artestriatus* (Eichhoff)	*Xyleborinus octiesdentatus* (Murayama)	*Xyleborus bispinatus* Eichhoff	*Xyleborus glabratus* Eichhoff	*Xylosandrus compactus* (Eichhoff)	*Xylosandrus crassiusculus* (Motschulsky)
Mass attacks	Using an aggregation pheromone	N	N		N	N	N	N	N	N	N	N	N	N	Y	Y	Y	Y	Y		N	N	N	N	N	N	N
Voltinism and sister broods	Multivoltine (more than one generation/year)	Y		N	N		Y		N		Y	N	Y	Y	Y	N	N	N	Y	N	Y				Y	Y	Y
Association with commodities	Associated with wood commodities	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N?	Y
Known introductions	Known to have been introduced into new areas	N	Y	N	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y
Impact	Capable of killing trees of some hosts	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N?	Y	Y	Y	Y
	Has decreased the value of wood commodities or quality of crops (e.g. orchards) for some hosts, but not recorded to kill host trees.	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Category in case studies	1. Known substantial damage; 2. Indications of damage, with some uncertainties; 3. No documented damage, but several potential risk factors exist	2	3	3	2	1	1	2	2	2	2	2	2	3	1	1	1	2	1	2	2	3	3	2	1	2	2
In EPPO?	Based on pest information sheets, recorded as present in the EPPO region	N	Y	N	N	N	Y	N	N	N	Y	Y	Y	Y	Y	N	N	N	N	N	Y	N	N	Y	N	Y	Y

3. Conclusion

The potential pest risk associated with bark and ambrosia beetles relates to a large number of generic factors which have been considered in the context of pest risk assessment (i.e. risks of entry, establishment, spread and impact). The species selected exhibit several of these factors, which can individually or in combination increase the pest risk (see Table 4). Examples of known combinations of factors facilitating successful invasions are: inbreeding strategy and polyphagy for Xyleborini (e.g. *Euwallacea*), pathogenic fungus and mass-attacks for *Pityophthorus juglandis*. However, the main factors that are driving successful establishment and impact vary from species to species and are not always fully identified.

This section has identified and detailed factors known to influence the risk of entry, establishment, spread and impact for bark and ambrosia beetles, as summarized in the table below.

Table 5. Summary of risk factors and their influence on entry, establishment, spread and impact (in bold, major factors)

Risk factor	level	Process	entry	establishment	spread	impact
Mating strategy	**Major**	**Inbreeding**	**X**	**X**		
Host condition	**Major**	**Ability to colonize live trees**	**X**	**X**		**X**
		Ability to live in cut wood	**X**			
Host specificity	**Major**	**Polyphagy**	**X**	**X**		**X**
		Ability to attack new host species when introduced to new locations	**X**	**X**		**X**
Associated fungi	**Major**	**Fungus-farming**		**X**		
		Association with a pathogenic fungus				**X**
		Inoculation through maturation feeding		**X**		**X**
Climatic requirements	**Major**	**Climatic suitability**		**X**	**X**	
Mass attacks	Medium	Aggregation pheromone				X
Dispersal capacity	**Major**	**Natural and human-assisted**	**X**	**X**	**X**	
Voltinism and sister broods	Medium	More than one generation			X	X
Association with wood commodities	**Major**	**Persistence in wood**	**X**			
Trade of wood commodities	**Major**	**Movement in trade**	**X**			
Known introductions	**Major**	**Capacity to move into new areas**	**X**	**X**		
Detection and identification in commodities and in trees	**Major**	**Small and cryptic insects**	**X**	**X**		
Difficulty of eradication and containment	**Major**	**Small and cryptic insects, low population levels**			**X**	**X**
Suitable habitats	**Major**	**Colonization of new habitats and natural range of plant species**	**X**	**X**	**X**	**X**
Management practices	Medium	Stressed trees		X		X
Known damage	**Major**	**Killing trees or decreased value**				**X**

Evaluation of impact

While known impact shows that there may be a risk, absence of impact does not mean that a species does not present a risk. Unexpected damage may occur only when the species reaches a new host, a new area, or become associated with a new pathogenic fungus etc. The pathogenicity of the associated fungi may also vary with the hosts they encounter.

Each species responds differently to new conditions

The examples in this study show clearly that there is always an uncertainty concerning the behaviour of a species when introduced into new areas, in terms of host range, establishment, spread and impact. The study relied on species for which detailed information was available. However, assessing risk is significantly more complicated, and subject to uncertainties, when limited information is available, or when introduction has not occurred or has not led (yet) to damage. There are probably hundreds if not thousands of Scolytinae and Platypodinae species of non-coniferous woody plants worldwide that are not yet present in the EPPO region and belong to this category.

Some species have adapted to different climatic conditions. Tropical or subtropical species have been introduced in the Mediterranean area. Although the risk of their establishment in temperate or colder areas may be lower, this is difficult to assess in most cases.

Finally, throughout the EPPO region, there is a huge diversity of non-coniferous woody plants that are important in the wild or in cultivation and need to be protected from potentially destructive pests. Climate change may have yet unknown consequences in terms of climatic suitability for the pests, but with climate change, stress of trees is likely to increase in the region in the future, and stressed trees are overall more susceptible to bark and ambrosia beetles. In particular, it is noticed that woody plants in urban environments are more stressed and therefore may be more susceptible to bark and ambrosia beetles than in other areas.

In conclusion, the introduction of a new bark or ambrosia beetle may potentially lead to serious impact. Although only a small proportion of all Scolytinae and Platypodinae probably have the characteristics for successful establishment and impact in the EPPO region, lack of knowledge regarding individual species and unexpected performance in case of introduction to a new area challenge the current approach of pest-specific risk analysis.

Can measures target specific host plants of importance for the EPPO region, can tropical wood be excluded?

From the current analysis, it can be concluded that the risk cannot be addressed by targeting only some particular hosts that are major species for the EPPO region (e.g. key forestry species), because many bark or ambrosia beetles are polyphagous and thus may be introduced on other hosts. Consequently, an approach using pest-specific PRA is too limited to cover the huge diversity of plant species being imported. It is noted that eradication and containment are extremely difficult to achieve.

Tropical wood is also considered to present a risk as species that are prone to attacking new hosts when introduced in new locations may be able to enter on such wood and then establish on new hosts in the EPPO region. There is a known trade of wood from tropical areas. Tropical and subtropical species are known to have established in other climatic conditions. Establishment of such species in the EPPO region is more likely to occur in the future with climate change.

Based on the analysis made in this study, it is recommended that EPPO member countries adopt horizontal measures for bark and ambrosia beetles for all non-coniferous wood from all origins.

Additional remarks

In addition to wood commodities, many species are potentially able to enter on plants for planting, cut branches, etc. This is not specific to bark and ambrosia beetles and applies to many pest groups. Cut branches are generally considered less likely or uncertain, because of their normal use that is unfavourable for survival and transfer to living hosts. The need for regulation of plants for planting in relation to Scolytinae and Platypodinae is emphasized.

SECTION 2. PHYTOSANITARY MEASURES

The EWG noted that ISPM 39 *International movement of wood* (FAO, 2017) states that

> *'National plant protection organizations (NPPOs) should use the pest risk analysis (PRA) to provide the technical justification for phytosanitary import requirements for quarantine pests associated with the international movement of wood.*
>
> *Proportionate to the pest risk identified, phytosanitary measures for managing the pest risk related to wood, including bark removal, treatment, chipping and inspection, should be applied.'*
>
> ....
>
> *The pest risk of the commodities addressed in this standard varies depending on: the wood's origin and species; characteristics such as the level of processing and the treatment the wood has undergone and the presence or absence of bark; and the intended use.*
>
> *This standard describes the general pest risk related to each wood commodity by indicating major pest groups associated with it. In addition to the risk factors listed above, the pest risk associated with a wood commodity may also depend on factors such as age, size, moisture content, pest status at origin and destination, and duration and mode of transport.*
>
> *Phytosanitary measures should not be required without appropriate technical justification based on PRA (as described in ISPM 2 (Framework for pest risk analysis) and ISPM 11 (Pest risk analysis for quarantine pests)), taking into account:*
>
> - *the pest status where the wood originated*
> - *the degree of processing before export*
> - *the ability of a pest to survive on or in the wood*
> - *the intended use of the wood*
> - *the likelihood of establishment of a pest in the PRA area, including the presence of a vector if needed for the dispersal of the pest.*

As explained in the introduction, lack of knowledge regarding individual species and unexpected performance in case of introduction to a new area challenge the current approach of pest-specific risk analysis. In this study it was shown that bark and ambrosia beetles from tropical origins have been introduced and established in temperate regions (see Section 1 of the study), Consequently, the EWG recommended that in order to reduce the risk of introduction of new bark beetles and ambrosia beetles (Scolytinae and Platypodinae) on non-coniferous wood commodities, horizontal measures should be proposed irrespective of the host plant species and the origin.

The measures proposed have been designed based on a review of the recommendations included in ISPM 39 *International movement of wood* (FAO, 2017) and risk management measures included in existing PRAs. The EWG considered measures that are already recommended and used in practice for such commodities. It did not aim at identifying novel pest risk management options.

The commodities (as described in PM 8 Standards) for which measures should be identified are

- Round wood with or without bark and sawn wood
- Isolated bark
- Harvesting wood residues and processing wood residues (except sawdust and shavings), wood chips and hogwood,

Treatments that are commonly recommended for wood commodities are effective for bark and ambrosia beetles (heat treatment, ionizing, fumigation). Such measures are included ISPM 39.

Treatments that target both bark and ambrosia beetles are recommended (i.e. bark free is not included as it would not be an appropriate measure for ambrosia beetles, similarly treatment of bark is recommended to cover bark beetles although such a measure is not needed for ambrosia beetles).

There are few measures in place for wood commodities of non-conifer wood in EPPO Countries and requiring such measures is very likely to have an impact on trade particularly for round wood.

Some issues were discussed more specifically during the EWG and are presented below:

Chipping to a certain size

ISPM 39 includes information on the likelihood of association of bark beetles and wood-boring beetles with wood chips of a specific size but also states that

> *The mechanical action of chipping or grinding wood can be effective in destroying most wood-dwelling pests. Reduction of the chip size to a maximum of 3 cm in at least two dimensions may mitigate the pest risk posed by most insects. However, fungi, nematodes and small insects such as some Scolytinae, or small Buprestidae, Bostrichidae or Anobiidae may continue to present a pest risk.*

Most species of Scolytinae and Platypodinae are small and their size is between 1 mm to 4 mm with some species reaching a little over 1 cm (see Section 1, 2.4) other wood-borer are larger e.g. *Cerambycidae* are mostly above 1 cm.

The EWG noted that ISPM 39 recognizes that small insects such as Scolytinae may still present a pest risk after chipping (see extract below), and this is valid for bark beetles and ambrosia beetles.

In the EPPO Standards PM 8 for non-conifer species a maximum size for wood chips of 2.5 cm in any direction is only recommended for Cerambycidae species (Apriona, *Anoplophora*, *Oemona hirta*[4]) species which are bigger in size than bark and ambrosia beetles.

In the EPPO PRA on *Pityophthorus juglandis* (EPPO, 2015c) it is stated:

> *The European Standard on solid fuel (CEN, 2010) identifies four classes of wood chips according to particle size (i.e. passing through round hole sieve of the specified size), with a fraction (3 to 6%) being allowed to be above the class size. Wood chips in the smallest class have a minimum size of 3-15 mm. In the largest class, 75% of wood chips should be comprised in the range 16-100 mm, and 6% can measure 200-350 mm (Alakangas, 2010). In the Netherlands, the common maximum size of wood chips (in any direction) is 200 mm (Kopinga et al., 2010). Because all life stages of P. juglandis are very small (1.5-1.9 mm for adults), remaining individuals would survive in wood chips of any size.*

In the Spanish PRA on *Euwallacea fornicatus* (NPPO Spain, 2015), the same conclusion that beetles would survive in wood chips of any commercial size is reached.

> ***As a conclusion, the EWG recommended that chipping to common commercial size should not be recommended as a measure for imported commodities (and by extension as a measure for non-compliant commodity)***

Pest-free area as a horizontal measure

The principle of including a generic requirement for pest free area (PFA) for bark and ambrosia beetles as a horizontal measure was discussed. The EWG concluded that it is not appropriate to include PFA in horizontal measures. A PFA is by definition related to specific pests, and its suitability and reliability as a measure has to be identified on a case by case basis depending on the biology of the species, the situation in the area(s) where it is present and the possibility of early detection. This is consistent with the conclusions reached in the Panel on Quarantine Pests for Forestry in 2015. Horizontal measures proposed in this study aim to provide protection against a wide range of non-coniferous bark and ambrosia beetles rather than a series of individual species.

As a conclusion, PFA as a measure may be evaluated when and if PRA(s) are performed on individual species which will allow NPPOs to gather information on the species present in the exporting country.

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[4] Chipped to pieces of less than 2.5 cm in any dimension or to 1.5 cm in 2 dimensions

3 Possible horizontal measures

- *Generic trapping programmes*

National plant protection organizations are encouraged to establish generic trapping programs near entry points.

- *Requirement not considered by the EWG to provide an appropriate level of protection*

Based on the outcomes of this study the **minimum** requirement suggested is that non-coniferous wood commodities **should be accompanied by a phytosanitary certificate ensuring that inspection will be performed prior to export**.

- *Treatments considered to provide a more adequate level of protection*

Treatments that target both bark and ambrosia beetles are recommended (i.e. bark free is not included as it would not be an appropriate measure for ambrosia beetles, similarly treatment of bark is recommended to cover bark beetles although such measure is not needed for ambrosia beetles).

Round wood with or without bark and sawn wood	Heat treatment according to EPPO Standard PM 10/6 **OR** Treated with ionizing radiation according to EPPO Standard PM 10/8 **OR** Appropriate fumigation, details to be specified on the phytosanitary certificate. **AND** Stored in conditions to prevent infestation prior to export and transported closed, to prevent infestation A higher level of protection can be achieved if the wood is debarked in addition to the measures proposed above.

Isolated bark	Heat treatment (until the core temperature reaches at least 56 °C for at least 30 min). **OR** Appropriate fumigation, details to be specified on the phytosanitary certificate. **AND** Stored in conditions to prevent infestation prior to export and transported closed, to prevent infestation

Harvesting wood residues, processing wood residues (except sawdust and shavings), wood chips, and hogwood	Heat treatment (until the core temperature reaches at least 56 °C for at least 30 min). **OR** Appropriate fumigation, details to be specified on the phytosanitary certificate. **AND** Stored in conditions to prevent infestation prior to export and transported closed, to prevent infestation

References

Atkinson TH, Rabaglia RJ, Bright DE. 1990. Newly detected exotic species of *Xyleborus* (Coleoptera: Scolytidae) with a revised key to species in eastern North America. The Canadian Entomologist 122: 92–104.

Atkinson TH, Riley EG. 2013. Atlas and checklist of the bark and ambrosia beetles of Texas and Oklahoma (Curculionidae: Scolytinae and Platypodinae). Insecta Mundi 292: 1-46.

Beaver RA. 1979. Host specificity of temperate and tropical animals. Nature 281:139–141.

Bickerstaff JRM. 2017. Morphological and Molecular Characterisation of Australian Pinhole Borers (Coleoptera: Curculionidae, Platypodinae). MSc Thesis, Western Sydney University.

Boddy L, Büntgen U, Egli S, Gange AC, Heegaard E, Kirk PM, Mohammad A, Kauserud H. 2014. Climate variation effects on fungal fruiting. Fungal Ecology 10: 20-33.

Brockerhoff EG, Bain J, Kimberley M, Knízek M. 2006. Interception frequency of exotic bark and ambrosia beetles (Coleoptera: Scolytinae) and relationship with establishment in New Zealand and worldwide. Can. J. For. Res. Vol. 36: 289-298.

Brune M. 2016. Urban trees under climate change. Potential impacts of dry spells and heat waves in three German regions in the 2050s. Report 24. Climate Service Center Germany, Hamburg.

Chase KD, Kelly D, Liebhold AM, Bader MK-F, Brockerhoff EG. 2017. Long-distance dispersal of non-native pine bark beetles from host resources. Ecological Entomology, 42(2): 173-183. doi: 10.1111/een.12371

Choo HY, Woo KS, Nobuchi A. 1983. A list of the bark and ambrosia beetles injurious to fruit and flowering trees from Korea (Coleoptera: Scolytidae). Korean Journal of Plant Protection, 22(3):171-173

Cognato AI, Hoebeke ER, Kajimura H, Smith SM. 2015. History of the Exotic Ambrosia Beetles *Euwallacea interjectus* and *Euwallacea validus* (Coleoptera: Curculionidae: Xyleborini) in the United States. Journal of Economic Entomology 108: 1129–1135. https://doi.org/10.1093/jee/tov073

Cognato AI, O'Donnell-Olson R, Rabaglia RJ. 2011. A native Asian ambrosia beetle *Xylosandrus amputatus* (Blandford) (Curculionidae: Scolytinae: Xyleborini) discovered in Florida, U.S.A. Coleopterists Bulletin 65:43–45.

Cognato AI, Rabaglia RJ, Vandenberg NJ. 2013. Another Asian ambrosia beetle, *Xyleborinus artestriatus* (Eichhoff 1878) (Coleoptera: Curculionidae: Scolytinae: Xyleborini), newly detected in North America. The Pan-Pacific Entomologist, 89(1), 27-31.

Cognato AI, Hoebeke ER, Kajimura H, Smith SM. 2015. History of the exotic ambrosia beetles *Euwallacea interjectus* and *Euwallacea validus* (Coleoptera: Curculionidae: Xyleborini) in the United States. Journal of Economic Entomology, 108(3), pp.1129-1135.

Cola L. 1971. Mit fremden Holzen eingeschleppte Insekten, insbesondere Scolytidae und Platypodidae. Anzeiger fur Schadlingskunde und Pflanzenschutz, 44(5):65-68.

Cola L. 1973. Mit fremden Holzern eingeschleppte Insekten, insbesondere Scolytidae und Platypodidae. (2. Beitrag). Anzeiger fur Schadlingskunde, Pflanzenund Umweltschutz 46(1):7-11.

Desprez-Loustau M-L, Robin C, Reynaud G, Déqué M, Badeau V, Piou D, Husson C, Marçais B. 2010. Simulating the effects of a climate-change scenario on the geographical range and activity of forest-pathogenic fungi, Canadian Journal of Plant Pathology, 29(2): 101-120.

Dodds KJ, Hanavan RP, DiGirolomo MF. 2017. Firewood collected after a catastrophic wind event: the bark beetle (Scolytinae) and woodborer (Buprestidae, Cerambycidae) community present over a 3-year period. Agricultural and Forest Entomology, 19:309-320.

EPPO. 2013. First report of *Anisandrus maiche* in Ukraine. RS 2013/30. EPPO Reporting Service February 2013.

EPPO. 2015a. EPPO Technical Document No. 1071, EPPO Study on wood commodities other than round wood, sawn wood and manufactured items. EPPO Paris. Available at https://www.eppo.int.

EPPO. 2015b. 15/20388 Forest pest risks associated with urban trees. Panel QPF point 3.

EPPO. 2015c. Pest risk analysis for Thousand cankers disease (*Geosmithia morbida* and *Pityophthorus juglandis*). EPPO, Paris. Available at https://www.eppo.int

EPPO. 2018. EPPO Global Database (available online). https://gd.eppo.int.

Faccoli M, Campo G, Perrotta G, Rassati D. 2016. Two newly introduced tropical bark and ambrosia beetles (Coleoptera: Curculionidae, Scolytinae) damaging figs (Ficus carica) in southern Italy. Zootaxa, 4138(1), 189-194.

Fahrner S, Aukema BH. 2018. Correlates of spread rates for introduced insects. Global ecology and biogeography, 27(6)734-743.

FAO. 2017. ISPM 39. *International movement of wood.* International Plant Protection Convention (IPPC), Food and Agriculture Organization (FAO). Rome, Italy.

FAO. 2019. ISPM 15 *Regulation of wood packaging material in international trade*. IPPC, FAO. Rome, Italy.

Fettig CJ, Klepzig KD, Billings RF, Munson S, Nebeker TE, Negrón JF, Nowak JT. 2007.The effectiveness of vegetation management practices for prevention and control of bark beetle infestations in coniferous forests of the western and southern United States. Forest Ecology and Management 238: 24–53.

Foit J, Kašák J, Májek T, Knížek M, Hoch G, Steyrer G. 2017. First observations on the breeding ecology of invasive *Dryocoetes himalayensis* Strohmeyer, 1908 (Coleoptera: Curculionidae: Scolytinae) in its introduced range in Europe – Short communication. Journal of Forest Science, 63(6): 290–292.

Formby JP, Rodgers III JC, Koch FH, Krishnan N, Duerr DA, Riggins JJ. 2018. Cold tolerance and invasive potential of the redbay ambrosia beetle (*Xyleborus glabratus*) in the eastern United States. Biol Invasions, 20(4), 995-1007.

Gaaliche B, Ben Abdelaali N, Mouttet R, Ben Halima-Kamel M, Hajlaoui MR. 2018. Nouveau signalement de *Hypocryphalus scabricollis* (Eichhoff, 1878) en Tunisie, un ravageur émergent sur figuier (*Ficus carica* L.). Bulletin OEPP/EPPO Bulletin, 48(1), 164-166.

Gao L, Cognato AI. 2018. *Acanthotomicus suncei*, a new sweetgum tree pest in China (Coleoptera: Curculionidae: Scolytinae: Ipini). Zootaxa, 4471, 595–599.

Garonna AP, Dole SA, Saracino A, Mazzoleni S, Cristinzio G. 2012. First record of the black twig borer *Xylosandrus compactus* (Eichhoff) (Coleoptera: Curculionidae, Scolytinae) from Europe. Zootaxa, 3251: 64-68.

GEFF 2017. Le Groupe des Entomologistes Forestiers Francophones en Savoie. http://agriculture.gouv.fr/le-groupe-des-entomologistes-forestiers-francophones-en-savoie. Consulted 16/12/2017.

Ghelardini L, Luchi N, Pecori F, Pepori AL, Danti R, Della Rocca G, Capretti P, Tsopelas P, Santini A. 2017. Ecology of invasive forest pathogens. Biological Invasions 19(11), pp. 3183-3200.

Gomez DF, Rabaglia RJ, Fairbanks KE, Hulcr J. 2018. North American Xyleborini north of Mexico: a review and key to genera and species (Coleoptera, Curculionidae, Scolytinae). ZooKeys, 768, 19.

Graniti A. 1998. Cypress canker: a pandemic in progress. Ann Rev Phytopathol 36:91-114.

Grégoire JC, Raffa KF, Lindgren BS. 2015. Economics and Politics of Bark Beetles. Chapter 15 in Bark Beetles, Biology and Ecology of Native and Invasive Species, 1st Edition, Vega F and Hofstetter R (eds), Academic Press.

Grosdidier M, Ioos R, Marçais B. 2018. Do higher summer temperatures restrict the dissemination of *Hymenoscyphus fraxineus* in France? Forest Pathology. 48(4) e12426.

Haack RA, Rabaglia RJ. 2013. Exotic bark and ambrosia beetles in the USA: potential and current invaders. Potential invasive pests of agricultural crops. CAB International, Wallingford, 48-74.

Haack RA, Petrice TR, Wiedenhoeft AC. 2010. Incidence of bark- and wood-boring insects in firewood: a survey at Michigan's Mackinac Bridge. J Econ Entomol. 103(5):1682-92.

Haack RA. 2001. Intercepted Scolytidae (Coleoptera) at U.S. ports of entry: 1985–2000. Integrated Pest Management Reviews, 6: 253–282.

Haack RA. 2006. Exotic bark-and wood-boring Coleoptera in the United States: recent establishments and interceptions. Canadian Journal of Forest Research, 36 (2): 269-288.

Hoebeke ER, Rabaglia RJ, Knižek M, Weaver JS. 2018. First records of *Cyclorhipidion fukiense* (Eggers) (Coleoptera: Curculionidae: Scolytinae: Xyleborini), an ambrosia beetle native to Asia, in North America. Zootaxa 4394: 243–250.

Hulcr J, Atkinson TH, Cognato AI, Jordal BH, McKenna DD. 2015. Morphology, Taxonomy, and Phylogenetics of Bark Beetles. Chapter 2 in Bark Beetles, Biology and Ecology of Native and Invasive Species, 1st Edition, Vega F and Hofstetter R (eds), Academic Press.

Hulcr J, Black A, Prior K, Chen CY, Li HF. 2017. Studies of ambrosia beetles (Coleoptera: Curculionidae) in their native ranges help predict invasion impact. Florida Entomologist, 100(2), 257-261.

Hulcr J, Stelinski LL. 2017. The Ambrosia Symbiosis: From Evolutionary Ecology to Practical Management. Annual Review of Entomology 62:1, 285-303.

Jacobi WR, Koski RD, Negron JF. 2013. Dutch elm disease pathogen transmission by the banded elm bark beetle *Scolytus schevyrewi*. For. Path. 43 (2013) 232–237.

Janin JL, Lieutier F. 1988. Early mating in the life-cycle of *Tomicus piniperda* L. (Coleoptera, Scolytidae) in the forest of Orleans (France). Agronomie 8, 169–172.

Jordal BH, Beaver RA, Kirkendall LR. 2001. Breaking taboos in the tropics: incest promotes colonization by wood-boring beetles. Global Ecology & Biogeography 10, 345–357.

Jordal, B. 2015. Molecular phylogeny and biogeography of the weevil subfamily Platypodinae reveals evolutionarily conserved range patterns. Molecular Phylogenetics and Evolution, 92:294-307.

Kamata N, Esaki K, Kato K, Igeta Y, Wada K. 2002. Potential impact of global warming on deciduous oak dieback caused by ambrosia fungus *Raffaelea* sp. carried by ambrosia beetle *Platypus quercivorus* (Coleoptera: Platypodidae) in Japan. Bulletin of Entomological Research 92: 119-126.

Kirisits T. 2004. Fungal associates of European bark beetles with special emphasis on the ophiostomatoid fungi. In Bark and Wood Boring Insects in Living Trees in Europe, a Synthesis (Lieutier, F., *et al*., eds), pp. 181-237, Springer.

Kirkendall LR, Biedermann PHW, Jordal BH. 2015. Evolution and Diversity of Bark and Ambrosia Beetles. Chapter 3 in Bark Beetles, Biology and Ecology of Native and Invasive Species, 1st Edition, Vega F and Hofstetter R (eds), Academic Press.

Kirkendall LR, Faccoli M. 2010. Bark beetles and pinhole borers (Curculionidae, Scolytinae, Platypodinae) alien to Europe. ZooKeys 56: 227–251.

Kostovcik M, Bateman CC, Kolarik M, Stelinski LL, Jordal BH, Hulcr J. 2015. The ambrosia symbiosis is specific in some species and promiscuous in others: evidence from community pyrosequencing. The ISME Journal (2015) 9, 126–138.

Kurz WA, Dymond CC, Stinson G, Rampley GJ, Neilson ET, Carroll AL, Ebata T, Safranyik L. 2008. Mountain pine beetle and forest carbon feedback to climate change. Nature, 452(7190), 987.

LaBonte JR. 2010. eradication of an exotic ambrosia beetle, *Xylosandrus crassiusculus* (Motschulsky), in Oregon. 2010 USDA Research Forum on Invasive Species.

Li Y, Zhang B, Wan YX, Wag ZL, Chen HL, Li XL. 2016. The ambrosia beetle *Anisandrus apicalis* (Coleoptera: Curculionidae:Scolytinae): A new pest of kiwifruit *Actinidia chinensis* in Guizhou,China. Chinese Journal of Applied Entomology, 2016-06.

Liebhold AM, McCullough DG, Blackburn LM, Frankel SJ, Von Holle B, Aukema JE. 2013. A highly aggregated geographical distribution of forest pest invasions in the USA. Diversity and Distributions, 1–9.

Loreto N. 2015. Improvement of protocols for the early-detection of alien wood-boring beetles in Italian ports. Tesi di laurea magistrale. Universuty of Padova.

Marchant KR. 1976. Worldwide introduction and establishment of bark and timber beetles (Coleoptera: Scolytidae and Platypodidae). MSc Thesis. Carleton University.

Marini L, Haack RA, Rabaglia RJ, Toffolo EP, Battisti A, Faccoli M. 2011. Exploring associations between international trade and environmental factors with establishment patterns of exotic Scolytinae. Biol Invasions 13:2275–2288.

Mendel Z, Protasov A, Maoz Y, Maymon M, Miller G, Elazar M, Freeman S. 2017. The role of *Euwallacea* nr. *fornicatus* (Coleoptera: Scolytinae) in the wilt syndrome of avocado trees in Israel. Phytoparasitica, 45(3), 341-359.

Mendel Z. 1983. Seasonal history of *Orthotomicus erosus* (Coleoptera: Scolytidae) in Israel. Phytoparasitica 11, 13–24.

Mifsud, D, Knížek M. 2009. The Bark Beetles (Coleoptera: Scolytidae) of the Maltese Islands (Central Mediterranean). Bulletin of the Entomological Society of Malta, 2, 25–52.

Miller DR, Rabaglia RJ. 2009. Ethanol and (−)-α-pinene: Attractant kairomones for bark and ambrosia beetles in the southeastern US. Journal of Chemical Ecology, 35(4), 435-448.

Montecchio L, Faccoli M. 2014. First record of thousand cankers disease *Geosmithia morbida* and walnut twig beetle *Pityophthorus juglandis* on *Juglans nigra* in Europe. Plant Disease, 98 (5): 696-696.

NPPO Spain. 2015. Express pest risk analysis for the ambrosia beetle *Euwallacea* sp. including all the species within the genus *Euwallacea* that are morphologically similar to *E. fornicatus*. Available at https://www.eppo.int

O'Donnell K, Libeskind-Hadas R, Hulcr J, Bateman C, Kasson MT, Ploetz RC, Konkol JL, Ploetz JN, Carrillo D, Campbell A, Duncan RE, Liyanage PNH, Eskalen A, Lynch SC, Geiser DM, Freeman S, Mendel Z, Sharon M, Aoki T, Cossé AA, Rooney AP. 2016. Invasive Asian Fusarium – *Euwallacea* ambrosia beetle mutualists pose a serious threat to forests, urban landscapes and the avocado industry. Phytoparasitica, 44:435–442

O'Donnell K, Sink S, Libeskind-Hadas R, Hulcr J, Kasson MT, Ploetz RC, Konkol JL, Ploetz JN, Carrillo D, Campbell A, Duncan RE. 2015. Discordant phylogenies suggest repeated host shifts in the *Fusarium–Euwallacea* ambrosia beetle mutualism. Fungal Genetics and Biology, 82, pp.277-290.

Okins KE, Thomas MC. 2010. A new North American record for *Xyleborinus andrewesi* (Coleoptera: Curculionidae: Scolytinae). Florida Entomologist 93(1): 133–134.

Paine TD, Raffa KF, Harrington TC. 1997. Interactions among scolytid bark beetles, their associated fungi, and live host conifers. Annual Rev. Entomol. 42, 179–206.

Ploetz RC, Hulcr J, Wingfield MJ, de Beer ZW. 2013. Destructive Tree Diseases Associated with Ambrosia and Bark Beetles: Black Swan Events in Tree Pathology? Plant Disease, July 2013, Volume 97, Number 7 Pages 856-872

Rabaglia RJ, Knızek M, Johnson W. 2010. First records of *Xyleborinus octiesdentatus* (Murayama) (Coleoptera, Curculionidae, Scolytinae) from North America. In: Cognato, A.I.; Knızek, M. (eds.) Sixty years of discovering scolytine and platypodine diversity: A tribute to Stephen L. Wood. ZooKeys 56:219–226.

Rabaglia RJ, Okins KE. 2011. Entomology section. Tri-ology 50(3): 6–9.

Rabaglia RJ, Vandenberg NJ, Acciavatti, RE. 2009. First records of *Anisandrus maiche* Stark (Coleoptera: Curculionidae: Scolytinae) in North America. Zootaxa 2137: 23–28.

Raffa KF, Grégoire J-C, Lindgren BS. 2015. Natural History and Ecology of Bark Beetles. Chapter 1 in Bark Beetles, Biology and Ecology of Native and Invasive Species, 1st Edition, Vega F and Hofstetter R (eds), Academic Press.

Ranger CM, Reding ME, Persad AB, Herms DA. 2010. Ability of stress-related volatiles to attract and induce attacks by *Xylosandrus germanus* and other ambrosia beetles. Agricultural and Forest Entomology (2010), 12, 177-185.

Ranger CM, Reding ME, Schultz PB, Oliver JB, Frank SD, Addesso KM, Krause C. 2016. Biology, ecology, and management of nonnative ambrosia beetles (Coleoptera: Curculionidae: Scolytinae) in ornamental plant nurseries. Journal of Integrated Pest Management, 7(1).

Ranger CM, Reding ME, Schultz PB, Oliver JB. 2013. Influence of flood-stress on ambrosia beetle host-selection and implications for their management in a changing climate. Agricultural and forest entomology, 15(1):56-64.

Rassati D, Faccoli M, Toffolo EP, Battisti A, Marini L. 2015. Improving the early detection of alien wood-boring beetles in ports and surrounding forests. J Appl Ecol, 52: 50–58. doi:10.1111/1365-2664.12347

Rassati D, Toffolo EP, Roques A, Battisti A, Faccoli M. 2014. Trapping wood boring beetles in Italian ports: a pilot study. Journal of pest science, 87(1), 61-69.

Rigot T, van Halder I, Jactel H. 2014. Landscape diversity slows the spread of an invasive forest pest species. Ecography 37: 1-11.

Sanguansub S, Goto H, Kamata N. 2012. Guild structure of ambrosia beetles attacking a deciduous oak tree *Quercus serrata* in relation to wood oldness and seasonality in three locations in the Central Japan. Entomological Science 15, 42–55.

Santini A, Faccoli M. 2015. Dutch elm disease and elm bark beetles: a century of association. iForest 8: 126-134 [online 2014-08-07] URL: http://www.sisef.it/ iforest/contents/?id=ifor1231-008

Seidl R, Rammer W, Jäger D, Lexer MJ. 2008. Impact of bark beetle (*Ips typographus* L.) disturbance on timber production and carbon sequestration in different management strategies under climate change. Forest Ecology and Management, 256(3), 209-220.

Seidl R, Schelhaas MJ, Rammer W, Verkerk PJ. 2014. Increasing forest disturbances in Europe and their impact on carbon storage. Nature climate change, 4(9), 806.

Seybold SJ, Penrose RL, Graves AD. 2016. Invasive Bark and Ambrosia Beetles in California Mediterranean Forest Ecosystems. Chapter In Insects and Diseases of Mediterranean Forest Systems pp 583-662.

Simmons DR, de Beer WZ, Huang YT, Bateman C, Campbell AS, Dreaden TJ, Li Y, Ploetz RC, Black A, Li HF, Chen CY. 2016. New Raffaelea species (Ophiostomatales) from the USA and Taiwan associated with ambrosia beetles and plant hosts. IMA fungus, 7(2), pp.265-273.

Six DL, Wingfield MJ. 2011. The role of phytopathogenicity in bark beetle–fungus symbioses: a challenge to the classic paradigm. Annu. Rev. Entomol. 56, 255–272.

Smith S, Cognato A. 2014. A taxonomic monograph of Nearctic *Scolytus* Geoffroy (Coleoptera, Curculionidae, Scolytinae). ZooKeys 450: 1-182. https://doi.org/10.3897/zookeys.450.7452

Southwood TRE. 1961. The number of species of insect associated with various trees. The Journal of Animal Ecology, 1-8.

Steininger MS, Hulcr J, Šigut M, Lucky A. 2015. Simple and Efficient Trap for Bark and Ambrosia Beetles (Coleoptera: Curculionidae) to Facilitate Invasive Species Monitoring and Citizen Involvement. J Econ Entomol. Jun;108(3):1115-23. doi: 10.1093/jee/tov014.

Storer C, Payton A, McDaniel S, Jordal B, Hulcr J. 2017. Cryptic genetic variation in an inbreeding and cosmopolitan pest, *Xylosandrus crassiusculus*, revealed using ddRADseq. Ecology and evolution, 7(24), pp.10974-10986.

USDA-APHIS. 2010. Risk Assessment of the Movement of Firewood within the United States. Animal and Plant Health Services, Raleigh, North Carolina.

Vannini A, Contarini M, Faccoli M, Della Valle M, Rodriguez CM, Mazzetto T, Guarneri D, Vettraino AM, Speranza S. 2017. First report of the ambrosia beetle *Xylosandrus compactus* and associated fungi in the Mediterranean maquis in Italy, and new host–pest associations. Bulletin OEPP/EPPO Bulletin, 47(1):100-103.

Vega F, Hofstetter R (eds). 2015. Biology and Ecology of Native and Invasive Species, 1st Edition, Academic Press, 640 pages.

Wagner MR, Cobbinah JR, Bosu PP. 2008. Forest Entomology in West Tropical Africa: Forests Insects of Ghana. Springer.

Webber JF, Gibbs JN. 1989. Insect dissemination of fungal pathogens of trees. In: Wilding N, Collins NM, Hammond PM, Webber JF (eds) Insect-fungus interactions. Academic, London, pp 161–189.

Wood SL. 1982. The bark and ambrosia beetles of North and Central America (Coleoptera: Scolytidae), a taxonomic monograph. Great Basin Nat. Mem. 6: 1-1356.

Wood SL, Bright DE. 1992. A catalog of Scolytidae and Platypodidae (Coleoptera), Part 2. Taxonomic Index. Great Basin Nat. Mem. 13:1-1553 (vol. A, B).

ANNEX 1. Case studies

Methodology. Representative bark and ambrosia beetle species were selected by the EWG (see *Introduction, Approach followed for this study*). A pest information sheet was developed for each species with background information on the species and a brief evaluation of potential risks. When an EPPO PRA was available (*Megaplatypus mutatus, Euwallacea fornicatus, Pityophthorus juglandis*), the pest information sheets was based on the PRA, supplemented with information published since the EPPO PRA. Where there was no EPPO PRA, the potential risks specified in the pest information sheets derived from a short analysis based on the (few) sources used to develop the pest information sheet. Individual pest information sheets were reviewed by a few experts.

This annex summarizes important elements relevant to the risk for the species studied. The pest information sheets are presented in Annex 2, and contain all details and references. The species are classified into three categories:
1. Known substantial damage;
2. Indications of damage, some uncertainties;
3. No documented damage, but several potential risk factors exist;

1. KNOWN SUBSTANTIAL DAMAGE

Euplatypus parallelus (see Pest information sheet for details and references)

Euplatypus parallelus was considered as a risk for Turkey in a PRA in 2015, following its interception in logs of *Tetraberlina bifoliata* from Cameroon (Africa). It has also been intercepted in Spain and China. *E. parallelus* has a subtropical and tropical distribution in the Americas (South America, Central America, Caribbean and Mexico to southern USA), Africa (except North African countries) and Australia. In Asia, it was first recorded in the 1970s in Sri Lanka and has then been reported in a large part of the continent, most recently in India. *E. parallelus* is highly polyphagous. It is mostly a secondary pest, but primary attacks can occur, especially on stressed trees. Impacts of *E. parallelus* relate to decrease of the wood value following attacks on live trees or recently felled wood, decrease of production on fruit trees, and death of trees, especially where it has a role in transmitting *Fusarium* wilt fungi (observed in Asia and the Seychelles). Wood is a known entry pathway. The host range of *E. parallelus* consists mostly of tropical trees (incl. major tropical woods such as teak, sapele, meranti, as well as *Pinus*, which are imported into the EPPO region), but it also includes species grown in the region such as *Eucalyptus*, *Quercus* and *Pinus*. *E. parallelus* has been able to attack new plants when introduced into new locations. It is absent from the EPPO region.

Euwallacea fornicatus sensu lato (see Pest information sheet for details and references)

In the USA, at least six *Euwallacea* sp. from Asia have been introduced: *Euwallacea validus* and *E. interjectus* (see category 2), *E. similis* (*E. denticulus*), and three cryptic species within the *Euwallacea fornicatus* species complex. *E. fornicatus sensu lato* (*s.l.* below) was identified as a risk for the EPPO region. It was added to the EPPO A2 List in 2016 but is not specifically regulated by EPPO countries to date. According to current knowledge, *E. fornicatus s.l.* is a complex of at least three cryptic species. All have a reproductive strategy based on sibling-mating and are polyphagous. *E. fornicatus s.l.* attacks live trees, and its wide host range includes many genera of woody plants that are present and important in the EPPO region. It has attacked new hosts in new introduction areas. Cryptic species have been found associated with different fungi. The three fungal associates of the cryptic species introduced into California, Israel and South Africa (*Fusarium euwallaceae*, *Graphium euwallaceae* and *Paracremonium pembeum*) have all been shown to be pathogenic. Damage and mortality by *E. fornicatus s.l.* have been recorded from the native range in Asia, as well as from the USA and Israel. In the USA and Israel, damage has been reported on avocado and on some ornamental trees. In Israel, *Acer negundo* trees were killed within 1 year. Only one of the cryptic species of *E. fornicatus s.l.* is currently present in the EPPO region in Israel. Knowledge is still missing on this species complex, but it would be important to prevent their introduction.

Pityophthorus juglandis (see Pest information sheet for details and references)

Pityophthorus juglandis and its associated fungus *Geosmithia morbida* together cause thousand cankers disease, which has had tremendous impact on *Juglans* in the USA. All *Juglans* species are potentially hosts, including *J. regia* and *J. nigra*. *P. juglandis* and *G. morbida* could have high economic, environmental and social impact in the EPPO region. To date, they are known to occur only in North America and in Italy. *P. juglandis* and *G. morbida* are known to have spread in the USA and into Italy. Further spread within Italy and to neighbouring countries may occur. *P. juglandis* may be difficult to detect before populations are already well established. Wood is the main pathway, and there is a known trade of the highly sensitive *J. nigra* from the USA, although part of the main production area in South-East USA is possibly not infested yet. *G. morbida* and *P. juglandis* have already been identified as a risk for the EPPO region, and were added to the EPPO A2 list in 2015.

***Platypus apicalis* and *Platypus gracilis*(see Pest information sheet for details and references)**

Platypus apicalis and *P. gracilis* occur in New Zealand, where they attack *Nothofagus* spp. and are vectors of the same fungus, *Sporothrix nothofagi*. *S. nothofagi* is highly pathogenic on *Nothofagus* spp. and has been shown able to kill trees on its own following inoculation. However, damage also results from mass-attacks by *P. apicalis* and *P. gracilis*, using an aggregation typical of aggressive bark beetles, which is unusual for a Platypodinae. Numerous galleries of the beetles are found in affected trees, which decreases wood value. These species attack healthy or weakened living trees, stumps, freshly felled trees and occasionally green sawn timber. In addition to mortality and decline of native *Nothofagus* spp., they have caused damage on non-reproductive hosts, especially in *Eucalyptus* plantations, on which abortive attacks reduce the value of the wood. Both species are able to reproduce on cut material or stumps of various species, other than their live standing hosts, which would help entry and establishment, and increase impact. A concern for the EPPO region would be if they would be able to attack new hosts in the EPPO region, and these proved to be susceptible to the highly pathogenic *S. nothofagi*. The main concern relates to Fagaceae trees, closely related to *Nothofagus*. *Nothofagus* spp. in the EPPO region are mostly cultivated as ornamentals (or planted on limited scale). However, Fagaceae is a family of great economic and environmental importance in the EPPO region, with the genera *Quercus*, *Fagus* and *Castanea*. *P. apicalis* and *P. gracilis* may reduce the value of the wood of a number of species, including non-reproductive hosts, such as *Eucalyptus*. Both species are absent from the EPPO region.

***Platypus quercivorus* (see Pest information sheet for details and references)**

Platypus quercivorus is an Asian species. In Japan, *P. quercivorus* and its symbiont *Raffaelea quercivora* are associated with Japanese oak wilt. This disease has not been reported in other Asian countries where *P. quercivorus* (and *R. quercivora*) occur. The reproductive hosts of *P. quercivorus* are Fagaceae, including many *Quercus* spp. but also *Castanea crenata* (Japanese chestnut), *Lithocarpus* spp. and *Castanopsis* spp. (but not *Fagus*, even in areas in Japan where *Quercus* were attacked). In Japan, the beetle and its associated fungus have caused the death of approximately 100 000-200 000 trees, mostly *Q. crispula* and *Q. serrata*, annually since about 1980. *P. quercivorus* is a tropical/subtropical species, but in Japan it has spread to more temperate areas and higher altitudes.

R. quercivora was added twice to the EPPO Alert List (1999-2002 and 2003-2008) and was eventually deleted by EPPO Panels because “insufficient data was available to conclude about the risks that this oak disease may present for the EPPO region. In particular, no data was available about the susceptibility of European species of oak.”. Ten years later, *P. quercivorus* and *R. quercivora* continue causing massive damage in Japan. They have spread, presumably as a result of climate change, to more temperate areas where they have encountered the very susceptible host *Q. crispula*. There has been one record on *Q. robur*, a species that is widespread and economically and environmentally invaluable in the EPPO region. No information on damage to *Q. robur* was found in the literature, but this species is not native to Japan and is likely not important there. Climatic conditions are similar in the Japanese distribution to part of the EPPO region, and the most probable obstacle to introduction may be the small volume of wood exported from Japan. *P. quercivorus* may find other Fagaceae hosts in the EPPO region, for example in the genera *Quercus* and *Castanea*.

***Xyleborus glabratus* (see Pest information sheet for details and references)**

Xyleborus glabratus is native to Asia and has been introduced into the USA. It attacks mostly Lauraceae (although hosts in other families are reported from its native range). Massive impact in the USA resulted from the encounter of the beetle and its fungal symbiont *Raffaelea lauricola*, causing laurel wilt, with the new hosts *Persea borbonia* and *P. palustris*, which proved very susceptible to the fungus. These species were widely present in the environment in South-Eastern USA and laurel wilt has killed over 300 million individuals. *X. glabratus* and *R. lauricola* have other hosts, although their importance is not always clear from the literature. On avocado, mortality has been recorded in the native range in Myanmar. In the USA, a hypothesis has recently been made that *X. glabratus* may not be the main vector of *R. lauricola* in avocado orchards in Florida (where it is rarely found). However, the mechanisms of transmission of the disease in avocado have not been fully elucidated yet. Regarding pathways, although *X. glabratus* is associated with the wood of its hosts, it is not clear whether those hosts are used to produce wood commodities that are traded internationally. Entry with host plants for planting is possible. The main concern for the EPPO region would be that, as happened in the USA, *X. glabratus* encounters a host that is very susceptible to the fungus, and that allows the beetle to reach epidemic levels. It is not clear whether there is such a Lauraceae species in the EPPO region. *Laurus nobilis*, which is widespread in the wild and in cultivation in the South of the region, is a host, but its susceptibility is not known to date. *X. glabratus* could also introduce laurel wilt into the EPPO region, after which it could spread into avocado crops, possibly with another ambrosia beetle species.

2. INDICATIONS OF DAMAGE, SOME UNCERTAINTIES

***Acanthotomicus* sp. from China**[1] **(see Pest information sheet for details and references)**

A previously undescribed species of *Acanthotomicus* has been reported to have killed over 10 000 *Liquidambar styraciflua* trees in 7 nurseries in Shanghai area, China, in 2013-2016. Its distribution in the rest of China or Asia is not known. The economic loss was estimated to at least 4 million USD. *L. styraciflua* is a North American species, which is used as landscape tree in China (whereas in the USA it is also used for wood production). The same *Acanthotomicus* sp. was found in China on a native *L. formosana*, and it is therefore suspected that this species has passed onto the new host *L. styraciflua*. This case illustrates the reverse situation of most examples in this study, i.e. a native beetle attacking an exotic plant. It was hypothesised that the same *Acanthotomicus* sp. may have caused one outbreak on *L. formosana* in the 1980s in Jiangsu province (adjacent to Shanghai). Concerns were raised for *L. styraciflua* in the USA, where it is an important species for wood production. The Chinese scientists are quoted mentioning that the probability of accidentally introducing *Acanthotomicus* sp. to North America is small, as “It is nearly impossible to import [American Sweetgum] to North America from China.”. However, this is not the case for the EPPO region, where there is no specific regulation on the import of plants or wood of *Liquidambar*. To date, there is too limited information on the pest to assess its potential risk for the EPPO region. In the EPPO region, *Liquidambar orientalis* is native to EPPO, and *L. styraciflua* and *L. formosana* are used as ornamental.

Cnestus mutilatus **(see Pest information sheet for details and references)**

Cnestus mutilatus originates from Asia and has been introduced to the USA (first report in 2002). Its host range includes temperate deciduous genera, such as *Acer*, *Castanea*, *Juglans*, *Prunus* and *Quercus*, although the known host species are used mostly as ornamental plants in the EPPO region. Damage is reported from China in relation to chestnut, eucalyptus, forest and fruit trees (only abstracts of articles were available for the present study). A few reports of damage to live plants in Asia were also found. In the USA, no damage has been observed, but concerns were expressed that *C. mutilatus* has not expressed its full potential and that its importance could increase. Due to its preference for small diameter material, the risk of entry is higher for plants for planting than for wood commodities. The host list does not include major native species from the EPPO region, but many temperate genera which are present in the wild, and used in forests, as crops or as ornamentals in the EPPO region. *C. mutilatus* appears to have low host specificity and was found attacking new species and families in the USA. Thus, it would probably find hosts that are appropriate for growing its symbiont fungi in the EPPO region. The potential impact is not known, and would depend on the species attacked: It would relate mostly to young plants, i.e. possibly a risk for nurseries and landscape plantings, or hampering forest regeneration.

Euwallacea interjectus* and *E. validus **(see Pest information sheet for details and references)**

Euwallacea interjectus and *E. validus* are two Asian species that have been introduced into North America. Both have been intercepted in various countries in wood commodities, including logs. In the USA, they seem to have spread: *E. validus* in the North-East, *E. interjectus* in the South-East. They have a wide host range and have attacked new hosts where introduced, with *E. validus* having a more temperate host range. There is little knowledge of their biology, but they are *Euwallacea* spp. and therefore inbreeders. Few reports of damage were found in the literature, but there are indications of attacks on live trees by *E. interjectus* in its native range on fig, and by *E. validus* on stressed trees in the USA. Both species are closely related to *E. fornicatus sensu lato* (see category 1), and both have been found involved in fungal plant diseases, and carrying potentially pathogenic fungi. Although information is lacking to assess precisely the risk from these species, they raise similar concerns as the related species *E. fornicatus sensu lato*.

Gnathotrupes* spp. of *Nothofagus **(see Pest information sheet for details and references)**

19 *Gnathotrupes* spp. (of which 3 are undescribed species) are associated with *Nothofagus* spp. in Chile and Argentina. *Gnathotrupes* spp. and their associated fungi are not well known, but some species colonize live trees and are associated with an emerging disease, Southern beech decline, that has caused mortality of *Nothofagus* spp. Hypothesis has been made that the disease may be caused by a fungus transported by a *Gnathotrupes* spp. The current knowledge points to an emerging pest problem on *Nothofagus*. *Nothofagus* spp. in the EPPO region are mostly cultivated as ornamentals (or planted on limited scale). However, they are closely related to Fagaceae, a family of great economic and environmental importance in the region, with the genera *Quercus*, *Fagus* and *Castanea*. Of the *Gnathotrupes* spp. attacking *Nothofagus*, only *G. fimbriata* has been found on other hosts, on logs of *Pinus contorta* (breeding population), and on *P. sylvestris* (type of material not specified). *Gnathotrupes* spp. are ambrosia beetles, and it is therefore not excluded that they would find a suitable substrate for raising their associated fungus in the EPPO region, and would be able to establish. Potential impact would depend on whether they find a host suitable for colonization, and on the level of susceptibility of that host to the associated fungi. So far, *Gnathotrupes* spp. are not known to have moved outside South America. Some authors note that such beetle species and their fungi should be investigated for their potential effects on Fagaceae in other parts of the world. There is limited knowledge to assess the risk, but in view of concerns regarding Fagaceae, their introduction should be prevented.

Hypothenemus ereditus **(see Pest information sheet for details and references)**

Hypothenemus eruditus sensu lato is an inbreeding and extremely polyphagous species (hosts are reported from over 60 families), with a wide distribution worldwide. In the EPPO region, it is reported from several Mediterranean countries, as well as from Azerbaijan and Georgia. Based on its distribution in other parts of the world, other parts of the EPPO region may have a suitable climate for its establishment. *H. eruditus* may attack many plants in the EPPO region. The limited information on damage found in the literature, arising from publications from the 1960s-80s, relate to seedlings and transplants, i.e. implying a risk for nurseries and young plantations. This species is reported to attack mostly small plant material (seedlings, leaf petioles etc.), and may therefore be mostly associated with plants for planting, but it has been intercepted on timber in the Republic of Korea. Considering its wide host range, abundance, wide distribution, and plants parts attacked, *H. eruditus* may have already had numerous opportunities to enter the EPPO region on plants for planting, which represents a huge trade, or on its other pathways. However, recent molecular studies support the existence of many potential cryptic species within *H. eruditus*. It implies uncertainties on which cryptic species have caused damage and on their distribution. Therefore, it is considered that impact may only occur if some aggressive cryptic species not yet present in the EPPO region are introduced from South-East Asia.

Megaplatypus mutatus **(see Pest information sheet for details and references)**

Megaplatypus mutatus is native to South America and was first found in Italy (Campania) in 2000. Its introduction into Italy was suspected to arise from a single trial shipment of poplar round wood with bark from Argentina in 1998. *M. mutatus* has been identified as a risk for the EPPO region and was added to the EPPO A2 List in 2007. It is not regulated by EPPO countries to date. This species is polyphagous, with known hosts in 35 non-coniferous and 2 coniferous genera (although not all hosts may be reproductive hosts). In South America and Italy, *Populus* spp. are its main hosts. In Italy, it has also been recorded on oak, pear, eucalyptus, peach, apricot, apple, cherry, mulberry, *Robinia*, as well as on new host genera (*Corylus*, *Castanea* and *Juglans*). In South America, it has caused serious damage in plantations, especially of poplar. In Italy, damage has been recorded on poplar, walnut and fruit trees. Its natural spread in Italy has been limited to date: first found in Campania in 2000, it was found in the adjacent region (southern Lazio) in 2016. In Argentina, *M. mutatus* has extended its range to temperate areas. *M. mutatus* may cause damage to a wide variety of trees which are present in the wild in the EPPO region or planted as forest trees, fruit trees, street trees, ornamentals and other uses. One major impact would be losses of yield and quality of poplar wood, if *M. mutatus* was introduced into areas where these trees are widely planted.

Monarthrum mali **(see Pest information sheet for details and references)**

Monarthrum mali is present in North America, and some spread has been reported from Eastern to Western USA. In the EPPO region, one specimen was trapped in Italy in 2007 in a natural reserve, and was considered to represent ‘at least a temporarily successful colonization’. The host range of *M. mali* includes Fagaceae (especially *Quercus* and *Fagus*), but also *Acer*, *Betula*, *Liquidambar* and *Tilia*, with rare records on conifers. *M. mali* is reported to probably breed in most non-coniferous trees in its range, and its host range is probably wider than reported. There are some references to damage in older literature, although not frequent, and old reports of attacks on live trees. Its associated ambrosia fungus has not been documented to date. *M. mali* is an example of a polyphagous ambrosia beetle species, whose wide host range may increase its risk of vectoring pathogenic fungi, and increase the likelihood of human-mediated spread.

Platypus koryoensis **(see Pest information sheet for details and references)**

Platypus koryoensis is closely related to *P. quercivorus* (see category 1), and is associated with the fungus *Raffaelea quercus-mongolicae*. *P. koryoensis* is recorded in the Republic of Korea, Far-East Russia and Taiwan. The main host of *P. koryoensis* in the Republic of Korea is *Quercus mongolica*, and it has also been reported on *Q. aliena* and *Q. serrata*. Other hosts have been reported, but their status is not known. *P. koryoensis* and *R. quercus-mongolica* have been associated with an emerging disease of *Quercus mongolica* in the Republic of Korean, and have spread within the country. *P. koryoensis* attacks and kills vigorous trees and has been associated with the death of 16 000 trees in 2006-2009 in Gyeonggi Province. The known hosts are mostly used as ornamentals in the EPPO region, and therefore have a limited presence; however, *Quercus* is an economically and environmentally important genus in the EPPO region. *P. koryoensis* being an ambrosia beetle, it is not excluded that it may attack other *Quercus* species. Although information is missing to assess the risks, potential losses would be massive if it finds a susceptible host in the EPPO region.

Platypus subgranosus **(see Pest information sheet for details and references)**

Platypus subgranosus is a pest of economic importance in Australia where it originates. It has been recorded on *Eucalyptus*, *Nothofagus* and *Pinus radiata*. *P. subgranosus* has known symbiotic associations with several fungi, including *Chalara australis*, *Leptographium* sp., *Hormpascus platypodis*, and *Raffaelea* sp. *P. granulosus* causes wood degradation in the process of infesting trees. However, its major impact has occurred in Tasmania where it was an incidental vector of the lethal disease *Chalara australis* on *Nothofagus cunninghamii*. The potential impact of *P. subgranosus* in the EPPO region would mostly relate to eucalyptus, especially if the pest was able to attack other *Eucalyptus* species than its known hosts. Economic impact may occur on *Eucalyptus* grown for timber (decrease of the value of the wood), and it may also have an impact on ornamental trees.

Scolytus schevyrewi **(see Pest information sheet for details and references)**

Scolytus schevyrewi is native to Asia and has been introduced into North America. *Ulmus* spp. (elms) are major hosts in Asia and North America, and *S. schevyrewi* has been shown to vector Dutch elm disease. It has caused damage to drought-stressed elms in China and the USA. *Ulmus* spp. are valuable forest and ornamental trees in the EPPO region. *S. schevyrewi* can cause mortality of elms, some European elms species are reported as hosts and the pest attacked new elm species when it was introduced into the USA. *S. schevyrewi* presents a higher risk for stressed elm trees, but it is likely that there are drought-stressed elm trees in cities in part of the EPPO region, as there are in North America. Even as secondary pest, *S. schevyrewi* is still potentially capable of causing significant damage and mortality to elms (as reported from China).

Damage is also reported from China on *Prunus* (including apricot, almond and *P. ferganiana*). *Prunus* are economically, environmentally and socially important in the EPPO region, and any damage, in particular to hosts commercially grown for fruit, would increase impact. Finally, if the host rangeof *S. schevyrewi* includes other species for which there are old records but no recent evidence (e.g. *Malus*, *Pyrus*, *Salix*), this would also add to the potential impact.

Xyleborus bispinatus (see Pest information sheet for details and references)

Xyleborus bispinatus is a tropical and subtropical species present in Central America and northern South America. It has been introduced into Mexico and South-East USA. In the EPPO region, it was found in Italy (Sicily) in 2014, and was trapped in France (Nice) in 2017. Data on its distribution and hosts is incomplete because it was previously considered as a synonym of *Xyleborus ferrugineus*. Known hosts include *Persea americana* (avocado), *P. palustris*, *Wodyetia bifurcata* (Arecaceae), *Quercus* (oak - Fagaceae) and *Swietenia macrophylla* (mahogany - Meliaceae). Of the known hosts, at least mahogany and oak are major traded woods. In 2014 and 2015, large infestations of *X. bispinatus* and *Hypocryphalus scabricollis* (Scolytinae) on fig (*Ficus carica*) were found in 8 localities of Sicily (Italy), and caused the rapid death and desiccation of many fig trees of various ages growing individually, in small groups or in large plantations for fruit production, as well as wild figs. Infested trees were destroyed. In Sicily, *X. bispinatus* has been found only on *F. carica* (wild and cultivated), and *X. bispinatus* was considered to play a secondary role in the attacks. No direct impact has been reported in areas of introduction to date, but data is lacking from its native distribution in South and Central America. Impact would depend on whether *X. bispinatus* would find a more susceptible host in the EPPO region. *X. bispinatus* could also have a secondary role in attacks by other beetles on *F. carica*, as observed in Italy.

Xylosandrus compactus (see Pest information sheet for details and references)

Xylosandrus compactus is thought to originate from East Asia and is widely distributed in Asia, Africa and South America. It is known to have been introduced into some Pacific Islands, South-East USA, and more recently Europe (Italy and France). *X. compactus* was added to EPPO Alert List in 2017. It is an inbreeding and extremely polyphagous ambrosia beetle, which would clearly be able to use other plants than its known hosts. It has been found associated with several pathogenic fungi. *X. compactus* has been introduced into several continents. In the USA, it has spread rapidly, including northwards where it has been able to adapt to cooler conditions than its native range. It has been reported as a pest of several plants in the tropics, including coffee and cocoa. In the USA, damage to ornamental plants in both urban landscape and forests was observed. In Italy, it has caused serious environmental damage in the Mediterranean maquis of the Circeo National Park (Lazio). Plants for planting are a clear pathway, because *X. compactus* attacks mostly twigs and branches of 0.5-6.5 cm diameter. A French PRA noted that cut trees are also a pathway, but that attacks on large trunks are exceptional. *X. compactus* is therefore unlikely to be found in most wood consignments, unless they contain whole trees or harvesting residues; it is not clear if those would be traded internationally. It is also not clear if such wood could be used for commodities such as wood chips, hogwood, processing wood residues or wood packaging material (e.g. dunnage). Bark on its own is considered a potential pathway as overwintering adults may take shelter under the bark.

Xylosandrus crassiusculus (see Pest information sheet for details and references)

Xylosandrus crassiusculus is considered to originate from Asia, and is now present on many continents. In the EPPO region, it has been found in Italy, France, Spain, Israel, and has been trapped in Slovenia in 2017 close to the Italian border and in the Netherlands. In terms of climate, *X. crassiusculus* has spread from tropical and subtropical areas, to the Mediterranean Basin and temperate areas in North America. *X. crassiusculus* is an inbreeding highly polyphagous species. Its hosts include species that are present in forest, fruit production, nurseries and in the wild in the EPPO region. In Asia and Oceania, damage reports seem to relate to young plants or stressed plants, and there are some reports of mortality. In the USA, it has become an important pest of ornamental and fruit trees, more particularly of nursery plants and trees used in landscaping. In the EPPO region, *Castanea sativa* was a new host in Italy, where *X. crassiusculus* has killed dozens of young chestnut trees (2-3 years old) recently planted in about 10 different sites. In France, mortality of carob trees in drought conditions has been observed. *X. crassiusculus* has the potential to at least become an important pest of ornamental and fruits trees as in the USA.

3. NO DOCUMENTED DAMAGE, BUT SEVERAL POTENTIAL RISK FACTORS EXIST

Ambrosiodmus rubricollis **(see Pest information sheet for details and references)**

Ambrosiodmus rubricollis is endemic to Asia, and has been introduced into the USA, Australia, Italy and Slovenia. In the EPPO region, it was found for the first time in Veneto in 2009, and has also been trapped in the neighbouring region of Friuli Venezia Giulia, in Campania, and in a nursery in Toscana in 2010. One specimen was trapped in Slovenia in 2018. *A. rubricollis* is highly polyphagous and is mostly associated with dead wood. However, it has also been recorded attacking live trees, including flood-stressed *Cornus florida* and peach trees (*Prunus persica*) in the USA, and was found in stressed peach trees in an orchard and *Aesculus hippocastanum* in a botanical garden in Italy. The latter was a new host record and *A. rubricollis* is probably not limited to its known hosts. *A. rubricollis* is not considered an aggressive species, but it has been introduced to several continents and has a high expansion rate. It is an inbreeding and polyphagous species. The known impact of *A. rubricollis* on live trees is minor, but the strong infestation observed in a peach orchard in 2008 in Italy may indicate a potential for impact.

Austroplatypus incompertus **(see Pest information sheet for details and references)**

Austroplatypus incompertus is associated with eucalypts, and occurs only in Australia. It attacks healthy trees. *A. incompertus* can infest high-value *Eucalyptus* species, causing loss of wood value because of the presence of the beetle galleries and fungal staining. The potential impact of *A. incompertus* in the EPPO region would mostly relate to eucalyptus, especially if the pest was able to attack other *Eucalyptus* species than its known hosts. Economic impact may occur on *Eucalyptus* grown for timber (decrease of wood value), and it may also have an impact on ornamental trees.

Phloeotribus liminaris **(see Pest information sheet for details and references)**

Phloeotribus liminaris is native to North America and is present in Canada and the Eastern half of the USA. In the USA, it is 'long a serious pest of peach orchards in southeastern US'. However, concerns seem to relate to its impact on *Prunus serotina*, a valuable wood in the USA, for example for veneer. *P. liminaris* mostly attacks weakened trees, but may attack healthy trees. In addition to *P. serotina*, hosts include *P. persica* and other wild and cultivated *Prunus*. In 2004, *P. liminaris* was found in one location in Lombardia region (northern Italy) on *P. serotina*. *P. liminaris* was trapped once in France, but is not considered established. It has been found associated with imported 'logs and timbers' of *P. serotina* in the Republic of Korea (Choi *et al*., 2003). In the EPPO region, *P. serotina* has been widely planted in the past, but is now considered invasive. Negative impacts of *P. liminaris* would therefore relate to other *Prunus* spp., especially forest and fruit species. To date, *P. liminaris* has not been found in other *Prunus* spp. in Italy.

Xyleborus artestriatus* and *X. octiesdentatus **(see Pest information sheet for details and references)**

Xyleborus artestriatus and *X. octiesdentatus* are native to Asia (with different distributions) and the Pacific (*X. artestriatus* only). They have both been introduced into the USA around 2010, and have been intercepted on wood packaging material in the EPPO region. Limited information is available, but both species present characteristics relevant to a potential risk: they are both Xyleborini, and the risk of introduction is enhanced by inbreeding. There is only one report of attacks on live trees for each species, but the related species *X. glabratus* and *X. saxeseni* have been recorded to attack live trees (occasionally for the latter, a European species). The known hosts of *X. artestriatus* and *X. octiesdentatus* are mostly tropical plants, although *Juglans regia* is also mentioned as a host of *X. artestriatus*, and the hosts in the USA are unknown. However, such ambrosia beetles are likely to be able to reproduce and maintain populations on others hosts. Their native or introduced distribution covers areas that are climatically similar to part of the EPPO region. Their introduction into the USA is recent and no damage has been recorded so far. Concerns were raised in the USA that associated ambrosia fungi may prove to be pathogenic on new hosts, as happened in the case of *X. glabratus*.

X. artestriatus and *X. octiesdentatus* illustrate species that have moved internationally, are known to be associated with wood, for which little information is available to date, but which have some potential risk characteristics. Several Xyleborini in this study, such as *X. glabratus* or *Euwallacea fornicatus sensu lato*, were not well known prior to introductions, but have been introduced and now cause damage. Others like *X.*

saxeseni have caused damage in some areas of introduction, although not consistently (attacks on dying trees and logs in South Africa and New Zealand; no economic importance in North America although often attacking fruit trees - CABI CPC). Finally, others such as *X. alni* (native to Asia previously known in North America only from Oregon, Washington and British Columbia) to date are only known to have spread (Rabaglia *et al*., 2008). *X. artestriatus* and *X. octiesdentatus* also illustrate cases where one is not certain to find information from the native area, in this case Asia (language; 'old' publications from mid-1900s could not be retrieved on the Internet; no recent references were found).

Additional references (X. saxeseni, X. alni)

CABI CPC. CABI Crop Protection Compendium.

Rabaglia R, Duerr D, Acciavatti R, Ragenovich I. 2008. Early Detection and Rapid Response for Non-Native Bark and Ambrosia Beetles. Summary of the 2001-2005 Pilot Project. USDA, Forest Service, Forest Health Protection.

ANNEX 2. Pest information sheets

This text is an integral part of the *EPPO Study on bark and ambrosia beetles associated with imported non-coniferous wood* and should be read in conjunction with the study

Pest information sheet
Bark beetle

ACANTHOTOMICUS SP. FROM CHINA[5] (COLEOPTERA: SCOLYTINAE)

sweetgum inscriber

EPPO Lists: Not listed. This information sheet is based on very few publications available to date on this species, which was recently found on *Liquidambar styraciflua* in China. The assessment of potential risks in this information sheet is not based on a full PRA for the EPPO region, but on an assessment of the limited information for that species used to prepare the information sheet.

PEST OVERVIEW

Taxonomy

The specimens of *Acanthotomicus* sp. collected in the Shanghai area, China, on *Liquidambar styraciflua* were identified to the genus level, and some evidence indicates that it may be a yet undescribed species (Gao *et al.*, 2017a). *Acanthotomicus* spp. are true bark beetles, and the genus contains 94 described species (Hulcr *et al.*, 2015). *Acanthotomicus*, like *Ips*, are part of the tribe Ipini (Wood and Bright, 1992).

Associated fungi

In infested *L. styraciflua* in China, there was no obvious sign of a fungal pathogen (absence of wood staining) (Gao *et al.*, 2017a). However, three fungal species were identified from galleries, larvae and adults: *Geosmithia* sp., *Phaeoacremonium* sp. and *Trichoderma* sp.; their pathogenicity has not been determined to date (Gao *et al.*, 2017b).

Morphology and biology (all information is from Gao *et al.*, 2017a)

The *Acanthotomicus* sp. found mass-attacking *Liquidambar* in Shanghai area (China) appears to be polygynous and to have two to three generations per year. It overwinters as mature larvae, pupae, and adults in the phloem. All life stages seem to be associated with the phloem (see also photos in Gao *et al.*, 2017a). Infestations were observed on trees of a diameter at breast height (DBH) in the range 5-25 cm. Attacks are mostly on the trunk, but can also occur on branches. Most attacked trees did not display any apparent prior stress. There were no obvious symptoms of associated pathogenic fungi (no wood staining). Some beetles drown in the abundant resin produced by the attacked *L. styraciflua* trees, but the accumulation of attackers may eventually exhaust tree defenses. Mortality caused by *Acanthotomicus* sp. in China is the first report of apparently healthy *L. styraciflua* trees killed by bark beetle attacks.

No information was found on the size of adults, but they are presumably minute as exit holes measure about 1 mm.

Spread biology

Both males and females fly (Gao *et al.*, 2017a). No details were found on the dispersal capacity, but the development of the outbreak in China was quite rapid and affected non-adjacent nurseries throughout Shanghai (Gao *et al.*, 2017a).

Nature of the damage

Attacks by *Acanthotomicus* sp. may lead to the decline and death of trees. No staining of the wood was observed (Gao *et al.*, 2017a).

Detection and identification

- *Symptoms.* Abundant resin exudates from the wounds of attacked *L. styraciflua*. Successful reproduction can be detected by the presence of large numbers of small circular exit holes (ca. 1 mm). Infested trees retain

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[5] This species was known as *Acanthotomicus* sp. at the time of the Study (and this name is used throughout), but has more recently recognized as a new species, *Acanthotomicus suncei* (Gao and Cognato, 2018).

dead leaves until winter, and there is no budding or any signs of life in the following spring (Gao *et al.*, 2017a).

- *Trapping*. No information is available.
- *Identification*. *Acanthotomicus* spp. are morphologically similar to *Ips* spp. There may have been one case of misidentification in the 1980s in China (see below). The specimens collected in recent years were identified to genus using Wood's (1986) key to Scolytidae genera (Gao *et al.*, 2017a).

Distribution

Acanthotomicus sp. was described from the Shanghai area in China (Gao *et al.*, 2017a). Its distribution in the rest of China or Asia is not known (Susaeta *et al.*, 2017). Gao *et al.* (2017a) hypothesise that the same species may have caused an outbreak in the 1980s in Jiangsu province (adjacent to Shanghai), but this is unconfirmed as no thorough identification of the insect was conducted. These previous observations lead them to suggest that the species may be native to China.

Host plants

Acanthotomicus sp. was first found on the North American species *Liquidambar styraciflua* (Altingiaceae), then on the Asian native species *L. formosana*. *L. styraciflua* appears to be highly susceptible to this bark beetle. In its native range (North and Central America), *L. styraciflua* is ‘highly resistant to pathogens and insects’ (Gao *et al.*, 2017a). A number of species are reported attacking *L. styraciflua* in the present study [EPPO study on bark and ambrosia beetles], and in China *Cnestus mutilatus* and *Xylosandrus crassiusculus* are often found in logs of *L. styraciflua* attacked by *Acanthotomicus* sp. (Gao *et al.*, 2017a).

In the EPPO region, *L. styraciflua* and *L. formosana* are used mainly as ornamentals (see *Establishment*). *Acanthotomicus* sp. has probably passed onto *L. styraciflua* (Gao *et al.*, 2017a), and other *Liquidambar* may be or become hosts, such as the Asian *L. acalycina* and the *L. orientalis* native to the EPPO region (see *Establishment*).

It is not known if *Acanthotomicus* sp. have other hosts, but the host range of bark beetles is generally limited. Only one or very few host plants are listed for described *Acanthotomicus* covered in Wood and Bright (1992).

Known impacts and control in current distribution

L. styraciflua was introduced into Shanghai, China, at the end of the 20th century as an ornamental tree, and since then it has been widely planted in eastern and central China, and is a valued landscape tree (Gao *et al.*, 2017a). In the Shanghai area, over 10 000 *Liquidambar styraciflua* trees of various diameters have been killed in 7 nurseries in 2013-2016. The economic loss was estimated to at least 4 million USD, based on a minimal market price of 400 USD per tree. There has not been a comprehensive survey in the area and this report related to 7 infested nurseries (out of 13 surveyed). Additional damage may have been caused in other nurseries and private gardens. A few individual Chinese sweetgums, *L. formosana*, were also found attacked by *Acanthotomicus* sp. in Shanghai (Gao *et al.*, 2017a).

Concerns were raised for *L. styraciflua* in the USA (Susaeta *et al.*, 2017, Walker, 2017). *L. styraciflua* is an ecologically and economically (wood production, biomass) important species in the USA, and is also common in urban forests (Susaeta *et al.*, 2017). Potential losses to plantations in Southern USA in case of introduction of *Acanthotomicus* sp. were estimated, through modelling and a worse-case scenario taking account of timber production only, at 151.9 million USD (4.6 million USD annually) (Susaeta *et al.*, 2017).

Control: No information was found.

POTENTIAL RISKS FOR THE EPPO REGION

Pathways

Entry

According to the limited information available, life stages of *Acanthotomicus* sp. are associated with the phloem, and the insect is associated with material of various diameters. *Acanthotomicus* sp. could therefore be associated with *Liquidambar* wood with bark. Gao *et al.* (2017a) mention ‘logs of *L. styraciflua’* attacked by *Acanthotomicus* sp. (in which *C. mutilatus* and *X. crassiusculus* are also often found). The wood of *L. styraciflua* is used worldwide, but it is probably produced mostly in the Americas. In China, *L. styraciflua* appears to be used mostly as an ornamental. No information was found on possible planting for wood production in China. It is not known if the wood of the other known host, *L. formosana*, is traded. Chinese scientists mentioned that the probability of accidental introduction of *Acanthotomicus* sp. into North America is small, as "It is nearly impossible to import [American Sweetgum] to North America from China." (Walker, 2017). This is not the case for the EPPO region, where there is no specific regulation on the import of plants or wood of *Liquidambar*. No data was sought on the trade of *Liquidambar* wood into the EPPO region. Regarding other wood commodities, it is not clear if *Liquidambar* wood is used. Susaeta *et al.* (2017) mention that the occurrence of American and Chinese *Liquidambar* in wood packaging material production in Asia should be investigated. Processes applied to produce wood commodities may destroy some individuals (even if *Acanthotomicus* sp. is very small). The wood would also degrade and may not be able to sustain development of the pest. The likelihood of entry on wood chips, hogwood and processing wood residues would be lower than on round wood, as individuals would have to survive processing and transport, and transfer to a suitable host is less likely. Finally, *Liquidambar* bark on its own could carry the pest, but no data was found on whether it is used and traded.

Acanthotomicus sp. was found in nurseries and is therefore associated with plants for planting of *L. styraciflua* in China. Plants for planting are subject to a degree of control during production, during which attacked plants may be detected and discarded. It is unclear from Gao *et al.* (2017a) how rapidly after the attacks the trees show symptoms. *Acanthotomicus* sp. is presumably minute (see *Morphology*) and may not be detected. Entry on cut branches is less likely, as they are normally used indoors and the pest is unlikely to be able to transfer to a suitable host. It is also not known if *Liquidambar* cut branches are traded.

Summary of pathways (uncertain pathways are marked with '?'):

- *Liquidambar wood (round or sawn, with bark, incl. firewood)*
- *Liquidambar plants for planting (except seeds)*
- *wood packaging material if not treated according to ISPM 15*
- *non-coniferous wood chips, hogwood, processing wood residues (except sawdust and shavings)*
- *Liquidambar bark?*
- *Liquidambar cut branches?*

Spread (following introduction, i.e. within EPPO region)

No information on spread in China is available, apart from the mention of 'epidemic spread' in Gao *et al.* (2017a), and the fact that nurseries all across Shanghai were contaminated. It is expected that both natural spread and human-assisted spread would occur if *Acanthotomicus* sp. was introduced to the EPPO region. However, spread would also depend on the host range. If only *Liquidambar* spp. are attacked, spread would probably be limited.

Establishment

There is not enough information on the distribution and biology of *Acanthotomicus* sp. to fully assess its climatic requirements. However, according to the climate classification of Köppen Geiger (see Annex 6 of the study), Shanghai is situated within the climate type Cfa[6], which is present in part of the EPPO region, such as the Black Sea, Northern Italy and part of the Balkans. It is not known if *Acanthotomicus* sp. would be able to establish under other climatic conditions. For example, the native *L. orientalis*, which may be or become a host, occurs in an area of climate type Csa[6] (i.e. dry summers instead of fully humid for Cfa).

Regarding hosts, *L. styraciflua* was introduced to Europe in the 19th century (Hsu and Andrews, 2004) and is a popular ornamental tree with many varieties available, also in the EPPO region (general Internet search). It is a subtropical and tropical species 'not known to temperate foresters' (McCarter and Hughes, 1984). The Asian *L. formosana* (host) and *L. acalycina* are also used as ornamentals (Hsu and Andrews, 2004). Finally, *L. orientalis* is native to Rhodos and Turkey (limited part of the south-east), where it occurs in riparian habitats; it is also used as ornamental in other parts of the region (Hsu and Andrews, 2004; Euforgen, 2018, including map). The full host range of *Acanthotomicus* sp. is not known.

Host plants and suitable climatic conditions may allow establishment in part of the EPPO region.

Potential impact (including consideration of host plants)

The known hosts *L. styraciflua* and *L. formosana* are probably used mostly as ornamentals in the EPPO region. Impact would result from death of trees, such as in nurseries, parks, gardens and urban environments. Similar impacts would occur where *L. orientalis* is used as ornamentals. In the area where *L. orientalis* is present in the wild/native, its oil provides a key source of income for local populations, as well as good

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[6] **Cfa**: warm temperate climate, fully humid, hot summer; **Csa**: warm temperate climate, dry and hot summer

quality firewood (the wood is not used for construction) (Euforgen, 2018). Attacks by *Acanthotomicus* sp. may therefore result in social impact locally.

References

Euforgen. 2018. *Liquidambar orientalis*. http://www.euforgen.org/species/liquidambar-orientalis/ and map.

Gao L, Li Y, Xu Y, Hulcr J, Cognato AI, Wang J-G, Ju R-T. 2017a. *Acanthotomicus* sp. (Coleoptera: Curculionidae: Scolytinae), a New Destructive Insect Pest of North American Sweetgum Liquidambar styraciflua in China. Journal of Economic Entomology, 110(4), 2017, 1592–1595.

Gao *et al*. 2017b. (高 磊, 李 猷, 徐 颖，Cognato AI,鞠瑞亭,王建国. 2017). 种为害北美枫香的新害虫——枫香刺小蠹 [A new insect pest of North American sweetgum]. Abstracts of Annual Meeting, October 2017. Chinese Society of Entomology 2017.

Gao L, Cognato AI. 2018. *Acanthotomicus suncei*, a new sweetgum tree pest in China (Coleoptera: Curculionidae: Scolytinae: Ipini). Zootaxa. 4471(3):595-599.

Hulcr J, Atkinson TH, Cognato AI, Jordal BH, McKenna DD. 2015. Morphology, Taxonomy, and Phylogenetics of Bark Beetles. Chapter 2 in Bark Beetles, Biology and Ecology of Native and Invasive Species, 1st Edition, Vega F and Hofstetter R (eds), Academic Press.

Hsu E, Andrews S. 2004. Liquidambar. Tree of the year. International Dendrology Society. http://www.dendrology.org/publications/tree-of-the-year

McCarter PS, Hughes CE. 1984. *Liquidambar styraciflua* L.- A Species of Potential for the tropics. Commonw. For. Rev. 63(3).

Nobuchi A. 1974. Studies on Scolytidae XII. The bark beetles of the tribe Ipini in Japan (Coleoptera). BulL Gov. For. Exp. Sta. No. 266, 33-60.

Susaeta A, Soto JR, Adams DC, Hulcr J. 2017. Expected Timber-Based Economic Impacts of a Wood-Boring Beetle (*Acanthotomicus* sp.) that Kills American Sweetgum. Journal of Economic Entomology, 110(4): 1942-1945.

Walker MS. 2017. American Sweetgum Picks Up a Beetle Pest in China. Entomology Today. 5 May 2017. https://entomologytoday.org/2017/05/05/american-sweetgum-picks-up-a-beetle-pest-in-china/

Wood SL. 1986. A reclassification of the genera of Scolytidae (Coleoptera). Great Basin Nat. Mem. 10, 1–126.

Wood SL, Bright DE. 1992. A catalog of Scolytidae and Platypodidae (Coleoptera), Part 2. Taxonomic Index. Great Basin Nat. Mem. 13:1-1553 (vol. A, B).

This text is an integral part of the *EPPO Study on bark and ambrosia beetles associated with imported non-coniferous wood* and should be read in conjunction with the study

Pest information sheet
Ambrosia beetle

AMBROSIODMUS RUBRICOLLIS (COLEOPTERA: SCOLYTINAE)

EPPO Lists: Not listed. The assessment of potential risks in this information sheet is not based on a full PRA for the EPPO region, but on an assessment of the limited information for that species used to prepare the information sheet.

PEST OVERVIEW

Taxonomy

Ambrosiodmus rubricollis (Eichhoff 1875); Synonyms: *Xyleborus rubricollis* Eichhoff 1875; *Xyleborus taboensis* Schedl 1952; *Xyleborus strohmeyeri* Schedl 1975.

Associated fungi

Flavodon ambrosius was identified as the mutualist fungus of several *Ambrosiodmus* and *Ambrosiophilus* spp. around the world, including *A. rubricollis*. It is the only known ambrosial basidiomycete. *F. ambrosius* is a true wood-degrading saprophyte (not pathogenic), which explain why *A. rubricollis* can attack dead wood (see below) (Li *et al.*, 2015, 2017).

Morphology and biology

Adults measure ca. 1.6-2.7 mm (Bright, 1968). Rassati *et al.* (2016) note that the biology and ecology of *A. rubricollis* have not been deeply investigated yet. *Ambrosiodmius* species inbreed, i.e. females mate with siblings before emerging from the host (Faccoli *et al.*, 2009). *A. rubricollis* develops mainly in dead and decayed wood (Faccoli *et al.*, 2009; Li *et al.*, 2015). *Ambrosiodmus* species appear to be able to colonize wood throughout the process of its decay, including later stages when xylem is co-colonized by competitive wood-rot fungi (Li *et al.*, 2015). It has been found infesting dead saplings and cut poles of 2-15 cm diameter (Browne, 1961).

A. rubricollis has also been recorded on live plants. Kovach and Gorsuch (1985) reported attacks on trunks of peach trees of ca. 15 cm diameter, with some entrance holes found 10 cm below the soil line; no known stress factor could be associated with the infested trees. *A. rubricollis* was also recovered from artificially flood-stressed potted *Cornus florida* in Ohio of ca. 2 cm diameter (Ranger, 2015). In Italy, it has been recorded in the sapwood of living stressed trees infected by *Armillaria mellea* (honey fungus): *Aesculus hippocastanum* and *Prunus persica* (see details below; Faccoli *et al.*, 2009).

Spread biology

No details were found.

Nature of the damage

A. rubricollis tunnels in the sapwood. No details were found on damage to the trees. The only known associated fungus to date is a saprophyte (see *Associated fungi*).

Detection and identification

- *Symptoms*. No specific information on symptoms was found in the literature, but they are probably similar to other ambrosia beetles.
- *Trapping*. It was collected in traps baited with exotic *Ips* lure, ethanol lure, and ethanol + α-pinene lure in Ohio and Georgia (Ghandi *et al.*, 2010; Sheehan *et al.* 2018). In Italy, it was collected in a pheromone trap baited with ipsdienol and ipsenol (Faccoli *et al.*, 2009).
- *Identification*. In Europe, *A. rubricollis* is the only *Ambrosiodmus* species known, and is easily distinguished from other European species of the tribe Xyleborini (characters indicated in Faccoli *et al.*, 2009). A key to some *Ambrosiodmus* spp. is available in Gomez *et al.* (2018 – for North America). Sequences of *A. rubricollis* are available in GenBank (Cognato *et al.*, 2011).

Distribution (see Table 1)

A rubricollis is endemic to Asia. In the USA, it was first found in Maryland in 1942 (Bright, 1968), and has since spread throughout the Southeast, then East and into the Midwest (Rabaglia *et al.* 2006, Lightle *et al.* 2007), reaching Michigan in the North (Cognato *et al.*, 2009). Reed and Muzika (2010) reported findings during surveys in forest stands in Missouri, and noted that it had previously been collected only in urban and industrial areas of the Midwest. In Australia, *A. rubricollis* is also recorded as introduced (Wood & Bright 1992), but no details were found.

In the EPPO region, *A. rubricollis* is present in Italy and Slovenia. In Italy, it was first recorded in the Veneto region in 2009, first on a live *Aesculus hippocastanum* tree in the botanical garden of Padova, then in about 80 peach trees in an orchard in Alpo di Villafranca, Verona, while one individual was trapped at the international harbour of Venice (Faccoli *et al.*, 2009). Infested trees were stressed and colonized by the honey fungus *Armillaria mellea*. *A. rubricollis* was considered established (three different localities separated by more than 100 km, large number of overwintering and breeding adults found, infested *A. hippocastanum* hosting overwintering adults) (Faccoli *et al.*, 2009; Kirkendall and Faccoli, 2010; M. Faccoli, pers. comm.). *A. rubricollis* was later trapped in the neighbouring region of Friuli Venezia-Giulia, in Campania in 2013 (no details provided), as well as in a nursery in Toscana in 2010 (Inghilesi, 2012 abstract; Inghilesi *et al.*, 2013). In Slovenia, one specimen of *A. rubricollis* was trapped in March 2018 in a forest in Tolmin municipality (Western Slovenia), and it is considered present (NPPO of Slovenia, 2018).

Host plants (see Table 2)

A. rubricollis is ‘extremely polyphagous on broadleaved trees and shrubs, and is occasionally reported also from conifers’ (Faccoli *et al.*, 2009, citing others). Common host species include *Carya* spp., *Cornus* spp., *Prunus* spp., and *Quercus* spp. (Lightle *et al.*, 2007 citing Wood, 1982). *A. hippocastanum* in Italy was a new host (Faccoli *et al.*, 2009). A list of over 40 hosts in 21 families is included in Table 2.

Known impacts and control in current distribution

A. rubricollis is not considered an aggressive species because it develops mainly in dead wood, but it is an invasive species with a high expansion rate (Faccoli *et al.*, 2009). Nevertheless, in the USA, Wood (1977) noted that *A. rubricollis* may be of local economic concern. Very few reports of attacks on live plants in the USA were found, but one related to healthy peach trees (Kovach and Gorsuch, 1985). White (1987) refers to very few reported cases of Scolytinae pests infesting peach tree orchards and notes that *A. rubricollis* is not considered a pest. Based on information obtained from USDA-Aphis (letter on pests of US peaches, nectarines and plums), Biosecurity Australia (2010) considered *A. rubricollis* associated with production of plum, nectarine and (or) peach.

In Italy, *A. rubricollis* was found attacking stressed trees (see *Distribution*). Faccoli *et al.* (2009) stated that the strong infestation observed in a peach orchard in 2008 could be a first indicator of the potential harmfulness of the species in a new continent, although the trees were in poor conditions. It is not clear if damage was observed in the nursery where it was later trapped in Toscana, nor in Friuli Venezia-Giulia.

Finally, no data was found on the situation and impact in Australia (where *A. rubricollis* is recorded as introduced) nor in Asia.

Control: No mention of control was found.

POTENTIAL RISKS FOR THE EPPO REGION

Pathways

Entry

A. rubricollis is considered more likely to have been introduced into Italy on dead wood or wood packaging material than on living plants (Faccoli *et al.*, 2009). Life stages are associated with the xylem. *A. rubricollis* may be associated with wood commodities and, as it attacks mainly dead and decayed wood, may be less affected by the degradation and decreased humidity in the wood. Processes applied to produce wood commodities would destroy some individuals. The likelihood of entry on wood chips, hogwood and processing wood residues would be lower than on round wood, as individuals would have to survive processing and transport, and transfer to a suitable host is less likely. Bark on its own is an unlikely pathway.

A. rubricollis has been only occasionally been recorded on live plants, and there is limited information on its association with nursery plants (finding in a nursery in Toscana, Italy, and attracted by flood-stressed *Cornus florida* potted trees of ca. 2 cm diameter in Ohio). Plants for planting may be a pathway, although they are subject to a degree of control during production, during which attacked plants may be detected and discarded. Entry on cut branches is less likely than plants for planting, as they are also normally used indoors and the pest is unlikely to be able to transfer to a suitable host.

Finally, *A. rubricollis* is an inbreeder, a trait favourable to entry and establishment.

Summary of pathways (uncertain pathways are marked with '?'):

- *wood (round or sawn, with or without bark, incl. firewood) of hosts*
- *wood chips, hogwood, processing wood residues (except sawdust and shavings)*
- *wood packaging material if not treated according to ISPM 15*
- *plants for planting (except seeds) of hosts?*
- *cut branches of hosts (incl. Christmas trees)?*

Because of the large and uncertain host range, pathways may cover all non-coniferous species, and possibly also all coniferous species (including Christmas trees).

Spread (following introduction, i.e. within EPPO region)

A. rubricollis could spread naturally and through human-assisted pathways. Human-assisted pathways may lead to multiple introductions from which local spread could occur. In the USA, *A. rubricollis* is reported to have spread (Rabaglia *et al.* 2006, Lightle *et al.* 2007). Some spread may have occurred in Italy where it was found in several places in Veneto and in the neighbouring region of Friuli Venezia Giulia, as well as in a nursery in Toscana. Natural spread is considered the most likely origin of the specimen trapped in Slovenia (NPPO of Slovenia, 2018). Spread from Italy to Switzerland is less likely due to the obstacle of the Alps, as well as to France because the outbreaks are still far from the border.

Establishment

A. rubricollis is native to tropical Asia (Rassati *et al.* 2014). It has established in a wide range of climates in the USA and in Italy. It was able to survive winter in the North of Italy (Veneto). Based on the classification of Köppen-Geiger (see Annex 6 of the study), the climate type Cfa[7] is present in a large part of the distribution of *A. rubricollis* in the USA, as well as in part of the EPPO region, such as the Black Sea, Northern Italy and part of the Balkans. The few records from Italy suggest that it may be able to establish in more temperate and Mediterranean climates.

Regarding hosts, *A. rubricollis* has a wide host range comprising many genera that are widespread in the EPPO region in the wild or in cultivation (e.g. *Alnus*, *Prunus*, *Salix*, *Quercus*). The host range comprises species that are widespread mostly in the southern part of the EPPO region (such as *Prunus persica* and *P. armeniaca*), and as ornamentals in gardens or in protected cultivation elsewhere. Its large host range and the findings on new hosts, such as *Aesculus hippocastanum*, suggest that it will be able to attack other plant species, including dead and decayed wood, provided it finds suitable conditions for its development.

Areas with suitable climates and host plants are available in the EPPO region, where establishment is possible.

Potential impact (including consideration of host plants)

Although *A. rubricollis* may be able to attack and breed on many species, the main record of concern in the literature relates to peach trees both in Italy and the USA. It may be able to maintain populations in many different habitats, including both wild and cultivated habitats. Its significance for young plants (in nurseries) is not known.

Table 1. Distribution

Distribution	**Reference**	**Comments**
EPPO region		
Italy	Faccoli *et al.*, 2009	Introduced. First record in Veneto (Faccoli *et al.*, 2009), then Friuli Venezia Giulia and Toscana (for both no details - see *Distribution*).

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[7] **Cfa**: warm temperate climate, fully humid, hot summer.

Asia		
China - Anhui, Fujian, Hebei, Hunan, Shandong, Shanxi, Sichuan, Xizang (Tibet) - Heilongjiang, Guizhou, Yunnan	- Atkinson, 2018 citing Wood and Bright, 1992 - Bright, 2014	
India (Assam)	Atkinson, 2018, citing Wood and Bright, 1992	
Japan	Beaver and Browne, 1978	
Korea Rep.	Choo *et al.*, 1983	
Malaysia	Beaver and Browne, 1978	
Taiwan	Beaver and Browne, 1978	
Thailand	Atkinson, 2018, citing Wood and Bright, 1992	
Vietnam	Atkinson, 2018, citing Wood and Bright, 1992	
North America		
Mexico	Atkinson, 2018 citing Wood 2007	Introduced
USA: - Maryland - Alabama, Connecticut, Delaware, Florida, Louisiana, Maryland, Mississippi, Pennsylvania, South Carolina, Tennessee, Virginia - Ohio - Michigan - Georgia - Missouri - North Carolina, Pennsylvania - Illinois - Indiana - Texas - Arkansas, Oklahoma *Uncertain records*: Kansas, Kentucky, Nebraska, New Jersey, New York, North Carolina, Rhode Island, West Virginia	- Bright, 1968 - Rabaglia *et al.*, 2006 - Lightle *et al.*, 2007 (first record) - Cognato *et al.*, 2009 - Miller and Rabaglia, 2009 - Reed and Muzika, 2010 - Bright 2014 -Helm and Molano-Flores, 2015 - Atkinson, 2018 citing Deyrup, 1981 - Atkinson and Riley, 2013 - Gomez *et al.*, 2018, citing others -Atkinson, 2018	Introduced. Haack and Rabaglia (2013) mention 21 states, and there are more in Atkinson (2018) possibly indicating further spread. Considered uncertain here because unpublished
Oceania		
Australia	Atkinson, 2018 citing Wood and Bright, 1992	Introduced. No details found.

Table 2. Hosts (some references below refer to other publications)

Family	**Genus/Species**	**Reference**
Anacardiaceae	*Rhus*	Atkinson, 2018
Aquifoliaceae	*Ilex*	Atkinson, 2018
Betulaceae	*Alnus sibirica*	Faccoli *et al.*, 2009
Combretaceae	*Terminalia myriocarpa*	Atkinson, 2018
Cornaceae	*Cornus*	Atkinson, 2018
Cornaceae	*Cornus florida*	Ranger *et al.*, 2015
Cupressaceae	*Cunninghamia lanceolata*	Faccoli *et al.*, 2009
Cupressaceae	*Cuprocyparis leylandii (as Cupressocyparis)*	Atkinson, 2018
Cupressaceae	*Platycladus orientalis* (as *Biota*)	Faccoli *et al.*, 2009
Ebenaceae	*Diospyros kaki*	Choo *et al.*, 1983
Fabaceae	*Cercis chinensis*	Choo *et al.*, 1983
Fabaceae	*Sophora japonica*	Faccoli *et al.*, 2009
Fabaceae	*Acacia*	Atkinson, 2018

Family	Genus/Species	Reference
Fabaceae	*Hovea*	Atkinson, 2018
Fagaceae	*Castanea*	Atkinson, 2018
Fagaceae	*Castanea crenata*	Choo *et al.*, 1983
Fagaceae	*Quercus*	Atkinson, 2018
Fagaceae	*Quercus serrata*	Sanguansub *et al.*, 2012
Juglandaceae	*Carya*	Faccoli *et al.*, 2009
Juglandaceae	*Carya glabrata*	Faccoli *et al.*, 2009
Juglandaceae	*Carya illinoensis*	Atkinson, 2018
Juglandaceae	*Carya ovata*	Atkinson, 2018
Juglandaceae	*Juglans nigra*	Atkinson, 2018
Lamiaceae	*Vitex negundo*	Faccoli *et al.*, 2009
Lauraceae	*Cinnamomum*	Faccoli *et al.*, 2009
Lauraceae	*Machilus*	Atkinson, 2018
Moraceae	*Morus*	Atkinson, 2018
Moraceae	*Morus alba*	Faccoli *et al.*, 2009
Myricaceae	*Myrica*	Atkinson, 2018
Oleaceae	*Fraxinus chinensis*	Faccoli *et al.*, 2009
Oleaceae	*Ligustrum*	Atkinson, 2018
Oleaceae	*Ligustrum lucidum*	Faccoli *et al.*, 2009
Pinaceae	*Abies fabri*	Faccoli *et al.*, 2009
Pinaceae	*Pinus merkusii*	Faccoli *et al.*, 2009
Rosaceae	*Prunus*	Faccoli *et al.*, 2009
Rosaceae	*Prunus armeniaca*	Choo *et al.*, 1983
Rosaceae	*Prunus persica*	Atkinson, 2018
Rubiaceae	*Gardenia angusta*	Atkinson, 2018
Salicaceae	*Populus*	Faccoli *et al.*, 2009
Salicaceae	*Salix*	Atkinson, 2018
Sapindaceae	*Aesculus hippocastanum*	Faccoli *et al.*, 2009
Theaceae	*Schima superba*	Faccoli *et al.*, 2009
Ulmaceae	*Ulmus americana*	Atkinson, 2018

References (all URLs were accessed in January 2018)

Atkinson TH. 2018. Bark and Ambrosia Beetles. Online database. http://www.barkbeetles.info/index.php

Atkinson TH, Riley EG. 2013. Atlas and Checklist of the bark and ambrosia beetles of Texas and Oklahoma (Curculionidae: Scolytinae and Platypodinae). Insecta Mundi 292: 1-46.

Beaver RA, Browne FG. 1978.The Scolytidae and Platypodidae (Coleoptera) of Penang, Malaysia. Oriental Insects 12 (4).

Biosecurity Australia. 2010. Provisional final import risk analysis report for fresh stone fruit from California, Idaho, Oregon and Washington. Biosecurity Australia, Canberra. http://www.agriculture.gov.au/SiteCollectionDocuments/ba/plant/2011/Provisional_Final_IRA_Report_-_US_Stone_fruit.pdf

Bright DE. 1968. Review of the tribe Xyleborini in America north of Mexico (Coleoptera: Scolytidae). Can. Entomol. 100: 1288-1323.

Bright DE. 2014. A Catalog of Scolytidae and Platypodidae (Coleoptera), Supplement 3 (2000-2010), with notes on subfamily and tribal reclassifications". Insecta Mundi. 861. http://digitalcommons.unl.edu/insectamundi/861

Browne FG. 1961. The biology of Malayan Scolytidae and Platypodidae. Malayan Forest Records 22: 1-255.

Choo HY, Woo KS, Nobuchi A. 1983. A list of the bark and ambrosia beetles injurious to fruit and flowering trees from Korea (Coleoptera: Scolytidae). Korean Journal of Plant Protection, 22(3):171-173

Cognato AI, Barc N, Philip M, Mech R, Smith AD, Galbraith E, Storer AJ, Kirkendall LR. 2009. The native and introduced bark and ambrosia beetles of Michigan (Coleoptera: Curculionidae, Scolytinae). The Great Lakes Entomologist, Vol. 42, Nos. 3 & 4, 101-120.

Cognato AI, Hulcr J, Dole SA, Jordal BH. 2011. Phylogeny of haplo–diploid, fungus-growing ambrosia beetles (Curculionidae: Scolytinae: Xyleborini) inferred from molecular and morphological data. Zoologica Scripta a 2011 The Norwegian Academy of Science and Letters, 40, 2, March 2011, pp174–186.

Faccoli M, Frigimelica G, Mori N, Toffolo EP, Vettorazzo M, Simonato M. 2009. First record of *Ambrosiodmus* (Hopkins, 1915) (Coleoptera: Curculionidae, Scolytinae) in Europe. Zootaxa 2303: 57–60.

Gandhi KJ, Cognato AI, Lightle DM, Mosley BJ, Nielsen DG, Herms DA. 2010. Species composition, seasonal activity, and semiochemical response of native and exotic bark and ambrosia beetles (Coleoptera: Curculionidae: Scolytinae) in northeastern Ohio. J Econ Entomol. 103(4):1187-1195.

Gomez DF, Rabaglia RJ, Fairbanks KE, Hulcr J. 2018. North American Xyleborini north of Mexico: a review and key to genera and species (Coleoptera, Curculionidae, Scolytinae). ZooKeys, 768, 19.

Haack RA, Rabaglia RJ. 2013. Exotic bark and ambrosia beetles in the USA: potential and current invaders. Potential invasive pests of agricultural crops. CAB International, Wallingford, 48-74.

Helm C, Molano-Flores B. 2015. New Records of Native and Non-Native Bark and Ambrosia Beetles (Coleoptera: Curculionidae: Scolytinae) in Illinois. Great Lakes Entomol. 48(3-4):137-149.

Inghilesi AF, Anselmi M, Gherardi F, Mazza G, Pennacchio F, Stasolla G, Cervo R. 2013. Poster. Bio- and allodiversity of Scolytidae and non-target arthropods in nurseries. 73° Congresso Dell'unione Zoologica Italiana Firenze 24 -27 Settembre 2012 Riassunti Dei Contributi a cura di E. Baistrocchi, M. Zaccaroni. Firenze University Press.

Inghilesi AF. 2012. Management of the Invasions of Allochthonous Arthropods: Pathways of Introduction and Eto-ecological Aspects: Tesi. Università degli studi di Firenze. Dipartimento di biologia evoluzionistica Leo Pardi.

Kirkendall LR, Faccoli M. 2010. Bark beetles and pinhole borers (Curculionidae, Scolytinae, Platypodinae) alien to Europe. ZooKeys 56: 227–251.

Kovach J, Gorsuch CS. 1985. Survey Of Ambrosia Beetle Species' Infesting South Carolina Peach Orchards And A Taxonomic Key For The Most Common Species'". J. Agric. Entomol. 2(3): 238-247.

Li Y, Bateman CC, Skelton J, Jusino MA, Nolen ZJ, Simmons DR, Hulcr J. 2017. Wood decay fungus *Flavodon ambrosius* (Basidiomycota: Polyporales) is widely farmed by two genera of ambrosia beetles. Fungal Biol. 121(11):984-989.

Li Y, Simmons DR, Bateman CC, Short DP, Kasson MT, Rabaglia RJ, Hulcr J. 2015. New Fungus-Insect Symbiosis: Culturing, Molecular, and Histological Methods Determine Saprophytic Polyporales Mutualists of *Ambrosiodmus* Ambrosia Beetles. PLoS One. 14;10(9):e0137689.

Lightle DM, Gandhi KJK, Cognato AI, Mosley BJ, Nielsen DG, Herms DA. 2007. New reports of exotic and native ambrosia and bark beetle species (Coleoptera: Curculionidae: Scolytinae) from Ohio. The Great Lakes Entomologist Vol. 40 (3 & 4), 10.

Miller DR, Rabaglia RJ. 2009. Ethanol and (−)-α-Pinene: Attractant Kairomones for Bark and Ambrosia Beetles in the Southeastern US. Journal of Chemical Ecology, 35(4), 435-448.

NPPO of Slovenia. 2018. First confirmed presence of *Ambrosiodmus rubricollis* (Eichhoff, 1875) in the territory of Slovenia. Pest Report.

Rabaglia RJ, Dole SA, Cognato AI. 2006. Review of American Xyleborina (Coleoptera: Curculionidae: Scolytinae) occurring north of Mexico, with an illustrated key. Annals of the Entomological Society of America, 99, 1034-1056.

Ranger CM, Schultz PB, Frank SD, Chong JH, Reding ME. 2015. Non-Native Ambrosia Beetles as Opportunistic Exploiters of Living but Weakened Trees. PLoS ONE 10(7): e0131496. doi:10.1371/ journal.pone.0131496.

Rassati D, Leutier F, Faccoli M. 2016. Alien wood-boring beetles in Mediterranean regions. Chapter 11 in Insects and Diseases of Mediterranean Forest Systems. Paine TD, Lieutier F. (eds), Springer, 892 pages.

Rassati D, Toffolo EP, Roques A, Battisti A, Faccoli M. 2014. Trapping wood boring beetles in Italian ports: a pilot study. J Pest Sci 87:61–69.

Reed SE, Muzika RM. 2010. The influence of forest stand and site characteristics on the composition of exotic dominated ambrosia beetle communities (Coleoptera: Curculionidae: Scolytinae). Environ Entomol. 39(5):1482-1491.

Regione Campania. 2013. UOD Fitosanitario Regionale. Piano d'azione URCOFUI. Giunta Regionale della Campania, Direzione Generale per le Politiche Agricole, Alimentari e Forestali, Dipartimento della Salute e delle Risorse Naturali. from http://burc.regione.campania.it

Sanguansub S, Goto H, Kamata N. 2012. Guild structure of ambrosia beetles attacking a deciduous oak tree *Quercus serrata* in relation to wood oldness and seasonality in three locations in the Central Japan. Entomological Science 15, 42–55.

Sheehan TN, Ulyshen MD, Horn S, Hoebeke ER. 2018. Vertical and horizontal distribution of bark and woodboring beetles by feeding guild: is there an optimal trap location for detection? Journal of Pest Science, 1-15.

Takagi K. 1967. The Storage Organ of Symbiotic Fungus in the Ambrosia Beetle *Xyleborus rubricollis* Eichhoff: Coleoptera: Scolytidae. Applied entomology and zoology. vol. 2(3), 168-170.

White KJ. 1987. Scolytid pest of stone fruit orchards. MSc thesis, University of Victoria.

Wood SL. 1977. Introduced and exported American Scolytidae (Coleoptera). Great Basin Naturalist: Vol. 37: No. 1, Article 5, 67-74. Available at: http://scholarsarchive.byu.edu/gbn/vol37/iss1/5

Wood SL, Bright DE. 1992. A catalog of Scolytidae and Platypodidae (Coleoptera), Part 2. Taxonomic Index. Great Basin Nat. Mem. 13:1-1553 (vol. A, B).

This text is an integral part of the *EPPO Study on bark and ambrosia beetles associated with imported non-coniferous wood* and should be read in conjunction with the study

Pest information sheet
Ambrosia beetle

AUSTROPLATYPUS INCOMPERTUS AND *PLATYPUS SUBGRANOSUS* (COLEOPTERA: PLATYPODINAE)

horizontal borer and mountain pinhole borer

EPPO Lists: Not listed. The assessment of potential risks in this information sheet is not based on a full PRA for the EPPO region, but on an assessment of the limited information for that species used to prepare the information sheet. These two species are treated together due to similarities in their distribution, hosts and biology.

PEST OVERVIEW

Taxonomy

- *Austroplatypus incompertus* (Schedl, 1968)
- *Platypus subgranosus* Schedl, 1936

Associated fungi

- *A. incompertus.* Symbiont *Ambrosiella* sp. (Ploetz *et al.*, 2003), mentioning an ‘unclear involvement of symbiont’ in the degradation of wood quality.
- *P. subgranosus.* Symbiont *Leptographium lundbergii*. In addition, in Tasmania, *P. subgranosus* was found to be involved in the widespread mortality of *Nothofagus cunninghamii*, as ‘inadvertent vector’ of *Chalara australis. P. subgranosus* infests trees dying from the disease. Frass containing the fungus is then carried by the wind into wounds of otherwise healthy *N. cunninghamii* trees. The fungus normally spreads by root contact (Kliejunas *et al.*, 2003, citing others). Bickerstaff (2017) also mentions *Hormpascus platypodis* and *Raffaelea* sp.

All fungi above are presumably not pathogenic except *C. australis*: Bickerstaff (2017) mention that there is no incidence of *Platypus*-mediated tree diseases within Australia (apart from *C. australis*).

Morphology and biology

A. incompertus and *P. subgranosus* are wood boring ambrosia beetles.

- *A. incompertus*. Adults measure 6 mm. The morphology of *A. incompertus* is detailed in Kent (2010). *A. incompertus* has been reported to attack live healthy and undamaged trees, such as rough-barked live eucalypts over 35 cm in diameter (Kliejunas *et al.*, 2003, citing others). Galleries of *A. incompertus* extend into the sapwood and may also be deep into the heartwood. The formation of galleries that extend deep into the heartwood of mature trees is done over is done over several offspring cohorts produced by the same foundress female during the whole lifetime of the system, and galleries are added as the colony develops. Smith *et al.* (2018) showed that the gallery systems are always inhabited by a single core family, consisting of a lifetime inseminated mother, permanently unmated daughter workers, and immatures that are always full siblings to each other and their adult caretakers. The foundress female is attracted by a male, mates on a tree, and initiates a gallery system on her own. It takes 4 years from gallery initiation until dispersal of the first adult offspring. The female may survive for over 30 years. Because of lifetime storage of sperm from the original mate, a female may produce many generations during its lifetime. While males offspring disperse, female offspring either disperse to mate and found their own colony, or assume unmated worker roles in the colony, probably surviving for many years without any reproductive potential (Smith *et al.*, 2018). Some *Eucalyptus delegatensis* in Victoria were found to have been infested for up to 36 years and still contained live insects and fungi in galleries long after the initial attack, indicating that a population had survived and reproduced during many years in the trees (Kliejunas *et al.*, 2003, citing others). Smith *et al.* (2018) note that attacks on live trees is a necessity to maintain viable colonies over many years. However, even after felling, some adults were observed to emerge for 3 years from an infested tree after felling (Kliejunas *et al.*, 2003, citing others).
- *P. subgranosus.* Adults measure 4 mm (Candy, 1990). *P. subgranosus* infests live trees and fresh logs. There is only one generation per gallery. A generation takes 10 months to 5 years depending on temperatures, with

an average 2-3 years in the Central Highlands of Victoria. Long-established colonies of *P. subgranosus* in pure stands of live *Eucalyptus nitens* in eastern Victoria have been found (Kliejunas *et al.*, 2003, citing others). On *Pinus radiata,* infestations have been on damaged trees only (Kliejunas *et al.*, 2003 citing others). *P. subgranosus* attacks weakened live trees according to Bickerstaff (2017). However, in Tasmania, apparently healthy *N. cunninghamii* are attacked (Candy, 1990). In studies, densities of 420 attacks per m^2 were observed on *N. cunninghamii* inoculated with *C. australis,* and some emergence was observed from logs of diameter ca. 12 cm-40 cm (Candy, 1990).

Spread biology

Both males and females fly. For *P. subgranosus*, the flight capacity is described as 'weak and slow' (Kliejunas *et al.*, 2003, citing others). No information was found for *A. incompertus*.

Nature of the damage

P. subgranosus and *A. incompertus* tunnel into the wood, and lead to wood staining, both affecting wood quality. *P. subgranosus* has been involved in the spread of *Chalara australis* causing mortality of *N. cunninghamii* in Tasmania (Kliejunas *et al.*, 2003).

Detection and identification

- *Symptoms.* For both species, frass and holes may be observed.
- *Trapping*. Ethanol is an attractant for *P. subgranosus* (Candy, 1990, citing others).
- *Identification*. An identification of Australian pinhole borers is given in Bickerstaff (2017). A full, illustrated description of the external morphology of *A. incompertus* has been published by Kent (2010).

Distribution

- *A. incompertus*. Australia (Victoria, New South Wales) (Kent, 2008).
- *P. subgranosus*: Australia (Queensland, Tasmania, Victoria) (Kliejunas *et al.*, 2003, citing others).

Host plants

- *A. incompertus*. Only eucalypts[8] (Myrtaceae) are hosts: *Eucalyptus agglomerata, E. andrewsii, E. baxteri, E. botryoides, E. cameronii, E. consideniana, E. delegatensis (E. gigantea), E. dives, E. fastigata, E. globoidea (E. scabra), E. laevopinea, E. macrorhyncha, E. muelleriana, E. obliqua, E. pilularis, E. radiata, E. resinifera, E. sieberi, Corymbia gummifera* (Kent, 2008), *E. eugenioides* (Kliejunas *et al.*, 2003). Kent (2008) notes that the current host list is probably not exhaustive.
- *P. subgranosus***.** Most host are eucalypts[8] (Myrtaceae): *Eucalyptus delegatensis, E. goniocalyx, E. nitens, E. obliqua, E. regnans, E. saligna, Corymbia maculata*), but it has also been found on *Nothofagus cunninghamii* (Nothofagaceae or Fagaceae depending on sources) and *Pinus radiata* (Pinaceae) (Kliejunas *et al.*, 2003). On *Eucryphia lucida, Atherosperma moschatum, Phyllocladus aspleniifolius* and *Anodopetalum biglandulosum*, galleries are formed but brood production is not known (Candy, 1990 citing others). Wood and Bright (1992) also mention *Brachychiton acerifolius, B. populneus, Pterocymbium beccarii* (Malvaceae), *Scolopia brownii* (Salicaceae), but no mention of these hosts was found elsewhere. Candy (1990) notes that sawn timber and 'edgings' of *Dacrydium* (*Lagarostrobus*) *franklinii* (Podocarpaceae, conifer) can be attacked, but that attacks on freshly sawn timber does not result in successful brood production because the timber dries out relatively quickly compared to the length of the life cycle, resulting in desiccation.

A number of other *Eucalyptus* spp. native to Australia are grown in the EPPO region such as *E. globulus, E. camaldulensis, E. gunnii, E. viminalis* (see Spread). Some are present in Australian States where *P. subgranosus* and *A. incompertus* occur but are not reported as hosts. It is not known whether the lack of reports on these species are due to the fact that they are more resistant to the pests or are not present in the same geographic areas.

Known impacts and control in current distribution

- *A. incompertus* can infest high-value *Eucalyptus* species, causing loss of wood value because of the presence of the beetle galleries and fungal staining (Kliejunas *et al.*, 2003, citing others). It causes visual and structural defects to the wood (Kent, 2008). Bickerstaff (2017) mentions that *A. incompertus* resides in living eucalypt

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[8] In the broad sense, including the genus *Corymbia*, previously included under *Eucalyptus*.

trees with no adverse effects to the hosts health, which is consistent with the observation that infested trees can produce new broods during many years (see *Morphology and biology* above).

- *P. granulosus* causes wood degradation in the process of infesting trees (Kliejunas *et al.*, 2003, citing others). However, its major impact has occurred in Tasmania where it was an incidental vector of the lethal disease *Chalara australis* on *Nothofagus cunninghamii*.

Control: Kliejunas *et al.* (2003) mention that no control is available against these species.

POTENTIAL RISKS FOR THE EPPO REGION

Pathways

Entry

P. subgranosus and *A. incompertus* are associated with wood and can attack large diameter trees. All commodities of host wood may be a pathway. If log moisture remains suitable, both species can survive in this material for some time (Kliejunas *et al.*, 2003, citing authors. Adults of *A. incompertus* were observed to emerge from an infested tree 3 years after felling (see *Morphology and biology*). However, the wood would degrade and may not be able to sustain development of the pest (as seen for *P. subgranosus* on sawn timber of *Dacrydium franklinii*).The likelihood of entry on wood chips, hogwood and processing wood residues would be lower than on round wood, as likelihood of survival processing and transport is lower, as well as transfer to a suitable host. Data on the trade of eucalyptus round wood is available from Eurostat. In 2017, imports from Australia (ca. 4000 kg by 2 countries, UK and the Netherlands). Eucalyptus is also used as wood packaging material. Eucalypts are a known pathway for invasive pests (Hurley *et al.*, 2016). Once in the EPPO region, *P. subgranosus* and *A. incompertus* may be able to transfer to hosts, either live or freshly cut.

It is not known if small diameter material can be attacked, i.e. whether plants for planting or cut branches could be a pathway. The fact that trees infested by *A. incompertus* survive over several years could make plants for planting a likely pathway for this species if small diameter trees can be infested. Plants for planting are subject to a degree of control during production, during which attacked plants may be detected and discarded. Entry on cut branches is less likely as these are normally used indoors, and the pests are unlikely to be able to transfer to a suitable host (it is also not known if eucalyptus branches are traded).

Summary of pathways (uncertain pathways are marked with '?'):

Austroplatypus incompertus:

- *wood (round or sawn, with or without bark, including firewood) of hosts*
- *non-coniferous wood chips, hogwood, processing wood residues (except sawdust and shavings)*
- *wood packaging material if not treated according to ISPM 15*
- *plants for planting (except seeds) of hosts?*
- *cut branches of hosts?*

Platypus subgranosus:

- *wood (round or sawn, with or without bark) of hosts*
- *wood chips, hogwood, processing wood residues (except sawdust and shavings)*
- *wood packaging material if not treated according to ISPM 15*
- *plants for planting (except seeds) of hosts?*
- *cut branches of hosts (incl. Christmas trees)?*

In both cases, because of the known host ranges, pathways may cover, in addition to known hosts, all eucalypts (i.e. including genera previously included under Eucalyptus).

Spread (following introduction, i.e. within EPPO region)

P. subgranosus and *A. incompertus* could spread naturally and through human-assisted pathways (wood). If *P. subgranosus* or *A. incompertus* were introduced into the EPPO region, spread would depend on their hosts. It may be limited if only known hosts are attacked.

Establishment

Based on the Köppen-Geiger classification (see Annex 6 of the study), the main climate types of Australian states where the pests are present (Victoria, New South Wales and Tasmania) are Cfa and Cfb[9], which occur

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[9] **Cfa**: warm temperate climate, fully humid, hot summer; **Cfb**: warm temperate climate, fully humid, warm summer

in the temperate part of the EPPO region, from UK to Spain in the West to Poland and the Black Sea in the East.

Eucalyptus spp. are not native to the EPPO region. They are most cultivated in temperate climates in UK, Ireland and France, as well as in the southern part of the EPPO region. Most known eucalypt hosts seem to be available as ornamentals in the EPPO region (general Internet search). In addition, *E. nitens* is planted in northern Portugal and Spain, France, United Kingdom and Ireland for pulpwood. Some other species are grown in the EPPO region, but are not known as hosts: *E. globulus* (introduced to the Iberian Peninsula and Northern Africa in the mid-19th century and planted for industrial purposes, currently mostly for pulpwood mainly in Spain, Portugal, and to a lesser extend in the southern parts of France and Italy); *E. camaldulensis* (Spain, Portugal, Italy, France, Greece, Malta, Cyprus**,** Turkey) (timber, shelterbelts, ornamental); *E. gunnii* (France, UK, Ireland) (ornamental, windbreak, wood fuel); *E. viminalis* (France, UK) (shelterbelts, ornamental). For *P. subgranosus*, *Pinus radiata* is among the most used non-native pines cultivated in Europe for timber production (EPPO, 2015), but attacks in Australia appear to have been observed only on damaged *P. radiata*. *N. cunninghamii* is available as ornamental in the EPPO region (general Internet search).

As potential host plants are present in areas of suitable climate in the EPPO region, the pests could establish.

Potential impact (including consideration of host plants)

The potential impact of *P. subgranosus* and *A. incompertus* in the EPPO region would relate mainly to reduction of wood quality of eucalyptus. It would be minor if only the known hosts are attacked, and would relate to impact on *E. nitens*. Staining may have an impact on pulp production (no information was sought). Economic impact would occur mostly if *Eucalyptus* grown for timber were attacked, where damage due to the presence of galleries and staining would impact the value of the wood. Both ambrosia beetles may also have an impact on ornamental trees, but not on biodiversity. Some eucalyptus species are considered invasive in some EPPO countries (e.g. *E. camaldulensis*); therefore, if these species affect invasive stands, this would be a positive impact. Finally, the potential for vectoring pathogenic fungi may be a concern, as happened for *P. subgranosus* in Tasmania.

References (all URLs were accessed in March 2018)

Bickerstaff JRM. 2017. Morphological and Molecular Characterisation of Australian Pinhole Borers (Coleoptera: Curculionidae, Platypodinae). MSc Thesis, Western Sydney University.

Candy SG. 1990. Biology of the mountain pinhole borer, *Platypus subgranosus* Schedl, in Tasmania. MSc Thesis, University of Tasmania, Hobart 23rd February 1990.

Cerasoli S, Caldeira MC, Pereira JS, Caudullo G, de Rigo D. 2016. *Eucalyptus globulus* and other eucalypts in Europe: distribution, habitat, usage and threats. In: San-Miguel-Ayanz, J., de Rigo, D., Caudullo, G., Houston Durrant, T., Mauri, A. (Eds.), European Atlas of Forest Tree Species. Publ. Off. EU, Luxembourg.

EPPO. 2015. Pest Risk Analysis for *Heterobasidion irregulare*. 15-21059. Available at https://www.eppo.int

Eurostat. 2018. http://ec.europa.eu.

Hurley BP, Garnas J, Wingfield MJ, Branco M, Richardson DM, Slippers B. 2016. Increasing numbers and intercontinental spread of invasive insects on eucalypts. Biological Invasions, 18(4), 921–933.

Kent DS. 2008. Distribution and host plant records of *Austroplatypus incompertus* (Schedl)(Coleoptera: Curculionidae: Platypodinae). Aust. Entomol. 35, 1–6.

Kent DS. 2010. The external morphology of *Austroplatypus incompertus* (Schedl) (Coleoptera, Curculionidae, Platypodinae). ZooKeys, (56), 121–140. Advance online publication. http://doi.org/10.3897/zookeys.56.521

Kliejunas JT, Burdsall HHJr, DeNitto GA, Eglitis A, Haugen DA, Harverty MI, Micales JA, Tkacz BM, Powell MR. 2003. Pest risk assessment of the importation into the United States of unprocessed logs and chips of eighteen Eucalypt Species from Australia. Gen. Tech. Rep. FPL-GTR-137. Madison, WI: US Department of Agriculture, Forest Service, Forest Products Laboratory. 206 p.

Ploetz RC, Hulcr J, Wingfield MJ, de Beer ZW. 2013. Destructive Tree Diseases Associated with Ambrosia and Bark Beetles: Black Swan Events in Tree Pathology? Plant Disease, 97(7):856- 872.

Smith SM, Kent DS, Boomsma JJ, Stow AJ. 2018. Monogamous sperm storage and permanent worker sterility in a long-lived ambrosia beetle. Nature Ecology & Evolution, 2: 1009-1018.

This text is an integral part of the *EPPO Study on bark and ambrosia beetles associated with imported non-coniferous wood* and should be read in conjunction with the study

Pest information sheet
Ambrosia beetle

CNESTUS MUTILATUS (COLEOPTERA: SCOLYTINAE)

camphor shot borer, sweetgum ambrosia beetle

EPPO Lists: Not listed. The assessment of potential risks in this information sheet is not based on a full PRA for the EPPO region, but on an assessment of the limited information for that species used to prepare the information sheet.

PEST OVERVIEW

Taxonomy

Cnestus mutilatus (Blandford 1894). Synonyms: *Xylosandrus mutilatus* (Blandford 1894); *Xyleborus mutilatus* Blandford 1894; *Xyleborus sampsoni* Eggers 1930; *Xyleborus banjoewangi* Schedl 1939; *Xyleborus taitonus* Eggers 1939.

Associated fungi

In Japan, *Ambrosiella* sp. (as an obligatory symbiont), *Paecilomyces* sp. and *Candida* sp. were found associated (Kajimura and Hijii, 1992), but were not fully described. *Ambrosiella beaveri* was described as the main symbiont in the USA (Six *et al.*, 2009), and other fungi were also found: *Geosmithia lavendula*, *G. obscura* (in two beetles) and *Candida homilentoma*. *G. lavendula* was previously reported as a laboratory air contaminant and an elm bark beetle associate in the USA, and in association with bark beetles in the Mediterranean area; *G. obscura* had been reported only from *Scolytus* in Europe (Six *et al.*, 2009). None of these fungi have been reported as being pathogenic.

Morphology and biology

Adults are relatively large for an ambrosia beetle, with females measuring 3.5-4 mm. In Nagoya (Central Honshu, Japan), *C. mutilatus* was found to be univoltine (Kajimura and Hijii, 1992), but Oliver *et al.* (2012) state that there may be more generations in Southern USA. Development from egg to callow adults takes 4-5 weeks. *C. mutilatus* is an inbreeder with a sibling-mating system (Kajimura and Hijii, 1992). In addition, female ambrosia beetles are able to lay eggs and produce brood even if they have not copulated and are not fertilized (parthenogenesis).

C. mutilatus appears to prefer host material that recently died (Kajimura and Hijii 1992, 1994; Schiefer and Bright, 2004 citing articles relating to Asia; Stone *et al.*, 2007). In Asian literature, it has sometimes been mentioned as a pest in crops (see *Known impact*), suggesting attacks on live plants. In Mississippi, attacks on live stressed plants were observed on *Acer saccharum*, *Ostrya virginiana* and *Cornus florida*, as well as one case of attack on healthy potted *Quercus shumardii* (ca. 3 m tall) in a nursery in Alabama (Stone *et al.*, 2007, citing others).

C. mutilatus attacks branches and stems. For example, attacks on stems were observed on a stressed *Liquidambar styraciflua* (Stone *et al.*, 2007). Despite its relatively ‘large’ size, *C. mutilatus* has been observed to prefer material of a small diameter (Schiefer and Bright, 2004), such as branches and the upper part of tree trunks (Stone *et al.*, 2007; Werle, 2016). Kajimura and Hijii (1992) established colonies by felling trees 1-5 cm in diameter. Stone *et al.* (2007) observed few successful attacks when the stem diameter at the point of attack was 3 cm or greater. In China, authors (Tang, 2000) stated that attacks occurred on parts of the branch having a diameter of 1.2 to 2.5 cm. In Louisiana, *C. mutilatus* was found associated with dead twigs (Ferro and Nguyen, 2016). *C. mutilatus* tunnels galleries into the xylem (Kajimura and Hijii, 1992).

Spread biology

No details were found. Oliver *et al.* (2012) mention that *C. mutilatus* has been ‘reported to be a strong flyer’ (details are not given). The spread in the USA appears to have been rapid since the first known specimens were collected in 1999 in Mississippi, and presumably were due in part to natural spread.

Nature of the damage

The major damage is due to tunnelling by the females, which may weaken the structural integrity of the host (Oliver *et al.*, 2012).

Detection and identification

- *Symptoms*. Plants may show leaf wilting, sawdust on branches or at the base of trees, circular entry holes (2 mm), sap oozing near sites of attacks, branch dieback, and eventually tree death (Oliver *et al.*, 2012).
- *Trapping*. *C. mutilatus* is attracted to ethanol, and trap logs baited with ethanol were effective in capturing these beetles (Coyle *et al.*, 2015). Conophothrin, which enhances captures of some other species if added to ethanol, decreased captures of *C. mutilatus* (Miller *et al.*, 2015).
- *Identification*. Adult morphology is described in Schiefer and Bright (2004). *C. mutilatus* is easily distinguished from other Xyleborini (details provided in Gomez *et al*., 2018).

Distribution (see Table1)

C. mutilatus is native to Asia (Olatinwo *et al.*, 2014 citing others) and has been introduced into the USA. In the USA, it was first reported from Mississippi in 2002, but specimens collected in 1999 in the same State were later found (Haack, 2006). It has then spread throughout the South-East, and possibly further North, according to some recent records considered uncertain in Table 1. In any case, *C. mutilatus* appears to be in the process of a rapid range expansion across South-East USA; in South Carolina, few individuals were first collected in 2010 and increased capture rates were observed from 2011 to 2013, with hundreds of individuals (Coyle *et al.*, 2015). *C. mutilatus* has not been reported in the EPPO region.

Host plants (see Table 2)

C. mutilatus is polyphagous and has been recorded from 20 host families worldwide, including in new species and families during studies in Mississippi, USA (Hamamelidaceae, Magnoliaceae, Pinaceae, Rosaceae, Ulmaceae and Vitaceae). It appears to have low host specificity (Stone *et al.*, 2007). Its host range includes temperate deciduous genera, such as *Acer, Castanea, Juglans, Prunus* or *Quercus*. The known host species are used mostly for ornamental purposes in the EPPO region.

Known impacts and control in current distribution

China appears to provide the only record of major impact worldwide repeated in recent US sources, as a major pest of young *Castanea mollissima* in Zhejiang, attacking trunks and branches (e.g. Six *et al.*, 2009, Beaver *et al.*, 2014, Stone *et al.* 2005, all citing Tang, J. Zhejiang Forestry College, 17 (2000) 417-420). The Chinese literature could not be fully exploited here for language reasons, but the following records found in Internet searches (abstracts in Chinese) also point to *C. mutilatus* being a pest in China: serious pest of chestnut in Qianshan county (Anhui province) (Zhang, 2009), considered presenting a high risk to eucalyptus in Guangxi (alongside others such as *Anoplophora glabripennis*; Huang *et al.*, 2013), covered in a study on attractants to monitor main pests of forest trees in Zhejiang (Mou *et al.*, 2007), among the bark beetles of Guizhou fruit trees (Luo *et al.*, 1986).

In Japan, Kajimura and Hijii (1992) reported attacks on dead material, and no recent reference to attacks on live plants was found. It has been reported as an ‘injurious insect’ as camphor shoot-borer (details were not available - Shiraki, 1952 cited in Schiefer and Bright, 2004).

In the Korean Republic, *C. mutilatus* was the most abundant species in a study on the wood-boring and bark beetle community in monoculture plantations of white pines (*Pinus koraiensis*). It is a native species that has not caused outbreaks. However, the authors concluded that it should be considered a potential pest and, in the context of climate change, a threat to Korean white pine forest health (Choi *et al.*, 2017).

Referring to Asia, Ebeling (1959 cited in Schiefer and Bright, 2004) listed *C. mutilatus* as a minor pest of avocado.

In the USA, concerns are expressed in the literature that *C. mutilatus* has not expressed its full potential for damage and that its importance could increase in the future: it has been introduced only recently, but it has spread considerably since its introduction, it has a broad host range of native and ornamental plants, and is closely related to other *Xylosandrus* species, such as *X. compactus, X. crassiusculus, X. germanus* or *X.*

saxeni, which have emerged as pests of nurseries or ornamental trees plantations (e.g. Schiefer and Bright, 2004; Reding *et al.*, 2017; Klingeman *et al.*, 2017). In Tennessee, the potential impact of *C. mutilatus* was still unknown, but its affinity for small diameter stems increases concerns that it could become a significant economic and aesthetic pest of trees in nurseries and the landscape. Even if plants survive, their value will be reduced. Attacks on trees in containers used in research experiments were observed, and *C. mutilatus* also attacked *Liquidambar styraciflua* in a nursery (stressed plants, under-watered and in a substrate with insufficient air) (Oliver *et al.*, 2012). Considering its abundance in areas where it is well established, *C. mutilatus* was considered likely to have an impact on forest ecosystems in Eastern USA (Schiefer and Bright, 2004; Olatinwo *et al.*, 2014).

In Louisiana, unusual damage was observed, thought to be the first record of a Scolytinae attacking non-plant material, where large numbers of borings by females of *C. mutilatus* were observed on several plastic gasoline storage containers (containing gasoline with a 10% ethanol component, to which females were presumably attracted) (Carlton and Bayless, 2011).

Control: Little is known about insecticide management of the pest. Destroying infested plants and injured and unsalable nursery stock will reduce emergence at the nurseries and also lessen human-assisted spread; trees that are adapted to the site should be used, and good cultural practices should promote plant vigour and reduce stress (Oliver *et al.*, 2012). Reding *et al.* (2017) found that *C. mutilatus* and other ambrosia beetle species were attracted to ethanol-injected trap trees, and suggested that such trees might be used to attract ambrosia beetles, for example in the context of monitoring or push-pull strategies (i.e. strategies using repellents to push a pest away from vulnerable plants and attractants to pull it into traps or trap-plants – Cook *et al.*, 2007; Ranger *et al.*, 2016).

POTENTIAL RISKS FOR THE EPPO REGION

Pathways

Entry

C. mutilatus had not been intercepted in the USA prior to its introduction (Haack *et al.*, 2006). Life stages are associated with the xylem. *C. mutilatus* has a preference for small diameter material (twigs to branches or stems of a few cm diameter - see *Pest overview*), which may limit its association with wood commodities to those that include whole trees or harvesting residues (which may contain small-diameter material). It is not known if such material would be traded internationally, and whether such wood could be used for commodities such as firewood (as round wood), wood chips, hogwood, processing wood residues or wood packaging material. In addition, processing applied to produce wood commodities would destroy some individuals. The likelihood of entry on wood chips, hogwood and processing wood residues would be lower than on round wood as individuals would have to survive processing and transport, and transfer to a suitable host is less likely. The wood would also degrade and may not be able to sustain development of the pest. Bark on its own is an unlikely pathway.

C. mutilatus has sometimes been observed on nursery trees. Plants for planting may be a pathway, although they are subject to a degree of control during production, during which attacked plants may be detected and discarded. Cut branches are a less likely pathway, as they are normally used indoors, and the pest is unlikely to be able to transfer to a suitable host. It is also not known if there is a trade of any species to which *C. mutilatus* may be associated.

Finally, *C. mutilatus* is an inbreeder and the females are parthenogenetic, both of which is favourable for successful entry and establishment.

Summary of pathways (uncertain pathways are marked with '?'):

- *plants for planting (except seeds) of hosts*
- *wood (round or sawn, with or without bark, incl. firewood) of hosts?*
- *non-coniferous wood chips, hogwood, processing wood residues (except sawdust and shavings)*
- *wood packaging material if not treated according to ISPM 15*
- *cut branches of hosts?*

Pathways may also cover the known coniferous hosts.

Spread (following introduction, i.e. within EPPO region)

No data is available on the natural spread of *C. mutilatus*. *C. mutilatus* is known to have spread considerably in the USA in the past twenty years, but it is not known if this was due to natural spread or human-assisted pathways. In the EPPO region, it may spread naturally and through human-assisted pathways. Human-assisted pathway may help in creating multiple foci in the EPPO region, if introduced, from which local spread could occur.

Establishment

Based on the climate classification of Köppen Geiger (see Annex 6 of the study), *C. mutilatus* currently occurs mostly in one climate type that is also present in the EPPO region: Cfa[10], which is dominant in the largest part of its USA distribution. In the EPPO region, this climate type is present in areas such as the Black Sea, Northern Italy and part of the Balkans. In addition, *C. mutilatus* is possibly also present in the climate types Cfb and Dfb[10] (these climates occur in regions where the pest is recorded, but they cover only a small part of these areas, and it is not known if the pest occurs in these areas). In the EPPO region, this extends the area potentially suitable from a climatic point of view to Western and Central Europe and around the Black Sea (Cfb), and northwards and eastwards into the south of Scandinavia and Russia (as well as in Far-East Russia) (Dfb).

The host list does not include major native species from the EPPO region, but many temperate genera which are present in the wild, and used in forests, as crops or as ornamentals in the EPPO region (see *Host plants* above and in Table 2). *C. mutilatus* appears to have low host specificity and was found attacking new species and families in the USA. Thus, it would probably find some hosts that are appropriate for growing its symbiont fungi in the EPPO region.

Given the suitable ecological conditions, at least in some parts of the EPPO region, *C. mutilatus* has the potential to establish.

Potential impact (including consideration of host plants)

The potential impact would depend on the plant species attacked, on how far north it is able to establish and on the number of generations in warmer locations. Because small-diameter material is preferred, the main concern, as for the USA, possibly relates to small plants, such as in nurseries or landscape. If *C. mutilatus* reached in the EPPO region similar abundance as in the USA, this may raise concerns for forest ecosystems, as in the USA. In particular, it may hamper forest regeneration by attacking small plants, although there is no evidence of this to date.

Table 1. Distribution

	Reference	**Comments**
EPPO region		
Absent		
Asia		
China: -Anhui, Sichuan, Yunnan, Zhejiang -*Uncertain records*: Guizou, Guangxi	-Dole and Cognato, 2010 - Huang *et al.*, 2013; Luo *et al.*, 1986	- obtained from Google translation from Chinese, not verified
India (Andaman Isl., Assam)	Dole and Cognato, 2010	
Indonesia	Dole and Cognato, 2010	
Japan	Dole and Cognato, 2010	
Korea	Dole and Cognato, 2010	
Malaysia	Dole and Cognato, 2010	
Myanmar	Dole and Cognato, 2010	
Sri Lanka	Dole and Cognato, 2010	
Taiwan	Dole and Cognato, 2010	
Thailand	Dole and Cognato, 2010	
North America		
United States - Florida, Mississippi - Texas - Alabama, Arkansas, Georgia, Louisiana, North Carolina - Tennessee	 - Schiefer and Bright, 2004 - Cognato *et al.*, 2006 - Ghandi *et al.*, 2009 - Oliver *et al.*, 2012	Introduced - Mississippi: first found 1999 - first found 2005 - first found in 2008

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[10] **Cfa**: warm temperate climate, fully humid, hot summer; **Cfb**: warm temperate climate, fully humid, warm summer; **Dfb**: snow climate, fully humid, warm summer.

	Reference	**Comments**
- South Carolina - Kentucky - Pennsylvania - *Uncertain records*: Delaware, Illinois, Indiana, Maryland, Missouri, New Jersey, Ohio, Virginia, West Virginia	- Chong *et al.*, 2012 - Leavengood, 2013 - Gomez *et al.*, 2018 - Atkinson *et al.*, 2018	- considered uncertain, because based on unpublished records
Oceania		
New Guinea	Dole and Cognato, 2010	

Table 2. Hosts.
*Some records in Oliver *et al.* (2012) and Reding *et al.* (2007) refer to plants attacked after injection with ethanol

Family	**Genus/Species**	**Reference**
Altingiaceae	*Liquidambar styraciflua*	Oliver *et al.*, 2012
Arecaceae	*Calamus* spp.	Oliver *et al.*, 2012
Betulaceae	*Carpinus laxiflora*	Oliver *et al.*, 2012
Betulaceae	*Ostrya virginiana*	Oliver *et al.*, 2012
Cornaceae	*Cornus* spp.	Oliver *et al.*, 2012
Cornaceae	*Cornus florida*	Oliver *et al.*, 2012
Fabaceae	*Albizia* spp.	Oliver *et al.*, 2012
Fabaceae	*Cercis canadensis*	Werle, 2016
Fabaceae	*Ormosia hosiei*	Oliver *et al.*, 2012
Fagaceae	*Castanea* spp.	Oliver *et al.*, 2012
Fagaceae	*Castanea mollissima*	Oliver *et al.*, 2012
Fagaceae	*Fagus crenata*	Oliver *et al.*, 2012
Fagaceae	*Fagus grandifolia*	Oliver *et al.*, 2012
Fagaceae	*Quercus alba**	Oliver *et al.*, 2012
Fagaceae	*Quercus shumardii*	Oliver *et al.*, 2012
Juglandaceae	*Carya* spp.	Oliver *et al.*, 2012
Juglandaceae	*Juglans nigra**	Oliver *et al.*, 2012
Juglandaceae	*Platycarya strobilacea*	Oliver *et al.*, 2012
Lauraceae	*Benzoin* spp.	Oliver *et al.*, 2012
Lauraceae	*Cinnamomum camphora*	Oliver *et al.*, 2012
Lauraceae	*Lindera erythrocarpa*	Oliver *et al.*, 2012
Lauraceae	*Lindera (Parabenzoin) praecox*	Oliver *et al.*, 2012
Lauraceae	*Lindera triloba*	Oliver *et al.*, 2012
Lauraceae	*Persea thunbergii*	Oliver *et al.*, 2012
Magnoliaceae	*Liriodendron tulipifera**	Oliver *et al.*, 2012
Magnoliaceae	*Magnolia virginiana**	Oliver *et al.*, 2012
Meliaceae	*Melia azedarach*	Oliver *et al.*, 2012
Meliaceae	*Swietenia macrophylla*	Oliver *et al.*, 2012
Oleaceae	*Osmanthus fragrans*	Oliver *et al.*, 2012
Pinaceae	*Pinus taeda*	Oliver *et al.*, 2012
Proteaceae	*Grevillea robusta*	Oliver *et al.*, 2012
Rosaceae	*Prunus americana*	Oliver *et al.*, 2012
Rosaceae	*Prunus serotina*	Oliver *et al.*, 2012
Rosaceae	*Pyrus calleryana**	Reding *et al.*, 2007
Sapindaceae	*Acer* spp.	Oliver *et al.*, 2012
Sapindaceae	*Acer rubrum*	Oliver *et al.*, 2012
Sapindaceae	*Acer palmatum*	Oliver *et al.*, 2012
Sapindaceae	*Acer saccharum*	Oliver *et al.*, 2012
Sapindaceae	*Acer sieboldianum*	Oliver *et al.*, 2012
Sapindaceae	*Koelreuteria paniculata**	Oliver *et al.*, 2012
Taxodiaceae	*Cryptomeria japonica*	Oliver *et al.*, 2012
Theaceae	*Camellia* spp.	Oliver *et al.*, 2012
Ulmaceae	*Ulmus alata*	Oliver *et al.*, 2012
Vitaceae	*Vitis rotundifolia*	Oliver *et al.*, 2012

References

Atkinson TH. 2018. Bark and Ambrosia beetles. http://www.barkbeetles.info

Beaver RA, Sittichaya W, Liu L-Y. 2014. A Synopsis of the Scolytine Ambrosia Beetles of Thailand (Coleoptera: Curculionidae: Scolytinae). Zootaxa 3875(1): 1–82

Carlton C, Bayless V. 2011. A Case of *Cnestus mutilatus* (Blandford) (Curculionidae: Scolytinae: Xyleborini) Females Damaging Plastic Fuel Storage Containers in Louisiana, U.S.A. The Coleopterists Bulletin, 65(3):290-291.

Choi WI, Kim K-M, Koh S-H, Nam Y. 2017. A Study on the Community of Xylophagous Beetles in Korean White Pine, Pinus koraiensis, Forests. Korean J. Appl. Entomol. 56(1): 41-49.

Chong, J.-H., J. S. Weaver, and L. S. Reid. 2012. New records of bark and ambrosia beetles (Coleoptera: Curculionidae: Scolytinae) from South Carolina, U.S.A. The Coleopterists Bulletin 66(3): 250-252.

Cognato AI, Bográn CE, Rabaglia R. 2006. An exotic ambrosia beetle, *Xylosandrus mutilatus* (Blandford) (Scolytinae: Xyleborina) found in Texas. The Coleopterists Bulletin, 60(2):162-163.

Cook SM, Khan ZR, Pickett JA. 2007. The use of push-pull strategies in integrated pest management. Annu. Rev. Entomol., 52, 375-400.

Coyle DR, Brissey CL, Gandhi KJK. 2015. Species characterization and responses of subcortical insects to trap-logs and ethanol in a hardwood biomass plantation. Agricultural and Forest Entomology (2015), DOI: 10.1111/afe.12101

Dole SA, Cognato AI. 2010. Phylogenetic revision of *Xylosandrus* Reitter (Coleoptera: Curculionidae: Scolytinae: Xyleborina). Proceedings of the California Academy of Sciences, vol. 61, 451-545

Ebeling W. 1959. Subtropical fruit pests. University of California Press. pp. 285-320.

Ferro ML, Nguyen NH. 2006. Survey of Twig-Inhabiting Coleoptera in Louisiana, USA. The Coleopterists Bulletin, 70(3): 551–558. 2016.

Gandhi KJK, Audley J, Johnson J, Raines M. 2009. Camphor shot borer, *Xylosandrus mutilatus* (Blandford) (Coleoptera: Curculionidae), an adventive ambrosia beetle in Georgia. The Coleopterists Bulletin, 63(4):497-500.

Gomez DF, Rabaglia RJ, Fairbanks KEO, Hulcr J. 2018. North American Xyleborini north of Mexico: a review and key to genera and species (Coleoptera, Curculionidae, Scolytinae). ZooKeys 768: 19–68.

Haack RA. 2006. Exotic bark- and wood-boring Coleoptera in the United States: recent establishments and interceptions. Can. J. For. Res. 36: 269–288.

Huang Z, Pangzheng H, Zhang S, Cao S. 2013. Risk Analysis and Management Countermeasures of eucalyptus borer pests. [translated from Chinese abstract]

Kajimura H, Hijii N. 1992. Dynamics of the fungal symbionts in the gallery system and the mycangia of the ambrosia beetle, *Xylosandrus mutilatus* (Blandford) (Coleoptera: Scolytidae) in relation to its life history. Ecological Research 7, 107-117

Kajimura H, Hijii N. 1994. Reproduction and resource utilization of the ambrosia beetle, *Xylosandrus mutilatus*, in field and experimental populations. Entomol. exp. appl. 71: 121-132

Klingeman WE, Bray AM, Oliver JB, Ranger CM, Palmquist DE. 2017. Trap Style, Bait, and Height Deployments in Black Walnut Tree Canopies Help Inform Monitoring Strategies for Bark and Ambrosia Beetles (Coleoptera: Curculionidae: Scolytinae). Environmental Entomology, 46(5), 2017, 1120–1129.

Leavengood JM Jr. 2013. First record of the camphor shot borer, *Cnestus mutilatus* (Blandford 1894), (Curculionidae: Scolytinae: Xyleborini) in Kentucky. Insecta Mundi. 813.

Luo LY. 1986. Bark beetles of Guizhou fruit trees. [in Chinese]

Miller DR, Dodds KJ, Hoebeke ER, Poland TM, Willhite EA. 2015.Variation in Effects of Conophthorin on Catches of Ambrosia Beetles (Coleoptera: Curculionidae: Scolytinae) in Ethanol-Baited Traps in the United States. J. Econ. Entomol. 108(1): 183–191.

Mou A, You L, Yunhua Z, Li F, *et al*. 2007. Attractants to monitor main pests of forest trees. [translated from Chinese abstract]

Oliver J, Youssef N, Basham J, Bray A, Copley K, Hale F, Klingeman W, Halcomb M, Haun W. 2012. Camphor Shot Borer: A New Nursery and Landscape Pest in Tennessee ANR-ENT-01-2012. Tennessee State University.

Oliver J, Youssef N, Basham J, Bray A, Copley K, Hale F, Klingeman W, Halcomb M, Haun W. Camphor Shot Borer: A New Nursery and Landscape Pest in Tennessee. ANR-ENT-01-2012 SP 742. Tennessee State University Extension.

Ranger CM, Reding ME, Schultz PB, Oliver JB, Frank SD, Addesso KM, Chong JH, Sampson B, Werle C, Gill S, Krause C. 2016. Biology, Ecology, and Management of Non-native Ambrosia Beetles (Coleoptera: Curculionidae: Scolytinae) in Ornamental Plant Nurseries. Journal of Integrated Pest Management, 7(1), 9, 1-23.

Reding ME, Ranger CM, Oliver JB, Schultz PB, Youssef NN, Bray AM. 2017. Ethanol-injection induces attacks by ambrosia beetles (Coleoptera: Curculionidae: Scolytinae) on a variety of tree species. Agricultural and Forest Entomology, 19, 34–41.

Schiefer TL, Bright DE. 2004. *Xylosandrus mutilatus* (Blandford), an Exotic Ambrosia Beetle (Coleoptera: Curculionidae:Scolytinae: Xyleborini) New to North America. The Coleopterists Bulletin, Vol. 58, No. 3, pp. 431-438.

Shiraki T. 1952. Catalogue of injurious insects in Japan [Exclusive of animal parasites) [In Japanese] Preliminary Studies, Economic Science Section, Natural Resources Division, General Headquarters, Tokyo, Allied Powers Vol V.

Six DL, Stone WD, WZ de Beer, Woolfolk SW. 2009. *Ambrosiella beaveri*, sp. nov., Associated with an exotic ambrosia beetle, *Xylosandrus mutilatus* (Coleoptera: Curculionidae, Scolytinae), in Mississippi, USA. Antonie van Leeuwenhoek, 96:17–29.

Stone WD, Nebeker TE, Gerard PD. 2007. Host Plants Of *Xylosandrus mutilatus* In Mississippi. Source: Florida Entomologist, 90(1):191-195.

Stone WD, Nebeker TE, Monroe WA. 2005. Ultrastructure of the Mesonotal Mycangium of *Xylosandrus mutilatus* (Blandford), an Exotic Ambrosia Beetle (Coleoptera: Curculionidae: Scolytinae) by Light, Scanning, and Transmission Electron Microscopy. Microsc Microanal 11(Suppl 2), 172-173.

Tang W-Q. 2000. Biological characteristics of *Xyleborus mutilatus* and its control. Journal of Zhejiang Forestry College, 17, 417–420. [in Chinese with English summary]

Werle C. 2016. An Integrated Approach to Ambrosia Beetle Management in Ornamental Tree Nurseries: Biology of and Control Measures for Exotic Xyleborina". LSU Doctoral Dissertations. 3500.

Zhang G. 2009. Chestnut orchards. Biological disaster science management. Excerpt from "forestry biological disaster prevention". 板栗园. 生物灾害科学管理. 节选自《林业生物灾害防治》（张国庆著）[translated from Chinese abstract]

This text is an integral part of the *EPPO Study on bark and ambrosia beetles associated with imported non-coniferous wood* and should be read in conjunction with the study

Pest information sheet
Ambrosia beetle

EUPLATYPUS PARALLELUS (COLEOPTERA: PLATYPODINAE)

EPPO Lists: Not listed. The assessment of potential risks in this information sheet is not based on a full PRA for the EPPO region, but on an assessment of the limited information for that species used to prepare the information sheet.

PEST OVERVIEW

Taxonomy

Euplatypus parallelus (Fabricius, 1801). Synonyms: *Platypus parallelus, P. linearis, P. poeyi, P. subcostatus, P. dejeani, P. marseuli, P. proximus, P. compressus, P. regularis, P. rugulosis, P. reticulates, P. rotundatus, P. kratzii, P. lebasi, P. emarginatus, P. congoanus, P. triquetrus, P. mattai, P. difficillis, P. erichsoni, P. laevicollis, P. macklini, P. oblongus, P. praevius, P. puntulatus. P. subaequalis, P. wesmaeli, Bostrichus parallelus* (Atkinson, 2018).

Associated fungi

No information was found on the symbionts of *E. parallelus*. *E. parallelus* was found to transmit *Fusarium* wilt fungi, although normally not as a primary vector. In Asia and the Seychelles, an association has been noted for several leguminous tree species (e.g. *Pterocarpus indicus*, *Dalbergia sissoo*) between the presence of *Fusarium oxysporum* attacks by *E. parallelus*, and the subsequent death of the trees. However, the details of the interactions between stress factors, pathogen and beetle attacks, and whether *E. parallelus* acts as a vector, are not clear (Beaver, 2013, citing others). On *Pterocarpus indicus* in Indonesia, fungi in the genera *Aspergillus*, *Penicillium*, *Trichoderma*, *Fusarium*, *Acremonium*, *Gliocladium*, *Saccharomyces* and *Candida* were found associated (Tarno *et al.*, 2016). In Thailand, Bumrungsri *et al.* (2008) found 46 fungi associated with frass, sapwood, wood resin and larvae and adults. *Fusarium* spp. including *F. oxysporum* and *F. solani* were the dominant sporulating fungi, and were not found associated with adults. *E. parallelus* may help the movement of *Fusarium* spp. in the wood within its galleries.

Morphology and biology

Adults measure ca. 4 mm (Maruthadurai *et al*., 2013). No detailed study of the biology of *E. parallelus* was found, but its life cycle is typical of many Platypodinae, which complete most of their life cycle in the wood of their host, and feed on symbiotic fungi farmed in their tunnels. The gallery system is started by the male and continued by the female after mating (Beaver, 2013, citing others). Galleries may reach the heartwood of rubber trees with a large trunk diameter (da Silva, 2013).

E. parallelus tends to attack large logs or trunks but can also breed in smaller stems down to about 10 cm diameter (Beaver *et al.*, 2013). It is also reported on branches of some hosts (e.g. *Anacardium occidentale* in Maruthadurai *et al.*, 2013; *Pterocarpum indicum* in Tarno *et al.*, 2014).

E. parallelus is known to attack trees that recently died or dying trees, as well as living trees that have been stressed by fire, drought, pathogens or other causes, and occasionally apparently healthy trees, possibly in relation to high population levels leading to mass attacks (Bumrungsri *et al.*, 2008).

Spread biology

No specific information was found, but both males and females disperse (Beaver *et al.*, 2013), and could fly.

Nature of the damage

Damage is caused by the adults boring galleries that may extend deeply into the wood, and by pathogenic fungi introduced into the galleries (Gümüs and Ergün, 2015, citing others). Galleries create technical damage to the wood (holes surrounded by a blackened area caused by the ambrosia fungi) (Beaver *et al.*, 2013).

Detection and identification

- *Symptoms.* There may be entry holes on the trunk and branches, as well as powdery frass or strings of compacted sawdust on and at the base of the trees (Maruthadurai *et al.*, 2013). On *Pterocarpus indicus*, with a pathogenic fungus associated, other symptoms were fallen leaves, wilting and dying of trees (Tarno *et al.*, 2016).
- *Trapping.* Atkinson (2018) mentions trapping with ethanol as well as various light traps.
- *Identification.* Taxonomic keys by Atkinson (1989) and Wood (1993) can be used for the morphological identification of *E. parallelus* (Li *et al.*, 2018, citing others). The complete mitochondrial genome of *E. parallelus* is given in Yang *et al.* (2017).

Distribution (see Table 1)

E. parallelus is native to South and Central America and is present in the South of the USA (California, Texas and Florida) (Wood and Bright, 1992). It has been introduced into Africa, Asia and Oceania. In Asia, it was first recorded in Sri Lanka in the 1970s and is now present almost throughout East Asia (Beaver *et al.*, 2013 citing others). It was most recently recorded in India (Maruthadurai *et al.*, 2013) and China (Hainan Island) (Li, 2018).

No records of presence were found in the EPPO region. Several publications refer to the presence of the species in England (e.g. Atkinson, 2018; Allen, 1976; Whitehead, 2001), though it is probable that the few findings were casual importees, which never established populations (Whitehead, 2001). *E. parallelus* is considered absent in the UK Risk Register (2018). In France, it was trapped in 2016 in La Rochelle harbour (Denux *et al.*, 2017; GEFF, 2017), but is not established (L-M Nageleisen and T. Noblecourt, pers. comm. 2018-05).

Host plants (see Table 2)

E. parallelus is highly polyphagous without any preference for particular families of trees (Beaver, 2013, citing others). A list of 65 host species in 21 families was published in 1965 for the Afrotropical region, and many others have been recorded in other areas, including both non-coniferous and coniferous trees (Bumsrungsri *et al.*, 2008, citing Schedl, 1965, Zanuncio *et al.* 2002; 2005). Table 2, which is not complete and prepared from only a few publications, covers hosts in 29 families, with 9 genera of Fabaceae. *E. parallelus* has attacked new hosts in new areas. The host range covers mostly tropical and subtropical plants (including major tropical woods such as teak, sapele, meranti), which in the EPPO region may be cultivated as ornamentals. *Persea americana* is cultivated commercially in the Southern part of the EPPO region, as well as *Mangifera indica* to a more limited extent (Spain). *Eucalyptus* spp. are also cultivated commercially and as amenity trees in the southern part of the region. Finally, *Quercus* and *Pinus*, widespread in EPPO, are mentioned among the hosts, but host species were not specified in the respective sources.

Known impacts and control in current distribution

Although it is mentioned in several publications that *E. parallelus* is the most destructive Platypodinae in the world (e.g. Maruthadurai *et al.*, 2013), relatively few reports of damage were found over its entire range. *E. parallelus* is mostly a secondary pest, but primary attacks can occur (Bumrungsri *et al.*, 2008). Dense attacks, especially if combined with fungal attack, can kill trees, and mass attacks may kill stressed trees that might otherwise have survived (Beaver *et al.*, 2013, citing others). Impacts relate to decrease of the value of the wood following attacks on live trees or recently felled wood, decrease of production on fruit trees, and death of trees, especially where *E. parallelus* has a role in transmitting *Fusarium* wilt fungi.

Regarding damage to live trees, *E. parallelus* is found in natural environments in the Americas, but attacks in plantations have also been observed: in Brazil, on fire-stressed *Pinus* sp. (Zanuncio *et al.*, 2002), drought-stressed *Eucalyptus* hybrids (Zanuncio *et al.*, 2005), *Hevea brasiliensis* (da Silva *et al.*, 2013); in Colombia, on *Acacia mangium* (Medina and Florian, 2011). In Central America (especially Costa Rica but also others) and Brazil, *E. parallelus* is one of the wood borers attacking *Tectona grandis*, and that may cause loss of wood value due to the presence of galleries (Ferreira, 2016; Arguedas *et al.*, 2004; Arguedas and Solis, 2006; Arguedas *et al.*, 2015). In southern Thailand, it has caused damage to stressed mango and cashew trees (*Mangifera indica*, *Anacardium occidentale*) (Beaver *et al.*, 2013 citing others). In India, attacks on *Anacardium occidentale* were noted (Maruthadurai *et al.*, 2013), further damaging stressed trees and causing losses to producers.

In Asia and the Seychelles, mortality has been observed for several leguminous tree species (e.g. *Pterocarpus indicus*, *Dalbergia sissoo*) infested by both *Fusarium oxysporum* and *E. parallelus*, but the role of *E. parallelus* is not known (Beaver *et al.*, 2013 citing others). In Indonesia, *E. parallelus* was associated with mortality of roadside *Pterocarpus indicus*, and *Fusarium* was isolated (Tarno *et al.*, 2014, 2016). Also in Brazil, it was found associated with pathogenic fungi attacking *Hevea brasiliensis* (Beaver *et al.*, 2013 citing others).

E. parallelus can also cause economic damage by attacking felled trees, especially stems of large diameter, and freshly sawn timber. The presence of galleries reduces the quality and value of the wood, and of veneer produced from it (Beaver, 2013, citing others). *E. parallelus*, together with *Xyleborus affinis* was responsible for most of the damage caused to timber of 18 tree species in Amazonia, Brazil. In part of Thailand, *E. parallelus* was the dominant species attacking *Hevea brasiliensis* logs in piles, while attacks on sawn rubberwood timber were infrequent (Sittichaya and Beaver, 1999; Beaver *et al.*, 2013).

In the USA, where it occurs in Florida, California and Texas, Drooz *et al.* (1985) state that it causes minor damage as unfavourable climate prevents it from becoming abundant. Note that on *P. americana*, it was found emerging from wood, but no damage is reported (Carrillo *et al.*, 2012). No data were found on damage in other parts of the world (e.g. Africa and Oceania).

Control. No information has been found on control measures specific to *E. parallelus*.

POTENTIAL RISKS FOR THE EPPO REGION

Pathways

Entry

There are frequent mentions of association with wood in trade. *E. parallelus* was probably accidentally imported into Asia in timber or unseasoned wood after the Second World War, and is frequently intercepted in imported timber in Japan (Beaver *et al.*, 2013). In the Korean Republic, it was intercepted on *Shorea lepidota* (light red meranti; Choi *et al.*, 2003), and in China on logs from Sierra Leone (Yang *et al.*, 2017). In the EPPO region, it was intercepted in Turkey in logs of *Tetraberlinia bifoliata* from Cameroon (Gümüş and Ergün, 2015), and in Spain on wood of *Entandrophragma cylindricum* (sapele) from the Congo (EPPO, 2015). Finally, in the UK, it was intercepted on wood, most likely pine, in passenger baggage from a flight originating from Jamaica (UK Risk Register, unpublished background data); in addition few additional findings over time (Whitehead, 2001) are probably linked to imports.

Given its host range, *E. parallelus* is most likely to be associated with tropical wood, including teak, mahogany, sapele, meranti, shisham, rubberwood etc. In addition, it has occasionally attacked plantations of other trees that may be imported as wood, such as pine and eucalyptus in Brazil. As larvae survival decreases with drying, recently felled wood would be more suitable for survival. Processing applied to produce wood commodities would also destroy some individuals. The likelihood of entry on wood chips, hogwood and processing wood residues would be lower than on round wood as individuals would have to survive processing and transport, and transfer to a suitable host is less likely. Bark on its own is an unlikely pathway (life stages are in the wood).

Plants for planting or cut branches would be a pathway only if there are of a large size (a diameter >10 cm is mentioned). It is not known if plants for planting or cut branches of this size would be traded (except possibly Christmas trees).

Summary of pathways (uncertain pathways are marked with '?'):

- *wood (round or sawn, with or without bark, incl. firewood) of hosts*
- *wood packaging material if not treated according to ISPM 15*
- *wood chips, hogwood, processing wood residues (except sawdust and shavings)*
- *plants for planting (except seeds) of hosts?*
- *cut branches (incl. Christmas trees)?*

Because of the large and uncertain host range, pathways may cover all coniferous and non-coniferous species.

Spread (following introduction, i.e. within EPPO region)

E. parallelus would be able to spread naturally and through human-assisted pathway. Given its climatic requirements, the spread may be limited to part of the EPPO region. The success of new outbreaks would depend on whether it would be able to attack widespread trees in the EPPO region. If only the known hosts are attacked, spread would probably be limited. However, it is highly polyphagous and has been able to attack new hosts in new areas.

Establishment

E. parallelus is widely present in tropical and subtropical areas, including South America and Africa. It has spread within Asia for decades, but its northernmost limit is currently in Taiwan. Beaver *et al.* (2013, citing others) mention that it probably cannot survive and breed in the current climate of Japan's main islands. In North America, it is recorded in Florida, Texas and southern California, but the climate is considered unfavourable to building abundant populations (Drooz *et al.*, 1985). Based on the classification of Köppen-Geiger (see Annex 6 of the study), some climate types in USA States as well as Mexico (e.g. Cfa, Csa, Csb[11]) occur in the EPPO region around the Mediterranean Basin and eastwards to the Black Sea. It cannot be excluded that *E. parallelus* would be able to establish in the South of the EPPO region. Although Allen (1976) made the hypothesis that *E. parallelus* may occasionally form transient populations in the UK, it is not present in any oceanic temperate climate in its known range. Similarly, in France it was trapped in La Rochelle harbour, but is not established (see *Distribution*).

The current host range of *E. parallelus* consists mostly of tropical plants, but it has been able to attack new plant species in new locations (e.g. in Australia, see Table 2). Some known hosts may be grown mostly as ornamentals, and there is a certain presence of *Mangifera indica* in Spain and *Eucalyptus* in the southern part of EPPO. However, known hosts are not widespread in the EPPO region. *Quercus* and *Pinus* are mentioned among the hosts, but no details were found. Establishment would be facilitated if *E. parallelus* is able to attack new hosts at destination.

Potential impact (including consideration of host plants)

The potential impact would depend on whether *E. parallelus* would find new hosts in the EPPO region. In the USA where it is present in similar climates, it causes minor damage, and this would probably also be the case in the EPPO region. However, it would add to the ambrosia beetle fauna able to colonize live and recently felled trees with possible impact on wood value. One concern would be if it would become associated with pathogenic fungi and carry those into the trees, contributing to their spread and impact, as observed in other areas with *Fusarium oxysporum* that causes death of trees.

Table 1. Distribution

	Reference	**Comments**
EPPO region		
Absent: France	Denux *et al.*, 2017; GEFF, 2017	Trapped in La Rochelle harbour, not established
Absent: UK		England in mentioned in some sources (e.g. Atkinson, 2018). *E. parallelus* was found at a few occasions (see Allen 1976, Whitehead, 2001). It is probable that findings were casual importees, which never established populations (Whitehead, 2001). Considered absent in the UK Risk Register.
Africa		
Angola	Wood and Bright (1992)	
Cameroon	Wood and Bright (1992)	
Chad	Wood and Bright (1992)	
Congo	Wood and Bright (1992)	
Equatorial Guinea	Wood and Bright (1992)	
Fernando Po	Wood and Bright (1992)	
Gabon	Wood and Bright (1992)	
Ghana	Wood and Bright (1992)	
Guinea	Wood and Bright (1992)	
Ivory Coast	Wood and Bright (1992)	
Kenya	Wood and Bright (1992)	

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[11] **Cfa**: warm temperate climate, fully humid, hot summer; **Csa**: warm temperate climate, dry and hot summer; **Csb**: warm temperate climate, dry and warm summer

	Reference	Comments
Madagascar	Wood and Bright (1992)	
Nigeria	Wood and Bright (1992)	
Principe Island	Wood and Bright (1992)	
Sao Tome Island	Wood and Bright (1992)	
Senegal	Wood and Bright (1992)	
Seychelles	Beaver, 2013, citing others	
Sierra Leone	Wood and Bright (1992)	
South Africa	Wood and Bright (1992)	
Tanzania	Wood and Bright (1992)	
Togo	Wood and Bright (1992)	
Uganda	Wood and Bright (1992)	
Zaire	Wood and Bright (1992)	
Uncertain records: Liberia	Atkinson, 2018	Considered uncertain here as unpublished
Asia		
Bangladesh	Beaver, 2013, citing others	
Brunei Darussalam	Beaver, 2013, citing others	
Cambodia	Beaver, 2013	
China (Hainan island)	Li (2018)	New record
India	Maruthadurai *et al.* 2013	
Indonesia	Beaver, 2013, and citing others	From 1980s (Beaver, 2013)
Malaysia	Beaver, 2013	From 1980 (Beaver, 2013)
Philippines	Beaver, 2013	
Singapore	Beaver, 2013	
Sri Lanka	Beaver, 2013, citing others	From 1970s (Beaver, 2013)
Taiwan	Beaver, 2013	
Thailand	Beaver, 2013, and citing others	From 1980s
Uncertain records: Myanmar, Vietnam	Beaver, 2013, citing others	Based on declared interceptions in China with timber
North America		
USA: - California, Florida - Texas - Hawaii	 Wood and Bright (1992) Atkinson and Riley, 2013 Gillet and Rubinoff, 2017	 - new record
Mexico	Wood and Bright (1992)	
Central America		
Belize	Wood and Bright (1992)	
Costa Rica	Wood and Bright (1992)	
El Salvador	Wood and Bright (1992)	
Guatemala	Wood and Bright (1992)	
Honduras	Wood and Bright (1992)	
Nicaragua	Wood and Bright (1992)	
Panama	Wood and Bright (1992)	
Caribbean		
Cuba	Wood and Bright (1992)	
Dominican Republic	Wood and Bright (1992)	
Guadeloupe	Peck *et al.*, 2014	
Haiti	Wood and Bright (1992)	
Jamaica	Wood and Bright (1992)	

	Reference	**Comments**
Puerto Rico	Wood and Bright (1992)	
Uncertain records: - Bahamas, Cayman Isl., Dominica, Santa Lucia, Trinidad and Tobago, Virgin Isl.	Atkinson, 2018	Considered uncertain here as unpublished
South America		Native (Beaver, 2013)
Argentina	Wood and Bright (1992)	
Bolivia	Wood and Bright (1992)	
Brazil	Wood and Bright (1992)	
Chile	Wood and Bright (1992)	
Colombia	Wood and Bright (1992)	
Ecuador	Wood and Bright (1992)	
French Guyana	Wood and Bright (1992)	as ‘Cayenne’
Guyana	Wood and Bright (1992)	
Paraguay	Wood and Bright (1992)	
Peru	Wood and Bright (1992)	
Suriname	Wood and Bright (1992)	
Uruguay	Wood and Bright (1992)	
Venezuela	Wood and Bright (1992)	
Oceania		
Australia (Queensland)	Bickerstaff (2017)	
Borneo	Beaver, 2013, citing others	timber imported to Japan from Borneo Beaver, 2013, citing others
Papua New Guinea	Beaver, 2013	

Table 2. Hosts

Family	**Genus/Species**	**Reference**
Acanthaceae	*Avicennia*	Beaver, 2013, citing others
Anacardiaceae	*Anacardium occidentale*	Beaver *et al.*, 2013; Maruthadurai *et al.* 2013
Anacardiaceae	*Astronium graveolens*	Atkinson, 2018
Anacardiaceae	*Cedrela fissilis*	Schönherr and Pedrosa-Mac (1981) Brazil
Anacardiaceae	*Mangifera indica*	Atkinson, 2018
Anacardiaceae	*Metopium brownei*	Bright and Skidmore, 2002
Anacardiaceae	*Spondias purpurea*	Atkinson, 2018
Apocynaceae	*Aspidosperma megalocarpon*	Atkinson, 2018
Araucariaceae	*Araucaria angustifolia*	Schönherr and Pedrosa-Mac (1981) Brazil
Araucariaceae	*Araucaria cunninghamii*	Schedl (1979) Australia
Arecaceae	*Cocos nucifera*	Atkinson, 2018
Bignoniaceae	*Tabebuia*	Atkinson, 2018
Bombacaceae	*Ceiba aesculifolia*	Atkinson, 2018
Bombacaceae	*Ceiba*	Atkinson, 2018
Burseraceae	*Bursera*	Atkinson, 2018
Dipterocarpaceae	*Shorea lepidota*	From interception data, Choi *et al.*, 2003
Euphorbiaceae	*Croton*	Bright and Skidmore, 2002
Euphorbiaceae	*Croton nitens*	Atkinson, 2018
Euphorbiaceae	*Croton pseudoniveus*	Atkinson, 2018
Euphorbiaceae	*Hevea brasiliensis*	da Silva, 2013, Brazil; Bumrungsri *et al.*, 2008, citing others, Africa, Malaysia, India
Fabaceae	*Acrocarpus*	Atkinson, 2018
Fabaceae	*Caesalpinia ferrea*	Tarno *et al.*, 2014
Fabaceae	*Cassia*	Tarno *et al.*, 2014
Fabaceae	*Cassia javanica*	Gillet and Rubinoff, 2017, Hawaii
Fabaceae	*Colvillea racemosa*	Schedl (1979) Australia (Queensland)

Family	**Genus/Species**	**Reference**
Fabaceae	*Dalbergia sissoo*	Beaver *et al.*, 2013 citing others
Fabaceae	*Delonix regia*	Atkinson, 2018
Fabaceae	*Tetraberlinia bifoliata*	Interception data, Gümüs and Ergün, 2015
Fabaceae	*Erythrina brevifolia*	Atkinson, 2018
Fabaceae	*Lonchocarpus rugosus*	Bright and Skidmore, 2002
Fabaceae	*Lonchocarpus*	Atkinson, 2018
Fabaceae	*Pterocarpus indicus*	Bumrungsri *et al.*, 2008. Thailand
Fabaceae	*Pterocarpus rohrii*	Atkinson, 2018
Fagaceae	*Quercus*	Bright and Skidmore, 2002
Lamiaceae	*Tectona grandis*	Kirkendall and Ødegaard, 2007
Lamiaceae	*Gmelina arborea*	Bright and Skidmore, 2002
Lamiaceae	*Vitex guameri*	Atkinson, 2018
Lauraceae	*Persea americana*	Carrillo *et al.*, 2012
Lythraceae	*Sonneratia*	Beaver, 2013, citing others
Malvaceae	*Pterocymbium beccarii*	Schedl (1979) Australia (Queensland)
Meliaceae	*Carapa slateri*	Atkinson, 2018
Meliaceae	*Entandrophragma cylindricum*	Interception data, EPPO, 2015
Mimosaceae	*Acacia dolychostachya*	Atkinson, 2018
Mimosaceae	*Acacia guameri*	Atkinson, 2018
Mimosaceae	*Acacia mangium*	Bright and Skidmore, 2002
Mimosaceae	*Lysiloma bahamensis*	Atkinson, 2018
Moraceae	*Brosimum*	Bright and Skidmore, 2002
Moraceae	*Brosimum alicastrum*	Atkinson, 2018
Moraceae	*Cecropia obtusifolia*	Atkinson, 2018
Moraceae	*Ficus*	Bright and Skidmore, 2002
Moraceae	*Ficus cotinifolia*	Atkinson, 2018
Moraceae	*Ficus elastica*	Atkinson, 2018
Moraceae	*Ficus radulina*	Atkinson, 2018
Moraceae	*Ficus retusa nítida*	Atkinson, 2018
Myrtaceae	*Eucalyptus grandis* x *E. urophylla*	Beaver *et al.*, 2013 citing others
Nyctaginaceae	*Guapira*	Atkinson, 2018
Oleaceae	*Fraxinus uhdei*	Atkinson, 2018
Pinaceae	*Pinus*	Zanuncio *et al.*, 2002
Pinaceae	*Pinus oocarpa*	Atkinson, 2018
Polygonaceae	*Gymnopodium floribundum*	Atkinson, 2018
Proteaceae	*Macadamia*	Gillett and Rubinoff, 2017, Hawai
Sapindaceae	*Koelreuteria formanosa*	Atkinson, 2018
Sapindaceae	*Thouinidium decandrum*	Atkinson, 2018
Taxodiaceae	*Taxodium mucronatum*	Atkinson, 2018
Ulmaceae	*Celtis laevigata*	Atkinson, 2018
Vochysiaceae	*Qualea brevipedicellata*	Bright and Skidmore, 2002

References (all URLs were accessed in March 2018)

Allen AA. 1976. *Platypus parallelus* F. (=*linearis* Steph.) (Col.: Scolytidae) recaptured in Britain after 150 years. Entomologist's Record and Journal of Variation, 88, 57-58.

Allen AA. 1985. *Platypus parallelus* (F.) (Col., Scolytidae) again captured at light in S.E. London. Entomologist's Monthly Magazine, 121, 141.

Arguedas M, Chaverri P, Verjans J-M. 2004. Problemas fitosanitarios de la teca en Costa Rica. Recursos Naturales y Ambiente.

Arguedas M, Rodríguez M, Guevara M. 2015. Plagas Y Enfermedades En Plantaciones De Teca En Centroamérica. Conference. Guayaquil, Ecuador.

Atkinson TH, Riley EG. 2013. Atlas and checklist of the bark and ambrosia beetles of Texas and Oklahoma (Curculionidae: Scolytinae and Platypodinae). Insecta Mundi 3-22.

Atkinson TH. 2018. Bark and Ambrosia Beetles: http://www.barkbeetles.info

Beaver RA. 2013. The invasive neotropical Ambrosia beetle *Euplatypus parallelus* (Fabricius, 1801) in the Oriental region and its pests status (Coleopteral: Curculionidae, Platypodinae). Entomologist's Monthly Magazine, 149(1), 143-154.

Bickerstaff JRM. 2017. Morphological and Molecular Characterisation of Australian Pinhole Borers (Coleoptera: Curculionidae, Platypodinae). BSc thesis, GradDipConBio, Western Sydney University

Bright DE, Skidmore RE. 2002. A Catalog of Scolytidae and Platypodidae (Coleoptera).: Supplement 2 (1995-1999). National Research Council of Canada, NRC Research Press.

Bumrungsri S, Beaver R, Phongpaichit S, Sittichaya W. 2008. The infestation by an exotic ambrosia beetle, *Euplatypus parallelus* (F.) (Coleoptera: Curculionidae: Platypodinae) of Angsana trees (*Pterocarpus indicus* Willd.) in southern Thailand. Songklanakarin J. Sci. Technol. 30 (5), 579-582.

Carrillo D, Duncan RE, Peña JE. 2012. Ambrosia Beetles (Coleoptera: Curculionidae: Scolytinae) that Breed in Avocado Wood in Florida. Florida Entomologist, 95(3):573-579.

da Silva JCP, Putz P, Silveira EdC, Flechtmann CAH. 2013. Biological aspects of *Euplatypus parallelus* (F.) (Coleoptera, Curculionidae, Platypodinae) attacking Hevea brasiliensis (Willd. ex A. Juss.) in Sao Paulo Northwest, Brazil. III Congresso Brasileiro de Heveicultura – 24 a 26 de julho de 2013, Guarapari.

Denux O, Bernard A, Courtial B, Courtin C, Lorme P, Magnoux E, Phelut R, Pineau P, Robinet C, Roques A. 2017. Utilisation de pièges génériques pour la détection précoce d'insectes exotiques xylophages: focus sur les ports de Nouvelle – Aquitaine. http://draaf.nouvelle-aquitaine.agriculture.gouv.fr/IMG/pdf/Pour_diffusion_Denux_etal_2017_INRA_resultats_Portrap_et_ports_Aquitaine_cle0dfc13.pdf (accessed on 10 July 2018)

Drooz AT (ed). 1985. Insects of Eastern Forests. USDA. , Forest Service, 608 pp.

EPPO. 2015. EPPO report on notifications of non-compliance. EPPO Reporting Service no. 01 – 2015, Article 2015/012. Available at gd.eppo.int

Ferreira CSS. 2016. Diversidade De Curculionidae (Scolytinae, Platypodinae) E Bostrichidae Em Plantios De Teca, *Tectona grandis* L. F., 1782, No Estado Do Pará, Brasil. Thesis. Universidade Federal De São Carlos Centro De Ciências Agrárias Programa De Pós-Graduação Em Agroecologia E Desenvolvimento Rural.

GEFF. 2017. Newsletter. October 2017. Le Groupe des Entomologistes Forestiers Francophones en Savoie. Ministère de l'agriculture et de l'alimentation, France. Département de la Santé des Forêts.

Gillett CPDT, Rubinoff D. 2017. A Second Adventive Species of Pinhole-borer on the Islands of Oahu and Hawaii (Coleoptera: Curculionidae: Platypodinae). Proceedings of the Hawaiian Entomological Society, 49:51–57.

Gümüş EM, Ergün A. 2015. Report of a pest risk analysis for *Platypus parallelus* (Fabricus, 1801) for Turkey. Bulletin OEPP/EPPO Bulletin, 45 (1):112–118.

Kirkendall LR, Ødegaard F. 2007. Ongoing invasions of old-growth tropical forests: establishment of three incestuous beetle species in Central America (Curculionidae, Scolytinae). Zootaxa, 1588: 53-62.

Li Y, Zhou X, Lai S, Yin T, Ji Y, Wang S, Wang J, Hulcr J. 2018. First Record of *Euplatypus parallelus* (Coleoptera: Curculionidae) in China. Florida Entomologist, 101(1):141-143.

Maruthadurai R, Desai AR, Singh NP. 2013. First record of ambrosia beetle (*Euplatypus parallelus*) infestation on cashew from Goa, India. Phytoparasitica (2014) 42:57–59.

Mecke R, Galileo MHM. 2004. A review of the weevil fauna (Coleoptera, Curculionoidea) of *Araucaria angustifolia* (Bert.) O. Kuntze (Araucariaceae) in South Brazil. Revista Brasileira de Zoologia 21 (3): 505–513.

Medina AL, Florian OP. 2011. Insectos Fitófagos En Plantaciones Comerciales De Acacia Mangium Willd. En La Costa Atlántica Y La Orinoquia Colombiana. Colombia Forestal, 14(2), 175-188.

Peck SB, Thomas MC, Turnbow Jr RH. 2014. The diversity and distributions of the beetles (Insecta: Coleoptera) of the Guadeloupe Archipelago (Grande-Terre, Basse-Terre, La Désirade, Marie-Galante, Les Saintes, and PetiteTerre), Lesser Antilles. Insecta Mundi 2-21.

Schedl KE. 1979. Bark and Timber Beetles from Australia. Contribution to the morphology and taxonomy of the Scolytoidea. 326. Ent. Arb. Mus. Frey 28.

Schönherr J, Pedrosa-Mac JH.1981. Scolytoidea in den Aufforstungen Brasiliens. Ein Beitrag zur Kenntnis der Borkenkafer Siidamerikas. Z. ang. Ent. 92, 4841.

Tarno H, Septia ED, Aini LQ. 2016. Microbial Community Associated With Ambrosia Beetle, *Euplatypus parallelus* on Sonokembang, *Pterocarpus indicus* in Malang. Agrivita Journal of Agricultural Science, 38(3): 312-320.

Tarno H, Suprapto H, Himawan T. 2014. First Record of Ambrosia Beetle (*Euplatypus Paralellus* Fabricius) Infestation on Sonokembang (*Pterocarpus Indicus* Willd.) from Malang Indonesia. Agrivita Vol. 36 no.2 June.

UK Risk Register. Record for *Euplatypus parallelus*. https://secure.fera.defra.gov.uk/phiw/riskRegister/viewPestRisks.cfm?cslref=27625

Whitehead P. 2001. *Euplatypus parallelus* (Fabricius) (Col., Platypodidae) confirmed as British. Entomologist's Gazette 52:262.

Wood SL, Bright DE Jr. 1992. Great Basin Naturalist Memoirs. A Catalog of Scolytidae and Platypodidae (Coleoptera), Part 2: Taxonomic Index.

Yang Y, Wang XG, Li YX, Liu HX, Chai QX, Lian ZM, Wei ZM. 2017. The complete mitochondrial genome of *Euplatypus parallelus* (Coleoptera: Curculionidae), Mitochondrial DNA Part B, 2:1, 214-215, DOI: 10.1080/23802359.2016.1275840

Zanuncio JC, Sossai MF, Couto L, Pinto R. 2002. Occurrence of *Euplatypus parallelus*, *Euplatypus* sp. (col.: Euplatypodidae) and *Xyleborus affinis* (col.: Scolytidae) in *Pinus* sp. in Ribas do Rio Pardo, Mato Grosso do Sul, Brazil. Ocorrência de *Euplatypus parallelus*, *Euplatypus* sp. (col.: Euplatypodidae) e *Xyleborus affinis* (col.: Scolytidae) em *Pinus* sp. no município de Ribas do Rio Pardo, Mato Grosso do Sul. Revista Árvore, 26(3), 387-389. https://dx.doi.org/10.1590/S0100-67622002000300015

Zanuncio JC, Sossai MF, Flechtmann CAH, Zanuncio TV, Guimarães EM, Espindula MC. 2005. Plants of an *Eucalyptus* clone damaged by Scolytidae and Platypodidae (Coleoptera). Pesquisa Agropecuária Brasileira, 40(5), 513-515. https://dx.doi.org/10.1590/S0100-204X2005000500013

This text is an integral part of the *EPPO Study on bark and ambrosia beetles associated with imported non-coniferous wood* and should be read in conjunction with the study

Pest information sheet
Ambrosia beetle

EUWALLACEA FORNICATUS SENSU LATO (COLEOPTERA: SCOLYTINAE)

tea shot hole borer, polyphagous shot hole borer, Kuroshio shot hole borer

EPPO lists: Euwallacea fornicatus sensu lato was added to EPPO A2 List of pests recommended for regulation in 2016. It is currently not regulated by EPPO countries (EPPO Global Database; EPPO, 2018). The assessment of potential risks in this pest information sheets results from a comprehensive PRA carried out by an EPPO Expert Working Group on PRA (NPPO Spain, 2015; EPPO, 2017). The background information in Pest overview originates from the EPPO PRA and from literature published since 2015.

PEST OVERVIEW

In the 2000s, an *Euwallacea* sp. and one of its symbiotic fungi (*Fusarium euwallaceae*) were detected in California and Israel attacking avocado and other trees, and have since become a serious problem for the avocado industry. The beetle is morphologically indistinguishable from *Euwallacea fornicatus* (tea shot hole borer) but differences in mitochondrial and nuclear DNA suggested it was a distinct species. Several other sibling species have been identified. This datasheet covers all sibling species as "*Euwallacea fornicatus sensu lato*". Extensive research is being conducted, and more knowledge should become available in the coming years.

Taxonomy

The taxonomy of *Euwallacea sensu lato* is not fully resolved. O'Donnell *et al.* (2015) identified six possible phylogenetically distinct species (*Euwallacea* sp. #1-6). Stouthamer *et al.* (2017) using 295 specimens from different origins showed a genetic division into 5 groups (3 major clades, two of which including 2 subclades). They concluded that there are likely to be at least 3 different sibling species, for which further analysis is needed: *E. fornicatus sensu stricto* (tea shot hole borer, i.e. *E. fornicatus* (Eichhoff, 1868)), an *Euwallacea* sp. found in California and Israel (polyphagous shot hole borer), and another found in California (Kuroshio shot hole borer). The correspondence between O'Donnell *et al.* (2015) and Stouthamer *et al.* (2017) is indicated in Table 1, because the sibling species #1-6 proposed in O'Donnell *et al.* (2015) have been used extensively in the literature before Stouthamer *et al.* (2017) was published. The present datasheet mentions when the information is known to relate to specific sibling species. The common names are used as they are convenient to reflect the classification proposed in Stouthamer *et al.* (2017).

Possible sibling species	**Stouthamer *et al.* (2017)**	**O'Donnel *et al.* (2015): sibling species**
E. fornicatus sensu stricto tea shot hole borer, TSHB (at least Clade 1B, possibly including also Clade 1A)	Clade 1A (some specimens from Malaysia, Singapore and Thailand)	
	Clade 1B (*E. fornicatus sensu stricto*, tea shot hole borer), specimens from Sri Lanka, India, Thailand, Australia, Papua New Guinea, Taiwan, Hawaii, Florida	Euwallacea sp. #2 found in Florida
		Euwallacea sp. #3 from Queensland (Australia)
		Euwallacea sp. #4 from Sri Lanka, potentially the true *E. fornicatus*
Kuroshio shot hole borer, KSHB	Clade 2 with specimen from Taiwan, Okinawa, California, Mexico	*Euwallacea* sp. #5 found in California: Kuroshio Shot Hole Borer; one individual captured in Mexico (see *Distribution*)
Polyphagous shot hole borer, PSHB (at least Clade 3B, possibly including also Clade 3A)	Clade 3A: two individuals from castor bean in Taiwan	
	Clade 3B Vietnam, China, Taiwan, Okinawa, South Africa, California, Israel*	*Euwallacea* sp. #1 found in California and Israel: polyphagous shot hole borer

		Euwallacea sp. #6 from Papua New Guinea (not tested, from Cognato *et al.*, 2011)

* also reported very recently from South Africa, see *Distribution*.

Associated fungi

Different *Fusarium* species and other fungi have been found associated with different sibling species (O'Donnell *et al.*, 2015). When pathogenicity has been shown, this is indicated below; in other cases no information was found.

- *E. fornicatus sensu stricto* (as per Stouthamer *et al.*, 2017):
    - *Euwallacea fornicatus sensu stricto*, *Euwallacea* sp. #4: *Fusarium ambrosium* (AF-1)
    - *Euwallacea* sp. #2: *Fusarium* AF-6 and AF-8, and an unknown *Fusarium* sp.; also *Graphium euwallacea*, *Acremonium* sp. *Acremonium morum*, *Acremonium masseei*, *Elaphocordyceps* sp., three yeast species (Carillo *et al.*, 2016) as well as bacterial symbionts and wilts. *Graphium euwallacea* has been shown to be pathogenic (see next indent).
- Polyphagous shot hole borer (PSHB)/*Euwallacea* sp. #1: *F. euwallaceae* (AF-2), *Graphium euwallaceae* and *Paracremonium pembeum* (Freeman *et al.*, 2012, 2015). Lynch *et al.* (2016) conducted pathogenicity tests and showed that these 3 species are pathogenic to avocado and *Acer negundo*. *F. euwallaceae* is also pathogenic to *Platanus* x *acerifolia* (Paap *et al.*, 2018).
- Kuroshio shot hole borer (KSHB)/*Euwallacea* sp. #5: *Fusarium kuroshium* and *Graphium kuroshium* in the USA (Na *et al.*, 2018) (previously *Fusarium* sp. AF-12 and *Graphium* sp. - Carillo *et al.*, 2016). In pathogenicity tests, both were pathogenic to healthy, young avocado plants (Na *et al.*, 2018).

Morphology and biology (from NPPO Spain, 2015; EPPO, 2017, except where another reference is given)

Adults measure ca. 1.5-2.5 mm (Chen *et al.* 2017). Pictures are available on the Internet (e.g. https://cisr.ucr.edu/pdf/polyphagous_shot_hole_borer.pdf). *E. fornicatus sensu lato* can infest healthy plants. *Euwallacea* sp. develops in the xylem and spends almost its entire life within galleries of living branches. *Euwallacea fornicatus sensu lato* inbreeds. Mating takes place within the gallery between male and female offspring of the same parent female (sib-mating) and the species also presents haplodiploidy (Cooperband *et al.*, 2016). Mated females emerge through the original entrance tunnel and disperse. The life cycle takes ca. 40 days, and there are several generations per year (multivoltinism).

In Sri Lanka the optimum temperature for development of *E. fornicatus* is around 30°C for all stages, requiring 373 degree-days based on the lower development threshold of 15°C for the development of one generation. In Asia, *E. fornicatus* has a distribution limited to tropical and subtropical regions. Nevertheless, *Euwallacea* sp. in Israel and California (PSHB) are located in Mediterranean climate (NPPO Spain, 2015). In rearing experiments on artificial diet (Cooperband *et al.*, 2016), adults of the polyphagous shot hole borer (Euwallacea #1) and tea shot hole borer (Euwallacea #2) had a similar biology. Adults developed within 22 days at 24°C. Arrhenotokous reproduction (unfertilized eggs develop into males) was confirmed (Cooperband *et al.*, 2016). A cold tolerance study found significant mortality rates among PSHB colonies exposed to −5° or −1 °C but not to 0°, 1° or 5 °C.

Most attacks are to twigs and small branches or stems (Kirkendall and Ødegaard, 2007, citing others). On avocado, in early spring, before the onset of emergence, most of the mature and teneral adults are found at the base of dead branches previously colonized by the PSHB. In infested avocado orchards, the main source are beetles that develop in the small diameter branches; and beetles may also migrate from nearby infested vegetation, such as castor bean (*Ricinus communis*) (Mendel *et al.*, 2017). In Israel, on avocado, mostly small branches are attacked (2-10 cm diameter more attacked than >20 cm diameter), while large branches and trunks are attacked in *Acer negundo*. Reproduction in susceptible species (e.g. *A. negundo*, *Quercus pedunculiflora*, *Q. robur* or *Platanus orientalis*) occurred mostly in large branches. The colonization pattern in avocado and *A. negundo* (small branches versus large branches and trunks) has implications for the numbers of individuals that would develop in the trees. Reproduction in small avocado branches usually lasts one to sometimes two generations, three to four generations develop in the main branches of *A. negundo* where the population densities are much higher, permitting a substantial increase in infestation levels from this host. Repeated attacks may facilitate colonization (Mendel *et al.*, 2017).

Spread biology

Males are flightless and never leave the gallery. There are divergences in the literature about the flying capacity of *Euwallacea* sp. females. One study observed that the majority of the beetles flew to a distance of 1-3 m in one flight and reached a height of 1 m; other observations stated that the beetle is able to fly 'up to 500 yards (≈457 m)' (the latter was taken in the EPPO PRA as spread estimate). Byers *et al.* (2017, citing Calnaido 1965) noted that females of *E. fornicatus* were observed flying up to 24 min in the laboratory at 0.3 to 0.6 m/s and thus were calculated to be able to fly up to 864 m on the first dispersal flight without aid of wind.

Nature of the damage

E. fornicatus sensu lato tunnels into the wood, carrying its fungal symbiont into the trees. Infestations may lead to weakening leading to death of branches, or death of young and mature trees due the fungal pathogen. Tree mortality has been observed in Southern California on *Acer negundo, Alnus rhombifolia, Platanus racemosa, Ricinus communis, Quercus robur, Salix laevigata*. In Israel, *A. negundo* can be killed within a year of beetle attack, while mortality of avocado trees is quite rare (Mendel *et al.*, 2017).

Detection and identification

- *Symptoms.* Signs of infestation can include entry holes, presence of frass and small tubes of compacted sawdust, discoloration of the outer bark surrounding the beetle penetration site, large amounts of white powdery exudate covering penetration sites, brownish staining of the xylem under the infested spot, gumming, wilting of branches and leaf yellowing, branches broken at the site of beetle galleries, and dead trees (NPPO Spain, 2015; EPPO, 2017). On avocado, *Euwallacea* sp. #2 causes symptoms such as branch dieback, signs of beetle attack at junctions of small and mid-size shaded branches showing the presence white "sugar volcanoes" (Carrillo *et al.*, 2016).
- *Trapping.* Traps can be used to detect the pest. PSHB (*E. fornicatus* sp. #1) is attracted to quercivorol and pilot mass-trapping tests have been initiated by avocado growers in Israel (Dodge *et al.*, 2017; Byers *et al.*, 2017). Two attractants are available commercially in the USA: quercivorol, and a proprietary essential oil enriched in α-copaene (Owens *et al.*, 2018, citing others).

  In addition, pheromones of *E. fornicatus sensu stricto*, PBSH and KBSH (*Euwallacea* sp. #1, #2 and #5) have been identified but they are unlikely to be sex pheromones or long range attractants, and their behavioral and ecological function is not known (Cooperband *et al.*, 2017). Evidence suggests that quercivorol functions as a kairomone for members of the *E. fornicatus sensu lato* (Cooperband *et al.*, 2017).
- *Identification.* All sibling species are morphologically similar to *E. fornicatus sensu stricto*. Identification should identify both the insect and the fungus, since it is the latter which causes tree death. Molecular methods are available (the latest to date are in Stouthamer *et al.*, 2017). A simple PCR test for identification of *Euwallacea*-associated *Fusarium* sp. in the USA has also been developed (Short *et al.*, 2017).

  Cuticular hydrocarbon profiles of PSHB/*Euwallacea* #1 and *E. fornicatus* allow separation of these two species (Chen *et al.*, 2017).

Distribution (see Table 1)

E. fornicatus sensu lato is present in Asia, Oceania, some countries in Africa and the Americas and, for the EPPO region, in Israel. Which sibling species is present in which countries is known for some recent records, and for some specimens used in recent studies (see Tables under *Taxonomy* and in Attachment 1). However, there is no complete picture of the distribution of each potential sibling species to date. In Poland, *E. fornicatus* (cryptic species not mentioned) was found on one *Ficus religiosa* in a palm house in Poznań in 2016 (Witkowski *et al.*, 2018).

In South Africa, the PBSH (*Euwallacea* sp. #1) was recently found in one botanical garden, which is part of a new project using botanical gardens/arboreta as sentinel sites (Paap *et al.*, 2018).

Host plants (see Table 2)

E. fornicatus sensu lato has reproductive hosts ('true hosts' in which it can reproduce and the associated fungi can develop), and 'non-reproductive hosts' (in which the beetle can drill and infect the associated fungi without being able to reproduce). The host range has increased when the beetle has spread to new areas. In Florida, native wild hosts (*Lysiloma latisiliquum, Albizia lebbeck* and an unknown shrub) were found in natural areas close to an infested avocado grove, and infestations also observed in a nearby grove of *Annona muricata* (Owens *et al.*, 2018). NPPO Spain (2015) includes a list of over 70 reproductive host species in 27 families (see Table 2), and a list of all hosts covering 60 families. These lists are probably enlarged by newer studies (e.g. Mendel *et al.*, 2017 for Israel; Owens *et al.*, 2018 for Florida), but this was not analysed here. Both PSHB and the tea shot hole borer (TSHB) reproduce in relatively few of the species attacked (PSHB - 6% of 103 in California and 23% of 52 in Israel; TSHB - 16% of 49 in Sri Lanka) (Mendel *et al.*, 2017, citing others). Mendel *et al.* (2017) supported that *E. fornicatus sensu stricto* and other siblings differ in their host range.

In Asia, *E. fornicatus* has been recorded on more than 200 plant species and is considered to be a destructive pest of several economically important woody plants, such as tea (*Camellia sinensis*), avocado (*Persea americana*), *Citrus* and cocoa (*Theobroma cacao*). Plants in at least 48 other families have been reported as occasional hosts, including Anacardiaceae, Burseraceae, Fabaceae, Moraceae, and Salicaceae (NPPO Spain, 2015). Li *et al.* (2016) reported new hosts in an extensive study in the field and in collections: three new hosts belonged to plant families from which the pest had not been recorded before, Actinidiaceae (*Saurauia tristyla),* Oleaceae (*Ligustrum compactum*) and Pinaceae (*Pinus massoniana*; one record), this last record suggesting that the fungal mutualist is viable in conifers.

In California, the beetle had been found attacking over 200 species in the Los Angeles area (by autumn 2014) (University of California, 2017). Studies have been conducted to determine the main hosts of both *Euwallacea* sp. and *F. euwallaceae*, and in particular those which could sustain the whole life cycle of the beetle. New hosts keep being reported, such as *Juglans* in California (Hishinuma *et al.*, 2015 - black walnut, which was probably *J. californica* or *J. hindsii*). In Florida, *E. fornicatus* was originally found in association with avocado, but has since been found on new hosts in cultivated and natural conditions (see above).

In Israel, the main host of economic importance is avocado, but damage has also been reported on several ornamental trees including *Acer negundo, Quercus robur,* and *Ricinus communis*. *F. euwallaceae* has been isolated from *P. americana* and *A. negundo* (EPPO, 2017). The list of host plants was updated during a recent study. Mendel *et al.* (2017) found that 52 tree species from 26 families were attacked and reproduction occurred in 12 species, 8 of which considered highly susceptible. Among the native tree species *Platanus orientalis* was highly susceptible, in both ornamental and natural settings. *F. euwallaceae* was isolated from 33 of 41 plant species on which tests were conducted.

Known impacts and control in current distribution

In Asia, *E. fornicatus* is an important pest of tea crops in southern India and Sri Lanka. In southern India, *E. fornicatus* has recently become a serious pest of pomegranate (*Punica granatum*) (NPPO Spain, 2015; EPPO, 2017). *E. fornicatus* (TSHB) is a known pest of tea in Sri Lanka, Southern India, Borneo and Java; elsewhere, it is a pest in plantations, recently reforested plots and nurseries. In Vietnam, most damage is on plantations of *Acacia mangium*, and in Thailand, damage has been identified in durian orchards (Hulcr *et al.*, 2017). In China, in a study on the distribution and hosts of *Euwallacea* sp., Li *et al.* (2016) collected the pest mostly from weak, diseased or dead hosts, and did not corroborate previous data on aggressive attacks on *Litchi chinensis* in the south of China. Mass attacks were observed on relatively healthy *Acer buergerianum* and *Platanus orientalis* in an urban area of Kunming, Yunnan. However, in the literature (e.g. cited in Ge *et al.*, 2017), it is reported as having caused serious damage to economically important species such as *L. chinensis*, *Dimocarpus longan*, *Camellia* sp., in Fujian and Yunnan over many years. In 2014, damage to street trees (*A. buergerianum*, *Platanus acerifolia*, and *Paulownia* sp., etc.) was considerable in Kunming (Yunnan). In 2015, the pest was found for the first time in Zhejiang (Ge *et al.*, 2017).

In Israel, extensive damage on avocado has been reported, as well as on some ornamental trees (NPPO Spain, 2015). By early 2016, PSHB/Euwallacea sp. #1 had spread to nearly all the avocado cultivation areas in the country. All avocado cultivars were attacked, but the Hass cultivar was attacked more severely (Mendel *et al.*, 2017, citing others). *A. negundo* trees have been heavily damaged in the lowlands in Israel, while beetle reproduction was observed only in one location for another *Acer* species native to Israel, *A. syriacus* (Mendel *et al.*, 2017).

In California, *Euwallacea* sp. was found on a few ornamental trees in 2003-2010, and in 2010 was the presumptive cause of the death of a large number of *Acer negundo* street trees in Long Beach. In 2012 it was collected from a backyard avocado tree, and from several species in local botanical gardens. It is established in several counties and is still spreading (University of California, 2017). PSHB (*Euwallacea* sp. #1) is potentially a serious problem in avocado because, although it rarely kills the plants, it does kill infested limbs and reduces tree growth over a period of years (Byers *et al.*, 2017 citing others). The susceptibility of avocado cultivars to PSHB/*Euwallacea* sp. #1 varies, with cv. Zutano most frequently showing high attack rates and much gallery formation (Eatough Jones and Paine, 2017). The pest attacks trees in agricultural and urban settings where irrigation is common, and it was found that the irrigation regime did not impact the rate of attack (Umeda, 2017). In the parks of Orange County (California) (covering regional, wilderness and historical facilities, and coastal areas), management costs reached 1.7 million USD in 2013-2016; over 1250 trees were removed and 1300 treated. Out of about 7500 *Platanus racemosa* in that area (valued at over 32 million USD), 2500 were infested and 900 removed (OC Parks, 2018). Finally, *E. fornicatus* and *Euwallacea* sp. are listed as quarantine pests by several of California´s trading partners (NPPO Spain, 2015; EPPO, 2017).

In South Florida, *Euwallacea* sp. #2 was first found in a commercial avocado orchard in 2012, and surveys on 2013-2015 revealed its presence in one mango and seven additional avocado orchards, with sparse populations not causing conspicuous damage to avocado or other crops. In early 2016, an outbreak was detected in an avocado orchard, infesting approximately 1500 avocado trees. In an area-wide survey in the avocado production region of Miami-Dade County, it was found invading the entire commercial avocado production area. It has also been found outside avocado growing areas on isolated avocado trees and on *Persea palustris* (Carrillo *et al.*, 2016). In 2016, it was found in natural areas, and is considered as an increasingly serious threat to native forest stands. 13% of the *L. latisiliquum* trees in the natural area were infested (dead trees were observed but the article does not make a link between the presence of *E. fornicatus* sp. #2 and mortality). Damage was also observed in an orchard of *Annona muricata* (Owens *et al.*, 2018).

In Mexico, one individual was captured in 2015 (Euwallacea #5) and no potential host around the detection showed evidence of damage or symptoms of infestation (García-Avila *et al.*, 2016). In South Africa, the PSHB was recently found on *Platanus* x *acerifolia* in a botanical garden, but there was no evidence of reproduction (Paap *et al.*, 2018).

Regarding environmental impact, the pest complex was detected in native forest in California, as well as in Florida. In California, there have been significant impacts on trees in the urban environment leading to social impacts, and impacts on ornamental trees are also reported from Israel (Mendel *et al.*, 2017, citing others).

Control: Recommended measures for limiting the further spread of polyphagous shot hole borer in California are preventing the movement of infested wood and chipping infested wood on site (Chen *et al.*, 2017, referring http://ucanr.edu/sites/socaloakpests/Polyphagous_Shot_Hole_Borer/). Solarizing (i.e. covering infested logs with tarps in order to increase the temperature of the wood to reduce viability of the pest) can help to limit the spread (University of California, 2017).
Insecticide treatments may offer some protection to ornamental trees (e.g. pyrethroid sprays, stem injections of emamectine benzoate or soil application of systemic compounds) (Mendel *et al.*, 2017). The combination of a systemic insecticide (emamectin benzoate), a contact insecticide (bifenthrin), and a fungicide (metconazole) was found to provide some control on moderate and heavily *Platanus racemosa* trees in the USA (Eatough Jones *et al.*, 2018). Finally, Mayorquin *et al.* (2018) identified several pesticides that could be used in an IPM strategy to reduce infestation in low to moderately infested *Platanus racemosa* and potentially other landscape trees.
In avocado orchards, sanitation may be used to lower population levels (removal of colonized branches and pruning residues, and treating severed point with an insecticide), and mass-trapping is being investigated. Preventive sanitation is likely to be the main approach for reducing damage (Mendel *et al.*, 2017). Owens *et al.* (2018) suggest that natural areas around plantations may serve as an external source of infestation, which may influence management strategies (Owens *et al.*, 2018). Current research also investigates control methods against the associated fungi (e.g. through chemical or biological control methods; Mayorquin *et al.*, 2018; Guevara- Avendaño *et al.*, 2018).

POTENTIAL RISKS FOR THE EPPO REGION

Pathways

Entry

Plants for planting and packing crates have been suspected for known introductions (NPPO Spain, 2015). According to NPPO Spain (2015) and EPPO (2017) the main pathways of entry were:

- plants for planting (except seeds) of reproductive host species. Plants for planting of host plants can support all life stages of *Euwallacea* sp. The ambrosia beetle may attack main stems and larger branches of its hosts, or small branches. Attacks can be found on branches and twigs as small as 2cm in diameter.
- cut branches were considered a less likely pathway, and there was no data on trade of relevant hosts in the form of cut branches.- wood (round or sawn, with or without bark) of reproductive host species from where *Euwallacea fornicatus sensu lato* occurs. Host plants include species that are grown for wood production, e.g. *Acer, Populus, Quercus, Robinia pseudoacacia, Ulmus*. All life stages may be present in round wood and sawn wood (with or without bark). The pest may also be associated with wood chips or wood waste, although this was considered less likely.
- wood packaging material (WPM) if not treated according to ISPM 15.

Bark on its own is not a pathway (NPPO Spain, 2015; EPPO, 2017).

Finally*, E. fornicatus sensu lato* is an inbreeder, which is favourable to entry and establishment.

Summary of pathways (uncertain pathways are marked with '?'):

- *plants for planting (except seeds) of hosts*
- *wood (round or sawn, with or without bark, incl. firewood) of hosts*
- *wood packaging material if not treated according to ISPM 15*
- *non-coniferous wood chips, hogwood, processing wood residues (except sawdust and shavings)*
- *cut branches of hosts?*

Spread (following introduction, i.e. within EPPO region)

Some spread is known from places where the pest has been introduced. There are divergences in the literature about the flying capacity of *Euwallacea* sp. (see *Pest overview*) and the EPPO PRA considered that the beetle is able to fly up to about 450 m. It considered that natural spread was only local (although windborne dispersal might occur) and that *Euwallacea fornicatus sensu lato* will also be able to spread through human-assisted pathways.

Establishment

Euwallacea fornicatus sensu lato is native to tropical climates. However, it has also successfully established in temperate and Mediterranean climates (especially PSHB and KSHB). It has established in the EPPO region in Israel. In China, Li *et al.* (2016) found that *E. fornicatus* is mainly distributed in the humid and subtropical southern China, but also occurs in temperate and dry habitats. Umeda (2017) also found that irrigation regime did not have an impact on the rate of attack. The EPPO PRA (2016, 2017) concluded that ecoclimatic conditions are suitable in the Southern EPPO region (esp. countries with a Köppen-Geiger Csa[12] climate type: southern France, Greece, Cyprus, south-southwestern Italy, south Spain and south Portugal), and that it may also be able to establish under temperate climates in the Northern part. The PRA noted that it has the potential to establish in greenhouses of botanical gardens in the entire PRA area. It was noted that other ambrosia beetles from Asia have been able to adapt to different and colder climates than in their native region (e.g. *Euwallacea interjectus*) (EPPO, 2017). In a modelling study carried out in the USA, the predicted range of the PSHB extended to the Mediterranean coast, southern Portugal (corresponding broadly to the area defined above), and to a lesser extent further north in Western and Central Europe and parts of the Black Sea coast (Umeda, 2017).

E. fornicatus sensu lato has a large host range that has further increased in invaded areas. Possibilities for control are limited. In the EPPO region, there are many agricultural, forest and urban species that could be attacked: e.g. *Acacia* spp., *Acer negundo*, *Citrus* spp., *Ficus carica* (fig), *Persea americana* (avocado), *Platanus, Populus, Quercus, Salix.*

Potential host plants are present in areas of suitable climate in the EPPO region, and the pest could therefore establish.

Potential impact (including consideration of host plants)

In the EPPO region several host plants (including avocado and *Citrus*) are major agricultural hosts, and *Quercus* is a major forest host. Potential impacts are expected to be higher for the southern part of the EPPO region. *E. fornicatus sensu lato* could also cause impacts on various other species that are important in forests, urban landscape or other ornamentals, including mortality, as has been observed in areas where it has established. The presence of *Euwallacea* sp. will have an impact on internal markets and on exports of wood and plants for planting (EPPO, 2017).

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[12] see Annex 6 of the study. **Csa**: warm temperate climate, dry and hot summer.

Table 1. Distribution

	References	**Comments**
EPPO region		
Israel	EPPO Global database	PSHB/*Euwallacea* sp. #1. First record 2009 (Mendel *et al.*, 2012)
Poland	Witkowski *et al.*, 2018	2016, indoors, in a palm house
Africa		
Comoros	EPPO Global database	
Madagascar	EPPO Global database	
Réunion	EPPO Global database	
South Africa	EPPO Global database Paap *et al.* (2018)	PSHB/*Euwallacea* sp. #1, one haplotype has been found in two studies: one specimen from Durban included in the study of Stouthamer *et al.* (2017), and one record in Pietermaritzburg (Paap *et al.*, 2018)
Erroneous record: Sierra Leone		Reported by Karlhoven (1981) but thought to be erroneous (CABI CPC)
Asia		
Bangladesh	EPPO Global database	
Cambodia	EPPO Global database	
China - Beijing, Chongqing, Fujian, Guangdong, Guizhou, Hainan, Sichuan, Xizhang (Tibet), Guangxi, Yunnan - Zhejiang - Xianggang (Hong Kong)	 - Li *et al.* 2016, Ge *et al.*, 2017 - Ge *et al.*, 2017 citing Hu *et al.*, 2016 - EPPO Global Database	Mostly Southeast China. Maps are provided in the articles Beijing: greenhouse on *T. cacao* - first record 2015
India (Assam, Karnataka, Kerala, Maharashtra, Tamil Nadu, Uttar Pradesh, West Bengal)	EPPO Global database	
Indonesia	EPPO Global database	
Japan	EPPO Global database	
Lao	EPPO Global database	
Malaysia	EPPO Global database	
Myanmar	EPPO Global database	
Philippines	EPPO Global database	
Sri Lanka	EPPO Global database	TSHB/Euwallacea sp. #4
Taiwan	EPPO Global database	
Thailand	EPPO Global database	
Vietnam	EPPO Global database	
Uncertain records: Brunei Darussalam, New Caledonia	CABI CPC	Considered uncertain because refers to unpublished records
North America		
Mexico	EPPO Global database	KSHB/#5 (García-Avila *et al.* 2016). ‘Transitory and under eradication’ (EPPO Reporting Service 2018-04)
USA - California	EPPO Global database	 - PSHB/Euwallacea sp. #1 and KSHB/#5. First reported 2003 (Kirkendall and Ødegaard, 2007)

	References	**Comments**
- Florida - Hawaii		- TSHB/Euwallacea sp. #2 - first record 1980
Central America		
Guatemala	EPPO Global database	
Panama	EPPO Global database	First reported 1980 (Kirkendall and Ødegaard, 2007)
South America		
Brazil (Amazonas)	EPPO Global database	
Costa Rica	EPPO Global database	First reported 2007 (Kirkendall and Ødegaard, 2007)
Absent, unreliable records: Colombia, Venezuela	EPPO Global database	Referred to in a database Coleoptera Neotropical as present, but could not be confirmed by other sources
Oceania		
Australia	EPPO Global database	Queensland: TSHB/Euwallacea sp. #3
Fiji	EPPO Global database	
Micronesia	EPPO Global database	
Niue	EPPO Global database	
Palau	EPPO Global database	
Papua New Guinea	EPPO Global database	
Samoa	EPPO Global database	
Solomon Islands	EPPO Global database	
Vanuatu	EPPO Global database	

Table 2. Known reproductive hosts (from NPPO Spain, 2015)

Family	**Genus/Species**
Altingiaceae	*Liquidambar styraciflua*
Anacardiaceae	*Spondias dulcis*
Aquifoliaceae	*Ilex cornuta*
Betulaceae	*Alnus rhombifolia*
Burseraceae	*Canarium commune*
Burseraceae	*Canarium indicum* var. *indicum*
Burseraceae	*Protium serratum*
Dipterocarpaceae	*Shorea robusta*
Euphorbiaceae	*Hevea brasiliensis*
Euphorbiaceae	*Ricinus communis*
Fabaceae	*Acacia* spp.
Fabaceae	*Acacia visco*
Fabaceae	*Albizia falcata*
Fabaceae	*Albizia julibrissin*
Fabaceae	*Castanospermum australe*
Fabaceae	*Cercidium floridum*
Fabaceae	*Cercidium sonorae*
Fabaceae	*Crotalaria striata*
Fabaceae	*Crotalaria usaramoensis*
Fabaceae	*Erythrina corallodendron*
Fabaceae	*Erythrina humeana*
Fabaceae	*Inga vera*
Fabaceae	*Mimosa bracaatinga*
Fabaceae	*Paraserianthes falcataria*
Fabaceae	*Parkinsonia aculeata*
Fabaceae	*Archidendron jiringa* (*Pithecellobium lobatum*)

Family	**Genus/Species**
Fabaceae	*Prosopis articulata*
Fabaceae	*Robinia pseudoacacia*
Fabaceae	*Tephrosia candida*
Fabaceae	*Tephrosia vogelii*
Fabaceae	*Wisteria floribunda*
Fagaceae	*Quercus agrifolia*
Fagaceae	*Quercus engelmanni*
Fagaceae	*Quercus lobata*
Fagaceae	*Quercus robur*
Lamiaceae	*Gmelina arborea*
Lauraceae	*Persea americana*
Lauraceae	*Persea bombycina*
Lythraceae	*Punica granatum*
Magnoliaceae	*Magnolia grandiflora*
Malvaceae	*Brachychiton populneus*
Meleaceae	*Azadirachta indica*
Moraceae	*Artocarpus intege*r
Moraceae	*Ficus carica*
Moraceae	*Ficus toxicaria*
Moringaceae	*Moringa oleifera*
Myrtoideae	*Eucalyptus ficifolia*
Platanaceae	*Platanus acerifolia*
Platanaceae	*Platanus mexicana*
Platanaceae	*Platanus racemosa*
Podocarpaceae	*Afrocarpus falcatus*
Proteaceae	*Grevillea robusta*
Rutaceae	*Citrus* spp.

Family	**Genus/Species**
Rutaceae	*Geijera parviflora*
Salicaceae	*Populus fremontii*
Salicaceae	*Populus nigra*
Salicaceae	*Populus trichocarpa*
Salicaceae	*Salix babylonica*
Salicaceae	*Salix gooddingii*
Salicaceae	*Salix laevigata*
Salicaceae	*Salix lasiolepis*
Salicaceae	*Salix matsudana*
Salicaceae	*Salix nigra*
Sapindaceae	*Acer buergerianum*
Sapindaceae	*Acer macrophyllum*
Sapindaceae	*Acer negundo*
Sapindaceae	*Acer palmatum*
Sapindaceae	*Acer paxii*
Sapindaceae	*Alectryon excelsus*
Sapindaceae	*Cupaniopsis anacardioides*
Sapindaceae	*Koelreuteria elegans*
Sapindaceae	*Litchi chinensis*
Sapindaceae	*Nephelium lappaceum*
Sapindaceae	*Schleichera oleosa*
Simaroubaceae	*Ailanthus altissima*
Sterculiaceae	*Theobroma cacao*
Theaceae	*Camellia semiserrata*
Theaceae	*Camellia sinensis*
Ulmaceae	*Ulmus parvifolia*

References (all URLs were accessed in January 2018)

Byers JA, Maoz Y, Levi Zada A. 2017. Attraction of the *Euwallacea* sp. near *fornicatus* (Coleoptera: Curculionidae) to Quercivorol and to Infestations in Avocado. Journal of Economic Entomology, 110(4), 2017, 1512–1517.

Carrillo D, Cruz LF, Kendra PE, Narvaez TI, Montgomery WS, Monterroso A, De Grave C, Cooperband MF. 2016. Distribution, Pest Status and Fungal Associates of *Euwallacea* nr. *fornicatus* in Florida Avocado Groves. Forschler BT, ed. Insects. 2016;7(4):55. doi:10.3390/insects7040055.

Chen Y, Dallara PL, Nelson LJ, Coleman TW, Hishinuma SM, Carrillo D, Seybold SJ. 2017. Comparative morphometric and chemical analyses of phenotypes of two invasive ambrosia beetles (*Euwallacea* spp.) in the United States. Insect Science 24, 647–662.

Cooperband MF, Cossé AA, Jones TH, Carrillo D, Cleary K, Canlas I, Stouthamer R. 2017. Pheromones of three ambrosia beetles in the *Euwallacea fornicatus* species complex: ratios and preferences. PeerJ 5:e3957 https://doi.org/10.7717/peerj.3957

Cooperband MF, Stouthamer R, Carrillo D, Eskalen A, Thibault T, Cossé AA, Rugman-Jones PF. 2016. Biology of two members of the *Euwallacea fornicatus* species complex (Coleoptera: Curculionidae: Scolytinae), recently invasive in the USA, reared on an ambrosia beetle artificial diet. Agricultural and Forest Entomology, 18(3), 223-237.

Dodge C, Coolidge J, Cooperband M, Cossé A, Carrillo D, Stouthamer R. 2017. "Quercivorol as a lure for the polyphagous and Kuroshio shot hole borers, *Euwallacea* spp. nr. *fornicatus* (Coleoptera: Scolytinae), vectors of *Fusarium* dieback." PeerJ 5: e3656.

Eatough Jones M, Paine TD. 2017. Differences among avocado cultivars in susceptibility to polyphagous shot hole borer (*Euwallacea* spec.). Entomologia Experimentalis et Applicata, 163(3), 296-304.

Eatough Jones M, Kabashima J, Eskalen A, Dimson M, Mayorquin JS, Carrillo JD, Paine TD. 2017. Evaluations of insecticides and fungicides for reducing attack rates of a new invasive ambrosia beetle (*Euwallacea* sp., Coleoptera: Curculionidae: Scolytinae) in infested landscape trees in California. Journal of economic entomology, 110(4), 1611-1618.

EPPO. 2017. Report of a Pest Risk Analysis for *Euwallacea fornicatus sensu lato* and *Fusarium euwallaceae*. Available at https://www.eppo.int

EPPO. 2018. EPPO Global Database. gd.eppo.int

EPPO Reporting Service 18-04. 2018. Article 2018/068: New data on quarantine pests and pests of the EPPO Alert List. Available at https://www.eppo.int

Freeman S, Sharon M, Dori-Bachash M, Maymon M, Belausov E, Maoz Y, Margalit O, Protasov A, Mendel Z. 2015. Symbiotic association of three fungal species throughout the life cycle of the ambrosia beetle *Euwallacea* nr. *fornicatus*. Symbiosis DOI 10.1007/s13199-015-0356-9

Freeman S, Sharon M, Maymon M, Mendel Z, Protasov A, Aoki T, O'Donnell K. 2012. *Fusarium euwallaceae* sp. nov. - a symbiotic fungus of *Euwallacea* sp., an invasive ambrosia beetle in Israel and California. Mycologia, 105(6), 1595-1606.

García-Avila CJ, Trujillo-Arriaga FJ, López-Buenfil JA, González-Gómez R, Carrillo D, Cruz LF, Ruiz-Galván I, Quezada-Salinas A, Acevedo-Reyes N. 2016. First Report of *Euwallacea* nr. *fornicatus* (Coleoptera: Curculionidae) in Mexico. Florida Entomologist, 99(3):555-556.

Ge X, Jiang C, Chen L, Qiu S, Zhao Y, Wang T, Zong S. 2017. Predicting the potential distribution in China of *Euwallacea fornicates* (Eichhoff) under current and future climate conditions. Scientific Reports, 7. (with correction https://www.nature.com/articles/s41598-018-23580-3)

Guevara-Avendaño E, Carrillo JD, Ndinga-Muniania C, Moreno K, Méndez-Bravo A, Guerrero-Analco JA, Reverchon F. 2018. Antifungal activity of avocado rhizobacteria against *Fusarium euwallaceae* and *Graphium* spp., associated with *Euwallacea* spp. nr. *fornicatus*, and *Phytophthora cinnamomi*. Antonie van Leeuwenhoek, 111(4), 563-572.

Hishinuma SM, Dallara PL, Yaghmour MA, Zerillo MM, Parker CM, Roubtsova TV, Nguyen TL, Tisserat NA, Bostock RM, Flint ML, Seybold SJ. 2016. Wingnut (Juglandaceae) as a new generic host for *Pityophthorus juglandis* (Coleoptera: Curculionidae) and the thousand cankers disease pathogen, *Geosmithia morbida* (Ascomycota: Hypocreales). The Canadian Entomologist, 148(1):83-91.

Hulcr J, Black A, Prior K, Chen CY, Li HF. 2017. Studies of ambrosia beetles (Coleoptera: Curculionidae) in their native ranges help predict invasion impact. Florida Entomologist, 100(2), 257-261.

Kirkendall LR, Ødegaard F. 2007. Ongoing invasions of old-growth tropical forests: establishment of three incestuous beetle species in Central America (Curculionidae, Scolytinae). Zootaxa, 1588: 53-62.

Li Y, Gu X, Kasson MT, Bateman CC, Guo J, Huang Y, Hulcr J. 2016. Distribution, host records, and symbiotic fungi of *Euwallacea fornicatus* (Coleoptera: Curculionidae: Scolytinae) in China. Florida Entomologist, 99(4), 801-804.

Lynch SC, Twizeyimana M, Mayorquin JS, Wang DH, Na F, Kayim M, Kasson MT, Thu PQ, Bateman C, Rugman-Jones P, Hulcr J. 2016. Identification, pathogenicity and abundance of *Paracremonium pembeum* sp. nov. and *Graphium euwallaceae* sp. nov.—two newly discovered mycangial associates of the polyphagous shot hole borer (*Euwallacea* sp.) in California. Mycologia, 108(2), pp.313-329.

Mayorquin JS, Carrillo JD, Twizeyimana M, Peacock BB, Sugino KY, Na F, Eskalen A. 2018. Chemical Management of Invasive Shot Hole Borer and *Fusarium* Dieback in California Sycamore (*Platanus racemosa*) in Southern California. Plant Disease, PDIS-10.

Mendel Z, Protasov A, Sharon M, Zveibil A, Ben Yehuda S, O'Donnell K, Rabaglia R, Wysoki M, Freeman S (2012) An Asian ambrosia beetle *Euwallacea fornicatus* and its novel symbiotic fungus *Fusarium* sp. pose a serious threat to the Israeli avocado industry. Phytoparasitica 40:235–238

Mendel Z, Protasov A, Maoz Y, Maymon M, Miller G, Elazar M, Freeman S. 2017. The role of *Euwallacea* nr. *fornicatus* (Coleoptera: Scolytinae) in the wilt syndrome of avocado trees in Israel. Phytoparasitica, 45(3), 341-359.

Na F, Carrillo JD, Mayorquin JS, Ndinga-Muniania C, Stajich JE, Stouthamer R, Eskalen A. 2018. Two novel fungal symbionts *Fusarium kuroshium* sp. nov. and *Graphium kuroshium* sp. nov. of Kuroshio shot hole borer (*Euwallacea* sp. nr. *fornicatus*) cause *Fusarium* dieback on woody host species in California. Plant Disease, PDIS-07

NPPO Spain. 2015. Express pest risk analysis for the ambrosia beetle *Euwallacea* sp. including all the species within the genus *Euwallacea* that are morphologically similar to *E. fornicatus*. Available at https://www.eppo.int

O'Donnell K, Sink S, Libeskind-Hadas R, Hulcr J, Kasson MT, Ploetz RC, Konkol JL, Ploetz JN, Carrillo D, Campbell A, Duncan RE. 2015. Discordant phylogenies suggest repeated host shifts in the *Fusarium–Euwallacea* ambrosia beetle mutualism. Fungal Genetics and Biology, 82, pp.277-290.

OC Parks. 2018. Shot hole borer, managing the invasive beetle. Orange County Parks, California. Internet resource https://oc-parks-gis.maps.arcgis.com/apps/Cascade/index.html?appid=680fd0c9e73f4857a8477791f7ee796f

Owens D, Cruz LF, Montgomery WS, Narvaez TI, Schnell EQ, Tabanca N, Kendra PE. 2018. Host range expansion and increasing damage potential of *Euwallacea* nr. *fornicatus* (Coleoptera: Curculionidae) in Florida. Florida Entomologist, 101(2), 229-236.

Paap T, de Beer ZW, Migliorini D, Nel WJ, Wingfield MJ. 2018. The polyphagous shot hole borer (PSHB) and its fungal symbiont *Fusarium euwallaceae*: a new invasion in South Africa Australasian Plant Pathology, 47(2), 231-237.

Short DP, O'Donnell K, Stajich JE, Hulcr J, Kijimoto T, Berger MC, Macias AM, Spahr EJ, Bateman CC, Eskalen A, Lynch SC. 2017. PCR Multiplexes Discriminate Fusarium Symbionts of Invasive *Euwallacea* Ambrosia Beetles that Inflict Damage on Numerous Tree Species Throughout the United States. Plant Disease, 101(1), pp.233-240.

Stouthamer, Richard, *et al.* 2017. Tracing the origin of a cryptic invader: phylogeography of the *Euwallacea fornicatus* (Coleoptera: Curculionidae: Scolytinae) species complex. Agricultural and Forest Entomology.

Umeda CY. 2017. Environmental Effects on Polyphagous Shot Hole Borer. PhD thesis, University of California Riverside, September 2017

University of California. 2017. Polyphaguos shot hole borer. http://ucanr.edu/sites/socaloakpests/Polyphagous_Shot_Hole_Borer/

Witkowski R, Bełka M, Mazur A. 2018. First Case of Unintentional Introduction of *Euwallacea fornicatus* (Coleoptera: Curculionidae: Scolytinae) to Europe. Forest Research, 7:1

This text is an integral part of the *EPPO Study on bark and ambrosia beetles associated with imported non-coniferous wood* and should be read in conjunction with the study

Pest information sheet
Ambrosia beetle

EUWALLACEA INTERJECTUS AND *E. VALIDUS* (COLEOPTERA: SCOLYTINAE)

EPPO Lists: Not listed. The assessment of potential risks in this information sheet is not based on a full PRA for the EPPO region, but on an assessment of the limited information for that species used to prepare the information sheet. These two species are treated together due to similarities in their biology and distribution.

PEST OVERVIEW

Taxonomy

- *Euwallacea interjectus* (Blandford 1894). Synonyms: *Xyleborus interjectus* Blandford 1894; *Xyleborus pseudovalidus* Eggers 1925.
- *Euwallacea validus* (Eichhoff 1875). Synonym: *Xyleborus validus* Eichhoff 1875.

Associated fungi: *E. interjectus* was found to be associated with the species AF-3 of the ambrosia *Fusarium* clade[13] on *Acer negundo* in Florida. *E. validus* was found to carry two symbionts in its mycangia (which is unusual): AF-4 (Kasson *et al.*, 2013) and *Raffaela subfusca* (Simmons *et al.*, 2016). A *Graphium* sp. was also found associated with *E. validus* in Pennsylvania (Lynch *et al.*, 2016, citing others). No information was found on the pathogenicity of these fungi. However, *E. interjectus* and *E. validus* were both found to spread a pathogenic fungus through their galleries (*Ceratocystis ficicola* in Japan and *Verticillium nonalfalfae* in the USA, respectively – see *Known impact*).

Morphology and biology

Females of *Euwallacea* spp. measure ca. 4 mm (Smith and Hulcr, 2015 citing others). According to Samuelson (1981), *E. interjectus* uses mostly dead and dying trees as substrate for their brood. However, *E. interjectus* infests living *Ficus carica* trees in orchards in Japan, with female adults invading healthy tree trunks near the ground. Once a trunk is colonized, *E. interjectus* continues to reside in the same living tree for a few years as long as the condition in the trunk is suitable for their reproduction (Kajii *et al.*, 2013). No general information on the size of the material attacked was found, but studies in Kajii *et al.* (2013) used two *F. carica* trees infested by *E. interjectus*, which had a basal stem diameter of 29 cm and 14 cm respectively (with a trunk height/age of 43 cm/26 years and 39 cm/8 years, respectively).

E. validus apparently attacks stressed trees, dying trees, or trees that recently died (Berger, 2017). In epidemic outbreaks, ambrosia beetles may infest nearby healthy trees as well as stressed trees, including normally non-target species. In the Mid-Atlantic USA, *E. validus* usually has one generation per year (Berger, 2017). No information was found on the number of generations for *E. interjectus*.

Being Xyleborini, both species are inbreeders and haplodiploid. Mating takes place in the gallery between male and female offspring of the parent female (sibling mating) (Kawasaki *et al.*, 2016), and females then emerge (as *E. fornicatus sensu lato*, NPPO Spain, 2015). Females are able to lay eggs and produce a brood even if they have not copulated and are not fertilized (parthenogenesis).

On fig trees, *E. interjectus* galleries are in the xylem/sapwood (Kajii *et al.*, 2013). No information was found on the location of *E. validus* galleries, and the parts of plants attacked, but they are almost certainly also in the xylem, as related species are also in the xylem (incl. *E. interjectus* and *E. fornicatus* - see Datasheet).

Spread biology

No specific information was found. However, as for *E. fornicatus* (NPPO Spain, 2015), males are flightless and never leave the gallery.

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[13] The ambrosia *Fusarium* clade associated with *Euwallacea* sp. comprises 12 species. 2 are named (*F. euwallaceae* and *F. ambrosium*, associated with *E. fornicatus sensu lato*), others are named with 'AF' and a number (Short *et al.*, 2017 citing O'Donnell *et al.*, 2015).

Nature of the damage

No details were found, but it is presumably similar to that of *Euwallacea fornicatus sensu lato* (see Datasheet on that pest). Both species have been found to carry a pathogenic fungus into trees (see *Known impact*).

Detection and identification

- *Symptoms.* No specific information on symptoms was found but they are probably similar to other ambrosia beetles.
- *Trapping. E. validus* is attracted to ethanol and conophthorin enhances that attraction (Ranger *et al.*, 2014) and could be used in traps. Similarly, injecting ethanol into healthy trees was considered as a promising trap-tree strategy (Ranger *et al.*, 2010).
- *Identification.* Misidentification has occurred between *E. validus* and *E. interjectus* in the USA due to their very similar morphology. Morphological characters of *Euwallacea* spp. that can be used for identification are mentioned in Smith and Hulcr (2015). Keys have been developed in the USA to distinguish *Euwallacea* spp. (cited in NPPO Spain, 2015; also Gomez *et al*., 2018). Cognato *et al.* (2015) outlines morphological differences and clarifies the distribution of *E. validus* and *E. interjectus* in the USA by molecular studies. Regarding associated fungi, a simple PCR test for identification of *Euwallacea*-associated *Fusarium* sp. in the USA has recently been developed (Short *et al*., 2017).

Distribution (see Table 1)

E. validus and *E. interjectus* originate from Asia. *E. interjectus* has a wider distribution in Eastern Asia than *E. validus*. Both species were introduced into North America. In the USA, *E. validus* was first reported in New York in 1976, and *E. interjectus* in Hawaii in 1976 and in the continental USA in 2011 (Florida). Results of molecular studies suggest that *E. interjectus* became established in the USA on three occasions (Hawaii, 1976; Louisiana, 1984; Texas, 2011), and *E. validus* only on one occasion (New York, 1976) (Cognato *et al.*, 2015). In the USA, both species are now present in many States, *E. validus* currently occurring in the North-East, and *E. interjectus* in the South-East, with an area of syntopy (same habitat at the same time) in the North-East corner of Georgia and possibly western South Carolina (Cognato *et al.*, 2015 – also giving a distribution map for the USA). *E. validus* has also been found in Canada (Ontario) (Douglas *et al.*, 2013). *E. validus* and *E. interjectus* have not been reported in the EPPO region.

Host plants (see Table 2)

- *E. validus* breeds in a variety of non-coniferous and coniferous trees (Douglas *et al.*, 2013). Its hosts belong to many genera and families, incl. several species in the families Fagaceae, Salicaceae, Ulmaceae, Cupressaceae and Pinaceae (Table 2).
- *E. interjectus* appears to have a more subtropical/tropical host range, with hosts in families such as Anacardiaceae, Combretaceae, Fabaceae, Malvaceae, and one *Pinus* species.

Known impacts and control in current distribution

There is limited evidence of damage by *E. validus* and *E. interjectus* to date. In Japan, *E. interjectus* was shown to contribute to the symptom development of fig wilt caused by *Ceratocystis ficicola* in orchards, by spreading the fungus in the healthy sapwood through its galleries (Kajii *et al.*, 2013). In Alachua County (Florida), where *E. interjectus* was first recorded in 2011, several incidences of mass attack of live water-stressed box elder maples (*Acer negundo*) have been observed (Cognato *et al.*, 2015, citing others).

E. validus was implicated in the transmission of the fungus *Verticillium nonalfalfae* on *Ailanthus altissima* and *Acer pensylvanicum* in the USA (Cognato *et al.*, 2015, citing others). It was found associated with dying stands of *A. altissima* killed by *Verticillium* wilt in Pennsylvania (Kasson *et al.*, 2013 citing others). It may have significant ecological impact by spreading the *Verticillium* wilt in regions where *A. altissima* occurs (Smith and Hulcr, 2015).

Control: No information was found.

POTENTIAL RISKS FOR THE EPPO REGION

Pathways

Entry

E. interjectus is mentioned as frequently intercepted in Japan in imported timber (Beaver *et al.*, 2014 citing others), and is reported intercepted in the Korean Republic on ‘logs and timber’ of *Shorea lepidota* from

Malaysia (Choi *et al.*, 2003). *E. validus* has been intercepted from wooden packing crates of Japanese origin at numerous ports worldwide (Wood, 1977), and two interceptions from China in 1984-2008 in the USA are also reported (Haack and Rabaglia, 2013).

Unless the biology of *E. interjectus* and *E. validus* is significantly different than that of *Euwallacea fornicatus sensu lato*, the same pathways would be relevant for entry (summarized below). Non-coniferous hosts include genera that are grown for wood production such as, for *E. validus*, *Quercus, Fagus, Populus, Juglans, Ulmus*, and for *E. interjectus*, *Populus*, *Tectona* and *Terminalia*. However, biological data is missing to better define the wood pathways to which these species may be associated. Wood packaging material is a known pathway for *E. validus*. Processes applied to produce wood commodities would destroy some individuals. The likelihood of entry on wood chips, hogwood and processing wood residues would be lower than on round wood, as individuals would have to survive processing and transport, and transfer to a suitable host is less likely. The wood would also degrade and may not be able to sustain development of the pest. Bark on its own is an unlikely pathway.

The relevance of plants for planting would depend on whether these species can be present on seemingly healthy hosts, and whether plants of the required diameter would be traded. *E. interjectus* has been found on seemingly healthy *Ficus carica* in Japan. Information is insufficient to assess plants for planting and cut branches.

Finally, inbreeding is favourable to entry and establishment.

Summary of pathways (uncertain pathways are marked with '?'):

- *wood (round or sawn, with or without bark, including firewood) of hosts*
- *wood packaging material if not treated according to ISPM 15*
- *wood chips, hogwood, processing wood residues (except sawdust and shavings)*
- *plants for planting (except seeds) of hosts?*
- *cut branches (incl. Christmas trees) of hosts?*

For both species, because of the large and uncertain host range, pathways may cover all non-coniferous species, and also coniferous species.

Spread (following introduction, i.e. within EPPO region)

Data is not available on the natural spread of *E. interjectus* and *E. validus*, but both appear to have spread in the USA over the past 40 years. Hosts of *E. validus* are widespread in the EPPO region, while those of *E. interjectus* are probably of a more limited use and distribution. Both species are likely to be able to attack new hosts. Human-assisted pathways would favour spread within the region.

Establishment

E. interjectus and *E. validus* appear to occupy different climatic conditions in their current distribution. Based on the climate classification of Köppen Geiger (see Annex 6 of the study), similar areas in the EPPO region occur for both species in northern Italy, Balkans and around the Black Sea, for *E. validus* also northwards and eastwards to the south of Scandinavia and Russia, and for *E. interjectus* also south to the rest of the Mediterranean area. Even a single introduced mated female is potentially sufficient to start a new population.

Both species have a large host range and may attack new plant species at a destination. Especially for *E. validus*, the host range includes many hosts that are present in the wild, forests, orchards and in ornamental plantings in the EPPO region. Being ambrosia beetles, it is not excluded that they may be able to attack other hosts.

Given the suitable ecological conditions at least in some parts of the EPPO region, both *E. interjectus and E. validus* have the potential to establish.

Potential impact (including consideration of host plants)

Data is lacking on impact where these species occur. Both species are closely-related to *E. fornicatus sensu lato* and show characters that may create a risk of potential impact, including the association with species of the ambrosia *Fusarium* clade or other phytopathogenic fungi. The closely-related species *E. fornicatus sensu lato* has emerged in the USA and Israel as a damaging pest on avocado following its introduction.

Table 1. Distribution of *E. validus* and *E. interjectus*

EUWALLACEA VALIDUS	**References**	**Comments**
EPPO region		
Absent		
Asia		
China (Anhui, Fujian, Yunnan)	Atkinson, 2018 citing Wood & Bright, 1992	
Japan	Atkinson, 2018 citing Wood & Bright, 1992	
Korea Rep.	Atkinson, 2018 citing Wood & Bright, 1992	
Malaysia	Atkinson, 2018 citing Wood & Bright, 1992	
Myanmar (as Burma)	Atkinson, 2018 citing Wood & Bright, 1992	
Philippines	Atkinson, 2018 citing Wood & Bright, 1992	
Vietnam	Atkinson, 2018 citing Wood & Bright, 1992	
North America		
Canada (Ontario)	Douglas *et al.*, 2013	
USA (Alabama, Arkansas, Connecticut, Delaware, Georgia, Illinois, Indiana, Kentucky, Maryland, Massachusetts, Michigan, Mississippi, Missouri, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, Tennessee, Texas, Vermont, Virginia, West Virginia)	Atkinson, 2018	New York (1976) (Cognato *et al.*, 2015)
- South Carolina	- Coyle *et al.*, 2005	- first report
- Ohio	- Lightle *et al.*, 2007	- first report

EUWALLACEA INTERJECTUS	**References**	**Comments**
EPPO region		
Absent		
Asia		
China (Tibet (Xizang), Guangdong, Hunan, Sichuan, Taiwan, Yunnan, Zhejiang)	Atkinson, 2018 citing Wood & Bright, 1992	
India (Assam, Bengal, Maharashtra, Tamil Nadu, Uttar Pradesh)	Atkinson, 2018 citing Wood & Bright, 1992	
Indonesia	Atkinson, 2018 citing Wood & Bright, 1992	
Japan	Atkinson, 2018 citing Wood & Bright, 1992	
Malaysia	Atkinson, 2018 citing Wood & Bright, 1992	
Myanmar (as Burma)	Atkinson, 2018 citing Wood & Bright, 1992	
Nepal	Atkinson, 2018 citing Wood & Bright, 1992	
Philippines	Atkinson, 2018 citing Wood & Bright, 1992	
Sri Lanka	Atkinson, 2018 citing Wood & Bright, 1992	
Vietnam	Atkinson, 2018 citing Wood & Bright, 1992	
North America		
USA (Florida, Georgia, Kentucky, Louisiana, South Carolina, Texas, Virginia, Hawaii)	Atkinson, 2018	Hawaii: 1976 (Cognato *et al.*, 2015)

Table 2. Hosts. *E. validus* (from Atkinson, 2018)

Family	**Genus/Species**
Betulaceae	*Carpinus tschonoskii*
Cannabaceae	*Aphananthe aspera*
Cupressaceae	*Chamaecyparis obtusa*
Cupressaceae	*Cryptomeria japonica*
Cupressaceae	*Cunninghamia lanceolata*
Euphorbiaceae	*Mallotus japonicus*

Family	**Genus/Species**
Fabaceae	*Dalbergia hupeana*
Fagaceae	*Castanea crenata*
Fagaceae	*Fagus japonica* var. *multinervis*
Fagaceae	*Fagus* sp.
Fagaceae	*Quercus grosseserrata*
Fagaceae	*Quercus velutina*

Family	**Genus/Species**
Juglandaceae	*Juglans* sp.
Lauraceae	*Machilus* sp.
Magnoliaceae	*Magnolia obovata*
Malvaceae	*Tilia amurensis*
Moraceae	*Ficus carica*
Pinaceae	*Abies firma*
Pinaceae	*Pinus densiflora*
Pinaceae	*Pinus massoniana*
Pinaceae	*Pinus parvifolia*
Pinaceae	*Pinus sylvestris*
Pinaceae	*Pinus taiwanensis*

Family	**Genus/Species**
Pinaceae	*Pinus thunbergii*
Pinaceae	*Tsuga sieboldii*
Rosaceae	*Prunus serrulata*
Rutaceae	*Phellodendron amurense*
Salicaceae	*Populus deltoides*
Salicaceae	*Populus glandulosa*
Simaroubaceae	*Ailanthus altissima*
Theaceae	*Cleyera japonica*
Ulmaceae	*Celtis sinensis*
Ulmaceae	*Ulmus pumila*
Ulmaceae	*Zelkova serrata*

Hosts of *E. interjectus* (from Atkinson, 2018)

Family	**Genus/Species**
Anacardiaceae	*Mangifera indica*
Anacardiaceae	*Odina wodier*
Anacardiaceae	*Spondias mangifera*
Burseraceae	*Garuga pinnata*
Combretaceae	*Terminalia bellirica*
Combretaceae	*Terminalia myriocarpa*
Combretaceae	*Terminalia nudiflora*
Dipterocarpaceae	*Shorea assamica*
Dipterocarpaceae	*Shorea robusta*
Euphorbiaceae	*Euphorbia royleana*
Euphorbiaceae	*Hevea brasiliensis*
Euphorbiaceae	*Macaranga denticulata*
Fabaceae	*Delonix elata*
Fabaceae	*Erythrina* sp.
Fabaceae	*Pterocarpus marsupium*
Fabaceae	*Wisteria* sp.
Fabaceae	*Xylia xylocarpa*
Fagaceae	*Castanopsis indica*
Lamiaceae	*Gmelina arborea*
Lamiaceae	*Tectona grandis*
Lauraceae	*Machilus* sp.

Family	**Genus/Species**
Malvaceae	*Bombax ceiba*
Malvaceae	*Bombax insigne* (as *Salmalia insignis)*
Malvaceae	*Kydia calycina*
Malvaceae	*Pterygota alata* (*Sterculia alata*)
Malvaceae	*Pterocymbium tinctorium* (*Sterculia campanulata*)
Malvaceae	*Sterculia villosa* (*S. ornata*)
Malvaceae	*Theobroma cacao*
Moraceae	*Artocarpus integrifolia*
Moraceae	*Ficus* sp.
Moraceae	*Maclura cochinchinensis*
Pinaceae	*Pinus massoniana*
Rubiaceae	*Neolamarckia cadambae* (*Anthocephalus cadamba*)
Rubiaceae	*Hymenodictyon orixense* (*H. excelsum*)
Rubiaceae	*Nauclea orientalis*
Salicaceae	*Populus* sp.
Sapindaceae	*Acer negundo*
Sapindaceae	*Koelreuteria paniculata*

References (all URLs were accessed in January 2018)

Atkinson TH. 2018. Bark and Ambrosia Beetles. Online database. http://www.barkbeetles.info/index.php

Beaver RA, Sittichaya W, Liu L-Y. 2014. A Synopsis of the Scolytine Ambrosia Beetles of Thailand (Coleoptera: Curculionidae: Scolytinae). Zootaxa 3875(1): 001–082.

Berger MC. 2017. Interactions between *Euwallacea* Ambrosia Beetles, Their Fungal Symbionts and the Native Trees They Attack in the Eastern United States Matthew C. Berger Thesis submitted to the Davis College of Agriculture, Natural Resources and Design at West Virginia.

Choi EG, Choo HY, Lee DW, Lee SM, Park JK. 2003. Scolytidae, Platypodidae, Bostrichidae and Lyctidae Intercepted from Imported Timbers at Busan Port Entry. Korean Journal of Applied Entomology: Vol.42 No.3 pp.173-184.

Cognato AI, Hoebeke ER, Kajimura H, Smith SM. 2015. History of the exotic ambrosia beetles *Euwallacea interjectus* and *Euwallacea validus* (Coleoptera: Curculionidae: Xyleborini) in the United States. Journal of economic entomology, 108(3), pp. 1129-1135.

Coyle DR, Booth DC, Wallace MS. 2005. Ambrosia beetle (Coleoptera: Scolytidae) species, flight, and attack on living eastern cottonwood trees. Journal of economic entomology, 98(6), pp.2049-2057.

Douglas H, Bouchard P, Anderson RS *et al.* 2013. New Curculionoidea (Coleoptera) records for Canada. Zookeys Issue: 309, 13-48.

EPPO. 2017. Report of a Pest Risk Analysis for *Euwallacea fornicatus sensu lato* and *Fusarium euwallaceae*. Available at https://www.eppo.int

Gomez DF, Rabaglia RJ, Fairbanks KEO, Hulcr J. 2018. North American Xyleborini north of Mexico: a review and key to genera and species (Coleoptera, Curculionidae, Scolytinae). ZooKeys 768: 19–68.

Haack RA, Rabaglia RJ. 2013. Exotic bark and ambrosia beetles in the USA: potential and current invaders. *Potential invasive pests of agricultural crops. CAB International, Wallingford*, 48-74.

Kajii C, Morita T, Jikumaru S, Kajimura H, Yamaoka Y, Kuroda K. 2013. Xylem dysfunction in *Ficus carica* infected with wilt fungus *Ceratocystis ficicola* and the role of the vector beetle *Euwallacea interjectus*. IAWA Journal, 34(3), pp.301-312.

Kasson MT, O'Donnell K, Rooney AP, Sink S, Ploetz RC, Ploetz JN, Konkol JL, Carrillo D, Freeman S, Mendel Z, Smith JA. 2013. An inordinate fondness for *Fusarium*: phylogenetic diversity of fusaria cultivated by ambrosia beetles in the genus *Euwallacea* on avocado and other plant hosts. Fungal Genetics and Biology, 56, pp.147-157.

Kawasaki Y, Schuler H, Stauffer C, Lakatos F, Kajimura H. 2016. Wolbachia endosymbionts in haplodiploid and diploid scolytine beetles (Coleoptera: Curculionidae: Scolytinae). Environmental microbiology reports, 8(5), pp.680-688.

Kottek M, Grieser J, Beck C, Rudolf B, Rubel F. 2006. World Map of the Köppen-Geiger climate classification updated. Meteorol. Z., 15, 259-263. DOI: 10.1127/0941-2948/2006/0130.

Lightle DM, Gandhi KJ, Cognato AI, Mosley BJ, Nielsen DG, Herms DA. 2007. New reports of exotic and native ambrosia and bark beetle species (Coleoptera: Curculionidae: Scolytinae) from Ohio. Great Lakes Entomol, 40, pp.194-200.

Lynch SC, Twizeyimana M, Mayorquin JS, Wang DH, Na F, Kayim M, Kasson MT, Thu PQ, Bateman C, Rugman-Jones P, Hulcr J. 2016. Identification, pathogenicity and abundance of *Paracremonium pembeum* sp. nov. and *Graphium euwallaceae* sp. nov.—two newly discovered mycangial associates of the polyphagous shot hole borer (*Euwallacea* sp.) in California. Mycologia, 108(2), pp.313-329.

NPPO Spain. 2015. Express pest risk analysis for the ambrosia beetle *Euwallacea* sp. including all the species within the genus *Euwallacea* that are morphologically similar to *E. fornicatus*. Available at https://www.eppo.int

O'Donnell K, Sink S, Libeskind-Hadas R, Hulcr J, Kasson MT, Ploetz RC, Konkol JL, Ploetz JN, Carrillo D, Campbell A, Duncan RE. 2015. Discordant phylogenies suggest repeated host shifts in the *Fusarium–Euwallacea* ambrosia beetle mutualism. Fungal Genetics and Biology, 82, pp.277-290.

O'Donnell K, Libeskind-Hadas R, Hulcr J, Bateman C, Kasson MT, Ploetz RC, Konkol JL, Ploetz JN, Carrillo D, Campbell A, Duncan RE, Liyanage PNH, Eskalen A, Lynch SC, Geiser DM, Freeman S, Mendel Z, Sharon M, Aoki T, Cossé AA, Rooney AP. 2016. Invasive Asian *Fusarium* – *Euwallacea* ambrosia beetle mutualists pose a serious threat to forests, urban landscapes and the avocado industry. Phytoparasitica, 44:435–442.

Ranger CM, Gorzlancyk AM, Addesso KM, Oliver JB, Reding ME, Schultz PB, and Held DW. 2014. Conophthorin enhances the electroantennogram and field behavioural response of *Xylosandrus germanus* (Coleoptera: Curculionidae) to ethanol. Agricultural and forest entomology, 16(4), pp.327-334.

Ranger CM, Reding ME, Persad AB, Herms DA. 2010. Ability of stress-related volatiles to attract and induce attacks by *Xylosandrus germanus* and other ambrosia beetles. Agricultural and Forest Entomology, 12(2), pp.177-185.

Samuelson, G. A. 1981. A synopsis of Hawaiian Xyleborini (Coleoptera: Scolytidae). Pac. Insects 23: 50–92.

Sangwook P. 2016. Taxonomic Review of Scolytinae and Platypodinae (Coleoptera: Curculionidae) in Korea Doctoral dissertation.

Short DP, O'Donnell K, Stajich JE, Hulcr J, Kijimoto T, Berger MC, Macias AM, Spahr EJ, Bateman CC, Eskalen A, Lynch SC. 2017. PCR Multiplexes Discriminate *Fusarium* Symbionts of Invasive *Euwallacea* Ambrosia Beetles that Inflict Damage on Numerous Tree Species Throughout the United States. Plant Disease, 101(1), pp.233-240.

Simmons DR, de Beer WZ, Huang YT, Bateman C, Campbell AS, Dreaden TJ, Li Y, Ploetz RC, Black A, Li HF, Chen CY. 2016. New *Raffaelea* species (Ophiostomatales) from the USA and Taiwan associated with ambrosia beetles and plant hosts. IMA fungus, 7(2), pp.265-273.

Smith SM, Hulcr J. 2015. *Scolytus* and other economically important bark and ambrosia beetles. Chapter 12 in Bark Beetles. Biology and Ecology of Native and Invasive Species. *Edited by: Fernando E. Vega and Richard W. Hofstetter*. ISBN: 978-0-12-417156-5, Elsevier.

Wood SL. 1977. Introduced and exported American Scolytidae (Coleoptera). *Great Basin Naturalist*: Vol. 37: No. 1, Article 5, 67 – 74. Available at: http://scholarsarchive.byu.edu/gbn/vol37/iss1/5

This text is an integral part of the *EPPO Study on bark and ambrosia beetles associated with imported non-coniferous wood* and should be read in conjunction with the study

Pest information sheet
Ambrosia beetle

GNATHOTRUPES SPP. OF *NOTHOFAGUS* SPP. (COLEOPTERA: SCOLYTINAE)

EPPO Lists: Not listed. The assessment of potential risks in this information sheet is not based on a full PRA for the EPPO region, but on an assessment of the limited information for that species used to prepare the information sheet.

PEST OVERVIEW

The genus *Gnathotrupes* currently contains 31 species, all from the Americas (Wood and Bright, 1992; Wood, 2007). 16 *Gnathotrupes* species associated with *Nothofagus*[14] (Southern beech) are listed in Table 1. In addition, at least 3 undescribed species are also associated with *Nothofagus* (Kirkendall, 2011). In recent decades, Southern beech decline has affected *Nothofagus* trees in Chile. Its causes are unknown to date, but the hypothesis has been made that it could be caused by a fungus transported by a *Gnathotrupes* species (Kirkendall, 2011). The correlation between the presence of *Gnathotrupes* galleries and diseased trees has been reported in studies on *N. pumilio* and *N. antarctica* (De Errasti, 2016; De Errasti *et al.*, 2016). Consequently, *Gnathotrupes* was included in this study as the case of an emerging decline associated with one or several fungus vectored by ambrosia beetles. It should be noted that limited information has been published on *Gnathotrupes* spp. of *Nothofagus*.

Taxonomy

Gnathotrupes spp. associated with *Nothofagus* in Chile and Argentina (Aguayo Silva *et al.*, 2008; Naumann-Etienne *et al.*) are listed in Table 1. There is a synonymy issue for the *Gnathotrichus* spp. (*G. nanulus* and *G. vafer*), the *Gnathoglochinus* sp. (*G. impressus*) the *Gnathocortus* sp. (*G. caliculus*) and the *Gnathomimus* sp. (*G. nothofagi*) in Naumann-Etienne (1978). All these genera names are considered synonyms of *Gnathotrupes* by Wood and Bright (1992). *G. similis* is a synonym of *G. barbifer*; *G. solidus* is a synonym of *G. velatus*, *G. ciliatus* is a synonym of *G. longiusculus* (Aguayo Silva *et al.*, 2008).

Associated fungi

A yeast had been found associated with declining *Nothofagus* trees (Kirkendall, 2011). A recent study on fungi associated with *Nothofagus* in the Patagonian Andes of Argentina (De Errasti, 2016; De Errasti *et al.*, 2016) identified 8 *Ophiostoma* species, 1 *Leptographium* species, and 1 species in the *Sporothrix lignivora* complex. *L. gestamen* and *S. cabralii* (both new species) were obtained from dead or declining *Nothofagus* trees, associated with galleries of *Gnathotrupes*. Their pathogenicity was not tested in the study (and is not known to date), but the authors raise the question as to whether they could contribute to *Nothofagus* decline.

Morphology and biology

Gnathotrupes are small beetles that measure about 2.5-4 mm long depending on the species. Aguayo Silva *et al.* (2008) provide pictures of adults of 13 *Gnathotrupes* on *Nothofagus*, and of galleries for *G. fimbriatus*, *G. longiusculus* and *G. vafer*, that extend into the wood. Naumann-Etienne (1978) provides drawings of the gallery patterns of *G. pustulatus*, *G. cirratus*, *G. vafer* and *G. nanulus*, as well as of morphological features (antennae, pronotum, head and mandibles, and elytral declivities) for several species. The genus is said to be monogynous (Wood 2007, Kirkendall *et al.* 2015), but the *Nothofagus*-breeding species studied by Naumann-Etienne (1978) are bigynous. The life cycle of some *Gnathotrupes* spp. of *Nothofagus* is not well known, although there is some information for the majority of species (Naumann-Etienne, 1978). For most species, a ‘family’ is composed of a male, which creates the entrance hole, and two, rarely more, females. All elements below are from Aguayo Silva *et al.* (2008) except if another source is indicated. The species described below all attack live *Nothofagus*. Entry holes are in twigs, branches and trunks of *Nothofagus* (depending on the species, see below).

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[14] *Nothofagus* is classified under Fagaceae or in its own family Nothofagaceae depending on the sources (e.g. respectively the Index Nominum Genericorum (ING) and the International Plant Names Index (IPNI)).

Damage by *G. fimbriatus* can be located anywhere in the tree (twigs, branches or trunk), on all diameter wood. Kirkendall (2008) collected *G. fimbriatus* from (or saw distinctive galleries in) trunks, branches and saplings, suggesting that it has an unusually broad niche. *G. fimbriatus* is thought to have an annual life cycle similar to the *Gnathotrupes* spp. of the National Park Nahuel Huapi in Argentina (citing Naumann- Etienne, 1978). In Chile, adults are found from November to April. Eggs are laid in vertical larval galleries, while associated species in the same habitats make horizontal galleries.

G. vafer attacks mostly trunks (Naumann-Etienne, 1978) of more than 20 cm in diameter. Branch and tree mortality may occur. Adults fly in winter. In Argentina, *G. vafer* mostly attacks the lower part of fallen trunks, while in outbreaks in Aysén (Chile) *G. vafer* was found in live trunks. Eggs are laid in vertical larval pockets (longitudinal), very close to each other. Imagos overwinter under bark 'scales' (citing Naumann-Etienne, 1978).

G. barbifer, G. nanus, G. velatus (as well as a yet undescribed species) seem to have the same ecology as *G. vafer* Aguayo Silva *et al.* (2008). However, *G. nanus* attacks dying thick branches on standing trees as well as trunks, *G. velatus* prefers thicker branches and is often found on felled logs (Naumann-Etienne, 1978).

G. longipennis attacks thick branches and trunks, while *G. consobrinus* is associated with thick branches. *G. consobrinus* and *G. longipennis* were collected in freshly felled logs or near wounds in standing trees (Naumann-Etienne, 1978).

G. cirratus, *G. impressus* and *G. pustulatus* attack branches, mostly of moderate diameter (10-20 cm) (Naumann-Etienne, 1978).

G. longiusculus mostly attacks twigs and small branches, and some death of these is observed. The mortality of branches in the Region of Magallanes and Antarctica Chilean appears to be due to *G. longiusculus* and *G. fimbriatus*. Eggs are laid in galleries that are horizontal and transversal to the main gallery.

G. caliculus, *G. naumannii* and *G. nothofagi* use the galleries of other *Gnathotrupes* species (Naumann-Etienne, 1978). The same author qualifies them as "cleptoinquilines".

Spread biology
No details are available in the literature. For *G. vafer*, *G. fimbriatus* and *G. longiusculus*, Aguayo Silva *et al.* (2008) state that they have a high dispersal capacity 'as all Scolytinae' and that both sexes are good flyers.

Nature of the damage
Gnathotrupes tunnel galleries that extend into the wood, though not very deeply. They cause death of branches or vertical segments of the bark (on large branches and trunks), fall of branches or twig, death of whole trees. It is not known if mortality of twigs, branches or trunk is due to direct damage, or to an ambrosia fungus or pathogen carried by the beetles (Aguayo Silva *et al.*, 2008). Depending on species, different plant parts are attacked.

Detection and identification

- *Symptoms.* Dying branches or twigs may be observed (with yellowing leaves), as well as dead or fallen branches. For some species, dead trees (e.g. *G. fimbriatus, G. vafer*). Small entry holes are present on the infested trees and there is an accumulation of fine white sawdust. The galleries of *Gnathotrupes* species differ. Illustrations are given in Naumann-Etienne (1978).
- *Trapping.* No information was found.
- *Identification.* Wood (2007) provides a key to *Gnathotrupes* spp. and morphological characters of species on *Nothofagus* are also available in Naumann-Etienne (1978).

Distribution (see Table 1)
The *Gnathotrupes* spp. associated with *Nothofagus* are reported from Chile and Argentina (see Table 1).

Host plants (see Table 1)

The *Gnathotrupes* spp. considered here all attack *Nothofagus* spp. Some details of host species are given in Table 1. *G. fimbriatus* has been shown to attack hosts in other genera: a breeding population was found on *Pinus contorta* logs (Kirkendall, 2008) and *G. fimbriatus* was also found on *P. sylvestris* (no details on the type of material - Informativo Fitosanitario Forestal, 2012). The records on *Pinus* each came from one specific location.

Known impacts and control in current distribution

Damage by *Gnathotrupes* spp. may cause growth reduction and complete tree mortality, but has not been quantified (Aguayo Silva *et al.*, 2008). Infestation by *Gnathotrupes* may be associated with dying and dead and dying trees, and a high level of tree mortality is so far known only in the Aysen region. In other regions, dying and dead branches are observed, leading to branch fall. *Gnathotrupes* are thought to be involved in Southern beech decline in Chile, and the hypothesis has been made that the decline could be caused by a fungus vectored by a *Gnathotrupes* spp. (Kirkendall, 2011). In Aysen, Alvarado (2016) mentions massive mortality of *Nothofagus dombeyi* caused by populations increase of *Gnathotrupes* spp. the latter a consequence of temperature increase.

Control: No control method is mentioned in the literature available.

POTENTIAL RISKS FOR THE EPPO REGION

Pathways

Entry

Wood of the hosts would be a suitable pathway, but there is insufficient knowledge to fully analyse the possible association of different *Gnathotrupes* species with different wood commodities. Species attacking only branches are unlikely to be associated with round wood (unless wood commodities include whole trees or harvesting residues that may carry these species). *Nothofagus* is used as wood, although the little detailed data available on wood trade (see Annex 5 of the study) only refers to *N. cunninghamii* and *N. obliqua* (not listed as hosts above). Among known hosts, at least *N. dombeyi* and *N. pumilio* are known commercial timber tree species (Mark *et al.*, 2014). No data was found on whether *Nothofagus* wood is used in commodities such as wood chips, hogwood, processing wood residues or wood packaging material. Processes applied to produce wood commodities would destroy some individuals. The wood would also degrade and may not be able to sustain development of the pest. The likelihood of entry on wood chips, hogwood and processing wood residues would be lower than on round wood, as individuals would have to survive processing and transport, and transfer to a suitable host is less likely. There was one finding of *G. fimbriata* on *Pinus contorta* and on *P. sylvestris.* Finally, bark on its own is an unlikely pathway.

Some species are associated with twigs and small branches, and plants for planting may be a pathway; no information was found on attacks by some *Gnathotrupes* spp. on nursery plants. Plants for planting are normally subject to controls during production, and attached plants may be detected and discarded. Data from the EU Project Isefor (Increasing sustainability of European forests: Modelling for security against invasive pests and pathogens under climate change) also reports occasional import of plants for planting of *Nothofagus* from Chile, between 1 and 1500 pieces per year in the period 2003-2010, in total over 3100 pieces. Cut branches are a less likely pathway as they are used indoors and the pest is unlikely to be able to transfer to a suitable host. It is also not known if there is a trade.

Summary of pathways (uncertain pathways are marked with '?'):

- *Nothofagus wood (round or sawn, with or without bark, incl. firewood)*
- *non-coniferous wood chips, hogwood, processing wood residues (except sawdust and shavings)*
- *wood packaging material if not treated according to ISPM 15*
- *Nothofagus plants for planting (except seeds)?*
- *Nothofagus cut branches?*

Pathways may also cover the known coniferous hosts (for G. fimbriatus).

Spread (following introduction, i.e. within EPPO region)

There is no information on natural dispersal of *Gnathotrupes* spp, but almost all bark beetles can fly long distances (several hundred meters to several kilometres). *Nothofagus* are probably mostly used as ornamentals in the EPPO region. However, small-scale plantations are reported as widespread in the UK (*N. obliqua* and *N. alpina* - Scanu *et al.*, 2012). If *Gnathotrupes* are not able to infest Fagaceae hosts and are restricted to *Nothofagus*, spread would be limited. However, most ambrosia beetles are polyphagous, and they may be able to attack other hosts. For *G. fimbriatus*, it is not known if it could create outbreaks and spread using *Pinus sylvestris* or *P. contorta* as hosts. Given that it has been able to breed on *Pinus*, a host taxonomically very far from its original host, it is not unlikely that it would attack others, more closely related, such as other Fagaceae. Human-assisted pathway may help in creating multiple foci in the EPPO region, if introduced.

Establishment

Based on the climate types in the Köppen-Geiger classification (see Annex 6 of the study), *Gnathotrupes* are present in temperate to cold climates in Chile and Argentina, which are also present in the EPPO region (oceanic Europe incl. UK and Ireland to Central Europe, to Scandinavia in the North and Russia to the East).

Gnathotrupes spp. are mostly associated with *Nothofagus*, which have a limited presence in the EPPO region (see *Spread*). The likelihood of establishment would be higher if they were able to attack Fagaceae or other hosts in the EPPO region. This is not excluded especially for *G. fimbriatus* (see *Spread*). *G. fimbriatus* may be able to establish populations on *Pinus*, at least on logs. Its known host *Pinus sylvestris* is widespread and *P. contorta* (on which logs a breeding population was found) is planted for wood production. Finally, *Gnathotrupes* spp. are ambrosia beetles, and although they show a strong host association to *Nothofagus* in Argentina and Chile, it is not excluded that they may be able to attack other hosts.

Potential impact (including consideration of host plants)

If only *Nothofagus* are attacked, the potential impact of *Gnathotrupes* in the EPPO region would be limited (grown only as ornamentals or small plantations). However, the overall potential impact would depend on whether *Gnathotrupes* spp. would be able to extend their host range, especially within the Fagaceae. Genera such as *Fagus*, *Quercus* or *Castanea* are of major importance for the EPPO region, and occur in a wide diversity of habitats, including in the wild, or in cultivation for wood, ornamentals or fruit. For *G. fimbriatus*, *Pinus sylvestris* (native in the EPPO region) is environmentally and economically important, and *P. contorta* is planted for wood production. However, it is not known if *G. fimbriatus* could cause damage on these hosts. In all cases, the impact would also depend on whether some fungi pathogenic to *Nothofagus* are associated with *Gnathotrupes* and could be pathogenic on other hosts.

Table 1. *Gnathotrupes* spp. of *Nothofagus* (mostly from Aguayo Silva *et al.*, 2008. Marked with *, also Kirkendall *et al.*, 2008, Informativo Fitosanitario Forestal, 2012, Naumann-Etienne, 1978; Wood, 2007). Distribution: AR = Argentina, CL = Chile. Data are from Aguayo Silva *et al.* (2008, citing other sources) and, for species only in Argentina, Naumann-Etienne (1978)).

***Gnathotrupes* species**	**Host species**	**Distribution**
G. barbifer Schedl, 1967	*N. dombeyi*, *N. pumilio*	Regions of Los Lagos (Chiloe), Aysén (El Manso)(CL); Parque Nacional Nahuel Huapi (AR)
G. caliculus (Schedl, 1975)	*N. dombeyi*	Region of Aysén (El Manso) (CL); Parque Nacional Nahuel Huapi (AR)
G. cirratus Schedl, 1975*	*N. antarctica, N. dombeyi*	AR
G. consobrinus (Eichhoff, 1878)*	*N. dombeyi*	Regions of Valparaíso, La Araucania (Cherquenco), Los Lagos (Los Muermos), Aysén (El Manso), Coquimbo (Parque Nacional Fray Jorge) (CL)
G. fimbriatus (Schedl, 1975)	*N. pumilio, N. dombeyi*, *N. betuloides, N. nervosa**, possibly others; also *Pinus contorta*, P. sylvestris**	Southern Chile, from region del Maule to region Magallanes y La Antártica Chilena (CL).
G. herbertfranzi (Schedl, 1973)	*N. dombeyi*, *N. pumilio*	Regions La Araucania (Malalcahuello), Los Lagos (Antillanca), Aysén (El Manso), Magallanes y La Antártica Chilena (Montealto) (CL)
G. impressus (Schedl, 1975)	*N. antarctica*, *N. dombeyi*	Region Aysén (El Manso) (CL); Parque Nacional Nahuel Huapi (AR)
G. longipennis (Blanchard, 1851)*	*N. dombeyi*, polyphagous	Regions Valparaíso (Valparaíso, Zapallar), Los Ríos (Valdivia), La Araucania (Curacautin);

Gnathotrupes **species**	**Host species**	**Distribution**
		Aysén (El Manso) (CL), Parque Nacional Nahuel Huapi (AR)
G. longiusculus (Schedl, 1951)	*N. dombeyi*, *N. pumilio*, possibly others	Southern Chile, from region del Maule to region Magallanes y La Antártica Chilena (CL); Parque Nacional Nahuel Huapi and Tierra del Fuego (AR)
G. nanulus (Schedl, 1972)*	*N. dombeyi*	Parque Nacional Nahuel Huapi (AR)
G. nanus (Eichhoff, 1878)	*N. dombeyi*, *N. pumilio*	Regions Bío-Bío (Conception); Aysén (El Manso) (CL), Parque Nacional Nahuel Huapi (AR)
G. naumanni (Schedl, 1975)*	*N. dombeyi*	Parque Nacional Nahuel Huapi (AR)
G. nothofagi Schedl, 1975	*N. dombeyi*	Region Aysén (El Manso) (CL); Parque Nacional Nahuel Huapi (AR)
G. pustulatus Schedl, 1975	*N. dombeyi*, *N. pumilio*	Regions Los Lagos (Puerto Varas), Aysén (El Manso) (CL); Parque Nacional Nahuel Huapi (AR)
G. vafer (Schedl, 1975)	*N. pumilio*, *N. dombeyi*, *N. betuloides*, possibly others	Regions Aysén (El Manso)(CL); Parque Nacional Nahuel Huapi (AR). Probably more widely distributed
G. velatus Schedl, 1975	*N. dombeyi*	Region Aysén (Reserva Nacional Cerro Castillo) (CL); Parque Nacional Nahuel Huapi (AR)

References (all URLs were accessed in January 2018)

Aguayo Silva J, Ojeda Alvarado A, Baldini Urrutia A, Cerda Martinez L, Emanuelli Avilés P, Kirkendall LR, Sartori Ruilova A. 2008. Manual de plagas y enfermedades del bosque nativo en Chile Manual de Cooperación Técnica. FAO, Santiago de Chile

Alvarado AB. 2016. Bosque nativo, comunidades y cambio climático. Avances en el Diseño y Preparación de la Estrategia Nacional de Cambio Climático y Recursos Vegetacionales de Chile (ENCCRV), y Propuestas para su implementación. 230 p

De Errasti A, De Beer ZW, Coetzee MPA, Roux J, Rajchenberg M, Wingfield MJ. 2016. Three new species of Ophiostomatales from *Nothofagus* in Patagonia. Mycological progress, 15(2), p.17.

De Errasti A. 2016. Hongos manchadores de albura en especies forestales exóticas y nativas de los Andes Patagónicos: taxonomía, patogenicidad y manejo 2016 06 27 Tesis Doctoral Facultad de Ciencias Exactas y Naturales Universidad de Buenos Aires

Hulcr J, Stelinski LL. 2017. The Ambrosia Symbiosis: From Evolutionary Ecology to Practical Management. Annu. Rev. Entomol. 62:285–303

Informativo Fitosanitario Forestal, 2012. Article on *Gnathotrupes fimbriatus*. no. 8, Agosto de 2012. Gobierno de Chile.

Kirkendall LR. 2011. Native ambrosia beetles (*Gnathotrupes* spp.) and Southern Beech Decline in Chile. In: IUFRO WP.7.03.05 - Novel risks with bark and wood boring insects in broadleaved and conifer forests, Sopron, Hungary

Kirkendall LR, Biedermann PHW, Jordal BH. 2015. Evolution and Diversity of Bark and Ambrosia Beetles. Chapter 3 in Bark Beetles, Biology and Ecology of Native and Invasive Species, 1st Edition, Vega F and Hofstetter R (eds), Academic Press

Kirkendall LR. 2008. *Gnathotrupes fimbriatus*: an ambrosia beetle attacking southern beech (*Nothofagus* spp). Internet article. http://folk.uib.no/nzllk/bark%20beetle%20websites/Kirkendalls_bark_beetles/Gnathotrupes_fimbriatus.html

Mark J, Newton AC, Oldfield S, Rivers M. 2014. International Timber Trade: A working list of commercial timber tree species Botanic Gardens Conservation International, Richmond, UK.

Naumann-Etienne K. 1978. Morphological, zoogeographical and biological aspects of the Scolytidae from *Nothofagus dombeyi* in Argentina. Studies on Neotropical Fauna and Environment 13:51-62

Scanu B, Jones B, Webber JF. 2012. A new disease of *Nothofagus* in Britain caused by *Phytophthora pseudosyringae*. New Disease Reports 25, 27.

Wood SL, Bright DE. 1992. A Catalog of Scolytidae and Platypodidae (Coleoptera), Part 2: Taxonomic Index. Great Basin Nat. Mem. 13:1–1553

Wood SL. 2007. The Bark and Ambrosia Beetles of South America (Coleoptera, Scolytidae). Provo, Utah: Monte L. Bean Life Science Museum, Brigham Young University. 230 plates, 900 pp.

This text is an integral part of the *EPPO Study on bark and ambrosia beetles associated with imported non-coniferous wood* and should be read in conjunction with the study

Pest information sheet
Bark beetle

HYPOTHENEMUS ERUDITUS (COLEOPTERA: SCOLYTINAE)

EPPO Lists: Not listed. The assessment of potential risks in this information sheet is not based on a full PRA for the EPPO region, but on an assessment of the limited information for that species used to prepare the information sheet.

PEST OVERVIEW

Taxonomy

Hypothenemus eruditus Westwood, 1836. *H. eruditus* currently has 71 recognized synonyms (Vega *et al.*, 2015). Recent molecular studies support the existence of many potential sibling species, and the authors support that many sequenced taxonomic units or current synonyms deserve species status (Kamberstad, 2011; Kamberstad *et al.*, 2017). The information here refers to *H. eruditus sensu lato*.

Associated fungi

The following fungi were found associated with this species: *Ophiostoma pluriannulatum*, *O. quercus*, *Fusarium circinatum*, *F. culmorum*, *F. lateritium*, *Pesotum fragrans* (Lopez Romero *et al.*, 2007). *F. circinatum* is pathogenic on *Pinus*. No information was sought on the pathogenicity of other species.

Morphology and biology

Adults measure ca. 1 mm long (Huang *et al.*, 2016, citing others; see this publication for details on the morphology of the different life stages). In addition to plants, *H. eruditus* has been recorded in various other material, such as fungal fruiting bodies, manufactured products, drawing boards, book bindings/covers (hence its species name) (Vega *et al.*, 2015; Browne, 1961; Karlshoven, 1958), and in the galleries of other beetles (Huang *et al.*, 2016 – Beaver, 1987, in old longhorn tunnels in dead stems of *Cajanus cajan*).

On plants, *H. eruditus* develops in the phloem of small branches (Lopez Romero *et al.*, 2007), but also in the bark of trunks or branches, in flowers, weeds, grasses and seeds (Wood, 1977). It is apparently especially associated with leaf petioles or twigs, but also seeds and fruits (Vega *et al.*, 2015; Huang *et al.*, 2016). Karlshoven (1958) includes an extensive list of findings in Java, that mention: bark, pods, withered plant parts, saplings and seedling stems, old fallen fruits (*Castanea*), dry fruits (several plant species) and coffee berries.

H. eruditus is an inbreeder. Females mate usually with males from the same brood/gallery (i.e. sibling-mating), or with non-sibling males when different galleries meet (Huang *et al.*, 2016). Dispersing mated females exit via the original entrance hole or through new exit holes (Huang *et al.*, 2016). In the field, development (egg to adult) takes approximately 28 days (Huang *et al.* 2016, citing Browne 1961). *H. eruditus* is 'unusually tolerant to low humidities' (Browne, 1961).

Spread biology

Females of *H. eruditus* fly, but no details were found on their flight capacity. Males are flightless (Huang *et al.*, 2016).

Nature of the damage

In small branches, *H. eruditus* tunnels irregular and shallow galleries, with the maternal gallery generally measuring 1-3 cm (Lopez Romero *et al.*, 2007).

Detection and identification

H. eruditus is highly attracted to ethanol (Huang *et al.*, 2016). *H. eruditus* can be confused with *H. seriatus* and *H. birmanus*. Differences are detailed in Han *et al.* (2016). Its small size makes morphological identification difficult, and there may also be a large number of cryptic species in the *H. eruditus* complex (see Taxonomy).

Distribution (see Table 1)

H. eruditus is present in all tropical and subtropical regions of the world and its distribution also extends to many temperate regions (Huang *et al.*, 2016). In the EPPO region, there are records from some Mediterranean countries, as well as Azerbaijan and Georgia. It is considered by some sources as the world's most common Scolytinae, because of its wide geographical distribution and host range (e.g. Kamberstad *et al.*, 2017). In California, its introduction is thought to have occurred over 100–150 years ago (Seybold *et al.*, 2016).

Host plants (Table 2)

H. eruditus is qualified as a "super generalist" since it can feed on a wide variety of phylogenetically diverse plants (Huang *et al.*, 2016). Its deciduous hosts include numerous tropical, subtropical and temperate species, including wild and cultivated forest and fruit species. A comprehensive list is provided in Atkinson (2018), and mentions hosts species in over 110 genera and 50 families. A few of the hosts that are present in the EPPO region are: *Ficus carica, Alnus, Castanea, Citrus, Diospyros kaki, Eucalyptus, Eriobotrya japonica, Fraxinus, Juglans, Malus, Morus, Pistacia, Prunus, Pyrus, Salix, Tilia* (hosts extracted from Lopez Romero *et al.*, 2007 and Atkinson, 2018). *H. eruditus* has also been recorded on conifers (*Pinus, Cryptomeria japonica, Abies balsamea*) and on non-woody plants such as *Saccharum officinarum*. Seybold *et al.* (2016) mention it was also recorded on weeds. Despite the already extensive host range and the fact that it has been documented for a long time, new host records are still published (e.g. *Alnus* and *Pterocarya fraxinifolia* in Iran, Amini *et al.*, 2017). It is probable that the list of host plants, at least with regards deciduous trees and bushes, is longer than currently documented. Some hosts are listed in Table 2.

Known impacts and control in current distribution

Lopez Romero *et al.* (2007) considers *H. eruditus* to be of potential economic importance, because of previous observations in various tropical countries showing that it is capable of killing transplants and seedlings (citing Beaver, 1987). Death of cocoa seedlings has been reported (Vega *et al.*, 2015, citing others; Browne, 1961). Beaver and Browne (1978) and Beaver (1987) refer in a general manner to damage to transplants and seedlings citing older publications; however, these could not be found, and it was not possible to determine on which other hosts mortality has been observed. Finally, Wood (1977) mentions that *H. eruditus* is frequently of economic importance in mature seeds or pods in the field and in storage.

More recent references from various countries do not indicate damage. Huang *et al.* (2016) note that, despite its prevalence, *H. eruditus* does not cause any significant economic damage and requires no management. It has been reported inside coffee berries, but does not consume the seeds and does not reproduce in them (Han *et al.*, 2016, citing others). In País Vasco (Spain), it has also presented a phoretic association with the pathogenic fungus *Fusarium circinatum* (Lopez Romero *et al.*, 2007). *H. eruditus* was the most abundant bark and ambrosia beetle species in a *Pinus taeda* and an *Eucalyptus grandis* stand in the state of Parana (Brazil), but it was not amongst the species found to be aggressive during this study (Flechtmann *et al.*, 2001). *H. eruditus* was common during a survey of Scolytinae in hazelnut orchards in Turkey (Tuncer *et al.*, 2017).

Control: No mention of control was found in the literature.

POTENTIAL RISKS FOR THE EPPO REGION

Pathways

Entry

When plants are attacked, life stages are in the bark. Wood commodities with bark may be a pathway. Regarding round wood and sawn wood, it is not clear if it is associated with large diameter trunks, as the information available appears to refer to small-size material, but it may be associated with commodities using small diameter material (e.g. possibly firewood as round wood). It has also been intercepted in the Korean Republic on 'logs and timber' of *Aralia elata* from China (Choi *et al.*, 2003), and round and sawn wood are therefore considered a pathway. Processes applied to produce wood commodities may destroy some individuals (even if *H. eruditus* is very small). The likelihood of entry on wood chips, hogwood and processing wood residues would be lower than on round wood, as individuals would have to survive processing and transport, and transfer to a suitable host is less likely. Finally, bark on its own could carry the pest. There has been one record on veneer, for which it is assumed that *H. eruditus* would have infested already processed material, and processed wood commodities may therefore also be a pathway (which is an unusual case among bark beetles).

H. eruditus appears to attack mostly small-diameter plant material, including branches, seedlings, leaf petioles and twigs, and plants for planting could therefore be a main pathway. It could also be associated with cut branches of non-coniferous woody plants. It has been mentioned in association with fruits (including pods, coffee berries, chestnut etc., but this seems to relate to old fallen fruit) and various material (which it could contaminate).

Due to its large host range, and frequent new host records, all woody deciduous plants may be considered as potential hosts, as well as the known coniferous and herbaceous hosts.

Finally, *H. eruditus* is an inbreeder, which is favourable to entry and establishment.

Summary of pathways (uncertain pathways are marked with '?'):

- *wood (round or sawn, with bark, incl. firewood) of hosts*
- *bark of hosts*
- *wood chips, hogwood, processing wood residues (except sawdust and shavings)*
- *wood packaging material if not treated according to ISPM 15*
- *processed wood material (e.g. plywood, veneer)*
- *plants for planting (except seeds) of hosts*
- *cut branches of hosts*
- *host fruit?*
- *hitchhiking on various material?*

Because of the large and uncertain host range, pathways may cover all non-coniferous species (as well as known coniferous and herbaceous hosts where relevant).

Spread (following introduction, i.e. within EPPO region)

There is no specific information on natural spread, but females fly. *H. eruditus* may be associated with a wide variety of plant material exchanged between countries. Human-assisted pathways would contribute to spread.

Establishment

H. eruditus is already established in part of the EPPO region. The host range is not limiting as it may attack many species. *H. eruditus* appears overall to favour tropical and subtropical climates, although it thrives in the Mediterranean and in countries with hot summers and cold winters (North of Iran, Azerbaijan and Turkey). In the UK, it has not established outdoors. It may be that different cryptic species have different climatic requirements, but there are only few records from temperate areas to date. Therefore, establishment in the oceanic and temperate part of the EPPO region is considered less likely.

Potential impact (including consideration of host plants)

H. eruditus is highly polyphagous and may attack many plants and plant products in the EPPO region. There are references from the 1960s-80s on damage related to seedlings and transplants, i.e. implying a risk for nurseries and young plantations, and possibly hosts in the wild. However, the literature overall reflects little damage in its current distribution, including in EPPO countries. *H. eruditus* is now considered to be a complex of species, and it is not known if the death of seedlings and transplants reported from South-East Asia, may be due to one or several aggressive cryptic species (there is currently no evidence of this). Considering its wide host range, its abundance, wide distribution, and the fact that it attacks small material (seedlings, leaf petioles etc.), and may therefore be associated with plants for planting, *H. eruditus* may have already had numerous possible occasions to enter the EPPO region on plants for planting, which represents a huge trade. It is considered that impact may only occur if some aggressive cryptic species not yet present in the EPPO region are introduced from South-East Asia.

Table 1. Distribution

All records are from Atkinson (2018) except where a reference is given.

	Reference
EPPO region	
Algeria	
France	
Georgia	
Israel	
Italy	Masutti, 1968
Malta	Mifsud & Colonnelli, 2010
Morocco	
Spain	
Turkey	Tuncer *et al.*, 2017
UK	indoors, Turner and Beaver, 2015
Uncertain: Azerbaijan	unpublished record
Africa	
Algeria	
Angola	
Azores	
Cameroon	
Canary Island	
Cote d'Ivoire	
Egypt	
Gabon	
Ghana	
Guinea	
Liberia	
Madagascar	
Morocco	
Nigeria	
South Africa	
Seychelles	
Sierra Leone	
Tanzania	
Togo	
Uganda	
Zaire	
Asia	
Burma	
India	
Indonesia	
Iran	
Japan	
Malaysia	
Marquesas Isl.	
Philippines	
Sri Lanka	
Thailand	
Vietnam	
Uncertain: Taiwan	unpublished record
North America	
Canada (Ontario)	
Mexico	
USA (Alabama, California, Delaware, Dist. of Columbia, Florida, Georgia, Illinois, Indiana, Louisiana, Maryland, Michigan, Minnesota, Mississippi, New Hampshire, New Jersey, New York, North Carolina, Oklahoma, Pennsylvania, South Carolina, Tennessee, Texas, Virginia, West Virginia, Hawaii). *Uncertain*: Massachusetts, Nebraska	unpublished records
Central America	
Costa Rica	
Guatemala	
Honduras	
Nicaragua	
Panamá	
Uncertain: El Salvador	unpublished records
Caribbean	
Cuba	
Dominica	
Guadeloupe	
Jamaica	
Nevis	
Puerto Rico	
Rep. Dominicana	
Uncertain: Bahamas, St. Vincent, Virgin Isl.	unpublished records
South America	
Argentina	
Brazil (Amapá, Bahia, Ceará, Goias, Mato Grosso do Sul, Paraiba, Pernambuco, Rio Grande do Sul, Santa Catarina, São Paulo)	Some states correspond to unpublished records in Atkinson, 2018
Colombia	
Ecuador	
Peru	
Trinidad and Tobago	
Venezuela	
Uncertain: Guyana, Venezuela	unpublished records
Oceania	
Australia (New South Wales). *Uncertain*: Queensland	unpublished record
Cook Islands	
Fiji	
Micronesia	
New Caledonia	

Table 2. Host genera in Atkinson (2018)

Family	Genus
Acanthaceae	*Avicennia*
Altingiaceae	*Liquidambar*
Anacardiaceae	*Astronium*
Anacardiaceae	*Mangifera*
Anacardiaceae	*Rhus*
Anacardiaceae	*Spondias*
Anacardiaceae	*Toxicodendron*
Annonaceae	*Annona*
Annonaceae	*Asimina*
Apocynaceae	*Plumeria*
Apocynaceae	*Thevetia*
Apocynaceae	*Sarcostemma*
Aquifoliaceae	*Ilex*
Arecaceae	*Cocos*
Asparagaceae	*Yucca*
Betulaceae	*Alnus*
Betulaceae	*Carpinus*
Bignoniaceae	*Jacaranda*
Bignoniaceae	*Tabebuia*
Bixaceae	*Bixa*
Boraginaceae	*Cordia*
Burseraceae	*Bursera*
Burseraceae	*Protium*
Burseraceae	*Tetragastris*
Capparaceae	*Crateva*
Capparaceae	*Capparis*
Caricaceae	*Carica*
Celastraceae	*Euonymus*
Combretaceae	*Terminalia*
Convolvulaceae	*Calonyction*
Convolvulaceae	*Ipomoea*
Cornaceae	*Cornus*
Cucurbitaceae	*Lagenaria*
Cucurbitaceae	*Luffa*
Cucurbitaceae	*Melothria*
Cucurbitaceae	*Schizocarpum*
Ebenaceae	*Diospyros*
Euphorbiaceae	*Croton*
Euphorbiaceae	*Hura*
Euphorbiaceae	*Jatropha*
Euphorbiaceae	*Mabea*
Euphorbiaceae	*Manihot*
Euphorbiaceae	*Ricinus*
Fabaceae	*Caesalpinia*
Fabaceae	*Delonix*
Fabaceae	*Senna*
Fabaceae	*Tamarindus*
Fabaceae	*Copaifera*
Fabaceae	*Acacia*
Fabaceae	*Albizzia*
Fabaceae	*Inga*
Fabaceae	*Pentaclethra*
Fabaceae	*Pithecellobium*
Fabaceae	*Andira*
Fabaceae	*Cercis*
Fabaceae	*Gleditsia*
Fabaceae	*Lonchocarpus*
Fagaceae	*Quercus*
Hamamelidaceae	*Hamamelis*
Juglandaceae	*Carya*
Juglandaceae	*Juglans*
Juglandaceae	*Pterocarya*
Lamiaceae	*Gmelina*
Lamiaceae	*Tectona*
Lauraceae	*Persea*
Lecythidaceae	*Eschweilera*
Lecythidaceae	*Gustavia*
Magnoliaceae	*Liriodendron*
Magnoliaceae	*Magnolia*
Malpighiaceae	*Byrsonima*
Malvaceae	*Ceiba*
Malvaceae	*Quararibea*
Malvaceae	*Apeiba*
Malvaceae	*Gossypium*
Malvaceae	*Guazuma*
Malvaceae	*Luhea*
Malvaceae	*Theobroma*
Malvaceae	*Tilia*
Melastomataceae	*Miconia*
Meliaceae	*Swietenia*
Moraceae	*Artocarpus*
Moraceae	*Brosimum*
Moraceae	*Castilla*
Moraceae	*Cecropia*
Moraceae	*Ficus*
Moraceae	*Morus*
Moraceae	*Trophis*
Moringaceae	*Moringa*
Musaceae	*Musa*
Myristicaceae	*Myristica*
Myrtaceae	*Psidium*
Olacaceae	*Ximenia*
Pinaceae	*Abies*
Poaceae	*Olmeca*
Poaceae	*Saccharum*
Pteridaceae	*Acrostichum*
Rhamnaceae	*Ziziphus*
Rhizophoraceae	*Rhizophora*
Rosaceae	*Malus*
Rosaceae	*Prunus*
Rutaceae	*Citrus*
Rutaceae	*Esenbeckia*
Salicaceae	*Salix*
Sapindaceae	*Acer*
Sapindaceae	*Cardiospermum*
Sapindaceae	*Cupania*
Sapindaceae	*Melicoccus*
Sapindaceae	*Serjania*
Sapotaceae	*Pouteria*
Solanaceae	*Cestrum*
Theaceae	*Camelia*
Ulmaceae	*Celtis*
Ulmaceae	*Ulmus*
Vitaceae	*Vitis*

References (All URLs were accessed in January 2018)

Amini S, Nozari J, Mandelshtam MY, Knížek M, Etemad V, Faccoli M. 2017. New records of Iranian bark beetles (Coleoptera: Curculionidae, Scolytinae) and their host plants. Zootaxa. 2017 Nov 17;4350(2):396-400. doi: 10.11646/zootaxa.4350.2.13. (abstract)

Atkinson TH. 2018. Bark and Ambrosia beetles. http://www.barkbeetles.info

Beaver RA. 1987. The bark and ambrosia beetles (Coleoptera: Scolytidae and Platypodidae) of Tonga. New Zealand Entomologist, 9: 64-70.

Beaver RA, Browne FG. 1978.The Scolytidae and Platypodidae (Coleoptera) of Penang, Malaysia. Oriental Insects Vol. 12(4)

Browne FG. 1961. The biology of Malayan Scolytidae and Platypodidae. Malayan Forest Records 22: 1-255.

Choi EG, Choo HY, Lee DW, Lee SM, Park JK. 2003. Scolytidae, Platypodidae, Bostrichidae and Lyctidae Intercepted from Imported Timbers at Busan Port Entry. Korean Journal of Applied Entomology: Vol.42 No.3 pp.173-184

Flechtmann CAH, Ottati ALT, Berisford CW. 2001. Ambrosia and bark beetles (Scolytidae: Coleoptera) in pine and eucalypt stands in southern Brazil. Forest Ecology and Management 142 (2001) 183-191.

Huang YT, Hulcr,J, Johnson AJ, Lucky A. 2016. *Hypothenemus eruditus* Westwood, 1836 (Insecta: Coleoptera: Curculionidae: Scolytinae). Publication Number: EENY-664. Publication Date: August 2016. Featured Creatures University of Florida's Entomology and Nematology Department and the Florida Department of Agriculture and Consumer Services' Division of Plant Industry. http://entnemdept.ufl.edu/creatures/trees/beetles/Hypothenemus_eruditus.htm

Hulcr J, Atkinson TH, Cognato AI, Jordal BH, McKenna DD. 2015. Morphology, Taxonomy, and Phylogenetics of Bark Beetles. Chapter in Bark Beetles. Biology and Ecology of Native and Invasive Species. *Edited by:Fernando E. Vega and Richard W. Hofstetter*. ISBN: 978-0-12-417156-5, Elsevier

Johnson AJ, Kendra PE, Skelton J, Hulcr J. 2016. Species Diversity, Phenology, and Temporal Flight Patterns of *Hypothenemus* Pygmy Borers (Coleoptera: Curculionidae: Scolytinae) in South Florida. Environ Entomol. 2016 Apr 22. pii: nvw039.

Kalshoveln LGE. 1958. Studies on the biology of Indonesian Scolytoidea. 4. Data on the habits of Scolytidae. First part. Tijdschr. Ent. 101: 157-180.

Kambestad M. 2011. Coexistence of habitat generalists in neotropical petiole-breeding bark beetles: molecular evidence reveals cryptic diversity, but no niche segregation. M.S. thesis, University of Bergen.

Kambestad, M., Kirkendall, L.R., Knutsen IL, Jordal BH. 2017. Cryptic and pseudo-cryptic diversity in the world's most common bark beetle-*Hypothenemus eruditus*. Org Divers Evol (2017) 17: 633-652.

López Romero S, Romón Ochoa P, Iturrondobeitia JC, Goldaracena Lafuente A. 2007. Los escolítidos de las coníferas del País Vasco: guía práctica para su identificación y control - 1ª ed. - Colección Lur Nº 11Vitoria-Gasteiz: Eusko Jaurlaritzaren Argitalpen Zerbitzu Nagusia = Servicio Central de Publicaciones del Gobierno Vasco, 2007

Lunz AM, Acacio E, De Carvalho G. 2002. Degradação da Madeira de Seis Essências Arbóreas Disposta Perpendicularmente ao Solo Causada por Scolytidae (Coleoptera). Neotropical Entomology 31(3), 351-357

Masutti L 1968. Notizie sulla distribuzione in Italia dell'Hypothenemus eruditus Westwood (Coleoptera, Scolytidae). Annali Museo Civico Storia Naturale Genova 77: 360-370

Padil. 2017. PaDIL – High quality images and Information tools designed for Biosecurity and Biodiversity. Biosecurity and Biodiversity: protecting against invasive pests and diseases and discovery of native species. Australian Government Department of Agriculture and Water Resources. http://www.padil.gov.au/pests-and-diseases/pest/references/135829

Seybold SJ, Penrose RL, Graves AD. 2016. Invasive Bark and Ambrosia Beetles in California Mediterranean Forest Ecosystems. Chapter In Insects and Diseases of Mediterranean Forest Systems pp 583-662.

Tuncer C, Knížek M, Hulcr J. 2017. Scolytinae in hazelnut orchards of Turkey: clarification of species and identification key (Coleoptera, Curculionidae). ZooKeys 710: 65–76. https://doi.org/10.3897/zookeys.710.15047

Turner CR, Beaver RA. 2015. *Hypothenemus eruditus* Westwood and *Hypothenemus seriatus* (Eichhoff) (Curculionidae: Scolytinae: Cryphalini) in Britain. The Coleopterist 24(1):12-15, April 2015

Vega FE, Infante F, Johnson AJ. 2015. The Genus *Hypothenemus*, with Emphasis on *H. hampei*, the Coffee Berry Borer. Chapter in bark Beetles. Biology and Ecology of Native and Invasive Species. *Edited by:Fernando E. Vega and Richard W. Hofstetter*. ISBN: 978-0-12-417156-5, Elsevier

This text is an integral part of the *EPPO Study on bark and ambrosia beetles associated with imported non-coniferous wood* and should be read in conjunction with the study

Pest information sheet
Ambrosia beetle

MEGAPLATYPUS MUTATUS (COLEOPTERA: PLATYPODINAE)

taladrillo grande de los forestales, barreno de los forestales y frutales (Spanish)

EPPO Lists: Megaplatypus mutatus was added to the EPPO A2 List of pests recommended for regulation in 2007. It is currently not regulated by EPPO countries (EPPO Global Database; EPPO, 2018). This pest information sheet uses information from the EPPO PRA and data sheet (EPPO, 2007, 2009) as well as from the literature published since.

PEST OVERVIEW

Taxonomy

Megaplatypus mutatus (Chapuis), Synonyms: *Platypus sulcatus* Chapuis, *Platypus plicatus* Brèthes, *Platypus mutatus* Chapuis (EPPO, 2009).

Associated fungi

Raffaelea santoroi (non-pathogenic) was the only known symbiont until recently (EPPO, 2009). In a recent study (Ceriani-Nakamurakare *et al.*, 2016a), 19 fungi were recovered in galleries of *M. mutatus* and 12 in adults and larvae. Most strains belonged to *Fusarium solani,* and other species included *Raffaelea arxii*, three *Raffaelea* sp., and *Graphium basitruncatum*; *R. santoroi* was not recovered, which suggests an occasional association. The authors concluded that especially *Fusarium*, *Raffaelea* and *Graphium* may have a role in the association with *M. mutatus*, and that the interaction with *F. solani* species complex is particularly relevant due to its potential role as a plant pathogen. No information was found on the pathogenicity of the other fungi associated with *M. mutatus*.

Morphology and biology (from EPPO, 2009 and EPPO PRA, 2007, both citing other sources)

Adults measure ca. 7-9 mm long, and are relatively large for ambrosia beetles. The morphology of the life stages of *M. mutatus* is described in detail in EPPO (2009). *M. mutatus* has one generation per year in South America and in Italy. It overwinters mainly as mature larvae or immature adults. Occasionally a few adults emerge before winter but, if a second generation is started, it is interrupted by cold. Adults appear in the field in late spring-early summer. Males start emerging a few days before females, and fly to tree trunks over 15 cm in diameter, in which they bore a radial gallery directed towards the centre of the trunk, and attract females by releasing a specific pheromone. After emergence, the adult has to find a new host within a maximum of 5 days. After mating, the two adults bore new galleries inside the trunk, in which the female lays 100–200 eggs over a period of 2–3 months. The first and second instar larvae of *M. mutatus* are mycetophagous, later they become xylophagous. The larvae generally reach maturity in the 5 months before the cold season or in early spring. They pupate in spring. The mean diameter of galleries of *M. mutatus* is 4.5 mm, but the diameter of larvae is 2.5 mm. The pest is known to have a very low rate of success in penetrating and reproducing in a tree (EPPO PRA, 2007). On certain hosts (such as cherry, apricot), there may be a large number of entry holes but galleries remain superficial and are blocked by the sap produced by the plant in reaction to the attack, and the pest does not complete its development (Griffo *et al.*, 2012; SFR Campania, 2015).

Spread biology

Adults fly, generally within a range of 50-100 m from the emergence hole. The adult is not a very good flyer, and is not likely to spread more than 100 m (EPPO, 2009, giving sources).

Nature of the damage

M. platypus is a primary pest and attacks only live standing trees. It does not attack declining trees or cut wood, and will only be present in them as a result of earlier primary attack. *M. mutatus* tunnels in the xylem, which weakens the trees, reducing yield (in wood volume) and causing breakage by wind, and even killing trees which are highly stressed. A major damage is loss of wood quality and value due to the presence of galleries and their dark fungal discoloration. Fruit trees are weakened by the galleries, produce less fruit, and become liable to breakage by wind (EPPO, 2009).

Detection and identification

- *Symptoms*. The main sign of infestation is the presence of holes 3 mm wide, exuding dust, sap and frass in early summer (EPPO, 2009; Alfaro *et al.*, 2007). The galleries are lined with the black fungal mycelium (EPPO, 2009). Nursery practices are considered sufficient to detect an infestation as evidenced by the production of sawdust (inspection of the trunks) (EPPO PRA, 2007).
- *Trapping*. The sex pheromones of *M. mutatus* males have been identified (EPPO, 2009 citing others) and work carried out in their use (e.g. Funes *et al.*, 2009). Pheromone traps were used for monitoring in Campania (Gonzalez-Audino *et al.*, 2013).
- *Identification*. The morphology of life stages is described in EPPO (2009, citing sources).

Distribution (see Table 1)

M. mutatus is native to South America. It was first found in Italy in 2000 in Campania, and was still restricted to that area in 2006 (EPPO PRA, 2007), and was found in Southern Lazio in 2016 (Regione Lazio, 2017).

Host plants (see Table 2)

M. mutatus is highly polyphagous, with known hosts belonging to over 35 non-coniferous and 2 coniferous genera. In South America and Italy, *Populus* are the main hosts. In Italy, it was recorded in Campania on: poplar, oak, pear, eucalyptus, peach, apricot, apple, cherry, mulberry, *Robinia* as well as some new host genera (*Corylus*, *Castanea* and *Juglans*), and was observed to complete its development only on some of these species (in 2007: poplar, hazelnut and apple) (SFR Campania, 2015). It is not clear if all hosts in Table 2 are breeding hosts.

Known impacts and control in current distribution

In South America, some poplar producers have lost their high quality wood market and have been obliged to diversify their activity to maintain their income, or else have lost income because of trading a lower quality product (EPPO, 2009). In Argentina, *M. mutatus* is a serious problem in commercial plantations of a number of broadleaf tree species, but is especially damaging to poplars (*Populus deltoides*) because it reduces wood quality and makes it unsuitable for certain uses (Alfaro *et al.*, 2007). On average 4 to 40% of trees are attacked in infested areas (EPPO PRA, 2007). *M. mutatus* has threatened an area of protected trees (*Salix*) in Argentina (EPPO PRA, 2007) (no details were found on possible damage in that area). On *Casuarina cunninghamiana* (an exotic tree commonly used in windbreaks) in Argentina, damage has worsened since the first symptoms were observed in 2007, with complete loss of windbreaks in some cases. In a survey in farms of Entre Rios and Corrientes Provinces, the loss of windbreaks reached 5-90% (Ramos *et al.*, 2015). In the same area, concerns were raised about possible attacks on *Eucalyptus* (the most important forest tree of that area), because of damage reported on *E. camaldulensis* in Uruguay with multiple internal galleries causing breakage (Ramos *et al.*, 2015).

In Italy, *M. mutatus* has caused damage to poplar (reduction of wood quality) and to fruit and nut crops (*Malus, Corylus*) (EPPO, 2009). Walnut and poplar plantations grown for timber production have sustained the greatest economic damage according to Alfaro *et al.* (2007). Severe infestations were noticed in the province of Caserta, mainly on *Corylus avellana*, but also on *Prunus cerasus*, *Pyrus communis* and *Malus domestica* (EPPO, 2004). On plum and kaki (persimmon), the percentage of plants attacked can reach 30% in some cases (Griffo *et al.*, 2012).

Control: In Argentina, early detection and destruction of infested trees is used, as well as injecting insecticides into the galleries or spraying trunks during peak adult emergence in spring (EPPO PRA, 2007). Pheromone-baited traps have been investigated on hazelnut and poplar for mating disruption; although labor intensive, they allow to reduce damage (Funes *et al.*, 2011; Ceriani-Nakamurakare *et al.*, 2016b) and in Italy, the number of active galleries was reduced by 65% on poplar and 56% on hazelnut (Griffo *et al.*, 2012).

POTENTIAL RISKS FOR THE EPPO REGION

Pathways

Entry

The introduction of *M. mutatus* into Italy might be linked to a single trial shipment of poplar round wood with bark from Argentina in 1998. No record of interceptions was found in the literature. The main pathways of entry, as defined in the EPPO PRA (2007), are: plants for planting of host plants with trunks of more than 15 cm diameter; round wood of host plants of more than 15 cm diameter; sawn wood and wood packaging material. The risk of sawn wood was perceived to be lower than round wood because the survival of larvae will be lower as humidity declines. It was noted that wood processing will destroy the pest (poplar wood is mostly processed for pulp, paper, cardboard and plywood production). Debarking will not eliminate the possibility of association of the pest with wood commodities. The host genera mostly traded as wood according to the EPPO PRA (2007) were *Acer, Eucalyptus, Pinus, Platanus, Populus, Quercus, Ulmus, Juglans, Balfourodendron, Cedrela, Castanea*. The likelihood of entry of the pest was overall considered to be low in the EPPO PRA, because at that time few commodities were imported from areas where the pest occurs (the current situation has not been investigated here).

A number of pathways were not mentioned in the EPPO PRA, and are mentioned here for consistency with other pest information sheets in this study. The likelihood of entry on wood chips, hogwood and processing wood residues would be lower than on round wood, as individuals would have to survive processing and transport, and transfer to a suitable host is less likely. Bark on its own is an unlikely pathway (life stages are associated with the xylem). Finally, cut branches are an unlikely pathway unless of a large diameter. This may be the case for the coniferous hosts (as Christmas trees), though there is no information that these are traded; such material is normally used indoors, and the pest is unlikely to be able to transfer to a suitable host.

Summary of pathways:

- *wood (round or sawn, with or without bark, incl. firewood) of hosts of more than 15 cm diameter*
- *wood packaging material if not treated according to ISPM 15*
- *plants for planting (except seeds) of hosts (with trunks of more than 15 cm diameter)*
- *wood chips, hogwood, processing wood residues (except sawdust and shavings)*
- *cut branches (Christmas trees) of coniferous hosts?*

Spread (following introduction, i.e. within EPPO region)

Spread within Italy following the first finding in 2000 has been limited, in the sense that the pest is reported only from two adjacent areas. From 2000 to 2007, the area of distribution of *M. mutatus* increased from 130 km^2 to 587 km^2 (Allegro and Griffo, 2008). Between 2008 and 2012, the infestation's boundary had extended on average by 5 km per year (Griffo *et al.*, 2012). These rates of spread are higher than natural spread reflected under *Spread biology*. It is not known if the potential for natural spread is higher than previously reported, or if human-assisted pathways have played a role in the local spread in Italy (however, the pest has not been reported elsewhere in Italy, which could show more importance of human-assisted pathways). In 2016, *M. mutatus* was found in Southern Lazio, which is the region adjacent to Campania (Regione Lazio, 2017). Natural spread towards the rest of the EPPO region is expected to be slow, as the current distribution in Italy is far from any borders. Human-assisted pathways, especially the transport of poplar wood, may lead to multiple introductions from which local spread could occur, especially if it reaches areas of poplar plantations for wood production.

Establishment

Areas with suitable climates and host plants are available in the EPPO region, therefore establishment is possible. The availability of host plants will not restrict establishment: known hosts are widespread in the EPPO region, and *M. mutatus* is known to have attacked new hosts in South America and in Italy. The major host *Populus* is widely present in the EPPO region, in the wild, in plantations for wood production or other purposes, and as ornamentals. *M. mutatus* is already established in Italy (Campania, Lazio). Using a CLIMEX study (which had a high uncertainty), the EPPO PRA (2007) defined that the coasts of the following countries had a largely similar climate to Campania: Albania, Algeria, Croatia, France, Greece, Portugal, Spain and Turkey. It concluded that the whole Mediterranean coasts and Portugal were at risk (incl. Israel and North African countries). Considering that *M. mutatus* may have a slightly lower degree day per generation requirement than expected, this area could possibly be extended to Northern Italy, Austria, Azerbaijan, Bulgaria, Georgia, Hungary, Moldova, Republic of Macedonia, Romania, Russia, Slovakia, Slovenia, Ukraine (EPPO PRA, 2007). A wider establishment than originally assessed may also be expected as in Argentina it has extended its range into temperate regions (Neuquén in Patagonia, ca. 39°S) (Alfaro *et al.*, 2007).

Potential impact (including consideration of host plants)

M. mutatus may cause damage to a wide variety of trees which are present in the wild in the EPPO region or planted as forest trees, fruit trees, street trees, ornamentals and other purposes. One major impact would be loss of yield and quality of poplar wood, if it was introduced in areas where these trees are widely planted (e.g. Northern Italy). The limited natural spread may limit impact and allow for containment (if measures are applied). The potential impact was estimated to be high in the EPPO PRA (2007).

Table 1. Distribution

	Reference	Comments
EPPO region		
Italy	EPPO Global Database	First record in 2000 (province of Caserta, Campania). Still restricted to this area in 2006 (EPPO PRA, 2007). Found in Southern Lazio in 2016 (Regione Lazio, 2017).
South America		
Argentina	EPPO Global Database	
Bolivia	EPPO Global Database	
Brazil (Bahia, Espirito Santo, Parana, Rio de Janeiro, Rio Grande do Sul, Santa Catarina)	EPPO Global Database	
French Guiana	EPPO Global Database	
Paraguay	EPPO Global Database	
Peru	EPPO Global Database	
Uruguay	EPPO Global Database	
Venezuela	EPPO Global Database	
Absent, unreliable records: Colombia, Costa Rica	EPPO Global Database	

Table 2. Host plants (It is not clear if all hosts below are breeding hosts).

Family	Genus/Species	Reference
Altingiaceae	*Liquidambar styraciflua*	Giménez and Etiennot, 2003
Calophyllaceae	*Calophyllum*	Alfaro *et al.*, 2007
Calophyllaceae	*C. brasiliense*	Giménez and Etiennot, 2003
Casuarinaceae	*Casuarina*	Alfaro *et al.*, 2007
Casuarinaceae	*C. cunninghamiana*	Giménez and Etiennot, 2003
Casuarinaceae	*C. verticillata = C. stricta*	CPHST, 2016 citing others
Corylaceae	*Corylus avellana*	Allegro and Griffo, 2008
Cupressaceae	*Taxodium distichum*	Giménez and Etiennot, 2003
Ebenaceae	*Diospyros kaki*	Griffo *et al.*, 2012
Euphorbiaceae	*Sebastiania klotzschiana=S. commersoniana*	Giménez and Etiennot, 2003
Fabaceae	*Acacia*	Giménez and Etiennot, 2003
Fabaceae	*A. mearnsii*	Vinha Zanubcio *et al.*, 2010
Fabaceae	*Caesalpinia echinata*	Vinha Zanubcio *et al.*, 2010
Fabaceae	*Erythrina*	Alfaro *et al.*, 2007
Fabaceae	*E. crista-galli*	Giménez and Etiennot, 2003
Fabaceae	*Robinia pseudoacacia*	Giménez and Etiennot, 2003
Fagaceae	*Castanea sativa*	Allegro and Griffo, 2008
Fagaceae	*Quercus*	Giménez and Etiennot, 2003
Fagaceae	*Q. palustris*	Giménez and Etiennot, 2003
Fagaceae	*Q. robur*	Giménez and Etiennot, 2003
Fagaceae	*Q. rubra var. ambigua=Q. borealis*	Giménez and Etiennot, 2003
Juglandaceae	*Juglans regia*	Allegro and Griffo, 2008
Lamiaceae	*Vitex megapotamica*	Giménez and Etiennot, 2003
Lauraceae	*Laurus nobilis*	Giménez and Etiennot, 2003
Lauraceae	*Persea*	Alfaro *et al.*, 2007
Lauraceae	*P. americana*	EPPO GD

Family	Genus/Species	Reference
Magnoliaceae	*Magnolia grandiflora*	Giménez and Etiennot, 2003
Malvaceae	*Luehea divaricata*	Giménez and Etiennot, 2003
Malvaceae	*Tilia moltkei*	Giménez and Etiennot, 2003
Meliaceae	*Cedrela*	Alfaro *et al.*, 2007
Meliaceae	*C. tubiflora*	Giménez and Etiennot, 2003
Meliaceae	*Melia azedarach*	Giménez and Etiennot, 2003
Myrtaceae	*Angophora euryphylla*	Giménez and Etiennot, 2003
Myrtaceae	*Eucalyptus*	Giménez and Etiennot, 2003
Myrtaceae	*E. camaldulensis*	Giménez and Etiennot, 2003
Myrtaceae	*E. dunnii*	Giménez and Etiennot, 2003
Myrtaceae	*E. robusta*	Giménez and Etiennot, 2003
Myrtaceae	*E. tereticornis*	Giménez, 2009, citing others
Myrtaceae	*E. urophylla* × *E. camaldulensis*	Vinha Zanubcio *et al.*, 2010
Myrtaceae	*E. urophylla* × *E. grandis*	Vinha Zanubcio *et al.*, 2010
Oleaceae	*Fraxinus*	Giménez and Etiennot, 2003
Oleaceae	*F. excelsior*	Giménez and Etiennot, 2003
Oleaceae	*Ligustrum lucidum*	Giménez and Etiennot, 2003
Pinaceae	*Pinus*	Giménez and Etiennot, 2003
Platanaceae	*Platanus x acerifolia*	Giménez and Etiennot, 2003
Proteaceae	*Grevillea*	Alfaro *et al.*, 2007
Proteaceae	*G. robusta*	Giménez and Etiennot, 2003
Rosaceae	*Malus domestica*	EPPO, 2004 citing source
Rosaceae	*Malus sylvestris*	Giménez and Etiennot, 2003
Rosaceae	*Prunus armeniaca*	Allegro and Griffo, 2008
Rosaceae	*Prunus avium*	Allegro and Griffo, 2008
Rosaceae	*Prunus cerasus*	EPPO, 2004 citing source
Rosaceae	*Prunus pensylvanica*	EPPO GD
Rosaceae	*Prunus persica*	Giménez and Etiennot, 2003
Rosaceae	*Pyrus communis*	Giménez and Etiennot, 2003
Rutaceae	*Balfourodendron*	Alfaro *et al.*, 2007
Rutaceae	*B. riedelianum*	Giménez and Etiennot, 2003
Rutaceae	*Citrus*	Giménez and Etiennot, 2003
Salicaceae	*Populus*	Giménez and Etiennot, 2003
Salicaceae	*P. alba*	Giménez and Etiennot, 2003
Salicaceae	*P. deltoides*	Giménez and Etiennot, 2003
Salicaceae	*P. x canadensis*	Allegro and Griffo, 2008
Salicaceae	*P. x euroamericana*	Giménez and Etiennot, 2003
Salicaceae	*Salix alba*	Giménez and Etiennot, 2003
Salicaceae	*Salix babylonica*	Giménez and Etiennot, 2003
Salicaceae	*Salix nigra*	Giménez and Etiennot, 2003
Sapindaceae	*Acer*	EPPO, 2009
Sapindaceae	*A. negundo*	Giménez and Etiennot, 2003
Simaroubaceae	*Ailanthus*	EPPO, 2009
Simaroubaceae	*A. altissima*	Giménez and Etiennot, 2003
Ulmaceae	*Ulmus*	Giménez and Etiennot, 2003
Ulmaceae	*U. pumila*	Giménez and Etiennot, 2003

References (all URLs were accessed in January 2018)

Alfaro RI, Humble LM, Gonzalez P, Villaverde R, Allegro G. 2007. The threat of the ambrosia beetle *Megaplatypus mutatus* (Chapuis) (*Platypus mutatus* Chapuis) to world poplar resources. Forestry 80, 471–479.

Allegro G. 2008. Platipo. *Megaplatypus mutatus* Chapuis (Coleoptera, Platypodidae). Consiglio per la Ricerca e la Sperimentazione in Agricoltura (CRA), Italy. http://www.agricoltura.regione.lazio.it/binary/prtl_sfr/tbl_misure/platipo_cra.pdf

Allegro G, Griffo R. 2008. I rischi di diffusione di *Megaplatypus mutatus*. L'Informatore Agrario 13/2008, 73-77.

Ceriani-Nakamurakare E, Slodowicz M, Carmaran C, Gonzalez-Audino P. 2016b. Development of natural waxes dispensers for pheromones and use in mating disruption of the ambrosia beetle *Megaplatypus mutatus* in poplar (*Populus* spp) plantations. Agroforest Syst

Ceriani-Nakamurakare E, Slodowicz M, Gonzalez-Audino P, Dolinko A, Carmara C. 2016a. Mycobiota associated with the ambrosia beetle *Megaplatypus mutatus*: threat to poplar plantations. Forestry 2016; 89, 191–200

CPHST. 2016. Exotic Wood Borer/Bark Beetle *Megaplatypus mutatus* Survey Reference. Last updated: July 29, 2016.

EPPO. 2007. Pest Risk Analysis for *Megaplatypus mutatus.* Available at https://www.eppo.int

EPPO. 2009. Data sheets on pests recommended for regulation – *Megaplatypus mutatus*. EPPO Bulletin 39: 55-58.

EPPO. 2004. New information on *Platypus mutatus*. Article 2004/166, EPPO Reporting Service no. 11 – 2004. Available at gd.eppo.int

EPPO. 2018. EPPO Global Database. gd.eppo.int

Funes H, Griffo R, Zerba E, Gonzalez-Audino P. 2011. Mating disruption of the ambrosia beetle *Megaplatypus mutatus* in poplar and hazelnut plantations using reservoir systems for pheromones. Entomologia Experimentalis et Applicata 139: 226–234, 2011

Funes H, Zerba E, Gonzalez-Audino P. 2009. Comparison of Three Types of Traps Baited With Sexual Pheromones for Ambrosia Beetle *Megaplatypus mutatus* (Coleoptera: Platypodinae) in Poplar Plantations. Journal Of Economic Entomology 102, 4

Giménez RA, Etiennot AE. 2003. Host range of *Platypus mutatus* (Chapuis, 1865) (Coleoptera: Platypodidae). Entomotropica Vol. 18(2): 89-94.

Gonzalez-Audino P, Griffo R, Gatti P, Allegro G, Zerba E. 2013. Pheromone detection of the introduced forest pest *Megaplatypus mutatus* (=*Platypus mutatus*) (Chapuis) (Platypodinae, Curculionidae) in Italy. Agroforest Syst 87:109–115

Griffo G, Pesapane G, Funes H, Gonzalez-Audino P, Germinara GS. 2012. Diffusione e controllo di platipo in Campania L'Informatore Agrario. 31/2012

Ramos S, Ceriani-Nakamurakare E, Gómez D, Landi L. 2015. Indigenous *Megaplatypus mutatus* associated to wilting of *Casuarina* in Argentina. INIA-INTA, Argentina

SFR Campania. 2015. *Megaplatypus mutatus*. Servizio Fitosanitario Regionale – Campania http://www.agricoltura.regione.campania.it/difesa/platypus.htm.

Vinha Zanuncio AJ, Pastori PL, Kirkendall LR, Lino-Neto J, Serrão JE, Zanuncio JC. 2010. *Megaplatypus mutatus* (Chapuis) (Coleoptera: Curculionidae: Platypodinae) Attacks Hybrid *Eucalyptus* L'Héritier De Brutelle Clones In Southern Espírito Santo, Brazil.The Coleopterists Bulletin, 64(1):81-83.

This text is an integral part of the *EPPO Study on bark and ambrosia beetles associated with imported non-coniferous wood* and should be read in conjunction with the study

Pest information sheet
Ambrosia beetle

MONARTHRUM MALI (COLEOPTERA: SCOLYTINAE)

apple wood stainer

EPPO Lists: Not listed. The assessment of potential risks in this information sheet is not based on a full PRA for the EPPO region, but on an assessment of the limited information for that species used to prepare the information sheet.

PEST OVERVIEW

Taxonomy

Monarthrum mali (Fitch 1855). Synonyms: *Pterocyclon mali, Tomicus mali, Pterocyclon longulum, Monarthrum praeustum; Pterocyclon praeustum; Pterocyclon omissum.* Bright & Torres (2006) synonymized *M. praeustum* Eggers (known from the Caribbean) with *M. mali* Fitch (eastern North America). However, some authors believe these may be distinct (e.g. Atkinson, 2018). In this datasheet, *M. mali* and *M. praeustum* are considered as synonyms, but when information is known to relate to *M. praeustum*, this is specified.

Associated fungi

No specific information was found, but the genus *Monarthrum* is xylomycetophagous (fungus-farming ambrosia beetles), and female *M. mali* have mycangia for carrying the associated fungus (cited in Smith and Hulcr, 2015).

Morphology and biology

Adults of *M. mali* measure ca. 2 mm and are reddish-brown to nearly black (Brooks, 1916, Kirkendall *et al.*, 2008 citing others). Relatively little is known about its biology and life cycle. *M. mali* breeds in dying, injured or recently cut logs and stumps, of practically all species of hardwoods (Baker, 1972; Kirkendall *et al.*, 2008; Smith and Hulcr, 2015, citing others). Brooks (1916) refers to attacks on young apple trees 50 years before his publication (apparently live orchard trees). Males are strongly attracted to ethanol, and are the sex that colonizes new breeding material. It is very likely that males produce a long-distance pheromone attractive to both sexes (Kirkendall *et al.*, 2008, citing others). Males initiate galleries boring into the xylem (Smith and Hulcr, 2015). Female galleries extend into the wood (Felt, 1905; Smith and Hulcr, 2015 citing others). *M. mali* has a preference for trees above 24 cm DBH (Smith and Hulcr, 2015, citing others). *M. mali* was trapped in Tennessee between mid- January and mid-October (Oliver & Mannion 2001). This may reflect multiple generations per year in suitably warm climates, but no published information was found.

Spread biology

The flight capacity of *M. mali* was studied under controlled conditions in a flight mill (Seo *et al.*, 2017). Over 50% of the *M. mali* tested flew >100 m during a 24-h period, with 18% flying 500-1000 m and 5% flying >1000 m. The longest single flight distance was ca. 37 m, and the average total flight distance ca. 214 m. This shows a relatively limited dispersal capability without wind or anthropogenic assistance (Seo *et al.*, 2017).

Nature of the damage

M. mali tunnels into the xylem and its associated fungus/fungi lead to a dark staining of the wood.

Detection and identification

- *Symptoms:* Felt (1905) mentions the following symptoms: withering leaves, bark becoming loosened from the wood, emergence holes, and galleries in the wood.
- *Trapping. M. mali* is attracted to ethanol (Klingeman *et al.*, 2017).

- *Identification*. Diagnosis characters for *M. mali* are given in Smith and Hulcr (2015). In Italy, it may be confused with *Gnathotrichus materiarius* (larger, also introduced) and differentiating characters are given in Kirkendall *et al.*, 2008 (citing others).

Distribution (see Table 1)

Monarthrum mali is abundant throughout eastern North America (Kirkendall, 2008), and has been introduced into a few Western US states (see Appendix 1). All records for the Caribbean relate to *M. praeustum*, which is considered as a synonym by some authors, but not all (see *Taxonomy* above).

In the EPPO region, one specimen was collected in 2007 in Belluno province (Veneto region, Italy), and given the conditions (trapping in a nature reserve), it was considered as established in that area and resulting from a recent introduction, which may represent «at least a temporarily successful colonization»; at that time, it had not been found in other trapping locations in Italy (Kirkendall *et al.*, 2008; Kirkendall and Faccoli, 2010). No further record for Italy was found.

Host plants (see Table 2)

M. mali commonly occurs on Fagaceae, especially *Quercus* and *Fagus*, but also *Acer*, *Betula*, *Liquidambar*, *Tilia*. There are rare records for *Pinus* and *Tsuga*, suggesting that conifers are not typical hosts (Smith and Hulcr, 2015). *M. mali* probably breeds in most non-coniferous trees in its range according to Kirkendall *et al.* (2008). Consequently, the host range is probably much wider than reported in Table 2.

Known impacts and control in current distribution

Brooks (1916) noted that *M. mali* feeds on forest and orchard trees, casks used for liquids (e.g. wine casks, causing leaking and loss - Smith and Hulcr, 2015, citing others), manufactured mahogany lumber, and that it attacked apple, plum, cherry and orange trees. The same author reports that it is not a common orchard pest, but that ‘about 50 years ago’ it attracted attention as a pest of apple trees in Massachusetts, where it riddled the trunks of many young trees. *M. mali* has also been shown to be destructive to green lumber and fresh logs of *Liquidambar styraciflua* in the Gulf States of the USA (Baker 1972). The dark staining from the ambrosia fungi and the beetles’ tunnels can lower the value of wood for certain uses (Kirkendall *et al.*, 2008). No mention of impact was found from US States where it has been introduced or from Italy.

Control. No control methods are mentioned, except for general methods against bark beetles infestations in Brooks (1916).

POTENTIAL RISKS FOR THE EPPO REGION

Pathways

Entry

Life stages of *M. mali* are associated with the xylem, and *M. mali* may be associated with wood commodities. There is little information available about the biology of *M. mali* and the type of material attacked. It is known to prefer trees >24 cm diameter at breast height (DBH), although attacks on «young» apple trees were reported (the age, which may give an indication of the diameter, is not specified). *M. mali* was collected from firewood following a storm event, mostly on *Acer rubrum* and *Fraxinus americana*, and much fewer individuals on *Betula*, *Quercus* and *Pinus* (Dodds *et al.*, 2017). *M. mali* is reported to probably breed in most deciduous trees in its range, and hosts are possibly not limited to the known hosts in Table 2. Processes applied to produce wood commodities would destroy some individuals. The wood would also degrade and may not be able to sustain development of the pest. The likelihood of entry on wood chips, hogwood and processing wood residues would be lower than on round wood, as individuals would have to survive processing and transport, and transfer to a suitable host is less likely. Bark on its own is an unlikely pathway.

Plants for planting and cut branches are less likely pathways (due to the reference found on preferred diameter). In addition, plants for planting are normally subject to controls during production, and attacked plants may be detected and discarded. Cut branches are used indoors, and the pest is unlikely to be able to transfer to a suitable host.

There may be other factors restricting the association with the different pathways (or establishment), but this outlined analysis did not identify any. Given its abundance in Eastern USA, wide host range, and trade of wood from North America, it is surprising that there have not been more introductions.

Summary of pathways (uncertain pathways are marked with ‘?’):

- *wood (round or sawn, with or without bark, including firewood) of hosts*
- *non-coniferous wood chips, hogwood, processing wood residues (except sawdust and shavings)*
- *wood packaging material if not treated according to ISPM 15*
- *plants for planting (except seeds) of hosts?*
- *cut branches of hosts?*

Because of the large and uncertain host range, pathways may cover all non-coniferous species.
The pathways may also cover known coniferous hosts (though considered non typical hosts in the literature – see Hosts)

Spread (following introduction, i.e. within EPPO region)
Only one specimen was collected in Italy, and it is not known if spread has occurred (although this may take time). *M. mali* appears to be capable of dispersal over a large part of the year (climate allowing); in Tennessee it was collected in ethanol baited traps between mid-January and mid-October (Oliver & Mannion 2001). The beetle may also spread through human-assisted pathways. In Italy, it was found in a nature reserve, from which there is presumably no traded commodities. In the USA, the records in Western States are separated from the native range in Eastern USA, and are most likely due to human-assisted pathways. If *M. mali* was introduced into an area where commodities are produced, it may establish in multiple locations elsewhere through human-assisted pathways.

Establishment
M. mali is considered established in Italy. In the Americas, it appears to be present in a wide range of climates that, based on the climate classification of Köppen-Geiger (see Annex 6 of the study), are also represented in most of the EPPO region. *M. mali* has a very wide host range, which would favour establishment. Many host genera grow in the EPPO region in the wild or in cultivation. Areas with suitable climates and host plants are available in the EPPO region, therefore establishment is possible.

Potential impact (including consideration of host plants)
Little damage is recorded in the literature in the current distribution of *M. mali*. However, it is not excluded that *M. mali* may cause local damage in conditions favourable to its biology and where host plants are suitable (i.e. the type of effect reported from the USA on *Malus* or *Liquidambar styraciflua*).

Table 1. Distribution

	Reference	**Comments**
EPPO region		
Italy	Kirkendall *et al.*, 2008	One specimen trapped in 2007, probably established (Kirkendall *et al.*, 2008; Kirkendall and Faccoli, 2010).
North America		
Canada - Ontario, Quebec, New Brunswick, Nova Scotia *Uncertain record:* British Columbia	- Majka *et al.*, 2017 - Atkinson, 2018 citing Wood, 1982	- no other record found, nor in Canadian sources, possibly a mislabelled or interception record.
USA (Alabama, Arkansas, Connecticut, Delaware, District of Columbia, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Hampshire, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Virginia,	Atkinson, 2018	*M. mali* has spread within the US, at least to the western states of California, Oregon, Vermont. In Oregon, it was thought to have arrived on untreated, hardwood railroad ties from the Southeast (Oregon Invasive Species Council, 2004). It was introduced to California (Seybold *et al.*, 2016). In Oregon, it is expected to establish (Nelson *et al.*, 2006)

	Reference	Comments
West Virginia, Wisconsin) - Vermont - California - Oregon	 - Atkinson *et al.*, 1991 - Seybold *et al.*, 2016 - Nelson *et al.*, 2006	
Uncertain record: Mexico	Atkinson, 2018	Considered uncertain because refers to an unpublished source
Caribbean		
Bahamas	Atkinson, 2018	Relates to *M. praeustum* (see *Taxonomy*)
Cuba	Atkinson, 2018	Relates to *M. praeustum* (see *Taxonomy*)
Dominica	Bright and Torres, 2006	Relates to *M. praeustum* (see *Taxonomy*)
Dominican Rep.	Atkinson, 2018	Relates to *M. praeustum* (see *Taxonomy*)
Guadeloupe	Bright and Torres, 2006	Relates to *M. praeustum* (see *Taxonomy*)
Puerto Rico	Bright and Torres, 2006	Relates to *M. praeustum* (see *Taxonomy*)
Asia		
Uncertain record: 'northern Asia'	Padil (2017)	No reference given; no record was found in the literature.

Table 2. Hosts

Family	Genus/Species	Reference
Altingiaceae	*Liquidambar styraciflua*	Atkinson, 2018
Betulaceae	*Betula*	Dodds *et al.*, 2017
Betulaceae	*Betula lutea*	Atkinson, 2018
Burseraceae	*Dacryodes excelsa*	Atkinson, 2018
Cornaceae	*Cornus florida*	Atkinson, 2018
Cornaceae	*Nyssa* sp.	Atkinson, 2018
Fabaceae	*Inga laurina*	Atkinson, 2018
Fagaceae	*Fagus grandifolia*	Atkinson, 2018
Fagaceae	*Quercus alba*	Atkinson, 2018
Fagaceae	*Quercus laevis*	Atkinson, 2018
Fagaceae	*Quercus nigra*	Atkinson, 2018
Fagaceae	*Quercus prinus*	Atkinson, 2018
Fagaceae	*Quercus rubra*	Dodds *et al.*, 2017
Fagaceae	*Quercus stellata*	Atkinson, 2018
Juglandaceae	*Juglans cinerea*	Atkinson, 2018
Juglandaceae	*Juglans nigra*	Reed *et al.*, 2015
Lauraceae	*Persea palustris*	Seo *et al.*, 2017
Malvaceae	*Tilia* sp.	Atkinson, 2018
Oleaceae	*Fraxinus americana*	Dodds *et al.*, 2017
Rosaceae	*Malus*	As apple, Brooks *et al.*, 1916
Rosaceae	*Prunus*	As plum & cherry, Brooks *et al.*, 1916
Rutaceae	*Citrus*	As orange, Brooks *et al.*, 1916
Sapindaceae	*Acer rubrum*	Dodds *et al.*, 2017
Sapotaceae	*Manilkara bidentatus*	Atkinson, 2018

References (all URLs were accessed in January 2018)

Atkinson TH. 2018. Bark and Ambrosia beetles. http://www.barkbeetles.info

Atkinson TH, Rabaglia RJ, Peck SB, Foltz JL. 1991. New records of Scolytidae and Platypodidae (Coleoptera) from the United States and Bahamas. Coleopterists Bulletin. 45. 152-164.

Baker WL. 1972. Eastern forest insects. Miscellaneous publication / United States. Dept. of Agriculture, no. 1175.

Bright DE, Torres JA. 2006. Studies on West Indian Scolytidae (Coleoptera). A review of the Scolytidae of Puerto Rico, U.S.A. with descriptions of one new genus, fourteen new species and notes on new synonymy (Coleoptera: Scolytidae). Koleopterologische Rundschau 76 389–428.

Brooks FE. 1916. Orchard barkbeetles and pinhole borers, and how to control them. United States Department of Agriculture, Farmers' Bulletin. 763, November 29, 1916.

Dodds KJ, Hanavan RP, DiGirolomo MF. 2017. Firewood collected after a catastrophic wind event: the bark beetle (Scolytinae) and woodborer (Buprestidae, Cerambycidae) community present over a 3-year period. Agricultural and Forest Entomology, 19, 309–320 DOI: 10.1111/afe.12210

Felt EP. 1905. Insects affecting park and woodland trees. Memoir 8. New York State Museum.

Kirkendall LR, Dal Cortivo M, Gatti E. 2008. First record of the ambrosia beetle, *Monarthrum mali* (Curculionidae, Scolytinae) in Europe. J Pest Sci (2008) 81:175–178

Kirkendall LR, Faccoli M. 2010. Bark beetles and pinhole borers (Curculionidae, Scolytinae, Platypodinae) alien to Europe. ZooKeys 56: 227–251 (2010).

Kirkendall LR. 2008. *Monarthrum mali*: a North American ambrosia beetle in Europe. http://folk.uib.no/nzllk/bark%20beetle%20websites/Kirkendalls_bark_beetles/Monarthrum_mali.html

Klingeman WE, Bray AM, Oliver JB, Ranger CM, Palmquist DE. 2017. Trap Style, Bait, and Height Deployments in Black Walnut Tree Canopies Help Inform Monitoring Strategies for Bark and Ambrosia Beetles (Coleoptera: Curculionidae: Scolytinae). Environmental Entomology, 46(5), 2017, 1120–1129

Majka CG, Anderson RS, McCorquodale DB (2007a) The weevils (Coleoptera: Curculionoidea) of the Maritime Provinces of Canada, II: new records from Nova Scotia and Prince Edward Island and regional zoogeography. The Canadian Entomologist 139: 397-442.

Nelson A, Kanaskie A, Sprengel K, Overhulser D, McWilliams M. 2006. Forest Health Highlights. In Oregon – 2005. Oregon Department of Forestry USDA Forest Service, Pacific Northwest Region

Oliver JB, Mannion CM. 2001. Ambrosia beetle (Coleoptera: Scolytidae) species attacking chestnut and captured in ethanol-baited traps in middle Tennessee. Environmental Entomology, 30, 909-918.

Oregon Invasive Species Council. 2004. Invasive Species in Oregon. Report Card, 2004. Oregon Invasive Species Council

Reed SE, Juzwik J, English JT, Ginzel MD. 2015. Colonization of Artificially Stressed Black Walnut Trees by Ambrosia Beetle, Bark Beetle, and Other Weevil Species (Coleoptera: Curculionidae) in Indiana and Missouri. Environ. Entomol. 44(6): 1455–1464.

Seo M, Martini X, Rivera MJ, Stelinski LL. 2017. Flight Capacities and Diurnal Flight Patterns of the Ambrosia Beetles, *Xyleborus glabratus* and *Monarthrum mali* (Coleoptera: Curculionidae). Environmental Entomology, 46(3), 2017, 729–734

Seybold SJ, Penrose RL, Graves AD. 2016. Invasive Bark and Ambrosia Beetles in California Mediterranean Forest Ecosystems. Chapter In Insects and Diseases of Mediterranean Forest Systems pp 583-662.

Smith SM, Hulcr J. 2015. *Scolytus* and other economically important bark and ambrosia beetles. Chapter 12 in Bark Beetles. Biology and Ecology of Native and Invasive Species. Edited by:Fernando E. Vega and Richard W. Hofstetter. Elsevier

This text is an integral part of the *EPPO Study on bark and ambrosia beetles associated with imported non-coniferous wood* and should be read in conjunction with the study

Pest information sheet
Bark beetle

PHLOEOTRIBUS LIMINARIS (COLEOPTERA: SCOLYTINAE)

peach bark beetle

EPPO Lists: Not listed. The assessment of potential risks in this information sheet is not based on a full PRA for the EPPO region, but on an assessment of the limited information for that species used to prepare the information sheet.

PEST OVERVIEW

Taxonomy

Phloeotribus liminaris (Harris 1852). Synonyms: *Phloeophthorus liminaris, Phthorophloeus liminaris, Tomicus liminaris, Phthorophloeus mississippiensis* (Atkinson, 2018).

Associated fungi

No mention of fungal associations was found.

Morphology and biology

Phloeotribus liminaris adults measure ca. 2-2.5 mm (Pennacchio *et al.,* 2004). *P. liminaris* has two generations per year in North America, or sometimes three in the southernmost latitudes (Wood, 1982). In Italy, *P. liminaris* was observed to have two generations per year and it overwinters as adults (Pennacchio *et al.*, 2011). In the reproductive phase, *P. liminaris* usually attacks damaged or weakened host trees, as well as material deriving from felling (Pennacchio *et al.,* 2004, citing others). Population build-ups due to breeding in slash or wind-thrown trees can lead to massive attacks on healthy trees during breeding. However, normally beetles tunnelling in healthy trees usually are either pitched out or killed by the gum reaction (Kirkendall *et al.*, 2015 citing others). *P. liminaris* overwinters in both adult and larval stages (Hanavan *et al.* 2012, citing others). Adults overwinter either in short, individual galleries dug in the internal bark of host trees in good or deteriorated vegetative conditions, or in breeding galleries in dead trees (Wood, 1982; Pennacchio *et al.*, 2004). This phase is responsible for damage to wood (see below).

Spring broods are produced by both overwintering parent adults and developed adult progeny from overwintering larvae (Hanavan *et al.*, 2012, citing others). The female initiates the reproductive attacks by boring a short entrance tunnel through the inner bark to the outer wood layer in weakened or damaged trees (Pennacchio *et al.*, 2004). The male then enters, mating takes place and the female constructs a subcortical egg tunnel, 2-7 cm long, and deposits 80-100 eggs in niches. The larvae feed on the inner bark and outer wood, resulting in short, deeply engraved tunnels (Guthmiller and Hall, 2001; Barnd and Ginzl, 2009). The next generation adults emerge and disperse in search of live host trees, where they carve overwintering niches between the bark and cambium (Pennacchio *et al.*, 2004, citing others). Entrance holes of winter refuges are in bark cracks (Pennacchio *et al.*, 2004).

Males are attracted to *Prunus serotina* trunks infested with female beetles, suggesting that females release a sex pheromone (VanDerLaan-Hannon and Ginzel, 2011; Ethington *et al.*, 2016). Furthermore, according to experiments, adults are attracted to benzaldehyde, suggesting that they locate suitable hosts by orienting to cherry volatiles (Ethington *et al.*, 2016).

A study by Hanavan *et al.* (2012) with *P. serotina* indicates that brood galleries are mainly located in the lower half of the tree trunk (noted as consistent with other authors' findings), whereas they are less frequent in both live and dead branches, and then only in branches exceeding 2.5 cm in diameter.

Spread biology

Both males and females are able to fly, but no specific information was found on the dispersal capacity. Movement among stands is not currently understood (Hanavan *et al.*, 2012).

Nature of the damage

P. liminaris tunnels into the bark. In the wintering phase, the pest may dig refuges in the internal bark of trees in good vegetative conditions, leading in subsequent years to damage to the cambium, causing irregular growth of woody tissues and the formation of gum spots in the wood (Pennacchio *et al.*, 2004). Galleries extend into the living tissue beneath the bark (cambial layer and outer cortex), which often causes gummosis and localized growth abnormalities. Although gumming can result from wounds caused by other insects, fungal infection and abiotic factors, it appears that attacks by *P. liminaris* are a major cause of gum spots in *P. serotina* saw-timber (Barnd and Ginzl, 2009).

There is conflicting information about mortality in the literature. Hanavan *et al.* (2012, citing others) note that the beetles are not tree killers but result in a lower grading of *P. serotina* wood due to gummosis. Forest Health Fact Sheet (2011) mentions that trees are rarely killed, but usually weakened which may predispose the tree to other pests. Other sources refer to mortality (of *P. serotina*). Michigan State University (2014) states that the tunnelling can kill the tree, Allen (1999) that large infestations on *P. serotina* lead to girdling of the tree, and death within one or two growing seasons. Guthmiller and Hall (2001) mentions serious mortality in forest-grown *P. serotina* in New York State.

Detection and identification

- *Symptoms.* When the beetle density is very high, external signs on the tree of the presence of the beetle can be observed: abundant accumulation of frass at the tree base and between bark cracks, emission of gum from entrance holes (Pennacchio *et al.*, 2004). It is noted that other bark beetles such as *Dryocoetes betulae* and *Scolytus rugulosus* also cause gummosis in *P. serotina*, although to a far lesser extent (Barnd and Ginzel, 2009).
- *Trapping.* Chemical attractants noted by Atkinson (2018) are: alpha pinene + ethanol, or only ethanol; and light trapping methods such as: mercury vapor + ultraviolet, or ultraviolet on its own.
- *Identification.* A morphological description is provided in Pennacchio *et al.* (2004). Some sequences of *P. liminaris* are available in GenBank (https://www.ncbi.nlm.nih.gov).

Distribution (see Table 1)

P. liminaris is native to North America. It is present in Canada and the Eastern half of the USA, from North to South and is widespread in the native range of *P. serotina* (Pennacchio *et al.*, 2004, citing others; Barnd and Ginzel, 2009).

In the EPPO region, *P. liminaris* was found in 2004 in mixed woods in the Ticino River Park (Lombardia region, northern Italy), where many trees of *P. serotina*, 10-20 cm in diameter and aged 25-45 years, were heavily colonized by wintering and adult refuges, suggesting that the introduction was not recent (Pennacchio *et al.*, 2004). It was later found in Pombia (Piemonte) in the Parco Naturale della Valle del Ticino (Pennacchio *et al.*, 2011).

P. liminaris is listed for France in the catalogue of Alonso-Zarazaga *et al.* (2017). However, it has been trapped only once (Noblecourt and Lessieur, 2016), has never been seen since, and is not established (L-M Nageleisen and T. Noblecourt, pers. comm. 2018-05).

Host plants (see Table 2)

Hosts of *P. liminaris* are *Prunus* spp. (Rosaceae). *P. serotina* is the preferred host, but *P. persica* is also mentioned. Hosts include other wild and cultivated *Prunus*, such as *P. americana*, *P. angustifolia*, *P. mexicana*, P. *pensylvanica* (See Table 2).

In Italy, only *P. serotina* was found infested, and *P. avium*, *P. padus* and *P. laurocerasus* in the same areas were not reproductive hosts. Only signs of maturation feeding and failed attempts to bore galleries were observed in *P. padus*. In addition, trials consisting in offering fresh trunks of *P. armeniaca*, *P. persica*, *P. domestica* and *P. laurocerasus* close to attacked *P. serotina* in areas of high infestation during the flight period did not result in successful colonization (Pennacchio *et al.*, 2011).

Kirkendall *et al.* (2015) mentions 'mulberry' in relation to damage and mortality observed on some trees (including *Prunus*) in the USA in the 1900s (citing Wilson *et al.*, 1909; Beal and Massey, 1945), while Atkinson (2018) lists *Maclura pomifera* (Moraceae) as a host (based on an unpublished record). The original published records were not available, and the host status of Moraceae is not clear. No other non-Rosaceae host were found.

Known impacts and control in current distribution

In the USA, *P. liminaris* was studied in the early 1900s as it started damaging and even killing peach, black cherry, wild cherry trees and mulberry in the Northeastern USA. Before that, it was not considered an economic problem, though originally described as associated with "peach yellows" (Kirkendall *et al.*, 2015 citing others). The main damage is due to gum spotting (gummosis), which reduces the commercial value of the wood. *P. serotina* wood is used in the production of cabinets, musical instruments and other valuable articles (Pennacchio *et al.*, 2004, citing others). Gum spotting can reduce the veneer value of *P. serotina* by 50–90% (Kirkendall *et al.*, 2015, citing others).

An outbreak of thousands of adults was reported in a stand of mature *P. serotina* in 2000 in Wisconsin, where the beetles emerged from logging slash and attacked live standing trees, stressed by water-logged soils. This was the first damage by *P. liminaris* in Wisconsin, whereas it had long been a serious pest of peach orchards in southeastern USA, and had caused serious mortality in forest grown black cherry in New York State (Guthmiller and Hall, 2001).

In Italy, the possible damage by *P. liminaris* to *P. serotina* did not raise particular concerns, since this tree is an invasive species in the forests of that region. Pennacchio *et al.* (2004) reported that studies on the bioecology have been initiated in areas of recent introduction, in view of potential damage to *Prunus* orchards, particularly the extensive cultivations of *P. persica* in the Po Valley. In later observations, no species other than *P. serotina* was found to be attacked in Italy (see *Host plants*) (Pennacchio *et al.*, 2011).

Control: In the USA, the only known control strategy is utilizing traditional silvicultural practices such as destroying infested wood. No natural enemies are known for having a decisive role in the control (Pennacchio *et al.*, 2004, citing others). Frank and Mizell (2009) note that often only newly transplanted trees and shrubs or high value ornamental trees justify the cost of chemical management.

POTENTIAL RISKS FOR THE EPPO REGION

Pathways

Entry

Life stages of *P. liminaris* are associated with the bark. *P. liminaris* entered Italy with an unknown pathway. *P. liminaris* has also been intercepted in the Republic of Korea on imported 'logs and timbers' of *P. serotina* from the USA (Choi *et al.*, 2003). Given its biology and host range, all wood of *Prunus* hosts with bark, especially of *P. serotina*, may be a pathway. No information was found on the trade of *P. serotina* wood from North America into the EPPO region. Cases of non-compliance recorded in the EU include some on wood of *Prunus* sp. and *Prunus avium*, i.e. indicating some trade. Residual wood of *P. serotina* could potentially be a minor part of imported wood chips, wood waste or used in constructing wood packaging material. Processes applied to produce wood commodities would destroy some individuals. The wood would also degrade and may not be able to sustain development of the pest. The likelihood of entry on wood chips, hogwood and processing wood residues would be lower than on round wood, as individuals would have to survive processing and transport, and transfer to a suitable host. Bark may be a pathway, but no information was sought on whether bark of *Prunus* is traded.

Plants for planting and cut branches of a certain diameter may be a pathway, but data is lacking (the only information refers to a minimum diameter of 2.5 cm for infestation of *P. serotina* branches). Plants for planting are normally subject to controls during production, and attacked plants may be detected and discarded. Cut branches are a less likely pathway, as they are used indoors, and the pest is unlikely to be able to transfer to a suitable host. No information was sought on the trade of such commodities.

Summary of pathways (uncertain pathways are marked with '?'):

- *wood (round or sawn, with bark, incl. firewood) of hosts*
- *non-coniferous wood chips, hogwood, processing wood residues (except sawdust and shavings)*
- *wood packaging material if not treated according to ISPM 15*
- *bark of hosts?*
- *plants for planting (except seeds) of hosts?*
- *cut branches of hosts?*

Because of the uncertain host range within Prunus, pathways may cover all Prunus species.

Spread (following introduction, i.e. within EPPO region)
Some natural spread would probably occur as adults fly. Hosts are widely present in the EPPO region (see *Establishment*). No information on the spread in North America is available. From the limited information available on the situation in Italy, local spread among stands of living trees appears to be rather slow (rather old and intensive infestation, yet in a limited area). Human-assisted pathways, especially wood or wood waste, may help in creating multiple foci in the EPPO region thus contributing to spread.

Establishment
Areas with suitable climates and host plants are available in the EPPO region, therefore establishment is possible. Based on the classification of Köppen Geiger (see Annex 6 of the study), *P. liminaris* is present in the USA and Canada at least in the climate type Cfa and Dfb[15], which in the EPPO region occur at the Black Sea, Northern Italy and part of the Balkans, as well as the Western part of Russia and neighbouring countries, and the south of Scandinavia. The winter temperatures would not be a limiting factor. In the USA, it is possibly also present in the climate type Cfb[15], but this is not verified based on the limited information available. This would extend the potential suitable area to all oceanic temperate climates of the EPPO region, from the UK and northern Iberic peninsula through to Russia.

Prunus are present in a wide variety of habitats in the EPPO region, including in the wild, planted as forest trees or orchards, and as landscape and ornamental trees. The major host *P. serotina* (EPPO List of Invasive Alien Plants) is widespread in the EPPO region. It was introduced as early as the 17th century and planted as an ornamental, for wood production or soil amelioration; *P. serotina* has become invasive especially in those countries where it had been introduced for forestry use (CABI, 2018, citing others).

The host *P. persica* is grown commercially in the southern part of the region, and is also present in gardens in other areas. Other *Prunus* spp. are widely cultivated commercially for fruit production and in gardens, such as cherries, plums, apricot, almond. Establishment would also depend on whether it is able to attack other *Prunus*. *P. liminaris* has been recorded on several *Prunus* spp. in the USA, and it is not excluded that it may attack others, should it be introduced into the EPPO region. This is especially the case for fruit trees (although it has apparently not been recorded in the USA on some major fruit trees such as apricot or almond). In the Western part of the EPPO region, *Prunus avium*, *P. cerasifera*, *P. mahaleb*, *P. padus* and *P. spinosa* are present in natural environments (San-Miguel-Ayanz *et al.*, 2016).

Potential impact (including consideration of host plants)
P. serotina is widely present in the EPPO region, but is considered invasive in many parts. Therefore if *P. liminaris* affects invasive stands of *P. serotina*, this would be a positive impact. Negative impacts of *P. liminaris* would therefore relate to other *Prunus* spp., especially forest and fruit species. Peach, grown intensively in large parts of Southern Europe is reported as a host; it is not known if current cultivation practices, including good sanitation, would prevent impact. To date, *P. liminaris* has not been found in other *Prunus* spp. in Italy.

Table 1. Distribution

	Reference	**Comments (with references)**
EPPO region		
Italy	Pennacchio *et al.* (2004, 2011)	Lombardia, Piemonte
Absent: France, trapped once only	Noblecourt & Lessieur (2016)	Also mentioned in Alonso-Zarazaga *et al.* (2017), but not established
North America		
Canada (Manitoba, Quebec, Ontario, New Brunswick, Saskatchewan)	Atkinson, 2018 citing others	
USA - Connecticut, Delaware, District of Columbia, Florida, Iowa, Kentucky,	-Pennacchio *et al.* (2004, citing others)	

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[15] **Cfa**: warm temperate climate, fully humid, hot summer; **Cfb**: warm temperate climate, fully humid, warm summer; **Dfb**: snow climate, fully humid, warm summer.

	Reference	**Comments (with references)**
Maryland, Massachusetts, Michigan, Mississippi, Missouri, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Virginia, West Virginia, Wisconsin		
- Indiana, Minnesota, Oklahoma, Texas	- Atkinson, 2018, citing others	
- Illinois	- Helm and Molano-Flores, 2017	
Uncertain records: Alabama, Arkansas, Georgia, Louisiana, Rhode Island, Tennessee, Vermont	- Atkinson, 2018	Considered uncertain here, because referring to unpublished records

Table 2. Hosts

***Prunus* species**	**Family**	**Reference**
P. serotina	Rosaceae	Wood and Bright, 1992
P. americana	Rosaceae	Wood and Bright, 1992
P. angustifolia	Rosaceae	Wood and Bright, 1992
P. persica	Rosaceae	Wood and Bright, 1992
P. mexicana	Rosaceae	Atkinson *et al.*, 2013
P. pensylvanica	Rosaceae	Atkinson 2018 citing others

Uncertain hosts	**Family**	**Reference**
P. cerasus	Rosaceae	Atkinson 2018 (unpublished record)
P. umbellata	Rosaceae	Atkinson 2018 (unpublished record)
Maclura pomifera	Moraceae	Atkinson, 2018 (unpublished record)
'mulberry'		Kirkendall *et al.*, 2015 citing others

References (all URLs were accessed in March 2018)

Adams KB, Allen DC. 2003. Peach Bark Beetle: A Potential Threat to Black Cherry https://www.fs.fed.us/foresthealth/fhm/posters/posters03/pb_beetle.pdf. In: Workshop on Peach Bark Beetle. A Region's Black Cherry Resource Under Siege http://www.esf.edu/outreach/pd/2004/beetle.pdf

Allen DC. 1999. Peach bark beetle and black cherry. The New York Forest Owner 37:4 • July/August 1999. http://www.dec.ny.gov/docs/lands_forests_pdf/peachbb.pdf

Alonso-Zarazaga MA, Barrios H, Borovec R, Bouchard P, Caldara R, Colonnelli E, Gültekin L, Hlaváþ P, Korotyaev B, Lyal CHC, Machado A, Meregalli M, Pierotti H, Ren L, Sánchez-Ruiz M, Sforzi A, Silfverberg H, Skuhrovec J, Trýzna M, Velázquez de Castro AJ & Yunakov NN. 2017. Cooperative Catalogue of Palaearctic Coleoptera Curculionoidae. Monografías electrónicas SEA 8, Sociedad Entomológica Aragonesa S.E.A.

Atkinson TH. 2018. Bark and Ambrosia Beetles: http://www.barkbeetles.info/regional_chklist_target_species.php?lookUp=748

Barnd BD, Ginzl MD. 2009. Causes of Gummosis in Black Cherry (*Prunus serotina*). Purdue University, Purdue Extension FNR-229-W

Choi EG, Choo HY, Lee DW, Lee SM, Park JK. 2003. Scolytidae, Platypodidae, Bostrichidae and Lyctidae Intercepted from Imported Timbers at Busan Port Entry. Korean Journal of Applied Entomology:: Vol.42 No.3 pp.173-184

Ethington MW, Hughes GP, Ginzel MD. 2016. Chemically-mediated host colonization of black cherry trees, *Prunus serotina*, by the peach bark beetle, *Phloeotribus liminaris* (Coleoptera: Scolytinae). XXV International Congress of Entomology, Florida, USA. D3541

Forest Health Fact Sheet. Bark Beeltles. 2011. Factsheet. Pennsylvania Dept Conservation and Natural Resources http://www.docs.dcnr.pa.gov/cs/groups/public/documents/document/dcnr_006854.pdf

Frank DL, Mizell RF. 2009. Native and Exotic Insect Borers Are Important Crop Pests in the U.S. University of Florida, IFAS Extension ENY-730

Guthmiller M, Hall D. 2001. Black Cherry Pest Alert! WI DNR Forest Health Protection

Hanavan RP, Adams KB, Allen DC. 2012. Abundance and Distribution of Peach Bark Beetle in Northern Hardwood Stands of New York. Northern J Appl Forestry 29: 128-132

Hanavan RP, Allen DC. 2005. A State-wide Assessment of the Abundance and Distribution of the Peach Bark Beetle, *Phloeotribus liminaris* (Coleoptera: Scolytidae): a Potential Threat to Black Cherry. In: Kenefic LS, Twery MJ: Changing Forests - Challenging Times: Proc New England Society of American Foresters 85th Winter Meeting. Gen. Tech. Rep. NE-325:45

Helm C, Molano-Flores B. 2017. New records of native and non-native bark and ambrosia beetles (Coleoptera: Curculionidae: Scolytinae) in Illinois. The Great Lakes Entomologist, 48(3), 6.

Kirkendall LR, Biedermann PH, Jordal BH. 2015. Evolution and diversity of bark and ambrosia beetles. Chapter In: Vega FE, Hofstetter RW: Bark beetles: biology and ecology of native and invasive species. Academic Press: 85–156

Michigan State University. 2014. Integrated Pest Management: http://www.ipm.msu.edu/insects/peach_bark_beetle

Noblecourt T, Lessieur D. 2016. Premier signalement de *Phloeotribus liminaris* (Harris, 1852) en France. *L'Entomologiste*, 72(6): 405.

Pennacchio F, Faggi M, Gattle, Caronni F, Colombo M, Roversi PF. 2004. First record of *Phloeotribus liminaris* (Harris) from Europe (Coleoptera Scolytidae). Redia LXXXVII: 85-89

Pennacchio F, Binazzi F, Colombo M, Jucker C, Caronni F, Roversi PF. 2011. *Phloeotribus liminaris*, scolitide esotico infeudato alle prunoidee. Atti del XXIII Congresso Nazionale Italiano di Entomologia. Genova, 13-16 giugno 2011: 73.

San-Miguel-Ayanz J, de Rigo D, Caudullo G, Houston Durrant T, Mauri A (Eds.). 2016. European Atlas of Forest Tree Species. Publication Office of the European Union, Luxembourg.

CABI. 2018. Invasive species compendium. https://www.cabi.org/isc/

VanDerLaan-Hannon NR, Ginzel MD. 2011. Role of Semiochemicals in the Host Colonization Behavior of the Peach Bark Beetle, *Phloeotribus liminaris* (Coleoptera: Curculionidae: Scolytinae). Dept of Forestry and Natural Resources. Hardwood Tree Improvement and Regeneration Center Purdue University, West Lafayette, IN 47907. https://htirc.org/wp-content/themes/child_theme/assets/pdf/Nikki%20VanDerLaan-Hannon2011.pdf

Wood SL. 1982. The bark and ambrosia beetles of North and Central America (Coleoptera: Scolytidae), a taxonomic monograph. Great Basin Naturalist Memoirs 6: 1- 1356.

This text is an integral part of the *EPPO Study on bark and ambrosia beetles associated with imported non-coniferous wood* and should be read in conjunction with the study

Pest information sheet
Bark beetle

PITYOPHTHORUS JUGLANDIS (COLEOPTERA: SCOLYTINAE)

walnut twig beetle

EPPO lists: Geosmithia morbida and its vector *Pityophthorus juglandis* were added to EPPO A2 List of pests recommended for regulation in 2015. *P. juglandis* and *G. morbida* are currently not regulated by EPPO countries (EPPO Global Database; EPPO, 2018). The assessment of potential risks results from a comprehensive PRA carried out by an EPPO Expert Working Group on PRA. The present datasheet is mostly based on the EPPO PRA and draft EPPO datasheet (EPPO, 2015a, 2015b), complemented with new data from references published since 2015.

PEST OVERVIEW

Taxonomy

Pityophthorus juglandis Blackman, 1928. Based on the analysis of various DNA sequences, Rugman-Jones *et al.* (2015) identified two clearly separated lineages, but conclude that further studies are needed to determine whether these correspond to two cryptic species. One lineage was responsible for recent expansion of the range of *P. juglandis* and the spread of *G. morbida* in North America (Rugman-Jones *et al.*, 2015).

Associated fungi

Geosmithia morbida (pathogenic). All known isolates are currently considered as one species (EPPO, 2015a citing others). Kolarik *et al.* (2017) identified four additional *Geosmithia* sp. in the galleries of *P. juglandis*. In addition, *Fusarium solani* has also been isolated from cankers on *Juglans*; its role in tree mortality is not known, although this fungus is known to be pathogenic to *J. nigra* and may contribute to canker development on the main trunk and tree mortality (EPPO, 2015a).

G. morbida and *P. juglandis* together cause thousand cankers disease, a disease that has been devastating on walnuts in the USA (EPPO, 2015a).

Morphology and biology (from EPPO, 2015b, except where a source is indicated)

Adults of *P. juglandis* are minute, 1.5-1.9 mm long and yellowish-brown in colour. At emergence, most *P. juglandis* adults fly to branches to mate and excavate new galleries for laying eggs, while some may remain in the trunk and expand overwintering cavities. Males excavate a small nuptial chamber under the bark, release sex pheromones, and are joined by a few females. Females create egg galleries under the bark, which are generally across the grain of the wood. Adults emerge through minute, round exit holes. Emerging adults carry on their cuticule spores of *G. morbida* that can create new infections when they tunnel into other branches or trunks to feed, reproduce or overwinter. After the tree starts showing foliar symptoms, enormous numbers of *P. juglandis* may emerge from the trees. In an extreme case in Colorado, 23 040 adults emerged from 2 logs of *J. nigra* (circa 6 adults emerging/cm^2 log surface). A single generation was observed to be completed in 7 weeks in logs at room temperature. In general, there are 2-3 overlapping generations, depending on climatic conditions (EPPO, 2015b). In Northern Italy, two overlapping generations were observed (Faccoli *et al.*, 2016).

In areas with cold winters (e.g. Colorado), *P. juglandis* overwinters as dormant adults in cavities in the bark of the trunk, and as larvae that may continue development during warm periods. In areas with mild winter (e.g. California), overwintering stages include larvae at all stages of development.

P. juglandis flight activity peaks at temperatures between 23-24ºC and ceases below 17-18ºC. Under experimental conditions, lower lethal temperatures (LT99) reported for adults and larvae differed in two studies (ca. -18 in one, below -22 C in the other; Luna *et al.* 2013; Peachey 2012). *P. juglandis* survived in infested trees in Colorado where temperatures reached −29°C in February 2011, suggesting that it could survive the winter in much of the native range of *J. nigra*, but may be limited in areas where temperatures regularly drop below the lower lethal temperature. The degree-days requirements for *P. juglandis* are unknown.

P. juglandis attacks standing living trees, including healthy trees. Entry and emergence holes are present on the bark on larger diameter branches (generally above 1.5 cm on *J. nigra*) or on stems. In caged experiments, entrance holes have been observed in *J. nigra* seedlings with basal diameter as small as 0.55 cm. *P. juglandis* was shown to infest logs in certain conditions (e.g. reinfesting treated logs). In Italy, cankers and holes were observed on 1-1.5 cm diameter twigs in the field; *G. morbida* can be artificially inoculated on *J. nigra* and *J. regia*, and create cankers in 5-10 mm diameter plants (2-year old). In a field based experiment to determine whether *P. juglandis* colonized young walnut nursery trees, and therefore whether those presented a risk of transporting the pest, Audley *et al.* (2017) found that even though some adults initiated colonization (entry holes, some galleries) on trees baited with a pheromone lure, there was no successful establishment nor any evidence of reproduction even in the largest diameter trees (the average diameter at the base of the smaller and larger trees was 1.8 cm and 2.4 cm, respectively).

In infected trees, *G. morbida* is located in the phloem and cambium, and grows within and around the feeding sites and galleries of *P. juglandis* where it was introduced, killing tissues and producing cankers. *G. morbida* does not produce deep staining of the wood, but it may reach the sapwood (superficially) at advanced stages of the disease, and may result in a brown to black discoloration of the sapwood.

P. juglandis does not show some characteristics typical of most bark beetles: there does not seem to be a close relationship between the health of the tree and susceptibility, and there is no evidence of the need of critical numbers to establish in a tree to overwhelm tree defences (EPPO, 2015a), although the insects do produce, and respond to, aggregation pheromones (Seybold *et al.* 2012a, 2012b).

Spread biology

The EPPO PRA (EPPO, 2015a) noted that the flight capacity of *P. juglandis* was unknown, but that other small bark beetles of similar size are capable of flying long distances (e.g. distances of 86 km noted for *Pityogenes chalcographus*). Recent results in a flight mill experiment in the USA (Kees *et al.*, 2017) indicated a maximum total flight distance of 3.6 km in 24h, and the mean and median distances were 372 m and 158 m, respectively. *P. juglandis* adults flew for 34 min on average within a 24-h flight trial. On the basis of the low flight capacity observed, the authors conclude that natural dispersal may only contribute marginally to spread, and expected that natural flight capacity is limited to not more than 3 or 4 km at the extremes (with an assumption that the beetle only flies for about 5 days), and that insects will remain somewhat localized at sites of introduction in the short term. However, the authors of this study noted that survival of the beetles (which had to be imported in Minnesota from California) was exceedingly low, possibly due to low air humidity or the absence of adult feeding (B. Aukema, pers. comm.). This could have somehow biased the tests' results.

Nature of the damage

Thousand cankers disease produces progressive crown dieback resulting in reduced growth rates and, in extreme cases, tree mortality. The fungus is not systemic but, with multiple infestations on the tree, multiple cankers coalesce, cutting off the supply of nutrients, which results in dieback of branches and the subsequent death of the tree. Timber quality can be affected by reduced growth and yield. Nut production/yield may be reduced in diseased trees or because of tree mortality (but there is no direct damage to nuts) (EPPO, 2015a). Other organisms may also contribute to tree decline during the last stages of the disease. Once crown symptoms become visible, death may occur within a few years (e.g. 2-5), with some trees having a slower dieback over many years.

Detection and identification

- *Symptoms.* Thousand cankers disease can result in crown symptoms and usually causes cankers on branches and trunks. At early stages of the disease, the only indications of damage are the entry holes of *P. juglandis*. The first symptoms in the crown are leaf yellowing, wilting of foliage and thinning, followed by twig and branch dieback. Dead leaves generally fall from declining branches. Branches fail to leaf out in spring. Symptoms only appear after considerable canker formation (probably after several years depending on the tree species and dimensions), and vary in different locations. Entry and emergence holes of *P. juglandis* can be observed on the bark on larger diameter branches (generally above 1.5 cm on *J. nigra*) or on stems but these are difficult to see when bark is deeply furrowed.

- *Trapping.* Pheromones and traps are available. Pheromone-baited branches are used in low population areas to sample for *G. morbida*. Detailed survey guidelines, including visual surveys and sampling, have been developed in the USA and references are given in EPPO (2015b). Recently, Blood *et al.* (2018) demonstrated that *P. juglandis* is not attracted to ethanol, but is attracted by volatiles from *J. nigra* and *G. morbida*, and is repelled by limonene.
- *Identification*. Morphological characters that allow distinguishing adults of *P. juglandis* from other *Pityophthorus* spp. have been published, as well as a screening aid to help differentiate *P. juglandis* from other bark beetles in trap samples or specimens collected from suspect walnut trees in the USA (LaBonte and Rabaglia 2012). *G. morbida* should be cultured for species confirmation. It can easily be identified based on morphological characteristics. Its identity can be confirmed by sequencing the rDNA ITS region. Recently, a PCR-based rapid molecular detection protocol for *P. juglandis* and *G. morbida* was proposed (Oren *et al.*, 2018).

Distribution (see Table 1)

P. juglandis is present in North America (USA and Mexico) and in Italy. In a few cases, either *G. morbida* or *P. juglandis* have been found, and the reasons are not fully elucidated yet.

In Italy, *P. juglandis* was first found in the Veneto region in 2013. The number of sites found to be colonized by the beetle in the Veneto region increased from 13 in 2014 to 29 in 2017 (Faccoli, pers. observation based on pheromone trap survey). It was found associated with *Geosmithia morbida* at a few sites. In 2014 it was also found in Lombardy. In 2015, *P. juglandis* and the associated fungus *G. morbida* were found in two black walnut (*Juglans nigra*) plantations in Piemonte region, municipality of Rondisone (TO), more than 320 km west of the first recorded site (Faccoli *et al.*, 2016a). In 2015, two adults were trapped in Friuli Venezia Giulia (Porcia, PN) and in the following year (2016) the species was found again in 4 different sites of the same region. The fungus *G. morbida* was not detected in Friuli Venezia-Giulia nor in Lombardia (Montecchio *et al.*, 2016).

Host plants (see Table 2)

The hosts of *P. juglandis* all belong to the family Juglandaceae, genera *Juglans* and *Pterocarya*. Based on observations in the *Juglans* collection of the USDA-ARS National Clonal Germplasm Repository in California, *P. juglandis* is considered to have the capacity to develop in all species of *Juglans* that it may encounter (Hishinuma *et al.*, 2016). Among *Juglans* hosts, *J. major* is considered to be a native host of *P. juglandis*, and *J. californica* may also possibly be an indigenous or native host (EPPO, 2015b). *Carya* species (also Juglandaceae) are not hosts of *P. juglandis* and *G. morbida* (EPPO, 2015b).

The susceptibility to thousand cankers disease varies between species and hybrids, and between trees of the same species. This is also the case for the most susceptible *J. nigra*, for which healthy trees may be found in areas severely impacted by the disease. *J. major* and *J. nigra* consistently appear as the least and most susceptible host species respectively. All other known *Juglans* hosts infested in the field or in collections, as well as hybrids, seem to fall in an intermediate category. *J. regia* (the most important species for the EPPO region), is susceptible but seems to present a wide intraspecific variation (EPPO, 2015b).

Known impacts and control in current distribution (all from EPPO, 2015b, except if another source is indicated)

In the USA, to date amenity trees have been most affected. However, the greatest potential impacts of thousand cankers disease are considered on timber production (primarily *J. nigra*) with additional losses to nut production (primarily *J. regia*). In one area of the USA, Boulder Colorado, where thousand cankers disease has been present for over a decade, the value of affected plants is estimated at approximately 3 million USD and over 60% of trees died within 6 years of the disease's original detection. Many municipalities and homeowners in the USA have already incurred costs associated with the loss of *Juglans* amenity plants due to tree removal and replacement costs, indirect effects on shade, heating/cooling, and added landscape value to property.

P. juglandis has been present in Southern California, but historically has not been an issue in cultivated *J. regia* until recent years. Certain rootstocks on which nut-producing *J. regia* may be grown (e.g. ‘Paradox’ a hybrid of *J. hindsii* x *J. regia*) are susceptible to thousand cankers disease. *J. regia* is considered to be less susceptible to thousand cankers disease than are some other *Juglans* species (e.g. *J. nigra*, *J. hindsii*), however, mortality, although not extensive, has been observed.

There are also costs incurred by government and universities associated with survey and detection, monitoring, public outreach, and development and implementation of interstate quarantines.

Social damage in the USA is currently due to death of amenity and garden trees, but losses of jobs are anticipated for the future.

In Italy, *P. juglandis* was found in Northern Italy (Veneto) since 2013 in 5 black walnut plantations. In the following years the pest was found in 13 (2014), 17 (2015), 26 (2016) and 29 (2017) new sites (M. Faccoli, pers. obs.). The damage, in term of number of infested trees, greatly varied according to the different plantations from a few trees to about 25-30% of the plants.

Control: No control methods are currently available to effectively protect individual trees from developing thousand cankers disease or to cure diseased trees. Research is actively conducted on control methods (chemical, biological control, semiochemical, resistant cultivars) of this recently-recognized pest complex. In laboratory and field trials, Castrillo *et al.* (2017) found that exposure of beetles to walnut logs sprayed with the entomopathogenic fungi *Beauveria bassiana* and *Metarhizium brunneum* reduced populations, and have a potential use in integrated management. Blood *et al.* (2018) identified attractants and a repellent and concluded that it may be possible to use them in push-pull strategies, which remain to be developed.

POTENTIAL RISKS FOR THE EPPO REGION

Pathways

Entry

In Italy, the most likely pathway for introduction may have been fresh infested walnut wood and timber (with bark) from the USA. From genetic analysis, all the analysed populations appear to have derived from a single introduction (Faccoli *et al.*, 2016). The EPPO PRA (EPPO, 2015a) stated that the likelihood of entry was high, especially on wood with bark of *Juglans* and *Pterocarya* and wood packaging material if ISPM 15 is not applied. From the biological point of view, wood is very favourable for entry, and there is trade of walnut roundwood and sawn wood, and also firewood, to a large number of EPPO countries where *Juglans* species are grown.

The likelihood of entry on wood chips and wood waste is considered low, but not excluded (EPPO, 2015a). Entry would require that individuals survive processing and transport, and transfer to a suitable host. The volume and frequency of trade are favourable to entry, but walnut is not likely to constitute a high percentage of any load of wood chips. *P. juglandis* would be more exposed to desiccation in chips than in wood, and transfer would require that wood chips are stored outdoors or used in particular conditions (mulch).

The likelihood of entry on bark on its own is considered as low, and no information could be found on existing trade (EPPO, 2015a).

The probably of entry would increase if trade volumes further increase and the pests further spread widely to Eastern USA, where the main walnut wood-producing States are located. From Italy, most production plantations of *Juglans* were established in the 1990s and the trees are well below dimensions that are usually used commercially; the current volumes of *Juglans* wood traded from Italy are therefore likely to be much lower than from the USA.

Plants for planting are also a very suitable entry pathway (EPPO, 2015a), if there is a trade. The recent results in Audley *et al.* (2017 - above) shows some temporary association of adults with small trees, although no offspring was produced in their experiments. Cut branches of *Juglans* and *Pterocarya* is considered a very unlikely pathway (unlikely to be traded, not mentioned in relation to possible pathways in the USA) (EPPO; 2015a).

Summary of pathways (uncertain pathways are marked with '?'):

- *wood (round or sawn, with or without bark, incl. firewood) of Juglans and Pterocarya*
- *non-coniferous wood chips, hogwood, processing wood residues (except sawdust and shavings)*
- *wood packaging material if not treated according to ISPM 15*
- *plants for planting (except seeds) of Juglans and Pterocarya*
- *bark of hosts?*

Spread (following introduction, i.e. within EPPO region)

P. juglandis flies and is expected to spread naturally from areas within the EPPO region where it becomes established. Natural spread has occurred in the USA, although human-assisted pathways are considered more important for spread and are critical for spread over long distances and across geographic barriers. The EPPO PRA estimated that natural spread from Italy was likely to happen towards Slovenia, Austria and Croatia in the East, and possibly to France in the West (further away). However, human-assisted spread will be the main means of spread in the EPPO region. An illustration of this is the finding of *P. juglandis* and *G. morbida* in Piemonte in 2015, more than 320 km from the first recorded site in 2013 (see above).

Establishment

P. juglandis and *G. morbida* have the potential to establish throughout the EPPO region where *Juglans* species occur, and climate was not considered a limiting factor in the EPPO PRA. Among the host plants of *P. juglandis,* at least *J. regia*, *J. nigra* (although a North American species, see below) and *J. mandshurica* occur naturally in the PRA area. These species as well as many other *Juglans* spp. are also grown commercially (for wood or nuts) and as amenity trees (parks, gardens). *Pterocarya* would presumably be grown as amenity trees. *J. regia* is the most widespread *Juglans* in the PRA area, used commercially for nut and wood production, and as amenity tree. *J. nigra* has been used as a forest tree since the 19th century and is acclimatized from Western Europe (including Italy) to Ukraine and Russia, through Central Europe. It is extensively planted for wood production in parts of central and eastern Europe, and is available for sale as ornamental. 11 *Juglans* spp. of various origins were recorded as being available for sale in nurseries in Europe, as well as five *Pterocarya* spp. including the known hosts.

P. juglandis is able to develop on healthy or stressed trees, and on cut trees. The current management practices in orchards and forests in the EPPO region were not considered to hinder its establishment. Finally, small populations are believed to be able to start an outbreak, although *P. juglandis* may be present in huge numbers in logs, which would help establishment of populations. There is a possibility that adults may be present all year round in the southern part of the PRA area. Finally, it has adapted to several *Juglans* species other than those present in its native range, and is very successful on some of them. It is very likely that it could move to yet other *Juglans* species.

Potential impact (including consideration of host plants)

All walnut trees in the EPPO regions are at risk in the long term. The greatest risk is to *J. regia* nut production, with secondary losses to timber (*J. regia*, *J. nigra*) and amenity plants. Environmental impacts may occur on walnuts in the wild, especially when they reach areas where those are important (e.g. sensitive environments, mountains, pure wild stands in Central Asia). The social impact may be locally high in areas of intensive plantation or orchards, and in areas where walnuts are an important source of income for local populations (either collected from the wild, orchards or gardens). *P. juglandis* and *G. morbida* are likely to be more damaging (more generations of *P. juglandis*) in the Southern and Eastern parts of the EPPO region, where walnuts are also grown more widely. Faccoli *et al.* (2016) noted that given its widespread presence and rapid reproduction and dispersal, *P. juglandis* might quickly increase its abundance and distribution in Italy and other European countries, and that damage will probably increase in the near future, leading to a gradual decline of walnut health and a progressive reduction in the number of *J. nigra* plantations.

Table 1. Distribution (all records from EPPO Global Database, with additional references)

	Comments
EPPO region	
Northern Italy (Veneto, Lombardia, Piemonte, Friuli Venezia Giulia)	First found in Veneto in 2013, later in 3 other regions of Northern Italy. In Lombardia and Friuli Venezia Giulia, as of Montecchio *et al.* (2016), only *P. juglandis* had been found (trapped), not *G. morbida* and no symptoms of the disease had been observed.
North America	
Mexico	Only *P. juglandis* has been recorded, in the state of Chihuahua. These findings pre-date by many decades the discovery of thousand cankers disease and description of *G. morbida*. There are no known recent attempts to make dedicated collections of either organism in Mexico (EPPO, 2015a).
USA (Arizona, California, Colorado, Idaho, Indiana, Maryland, Nevada,	In Indiana, only *G. morbida* had been found at the time of the EPPO PRA, but the presence of *P. juglandis* has later been confirmed

	Comments
New Mexico, North Carolina, Ohio, Oregon, Pennsylvania, Tennessee, Utah, Virginia, Washington)	(EPPO, 2018)

Table 2. Hosts

Family	Species	Reference
Juglandaceae	*Juglans ailantifolia*	EPPO, 2015a
Juglandaceae	*Juglans californica*	EPPO, 2015a
Juglandaceae	*Juglans cinerea*	EPPO, 2015a
Juglandaceae	*Juglans hindsii*	EPPO, 2015a
Juglandaceae	*Juglans major*	EPPO, 2015a
Juglandaceae	*Juglans mandshurica*	EPPO, 2015a
Juglandaceae	*Juglans microcarpa*	EPPO, 2015a
Juglandaceae	*Juglans mollis*	EPPO, 2015a
Juglandaceae	*Juglans nigra*	EPPO, 2015a
Juglandaceae	*Juglans regia*	EPPO, 2015a
Juglandaceae	*Juglans* hybrids, e.g. Paradox rootstock *J. hindsii* x *J. regia*, *J. nigra* x *J. hindsii*, *J. cinerea* x *J. ailantifolia*, *J. nigra* × *J. regia*	EPPO, 2015a
Juglandaceae	*Pterocarya fraxinifolia*	Hishinuma *et al.*, 2016
Juglandaceae	*Pterocarya stenoptera*	Hishinuma *et al.*, 2016
Juglandaceae	*Pterocarya rhoifolia*	Hishinuma *et al.*, 2016

References

Audley J, Klingeman WE, Mayfield AE, Myers SW, Taylor A. 2017. Walnut Twig Beetle (Coleoptera: Curculionidae: Scolytinae) Colonization of Eastern Black Walnut Nursery Trees. Journal of Insect Science (2017) 17(3): 70; 1–9

Audley J, Taylor A, Klingeman WE, Mayfield AE, Myers SW. 2016. Insecticide Dip Treatments to Prevent Walnut Twig Beetle Colonization of Black Walnut Logs. Forest Products Journal Vol. 66, No. ¾.

Blood BL, Klingeman WE, Paschen MA, Hadžiabdić D, Couture JJ, Ginzel MD. 2018. Behavioral Responses of *Pityophthorus juglandis* (Coleoptera: Curculionidae: Scolytinae) to Volatiles of Black Walnut and *Geosmithia morbida* (Ascomycota: Hypocreales: Bionectriaceae), the Causal Agent of Thousand Cankers Disease. Environmental Entomology, XX(X), 2018, 1–10

Castrillo LA, Mayfield AE, Griggs MH, Camp R, Mudder B, Taylor A, Vandenberg JD. 2017. Mortality and reduced brood production in walnut twig beetles, *Pityophthorus juglandis* (Coleoptera: Curculionidae), following exposure to commercial strains of entomopathogenic fungi Beauveria bassiana and Metarhizium brunneum. Biological Control, Volume 114, Pages 79-86

EPPO. 2015a. EPPO Pest Risk Analysis for Thousand cankers disease (*Geosmithia morbida* and *Pityophthorus juglandis*). Available at https://www.eppo.int

EPPO. 2015b. unpublished. Draft EPPO Datasheet on *Pityophthorus juglandis* and *Geosmithia morbida*. Prepared by a PRA EWG. Working Party document 15-20696.

EPPO. 2018. EPPO Global Database. gd.eppo.int

Faccoli M, Simonato M, Rassati D. 2016. Life history and geographical distribution of the walnut twig beetle, *Pityophthorus juglandis* (Coleoptera: Scolytinae), in southern Europe. Journal of Applied Entomology 140(9), 697-705.

Hishinuma SM, Dallara PL, Yaghmour MA, Zerillo MM, Parker CM, Roubtsova TV, Nguyen TL, Tisserat NA, Bostock RM, Flint ML, Seybold SJ. 2016. Wingnut (Juglandaceae) as a new generic host for *Pityophthorus juglandis* (Coleoptera: Curculionidae) and the thousand cankers disease pathogen, *Geosmithia morbida* (Ascomycota: Hypocreales). The Canadian Entomologist, Volume 148, Issue 1, pp. 83-91.

Kees AM, Hefty AR, Venette RC, Seybold SJ, Aukema BH. 2017. Flight Capacity of the Walnut Twig Beetle (Coleoptera: Scolytidae) on a Laboratory Flight Mill. Environmental Entomology, 46(3), 633–641.

Kolařík M, Hulcr J, Tisserat N, De Beer W, Kostovčík M, Kolaříková Z, Seybold SJ, Rizzo DM. 2017. Geosmithia associated with bark beetles and woodborers in the western USA: taxonomic diversity and vector specificity. Mycologia Vol. 109(2) , 185-199.

LaBonte JR, Rabaglia R. 2012. A screening aid for the identification of the walnut twig beetle, *Pityophthorus juglandis* Blackman. Availiable online. caps.ceris.purdue.edu/webfm_send/854.

Luna EK, Sitz RA, Cranshaw WS, Tisserat NA. 2013. The Effect of Temperature on Survival of *Pityophthorus juglandis* (Coleoptera: Curculionidae). Environ Entomol., 42(5):1085-91.

Montecchio L, Vettorazzo M, Faccoli M. 2016. Thousand cankers disease in Europe: an overview. Bulletin OEPP/EPPO Bulletin 46 (2), 335–340.

Oren E, Klingeman W, Gazis R, Moulton J, Lambdin P, Coggeshall M, Hulcr J, Seybold SJ, Hadziabdic D. 2018. A novel molecular toolkit for rapid detection of the pathogen and primary vector of thousand cankers disease. PLoS ONE 13(1): e0185087.

Peachey E. 2012. Studies on the walnut twig beetle (WTB), *Pityophthorus juglandis*, in relation to its association with *Geosmithia morbida*, its survival in felled logs, and its sensitivity to temperature extremes. Master's thesis. Colorado State University.

Rugman-Jones PF, Seybold SJ, Graves AD, Stouthamer R. 2015. Phylogeography of the Walnut Twig Beetle, *Pityophthorus juglandis*, the Vector of Thousand Cankers Disease in North American Walnut Trees. PLoS ONE 10(2): e0118264.

Seybold SJ, Dallara PL, Hishinuma SM, Flint ML. 2012a. Detecting and identifying the walnut twig beetle: Monitoring guidelines for the invasive vector of thousand cankers disease of walnut, University of California Agriculture and Natural Resources, Statewide Integrated Pest Management Program, 11 pp. http://www.ipm.ucdavis.edu/PMG/menu.thousandcankers.html

Seybold SJ, Dallara PL, Nelson LJ, Graves AD, Hishinuma SM, Gries R. 2012b. Methods of monitoring and controlling the walnut twig beetle, *Pityophthorus juglandis*. Patent application filed with the U.S. Patent and Trademark Office, U.S. Dept. ofCommerce, 13 July, 2012, U.S. Patent Application No. 13/548.319, 38 pp. + 7 Figs.

This text is an integral part of the *EPPO Study on bark and ambrosia beetles associated with imported non-coniferous wood* and should be read in conjunction with the study

Pest information sheet
Ambrosia beetle

PLATYPUS APICALIS AND *P. GRACILIS* (COLEOPTERA: PLATYPODINAE)

EPPO Lists: Not listed. The assessment of potential risks in this information sheet is not based on a full PRA for the EPPO region, but on an assessment of the limited information for that species used to prepare the information sheet. These two species are treated together due to similarities in their distribution and biology.

PEST OVERVIEW

Taxonomy

- *Platypus apicalis* White, 1846. Synonyms: *Crossotarsus apicalis* auct.; *Platypus douei* Chapuis, 1865; *Platypus castaneus* Broun, 1880.
- *Platypus gracilis* Broun, 1893. Synonyms: *Platypus inimicus* Broun, 1910b; *Platypus denticulatus* Browne, 1980.

Associated fungi

Sporothrix nothofagi is the symbiont of *P. apicalis* and *P. gracilis* and the related *Treptoplatypus caviceps* (Ploetz *et al.*, 2003). *S. nothofagi* is highly pathogenic on *Nothofagus* spp. The fungus alone is able to kill trees after artificial inoculation (Faulds, 1977, citing others). Faulds *et al.* (1977) mention that other fungi isolated on *Nothofagus* (yeasts, a *Ceratocystis* sp., others) were not pathogenic.
In experiments using artificial inoculation, *S. nothofagi* caused the death of healthy *Weinmannia racemosa*. Such mortality of healthy trees was also observed following attacks by *P. apicalis* and *P. gracilis* in the field (Payton, 1988). Scion (2009) mentions ‘susceptibility to a sapwood pathogen’ linked to attacks of *P. apicalis* on *Nothofagus obliqua*, *Castanea sativa*, and *Brachyglottis*, but it is not clear if the pathogen has been identified as *S. nothofagi*.

Morphology and biology

Adults of *P. apicalis* and *P. gracilis* measure less than 1 cm and 0.5 cm, respectively (Scion, 2009). *P. apicalis* and *P. gracilis* are wood-boring ambrosia beetles. They have a similar biology, and often occur together in the same material (Brockerhoff *et al.*, 2003, citing others).

P. apicalis and *P. gracilis* may attack healthy or weakened living trees, stumps, freshly felled trees, logs and larger branches, and occasionally green sawn timber (Scion, 2009). Apparently healthy trees can be attacked particularly if large head logs or stumps lay nearby, and the beetles invade indiscriminately the felled material and standing trees (Milligan, 1974b). *P. gracilis* can also establish in logs, stumps, and dead standing trees invaded in previous seasons. For example, broods have been established in *Nothofagus* logs felled 20 years previously, and galleries containing fully grown larvae have been found in the stump of a large *Nothofagus* felled 25 years previously (Scion, 2009). Broods of *P. apicalis* and *P. gracilis* may emerge from dead parts of a live tree (Scion, 2009).

Six centimetre diameter stems are rarely attacked, but abortive attacks are not uncommon on stems above 15 cm in diameter (Milligan, 1974b). Broods of *P. apicalis* can be reared in felled branches less than 10 cm in diameter (provided they lie in moist conditions) (Scion, 2009). Attacks of *P. apicalis* and *P. gracilis* are concentrated on the lower six metres of living trees (Milligan, 1974b).

P. gracilis (but not *P. apicalis*) commonly start tunnels from a concealed site (e.g. bark crevice) (Scion, 2009). *P. apicalis* is essentially limited to the sapwood, but fully grown larvae of *P. gracilis* extend their galleries throughout moist heartwood. Wood from trees that recently died, and which is persistently moist, is the most favourable habitat for the broods.

The life cycle of both species takes ca. 2 years and broods are produced (small groups of eggs) over a long period (Milligan, 1974b; Scion, 2009). Some individuals of *P. apicalis* emerge 2 years after gallery initiation, but 40% emerge later (most in the third season, few in the fourth season).

For *P. gracilis*, emergence begins 2 years after gallery initiation, but most broods (ca. 80% of the total) are produced in the third and fourth seasons. Brood production may continue for longer periods: more than half the galleries in a large-diameter stump and log of red beech continued to produce 6 years after nest initiation. During this period the maximum number of offspring per pair of beetles was 528, and the mean for 40 broods was 115 (Scion, 2009).

P. apicalis and *P. gracilis* are gregarious. They use an aggregation pheromone to initiate mass attacks, attracting other males and females (Milligan, 1974b, Ploetz *et al.*, 2003; Scion, 2009). Males are attracted to volatiles produced by dying or freshly felled trees and stumps. Rapidly growing eucalyptus trees also produce an attractant which causes males to fly from up to 800 m away to concentrate attack on the most vigorous trees in the stand and on parts (usually the base in young trees) where thickening/growth is highest. Attacks on these healthy trees are aborted as the beetles die, and before they have penetrated more than a few centimetres (however, these attacks damage the wood, see *Known impact*). Attraction to fast growing individuals leading to abortive attacks has been observed for other tree species (Scion, 2009).

Spread biology

Both males and females fly. No precise information was found on the flight capacity, but males have been reported to fly from up to 800 m away to attack rapidly growing eucalyptus trees (see above).

Nature of the damage

P. apicalis and *P. gracilis* tunnel into the wood, and the associated fungus *S. nothofagi* causes wood staining and is highly pathogenic to at least *Nothofagus* spp. and *Weinmannia racemosa* (able to cause tree mortality on its own). On *Nothofagus* spp., attacks may lead to tree death. In studies, attack by *Platypus* was induced experimentally in 12 *Nothofagus* trees selected as healthy and, following massive attack (maximum density of 968 to 1291 holes per m^2 of bark), three trees larger than 35 cm DBH[16] died within 2-4 years of the first attack; four smaller trees (20-30 cm DBH) suffered abnormal leaf fall and some twig dieback, but survived despite thinning of the crown (Milligan, 1974a).

However, abortive attacks cause timber defects in living trees which may be of considerable economic importance (Scion, 2009). Mass-attacks can lead to large scale mortality particularly involving *Nothofagus* spp. (Brockerhoff *et al.*, 2003, citing others).

Trees only lightly and abortively attacked were also observed to die because of *S. nothofagi* if a drought occurred in the following summer even without a second attack in the drought year, indicating that the pathogen can survive for at least a year in trees which were only abortively attacked (Milligan *et al.*, 1974b). Moisture stress induced by waterlogging or drought has been associated with enhanced tree mortality (Ploetz *et al.*, 2003). When a temporary stress that triggered an infestation is over, the trees may react and kill the beetles with gum or resins in their galleries, but if the trees are susceptible to the pathogen, the sapwood is progressively killed, this intensifies stress, further attacks occur, and the tree eventually dies (Scion, 2009).

Detection and identification

- *Symptoms.* For both species, ejected frass may protrude from the entrance hole, and then fall (Scion, 2009). Death of branches, holes, general decline of trees, and death.
- *Trapping*. *P. apicalis* and *P. gracilis* are attracted to stressed trees, i.e. ethanol is probably an attractant. No information was found on whether the aggregation pheromone has been synthesised.
- *Identification.* A description of life stages is provided in Scion (2009).

Distribution

Both species are native to New Zealand (Brockerhoff *et al.*, 2003).

- *P. apicalis*: New Zealand including Chatham Islands (Brockerhoff *et al.*, 2003).
  Absent: Australia. In Wood and Bright (1992), but considered doubtful in Brockerhoff *et al.* (2003), and PaDIL (2018) considers this species as absent.

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[16] diameter at breast height

- *P. gracilis*: New Zealand. A record from New Guinea appears to be erroneous (Brockerhoff *et al.*, 2003 citing others).

Host plants

- *P. apicalis*. Known reproductive hosts:
    - live trees: the native *Nothofagus fusca*, *N. menziesii*, *N. solandri* and *N. truncata*, *Weinmannia racemosa*, *Cordyline australis*, *Nothofagus obliqua* (South American species), *Castanea sativa* (European species) and *Brachyglottis* (probably *B. huntii*).
    - felled trees, stumps, logs, and felled branches less than 10 cm in diameter (provided they lie in moist situations): native *Nothofagus* spp. (as above), *Weinmannia racemosa*, *Agathis australis*, *Corynocarpus laevigatus*, *Dacrycarpus dacrydioides*, *Dacrydium cupressinum*, *Acer pseudoplatanus*, *Pinus muricata*, *P. nigra*, *P. ponderosa*, *P. radiata*, *P. taeda*, *Prumnopitys ferruginea*, *P. taxifolia*, *Pseudotsuga menziesii*, *Acer pseudoplatanus*, *Beilschmiedia tawa*, *Elaeocarpus hookerianus*, *Salix babylonica*.

Abortive attacks on live trees (i.e. unsuccessful reproduction) have been recorded on: native *Nothofagus* spp. (as above), *Acacia melanoxylon*, *Aristotelia serrata*, *Eucalyptus botryoides*, *E. delegatensis*, *E. fastigata*, *E. gunnii*, *E. macarthurii*, *E. nitens*, *E. obliqua*, *E. regnans*, *Populus trichocarpa*, *Quercus robur* and *Sequoia sempervirens* (Brockerhoff *et al.*, 2003, citing others; Scion, 2009).
Finally, tunnels were found in dead *Acacia dealbata*, *Dysoxylum spectabile*, *Diospyros kaki*, *Picea abies*, *Betula pendula*, *Ginkgo biloba*, *Rhus*, *Salix fragilis*, but it is not known whether brood can be reared.
On Chatham Islands, where main hosts do not occur, *P. apicalis* has been reported to "attack" (not known if reproductive hosts or not, and whether live trees or felled): *Coprosma chathamica*, *Corynocarpus laevigata*, *Melicytus chathamicus*, *Plagianthus regius subsp. chathamicus*, *Pseudopanax chathamicus*, *Brachyglottis huntii* and *Myrsine chathamica* (Scion, 2009).

- *P. gracilis***.** Known reproductive hosts are:
    - live trees: *Nothofagus fusca*, *N. menziesii*, *N. solandri*, *N. truncata*, *Carpodetus serratus* and *Weinmannia racemosa*,
    - stumps and larger diameter dead material: species above, as well as *Pinus* spp. and *Pseudotsuga menziesii*.

Abortive attacks are common in native *Nothofagus*, *Eucalyptus delegatensis*, *E. fastigata*, and *E. gunnii*, and occasional in *Phyllocladus alpinus*, *Dacrydium cupressinum*, *Dacrycarpus dacrydioides*.
Finally, tunnels were found in *Metrosideros robusta* and *M. umbellata*, but it is not known whether living trees are attacked or whether broods can emerge from these hosts (Scion, 2009).

Note: *Nothofagus* is classified under Fagaceae or its own genus Nothofagaceae depending on sources, respectively the *Index Nominum Genericorum (ING)* and the *International Plant Names Index (IPNI)*. *P. apicalis* has been recorded on *Castanea sativa*, and no other record on Fagaceae were found. However, Fagaceae are not frequent in New Zealand: only *Fagus sylvatica* and *Castanea sativa* are common in parks and gardens (https://floraseries.landcareresearch.co.nz/pages/Taxon.aspx?id=_e27ac9a9-18bc-4d46-8d06-8ad74f918b4f&fileName=Flora%204.xml).

Known impacts and control in current distribution

P. apicalis and *P. gracilis* associated with *S. nothofagi* have caused sapwood staining, reduction of the marketability of harvested timber and tree mortality (Ploetz *et al.*, 2003). Mortality of *Nothofagus* spp. in New Zealand was originally thought to be caused by *Nascioides enysi* (Coleoptera: Buprestidae), but was shown in the 1970s to be caused by a pathogenic fungus vectored by *Platypus* spp. (Faulds *et al.*, 1977).

Both species are of the greatest economic importance in *Nothofagus* forests, where they occupy an ecological niche comparable with that of the aggressive bark beetles in coniferous forests of the Northern Hemisphere. The pathogen can kill trees. Even if trees are not killed, beetle attacks cause damage to the heartwood, gum streaks in sapwood, and death and staining of part of the sapwood, which enables entry of wood-rotting fungi (Scion, 2009). Faulds *et al.* (1977) mention that many *Nothofagus* trees survived successive annual *Platypus* attacks and that stem defect arose mostly from sublethal attacks, although the pathogen may kill the trees.

Attacks are not restricted to weakened trees. Trees of a sufficient diameter to contain an appreciable core of heartwood died following heavy attack; smaller trees which suffered comparable attacks recovered but were left with a core of dead and discoloured sapwood (Milligan, 1974a).

Attacks by *P. apicalis* and *P. gracilis* on rapidly growing *Eucalyptus* (which are not reproductive hosts) may reduce the value of the wood produced (Scion, 2009). The overall impact could not be quantified because few plantations had reached commercial size, but during a minor mill study, all pieces sawn from the most rapidly grown of four 30-year-old *E. delegatensis* bore defects (gum) resulting from *Platypus* attack (only 2.8% pieces from the slowest grown trees were affected). In *E. gunnii*, *Platypus* tunnels extended further into the wood (Scion, 2009).

Steward (1989) studying the factors involved in forest decline in New Zealand noted that disturbances that cause physical injury to trees (e.g. snow breakage or windthrow) in *N. solandri* forests attract *Platypus* spp. The beetles then attack nearby living trees, especially large old trees and those under stress. Once some mortality has occurred, tree death is likely to spread rapidly, resulting in a dieback phenomenon. In *N. solandri* forests, an initial 2.3% loss of basal area due to snowbreak led to 11 % loss after ca. 10 years, and basal area was continuing to decline (Stewart, 1989 citing others).

Damage to native *Nothofagus* forests has presumably caused environmental impacts (although this is not mentioned directly in publications).

Control. Control of *Platypus* species using the entomopathogenic fungi *Beauveria bassiana* has been investigated, but the methods are not yet resolved (Scion, 2009). No control has been attempted in native forests. In *Nothofagus* plantations, control relies on good forest management practices to reduce damage (e.g. avoiding logging operations nearby, removing possible sources of beetles such as rejected logs or damaged standing trees, clear-felling and regeneration of stands, breaking down of wood residues on site (Scion, 2009).

POTENTIAL RISKS FOR THE EPPO REGION

Pathways

Entry

P. apicalis and *P. gracilis* are associated with wood of many species and can attack large diameter trees. Both species are able to reproduce on cut material of various species, including *Eucalyptus* spp., *Pinus* spp. and *Pseudotsuga menziesii* (for both) or *Acer pseudoplatanus*. Life stages are in the xylem, and all wood commodities may be a pathway. Processes applied to produce wood commodities would destroy some individuals. The likelihood of entry on wood chips, hogwood and processing wood residues would be lower than on round wood, as individuals would have to survive processing and transport, and transfer to a suitable host is less likely. In addition, both species seem to require a certain humidity for their broods, which may not be available in some commodities. *P. apicalis* and *P. gracilis* may be able to transfer from wood commodities to a living host or felled material. Bark on its own is an unlikely pathway.

Plants for planting may be a pathway, but there may be a size threshold for attacks; it is mentioned that 6-cm diameter stems are rarely attacked. Plants for planting are normally subject to controls during production, and attacked plants may be detected and discarded. It is not known if there is a trade. Cut branches are a less likely pathway, as they are used indoors, and the pest is unlikely to be able to transfer to a suitable host. It is not known if branches of hosts of a suitable size are traded.

Summary of pathways (uncertain pathways are marked with '?'):

- *wood (round or sawn, with or without bark, incl. firewood) of hosts*
- *wood chips, hogwood, processing wood residues (except sawdust and shavings)*
- *wood packaging material if not treated according to ISPM 15*
- *plants for planting (except seeds) of hosts?*
- *cut branches of hosts?*

Because of the large host ranges and recorded attacks on felled material of many species, pathways may cover all coniferous and non-coniferous species.

Spread (following introduction, i.e. within EPPO region)

P. apicalis or *P. gracilis* could spread naturally and through human-assisted pathways. If they were introduced into the EPPO region, spread would depend on their hosts. The major hosts *Nothofagus* spp. in the EPPO region are mostly cultivated as ornamentals or planted on limited scale. Small-scale plantations are reported as widespread in the UK (*N. obliqua* and *N. alpina* - Scanu *et al.*, 2012). However, Fagaceae is a family of great economic and environmental importance in the EPPO region, with the genera *Quercus*, *Fagus* and *Castanea*. Native New Zealand trees may be used as ornamentals or in botanical gardens. *Castanea sativa* (for *P. apicalis*) is widely grown in the EPPO region in the wild, and cultivated for fruit and wood, and as ornamental tree. Both beetle species are able to reproduce on cut material or stumps of various species, including widespread ones such as *Pinus* spp. and *Pseudotsuga menziesii* (for both) or *Acer pseudoplatanus, Salix babylonica* (for *P. apicalis*), which would contribute to their spread. Human-assisted pathways may help in creating multiple foci in the EPPO region, if introduced.

Establishment

Based on the classification of Köppen-Geiger (see Annex 6 of the study), the climates types in New Zealand are mostly Cfa and Cfb[17], which are also present in the temperate part of the EPPO region, from UK to Spain in the West to Poland and the Black Sea in the East.

The known hosts of *P. apicalis* and *P. gracilis*, in particularly *Nothofagus* on which mortality is reported, have a limited presence in the EPPO region, but the beetles may also establish populations on cut material of a wide variety of species (see *Spread* above). In New Zealand, they have also attacked exotic species, and this may happen in the EPPO region. If they were able to reproduce on new hosts such as Fagaceae, establishment will be more likely. Finally, the fecundity of *P. gracilis* is high, which may also favour establishment.

Potential impact (including consideration of host plants)

The potential impact of *P. apicalis* and *P. gracilis* on *Nothofagus* spp. only in the EPPO region would be minor (as they are grown only as ornamentals or in small plantations). The potential impact of *P. apicalis* on *Castanea sativa* is difficult to assess because limited information is available (this tree is only grown as an ornamental in New Zealand), but the literature indicates that it is susceptible to *S. nothofagi* (Scion, 2009). In addition, economic damage has been observed in New Zealand on a number of non-reproductive species, such as *Eucalyptus*, and such damage may also occur once populations are well established. Finally, both species may reduce the timber value of a number of species (including *Pinus*). The overall potential impact would also depend on whether *P. apicalis* and *P. gracilis* would extend their host range, especially in the Fagaceae, and of the pathogenicity of *S. nothofagi* on new hosts. Genera such as *Fagus*, *Quercus* or *Castanea* are of major importance for the EPPO region, and occur in a wide diversity of habitats, including in the wild, or in cultivation for wood, ornamentals or fruit.

References (all URLs were accessed in March 2018)

Brockerhoff EG, Knízek M, Bain J. 2003. Checklist of indigenous and adventive bark and ambrosia beetles (Curculionidae: Scolytinae and Platypodinae) of New Zealand and interceptions of exotic species (1952-2000). New Zealand Entomologist 26: 29-44.

Faulds W. 1977. A Pathogenic Fungus Associated with *Platypus* Attack on New Zealand Nothofagus Species. N.Z. J. For. Sci. 7(3): 384-396.

Milligan RH. 1974a. A Review of Beech Forest Pathology. NZ Journal of Forestry.

Milligan RH. 1974b. Insects Damaging Beech (*Nothofagus*) Forests. Proceedings of the New Zealand Ecological Society, 21.

PaDIL. 2018. High quality images and Information tools designed for Biosecurity and Biodiversity. http://www.padil.gov.au

Payton IJ. 1989. Fungal (Sporothrix) induced mortality of kamahi (*Weinmannia racemosa*) after attack by pinhole borer (*Platypus* spp.). New Zealand Journal of Botany, 27(3).

Ploetz RC, Hulcr J, Wingfield MJ, de Beer ZW. 2013. Destructive Tree Diseases Associated with Ambrosia and Bark Beetles: Black Swan Events in Tree Pathology? Plant Disease, 97(7):856-872.

Scanu B, Jones B, Webber JF. 2012. A new disease of *Nothofagus* in Britain caused by *Phytophthora pseudosyringae*. New Disease Reports 25, 27.

Scion. 2009. Pinhole borers, native. Forest and Timber Insects in New Zealand No. 37: The native pinhole borers. Limited revision 2001. Based on R.H. Milligan (1979) Pest and diseases of forestry in New Zealand.

Wood SL, Bright DE. 1992. A catalog of Scolytidae and Platypodidae (Coleoptera), Part 2. Taxonomic Index. Great Basin Nat. Mem. 13:1-1553 (vol. A, B).

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[17] **Cfa**: warm temperate climate, fully humid, hot summer; **Cfb**: warm temperate climate, fully humid, warm summer.

This text is an integral part of the *EPPO Study on bark and ambrosia beetles associated with imported non-coniferous wood* and should be read in conjunction with the study

Pest information sheet
Ambrosia beetle

PLATYPUS KORYOENSIS (COLEOPTERA: PLATYPODINAE)

EPPO Lists: Not listed. The assessment of potential risks in this information sheet is not based on a full PRA for the EPPO region, but on an assessment of the limited information for that species used to prepare the information sheet. Most information used originates from the Korean Republic, where *Platypus koryoensis* and its symbiont *Raffaelea quercus-mongolicae* have been found associated with mortality of oaks since 2004. No data were found for other countries where *P. koryoensis* is recorded (Taiwan and Far-East Russia).

PEST OVERVIEW

Taxonomy

Platypus koryoensis (Murayama, 1930). Synonym: *Crossotarsus koryoensis* (Murayama, 1930).

Associated fungi

Raffaelea quercus-mongolicae (Hong *et al.*, 2006; Kim *et al.*, 2009a), which is distinct from *R. quercivora* (associated with *P. quercivorus* and oak wilt in Japan) (Lee *et al.*, 2008). Other fungal associations have been studied in the Republic of Korea, and identified: 14 genera (from 11 orders) of filamentous fungi belonging to Ascomycota and Basidiomycota (Suh *et al.*, 2011), 104 species of decay fungi (Lee *et al.*, 2008), 8 yeast species (Suh *et al.*, 2013; Yun *et al.*, 2015).

The pathogenicity of associated fungi is not known, although it is suspected for *R. quercus-mongolicae*. *P. koryoensis* and *R. quercus-mongolicae* are considered to contribute to mortality of oak in the Republic of Korea, but the mechanism of tree death has not been explained, and other fungal associations of *P. koryoensis* have been studied (Suh *et al.*, 2011). *R. quercus-mongolicae* has shown ability to colonize sapwood, contribute to sapwood discoloration and disrupt sap flows around the inoculation sites of *Quercus mongolica*, but pathogenicity tests were inconclusive (Torii *et al.*, 2014). Molecular biological investigations on the pathogenicity of *R. quercus-mongolicae* have not been conducted, largely due to the need for genomic information. The draft genome sequence of a strain, which could be used for this purpose, was recently analysed (Jeon *et al.*, 2017). The role of the fungi identified has not been determined to date. Yun *et al.* (2015) noted that the yeasts identified had different abilities to produce enzymes involved in degradation of wood components.

Morphology and biology

Adults measure ca. 4 mm (Park and Lyu, 2007, which includes morphological characters and identification key for Platypodinae of Korea). Males and females tunnel into the wood (Moon *et al.* 2008). According to Lee *et al.* (2011, citing others), galleries are constructed mainly in the sapwood and occasionally in the heartwood.

P. koryoensis is univoltine in Central part of the Republic of Korea, and it overwinters in all life stages in galleries. Flights of emerging adults from brood trees begin in late April and peak in late June and early July (Nam *et al.*, 2013, citing others). Adult flight began when the air temperature was around 16 °C, and they were most active at 20-27°C. Nam *et al.* (2013) modelled the flight of *P. koryoensis* and showed that the median date of flight had changed progressively over the past 40 years, advancing by 9 days during this period as the annual mean temperature increased. The lower developmental threshold temperature for *P. koryoensis* was considered to be 5.8°C.

P. koryoensis is able to attack and kill vigorous trees (Lee *et al.*, 2011). *P. koryoensis* and *R. quercus-mongolicae* have been found both on living and dead stems of hosts (Kim *et al.*, 2009a). During the last years' mass-mortality of *Q. mongolica* trees in the Republic of Korea, intermediate to heavy infestation by *P. koryoensis* was always observed on dead *Q. mongolica* trees (Torii *et al.*, 2014 citing others). On *Q. mongolica*, *P. koryoensis* first infested the lower trunk (Lee *et al.*, 2011). In a study on the spatio-temporal distribution of *P. koryoensis*, it was aggregated near dead or partially dead trees in all sites. Results indicated that *P. koryoensis* prefers larger trees for initial attack and in the following years aggregated individuals disperse to new hosts (Nam *et al*., 2011).

Many trees can survive for one or more years after initial *P. koryoensis* infestation (only minor wilting was observed on many of these trees), and it is likely that in succeeding years, many trees will be attacked again by *P. koryoensis,* which will often result in total tree mortality (Lee *et al.*, 2011). It was noted that the level of damage by the disease increases as the number of beetle entrance holes increases, and management of beetle density is critical to reduce damage (Nam *et al.*, 2011; Nam *et al.*, 2013, citing others).

Spread biology

Both males and females fly and disperse (Lee *et al*., 2011). No details were found on the flight capacity of *P. koryoensis*, but it has spread within Korea.

Nature of the damage

Infested trees show wilting of the foliage throughout the entire crown after mass attack of *P. koryoensis* resulting in tree death within a few years (Lee *et al.*, 2011; Yun *et al.*, 2015).

Detection and identification

- *Symptoms*. Partial wilting and sap exudates near *P. koryoensis* entrance holes were observed (Lee *et al.*, 2011). Sticky traps and multi-funnel traps were found effective for monitoring (Kim *et al.*, 2010).
- *Trapping.* The male-produced aggregation pheromone blend in *P. koryoensis* has been determined (Kim *et al.*, 2009b). The pheromone component citral was effective to attract *P. koryoensis* and could be used to develop control methods (Kim *et al.*, 2017). Ethanol in trap logs was effective in trapping *P. koryoensis* (Son *et al.*, 2015).
- *Identification.* Hong *et al.* (2006) analyzed the morphological differences with the closely related species *P. quercivorus*, and Park and Lyu (2007) indicate morphological characters and an identification key for the Platypodinae of Korea. The draft genome sequence of *R. quercus-mongolicae* (strain KACC44405) has been determined and is in GenBank (Jeon *et al.*, 2017).

Distribution (see Table 1)

P. koryoensis is present in the Republic of Korea, Far-East Russia and Taiwan; a record in North-East China is uncertain (see Table 1). *P. koryoensis* was first recorded from Korea in 1930 (Kim *et al.*, 2009a, citing Hong *et al.* 2006), and has been found associated with mortality of oaks in the Republic of Korea since 2004. Kim *et al.* (2009a, citing others) mentions that the epidemic continued in the Republic of Korea and was spreading southwards.

R. quercus-mongolicae has been reported only from the Republic of Korea.

Host plants (see Table 2)

In the Republic of Korea, *P. koryoensis* and *R. quercus-mongolicae* are mostly associated with *Quercus mongolica*, and rarely with *Q. aliena* and *Q. serrata*, but these are less present in the original outbreak area in Central part of the Republic of Korea (Kim *et al.*, 2009a). *Carpinus laxiflora* and *Acer* are mentioned as hosts in Beaver and Shih (2003) based on a 1985 article, but no recent direct record was found. The host record for *C. laxiflora* is occasionally repeated in the Korean literature, but not that for *Acer*. The significance of these non-Fagaceae hosts is not known.

Known impacts and control in current distribution

P. koryoensis was first recorded in Korea in 1930, but oak mortality started occurring in 2004 (Gyeonggi Province). The Korean Forest Institute estimated that over 16000 trees had been killed in 2006-2009 in Gyeonggi Province (Nam *et al.*, 2013, citing others). Both forest and landscape oaks have been affected (Kim *et al.*, 2009c).

Kim *et al.* (2009a) make the hypothesis that the emergence of oak death may be linked to global warming, which has allowed *P. koryoensis* to extend its distribution in the Republic of Korea. Similarly, Nam *et al.* (2013) hypothesised that there is a link between the earlier flight period over the past 40 years (see *Morphology and biology*) and recent outbreaks.

Control: Control measures have been applied against *P. koryoensis* in the Republic of Korea, such as removing killed trees, using sticky sheets to cover the lower trunks of oak trees and trap large numbers of the beetles (Nam *et al.*, 2013, citing others), spraying pesticides (Kim *et al.*, 2017, citing others), fumigating infected trees using metham sodium (Kim *et al.*, 2017), using a water-based mass-trapping device (Park *et al.*, 2016).

POTENTIAL RISKS FOR THE EPPO REGION

Pathways

Entry

Life stages of *P. koryoensis* are associated with the xylem of its hosts. All wood commodities may be pathways. Processes applied to produce wood commodities would destroy some individuals. The likelihood of entry on wood chips, hogwood and processing wood residues would be lower than on round wood, as individuals would have to survive processing and transport, and transfer to a suitable host is less likely. The wood would also degrade and may not be able to sustain development of the pest. Current imports of *Quercus* or non-coniferous wood appear to be minor from the Republic of Korea, based on data in the EPPO PRA on *Massicus raddei* (EPPO, 2018). There is an uncertainty on the host status of *Carpinus laxiflora* and *Acer*. Bark on its own is an unlikely pathway.

It is not clear if small-sized plants are attacked, i.e. whether plants for planting or cut branches may also be a pathway. This could be the case at least for bonsais. Plants for planting are normally subject to controls during production, and attacked plants may be detected and discarded. Cut branches are a less likely pathway, as they are used indoors, and the pest is unlikely to be able to transfer to a suitable host. It is not known if there is a trade of host plants for planting or cut branches. *Acer* spp. are widely used to produce bonsais, but the host status is not clear.

Summary of pathways (uncertain pathways are marked with '?'):

- *wood (round or sawn, with or without bark, incl. firewood) of Quercus*
- *wood (round or sawn, with or without bark, incl. firewood) of Carpinus laxiflora and Acer?*
- *non-coniferous wood chips, hogwood, processing wood residues (except sawdust and shavings)*
- *wood packaging material if not treated according to ISPM 15*
- *plants for planting (except seeds) of Quercus hosts, Carpinus laxiflora and Acer?*
- *cut branches of Quercus hosts, Carpinus laxiflora and Acer?*

Spread (following introduction, i.e. within EPPO region)

P. koryoensis is known to have spread within Korea, but no detailed information was found. If only the known hosts are attacked, which have a limited presence in the EPPO region (see *Establishment*), spread may be limited. Spread will also depend on whether *P. koryoensis* is able to attack *Quercus* species present in the EPPO region, which would favour both natural spread and human-assisted spread (especially with *Quercus* wood).

Establishment

According to the climate types in the classification of Köppen Geiger (see Annex 6 of the study), the climate type Cfa[18] is present in the coastal areas of Central Korea, and in part of the EPPO region, such as the Black Sea, Northern Italy and part of the Balkans. The climate types of Far-East Russia (e.g. Dfb[18]) are present in Scandinavia and some countries bordering Russia to the west.

The known hosts of *P. koryoensis* have a limited presence in the EPPO region (mostly as ornamentals), except for *Acer* (but data is lacking on its host status). *P. koryoensis* is an ambrosia beetle, and although it has a strong host association to *Q. mongolica* in the Republic of Korea, it may be able to attack other species. *Quercus* are widespread in the PRA area, with the dominating native oaks in Europe and the Mediterranean area including *Q. robur*, *Q. pubescens*, *Q. petraea* and *Q. cerris*, and there are many other species such as *Q. suber*, *Q. ilex*, *Q. afares* (incl. in North Africa). A list of native *Quercus* is provided in the EPPO PRA on *Massicus raddei* (EPPO, 2018). The significance of other hosts is not known.

Consequently, establishment in the EPPO region is considered possible.

Potential impact (including consideration of host plants)

Potential impacts will depend on whether *P. koryoensis* is able to attack native species in its host genera or others in the EPPO region. If not, its impact will be limited because its known hosts are mostly grown as

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[18] **Cfa**: warm temperate climate, fully humid, hot summer; **Dfb**: snow climate, fully humid, warm summer.

ornamentals in the EPPO region. However, *P. koryoensis* is an ambrosia beetle and may find new hosts to grow its symbiotic fungus. The impact will also depend on the virulence of *Raffaelea quercus-mongolicae* on new hosts, and on whether it is associated with other pathogenic fungi. Potential economic and environmental impact could be massive if other *Quercus* spp. can be attacked and if they are very susceptible to the associated fungi. *Quercus* spp. are important in the environment (including in sensitive habitats), for wood production and as amenity trees.

Table 1. Distribution of *P. koryoensis*

	Reference	**Comments**
EPPO region		
Russian Far-East: Ussuri, Primorye	Park and Lyu, 2007	
Asia		
Korea Republic	Park and Lyu, 2007	First record in 1930 (Kim *et al.*, 2009a, citing Hong *et al.* 2006), but mortality of oak reported since 2004.
Taiwan	Park and Lyu, 2007	
Uncertain record: China (North-East)	Kim *et al.*, 2017	Citing a 2013 publication from the Korea Forest Research Institute. No other record was found in the literature. EPPO RS (2009) mentioned that investigations carried out in Northern China (Liaoning and Jilin provinces) did not detect *P. koryoensis* (although it was highly suspected that it occurred there).

Table 2. Hosts

Family	**Genus/Species**	**Reference**
Fagaceae	*Quercus mongolica*	Hong *et al.*, 2006
Fagaceae	*Quercus serrata*	Hong *et al.*, 2006
Fagaceae	*Quercus acutissima*	Hong *et al.*, 2006
Fagaceae	*Quercus aliena*	Hong *et al.*, 2006
Aceraceae	*Acer*	Beaver and Shih, 2003 citing others (no recent records)
Carpinaceae	*Carpinus laxiflora*	

References (all URLs were accessed in January 2018)

Beaver RA, Shih H-T. 2003. Checklist of Platypodidae (Coleoptera: Curculionoidea) from Taiwan. Plant Protection Bulletin (Taiwan) 45, 75-90.

EPPO RS. 2009. Studies on oak wilt caused by *Raffaelea* species in the Far East. EPPO Reporting Service. Article 2009/114.

EPPO. 2018. Pest Risk Analysis for *Massicus raddei* (Coleoptera: Cerambycidae), oak longhorn beetle. Available at https://www.eppo.int

Hong KJ, Kwon YD, Park SW, Lyu DP. *Platypus koryoensis* (Murayama) (Platypodidae; Coleoptera), the vector of oak wilt disease. Korean J Appl Entomol 2006;45:113-7. 2. Kim KH, Choi YJ, Seo ST, Shin HD. *Raffaelea quercusmongolicae* sp. nov. associated with *Platypus koryoensis* on oak in Korea. Mycotaxon 2009;110:189-97.

Jeon J, Kim K-T, Song H, Lee G-W, Cheong K, Kim H, Choi G, Lee Y-H, Stewart JE, Klopfenstein NB, Kim M-S. 2017. Draft genome sequence of the fungus associated with oak wilt mortality in South Korea, *Raffaelea quercus-mongolicae* KACC44405. Genome Announc 5:e00797-17. https://doi.org/10.1128/genomeA.00797-17.

Kim KH, Choi YJ, Seo ST, Shin HD. 2009a. *Raffaelea quercus-mongolicae* sp. nov. associated with *Platypus koryoensis* on oak in Korea. Mycotaxon. Volume 110, pp. 189–197.

Kim J, Lee SG, Shin SC, Kwon YD, Park IK. 2009b. Male-Produced Aggregation Pheromone Blend in *Platypus koryoensis.* J. Agric. Food Chem. 2009, 57, 1406–1412.

Kim J, Lee JS, Park IK, Choi WI. 2010. Influence of Trap Type and Location on Tree Trunk on *Platypus koryoensis* (Coleoptera: Platypodidae) Trapping. Kor. J. Appl. Entomol.49(2): 145-149.

Kim HK, Seo JW, Kang WJ, Lee JS, Cho WS, Seo ST, Kwon YD, Kwon GH, Kim GH. 2017. Attractant effect of citral on *Platypus koryoensis* (Coleoptera: Curculionidae). Entomological Research, 48(1), 27-31.

Lee JS, Jung HS, Lim YW. 2008. A checklist of decay fungi associated with oak trees in Korea. Korean J Mycol., 36:101-115.

Lee JS, Haack RA, Choi WI. 2011. Attack pattern of *Platypus koryoensis* (Coleoptera: Curculionidae: Platypodinae) in relation to crown dieback of Mongolian oak in Korea. Environ Entomol 40(6):1363-1369.

Moon MJ, Park JG, Kim KH. 2008. Fine structure of the mouthparts in the ambrosia beetle *Platypus koryoensis* (Coleoptera: Curculionidae: Platypodinae), Animal Cells and Systems, 12:2, 101-108.

Nam Y, Lee JS, Won DS, Kim JK, Choi WI. 2011. Spatio-temporal distribution pattern of an ambrosia beetle, *Platypus koryoensis* (Coleoptera: Platypodidae) within stands and its implications to forest. In: IUFRO WP.7.03.05 - Novel risks with bark and wood boring insects in broadleaved and conifer forests, Sopron, Hungary.

Nam Y, Koh SH, Won DS, Kim JK, Choi WI. 2013. An empirical predictive model for the flight period of *Platypus koryoensis* (Coleoptera: Platypodinae). Applied Entomology and Zoology, 48 (4):515–524.

Nam Y, Choi WI. 2014. Diurnal flight pattern of *Platypus koryoensis* (Coleoptera: Platypodinae) in relation to abiotic factors in Korea. Journal of Asia-Pacific Entomology. 17 (2014) 417–422.

Park S, Lyu D. 2007. Checklist of the family Platypodidae (Coloptera) in Korea. J. Asia-Pacific Entomol. 10(3): 275-280.

Park IK, Nam Y, Seo ST, Kim SW, Jung CS, Han HR. 2016. Development of a mass trapping device for the ambrosia beetle, *Platypus koryoensis*, an insect vector of oak wilt disease in Korea. Journal of Asia-Pacific Entomology, 19(1):39-43.

Son SY, Lee SK, Seo ST. 2015. Attractant Effect of Trap Logs Treated with Ethanol to *Platypus koryoensis* (Coleoptera: Platypodidae). Korean J. Appl. Entomol. 54(4):443-448.

Suh DY, Hyun MW, Kim SH, Seo ST, Kim KH. 2011. Filamentous fungi isolated from *Platypus koryoensis*, the insect vector of oak wilt disease in Korea. Mycobiology, 39:313-316.

Suh DY, Kim SH, Son SY, Seo ST, Kim KH. 2013. A New Record of *Candida kashinagacola* (Synonym *Ambrosiozyma kashinagacola*) from Galleries of *Platypus koryoensis*, the Oak Wilt Disease Vector, in Korea. Mycobiology, 41(4): 245-247.

Torii M, Matsuda Y, Seo ST, Kim KH, Ito SI, Moon MJ, Kim SH, Yamada T. 2014.The Effect of *Raffaelea quercus-mongolicae* Inoculations on the Formation of Non-conductive Sapwood of *Quercus mongolica*. Mycobiology, 42(2): 210-214.

Kim SW, Kim KS, Lamsal K, Kim YJ, Kim SB, Jung M, Sim SJ, Kim HS, Chang SJ, Kim JK, Lee YS. 2009c. An In Vitro Study of the Antifungal Effect of Silver Nanoparticles on Oak Wilt Pathogen *Raffaelea* sp. J. Microbiol. Biotechnol., 19(8), 760–764.

Yun YH, Suh DY, Yoo YD, Oh MH, Kim SH. 2015. Yeast Associated with the Ambrosia Beetle, *Platypus koryoensis*, the Pest of Oak Trees in Korea. Mycobiology, 43(4): 458-466.

This text is an integral part of the *EPPO Study on bark and ambrosia beetles associated with imported non-coniferous wood* and should be read in conjunction with the study

Pest information sheet
Ambrosia beetle

PLATYPUS QUERCIVORUS (COLEOPTERA: PLATYPODINAE)

oak ambrosia beetle. Associated disease: Japanese oak wilt

EPPO Lists: Not listed. The fungus associated with *Platypus quercivorus*, i.e. *Raffaelea quercivora*, was added to the EPPO Alert List in 1999, deleted in 2002, added again in 2003, and deleted in 2008 (it was then assessed that insufficient data was available to conclude about the risks for the EPPO region, especially the susceptibility of European species of oak). The assessment of potential risks in this information sheet is not based on a full PRA for the EPPO region, but on an assessment of the limited information for that species used to prepare the information sheet.

PEST OVERVIEW

Taxonomy

Platypus quercivorus (Murayama, 1925). Synonyms: *Crossotarsus quercivorus* Murayama, 1925; *Crossotarsus sexfenestratus* Beeson, 1937.

Associated fungi

Raffaelea quercivora (Kubono and Ito, 2002). Kinuura and Kobayashi (2006) demonstrated that *P. quercivorus* is a vector of *R. quercivora*, and that the mass mortality of Japanese oak trees is caused by mass attacks of *P. quercivorus*. Japanese oak wilt was the first known occurrence of mass-mortality of trees in the family Fagaceae, caused by a species of *Platypus* and an associated ambrosia fungus of the genus *Raffaelea* (CABI CPC, 2017, citing others). The loss of water conductance in sapwood colonized by *R. quercivora* around the galleries of *P. quercivorus* is the cause of oak wilt (Kuroda, 2001; Kusumoto *et al.*, 2014).
Other fungi were found associated with *P. quercivorus*, such as *Ophiostoma longicolla* (Masuya *et al.*, 1998), 38 fungus species, three of which were associated with all trees tested (*Candida* sp. 3, *Candida kashinagacola*, *R. quercivorus*), others included the yeasts *Ambrosiozyma* spp. (Endoh *et al.*, 2011). No information on their pathogenicity was found.

Morphology and biology

Adults measure ca. 4.5 mm (Davis *et al.*, 2005 citing Murayama, 1925). *P. quercivorus* is mostly univoltine in Japan, with occasionally a second generation. A male selects a tree for a breeding site, bores an entrance tunnel, and releases volatiles that attract other adults. After mating, the female tunnels into the tree. On average, 50 to 60 larvae develop in a single gallery system but the number of larvae can reach 160 (CABI CPC, citing others). *P. quercivorus* uses an aggregation pheromone (Kamata *et al.*, 2008). The parents are presumed to die before or during winter months because no eggs have been found in the spring. Most individuals overwinter as a larval stage and pupate in the following season (Esaki *et al.*, 2004, citing others).

P. quercivorus bores into the sapwood and occasionally the heartwood of oak trees (Endoh *et al.*, 2011). Entrance holes are mostly located in the lower part of a tree (<1.5 m, with a higher concentration close to the root collar) (Esaki *et al.*, 2004, 2009). There may be many individuals on a tree during an attack: Esaki *et al.* (2009) observed a final attack density of 173 entry holes per m^2 on average.

In Japan, *P. quercivorus* appears to attack both healthy and weakened trees (Kamata *et al.*, 2002), although Igeta *et al.* (2003 citing others) state that it has shown a tendency to invade trees that had been either cut down or blown down by typhoons. Outside of Japan (Taiwan, Thailand, Vietnam and Indonesia), Kusumoto *et al.* (2013) collected *P. quercivorus* only from fallen trees or big broken branches, and not from the healthy living trees.

P. quercivorus has been reported to preferentially attacks trees >15 cm DBH, with few attacks found on smaller trees (Esaki *et al.*, 2004 citing others). Similar observations were made by Akaishi *et al.* (2006) on *Q. serrata* and *Q. variabilis*, with no entry holes on trees < 15 cm DBH. On *Lithocarpus* (*Pasania*) *edulis*, Sato

(2003) found no entry holes on trees <8 cm DBH (Sato, 2003). In experiments on *Q. crispula*, Kinuura and Kobayachi (2006) found galleries with offspring on trees > 8.5 cm DBH (their experiment contained only 1 tree < 8 cm DBH). Similar values were found when analysing the DBH threshold for male flight (50% probability when DBH was 9.0 cm) and male beetles boring holes in trees (50% probability when DBH was 11.2 cm for trees with no infection history) (Yamasaki and Futai, 2008).

In experiments on logs, adult males bored holes into the water-soaked logs, but not on unsoaked logs when they were both provided together. The 50% cumulative adult emergence day ranged from 92 days to 127 days after the females were introduced to the galleries (Kitajima and Goto, 2004). This may indicate that males are less likely to choose dry logs.

The susceptibility of hosts varies. In Japan, *Q. crispula*[19] and *Q. serrata* were found to be more susceptible to *R. quercivora* than evergreen Fagaceae species (Murata *et al.*, 2005, 2007 cited in Kusumoto *et al.*, 2013, Kamata *et al.*, 2002, Endoh *et al.*, 2011). *Q. crispula* is preferred to *Q. serrata* and *Castanea crenata* (Yamasaki *et al.*, 2014b citing others). Yamasaki *et al.* (2007) showed that *Q. salicina* is less susceptible to attacks than *Q. crispula*.

Spread biology

Adults show a positive phototaxis, and the highest concentrations of flying beetles usually occur at the forest margins or at the edge of forest gaps. Adults tend to move upward along hillsides (Kamata *et al.*, 2002 Igeta *et al.*, 2003; Long Pham *et al.*, 2017). Adults were found to mostly fly below 2.5 m (Igeta *et al.*, 2004). CABI CPC (2017) mentions that adults are capable of sustained flight for at least 1 km and may also be dispersed on air currents (no reference is given). In experiments in a flight mill, some individuals flew 27 km (Fukaya *et al.*, 2015, 2016, Okada *et al.*, 2018).

Nature of the damage

P. quercivorus tunnels in the wood of host trees, and *R. quercivora* develops in the wood. *R. quercivora* can induce discoloration of the sapwood (Kusumoto *et al.*, 2013). Attacks can result in the loss of structural integrity in the wood and loss of wood quality (CABI CPC). In addition, attacks by *P. quercivorus* and *R. quercivora* may lead to tree wilting and mortality. Mentions of mortality were found in the literature especially in relation to *Q. crispula* (Kamata *et al.*, 2002), but also *Lithocarpus edulis* (Sato, 2003), *Castanea crenata* (Yamasaki *et al.*, 2014a), *Q. serrata*, *Q. robur*, *Q. laurifolia*, *Castanopsis cuspidata* (Endoh *et al.*, 2011). On *Q. crispula* and *Q. serrata* (trees that were later killed), it took three weeks from the first collection of the beetle to discoloration of all leaves (Kobayashi and Ueda, 2003). Oak trees with a 20-50 cm DBH and 20-30 m height generally wilt within 2-3 months following a major attack by *P. quercivorus* (Kubono and Ito, 2002).

Mortality differs greatly among species: in observations in outbreak areas (Kamata *et al.*, 2002), mortality of newly attacked *Q. crispula* reached 40%, and no mortality was observed in associated species of Fagaceae with similar numbers of entry holes. Few trees have also been killed in stands of evergreen Fagaceae in Japan (Kamata *et al.*, 2002). Tree death can occur the same year as a mass attack by *P. quercivorus*, but most oaks die within three years (Esaki *et al.*, 2009; Kamata *et al.*, 2002, Kubono and Ito 2002, Kobayashi and Ueda 2003). In a forest in eastern Kyoto Prefecture, the mortality of attacked *Q. crispula* reached 40-45% while that of *Castanea crenata* reached 13-23% (Yamasaki *et al.*, 2014a). Mortality of 8-28 cm diameter *Lithocarpus edulis* trees has been reported (Sato *et al.*, 2003). Attacks by *P. quercivorus* do not always result in the death of oak trees; ca. 40% of *Q. serrata* attacked by *P. quercivorus* have survived for 10 years following an attack (Hata *et al.*, 2014 citing Saito and Shibata 2012).

Detection and identification

- *Symptoms*. Symptoms of infestation include wilting in summer and/or reddish-brown discoloration of leaves, frass tubes projecting from the tree and sawdust near the base of the tree (CAPS-CERIS, 2013 citing others). Dead trees may be present. On wood, galleries and brown discoloration caused by *R. quercivora* may be observed.

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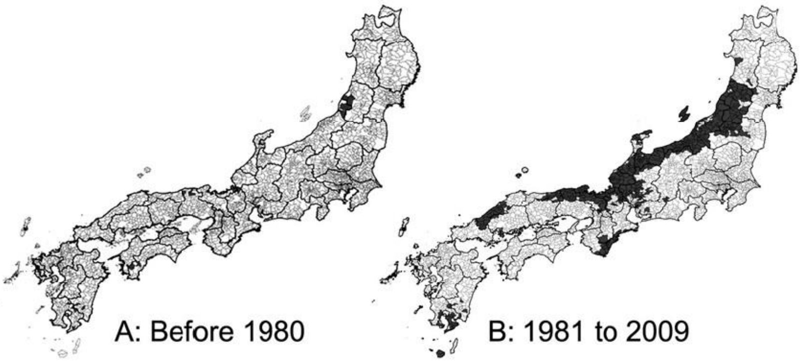
[19] The most recent literature refers to *'Q. crispula'*, and this name was also used here. Earlier references sometimes treat it as a synonym of *Q. mongolica*. *Q. crispula* is *Q. mongolica* subsp. *crispula* or *Q. mongolica* var. *grosseserrata*, and apparently a different entity than *Q. mongolica*.

- *Trapping*. Monitoring surveys may use visual inspection of symptoms, interception traps (Esaki *et al.*, 2002; Davis *et al.*, 2005 citing others), bait logs (Kobayashi *et al.* 2003, 2004), trapping with the synthetic aggregation pheromone for *P. quercivorus* (called quercivorol) [(1S,4R)-4-isopropyl-1-methyl-2-cyclohexen-1-ol abbreviated (-)-IMCH)] (Kamata *et al.*, 2008, Tokoro *et al.*, 2007).
- *Identification.* Adults of *P. quercivorus* are described in various publications. Davis *et al.* (2005) mentions that there is no identification key of *Platypus* spp. allowing to discriminate species in the USA. Molecular methods have been developed for *P. quercivorus* (e.g. Hamaguchi *et al.*, 2011) with some sequences in GenBank. The Draft Genome Sequence of *R. quercivora* JCM 11526 has been determined (Masuya *et al.*, 2016).

Distribution (see Table 1)

P. quercivorus is present only in Asia, from the Indian subcontinent to Japan, as well as in Papua New Guinea (Oceania) (see Table 1). Japan represents the northernmost distribution of the beetle (Kamata *et al.*, 2002). In Japan, it has sometimes been considered as exotic, but other authors argue that both the beetle and its fungus have been present for a long time (Kamata *et al.*, 2002; Ida and Takahashi, 2010). Japanese oak wilt disease has not been observed outside Japan, but *R. quercivora* has been collected in 4 other countries (Taiwan, Vietnam, Indonesia, Thailand - Kusumoto *et al.*, 2013).

A map of the spread of Japanese oak wilt in Japan is given in Kuroda *et al.* (2012) (the black shading highlights the spread).



Host plants (see Table 2)

Kamata *et al.* (2002, citing others) reports that 45 species of woody plants (in 27 genera of 17 families) have been recorded as hosts of *P. quercivorus*, but that attack density is significantly higher on Fagaceae. Hosts found in the available literature are in Table 2 (representing only 7 families). The reproductive hosts of *P. quercivorus* are Fagaceae, including many *Quercus* spp., *Castanea crenata* (Japanese chestnut), *Lithocarpus* spp. and *Castanopsis* spp. It is worth noting that attack on *Fagus* has never been reported, even in mixed oak-beech forests where oaks were attacked (e.g. Nakagima and Isida, 2014). Among the *Quercus* spp. present in the EPPO region, some Asian species are present in Far-East Russia, and *Q. robur* has a wide distribution in the western part of the region.

In field observations, *P. quercivorus* showed the lowest preference for *Q. crispula* in terms of number of trees attacked, but its reproductive success was highest on that tree, which is also susceptible to *R. quercivora*, leading to mortality. Three other Fagaceae (*Castanopsis sieboldii*, *Q. serrata* and *Q. acuta*) were preferred in terms of numbers of trees attacked, but showed lower reproductive success and susceptibility to *R. quercivora*. The spread of oak dieback and density of *P. quercivorus* was influenced by the percentage of *Q. crispula* in each stand. The authors also suggested that Japanese oak wilt resulted from the warmer climate since the late 1980s, which made it possible for *P. quercivorus* to extend its range to more northerly latitudes and higher altitudes, and encounter the susceptible *Q. crispula* (Kamata *et al.*, 2002).

Known impacts and control in current distribution

Countries other than Japan. No report of impact by *P. quercivorus* and *R. quercivora* was found in the literature, and Japanese oak wilt is not reported outside Japan, although both are known to occur together at least in some countries (see *Distribution*). Some isolates of *R. quercivorus* collected outside of Japan were shown to be able to induce wide discoloration on oak wood, and *P. quercivorus* was collected only from fallen trees or big broken branches, and not from healthy living trees. The authors make the hypothesis that host trees outside Japan may not be susceptible to *R. quercivora* or are able to resist attacks by *P. quercivorus*, or that *P. quercivorus* strains in other countries may not be as aggressive as in Japan, and not be able to attack healthy living trees (Kusumoto *et al.*, 2013).

Japan. The impact reported in Japan relates to oak. No information was found on damage to other Fagaceae or other hosts. Oak dieback has been recorded since the 1930s, but up to 1980, epidemics lasted for only a few years and were confined to a few areas on the west side of Japan; more recently epidemics have lasted for more than ten years, and the area of dieback has been spreading to new localities (Kamata *et al.*, 2002). Mass mortalities of oak trees (*Q. serrata* and *Q. crispula*) have been occurring since 1990 in Honshu, predominantly on Prefectures of the Coast of the Sea of Japan (Kubono and Ito, 2002, citing Ito and Yamada 1998), and also in the southern part of Kyushu Island and on the Kii Peninsula (Kinuura and Kobayashi, 2006 citing others). Ida and Takahashi (2010), based on old sources, support that Japanese oak wilt caused by *R. quercivora* and *P. quercivorus* has recurred occasionally in local areas with many large trees in the Nagano Prefecture since 1750; the disease was observed in an area since 2004, but similar damage had occurred in that area in 1750, in association with an insect infestation of trunks.

P. quercivorus and *R. quercivora* have killed approximately 100 000-200 000 trees annually since about 1980, the majority being *Q. serrata* and *Q. crispula* (Davis *et al.* 2005, citing Ito *et al.* 2003). The damage has affected 325 000 m^3 of *Q. crispula* and *Q. serrata* in 2010 (Takahashi *et al.*, 2015 citing the Japanese Forestry Agency). Oak wilt disease has been responsible for over 80 000 m^3 of damage (in stem volume) per year since 2007, and the damage in the Tohoku district (Northeastern Honshu), accounts for more than 30 % of the total damage (Saito *et al.*, 2016).

Davis *et al*. (2005) consider that the economic impact of *P. quercivorus* in Japan is difficult to measure, especially because it occurs together with other secondary pests. Damage associated with *P. quercivorus* was reported ca. 70 years ago, but it is not clear if it referred to mortality, and was caused by the beetle alone or the beetle together with *R. quercivora*. In Japan, mortality from *P. quercivorus* has been less severe in evergreen oaks than on deciduous oaks (Davis *et al.*, 2005 citing others).

Damage in secondary forests (‘satoyama’) surrounding rural communities have increased recently. Oak wilt has been observed on 40-70 years old stands that were previously used for fuel wood and charcoal production (coppiced), but were left unmanaged following the replacement of wood fuels in the 1950s. The traditional coppicing at 15-30 year intervals had been discontinued in Japan by 1980, leading to an increase in the size of tree trunks, making them more suitable to attacks by *P. quercivorus*, and populations have increased in aged ‘satoyama’ (Yamanaka *et al.*, 2011; Kuroda *et al.*, 2012).

In Kyoto National Garden, where 13 species of Fagaceae trees are present, *P. quercivorus* tunnelled in 342 trees, 71 of which died (Sekine *et al.*, 2011).

Environmental impact: *P. quercivorus* and *R. quercivora* have caused extensive tree mortality in oak forests, especially *Q. crispula* and *Q. serrata*. Serious damage occurs in ‘satoyamas’, where the disease kills tall trees, and sika deers eat seedlings and prevent forest regeneration (Sasaki *et al.*, 2014). Kuroda *et al.* (2012) noted concern linked to deterioration of biodiversity and soil erosion due to changes in the vegetation following mass mortality of oak trees. Tree mortality differs among species and over several years, the tree composition of forests changes (Kamata *et al.*, 2002).

Control: Several control methods have been proposed in Japan, including mass-trapping using pheromone baited traps, injection of *N*-methyl dithiocarbamic acid ammonium salt into the trunk of infected oak trees, application of creosote or fenitrothion on the bark surface, and wrapping oak trunks with vinyl sheeting or linen cloth (Iitzuka *et al.*, 2016, citing others). No biological control agent is available to date although some species have been investigated (e.g. in Qi *et al.*, 2011).

To reduce oak mortality in ‘satoyama’ forests, Kuroda *et al.* (2012) proposed that rejuvenation of trees by coppicing will be effective because *P. quercivorus* cannot propagate in thin trunks, including clear-cutting of aged forest to promote sprouting from the oak stumps (Kuroda *et al.*, 2012).

Oak log pile traps were found to be effective to reduce attacks by *P. quercivorus* in forests (Saito *et al.*, 2015, 2016). Saito *et al.* (2016) estimated that in 2009-2014, a total of 26 491 701 beetles were attracted to oak log pile traps, i.e. the preventive effect was claimed to be equivalent to ca. 26 500 oak trees. More trees were defoliated in the trapping area than in the trap-free area (3.3 trees per ha of oak forest versus 11.5 trees per ha of oak forest). Logs used for oak log pile traps were converted to wood chips in the following spring, before adult emergence, and used as fuel or for pulp.

POTENTIAL RISKS FOR THE EPPO REGION

Pathways

Entry

Life stages are associated with the xylem of host trees. *P. quercivorus* is reported to attack trees of a diameter >8 cm. All wood commodities may be a pathway. Processes applied to produce wood commodities would destroy some individuals; however, there may be many individuals in an infested log. The likelihood of entry on wood chips, hogwood and processing wood residues would be lower than on round wood, as individuals would have to survive processing and transport, and transfer to a suitable host is less likely. *P. quercivorus* has been found associated with the Fagaceae genera *Quercus, Castanea, Lithocarpus, Castanopsis*, though never with *Fagus* (although present in Japan). The wood would also degrade and not be able to sustain development of the pest. *P. quercivorus* and *R. quercivora* may not survive in logs with low moisture content according to Kobayashi *et al.* (2003, 2004). Current imports of *Quercus* or non-coniferous wood appear to be minor from Japan, based on data in the EPPO PRA on *Massicus raddei* (EPPO, 2018). Bark on its own is an unlikely pathway.

The fact that *P. quercivorus* is reported to attack trees of a diameter >8 cm would limit its association with plants for planting, although some traded nursery plants (incl. bonsais) may reach this size. However, no mention of attacks in nurseries were found in the literature. From the information available, *P. quercivorus* is associated with trunks, not branches.

Summary of pathways:

- *wood (round or sawn, with or without bark, incl. firewood) of hosts*
- *non-coniferous wood chips, hogwood, processing wood residues (except sawdust and shavings)*
- *wood packaging material if not treated according to ISPM 15*
- *plants for planting of hosts of a DBH >8 cm?*

Spread (following introduction, i.e. within EPPO region)

P. quercivorus is known to have spread in Japan. In the EPPO region, it could spread naturally and through human-assisted pathways. Spread will depend on whether *P. quercivorus* is able to attack *Quercus* or *Castanea* species present in the EPPO region, which would favour both natural spread and human-assisted spread (especially with *Quercus* wood). There has been one record on *Q. robur* in Japan; this species is widespread in the EPPO region and could facilitate spread.

Establishment

Areas with suitable climates and host plants are available in the EPPO region, therefore establishment is possible.

P. quercivorus has been reported in tropical and subtropical climates, as well as in Japan, where the change of climatic conditions in the 1980s is hypothesized to have allowed its spread to temperate areas and higher altitudes. *Q. crispula* is present in the cool temperate forests in Japan. Based on the climate classification of Köppen Geiger (see Annex 6 of the study), *P. quercivorus* in Japan is present in areas of climate Cfa and Dfb[20], which in the EPPO region occur in Northern Italy, part of the Balkan and Black Sea area, as well as Eastern Europe, the south of Scandinavia, European part of Russia and Russian Far-East. The climates in the rest of the distribution are not represented in the EPPO region. However, many areas in the EPPO region have climates that are intermediate between tropical/subtropical climates and the Dfb[20] climate type.

Among the known Fagaceae hosts, no data was found on the occurrence of *Q. crispula* in the EPPO region. *Q. mongolica* is present in Far-East Russia, which is however more northern than the northernmost distribution of *P. quercivorus* (climatic conditions may not be suitable). *Q. robur* is widespread in a large part of the EPPO region. Other known hosts of *P. quercivorus* have a limited presence in the EPPO region (mostly as ornamentals). However, some *Castanea* and *Quercus* species that are not recorded as hosts are widespread in the PRA area, such as *C. sativa*, *Q. pubescens*, *Q. petraea* and *Q. cerris*, as well as many other

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[20] **Cfa**: warm temperate climate, fully humid, hot summer; **Dfb**: snow climate, fully humid, warm summer.

Quercus species; they may be attacked by *P. quercivorus* if it was introduced into other parts of the EPPO region. A list of native *Quercus* is provided in the EPPO PRA on *Massicus raddei* (EPPO, 2018). The list of non-Fagaceae hosts in Table 2 is incomplete (see *Host plants*), but contains some plants that are grown as ornamentals in the EPPO region.

Potential impact (including consideration of host plants)

Quercus are economically and environmentally important trees in the EPPO region, and are present in the wild, and cultivated for wood or as amenity trees. Mortality is reported in Japan on *Quercus* species that are not widespread in the EPPO region, and damage may be limited to ornamental trees. Impact in the EPPO region would depend on the susceptibility (to *P. quercivorus* and *R. quercivora*) of the species of *Quercus* present in the region. *P. quercivorus* has been recorded on *Q. robur*, a species that is widespread and economically and environmentally invaluable in the EPPO region, but its susceptibility is not known. It is noted that when *P. quercivorus* and *R. quercivora* reached the new host *Q. crispula* in the temperate part of Japan, it proved to be the most susceptible species. Environmental impact may occur due to damage and death of trees (mainly *Quercus*, but possibly other hosts) in natural environments, effects on biodiversity, changes in forest composition, effects on endangered hosts, impact on sensitive habitats, etc.

In other Fagaceae host genera, *P. quercivorus* may have an impact trees grown as ornamentals in the EPPO region, as well as on *Castanea sativa* (currently not known as host), which is widely grown in the wild, and cultivated for fruit, wood, and as an ornamental tree. There is not enough data on non-Fagaceae hosts to analyse potential impact.

Table 1. Distribution

	Reference	Comments
EPPO region		
Absent		
Asia		
India	EPPO Global Database	
Indonesia	EPPO Global Database	
Japan - Honshu, Kyushu - *uncertain records*: Hokkaido, Ryukyu Archipelago	- EPPO Global Database - CABI CPC citing Hamaguchi and Goto, 2003	At least since the 1930s, possibly before (see *Distribution*) - original source was a poster at a conference, no other record was found in the Japanese literature
Taiwan	EPPO Global Database	
Thailand	Kusumoto *et al.* (2013)	
Vietnam	Kusumoto *et al.* (2013)	
Oceania		
Papua New Guinea	EPPO Global Database	

Table 2. Hosts

- **Fagaceae** (note: Davis *et al.*, 2005 cite others)

Genus/Species	Reference
Castanea crenata	Michimasa and Kazuyoshi, 2012
Castanopsis cuspidata	Endoh *et al.*, 2011
Castanopsis fabri	Kusomoto *et al.*, 2013
Castanopsis carlesii	Kusomoto *et al.*, 2013
Castanopsis javanica	Kusomoto *et al.*, 2013
Castanopsis sieboldii (*C. cuspidata* var. *sieboldii*)	Kamata *et al.*, 2002
Castanopsis sp.	Kusomoto *et al.*, 2013
Lithocarpus coalitus	Kusomoto *et al.*, 2013
Lithocarpus edulis (*Pasania edulis*)	Soné *et al.*, 1998
Lithocarpus glaber	Sekine *et al.*, 2011

Genus/Species	Reference
Lithocarpus sp.	Kusomoto *et al.*, 2013
Quercus acuta	Kamata *et al.*, 2002
Quercus acutissima	CABI CPC
Quercus crispuloserrata	Davis *et al.*, 2005
Quercus crispula (=*Q. mongolica* subsp. *crispula*, *Q. mongolica* var. *grosseserrata)*	Kamata *et al.*, 2002; Kubono and Ito, 2002
Quercus gilva	Davis *et al.*, 2005
Quercus glauca	Kobayashi and Ueda, 2005
Quercus laurifolia	Endoh *et al.*, 2011
Quercus myrsinifolia (or *myrsinaefolia*)	Davis *et al.*, 2005

Genus/Species	Reference
Quercus phillyraeoides	Kusomoto *et al.*, 2013
Quercus robur	Endoh *et al.*, 2011
Quercus salicina	Igeta *et al.*, 2004
Quercus serrata	Kamata *et al.*, 2002
Quercus sessilifolia	Davis *et al.*,
Quercus variabilis	Akaishi *et al.*, 2006

- **Other families** (note: Davis *et al.*, 2005 cite others)

Family	Genus/Species	Reference
Aquifoliaceae	*Ilex chinensis*	Davis *et al.*, 2005
Aquifoliaceae	*Ilex rotunda*	Sato, 2003
Araliaceae	*Fatsia japonica*	Sato, 2003
Cupressaceae	*Cryptomeria japonica*	Tarno *et al.*, 2011
Lauraceae	*Cinnamomum japonicum*	Sato, 2003
Lauraceae	*Lindera erythrocarpa*	Davis *et al.*, 2005
Lauraceae	*Neolitsea sericea*	Davis *et al.*, 2005
Lauraceae	*Persea* (=*Machilus*) *japonica*	Davis *et al.*, 2005
Lauraceae	*Persea* (=*Machilus*) *thunbergii*	Sato, 2003
Myricaceae	*Myrica rubra*	Sato, 2003
Rosaceae	*Prunus*	Davis *et al.*, 2005
Rosaceae	*Sorbus alnifolia*	Davis *et al.*, 2005
Rosaceae	*Sorbus japonica*	Tarno *et al.*, 2011

References

Akaishi D, Kamata N, Nakamura K. 2006. Initial Stage of an infestation of *Platypus quercivorus* (Coleoptera: Platypodidae) in a Secondary forest Dominated by *Quercus serrata* and *Quercus variabilis*. J. Jpn. For. Soc. 88, 274-278.

CABI CPC. 2017. *Platypus quercivorus* (oak ambrosia beetle). Crop Protection Compendium. www.cabi.org

CAPS-CERIS. 2013. *Platypus quercivorus* (Murayama). USDA-Aphis, CAPS CERIS.

Davis EE, French S, Venette RC. 2005. Mini Risk Assessment Ambrosia beetle: *Platypus quercivorus* Murayama [Coleoptera: Platypodidae]. USDA-Aphis, CAPS September 25, 2005.

Endoh R, Suzuki M, Okada G, Takeuchi Y, Futai K. 2011. Fungus Symbionts Colonizing the Galleries of the Ambrosia Beetle *Platypus quercivorus*. Microb Ecol, 62:106–120.

EPPO. 2018. Pest Risk Analysis for *Massicus raddei* (Coleoptera: Cerambycidae), oak longhorn beetle. Available at https://www.eppo.int

Esaki K, Kato K, Kamata N. 2009. Early Attack Distribution of the Oak Borer *Platypus quercivorus* (Coleoptera: Platypodidae) on the Trunk Surfaces of Newly Infested Trees. Journal of the Japanese Forest Society, 91(3): 208-211.

Esaki K, Kato K, Kamata N. 2004. Stand-level distribution and movement of *Platypus quercivorus* adults and patterns of incidence of new infestation. Agricultural and Forest Entomology 6: 71-82.

Esaki K, Kamata N, Kato K. 2002. A sticky screen trap for surveying aerial populations of the ambrosia beetle *Platypus quercivorus* (Coleoptera: Platypodidae). Applied Entomology and Zoology 37: 27-35.

Fukaya S, Okada R, Itou Y. 2015. Flight ablity of *Platypus quercivorus* measured by a flight mill. 126th Annual JFS Meeting, Session ID: K05, The Japanese Forest Society. [in Japanese]

Fukaya S, Okuda N, Okada R, Ito Y, Ikeno H, Yamasaki M. 2016. Flight ability of *Platypus quercivorus*.127th Annual JFS Meeting. Session ID: K6. The Japanese Forest Society. [in Japanese]

Hamaguchi K, Kato K, Esaki K, Kamata N. 2011. Isolation and characterization of 10 new microsatellite loci in the ambrosia beetle *Platypus quercivorus*. J For Res., 16:518–521.

Hata K, Iwai N, Sawada H. 2014. Attack by *Platypus quercivorus* Enhances Diameter Growth of Surviving *Quercus serrata*. For. Sci. 60(6):1024-1028.

Ida H, Takahashi S. 2010. Mass Mortality of Oak Trees Had already Occurred at the Edo Period. Journal of the Japanese Forest Society, Volume 92(2), 115-119.

Igeta Y, Esaki K, Kato K, Kamata N. 2004b. Spatial distribution of a flying ambrosia beetle *Platypus quercivorus* (Coleoptera: Platypodidae) at the stand level. Applied Entomology and Zoology 39: 583-589.

Igeta Y, Esaki K, Kato K, Kamata N. 2003. Influence of light conditions on the stand-level distribution and movement of the ambrosia beetle *Platypus quercivorus* (Coleoptera: Platypodidae). Applied Entomology and Zoology 38: 167-175.

Iidzuka H, Goto H, Osawa N. 2016. Gallery diameter of ambrosia beetles (Coleoptera: Scolytidae, Platypodidae) and insect fauna in *Quercus serrata* (Fagales: Fagaceae) suffering from Japanese oak wilt. Appl Entomol Zool, 51(3):421-427.

Kamata N, Esaki K, Kato K, Igeta Y, Wada K. 2002. Potential impact of global warming on deciduous oak dieback caused by ambrosia fungus Raffaelea sp. carried by ambrosia beetle *Platypus quercivorus* (Coleoptera: Platypodidae) in Japan. Bulletin of Entomological Research 92: 119-126.

Kamata N, Esaki K, Mori K, Takemoto H, Mitsunaga T, Honda H. 2008. Field trap test for bioassay of synthetic (1S,4R)-4-isopropyl-1-methyl-2-cyclohexen-1-ol as an aggregation pheromone of *Platypus quercivorus* (Coleoptera: Platipodidae). Journal of Forest Research 13: 122-126.

Kinuura H, Kobayashi M. 2006. Death of *Quercus crispula* by inoculation with adult *Platypus quercivorus* (Coleoptera: Platypodidae). Appl. Entomol. Zool. 41(1):123–128.

Kitajima H, Goto H. 2004. Rearing technique for the oak platypodid beetle, *Platypus quercivorus* (Murayama) (Coleoptera: Platypodidae), on soaked logs of deciduous oak tree, *Quercus serrata* Thunb. ex Murray. Applied Entomology and Zoology 39: 7-13.

Kobayashi M, Ueda A. 2003. Observation of Mass Attack and Artificial Reproduction in *Platypus quercivorus* (Murayama) (Coleoptera: Platypodidae). Jpn. J. Appl. Entomol. Zool. 47: 53–60.

Kobayashi M, Nozaki A, Ueda A. 2004. Influence of water content of host trees on attacking behavior of *Platypus quercivorus* (Murayama) (Coleoptera: Platypodidae) and on fungi in the galleries bored by the beetles. Japanese Journal of Applied Entomology and Zoology 48: 141-149.

Kobayashi, M., A. Ueda, and A. Nozaki. 2003. Influence of water content of bait logs on landing, boring, and reproduction of *Platypus quercivorus* (Murayama) (Coleoptera: Platypodidae). Journal of the Japanese Forestry Society 85: 100-107.

Kubono T, Ito S. 2002. *Raffaelea quercivora* sp. nov. associated with mass mortality of Japanese oak, and the ambrosia beetle (Platypus quercivorus). Mycoscience, Volume 43(3), 255-260.

Kuroda K. 2001. Responses of *Quercus* sapwood to infection with the pathogenic fungus of a new wilt disease vectored by the ambrosia beetle *Platypus quercivorus*. J Wood Sci 47:425–429.

Kuroda K, Osumi K, Oku H. 2012. Reestablishing the health of secondary forests "Satoyama" endangered by Japanese oak wilt: A preliminary report. Journal of Agricultural Extension and Rural Development Vol. 4(9), 192-198.

Kusumoto D, Masuya H, Hirao T, Goto H, Hamaguchi K, Chou W-I, Suasa-ard W, Buranapanichpan S, Uraichuen S, Kern-asa O, Sanguansub S, Panmongkol A, Quang TP, Kahono S, Julistiono H, Kamata N. 2014. Discoloration induced by *Raffaelea quercivora* isolates in *Quercus serrata* logs and its relation to phylogeny: a comparison among isolates with and without the Japanese oak wilt incidence including outside of Japan. J For Res, 19(4):404-410

Long Pham D, Ito Y, Okada R, Ikeno H, Isagi Y, Yamasaki M. 2017. Phototactic behavior of the ambrosia beetle *Platypus quercivorus* (Murayama) (Coleoptera: Platypodidae) before and after flight. J Insect Behav, 30:318–330

Masuya H, Manabe R-I, Ohkuma M, Endoh R. 2016. Draft genome sequence of Raffaelea quercivora JCM 11526, a Japanese oak wilt pathogen associated with the platypodid beetle, *Platypus quercivorus*. Genome Announc 4(4):e00755-16. doi:10.1128/genomeA.00755-16.

Masuya H, Kaneko S, Yamaoka Y. 1998. A new Ophiostoma species isolated from Japanese oak infested by *Platypus quercivorus*. Mycoscience 39: 347-350.

Nakajima H, Ishida M. 2014. Decline of *Quercus crispula* in abandoned coppice forests caused by secondary succession and Japanese oak wilt disease: Stand dynamics over twenty years. Forest Ecology and Management, 334: 18-27.

Okada R, Pham DL, Ito Y, Yamasaki M, Ikeno H. 2018. Measuring the Flight Ability of the Ambrosia Beetle, *Platypus quercivorus* (Murayama), Using a Low-Cost, Small, and Easily Constructed Flight Mill. J Vis Exp. 6 (138).

Qi H, Wang J, Endoh R, Takeuchi Y, Tarno H, Futai K. 2011. Pathogenicity of microorganisms isolated from the oak platypodid, *Platypus quercivorus* (Murayama) (Coleoptera: Platypodidae). Appl Entomol Zool, 46:201–210.

Saito S, Kondoh H, Takahashi A, Okada M, Miguchi H. 2016. Reducing damage caused by oak wilt disease transmitted by the ambrosia beetle *Platypus quercivorus* (Coleoptera: Platypodidae) using oak log pile traps. Appl Entomol Zool, 51(2):267-274.

Saito S, Miguchi H, Shoda-Kagaya E. 2015. Attracting effect of mass accumulated oak logs for *Platypus quercivorus*. J Forest Soc. 97(2):100–106. [in Japanese with English abstract]

Sasaki T, Kuroda K, Ishii H, Hotta K, Matsukawa S. 2014. Japanese oak wilt and grazing damage by sika deer are threatening the health of secondary forests, "satoyama". Conference paper

Sato Y. 2003. Infestation of the oak borer, *Platypus quercivorus* (Murayama), in Sakurajima Island, Kagoshima Prefecture. Kyushu J. For. Res. 56:95-100.

Sekine T, Takahashi H, Imai M, Nakanishi J, Kawatsu Y, Ida N, Yamamoto M, Wakabayashi D. 2011. Japanese Oak Wilt in Urban Forest: Damage Situation at Kyoto Gyoen National Garden. Journal of the Japanse Forest Society. 93(5), 239-243.

Takahashi YS, Matsushita N, Hogetsu T. 2015. Genotype distribution of *Raffaelea quercivora* in the oak galleries and its composition in the mycangia of *Platypus quercivorus*. For. Path. 45:149–154.

Tokoro M, Kobayashi M, Saito S, Kinuura H, Nakashima T, Shoda-Kagaya E, Kashiwagi T, Tebayashi S, Kim C, Mori K. 2007. Novel aggregation pheromone, (1S,4R)-p-menth-2-en-1-ol, of the ambrosia beetle, *Platypus quercivorus* (Coleoptera: Platypodidae). (Bulletin of FFPRI),6(1) (No.402), 49-57.

Yamanaka T, Nunokawa K, Saito S, Kondoh H, Shoda-Kagaya E, Makino S. 2011. Severe mass oak defoliation in Japan by oak wilt disease: Origin and propagation pattern of the defoliation. 96th ESA Annual Convention.

Yamasaki M, Futai K. 2008. Host selection by *Platypus quercivorus* (Murayama) (Coleoptera: Platypodidae) before and after flying to trees. Appl. Entomol. Zool. 43(2):249–257.

Yamasaki M, Ito Y, Ando M. 2014a. Mass attack by the ambrosia beetle *Platypus quercivorus* occurs in single trees and in groups of trees. Canadian Journal of Forest Research. 44: 243–249.

Yamasaki M, Ito Y, Ando M. 2014b. The effect of stem density on the probability of attack by the ambrosia beetle *Platypus quercivorus* varies with spatial scale. Agricultural and Forest Entomology, 16(1):54-62.

Yamasaki M, Iwatake A, Futai K. 2007. A low *Platypus quercivorus* hole density does not necessarily indicate a small flying population. J For Res, 12:384–387.

This text is an integral part of the *EPPO Study on bark and ambrosia beetles associated with imported non-coniferous wood* and should be read in conjunction with the study

Pest information sheet
Bark beetles

SCOLYTUS SCHEVYREWI (COLEOPTERA: SCOLYTINAE)
banded elm bark beetle

EPPO Lists: Scolytus schevyrewi was added to the EPPO Alert List in 2005 and deleted in 2008 (the EPPO Panel on Quarantine Pests for Forestry considered that it was not more damaging than existing European *Scolytus*). The assessment of potential risks in this information sheet is not based on a full PRA for the EPPO region, but on an assessment of the limited information for that species used to prepare the information sheet.

PEST OVERVIEW

Taxonomy

Scolytus schevyrewi Semenov, 1902. Synonyms: *Eccoptogaster emarginatus* Wichmann, 1915; *Eccoptogaster transcaspicus* Eggers, 1922; *Scolytus frankei* Wichmann, 1915; *Scolytus seulensis* Murayamas, 1930.

Beaver *et al.* (2016) note that *S. transcaspicus* (Eggers, 1922) (present in Iran, Kazakhstan, Russia (Daghestan, Astrakhan), Turkmenistan) has been treated as a synonym of *S. schevyrewi*, but is considered a distinct species by Petrov (2013). It is not known if some distribution or host records in this datasheet relate to *S. transcaspicus.*

Associated fungi

When *S. schevyrewi* was found in the USA in 2009, there was a concern that it could be a vector of Dutch elm disease (caused by *Ophiostoma novo-ulmi*, the aggressive strain of *Ophiostoma ulmi*), and that it may be a more efficient vector than the introduced European species *S. multistriatus*. *S. schevyrewi* was confirmed as a vector of *O. novo-ulmi* (Jacobi *et al.*, 2013), with low transmission rates, and the authors suggested that *S. schevyrewi* may be no better or even less effective as a vector than *S. multistriatus*. Zhu (2017) isolated fungi associated with *S. schevyrewi* in apricot orchards in Xinjiang (*Yamadazyma mexicana*, *Candida xinjiangensis*, *Wickerhamomyces ciferrii*, *Cladosporium macrocarpum*, *Meyerozyma guilliermondii* and *Paecilomyces* sp.) as well as a number of bacteria; potential plant pathogens among the fungi and bacteria found were: *Y. mexicana*, *C. macrocarpum*, and *Pantoea agglomerans*.

Morphology and biology (from Lee *et al.* 2009; Negrón *et al.*, 2005; Veuilleux, 2012; CABI CPC, all citing others)
Adults are 3-4 mm long, and are reddish black in colour with a black head. In China (location not specified), some authors reported 2-3 overlapping generations per year, with a life cycle of 40-45 days in the field; a study in Tajikistan found 3-4 generations per year; in the USA, there are 2-3 generations per year (Davis, 2011; Seybold *et al.*, 2016, citing Lee *et al.*, 2011). In the Kashi area of Xinjiang (North-West China), there were 3-4 generations per year, with a life cycle of 40-50 days (Zhu *et al.*, 2017). In experimental conditions in the USA (i.e. in favourable conditions), completion of the life cycle took fewer than 30 days (Negrón *et al.*, 2005, citing others). In Canada (Manitoba and Saskatchewan), *S. schevyrewi* has 2 generations, and possibly a third one (although it is unlikely that adults of the third generation would lay eggs or that eggs would successfully develop) (Veuilleux, 2012).

In China, *S. schevyrewi* was reported to overwinter as mature larvae, pupae or adults under the bark, while in Canada, it overwintered as mature larvae and, to a lesser extent, as pupae. Winter survival in Canada was low (Veuilleux, 2012).

Maturation feeding was reported to occur on the bark at the intersections of tender twigs. In Tajikistan, studies on *S. schevyrewi* and several other *Scolytus* indicated that they could reproduce without maturation feeding. The females then attack host trees by constructing individual entrance holes through the bark. It is believed that females release a pheromone to attract the males. Mating occurs on the bark surface, and each female constructs a single egg gallery in the inner bark, which contains ca. 60 eggs on average. The newly hatched larvae feed in the inner bark and construct individual galleries. When feeding is completed, the mature larvae construct pupal chambers in the outer bark and pupate (CABI CPC, citing others; Veuilleux, 2012). Veuilleux (2012) notes that the related species (and vectors of Dutch elm disease) *S. multistriatus* and *Hylurgopinus rufipes* can reach the xylem when feeding, and this is also likely for *S. schevyrewi*. On *P. armeniaca*, entry holes are located mostly on the main branches, but also on the trunk and other types of branches (lateral, bearing) (Zhu, 2017).

S. schevyrewi has been collected from broken elm branches, fallen elm trees, stacks of elm firewood, and drought-stressed elm trees, as well as from elms dying from Dutch elm disease (Maryland Extension, 2008, citing others). In Asia, *S. schevyrewi* usually attacks weakened or stressed trees, although during outbreaks it can also attack healthy *Ulmus*. *S. schevyrewi* is able to kill stressed *U. pumila* as a result of its feeding and breeding activities (Veuilleux, 2012, citing others). Although it is mentioned that occasional outbreaks can occur that result in widespread tree mortality (CABI CPC, citing others), this seems to mostly relate to stressed trees. On apricot, live trees are attacked (Zhu, 2017) (whether they are stressed is not indicated); the same publication appears to point to mortality of trees in Xinjiang (but this is not entirely clear in the abstract available).

Trees older than 4 years with trunks or branches greater than 5 cm in diameter are most likely to be attacked, especially in open areas or urban settings. Young trees or healthy trees are generally more resistant to attack (CABI CPC, citing others). Veuilleux (2012) noted that galleries can be constructed in the trunk and in branches with a diameter of ≥ 3 cm. Logs that are too small or too large seem to be unsuitable for brood galleries (Veuilleux, 2012). In experiments in the USA and Canada (reported in Veuilleux, 2012), the median diameter of colonized logs was 18 cm, and the smallest ones 8 cm diameter*;* Lee *et al.* (2011) studied infestation in ca. 10-24 cm diameter logs of *U. pumila* and found *S. schevyrewi* in all of them.

In the USA, *S. schevyrewi* was shown to have competitive advantages over the introduced European *S. multistriatus* (Lee and Seybold, 2010; Lee *et al.*, 2010, 2011), and it has now become much more abundant than *S. multistriatus* in some areas where both occur. There is some evidence that *S. schevyrewi* possibly has, since its introduction, already displaced *S. multistriatus* in Colorado and Wyoming (Lee *et al.* 2009), as well as California and Minnesota (Seybold *et al.*, 2016 citing others).

Spread biology

Adults are weak fliers and prefer to attack adjacent, freshly cut logs, stumps or host trees that are weakened by diseases, other insects, rodents, drought, extreme temperatures, etc. (CABI CPC, 2017).

Nature of the damage

S. schevyrewi tunnels galleries in the bark of its hosts. High larval densities lead to complete girdling and eventually tree death.

Detection and identification

- *Symptoms* include wilting of the foliage, boring dust on the trunks of heavily attacked trees, and occasionally sap flow on the bark surface near entrance holes. The consumption of inner bark leads to easy peeling and sloughing. Life stages and galleries can be seen when removing the bark. Adults can also be found in the outer bark of infested trees. Exit holes can be observed (CABI CPC, 2017).
- *Trapping.* Adults are attracted to funnel traps baited with either commercial Ips lures (ipsenol and ipsdienol) or *Scolytus multistriatus* lures [alpha-multistriatin plus 4-methyl-3-heptanol (threo isomer) and alpha-Cubenene) (CABI CPC, 2017). *U. pumila* trap logs were found to be a sensitive monitoring tool for detecting the presence of *S. schevyrewi* (Lee *et al.*, 2009).
- *Identification.* LaBonte (2010) gives a key for distinguishing *Scolytus schevyrewi* from other species of *Scolytus* in North and Central America (including the European species *S. multistriatus*). A molecular technique (RAPD-PCR) for separating *S. schevyrewi* and *S. multistriatus* is provided in Johnson *et al.* (2008).

Distribution (see Table 1)

S. schevyrewi is native to Asia, where it occurs in China, Mongolia, Korea, Russia and several Central Asian countries. It has therefore a limited distribution in the EPPO region. *S. schevyrewi* has been introduced to

Canada, Mexico and the USA. It has been reported in four provinces in Canada, and throughout the USA, except in the South-East.

Host plants (see Table 2)
Ulmus spp. are the major hosts of *S. schevyrewi*, which has attacked Asian, but also European and American species. In North America, *S. schevyrewi* has been found only on *Ulmus* spp. (Negrón *et al.*, 2005; Veuilleux, 2012; Campos-Bolaños *et al.*, 2015). In the USA, it attacked a new North American host, *U. americana* (Negrón *et al.*, 2005).

S. schevyrewi has been reported in older literature on hosts belonging to several other families (see Table 2). Recent publications from Xinjiang (China) support that several *Prunus* spp. are hosts (Zhu, 2017 - field; Zhong *et al*., 2018 – laboratory and field): *P. armeniaca* (apricot), *P. dulcis* (almond) and *P. ferganensis* (*P. persica* subsp. *ferganensis*). *P. armeniaca* was the most suitable host for development and reproduction (Zhong *et al*., 2018).

Records on some other hosts arise from older publications, and no recent evidence was found (in particular regarding *Malus*, *Pyrus* and *Salix*). Lee *et al.* (2011) considered that only *Ulmus* spp. are hosts, and note it is unclear from previous references on other hosts whether *S. schevyrewi* was colonizing or had developed in the hosts, or were simply collected on the host surface. Experiments conducted in the USA and Canada on the colonization of various previously reported hosts (on logs in the laboratory in the USA, Lee *et al.*, 2011; on trap logs outdoors, Veuilleux, 2012) found *S. schevyrewi* only on *Ulmus*, and not on *Caragana arborescens*, *Elaeagnus angustifolia*, *Prunus fontanesiana* and *Salix alba*. It was also not found in logs of *U. parvifolia* (Lee *et al.*, 2011) (which is not a reported host). *Salix babylonica* and *Elaeagnus angustifolia* were not attacked in recent investigations of hosts in Xinjiang (laboratory and field; Zhong *et al*., 2018).

Known impacts and control in current distribution
In the Karamay region of the Xinjiang Province, China, *S. schevyrewi* is a major pest of elm trees and has caused an average of 3-5% tree mortality of urban elms and 20-25% mortality of rural elms (CABI CPC citing Li *et al.*, 1987). Other authors consider that records of damage in China related to drought-stressed elms (Negrón *et al.* 2005, Lee *et al.*, 2009 citing others). Fan *et al*. (2015) refer to severe damage to elm forests in Yanchi County (Ningxia Province), with large scale destruction and death of trees. In Xinjiang (China), *S. schevyrewi* is an important pest of *Prunus*, especially apricot, and research is ongoing to develop management strategies (Zhu, 2017; Zhong *et al*., 2018). In the USA, *S. schevyrewi* has damaged drought-stressed elms in the arid Rocky Mountain and Intermountain regions where *U. pumila* is a primary shade tree. In 2004, 333 infested *U. pumila* trees were removed from Newcastle, Wyoming (Seybold *et al.*, 2016 citing Lee *et al.*, 2007). No mentions of attacks on other hosts were found in the literature, which may support the hypothesis that non-*Ulmus* hosts are accidental. However, part of the early literature on this pest was not readily available to EPPO (including publications from China).

Regarding initial concerns in North America in relation to Dutch elm disease, *S. schevyrewi* has not led to an increase of the disease. Jacobi *et al.* (2013) noted that the incidence of Dutch elm disease (DED) in Colorado has been decreasing, in parallel with *S. schevyrewi* displacing *S. multistriatus.* It is noted that in colder climates, DED transmission is done by *H. rufipes* (Jacobi *et al.*, 2007). The interactions between *S. schevyrewi* and *H. rufipes* have not been fully studied, but in experiments in Canada (Veuilleux, 2012), *S. schevyrewi* showed a preference for *U. pumila*, while *H. rufipes* preferred *U. americana*, implying that they might not compete with each other.

Control: In Asia, control involves the maintenance of tree vigour, coupled with cultural practices such as the sanitation-felling of wilting and dying trees, and topical insecticide treatment of infested trunks to prevent adult emergence (CABI CPC citing others). Removal of infested trees and destruction of bark (e.g. by chipping) have been used in the USA, and insecticide treatments may be applied to ornamental trees (Davis, 2011, CABI CPC).

Regarding the control of Dutch elm disease (DED), as *S. schevyrewi* has been shown to be a new vector, Jacobi *et al.* (2013) mentions that current management programmes involving removal of declining elms, rapid removal of DED-infected elms prior to beetle emergence, and planting of DED-resistant elms should continue to be effective management tactics.

POTENTIAL RISKS FOR THE EPPO REGION

Pathways

Entry

The life stages of this insect are present in the bark. Wood commodities of *Ulmus* with associated bark may all be pathways. Processes applied to produce wood commodities would destroy some individuals. The likelihood of entry on wood chips, hogwood and processing wood residues would be lower than on round wood, as individuals would have to survive processing and transport, and transfer to a suitable host is less likely. The wood would also degrade and not be able to sustain development of the pest. From a biological point of view, bark on its own may carry the pest, but it is not known if the bark of hosts is used and traded. No data specific to trade of *Ulmus* round wood was found.

Plants for planting of hosts may also be a pathway. Such plants are normally subject to controls during production, and attacked plants may be detected and discarded. Cut branches are a less likely pathway, as they are used indoors, and the pest is unlikely to be able to transfer to a suitable host; it is not known if cut branches of the hosts are used and traded.

Summary of pathways (uncertain pathways are marked with '?'):

- *wood (round or sawn, with bark, including firewood) of hosts*
- *non-coniferous wood chips, hogwood, processing wood residues (except sawdust and shavings)*
- *wood packaging material if not treated according to ISPM 15*
- *bark of hosts?*
- *plants for planting (except seeds) of hosts*
- *cut branches of hosts?*

According to current knowledge on hosts, pathways cover at least Ulmus spp. and the Prunus known hosts.

Spread (following introduction, i.e. within EPPO region)

Adults are reported to be weak flyers, but spread appears to have been rapid in the USA. Over long distances, human-assisted pathways could ensure spread.

Establishment

Establishment of *S. schevyrewi* in the EPPO region where it does not occur is considered possible. *S. schevyrewi* is present in North America in areas with a similar climate than the EPPO region. It is native to part of the EPPO region but has not spread to the Western part of the region. Elms are widely used as ornamentals, and also in shelterbelt and windbreak plantings, and veneer quality lumber. There are some native *Ulmus* species in the EPPO region. *Prunus* spp. are widespread in th wild or in cultivation (including for fruit and as ornamentals). In particular the known hosts *P. armeniaca* and *P. dulcis*, as well as *P. persica* (*P. ferganiana* is a subsp. of *P. persica*) are widely grown commercially in the southern part of the EPPO region, and are present elsewhere as ornamentals.

Potential impact (including consideration of host plants)

Ulmus species are valuable forest and ornamental trees in the EPPO region. *S. schevyrewi* can cause mortality of elms, some European elms species are reported as hosts and the pest attacked new elm species when it was introduced into the USA. *S. schevyrewi* presents a higher risk for stressed elm trees, but it is likely that there are drought-stressed elm trees in cities in parts of the region, as there are in North America The role that *S. schevyrewi* would have in the EPPO region with regards to the transmission of Dutch elm disease is not clear, and would depend on the elm species attacked and its interactions with existing vector species (mainly *S. scolytus*, but also *S. multistriatus* and *S. pygmaeus*). However, even as secondary pest, *S. schevyrewi* is still potentially capable of causing significant damage and mortality to elms (as reported from China). *Prunus* are economically, environmentally and socially important in the EPPO region, and damage to *Prunus*, in particular the known hosts commercially grown for fruit, would increase impact. Finally, if the host range includes other species for which there are old reports, this would also add to the potential impact.

Table 1. Distribution

	Reference	**Comments**
EPPO region		
- Kazakhstan, Kyrgyzstan, Russia (Eastern Siberia, Far-East), Tajikistan, Uzbekistan	- EPPO Global Database	

	Reference	Comments
- Turkmenistan, Uzbekistan, Tajikistan, Kyrgyzstan, East Siberia *(*Pribaikalje, Zabaikalje), Far East (Primorje) - also Kazakhstan, East Siberia (Irkutsk region), West Siberia (Altai) - West Siberia (Krasnoairsk Territory) *Unconfirmed record*: SE European Russia	- Stark, 1952 - Lafer *et al.*, 1996 - Akulov and Mandelshtam, 2012 - Burdaev, 2003	- First record in 2008, South of the territory - in Samara. considered uncertain because it is referring to an unpublished finding (collector, date and place missing)
Asia		
China: Hebei, Heilongjiang, Henan, Ningxia, Qinghai, Shaanxi, Xinjiang	EPPO Global Database	
Korea Dem. Rep.	EPPO Global Database	
Korea Rep.	EPPO Global Database	
Mongolia	EPPO Global Database	
Turkmenistan	EPPO Global Database	
North America		
Canada - Alberta, Manitoba, Ontario, Saskatchewan - British Columbia	- EPPO Global Database - Humble *et al.*, 2010	- First in Alberta in 2006 (Veuilleux, 2012, citing others) - First report in 2010
Mexico	Campos-Bolaños *et al.*, 2015	
USA: Arizona, California, Colorado, Connecticut, Delaware, Idaho, Illinois, Indiana, Kansas, Maryland, Michigan, Minnesota, Missouri, Montana, Nebraska, Nevada, New Jersey, New Mexico, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, South Dakota, Texas, Utah, Virginia, Washington, Wyoming	EPPO Global Database	First trapped in 2003 (Colorado, Utah), but present for several years (specimens in collections collected 1994, 1998, and 2000 in Colorado, New Mexico, and Oklahoma, respectively – Negrón, 2005). First trapped in California in 2002 (Seybold *et al.*, 2016).

Table 2. Hosts

All host records are from Negrón *et al.* (2005, citing others), except * Lafer *et al.*, 1996, **Zhu, 2017 and #Zhong *et al*. 2018 (the latter mentions laboratory and field experiments, but only the English abstract was used, which does not indicate if some species are experimental hosts only).

Family	Genus/Species
Ulmaceae	*Ulmus americana*
Ulmaceae	*Ulmus davidiana* var. *japonica* (*U. japonica*, *U. propinqua*)
Ulmaceae	*Ulmus laevis*
Ulmaceae	*Ulmus macrocarpa*
Ulmaceae	*Ulmus minor* (*U. carpinifolia*)
Ulmaceae	*Ulmus procera*
Ulmaceae	*Ulmus pumila*
Ulmaceae	*Ulmus thomasii*
Ulmaceae	*Ulmus* sp.
Fabaceae	*Caragana arborescens**
Fabaceae	*Caragana korshinskii*
Fabaceae	*Caragana* spp.
Elaeagnaceae	*Elaeagnus*

Family	Genus/Species
Elaeagnaceae	*Elaeagnus angustifolia*
Rosaceae	*Malus pumila*
Rosaceae	*Prunus dulcis* (*P. amygdalus*)
Rosaceae	*Prunus armeniaca#***
Rosaceae	*Prunus armeniaca* var. *ansu* (*P. ansu*)
Rosaceae	*Prunus dulcis#* (as *Amygdalus communis*)
Rosaceae	*Prunus ferganensis#* (*P. persica* subsp. *ferganensis*) (as *Amygdalus ferganensis*)
Rosaceae	*Prunus glandulosa*
Rosaceae	*Prunus padus* (*P. germanica*)
Rosaceae	*Prunus persica*

Family	Genus/Species
Rosaceae	*Prunus pseudocerasus*
Rosaceae	*Prunus salicina*
Rosaceae	*Prunus yedoensis*
Rosaceae	*Pyrus* x *bretschneideri*
Rosaceae	*Pyrus* sp.
Salicaceae	*Salix babylonica*
Salicaceae	*Salix* spp.

References

Akulov EN, Mandelshtam MY. 2012. [New findings of bark beetles (Coleoptera: Curculionidae: Scolytinae) in the South of the Krasnoyarsk Territory and in the Republic of Khakasia]. In [Ecological and Economic Consequences Invasion of wood insects]. Proceedings of the All-Russian Conference with International Participation, Krasnoyarsk, September 25-27, 2012. [in Russian]

Beaver RA, Ghahari H, Sanguansub S. 2016. An annotated checklist of Platypodinae and Scolytinae (Coleoptera: Curculionidae) from Iran. Zootaxa 4098 (3): 401–441.

Burdaev. 2003 https://www.zin.ru/Animalia/Coleoptera/eng/scol_sam.htm.

CABI CPC. 2017. Crop Protection Compendium. www.cabi.org

Campos-Bolaños R, Atkinson TH, Cibrian-Tovar D, Méndez-Montiel T. 2015. First record of *Scolytus schevyrewi* Semenov (Curculionidae: Scolytinae) in Mexico. Acta Zoológica Mexicana (n. s.), 31(1): 146-148.

Davis RS. 2011. Elm Bark Beetles and Dutch Elm Disease. ENT-147-11 September 2011Utah State University Extension and Utah Plant Pest Diagnostic Laboratory.

EPPO. 2008. Mini data sheet on *Scolytus schevyrewi*. Available at https://www.eppo.int

EPPO. 2017. EPPO Global Database. gd.eppo.int

Fan L, Niu H, Zhang J, Liu J, Yang M, Zong S. 2015.Extraction and identification of aggregation pheromone components of *Scolytus schevyrewi* Semenov(Coleoptera: Scolytidae) and trapping test. Acta Ecologica Sinica, 2015-03

Humble LM, John E, Smith J, Zilahi-Balogh GMG, Kimoto T, Noseworthy MK. 2010. First records of the banded elm bark beetle, *Scolytus schevyrewi* Semenov (Coleoptera: Curculionidae: Scolytinae), in British Columbia. Journal of the Entomological Society of British Columbia 107: 21-24.

Jacobi WR, Koski RD, Negron JF. 2013. Dutch elm disease pathogen transmission by the banded elm bark beetle *Scolytus schevyrewi*. For. Path. 43 (2013) 232–237.

Jacobi WR, Koski RD, Harrington TC, Witcosky JJ. 2007. Association of *Ophiostoma novo-ulmi* with *Scolytus schevyrewi* (Scolytidae) in Colorado. Plant Dis. 91:245-247.

Johnson PL, Hayes JL, Rinehart J, Sheppard WS, Smith SE. 2008. Characterization of two non-native invasive bark beetles, *Scolytus schevyrewi* and *Scolytus multistriatus* (Coleoptera: Curculionidae: Scolytinae). The Canadian Entomologist, 140(5):527-538

LaBonte JR. 2010. The Banded Elm Bark Beetle, *Scolytus schevyrewi* Semenov (Coleoptera, Curculionidae, Scolytinae) in North America: a taxonomic review and modifications to the Wood (1982) key to the species of *Scolytus* Geoffroy in North and Central America. ZooKeys 56: 207–218.

Lafer GSh, Egorov AB, Krivolutskaya GO, Kupianskaya AN, Lelej AS, Nemkov PG. 1996. [Key to the insects of Russian Far East. Vol. III. Coleoptera, Pt. 3]. Vladivostok: Dal'nauka. 556 p. (In Russian).

Lee JC, Seybold SJ. 2010. Host Acceptance and Larval Competition in the Banded and European Elm Bark Beetles, *Scolytus schevyrewi* and *S. multistriatus* (Coleoptera: Scolytidae): Potential Mechanisms for Competitive Displacement between Invasive Species. Insect Behav 23:19–34.

Lee JC, Negróón JF, McElwey SJ, Williams L, Witcosky JJ, Popp JB, Seybold SJ. 2011. Biology of the Invasive Banded Elm Bark Beetle (Coleoptera: Scolytidae) in the Western United States. Annals of the Entomological Society of America, 104(4):705-717.

Lee JC, Aguayo I, Aslin R, Durham G, Hamud SM, Moltzan BD, Munson AS, Negrón JF, Peterson T, Ragenovich IR, Witcosky JJ, Seybold SJ. 2009. Co-occurrence of the invasive banded and European elm bark beetles (Coleoptera: Scolytidae) in North America. Ann. Entomol. Soc. Am. 102: 426-436.

Lee JC, Hamud SM, Negrón JF, Witcosky JJ, Seybold SJ. 2010. Semiochemical-mediated ßight strategies of two invasive elm bark beetles: a potential factor in competitive displacement. Environ. Entomol. 39: 642-652.

Maryland Extension. 2008. Banded Elm Bark Beetle. Scolytus schevyrewi Semenov (Coleoptera: Curculionidae: Scolytinae). UMD Entomology Bulletin, 2008. University of Maryland Extension.

Negrón JF, Witcosky JJ, Cain RJ, LaBonte JR, Duerr DA, McElwey SJ, Lee JC, Seybold SJ. 2005. The banded elm bark beetle: a new threat to elms in North America. Am. Entomol. 51: 84-94.

Seybold SJ, Penrose RL, Graves AD. 2016. Invasive bark and ambrosia beetles in California Mediterranean forest ecosystems. In Insects and Diseases of Mediterranean Forest Systems (pp. 583-662). Springer International Publishing.

Stark VN. 1952. Bark beetles (Ipidae [Scolytidae]). In Fauna of USSR. Vol. 31. Moscow – Leningrad, 1952.

Zhong J, Zhu X, Xu B, Abudukeyimu K, Song B, Ma D, Yang S. 2018. Effects of different hosts on the feeding, development and reproduction of *Scolytus schevyrewi* Semenov. Plant Protection, 44(1): 143-146.

Zhu X. 2017. Occurrence and Damage Mechanism of *Scolytus Schevyrewi* Semenov in Apricot Orchard in Desert Oasis Area of Xinjiang. Thesis. Chinese Agricultural University.

This text is an integral part of the *EPPO Study on bark and ambrosia beetles associated with imported non-coniferous wood* and should be read in conjunction with the study

Pest information sheet
Ambrosia beetle

XYLEBORINUS ARTESTRIATUS AND *X. OCTIESDENTATUS* (COLEOPTERA: SCOLYTINAE)

EPPO Lists: Not listed. The assessment of potential risks in this information sheet is not based on a full PRA for the EPPO region, but on an assessment of the limited information for that species used to prepare the information sheet. These two species are treated together due to similarities in their biology.

PEST OVERVIEW

Taxonomy

- *Xyleborinus artestriatus* (Eichhoff 1878). Synonyms: *Xyleborus artestriatus* Eichhoff 1878; *Xyleborus laticollis* Blandford 1896; *Xyleborus rugipennis* Schedl 1953; *Xyleborinus beaveri* Browne 1978;
- *Xyleborinus octiesdentatus* (Murayama 1931). Synonym *Xyleborus octiesdentatus* Murayama 1931.

Associated fungi

The symbiotic fungi are not documented to date.

Morphology and biology

X. artestriatus measures ca. 2.5 mm (females) (Kalshoven, 1959). Females of *X. octiesdentatus* measure 2.1-2.4 mm (Rabaglia *et al.*, 2010). No specific information on the biology was found in the literature. However, *Xyleborus* species are all inbreeding polygynous and the adult female alone constructs the gallery system (Kirkendall, 1983).

Details are lacking on plant parts attacked. However, Kalshoven (1959) recovered specimens of *X. artestriatus* from different plant species in Java on the following material: borer-infested branch, dead branch, fire-scorched trunk, prematurely dying trees, as well as a young transplanted specimen of *Canarium commune* (Burseraceae), i.e. presumably alive. Murayama *et al.* (1931) described *X. octiesdentatus* from *Eurya japonica* (Theaceae) in the Republic of Korea, including its galleries, and mentions that, as "the wood of *Eurya* attacked by this insect started to degrade, in the absence of other pests, it is naturally proved that this insect is very harmful to living trees".

Spread biology

No information found.

Nature of the damage

X. artestriatus and *X. octiesdentatus* tunnel into their hosts.

Detection and identification

- *Symptoms*. No information was found.
- *Trapping*. Specific attractants are apparently not known to date. US sources mention trapping specimens in different baited funnel traps: for *X. artestriatus*, with ethanol, alpha-pinene + ethanol, and Ipslure (Cognato *et al.*, 2013); for *X. octiesdentatus* ethanol, α-β-pinene + ethanol, phoebe oil, and in a trap on a girdled yaupon [*Ilex vomitoria*] (Rabaglia *et al.*, 2010).
- *Identification*. Characters for the identification of adults are provided for *X. artestriatus* in Cognato *et al.* (2013) and for *X. octiesdentatus* in Rabaglia *et al.* (2010). A key to the *Xyleborinus* species present in North America is given in Gomez *et al.* (2018).

Distribution

Xyleborinus artestriatus is native to Asia and the Pacific (Myanmar, India, Sri Lanka, Taiwan, Thailand, Australia [Queensland], Indonesia, Fiji, New Guinea; Cognato *et al.*, 2013, citing others; Beaver *et al.*, 2014; Zimmerman, 1992). It was first trapped in the USA in Georgia (2010) and Texas (2011) (Cognato *et al.*, 2013). In Georgia, it was initially discovered near a warehouse, and by 2012 was documented in four additional warehouses located within 2.5 miles from the initial catch area. In 2015 and 2016, *X. artestriatus* was recovered in multiple traps and is considered to be established in the Savannah area (Bates *et al.*, 2015, 2016). *X. artestriatus* is a quarantine pest for China (Fu *et al.*, 2016).

Xyleborinus octiesdentatus is also native to Asia (China [Sichuan – Beaver *et al.*, 2008 citing others], Japan, South Korea; Rabaglia *et al.*, 2010 citing Wood and Bright 1992). In Japan, it is recorded in Shikoku and Kyushu (Shiraki, 1952). It was first trapped in the USA in 2008 (Alabama, Louisiana) (Rabaglia *et al.*, 2010), and was later found in South Carolina (Chong *et al.*, 2012) and Mississipi in 2012 (Seltzer *et al.*, 2013).

Host plants

- *X. artestriatus* has been recorded in its native range on the following hosts: *Eugenia jambolana* (Myrtaceae), *Ficus religiosa* (Moraceae), *Heritiera fomes* (Malvaceae), *Juglans regia* (Juglandaceae), *Lannea grandis* (Anacardiaceae), *Mallotus philippinensis* (Euphorbiaceae), *Mangifera indica* (Anacardiaceae), *Phyllanthus emblica* (Phyllanthaceae), *Semecarpus anacardium* (Anacardiaceae) and *Shorea robusta* (Dipterocarpaceae) (Cognato *et al.*, 2013, citing others). This list might not cover the whole host range e.g. Kalshoven (1959) mentions *Pithecellobium lobatum* (Mimosaceae), *Canarium commune* (Burseraceae), Butea *frondosa* (Fabaceae), *Bauhinia malabarica* (Caesalpiniaceae).
- *X. octiesdentatus* has been recorded in its native range on*: Carpinus laxiflora* (Corylaceae), *Cleyera* sp., *Eurya japonica* (Theaceae), *Illicium religiosum* (Illiaceae) and *Ilex rotunda* (Aquifoliaceae) (Rabaglia *et al.*, 2010, citing others).

  In the USA, both species have only been trapped, and their hosts have not been determined (Rabaglia *et al.*, 2010; Seltzer *et al.*, 2013; Bates *et al.*, 2015, 2016).

Known impacts and control in current distribution

- *X. artestriatus.* Cognato *et al.* (2013) state: «There are no reports indicating that this species or its symbiotic fungal associates are aggressive or attack healthy trees either in the US or in its native range».
- *X. octiesdentatus*. No information was found on damage in its native distribution. *X. octiesdentatus* was one of the species trapped in nurseries of ornamental trees in Mississippi (2013-2014) (Werle, 2016).

POTENTIAL RISKS FOR THE EPPO REGION

Pathways

Entry

X. artestriatus and *X. octiesdentatus* have been intercepted on wood packaging material in the EU (for *X. artestriatus* EPPO, 2016, 2017; for *X. octiesdentatus*, one interception, initially reported as *Xyleborinus* sp. and later identified to species; H. Krehan, pers. comm., 2018-09). There is not enough data to analyse pathways, but other wood commodities and possibly plants for planting of hosts may be pathways. Finally, inbreeding is favourable to entry and establishment.

Spread (following introduction, i.e. within EPPO region)

There is insufficient information to analyse the possible spread in the EPPO region, but it will be a combination of natural spread and spread via human-assisted pathways. Some natural spread of *X. artestriatus* has been observed in Georgia (USA) (Cognato *et al.*, 2013). It is not known if records of *X. octiesdentatus* in several States are due to natural spread or human-assisted pathways.

Establishment

Xyleborinus artestriatus is native to tropical regions, but has established in the USA in Georgia and Texas. The native range of *X. octiesdentatus* encompasses countries with different climate types, but it has also established in Southern USA. Based on the climate classification of Köppen-Geiger (see Annex 6 of the study), both species have established in areas of the climate type Csa[21], which in the EPPO region occur in

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[21] **Csa**: warm temperate climate, dry and hot summer.

Northern Italy, part of the Balkan and Black Sea area. It is not known if they may establish in drier or more temperate areas.

Considering hosts, *Juglans regia* is a host of *X. artestriatus* and is widespread in the PRA area. Other hosts of both species are mostly tropical plants and presumably present mostly as ornamentals. It is not known if other hosts would be attacked in new areas, but this is likely as both species would only need to find a suitable substrate to raise their ambrosia fungi.

Potential impact (including consideration of host plants)

No impact has been reported to date. As invasive polyphagous ambrosia beetles, they may have a potential for vectoring pathogenic fungi, although there is no evidence of this to date for *X. artestriatus* and *X. octiesdentatus*.

References

Bates C, McClure M, Womack L, Barnes C. 2015. Georgia Forestry Commission Forest Health Highlights. October 1, 2014 through September 30, 2015. Georgia Forestry Commission, USA.

Bates C, McClure M, Womack L, Barnes C. 2016. Georgia Forestry Commission Forest Health Highlights. October 1, 2015 through September 30, 2016. Georgia Forestry Commission, USA.

Beaver RA, Kajimura H, Goto H. 2008. Taxonomic Changes and New Records of Japanese Bark and Ambrosia Beetles (Coleoptera:Curculionidae: Scolytinae). Elytra, 36(2):231-239

Beaver RA, Sittichaya W, Liu L-Y. 2014. A Synopsis of the Scolytine Ambrosia Beetles of Thailand (Coleoptera: Curculionidae: Scolytinae). Zootaxa 3875: 1–82.

Chong JH, Weaver JS, Reid LS. 2012. New records of bark and ambrosia beetles (Coleoptera: Curculionidae: Scolytinae) from South Carolina, U.S.A. Coleopterists Bulletin 66: 250-252.

Choo HY, Woo KS. 1985. A list of Korean bark and ambrosia beetles, and their host plants. Korean Journal of Plant Protection 24:163-167.

Cognato AI, Rabaglia RJ, Vandenberg NJ. 2013. Another Asian ambrosia beetle, *Xyleborinus artestriatus* (Eichhoff 1878) (Coleoptera: Curculionidae: Scolytinae: Xyleborini), newly detected in North America. Pan-Pacific Entomologist, 89(1):27-31.

EPPO. 2016 & 2017. EPPO report on notifications of non-compliance. EPPO Reporting Service, articles 2016/144 (issue 2016-08), 2016/183 (issue 2016-10), 2017/054 (issue 2017-03), 2017/114 (issue 2017-06). Available at www.eppo.int

Fraedrich SW, Harrington TC, Rabaglia RJ, Ulyshen MD, Mayfield AE, Hanula JL, Eickwort JM, Miller DR. 2008. A fungal symbiont of the redbay ambrosia beetle causes a lethal wilt in redbay and other Lauraceae in the southeastern United States. Plant Dis. 92:215-224.

Fu *et al.* 2016. Quarantine pest – stripped bark beetle. [from translation of Chinese abstract).

Gomez DF, Rabaglia RJ, Fairbanks KE, Hulcr J. 2018. North American Xyleborini north of Mexico: a review and key to genera and species (Coleoptera, Curculionidae, Scolytinae). ZooKeys, 768, 19.

Kalshoven LGE. 1959. Studies on the biology of Indonesian Scolytoidea 4 Data on the habits of Scolytidea Second part. Tijdschrift voor Entomologie 102:135-173.

Kirkendall LR. 1983. The evolution of mating systems in bark and ambrosia beetles (Coleoptera: Scolytidae and Platypodidae). Zoological Journal of the Linnean Society 77, 293–352.

Murayama JJ. 1931. Revision des familles des Ipides et Platypides (Coleopteres) de l'ile de Quelpart. Annotationes Zoologicae Japonenses 1339-62, 2 pls.

Rabaglia RJ, Knížek M, Johnson W. 2010. First records of *Xyleborinus octiesdentatus* (Murayama) (Coleoptera, Curculionidae, Scolytinae) from North America. ZooKeys 56: 219–226.

Seltzer JL, Schiefer TL, Brown RL. 2013. Results from the Regional Identification Center of the USDAAPHIS (Eastern Region) at the Mississippi Entomological Museum for the 2012 and 2013 Wood Boring Beetle Surveys, Including New State and County Records for Alabama and Mississippi Report Midsouth Entomologist 6: 119-133.

Shiraki T. 1952. Catalogue of injurious insects in Japan [Exclusive of animal parasites) [In Japanese] Preliminary Studies, Economic Science Section, Natural Resources Division, General Headquarters, Tokyo, Allied Powers Vol V, 47, 82, 126, 128, 130, 162, 167 pp.

Werle C. 2016. An Integrated Approach to Ambrosia Beetle Management in Ornamental Tree Nurseries: Biology of and Control Measures for Exotic Xyleborina. LSU Doctoral Dissertations. 3500.

Zimmerman EC. 1992. Australian Weevils. CSIRO, Canberra, Australia 633 pp.

This text is an integral part of the *EPPO Study on bark and ambrosia beetles associated with imported non-coniferous wood* and should be read in conjunction with the study

Pest information sheet
Ambrosia beetle

XYLEBORUS BISPINATUS (COLEOPTERA: SCOLYTINAE)

EPPO Lists: Not listed. The assessment of potential risks in this information sheet is not based on a full PRA for the EPPO region, but on an assessment of the limited information for that species used to prepare the information sheet.

PEST OVERVIEW

Taxonomy

Xyleborus bispinatus Eichhoff 1868. *X. bispinatus* was long considered a synonym of *Xyleborus ferrugineus*, an invasive species currently found in all tropical and warm temperate areas of the world (Bright 1968; Wood 1982; Wood & Bright 1992). However, *X. bispinatus* was removed recently from synonymy with *X. ferrugineus* (Rabaglia 2005, Kirkendall and Jordal, 2006). Later, Atkinson *et al.* (2013) discussed new characters allowing the definitive separation of these two species, finally confirmed also by Gohli *et al.* (2016). The exact distribution and host range of *X. bispinatus* are therefore not completely known to date.

Associated fungi

The primary symbiont fungus of *X. bispinatus* is not known (Saucedo *et al.*, 2018). *X. bispinatus*, like a number of other ambrosia beetle species, has been shown to acquire *Raffaelea lauricola* (the highly pathogenic symbiont of *Xyleborus glabratus* – see Pest information sheet) when feeding on diseased avocado plants (Menocal *et al.*, 2018a citing others). In Florida, four *Raffaelea* spp. were found associated with *X. bispinatus*: *R. lauricola*, *R. arxii*, *R. subalba* and *R. subfusca*; in feeding experiments *X. bispinatus* was able to reproduce when fed with each of those, indicating that it can produce at least one generation using these fungi (Saucedo *et al.*, 2018). The authors stress however that *R. lauricola* is not the obligate symbiont of *X. bispinatus*, although they note that *X. bispinatus* can carry large amounts of *R. lauricola*, ‘more than enough to kill susceptible avocado trees’ (*R. lauricola* is highly pathogenic once inoculated into a tree – see Pest information sheet for *X. glabratus*). The association with *R. lauricola* has been qualified as ‘frequent’ (in experiments, 35% of *X. bispinatus* individuals versus 60% of *X. glabratus* – Saucedo *et al.*, 2018 citing Ploetz *et al.* 2017). Based on the results of feeding experiments, both Menocal *et al.* (2018a) and Saucedo *et al.* (2018) appear to support the recent hypothesis that *X. bispinatus* may be a vector of *R. lauricola* in avocado orchards in Florida (where the main vector *X. glabratus* is rarely associated with diseased avocado trees). However, this has not been fully confirmed to date.

Morphology and biology

Adult females measure ca. 3 mm (2.8–3.2 mm). As in many *Xyleborus* species, a strong sexual dimorphism occurs with females larger than males (1.6–1.9 mm). *X. bispinatus* is an inbreeding species (Kirkendall and Jordal, 2006). Limited information about the life cycle was found. Females lay eggs throughout their whole lifetime (Saucedo *et al.*, 2018). In Sicily, *X. bispinatus* was found in dying or recently killed fig trees, associated with the more aggressive species *Hypocryphalus dilutus* (previously *H. scabricollis*) (Faccoli *et al.*, 2016). No information was found on whether it has been recorded attacking apparently healthy host trees, although trees that were found to be colonized in summer (2014) did not show any signs of stress or infestation in the previous months (spring 2014). No information was reported about size and diameter of the hosts attacked, although their age ranged between 6 to 50 years (Faccoli *et al.*, 2016).

Spread biology

No information was found, but in related *Xyleborus* species, only females fly. In flight studies, *X. bispinatus* was mostly caught in traps located at 0-4 m height in avocado orchards (Menocal *et al.*, 2018b).

Nature of the damage

As a *Xyleborus*, *X. bispinatus* tunnels galleries in the wood of its hosts. In avocado, transmission of *R. lauricola* may cause death of the trees (due to the fungus), but it is not confirmed to date that *X. bispinatus* is a vector (see *Associated fungi*).

Detection and identification

- *Symptoms.* As a *Xyleborus*, and in the absence of pathogenic fungi, symptoms would be the presence of holes on the trees and possibly frass on or at the base of trees.
- *Trapping*. Some captures of *X. bispinatus* have been made in traps with the following attractants: ethanol, ethanol + sulcatol, alpha pinene + ethanol, exotic *Ips* lure (Atkinson, 2018).
- *Identification.* Descriptions and photos of *X. bispinatus* are given in Kirkendall and Jordal (2006) and Atkinson *et al.* (2013). The latter details morphological differences between three species, *X. bispinatus*, *X. impressus* and *X. ferrugineus*, previously all under *X. ferrugineus* and whose distributions overlap in the Americas. Gomez *et al.* (2018) provides a key to *Xyleborinus* species (for the USA). Faccoli *et al.* (2016) gives characters differentiating *X. bispinatus* from European *Xyleborus* species.

Distribution (Table 1)

The exact distribution of *X. bispinatus* is not known (Kirkendall and Jordal, 2006). *X. bispinatus* is native to tropical and subtropical regions of the Americas. *X. bispinatus* and *X. ferrugineus* are sympatric in the Americas, and some records of *X. ferrugineus* (prior to 2006) may refer to *X. bispinatus* (Atkinson, 2018). *X. bispinatus* is known to occur from the northern part of South America through to Central America, north to Mexico and the Eastern coast of the USA. Faccoli *et al.* (2016) mentions that *X. bispinatus* has been introduced into some Eastern USA states, and it is present north to New York State, according to collection data. Known records are listed in Table 1.

In the EPPO region, large infestations of *X. bispinatus* were found in 2014 and 2015 in 8 localities of Sicily (Italy) on fig (*Ficus carica*). In addition, in France, *X. bispinatus* has been trapped in Nice (GEFF, 2017) and is considered established (L-M Nageleisen and T. Noblecourt, pers. comm. 2018-05).

Host plants

There is little data on the hosts of *X. bispinatus* as it was previously considered as a synonym of *X. ferrugineus*. In Florida, *X. bispinatus* was found on *Persea palustris*, *Persea americana* (Lauraceae), *Wodyetia bifurcata* (Aracaceae) (Atkinson *et al.*, 2013). Records also exist for *Quercus* (Fagaceae), *Swietenia macrophylla* (Meliaceae) (Perez *et al.*, 2015), *Hevea brasiliensis* (Euphorbiaceae), *Eschweilera biflava* (Lecythidaceae), *Lonchocarpus macrophyllus* (Fabaceae) (Atkinson, 2018). In Italy, it was found only on fig trees (*Ficus carica*, Moraceae) (Faccoli *et al.*, 2016). The host range is probably wider. *X. ferrugineus* is reported to be highly polyphagous, with ca. 200 non-coniferous hosts (Faccoli *et al.*, 2016).

Known impacts and control in current distribution

There is no information about the specific impact of *X. bispinatus* in its native areas. Menocal *et al.* (2018a, citing others) mention that there are no supporting data for the statement made in the literature that *X. ferrugineus* (under which *X. bispinatus* was previously classified) caused economic damage in lowland areas of the neotropics. Atkinson (2018) lists a new unpublished record (dated 2017) for *X. bispinatus* in Argentina on *Persea americana*. *X. bispinatus* on avocado is a cause of concern in Florida because of *R. lauricola* (see *Associated fungi*) and a similar concern may exist in other countries (neither *R. lauricola* nor its vector *X. glabratus* are reported from Argentina). No information was found on the impact on the wood value. However, *X. bispinatus* is mentioned by Faccoli *et al.* (2016) as being associated with tropical timber trade. As for other ambrosia beetles, the galleries and possibly fungal staining would presumably cause defects in the wood.

In the USA, no impact by *X. bispinatus* has been reported. Concerns relate to its possible role, not confirmed to date, as a vector of *R. lauricola* in avocado orchards (see *Associated fungi*).

In Italy, the large infestations of *X. bispinatus* and *H. dilutus* observed in 2014 and 2015 on *F. carica* caused the rapid death and desiccation of many fig trees of various ages growing individually, in small groups or in large plantations for fruit production, as well as wild figs. The authors consider that *X. bispinatus* was secondary in these attacks, and *H. dilutus* was the primary pest (Faccoli *et al.*, 2016).

Control: No mention of control was found where *X. bispinatus* is well established. In Italy when a mixed infestation with *H. dilutus* was found, infested trees were destroyed (Faccoli *et al.*, 2016).

POTENTIAL RISKS FOR THE EPPO REGION

Pathways

Entry

Life stages are associated with the wood of host trees. Faccoli *et al.* (2016) note that *X. bispinatus* has been introduced to other regions by the trade of tropical timber. Of the known hosts, at least *Swietenia macrophylla* (mahogany) and *Quercus* spp. are major traded woods. *X. bispinatus* is likely to be associated with wood commodities. Processes applied to produce wood commodities would destroy some individuals. The likelihood of entry on wood chips, hogwood and processing wood residues would be lower than on round wood, as individuals would have to survive processing and transport, and transfer to a suitable host is less likely. The wood would also degrade and not be able to sustain development of the pest. Bark on its own is an unlikely pathway.

Entry on plants for planting or cut branches may be possible if *X. bispinatus* can be associated with small diameter material (no data was available on this). Data from the EU Project Isefor (Increasing sustainability of European forests: Modelling for security against invasive pests and pathogens under climate change) for the period 2001-2010 reports imports of plants for planting of known hosts from some countries where *X. bispinatus* is known to occur (especially *Ficus*, but also *Persea*, *Quercus* and *Woodyetia*). Plants for planting are normally subject to controls during production, and attacked plants may be detected and discarded. Cut branches are a less likely pathway, as they are used indoors, and the pest is unlikely to be able to transfer to a suitable host. No data was sought on whether cut branches of hosts are used and traded.

One additional concern would be if *X. bispinatus* carrying *R. lauricola* entered into the EPPO region. To date, entry with *R. lauricola* would be more likely on plants for planting of *P. americana* from Florida. The association with the fungus has been found only in avocado orchards in Florida, and exports of wood of other species from Florida to the EPPO region are probably minimal or non-existent.

Finally, inbreeding is favourable to entry and establishment. *Summary of pathways (uncertain pathways are marked with '?'):*

- *wood (round or sawn, with or without bark, incl. firewood) of hosts*
- *wood packaging material if not treated according to ISPM 15*
- *non-coniferous wood chips, hogwood, processing wood residues (except sawdust and shavings)*
- *plants for planting (except seeds) of hosts?*
- *cut branches of hosts?*

Spread (following introduction, i.e. within EPPO region)

X. bispinatus could spread naturally and through human-assisted pathways. Of the hosts currently known, *Quercus* is widely present and traded in the EPPO region, and *F. carica* and *P. americana* are present mostly in the southern part of the region (see below).

Establishment

X. bispinatus is native to tropical and subtropical areas but has extended its distribution. Based on the classification of Köppen-Geiger (see Annex 6 of the study), at least the climate type Cfa[22] occurs in its North American distribution and also in the EPPO region. In the EPPO region, *X. bispinatus* has been found in the Mediterranean climate type Csa[22]. Together, these climate types occur around the Mediterranean and in Portugal, and to the Black Sea.

Regarding hosts, *F. carica* grows in the wild and in commercial cultivation in the southern part of the EPPO region, and is also cultivated in gardens in more temperate climates. *P. americana* is cultivated in the South of the EPPO region; if *X. bispinatus* carrying *R. lauricola* were introduced, they may contribute to the establishment of the fungus in the EPPO region, even if the vector *X. glabratus* was appropriately regulated to prevent its introduction. *Quercus* spp. are widespread in the EPPO region (although the species that are hosts of *X. bispinatus* are not known). Some other hosts are used as ornamental (e.g. *Woodyetia bifurcata*). The host range of *X. bispinatus* is not fully known.

As potential host plants are present in areas of suitable climate in the EPPO region, the pests could establish.

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[22] **Cfa**: warm temperate climate, fully humid, hot summer; **Csa**: warm temperate climate, summer dry, hot summer.

Potential impact (including consideration of host plants)

X. bispinatus could have a secondary role in attacks by other beetles on *F. carica*, as was observed in Italy with *H. dilutus*. No direct impact has been reported in areas of introduction to date, but data is lacking from its native distribution in South and Central America. Impact would depend on whether *X. bispinatus* would find a more susceptible host in the EPPO region. One major concern would be any impact linked to the transmission of *R. lauricola* in avocado orchards (however it is not confirmed to date that *X. bispinatus* is a vector - see *Associated fungi*).

Table 1. Distribution

	Reference	**Comments**
EPPO region		
Italy	Faccoli *et al.*, 2016	Sicily
France (trapped)	GEFF, 2017	Nice (trapped)
North America		
Mexico	Perez *et al.*, 2015	
USA - Florida - Georgia, Louisiana, North Carolina, Texas - *Uncertain records*: Indiana, Maryland, New York	 - Atkinson *et al.*, 2013 - Gomez *et al.*, 2018 - Atkinson, 2018	 - considered uncertain as unpublished
Central America		
Belize	Kirkendall and Jordal (2006)	
Costa Rica	Kirkendall and Jordal (2006)	including Cocos Island
Guatemala	Gomez *et al.*, 2018	
Honduras	Gomez *et al.*, 2018	
Panama	Gomez *et al.*, 2018	
South America		
Argentina	Gomez *et al.*, 2018	
Bolivia	Kirkendall and Jordal (2006)	
Brazil	Kirkendall and Jordal (2006)	
Colombia	Gomez *et al.*, 2018	
Ecuador	Kirkendall and Jordal (2006)	
Peru	Gomez *et al.*, 2018	
Venezuela	Gomez *et al.*, 2018	
Oceania		
Uncertain records: Papua New Guinea	Atkinson, 2018	Considered uncertain here as unpublished

References (all URLs were accessed in March 2018)

Atkinson TH. 2018. Bark and Ambrosia beetles. http://www.barkbeetles.info

Atkinson TH, Carrillo D, Duncan RE, Pena JE. 2013. Occurrence of *Xyleborus bispinatus* (Coleoptera: Curculionidae: Scolytinae) Eichhoff in southern Florida. Zootaxa 3669 (1): 096–100.

Faccoli M, Campo G, Perrotta G, Rassati D. 2016. Two newly introduced tropical bark and ambrosia beetles (Coleoptera: Curculionidae, Scolytinae) damaging figs (Ficus carica) in southern Italy. Zootaxa 4138 (1): 189–194

GEFF. 2017. Newsletter. Le Groupe des Entomologistes Forestiers Francophones en Savoie. Ministère de l'agriculture et de l'alimentation, France. Département de la Santé des Forêts.

Gomez DF, Rabaglia RJ, Fairbanks KEO, Hulcr J. 2018. North American Xyleborini north of Mexico: a review and key to genera and species (Coleoptera, Curculionidae, Scolytinae). ZooKeys 768: 19–68.

Kirkendall LR, Jordal BH. 2006. The bark and ambrosia beetles (Curculionidae, Scolytinae) of Cocos Island, Costa Rica and the role of mating systems in island zoogeography. Biological Journal of the Linnean Society, 89, 729–743.

Menocal O, Cruz LF, Kendra PE, Crane JH, Cooperband MF, Ploetz RC, Carrillo D. 2018a. *Xyleborus bispinatus* Reared on Artificial Media in the Presence or Absence of the Laurel Wilt Pathogen (*Raffaelea lauricola*). Insects. 9(1): 30.

Menocal O, Kendra PE, Montgomery WS, Crane JH, Carrillo D. 2018b. Vertical Distribution and Daily Flight Periodicity of Ambrosia Beetles (Coleoptera: Curculionidae) in Florida Avocado Orchards Affected by Laurel Wilt. Journal of Economic Entomology, 111(3):1190-1196.

Pérez Silva M, Equihua Martínez A, Estrada Venegas E.G, Muñoz Viveros AL, Valdez Carrazco JM, Sánchez Escudero J, Atkinson TH. 2015. Sinopsis de especies mexicanas del género *Xyleborus* Eichhoff, 1864 (Coleoptera: Curculionidae: Scolytinae). Acta Zoológica Mexicana (n. s.), 31(2): 239-250.

Saucedo JR, Ploetz RC, Konkol JL, Ángel M, Mantilla J, Menocal O, Carrillo D. 2018. Nutritional symbionts of a putative vector, *Xyleborus bispinatus*, of the laurel wilt pathogen of avocado, *Raffaelea lauricola*. Symbiosis, 75(1), 29–38.

This text is an integral part of the *EPPO Study on bark and ambrosia beetles associated with imported non-coniferous wood* and should be read in conjunction with the study

Pest information sheet
Ambrosia beetle

XYLEBORUS GLABRATUS (COLEOPTERA: SCOLYTINAE)

redbay ambrosia beetle

EPPO Lists: Xyleborus glabratus was added to the EPPO Alert List in 2014 (updated version: EPPO, 2018a). The assessment of potential risks in this information sheet is not based on a full PRA for the EPPO region, but on an assessment of the limited information for that species used to prepare the information sheet.

PEST OVERVIEW

Taxonomy

Xyleborus glabratus Eichhoff 1877. No synonyms.

Associated fungi

The ambrosia symbiont is *Raffaelea lauricola* (Fraedrich *et al.*, 2008), which proved to be pathogenic on *Persea borbonia* and *P. palustris*, and causes vascular wilt on *P. americana* (EPPO, 2018a). In addition, Harrington *et al.* (2010) found five other *Raffaelea* species associated with *X. glabratus*: *R. arxii*, and 4 new species *R. subalba, R. ellipticospora, R. fusca* and R. *subfusca*. No information was found on the pathogenicity of these species.

Morphology and biology

Adults are 2-3 mm long, slender and brown-black in colour. Adult females tunnel in the xylem, infecting the host with *R. lauricola*. A comprehensive summary, including detailed pictures, is provided by Mann *et al.* (2015), and additional general information can be found in Haack and Rabaglia (2013) and EPPO (2018a). Although little is known on the biology of the species, it is noted that, as in the other *Xyleborus* species (Kirkendall, 1983), the sex ratio is very strongly female-biased, reproduction is haplodiploid, the males are haploid, flightless and dwarfed, and mate with their sisters in the gallery where there were born. Single, fertilised females leave the galleries and colonise hosts.

Under controlled conditions, the optimal temperature was ca. 28 °C, no development was observed at 16 °C, and it is estimated that the lower threshold temperatures for egg and pupal development is ca. 14°C and 11°C (Brar *et al.*, 2015). At 25°C in logs (*Persea americana*, *P. borbonia* and *P. palustris*), teneral adults started appearing ca. 30 days after gallery initiation and mature females emerged after ca. 60 days (i.e. teneral adults spent ca. 30 days in the host) (Brar *et al.*, 2013). Formby *et al.* (2013, 2018) showed that *X. glabratus* is freeze-intolerant and chill-susceptible. The lower lethal temperature (−10.0°C) was warmer than the supercooling point (− 22.0°C), and chill injury was observed at −5°C. They concluded that temperatures will be limiting via chill injury where minimum winter temperatures are −6.2°C or colder for 12 h.

Xyleborus glabratus attacks healthy and stressed hosts (Hughes *et al.*, 2016). *Persea borbonia* of a diameter >2.5 cm were rapidly killed, but smaller diameter trees (< 2.5cm) survived for years. Trees < 2.5 cm were poor quality hosts for *X. glabratus*, and brood production was rare, took a very long time (emergence took 4-6 months), and produced small numbers of beetles. The smallest stem section with a successful gallery was 1.7 cm diameter (Maner *et al.*, 2014).

The presence of *P. borbonia* (redbay) has been key to the epidemics observed in the USA. In Georgia, laurel wilt nevertheless persisted in counties where *Sassafras* is common but redbay is rare (Haack and Rabaglia, 2013). At several sites in South Carolina and Georgia, populations of *X. glabratus* persisted but declined to very low levels over a period of nine years after initial invasion in areas where all larger trees (of preferred diameter) had been killed. It was suggested that once the initial phase of the infestation had killed all larger trees, *X. glabratus* performed poorly, and was not infesting other hosts (Maner *et al.*, 2014).

Spread biology

X. glabratus appears to be a poor flyer. According to recent studies in a flight mill, ca. 90% flew <20 m over a 24 h period, and only a very small proportion flew between 100-200 m. It is not known how far emerging females can fly before initiating boring, and results indicated that flights >10 m per day may be rare. The potential spread was estimated to be up to 250 m within forests during a period of two weeks (Seo *et al.*, 2017). It is unknown, though, how many days the beetles can fly and whether (and how) they proceed to regeneration feeding between flights.

Nature of the damage

Damage results from the tunnelling of *X. glabratus* infecting the tree with *R. lauricola*. The susceptibility of hosts varies, and American Lauraceae have generally proved to be more susceptible to the disease in the USA (Ploetz *et al.*, 2016b). Trees of highly susceptible species such as *P. borbonia*, *P. palustris* and sassafras die. *Persea borbonia* appears to have been the most susceptible species in the USA, and has been extensively killed. The whole crown wilts within few weeks to few months, resulting in eventual tree death (Fraedrich *et al.*, 2008). In contrast, *Cinnamomum camphora* is generally not killed, but wilt and dieback can occur in infected branches (Hughes *et al.*, 2016). Fraedrich *et al.* (2011) mention that aborted attacks by *X. glabratus* also allow infection by *R. lauricola*, and this may be important even for hosts that may not support brood production.

Detection and identification

- *Symptoms.* Entrance holes in the bark are either resinous or produce light-coloured boring dust. *X. glabratus* bores characteristic galleries in the wood. It can produce frass tubes that resemble ‘tooth picks’ extending out from the bark. It is more common to see piles of sawdust around the base of the tree than the tubes themselves. Symptoms of laurel wilt are typical of vascular wilt pathogens: vascular black discoloration, rapid wilting, necrosis of foliage and defoliation (EPPO, 2018a). In some species, wilted leaves may persist on the dead tree for a year or more (Hughes *et al.*, 2016).
- *Trapping*. Manuka oil lure and cubeb oil are attractants (Brar *et al.*, 2012, Hanuna *et al.*, 2013) as well as 50% a-copaene lure (Hughes *et al.*, 2017b, citing others). *X. glabratus* are attracted to the leaf odors of their hosts, redbay and *P. palustris* (swamp bay) (Martini *et al.*, 2015). Methyl salicylate and verbenone are repellent and could be used in push-pull strategies together with attractants (Hughes *et al.*, 2017b).
- *Identification.* Benzel (2015) provides details on identification, and comparisons with other species and Gomez *et al.* (2018) a key to *Xyleborus* species (for the USA).

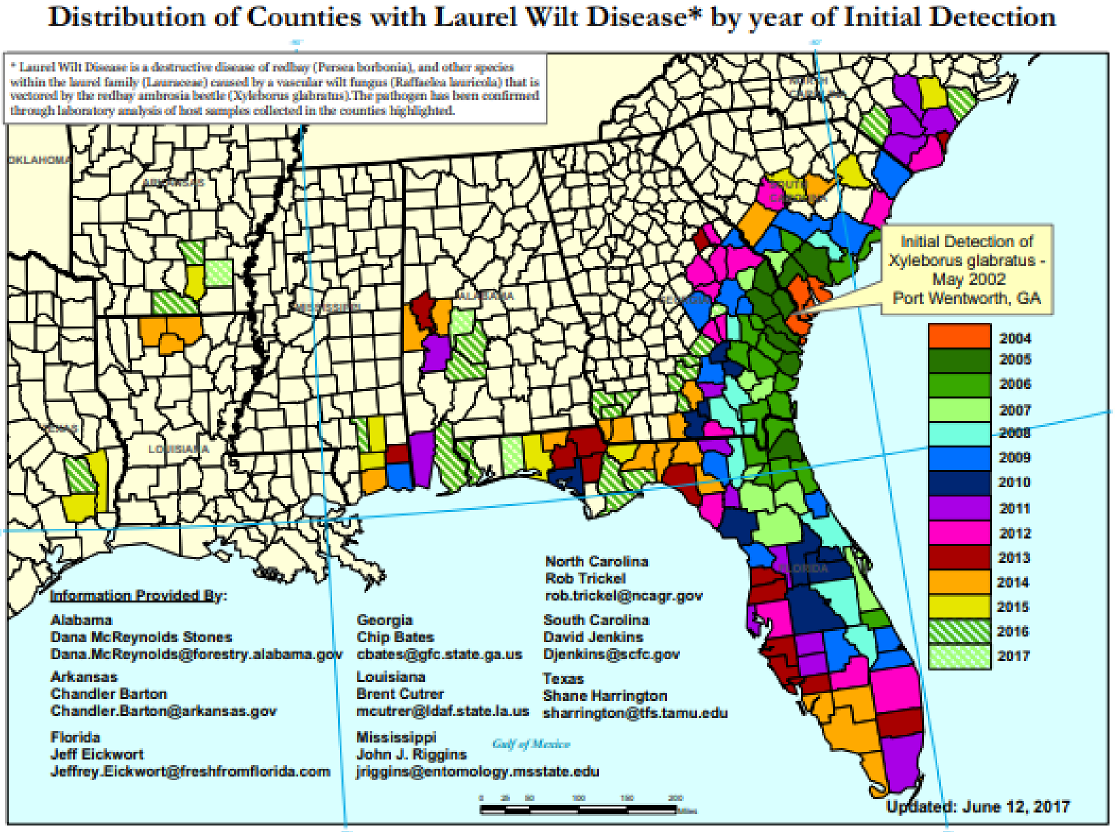
Distribution (see Table 1)

Xyleborus glabratus is native to Asia. In the USA, it was first trapped in May 2002 in a trap located at Port Wentworth (near Savannah, Georgia), and has since been recorded throughout the South-East (EPPO, 2018a; Gomez *et al*., 2018). Formby *et al.* (2018) provides a map illustrating spread in southern USA (see Map 1).

Host plants (see Table 2)

In Asia, *X. glabratus* has been found associated with many Lauraceae species, but also on trees of other families such as: *Leucaena glauca* (Fabaceae), *Lithocarpus edulis* (Fagaceae), *Schima superba* (Theaceae), *Shorea robusta* (Dipterocarpaceae) (EPPO, 2018a). In the USA, it has been recorded on Lauraceae, and has been found on *Persea borbonia* (redbay), *P. palustris* (swampbay), *P. humilis* (silkbay), *P. americana* (avocado), *Sassafras albidum*, *Lindera benzoin* (northern spicebush), *Cinnamomum camphora* (camphor), *Laurus nobilis* (bay laurel) (Brar *et al.*, 2015, Hughes *et al.*, 2014; Fraedrich *et al.*, 2016). *P. borbonia*, a North American species, is a key host and the most affected in the USA. The significance of non-Lauraceae hosts is not known.

Raffaelea lauricola has also been isolated from *Lindera melissifolia* and *Litsea aestivalis,* which are considered as endangered species but the impact of laurel wilt on these tree species remains uncertain (EPPO, 2018a). In experiments, some other Lauraceae species were found to be susceptible to laurel wilt: *Umbellularia californica* (California bay laurel) *Licaria triandra* (Gulf licaria), *Persea indica* (viñátigo) (Hughes *et al.*, 2016, citing others).



Map 1. Spread of *X. glabratus* is southern USA (from Formby *et al*., 2018)

Known impacts and control in current distribution

In Asia, neither *R. lauricola* nor *X. glabratus* had previously been reported to cause laurel wilt (Haack and Rabaglia, 2013), and *X. glabratus* was not considered of economic importance in its native range (Beaver and Liu, 2010). However, a first record of laurel wilt caused by *R. lauricola* was made in 2014 in Myanmar, killing avocado trees within 1-2 months of symptoms appearance (Ploetz *et al.*, 2016a).

In the USA, laurel wilt has caused widespread mortality of *P. borbonia* and *P. palustris*, killing nearly all trees in the colonized areas within 3-5 years after *X. glabratus* was first detected in 2002. In some areas, up to 90% tree mortality has been recorded. Both wild and urban populations of *P. borbonia* and *P. palustris* have been killed (Martini *et al.*, 2015). In South Carolina, laurel wilt has killed *P. borbonia* trees along the coast, and continues to spread (SCFH, 2016). Over 300 million *P. borbonia* are estimated to have been killed in the USA since the early 2000s (ca. 1/3 of the pre-invasion population). Based on genetic analysis, there was only one single introduction of *X. glabratus* and *R. lauricola* (Hughes *et al.*, 2017a). In some areas in Georgia, the composition of forest communities was altered by *R. lauricola*, as after the destruction of *P. borbonia*, and other tree species (e.g. *Magnolia virginiana* and *Gordonia lasianthus*) became dominant (EPPO, 2018a; Brar *et al.* 2015 citing others).

In the USA, the role of *X. glabratus* on avocado is not clear. In Florida, the first avocado tree killed by *R. lauricola* was found in 2006 and by 2011, the fungus had spread to the main avocado production area (Ploetz *et al.*, 2016b). As of July 2013, *R. lauricola* had been detected on 90 avocado trees in various commercial groves, and more than 1900 symptomatic trees had been removed as part of a suppression and sanitation strategy (EPPO, 2018a). Where the implementation of control measures was insufficient, laurel wilt has spread rapidly, resulting in loss of commercial viability and orchard abandonment. Rapid spread has especially been observed in areas with high density of *P. borbonia* and *P. palustris*. However, *X. glabratus* has rarely been trapped in affected commercial avocado orchards. *R. lauricola* has been found able to be associated (experimentally or naturally) to nine other ambrosia beetle species (e.g. *Xyleborus affinis*, *X. ferrugineus*, *X. volvulus*, *Xyleborinus gracilis*, *X. saxeseni*, *Xylosandrus crassiusculus*) (Ploetz *et al.*, 2016b). It is not known yet if the spread of the fungus in avocado is due to another species or to other factors.

Finally, numerous Lauraceae shrub and tree species native to North America are susceptible and threatened. *X. glabratus* and *R. lauricola* may also have negative impacts on the associated fauna and flora, as well impacts on ecosystems due to the death of hosts (Hughes *et al.*, 2017a).

Control. In the USA, cultural practices promoting the health of trees yield positive results. Removal and on-site destruction (by chipping or burning) of all infested trees (down to below soil surface) may reduce populations and slow the spread of the disease (Hughes *et al.*, 2016).

On avocado, the main control method against laurel wilt also consists of destroying infected trees. Surrounding trees can be protected from infection, temporarily, by injections of propiconazole (Hughes *et al.*, 2016; Ploetz *et al.*, 2016b). No efficacious and cost-effective control measures have been identified to date. Chemical control strategies had been developed for *X. glabratus*, in the expectation that it would pass from its natural habitats to avocado production, but it does not appear to be the main vector on avocado, and these strategies would need to be redesigned for other vectors, once identified (Ploetz *et al.*, 2016b).

POTENTIAL RISKS FOR THE EPPO REGION

Pathways

Entry

Life stages are associated with the wood of host trees. Haack and Rabaglia (2013) report only one interception, from China, in the period 1984-2008. In the USA, it is suspected that *X. glabratus* carrying *R. lauricola* was introduced with wood packaging material from Asia, and the movement of infested firewood was considered to be an important means of dissemination within the USA. Processes applied to produce wood commodities would destroy some individuals. The survival of *X. glabratus* and *R. lauricola* in wood chips made from infested *P. borbonia* trees has been studied. Chipping can significantly reduce the number of *X. glabratus* and limit the persistence of *R. lauricola* but does not completely eliminate them (EPPO, 2018a). The likelihood of entry on wood chips, hogwood and processing wood residues would be lower than on round wood, as individuals would have to survive processing and transport, and transfer to a suitable host is less likely. The wood would also degrade and not be able to sustain development of the pest. Bark on its own is an unlikely pathway.

A major issue for this pest is whether infested wood from host species is traded internationally. From Asia, it is not known how prevalent *X. glabratus* is on its known hosts, and it is not clear if non-Lauraceae are reproductive hosts. From the USA, it is unlikely that the main hosts *Persea borbonia* and *P. palustris* are traded as round (or sawn) wood, and it is not known if infested firewood would be traded internationally, or if these species may also be traded as wood chips, hogwood or processing wood residues. The wood of some other Lauraceae hosts such as *Cinnamomum camphora, Umbellaria californica* (experimental host only) is used and traded worldwide (www.wood-database.com; EPPO, 2017), but no data was available on trade into the EPPO region.

Entry on plants for planting may also be possible if these species are traded (e.g. hosts used as ornamentals in the EPPO region, such as *C. camphora* - EPPO, 2017). *X. glabratus* may also be associated with small diameter material, although trees < 2.5 cm are poor quality hosts and produce small numbers of beetles (Maner *et al.*, 2014). Data from the EU Project Isefor (Increasing sustainability of European forests: Modelling for security against invasive pests and pathogens under climate change) for the period 2001-2010 reports 4 *Persea* plants imported from the USA in 2003 and 10 from China in 2010. Plants for planting are normally subject to controls during production, and attacked plants may be detected and discarded. It is not clear if *X. glabratus* would be associated with the pathways, and some data is lacking on the trade of hosts. Cut branches are a less likely pathway, as they are used indoors, and the pest is unlikely to be able to transfer to a suitable host; in addition it is not known if the hosts are used and traded as cut branches. Avocado fruit is not a pathway.

Raffaelea lauricola has been found on more hosts than *X. glabratus* and associated with other ambrosia beetle species, which may have additional implications for entry.

Finally, inbreeding is favourable to entry and establishment.

Summary of pathways (uncertain pathways are marked with '?'):

- *wood packaging material if not treated according to ISPM 15*
- *wood (round or sawn, with or without bark, incl. firewood) of hosts*
- *non-coniferous wood chips, hogwood, processing wood residues (except sawdust and shavings)*
- *plants for planting (except seeds) of hosts*
- *cut branches of hosts?*

> *Because X. glabratus has attacked new Lauraceae hosts, in addition to known hosts, pathways may cover all Lauraceae.*

Spread (following introduction, i.e. within EPPO region)
In the USA, natural spread has occurred, but human-assisted movement of infested host material has been suspected where long-distance spread occurred (Haack and Rabaglia, 2013). In the EPPO region, the known hosts are mostly ornamental trees and would have a restricted distribution (e.g. *C. camphora* – EPPO, 2017). Only *Laurus nobilis* is more widespread in natural environments and in gardens, but its suitability for the development of *X. glabratus* is not known to date (only one record appears to have been made to date in the USA). *X. glabratus* is also not a good flyer, and finding hosts in areas where they are scarce (e.g. only ornamentals) may be difficult and limit spread. According to recent information, *P. americana* does not appear to be a good host for *X. glabratus*, although some mortality was recently reported in Asia. Therefore, spread would be limited, unless *X. glabratus* finds a suitable and susceptible host, as happened with *P. borbonis* and *P. palustris* in the USA. In this case, human-assisted pathways may also lead to multiple introductions from which local spread could occur.

Establishment
Establishment in the EPPO region is considered possible as areas with suitable conditions and host plants are available in the EPPO region.
In most of its range, *X. glabratus* occurs mostly in tropical and subtropical countries. However, based on the climate classification of Köppen-Geiger (see Annex 6 of the study), in the USA *X. glabratus* has established in Cfa[23] type climates, which occur in Northern Italy, Balkans and around the Black Sea. In addition, cold temperatures are limiting (via chill injury), and establishment may not occur in areas where minimum winter temperatures are -6.2° C or colder for 12 h (Formby *et al.*, 2018). This would exclude a large part of the EPPO region. There is therefore a strong uncertainty about whether it could establish in more temperate areas.
Establishment would also be limited by the presence of hosts, and would be influenced by whether *X. glabratus* is able to find new hosts. The known hosts *Laurus nobilis* and *Persea americana* are more widespread in the Mediterranean area, and Lauraceae are otherwise used mostly as ornamentals, but there are also some native Lauraceae in the EPPO region (see below).

Potential impact (including consideration of host plants)
The known hosts of *X. glabratus* are not widely present in the EPPO region and are mostly used as ornamentals. Only *Laurus nobilis* (host status unclear) is native to the Mediterranean area and widespread in Europe (EPPO, 2018a), in the wild in its native range and as an ornamental in other parts of the region. However, *X. glabratus* has found new hosts in the USA, and this may also happen in the EPPO region. Potential impacts would depend on the susceptibility of these species to *R. lauricola* and *X. glabratus*. Laurel forests of high patrimonial value (including Lauraceae genera such as *Apollonias, Ocotea, Persea*) are found in the Azores, Madeira (PT) and Islas Canarias (ES), but their susceptibility is not known (EPPO, 2018a).

Avocado is not widely grown in the EPPO region, but is of economic importance at least in Israel and Spain (EPPO, 2018a). Laurel wilt caused by *R. lauricola* could certainly threaten avocado production, but the role of *X. glabratus* in laurel wilt on avocado is not clear. In the USA, other ambrosia beetle species are suspected to vector the fungus in orchards, while in Myanmar, the possible vector was not mentioned. In the EPPO region the potential impact on avocado may arise from other vectors carrying the fungus. Until these vectors are known, *X. glabratus* is the only species that can be targeted to try and avoid the introduction and impacts by *R. lauricola* on avocado.

Table 1. Distribution of *X. glabratus*

	Reference	**Comments**
EPPO region		
Absent		Also *R. lauricola*
Asia		
Bangladesh	EPPO, 2018b	
China (Fujian, Hunan, Sichuan)	EPPO, 2018b	

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[23] **Cfa**: warm temperate climate, fully humid, hot summer.

	Reference	**Comments**
India (Assam, West Bengal)	EPPO, 2018b	
Japan (Kyushu)	EPPO, 2018b	Also *R. lauricola*
Myanmar	EPPO, 2018b	Also *R. lauricola*
Taiwan	EPPO, 2018b	Also *R. lauricola*
North America		
USA (Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Texas)	EPPO, 2018b	Alabama and Mississipi, 2010 (Formby *et al.*, 2012) *R. lauricola* recorded in the same states

Table 2. Hosts of *X. glabratus*, and other known hosts of *R. lauricola* only

Family	**Genus/Species**	**Reference**
Lauraceae	*Cinnamomum camphora*	Hughes *et al.*, 2016
Lauraceae	*Cinnamomum osmophloeum*	EPPO, 2018b
Lauraceae	*Laurus nobilis*	Hughes *et al.*, 2016
Lauraceae	*Lindera benzoin*	Fraedrich *et al.*, 2016
Lauraceae	*Lindera latifolia*	EPPO, 2018b
Lauraceae	*Litsea elongata*	EPPO, 2018b
Lauraceae	*Machilus nanmu*	EPPO, 2018a
Lauraceae	*Persea americana*	Hughes *et al.*, 2016
Lauraceae	*Persea borbonia*	Hughes *et al.*, 2016
Lauraceae	*Persea humilis*	Hughes *et al.*, 2016
Lauraceae	*Persea palustris*	Hughes *et al.*, 2016
Lauraceae	*Phoebe lanceolata*	EPPO, 2018a
Lauraceae	*Phoebe neurantha*	EPPO, 2018a
Lauraceae	*Phoebe zhennan*	EPPO, 2018a

Family	**Genus/Species**	**Reference**
Lauraceae	*Sassafras albidum*	Hughes *et al.*, 2016
Dipterocarpaceae	*Shorea*	EPPO, 2018b
Dipterocarpaceae	*Shorea robusta*	EPPO, 2018a
Fabaceae	*Leucaena*	EPPO, 2018b
Fabaceae	*Leucaena glauca*	EPPO, 2018a
Fagaceae	*Lithocarpus*	EPPO, 2018b
Fagaceae	*Lithocarpus edulis*	EPPO, 2018a
Theaceae	*Schima superba*	EPPO, 2018a
Species on which *R. lauricola* has been isolated		
Lauraceae	*Lindera melissifolia*	EPPO, 2018a
Lauraceae	*Litsea aestivalis*	EPPO, 2018a
Experimental hosts of *R. lauricola*		
Lauraceae	*Umbellularia californica*	Hughes *et al.* 2016
Lauraceae	*Persea indica*	Hughes *et al.* 2016
Lauraceae	*Licaria triandra*	Hughes *et al.* 2016

References

Beaver RA, Liu LY. 2010. An annotated synopsis of Taiwanese bark and ambrosia beetles, with new synonymy, new combinations and new records (Coleoptera: Curculionidae: Scolytinae). Zootaxa 2602: 1–47.

Benzel JS. 2015. Screening aid: Redbay ambrosia beetle, *Xyleborus glabratus* Eichhoff. Identification Technology Program (ITP), USDA-APHIS-PPQ-S&T, Fort Collins, CO. 7 pp.

Brar GS, Capinera JL, Kendra PE, McLean S, Peña JE. 2013. Life Cycle, Development, and Culture of *Xyleborus glabratus* (Coleoptera: Curculionidae: Scolytinae). Florida Entomologist 96(3):1158-1167.

Brar GS, Capinera JL, Kendra PE, Smith JA, Peña JE. 2015. Temperature-Dependent Development of *Xyleborus glabratus* (Coleoptera: Curculionidae: Scolytinae). Florida Entomologist, 98(3):856-864.

Brar GS, Capinera JL, McLean S, Kendra PE, Ploetz RC, Peña JE. 2012. Effect of Trap Size, Trap Height and Age of Lure on Sampling *Xyleborus glabratus* (Coleoptera: Curculionidae: Scolytinae), and its Flight Periodicity and Seasonality. Florida Entomologist 95(4):1003-1011.

EPPO. 2017. Pest Risk Analysis for *Cinnamomum camphora*. Available at https://www.eppo.int

EPPO. 2018a. *Raffaelea lauricola* (laurel wilt) and its insect vector (*Xyleborus glabratus*). Last updated in 2018. EPPO Alert List. Available at https://www.eppo.int

EPPO. 2018b. EPPO Global Database. available at gd.eppo.int

Formby JP, Krishnan N, Riggins JJ. 2013. Supercooling in the Redbay Ambrosia Beetle (Coleoptera: Curculionidae). Florida Entomologist, 96(4):1530-1540.

Formby JP, Rodgers III JC, Koch FH, Krishnan N, Duerr DA, Riggins JJ. 2018. Cold tolerance and invasive potential of the redbay ambrosia beetle (*Xyleborus glabratus*) in the eastern United States. Biol Invasions, 20(4), 995-1007.

Formby JP, Schiefer TL, Riggins JJ. 2012. First Records of *Xyleborus glabratus* (Coleoptera: Curculionidae) in Alabama and in Harrison County, Mississippi. Florida Entomologist, 95(1):192-193.

Fraedrich SW, Harrington TC, McDaniel BA, Best GS. 2016. First Report of Laurel Wilt, Caused by *Raffaelea lauricola*, on Spicebush (*Lindera benzoin*) in South Carolina. Plant Disease, 100(11): 2330.

Fraedrich SW, Harrington TC, Bates CA, Johnson J, Reid LS, Best GS, Leininger TD, Hawkins TS. 2011. Susceptibility to laurel wilt and disease incidence in two rare plant species, pondberry and pondspice. Plant Dis. 95:1056-1062.

Fraedrich SW, Harrington TC, Rabaglia RJ, Ulyshen MD, Mayfield AE III, Hanula JL, Eickwort JM, Miller DR. 2008. A fungal symbiont of the redbay ambrosia beetle causes a lethal wilt in redbay and other Lauraceae in the southeastern United States. Plant Dis. 92:215-224.

Gomez DF, Rabaglia RJ, Fairbanks KEO, Hulcr J. 2018. North American Xyleborini north of Mexico: a review and key to genera and species (Coleoptera, Curculionidae, Scolytinae). ZooKeys 768: 19–68.

Haack RA, Rabaglia RJ. 2013. Exotic bark and ambrosia beetles in the USA: potential and current invaders. Potential invasive pests of agricultural crops. CAB International, Wallingford, 48-74.

Hanula JL, Sullivan BT, Wakerchuk D. 2013. Variation in Manuka Oil Lure Efficacy for Capturing *Xyleborus glabratus* (Coleoptera: Curculionidae: Scolytinae), and Cubeb Oil as an Alternative Attractant. Environmental Entomology, 42(2):333-340.

Harrington TC, Aghayeva DN, Fraedrich SW. 2010. New combinations in *Raffaelea*, *Ambrosiella*, and *Hyalorhinocladiella*, and four new species from the redbay ambrosia beetle, *Xyleborus glabratus*. Mycotaxon, 111:337–361.

Hughes MA, Black A, Smith JA. 2014. First Report of Laurel Wilt Caused by *Raffaelea lauricola* on Bay Laurel (*Laurus nobilis*) in the United States. Plant Disease, 98(8), 1159.

Hughes MA, Riggins JJ, Koch FH, Cognato AI, Anderson C, Formby JP, Dreaden TJ, Ploetz RC, Smith JA. 2017a. No rest for the laurels: symbiotic invaders cause unprecedented damage to southern USA forests. Biol Invasions,19(7):2143-2157.

Hughes MA, Martini X, Kuhns E, Colee J, Mafra-Neto A, Stelinski LL, Smith JA. 2017b. Evaluation of repellents for the redbay ambrosia beetle, *Xyleborus glabratus*, vector of the laurel wilt pathogen. J. Appl. Entomol., 141: 653–664.

Hughes MA, Smith JA, Coyle DR, Warnell DB. 2016. Biology, Ecology, and Management of Laurel Wilt and the Redbay Ambrosia Beetle forest health. SREF-FH-006. A Regional Peer Reviewed Technology Bulletin published by Southern Regional Extension Forestry, William G. Hubbard, Regional Forester, ASRED/CES- Southern Region. IFAS Extension, University of Florida.

Kirkendall LR. 1983. The evolution of mating systems in bark and ambrosia beetles (Coleoptera: Scolytidae and Platypodidae). Zoological Journal of the Linnean Society 77, 293–352.

Maner LM, Hanula JL, Horn S. 2014. Population Trends of the Redbay Ambrosia Beetle (Coleoptera: Curculionidae: Scolytinae): Does Utilization of Small Diameter Redbay Trees Allow Populations to Persist? Florida Entomologist, 97(1):208-216.

Mann R, Hulcr J, Peña J, Stelinski L. 2015. Redbay Ambrosia Beetle *Xyleborus glabratus* Eichhoff (Insecta: Coleoptera: Curculionidae: Scolytinae). http://edis.ifas.ufl.edu/in886 (accessed 10 july 2018).

Martini X, Hughes MA, Smith JA, Stelinski LL. 2015. Attraction of Redbay Ambrosia Beetle, *Xyleborus glabratus*, to Leaf Volatiles of its Host Plants in North America. J ChemEcol, 41(7):613–621.

Ploetz RC, M. A. Hughes, P. E. Kendra, S. W. Fraedrich, D. Carrillo, L. L. Stelinski, J. Hulcr, A. E. Mayfield, III, T. L. Dreaden, J. H. Crane, E. A. Evans, B. A. Schaffer, and J. A. Rollins. 2016b. Recovery Plan for Laurel Wilt of Avocado, Caused by *Raffaelea lauricola*. Plant Health Prog, 18, 51-77.

Ploetz RC, Thant YY, Hughes MA, Dreaden TJ, Konkol JL, Kyaw AT, Smith JA, Harmon CL. 2016a. Laurel Wilt, Caused by *Raffaelea lauricola*, is Detected for the First Time Outside the Southeastern United States. Plant Disease, 100(10): 2166

SCFC. 2016. Forest Health, 2016 South Carolina highlights, South Carolina Forestry Commission.

Seo M, Martini X, Rivera MJ, Stelinski LL. 2017. Flight Capacities and Diurnal Flight Patterns of the Ambrosia Beetles, *Xyleborus glabratus* and *Monarthrum mali* (Coleoptera: Curculionidae). Environmental Entomology, 46(3), 729–734.

This text is an integral part of the *EPPO Study on bark and ambrosia beetles associated with imported non-coniferous wood* and should be read in conjunction with the study

Pest information sheet
Ambrosia beetle

XYLOSANDRUS COMPACTUS (COLEOPTERA: SCOLYTINAE)
black twig borer

EPPO Lists: Xylosandrus compactus was added to the EPPO Alert List in 2017 (EPPO, 2017). In the EPPO region, it is a quarantine pest for Israel (EPPO Global Database; EPPO, 2018). The assessment of risk in this datasheet is not based on a full PRA for the EPPO region, but on an assessment of the information for that species used to prepare the information sheet, including a PRA for France (ANSES, 2017).

PEST OVERVIEW

Taxonomy

Xylosandrus compactus (Eichhoff, 1875). Synonyms: *Xyleborus compactus* Eichhoff; *Xyleborus morstatti* Hagedorn, 1912; *Xylosandrus morstatti* (Hagedorn).

Associated fungi

18 fungal species have been recorded so far in the female mycangium, on the body or inside galleries of *X. compactus*. Some are known to be saprophytes (e.g. *Ambrosiella xylebori*, *A. macrospora*), but others are plant pathogenic (e.g. *Epicoccum nigrum*, *Fusarium solani*, *Geosmithia pallida*) and might play a role in the symptomatology observed on infested plants (EPPO, 2017; Vannini *et al.*, 2017). ANSES (2017 citing others) also mention *Cryptococcus* sp. *Cladosporium* sp., *Acremonium* sp. *Fusarium* spp., *Pestalotiopsis* sp. and *Verticillium* sp. Finally, a *Fusarium* sp. was recently found associated with *X. compactus* and wilting of cocoa in Uganda (Kagezi *et al.*, 2017).

Morphology and biology (from EPPO, 2017, except where a reference if indicated)
Adults measure 0.9-1.8 mm long (males are smaller than females). Females are shiny black and males reddish black in colour. *X. compactus* is an inbreeder. It is an arrhenotokous species (males derive from unfertilized eggs – females from fertilized ones). Mating primarily occurs between siblings just after adult emergence. After mating, the male remains in the gallery while the female leaves the tunnel through the entry hole and colonizes branches, boring an entry hole and a subsequent brood gallery. The number of larval stages appears to vary between locations (2 to 3 larval stages have been observed). There are several overlapping generations per year (EPPO, 2017). In Italy, two generations per year have been observed (ANSES, 2017, citing others).

X. compactus is mainly a borer of seedlings, shoots and small twigs, but it can also breed in cut branches up to a diameter of about 6 cm (rarely in larger material). The entrance holes bored by females are small (0.8 mm diameter) and are located on the underside of branches or the side of shoots (EPPO, 2017).

X. compactus attacks healthy plants as well as plants that are under stressed conditions such as drought, pruning, or recent transplanting (Greco and Wright, 2012). *X. compactus*, as well as the related species *X. crassiusculus* and *X. germanus*, have been reported as occasional pests of live trees and shrubs in their native southern and eastern Asia (Hulcr *et al.*, 2017, citing others).

Spread biology

Flight of adult females is the main means of movement and dispersal to new plants and new areas over short distances. In the literature, it is noted that adult females can disperse over at least 200 m, and that dispersal over several kilometres is probably possible, especially if wind-aided (EPPO, 2017).

Nature of the damage

Damage is caused by the wood boring activity of the insect and the introduction of ambrosia fungi which are necessary for larval development (EPPO, 2017). *X. compactus* attacks the shoot growth of the year, which may lead to breakage or death. Boring damage may have impact on the quality of products, but the most important damage is due to fungi (ANSES, 2017). *X. compactus* may cause the dieback of the thinner branches of the canopy or of entire young plants (1-2 years old) (Francardi *et al.*, 2017).

Detection and identification

- *Symptoms*. Infested plants display leaf and stem necrosis extending from the entrance hole. Flagging of branches occurs about 5-7 days after initial tunnelling and gallery formation. Wilting of twigs and branches usually becomes evident within weeks of infestation. Cankers are commonly seen around the attacked areas of larger twigs and branches (EPPO, 2017).
- *Trapping. X. compactus* is attracted by ethanol (ANSES, 2017, citing others) and repelled by verbenone (Dudley *et al.*, 2007; Burbano *et al.*, 2012).
- *Identification.* Keys to the females of *Xylosandrus* species in Europe are provided in Nageleisen *et al.* (2015) and Gallego *et al.* (2017).

Distribution (see Table 1)

X. compactus is thought to originate from East Asia (EPPO, 2017). It is widely distributed in Africa, Asia and South America. It has been introduced in some Pacific Islands, Southeastern USA, and more recently in Europe (Italy and France).

In Italy, *X. compactus* was first found in 2011 in urban parks in the province of Napoli (Campania region). It was later also found in Lazio, Liguria, Sicilia and Toscana. During summer 2016, the pest was found in the Lazio region causing serious decline and wilting of Mediterranean maquis plants in the Circeo National Park, in an area covering more than 13 ha, as well as in the neighbouring area of San Felice Circeo, the Villa Fogliano's Botanic Garden and a nursery in Fogliano (Vannini *et al.*, 2017; Francardi *et al.*, 2017; EPPO, 2018).

In France, it was first found in 2016 in an ornamental garden in the municipality of Saint-Jean-Cap-Ferrat (Provence-Alpes-Côte d'Azur) (ANSES, 2017). It has been observed several times on the French Riviera (L-M Nageleisen and T. Noblecourt, pers. comm. 2018-05).

Host plants (See Table 2)

X. compactus attacks over 224 plant species belonging to 60 families (ANSES, 2017). Table 2 includes over hosts in over 65 families. Most species are tropical or subtropical, but some have been introduced in southern Europe; the genera mentioned as widespread in France (ANSES, 2017) are, for example, *Acacia, Acer, Alnus, Azalea, Castanea, Celtis, Cornus, Eucalyptus, Fagus, Ficus, Fraxinus, Hibiscus, Liquidambar, Magnolia, Malus, Platanus, Quercus, Tilia*, and *Vitis*, and would also be present in most of the EPPO region in a wide diversity of habitats (in the wild, plantations for wood or fruit production, parks and gardens, cities etc.). In addition to a broad range of dicotyledonous trees and shrubs, *X. compactus* has been found attacking monocotyledonous plants such as orchids, ginger (*Zingiber*) and conifers (*Pinus* spp.) (EPPO, 2017).

In Italy, *X. compactus* has been recorded mainly on *Quercus ilex*, *Laurus nobilis* and *Ceratonia siliqua*, but it has also been found on *Viburnum tinus, Fraxinus ornus* and *Celtis australis.* In recent outbreaks in Lazio (including the Circeo National Park), it was found on a large number of evergreen maquis species such as *Q. ilex, Viburnum tinus, Ruscus aculeatus, Pistacia lentiscus, L. nobilis* and *C. siliqua* (EPPO, 2018) as well as on *Q. robur, Acer pseudoplatanus, Liquidambar styraciflua, Ficus carica, Magnolia grandiflora* (Francardi *et al.*, 2017). In France, it has been recorded on *Arbutus unedo, Laurus nobilis*, *Phillyrea* sp. and *Quercus ilex* (EPPO, 2017).

The host list is known to be incomplete and host plants of importance to the EPPO region can be found in other publications. For example, Chong *et al.* (2009) reports attacks in South Carolina on the following ornamentals, adding new species or families to the list: *Buxus sempervirens* (Buxaceae), *Hydrangea macrophylla* (Hydrangeaceae), *Morella* (*Myrica*) *cerifera* (Myricaceae), *Cercis canadensis*, or specifying species for genera on the host list, such as *Ficus carica*, *Gardenia jasminoides* and *Magnolia grandiflora*. Dixon *et al.* (2005) add also many species and families from Florida records, including *Carya* (Juglandaceae), *Salix* (Salicaceae). Several of these, apart from also being ornamentals in the EPPO region, are of major economic and environmental importance, such as *B. sempervirens, Ficus carica* or *Salix* spp.

According to ANSES (2017, citing Pennacchio *et al.*, 2012), hosts that may be attacked have the following characteristics: small diameter woody twigs, no hair at the twig surface, and no release of gum, latex or other liquids during attacks.

Known impacts and control in current distribution

According to the literature, the main economic host is coffee (more particularly *Coffea canephora*), and *X. compactus* is also recorded as a pest of tea (*Camelia sinensis*), cacao (*Theobroma cacao*), fruit trees (e.g. *Annona*, *Ficus carica*, *Macadamia ternifolia*, litchi (*Litchi chinensis*), avocado (*Persea americana*) and forest trees in young plantations (e.g. *Aucoumea* sp., *Eucalyptus*, *Entandrophragma*, *Khaya*, *Erythrina*, *Melia azedarach, Swietenia*) (EPPO, 2017). CABI CPC (2018 citing sources from the 1960s-2000s) mentions losses in India of 21% on 45-year old coffee plants and 23.5% on young plants; infestation rates of 60-70% in African mahogany in India; losses of ca. 20% of the coffee crop in Cameroon. In Japan, *X. compactus* was reported as a pest of tea causing extensive dieback, and in China an attack rate of 78% was recorded on the main stems of young chestnut trees. In Peru, *X. compactus* has been known since the 1970s, but it was reported for the first time on cocoa in 2014, causing serious damage in nurseries in the Peruvian Amazon region, and it can also cause important losses in nursey on *Myrciaria dubia* and *Swietenia macrophylla* (Delgado and Couturier, 2017). In Uganda, it was reported as a new but rapidly spreading pest of coffee and other species (Kagezi *et al.*, 2012), Bukomeko *et al.* (2018) highlight that since 2012 *X. compactus* has spread to 68 % of Robusta coffee farms in Uganda, where it infests 40 % of coffee trees per farm. It has also been reported as a pest of cocoa (Kagezi *et al.*, 2017). In Hawaii, it was first found in 1960 and was a sporadic pest on many crops, but it recently emerged as a significant and predictable pest in coffee, boring berries, reaching the endosperm and causing damage without making galleries or ovipositing (Greco and Wright, 2012, 2013).

In the USA, Chong *et al.* (2009) mention that *X. compactus* was reported as an occasional severe pest of landscape ornamentals in the southeastern USA in the mid-1970s. However, they observed damaged ornamental plants in both urban landscape and forests, suggesting that *X. compactus* is more abundant and widespread in South Carolina than previously reported.

In Italy, *X. compactus* has caused extensive withering and dieback of *Laurus nobilis* hedges in several coastal areas in Tuscany (province of Lucca) (Francardi *et al.*, 2017). It has affected *Ceratonia siliqua* in Sicily, and *Cupressus sempervirens* and *L. nobilis* in several urban areas in Rome (Lazio) (Francardi *et al.*, 2017, citing others). Dieback of thinner branches or entire young plants was observed in *Laurus nobilis* in the Fogliano’s plant nursery and in *Magnolia grandiflora* in the Villa Fogliano’s Botanical Garden (Francardi *et al.*, 2017). In the Circeo National Park (Lazio), serious damage has recently been observed on a large number of evergreen species of Mediterranean maquis in a natural habitat, such as *Q. ilex*, *Viburnum tinus, Ruscus aculeatus, Pistacia lentiscus*, *L. nobilis* and *C. siliqua* presented wilting branches (up to 2-3 cm in diameter) or mortality of young plants (Vannini *et al.*, 2017). Attacks on rare native species has also been reported from Hawaii (ANSES *et al.*, 2017, citing others), and La Réunion (Soubeyran, 2008). No damage has been reported from continental France to date.

Control: Reviewing available control methods, ANSES *et al.* (2017) notes that chemical control is difficult, although sometimes mentioned in the literature. Infested plants or plant parts should be cut and destroyed as soon as symptoms appear. At present there is no biological control agent available. In France, sanitation measures based on destruction of infested plants were recommended. Trapping could be put in place along the Mediterranean coast, and together with the fact that symptoms appear rapidly, this may allow for eradication or containment (ANSES, 2017).

POTENTIAL RISKS FOR THE EPPO REGION

Pathways

Entry

Plants for planting and cut branches are possible pathways as the pest attacks twigs and branches between 0.5-6.5 cm. Such plants are normally subject to controls during production, and attacked plants may be detected and discarded. Cut branches are a less likely pathway, as they are used indoors, and the pest is unlikely to be able to transfer to a suitable host. *X. compactus* has a very wide host range, which includes species used for fruit production, as ornamentals or as forest trees. While some hosts are likely traded as plants for planting, it is not known if cut branches of hosts are used and traded (no data was sought).

Bark on its own is considered a potential pathway because overwintering adults may take shelter under the bark (ANSES, 2017).

ANSES (2017) noted that cut trees are a pathway, but attacks on large trunks are exceptional. The host list of *X. compactus* includes major traded woods, such as *Quercus*, *Fagus*, mahoganies (*Swietenia*, *Khaya*, *Entandrophragma*), meranti (*Shorea*). *X. compactus* attacks mostly small diameter material, and is therefore unlikely to be found in most wood consignments. However, wood commodities that include whole trees or harvesting residues may carry the pest, such as firewood. It is not clear whether the hosts of *X. compactus* would be used in this manner, or if such commodities would be traded internationally. There is no data on whether such small wood could be used for commodities such as wood chips, hogwood, processing wood residues or wood packaging material (e.g. dunnage) (although some hosts are known to be used for such commodities, e.g. *Pinus*). However, some wood chips may be made from harvesting or processing residues, such as branches, tree tops and thinnings (EPPO, 2015).

Finally, *X. compactus* is an inbreeder, which is favourable to entry and establishment.

Summary of pathways (uncertain pathways are marked with '?'):

- *plants for planting (except seeds) of hosts*
- *cut branches of hosts (incl. Christmas trees)?*
- *bark of hosts*
- *wood (round or sawn, with or without bark, incl. firewood) of hosts?*
- *wood chips, hogwood, processing wood residues (except sawdust and shavings)*
- *wood packaging material if not treated according to ISPM 15*

Because of the large and uncertain host range, pathways may also cover all non-coniferous and coniferous woody plants.

Spread (following introduction, i.e. within EPPO region)

Natural spread may occur, and at long distances, trade of commodities, especially plants for planting can transport *X. compactus*. It is thought to have been introduced to other parts of the world most probably with trade of plants and wood (EPPO, 2017). ANSES (2017) observed that the pest has spread along the Mediterranean coast of France, and it has spread within few years along a large part of the Tyrrhenian coast of Italy, in several Italian regions. It is not known if the spread in Italy was natural or human-assisted or a combination of both.

Establishment

Areas with suitable climates and host plants are available in the EPPO region, therefore establishment is possible. In most of its range, *X. compactus* occurs mostly in tropical and subtropical countries. However, it has established in France and Italy in areas that are less warm than its native range. Based on the climate classification of Köppen Geiger (see Annex 6 of the study), the climate type of these areas is the Mediterranean climate type Csa[24], which occurs in Portugal and around the Mediterranean Basin, Turkey and the Black Sea. In the USA, *X. compactus* has established in Cfa[24] type climates, which occurs in Northern Italy, Balkans and around the Black Sea. There is an uncertainty about whether it would be able to establish in more temperate areas, and therefore may establish beyond Csa and Cfa type areas.

Although host plants in its native range relate to tropical plants, it has been reported from France, Italy and the USA on many more temperate and Mediterranean species. It is likely to be able to find hosts in other parts of the EPPO region.

Potential impact (including consideration of host plants)

Many woody plants attacked by *X. compactus* are important fruit crops, forest trees or woody ornamentals in the EPPO region. ANSES (2017) notes that given its large host range and the role of associated fungi (especially *F. solani*), it is not unreasonable to foresee damage to native forest, fruit or ornamental plants in France. The fact that serious damage has been reported in Lazio region (Italy) on several species in the Mediterranean maquis, clearly demonstrates that *X. compactus* has the potential to become a pest in natural environments (EPPO, 2017). *X. compactus* and *Xylosandrus crassiusculus* have caused damage in the Circeo National Park in Italy, and these species may represent a serious phytosanitary risk in this natural area because of the wide variety of susceptible plants in the park or in the neighbouring areas (Francardi *et al.*, 2017). The potential impact will also depend on whether the pest is able to establish in cooler areas.

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[24] **Csa**: warm temperate climate, summer dry, hot summer; **Cfa**: warm temperate climate, fully humid, hot summer.

Table 1. Distribution (all records are from EPPO Global Database, except where indicated)

EPPO region

Italy Campania, Lazio, Liguria, Sicilia and Toscana (first found in 2011)

France Provence-Alpes-Côte-d'Azur region (first found in 2016)

Africa

Benin
Cameroon
Central African Republic
Comoros
Congo
Congo (Democratic Republic of)
Cote d'Ivoire
Equatorial Guinea
Gabon
Ghana
Guinea
Guinea-Bissau
Kenya
Liberia
Madagascar
Mauritania
Mauritius
Nigeria
Reunion
Senegal
Seychelles
Sierra Leone
South Africa
Tanzania
Togo
Uganda
Zimbabwe

Asia

Cambodia
China (Guangdong, Guizhou, Hainan, Hunan)
East Timor
India (Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Tamil Nadu)
Indonesia (Irian Jaya, Java, Kalimantan, Sulawesi, Sumatra)
Japan (Hokkaido, Honshu, Kyushu, Ryukyu Archipelago, Shikoku)
Korea Rep. (first report, Sangwook, 2016)
Laos
Malaysia (Sabah, West)
Myanmar
Philippines
Singapore
Sri Lanka
Taiwan
Thailand
Vietnam

North America

USA

-Alabama, Florida, Georgia, Hawaii, Louisiana, Mississippi, South Carolina, Texas) (first found in 1941 in Florida; Haack and Rabaglia, 2013); North Carolina (Rabaglia *et al.*, 2006), Illinois, Pennsylvania (Gomez *et al.*, 2018)
Uncertain records: Arkansas, Indiana, Kentucky, Tennessee (Atkinson, 2018; considered uncertain as unpublished)

Caribbean

Cuba
Netherlands Antilles
Puerto Rico
Trinidad (Gomez *et al.*, 2018)
Virgin Islands (British)
Virgin Islands (US)

South America

Brazil (Amazonas, Goias, Tocantins)
Peru

Oceania
American Samoa
Fiji
Papua New Guinea
Samoa
Solomon Islands
Absent: New Zealand

Table 2. Host plants (from ANSES, 2017, which indicates sources; species from Chong *et al.*, 2009 or Dixon *et al.* 2005 are additional species, and are marked with * (also for new family records))

Family	**Genus/Species**
Acanthaceae	*Graptophyllum pictum*
Adoxaceae*	*Sambucus simpsonii**
Altingiaceae	*Liquidambar formosana*
Altingiaceae	*Liquidambar* spp.
Altingiaceae	*Liquidambar styraciflua**
Amaranthaceae	*Charpentiera* spp.
Anacardiaceae	*Anacardium occidentale*
Anacardiaceae	*Mangifera indica*
Anacardiaceae	*Schinus terebinthifolius*
Anacardiaceae	*Spondias purpurea*
Annonaceae	*Annona cherimola*
Annonaceae	*Annona glabra*
Annonaceae	*Annona montana*
Annonaceae	*Annona muricata*
Annonaceae	*Annona reticulata*
Annonaceae	*Annona squamosa*
Annonaceae	*Rollinia emarginata*
Apocynaceae	*Vinca* spp.
Aquifoliaceae	*Ilex anomala*
Araceae	*Anthurium andraeanum*
Araucariaceae	*Araucaria heterophylla*
Arecaceae	*Euterpe oleracea*
Betulaceae	*Alnus* spp.
Betulaceae	*Corylus* spp.
Betulaceae	*Ostrya* spp.
Bignoniaceae	*Tabebuia pentaphylla*
Bixaceae	*Bixa orellana L.*
Bombacaceae	*Matisia cordata*
Boraginaceae	*Cordia alliodora*
Buxaceae*	*Buxus sempervirens**
Cannabaceae	*Celtis laevigata**
Cannabaceae	*Celtis* spp.
Casuarinaceae	*Casuarina equisetifolia*
Celastraceae	*Perrottetia sandwicensis*
Cornaceae	*Cornus florida*
Dipterocarpaceae	*Shorea* spp.
Ebenaceae	*Diospyros* spp.
Ericaceae	*Azalea* spp.

Family	**Genus/Species**
Ericaceae	*Rhododendron* spp.
Euphorbiaceae	*Acalypha wilkesiana*
Euphorbiaceae	*Aleurites moluccana*
Euphorbiaceae	*Antidesma pulvinatum*
Euphorbiaceae	*Claoxylon sandwicense*
Euphorbiaceae	*Croton reflexifolius*
Euphorbiaceae	*Drypetes phyllanthoides*
Euphorbiaceae	*Hevea brasiliensis*
Fabaceae	*Acacia auriculiformis*
Fabaceae	*Acacia farnesiana*
Fabaceae	*Acacia koa*
Fabaceae	*Acacia mangium*
Fabaceae	*Acacia melanoxylon*
Fabaceae	*Albizzia lebbeck*
Fabaceae	*Andira inermis*
Fabaceae	*Caesalpinia kavaiensis*
Fabaceae	*Cassia glauca*
Fabaceae	*Cassia* spp.
Fabaceae	*Ceratonia siliqua*
Fabaceae	*Cercis canadensis**
Fabaceae	*Crotalaria* spp.
Fabaceae	*Dalbergia* spp.
Fabaceae	*Erythrina abyssinica*
Fabaceae	*Indigofera suffruticosa*
Fabaceae	*Inga paterno*
Fabaceae	*Leucaena leucocephala*
Fabaceae	*lnocarpus fagifer*
Fabaceae	*Pithecellobiutn dulce*
Fabaceae	*Prosopis pallida*
Fabaceae	*Samanea saman*
Fagaceae	*Castanea* spp.
Fagaceae	*Fagus* spp.
Fagaceae	*Quercus laurifolia**
Fagaceae	*Quercus nigra**
Fagaceae	*Quercus robur*
Flacourtiaceae	*Flacourtia indica*
Hydrangeaceae*	*Hydrangea macrophylla**
Juglandaceae*	*Carya glabra**
Juglandaceae*	*Carya illinoensis**
Lamiaceae	*Callicarpa americana**
Lamiaceae	*Callicarpa pedunculata*
Lamiaceae	*Vitex trifolia*
Lauraceae	*Cinnamomum camphora*
Lauraceae	*Cinnamomum verum*
Lauraceae	*Cryptocarya oahuensis*
Lauraceae	*Eusideroxylon zwageri*
Lauraceae	*Laurus nobilis*
Lauraceae	*Persea americana*
Lauraceae	*Persea borbonia**
Liliaceae	*Asparagus myriocladus*
Magnoliaceae	*Liriodendron* spp.
Magnoliaceae	*Magnolia grandiflora**
Magnoliaceae	*Magnolia* spp.
Malpighiaceae	*Byrsonima crassifolia*

Family	**Genus/Species**
Malvaceae	*Abutilon grandifolium*
Malvaceae	*Hibiscus elatus*
Malvaceae	*Hibiscus rosa-sinensis*
Malvaceae	*Hibiscus* spp.
Malvaceae	*Hibiscus tiliaceus*
Malvaceae	*Malvastrum*
Malvaceae	*Malvastrum coromandelianum*
Malvaceae	*Tilia* spp.
Malvaceae	*Melochia umbellata*
Malvaceae	*Theobroma cacao*
Malvaceae	*Theobroma grandiflorum*
Melastomataceae	*Clidemia hirta*
Melastomataceae	*Melastoma malabathricum*
Meliaceae	*Carapa guianensis*
Meliaceae	*Cedrela odorata*
Meliaceae	*Entandrophragma utile*
Meliaceae	*Khaya grandifoliola*
Meliaceae	*Khaya ivorensis*
Meliaceae	*Khaya nyasica**
Meliaceae	*Khaya senegalensis*
Meliaceae	*Melia azedarach*
Meliaceae	*Swietenia macrophylla*
Meliaceae	*Swietenia mahagoni*
Meliaceae	*Swietenia* spp.
Meliaceae	*Taona ciliata* var. *australis*
Meliaceae	*Toona ciliata*
Moraceae	*Ficus carica**
Moraceae	*Ficus* spp.
Moraceae	*Pseudomorus sandwicensis*
Myricaceae*	*Morella (Myrica) cerifera**
Myrsinaceae	*Myrsine lessertiana*
Myrtaceae	*Eucalyptus pilularis*
Myrtaceae	*Eucalyptus robusta*
Myrtaceae	*Eucalyptus sideroxylon*
Myrtaceae	*Eucalyptus* spp.
Myrtaceae	*Eugenia cumini*
Myrtaceae	*Eugenia malaccensis*
Myrtaceae	*Eugenia uniflora*
Myrtaceae	*Melaleuca leucadendra*
Myrtaceae	*Myrciaria dubia*
Myrtaceae	*Syncarpia glomulifera*
Myrtaceae	*Tristania conferta*
Oleaceae	*Fraxinus ornus*
Oleaceae	*Fraxinus uhdei*
Oleaceae	*Jasminum multiflorum*
Oleaceae	*Jasminum sambac*
Orchidaceae	*Cattleya* spp.
Orchidaceae	*Dendrobium* spp.
Orchidaceae	*Epidendrum* spp.
Passifloraceae	*Passiflora edulis*
Pinaceae	*Pinus* spp.
Pittosporaceae	*Pittosporum tobira*
Platanaceae	*Platanus occidentalis**

Family	Genus/Species
Platanaceae	*Platanus* spp.
Proteaceae	*Macadamia integrifolia*
Proteaceae	*Macadamia ternifolia* var. *integrifolia*
Punicaceae	*Punica granatum*
Rhamnaceae	*Colubrina oppositifolia*
Rosaceae	*Malus pumila*
Rosaceae	*Malus* spp.
Rosaceae	*Prunus laurocerasus*
Rosaceae	*Rubus rosifolius*
Rubiaceae	*Coffea arabica L.*
Rubiaceae	*Coffea canephora*
Rubiaceae	*Coprosma* spp.
Rubiaceae	*Gardenia jasminoides**
Rubiaceae	*Gardenia* spp.
Rubiaceae	*Gouldia* spp.
Rutaceae	*Casimiroa edulis*
Rutaceae	*Citrus reticulata*
Rutaceae	*Flindersia brayleyana*
Rutaceae	*Murraya paniculata*
Rutaceae	*Pelea* spp.
Salicaceae*	*Salix**
Santalaceae	*Santalum freycitzetianum*
Sapindaceae	*Acer barbatum**
Sapindaceae	*Acer negundo**
Sapindaceae	*Acer rubrum**

Family	Genus/Species
Sapindaceae	*Acer* spp.
Sapindaceae	*Alectryon* spp.
Sapindaceae	*Euphoria longana*
Sapindaceae	*Koelreuteria elegans**
Sapindaceae	*Litchi chinensis*
Sapindaceae	*Melicoccus bijugatus*
Sapindaceae	*Pometia pinnata*
Sapindaceae	*Sapindus oahuensis*
Sapindaceae	*Nephelium lappaceum*
Scrophulariaceae	*Buddleia asiatica*
Solanaceae	*Solanum sodomeum*
Symplocaceae*	*Symplocos tinctoria**
Theaceae	*Camellia sinensis*
Theaceae	*Camellia* spp.
Thymeliaceae	*Wikstroetnia* spp.
Ulmaceae	*Ulmus* spp.
Urticaceae	*Olmediella betschleriana*
Urticaceae	*Pipturus albidus*
Verbenaceae	*Citharexylum caudatum*
Verbenaceae	*Lantana camara*
Verbenaceae	*Stachytarpheta australis*
Vitaceae	*Vitis labruscana*
Vitaceae	*Vitis* spp.
Zingiberaceae	*Alpinia purpurata*
Zingiberaceae	*Tapeinochilos ananassae*

References (all URLs were accessed in January 2018)

ANSES. 2017. Évaluation du risque simplifiée sur *Xylosandrus compactus* (Eichhoff) identifiéen France métropolitaine. Avis de l'Anses. Rapport d'expertise collective. Available at https://www.anses.fr

Atkinson T. 2018. Bark and Ambrosia Beetles. Online database. http://www.barkbeetles.info/index.php

Bukometo H, Jassogne L, Kagezi GH, Mukasa D, Vaast P. 2018. Influence of shaded systems on *Xylosandrus compactus* infestation in Robusta coffee along a rainfall gradient in Uganda. Agricultural and Forest Entomology. 20: 327-333.

Burbano EG, Wright MG, Gillette NE, Mori S, Dudley N, Jones T, Kaufmann M. 2012. Efficacy of Traps, Lures, and Repellents for *Xylosandrus compactus* (Coleoptera: Curculionidae) and Other Ambrosia Beetles on Coffea arabica Plantations and Acacia koa Nurseries in Hawaii. Environ. Entomol. 41(1): 133-140.

CABI CPC. 2018. *Xylosandrus compactus* datasheet in CABI Compendium. www.cabi.org

Chong J-H, Reid L, Williamson M. 2009. Distribution, Host Plants, and Damage of the Black Twig Borer, *Xylosandrus compactus* (Eichhoff), in South Carolina. Journal of Agricultural and Urban Entomology, 26(4):199-208.

Delgado C, Couturier G. 2017. Primer registro de *Xylosandrus compactus* (Coleoptera: Curculionidae: Scolytinae) sobre cacao en Perú [First record of *Xylosandrus compactus* (Coleoptera: Curculionidae: Scolytinae) on cocoa in Peru]. Revista Colombiana de Entomología 43(1):121-124.

Dixon WN, Woodruff RE, Foltz JL. 2005. *Xylosandrus compactus* (Eichhoff) (Insecta: Coleoptera: Curculionidae: Scolytinae). EENY-311. First published in December 2003, Latest revision: September 2005. University of Florida. http://entnemdept.ufl.edu/creatures/trees/black_twig_borer.htm

Dudley N, Stein JD, Jones T, Gillette N. 2007. Semiochemicals provide a deterrent to the black twig borer, *Xylosandrus compactus* (Coleoptera: Curculionidae, Scolytinae). Proceedings—Interagency Research Forum on Gypsy Moth and other Invasive Species.

EPPO. 2015. EPPO Technical Document No. 1071, EPPO Study on wood commodities other than round wood, sawn wood and manufactured items. EPPO Paris. Available at https://www.eppo.int

EPPO. 2017. *Xylosandrus compactus*. EPPO Alert List. Available at https://www.eppo.int

EPPO. 2018. EPPO Global Database. gd.eppo.int

Francardi V, Noal A, Francescato S, Pinto R, Bruni A, Loffredi L, Bucini D, Guarnieri D, Bellantuono M, Esposito N, Nuccitelli L, Binazzi F, Vitale S, di Giambattista G, Roversi PF, Pennacchio F, 2017: Coexistence of *Xylosandrus crassiusculus* (Motschulsky) and *X. compactus* (Eichhoff) (Coleoptera Curculionidae Scolytinae) in the National Park of Circeo (Lazio, Italy), Redia, 100: 149-155.

Gallego D, Lencina JL, Mas H, Ceveró J, Faccoli M. 2017. First record of the Granulate Ambrosia Beetle, *Xylosandrus crassiusculus* (Coleoptera: Curculionidae, Scolytinae), in the Iberian Peninsula. Zootaxa 4273(3): 431-434.

Gomez DF, Rabaglia RJ, Fairbanks KEO, Hulcr J. 2018. North American Xyleborini north of Mexico: a review and key to genera and species (Coleoptera, Curculionidae, Scolytinae). ZooKeys 768: 19–68.

Greco EB, Wright MG. 2012. First Report of Exploitation of Coffee Beans by Black Twig Borer (*Xylosandrus compactus*) and Tropical Nut Borer(*Hypothenemus obscurus*) (Coleoptera; Curculionidae: Scolytinae) in Hawaii Proceedings of the Hawaiian Entomological Society, 44:71–78.

Greco EB, Wright MG. 2013. Dispersion and Sequential Sampling Plan for *Xylosandrus compactus* (Coleoptera: Curculionidae) Infesting Hawaii Coffee Plantations. Environmental Entomology, 42(2).

Haack RA, Rabaglia RJ. 2013. Exotic bark and ambrosia beetles in the USA: potential and current invaders. Potential invasive pests of agricultural crops. CAB International, Wallingford, 48-74.

Hulcr J, Black A, Prior K, Chen CY, Li HF. 2017. Studies of ambrosia beetles (Coleoptera: Curculionidae) in their native ranges help predict invasion impact. Florida Entomologist, 100(2), 257-261.

Kagezi GH, Kucel P, Mukasa D, Van Asten P, Musoli PC, Kangire A. 2012. Preliminary report on the status and host plant utilization by the Black Coffee Twig Borer, *Xylosandrus compactus* (Eichhoff) (Coleoptera: Curculionidae) in Uganda. In: Proceedings of the 24th International Conference on Coffee Science (ASIC), (pp. 1323-1326), 11-16 November, San Jose, Costa Rica.

Kagezi GH, Sseruyange J, Kucel P, Kobusinge J, Nakibuule L, Kabole C, Wagoire WW. 2017. *Fusarium* spp. associated with *Xylosandrus compactus* causing wilting in cocoa. Journal of Plant Pathology, 99(2), 533-543.

Nageleisen LM, Bouget C, Noblecourt T. 2015. Les Scolytes du genre *Xylosandrus* en France (Coleoptera Curculionidae Scolytinae). L'Entomologiste, 71(4): 267 – 271.

Rabaglia RJ, Dole SA, Cognato AI. 2006. Review of American Xyleborina (Coleoptera: Curculionidae: Scolytinae) occurring north of Mexico, with an illustrated key. Annals of the Entomological Society of America, 99, 1034-1056.

Sangwook P. 2016. Taxonomic Review of Scolytinae and Platypodinae (Coleoptera: Curculionidae) in Korea Doctoral dissertation.

Soubeyran Y. 2008. Espèces exotiques envahissantes dans les collectivités françaises d'outre-mer. Etat des lieux et recommandations. Collection Planète Nature. Comité français de l'UICN, Paris, France.

Vannini A, Contarini M, Faccoli M, Della Valle M, Rodriguez CM, Mazzetto T, Guarneri D, Vettraino AM, Speranza S. 2017. First report of the ambrosia beetle *Xylosandrus compactus* and associated fungi in the Mediterranean maquis in Italy, and new host–pest associations. Bulletin OEPP/EPPO Bulletin, 47(1):100-103.

This text is an integral part of the *EPPO Study on bark and ambrosia beetles associated with imported non-coniferous wood* and should be read in conjunction with the study

Pest information sheet
Ambrosia beetle

XYLOSANDRUS CRASSIUSCULUS (COLEOPTERA: SCOLYTINAE)

‘Asian’ ambrosia beetle, granulate ambrosia beetle

EPPO lists: Xylosandrus crassiusculus was added to the EPPO Alert List in 2009, updated since (EPPO, 2018a). It is currently not regulated by EPPO countries (EPPO Global Database; EPPO, 2018b). The assessment of potential risks in this information sheet is not based on a full PRA for the EPPO region, but on an assessment of the information for that species used to prepare the information sheet. PRAs prepared for Slovenia (Slovenian Forestry Institute, 2017) and for UK (Defra, 2015) were reviewed.

PEST OVERVIEW

Taxonomy

Xylosandrus crassiusculus (Motschulsky 1866). Synonyms: *Phloeotrogus crassiusculus* Motschulsky 1866; *Xyleborus semiopacus* Eichhoff 1878; *Xyleborus semigranosus* Blandford 1896; *Dryocoetes bengalensis* Stebbing 1908; *Xyleborus mascarenus* Hagedorn 1908; *Xyleborus ebriosus* Niisima 1909; *Xyleborus okoumeensis* Schedl 1935; *Xyleborus declivigranulatus* Schedl 1936.

Associated fungi

Mycangial symbiont *Ambrosiella roeperi* (Harrington *et al.*, 2014); no mention of its pathogenicity was found. Other fungi were isolated from galleries: *Aspergillus niger*, *Candida*, *Fusarium lateritium*, *F. oxysporum*, *F. solani*, *Nectria cinnabarina*, *Penicillium* spp., *Pestalotia* spp., *Phomopsis* spp., *Pichia* spp. and *Saccharomycopsis* spp.; particularly species in the genera *Ophiostoma*, *Fusarium*, and *Phomopsis* can be plant pathogenic (Ranger *et al.*, 2016, citing others). In Italy, some potentially pathogenic fungi of *Ceratonia siliqua* such as *Fusarium solani*, *Botryosphaeria obtusa* and *Phomopsis theicola* were isolated in association with necrosis close to holes made by *X. crassiusculus* (Francardi *et al.*, 2017).

Morphology and biology

Adults measure 1.5-3 mm and are dark reddish brown in colour. Populations essentially contain females (1:10 male-female ratio). *X. crassiusculus* is haplodiploid (males derive from unfertilized eggs), and presents high levels of inbreeding among siblings within the gallery system (Ranger *et al.*, 2016 citing others). Emerging females leave infested plants and disperse to colonize hosts. They bore a tunnel with a brood chamber and one or more branches into the sapwood of their host (and sometimes the heartwood). Larvae hatch and feed on the symbiotic fungus growing inside the galleries. In the tropics, breeding is continuous throughout the year with overlapping generations (up to four generations per year in Taiwan (Oliver and Mannion, 2001 citing others). In South-Eastern USA, beetles are active from March to the autumn, and the life cycle takes about 55 days, with usually two generations per year (EPPO, 2018a).

Adults bore into twigs, branches or small trunks of woody host plants and introduce the symbiotic ambrosia fungus on which adults and larvae feed. Ranger *et al.* (2016, citing others) note that *X. crassiusculus* prefers stems and trunks to branches, and that although it has a preference for stems below 7.5 cm diameter, it is not strongly size-selective and also attacks recently cut stumps and logs stored in mill yards. In Japan, *X. crassiusculus* was found in logs (12-20 cm diameter) of *Pasania edulis* (Sone *et al.*, 1998). On grapevine, *X. crassiusculus* attacked mostly the main trunk (Reddy and Verghese, 2006). Browne (1963) noted that seedlings or saplings of less than 1 cm diameter are not attacked. Attacks on live trees usually occur at the base of the plant in young trees or at the sites of lesions or bark wounds on older trees (Pennacchio *et al.*, 2003 citing others). Smith and Hulcr (2015) note that *X. crassiusculus* has the ability to thrive on relatively dry lumber and is able to produce very abundant offspring within a single year if given sufficient supply of wood.

X. crassiusculus is apparently able to attack healthy plants (EPPO, 2018a). However, stress conditions due to water damage, improper planting, drought stress, low temperature, and diseases are considered to play an important role in the selection behaviour of *X. crassiusculus* (Landi *et al.*, 2017 citing Gorzlancyk *et al.* 2013). Ranger *et al.* (2016, citing others) note that plants that are 'apparently healthy' are likely to be experiencing or have a history of physiologically stress at the time of attack. In addition to water-related stress (flooding, inadequate drainage), field observations from ornamental plant nurseries suggest that frost injury or low temperature stress may predispose intolerant trees to attack. *X. crassiusculus* is known to attack healthy newly transplanted trees, especially in nurseries (Lightle *et al.*, 2007, citing Solomon 1995).

Spread biology

Adult males do not fly. Adult females can fly but there is no data on their flight capacity. Ranger *et al.* (2016) mention that *X. crassiusculus* generally flies low to the ground, with traps below 3 m found more effective (citing others). Grégoire *et al.*, (2001) suggested that the closely related species *X. germanus* has sufficient mobility to cover 2 km. Based on data on the flight capability of similar species, the Slovenian PRA concluded that *X. crassiusculus* can fly several 100 metres or several kilometres (citing Grégoire *et al.* 2001, Putz 2014), and when assisted by wind, may passively travel over greater distances.

Nature of the damage

Infested plants show progressive wilting, branch dieback, shoot breakage and general decline. Newly planted seedlings are often attacked at the root collar and the resulting girdling can stunt or kill the young tree (EPPO, 2018a). Damage on grapevine in India seems to relate to established vineyards, but the original reference was not found (cited in Reddy and Verghese, 2006). Infested wood presents galleries and discolouration due to the associated fungus, thus reducing wood quality for timber use. *Xylosandrus* spp. generally do not cause rapid mortality of trees, except for small diameter hosts in case of mass attacks; for large trees, a progressive wilting of the foliage is observed (Nageleisen *et al.*, 2015), as well as dieback (Francardi *et al.*, 2017). Cases of mortality due to *X. crassiusculus* as reported in the literature are mentioned under *Known impact*.

Detection and identification

- *Symptoms*. Symptoms include wilting and decline of trees, powdery frass coming out of entry holes in the form of toothpick-like structures or piling up in small amounts on the ground (base of the host). Abundant gummosis is produced on the bark of some species (*Prunus* spp., carob trees).
- *Trapping*. *X. crassiusculus* are attracted to ethanol (Reding *et al.*, 2011). Conophthorin enhances the attractant effect of ethanol on *X. crassiusculus*, and verbenone is a deterrent (Van der Laan and Ginzel, 2013).
- *Identification*. Keys for the identification of females of *Xylosandrus* species in Europe are provided in Pennacchio *et al.* (2003), Nageleisen *et al.* (2015), Gallego *et al.* (2017), Francardi *et al.* (2017). Molecular identification methods are available (Landi *et al.*, 2017).

Distribution (see Table 1)

X. crassiusculus is considered to originate from Asia, and to have been introduced into Africa hundreds of years ago. More recently, it has been introduced into the Americas (detected in the USA in the 1970s; in Costa Rica and Panama in the 1990s, in several South American countries after 2000) (EPPO, 2018a). It is also present in Oceania.

In Asia, it is found in India, South-East Asia, China and north to Korea and Japan and also at relatively high elevations in the Himalayas in Bhutan and Tibet (Fletchmann and Atkinson, 2016, citing others). In the USA, the dry climate of southern Texas and northeastern Mexico and associated scrub and grassland communities appear to form a natural barrier to the unaided dispersal (Fletchmann and Atkinson, 2016). In South America, Landi *et al.* (2017) suggest that the expansion of *X. crassiusculus* continues, with recent findings in Argentina and Uruguay.

In the EPPO region, *X. crassiusculus* has been found to date in five countries:

- In Italy, *X. crassiusculus* was first found in 2003 in Tuscany (near Pisa) in a mixed forest dominated by *Pinus pinaster* and *Quercus cerris*. Following further trapping, it was considered established. In 2007, infested *Ceratonia siliqua* (carob) were found in gardens in Liguria. In Veneto, few specimens of *X. crassiusculus* were trapped at the Marghera harbour near Venezia in 2010 (EPPO, 2017, 2018a), and many specimens were also found in the municipality of Selva del Montenello (Faccoli *et al.*, 2011). In 2016, severe attacks were also recorded on *Ceratonia siliqua* in the National Park of Circeo, Lazio

(Francardi *et al.*, 2017). *X. crassiusculus* has also been found in Friuli Venezia Giulia (Gallego *et al.*, 2017, citing pers. obs.). In spring 2018, large infestations of *X. crassiusculus* together with *X. germanus* were recorded in many chestnut plantations of Piemonte (Cuneo province) (M. Faccoli, pers. obs., 2018-03). This is the first record of *X. crassiusculus* on chestnut in Europe and the first record for Piemonte.

- In France, *X. crassiusculus* was found in 2014 infesting carob trees (*Ceratonia siliqua*) in a stand growing in an urban area of Nice, Southeastern France. It has been observed several times on the French Riviera (L-M Nageleisen and T. Noblecourt, pers. comm. 2018-05).
- In Spain, *X. crassiusculus* was first found in October 2016 on four dead carob trees (*Ceratonia siliqua*) in an abandoned mountain orchard used as green space, near Benifalló (Valencia) and two neighbour live carob trees were infested (Gallego *et al.*, 2017).
- In Slovenia *X. crassiusculus* was detected for the first time close to the Italian border in August 2017 (121 specimens in a single trap at the edge of a deciduous forest and near a vineyard). No infested plants or signs of *X. crassiusculus* have been observed (EPPO RS, 2018).
- In the Netherlands, four specimens of *X. crassiusculus* were trapped in June-August 2017 in 3 locations where commodities with wood packaging material are imported from various sources (NPPO of the Netherlands, 2018).

Host plants (Table 2)

X. crassiusculus is a highly polyphagous pest on many deciduous tree and shrub species. Over 120 hosts have been reported in the literature (Atkinson *et al.*, 2014). Host genera as per Atkinson (2018) are given in Table 2. In tropical areas, it has been reported on economically important crops (e.g. *Camellia sinensis, Carica papaya, Cocos nucifera, Coffea arabica, Mangifera indica, Theobroma cacao*) or forest tree species (e.g. *Aucoumea klaineana, Tectona grandis*). In more temperate areas, it has been reported on many fruit and nut crops (e.g. *Carya illinoinensis* (pecan), *Ceratonia siliqua* (carob), *Diospyros kaki, Ficus carica* (fig), *Malus domestica* (apple), *Prunus avium* (cherry), *P. domestica* (plum), *P. persica* (peach), as well as on many forest and ornamental woody species (e.g. *Acacia, Alnus, Azalea, Cornus, Eucalyptus, Hibiscus, Koelreuteria, Lagerstroemia, Liquidambar, Magnolia, Prunus, Quercus, Populus, Salix, Ulmus*) (EPPO, 2018a). A few records mention conifers: *Juniperus* spp. (Horn and Horn 2006); *Pinus* (Slovenian Forestry Institute, 2017 citing Wood, 1982).

To date, in France, Italy and Spain, it has been found on *Ceratonia siliqua* (carob tree), in France also on *Cercis siliquastrum* (Judas tree) and, in a trial, was able to attack logs of chestnut (*Castanea sativa*), oleaster (*Olea oleaster*), European hop-hornbeam (*Ostrya carpinifolia*), and green oak (*Quercus ilex*) (the conditions of the trial did not allow it to be shown whether the pest reproduced) (DSF, 2018); in Italy *X. crassiusculus* was first recorded on sweet chestnut (*Castanea sativa*) in 2018 (M. Faccoli, pers. obs.). In Italy and Slovenia, it has also been trapped in a forested area (Pennacchio *et al.*, 2003, EPPO RS, 2018), where it may have other yet undetermined hosts. The pest was not observed on hosts in Slovenia (only trapped in a forested area).

Known impacts and control in current distribution

In the EPPO region, *X. crassiusculus* has been found in natural areas and on few ornamental species that have a limited use in the region, as well as on *Castanea sativa*. Some damage has recently started to be reported. In Italy in 2016, severe attacks on *Ceratonia siliqua* were recorded in the Circeo National Park in association with *X. compactus* (Francardi *et al.*, 2017). In spring 2018, large infestations in Piemonte (together with *X. germanus*) killed several dozen young chestnut trees (2-3 years old) recently planted in about 10 different sites. In France, mortality of carob trees have been reported, in conjunction with drought conditions (DSF, 2018).

In Asia, *X. crassiusculus*, has been reported as an occasional pest of live trees and shrubs (Hulcr *et al.*, 2017, citing others). It is considered a pest of *Acacia* in Vietnam, and a serious pest of hardwood plantations and young trees in nurseries (Thu *et al.*, 2010). In Thailand, *X. crassiusculus* attacks newly sawn rubberwood and is common in durian plantations (Beaver *et al.*, 2014 citing others). In Pakistan, tree mortality has been reported on *Mangifera indica* (EPPO, 2018a), where decline and death is observed mostly in neglected/badly managed orchards, and sometimes in conditions of shortage of irrigation water (http://www.pakistaneconomist.com/issue2004/issue48/i&e6.php, Khuhro *et al.*, 2017).

In India, *X. crassiusculus* is a sporadic pest in certain *Vitis vinifera*-growing areas (Mani *et al.*, 2013). It has become a serious grapevine pest in part of Karnataka and Andhra Pradesh, where mortality may occur; following attacks, the plants begin to dry, and they die within 15-20 months (Reddy and Verghese, 2006). The yield of untreated grapevines is reduced (Keshavareddy and Verghese, 2008). From the literature, it would appear that it does not attack only young plants, as trials on control methods were carried out in a 21-year old vineyard (Reddy and Verghese, 2006). In India, *X. crassiusculus* was also implicated in the death of *Grevillea robusta* (the most common of 9 Coleopteran borers) (Sreedharan *et al.*, 1991).

Mortality has been observed in Fiji on seedlings of *S. macrophylla* (mahogany). In Costa Rica and Panama, *X. crassiusculus* has been found in primary tropical forests on many tree species. However, in these natural forests, it is not known if it can kill healthy trees (EPPO, 2018a). In Ghana *X. crassiusculus* has almost completely destroyed young plantations of *Khaya ivorensis* and *Aucoumea klaineana*, with the sapling stems cut into several pieces by tunnels running in various direction; attacks occurred shortly after transplanting, only when rather unusually large planting stock had been used (Browne, 1963).

In the USA, *X. crassiusculus* has become an important pest of ornamental and fruit trees, more particularly in nurseries and trees used in landscaping. Although no figures are given, it is stated that *X. crassiusculus* has caused moderate to heavy losses in US nurseries (e.g. on potted *Quercus shumardii* and *Ulmus parviflora*), on chestnut, peach and pecan orchards (EPPO, 2018a; Horn and Horn, 2006). In Maryland, where *X. germanus* and *X. crassiusculus* were recorded feeding on over 140 plant species during monitoring in nurseries in 2002-2014, and causing damage, Gill (2014) mentions specifically *X. crassiusculus* in relation to azalea (a private arboretum reported extensive loss of azalea plants every year since 2008), European beech (*Fagus sylvatica*), *Carpinus*, paperbark maple, *Cornus kousa* hybrids, Rose of Sharon and Japanese maple. Attacks, leading to some mortality, on young apparently healthy peach trees in orchards were observed (Kovach and Gorsuch, 1985). Mortality of *Castanea mollissima* (small trees in an experiment, 1-2 cm trunk diameter at 15.2 cm high) was also observed (Oliver and Mannion, 2001). Atkinson *et al.* (2014) reports attacks leading to death on 3 m saplings of *Quercus shumardii* (Shumard oaks) with no visible stress or other attacks, and attacks on large *Ulmus parvifolia* (Drake elm) saplings, which did not directly kill the plants. In ornamental nurseries, mass attacks can result in extensive losses. Although they do not always result in plant death, the growth, aesthetic, and economic value of nursery plants can be negatively affected. Tunnelling by ambrosia beetles can kill small-diameter plants or make them unmarketable, and ornamental producers generally have very little to no tolerance for ambrosia beetle attacks (Ranger *et al.*, 2016, citing others). *X. crassiusculus* has become one of the most damaging insect pests for deciduous trees growers, as they invest a lot of time and money on its control (Werle *et al.*, 2012). *X. crassiusculus* has frequently been listed as the most destructive ambrosia beetle in the southeastern USA (Werle, 2016, citing others).

Finally, *X. crassiusculus* has caused economic damage by boring into stored hardwood lumber (Landi *et al.*, 2017 citing others). *X. crassiusculus* was a major component of an ambrosia beetle infestation in the sapwood of *Liquidambar styraciflua* (sweetgum) logs at a mill yard in Florida in 1999, due to storage of too many logs too long before processing (Atkinson *et al.*, 2014). Smith and Hulcr (2015, citing a pers. comm.) state that losses of significant volumes of timber, particularly hardwood, have increasingly been reported from Florida and Georgia (Smith and Hulcr, 2015).

Some impact due to attacks by *X. crassiusculus* and *X. compactus* in the Circeo National Park have been reported (Francardi *et al.*, 2017). The authors concluded that *X. crassiusculus* and *X. compactus* may represent a serious phytosanitary risk in the Circeo National Park because of the wide variety of susceptible plants in the park or in the neighbouring areas.

Control: In relation to the finding in Italy, Pennacchio *et al.* (2003) stated that the main control method is rapid felling of colonized trees and burning of the wood before adult emergence. Moreover, stacks of wood should be quickly destroyed if there are signs of the presence of *X. crassiusculus*. For valuable wood or in young plantations, Pennacchio *et al.* (2003) mentions that pyrethroid treatments may be applied during the flight and early breeding period, in order to kill adults in the initial phase of penetration. Injection of emamectine benzoate might be used to prevent or cure the attack of individual trees of high aesthetic or conservation value. In the USA, insecticide treatments (incl. pyrethroids) have been applied in nurseries to protect plants from attack (Frank and Sadof, 2011; Ranger *et al.*, 2016).

Trapping should be used to detect the arrival of the pest, and inspections conducted to detect attacked trees. Multifunnel or crossvane interception traps, baited with ethanol, can be used. Multipheromone traps (using current bark beetle's aggregation pheromone components) are the subject of research in Europe. Attacked trees should be left in the nursery until the trunk is fully attacked (in order to focus attacks on infested trees), then removed and buried or burned (Mizell and Riddle, 2004). *X. crassiusculus* was reported as eradicated in Oregon (LaBonte, 2010).

New management strategies are being envisaged, but not fully developed yet, such as push-pull strategy using repellents (e.g. verbenone) to push the pest away from vulnerable nursery stock and attractants (e.g. ethanol) to pull it into annihilative traps (Ranger *et al.*, 2016). Reding *et al.* (2017) found that *X. crassiusculus* and other ambrosia beetle species were attracted to ethanol-injected trap trees, and suggested such trees might be used to attract ambrosia beetles, for example in the context of monitoring or push-pull strategies.

POTENTIAL RISKS FOR THE EPPO REGION

Pathways

Entry

X. crassiusculus has been intercepted in the USA (Haack and Rabaglia, 2013) and in New Zealand on 'unspecified casewood' (Brockerhoff *et al.*, 2003), here interpreted to be wood packaging material. *X. crassiusculus* has also been intercepted in the EU on wood packaging material at several occasions (e.g. Europhyt, 2016, 2017; NPPO of the Netherlands, 2018). Numerous cases of entry to new areas are known. Life stages are associated with the xylem. *X. crassiusculus* has a preference for the lower part of relatively small trees, but has also been found on logs. All wood commodities may therefore be pathways. Processes applied to produce wood commodities would destroy some individuals. The likelihood of entry on wood chips, hogwood and processing wood residues would be lower than on round wood, as individuals would have to survive processing and transport, and transfer to a suitable host is less likely. The wood would also degrade and not be able to sustain development of the pest (*X. crassiusculus* needs a sufficient level of humidity). Bark on its own is an unlikely pathway.

Plants for planting may be a pathway, although such plants are normally subject to controls during production, and attacked plants may be detected and discarded. *X. crassiusculus* is an important nursery pest in part of the USA. In the EPPO region, *X. crassiusculus* has been reported in forests or gardens (and in a plantation of the sweet chestnut), and not in nurseries. Plants for planting are currently considered a pathway from outside the EPPO region. Cut branches are a less likely pathway, as they are used indoors, and the pest is unlikely to fly to a suitable host. It is not known if cut branches of hosts are used and traded.

Finally, *X. crassiusculus* is an inbreeder, which is favourable to entry and establishment.

Summary of pathways (uncertain pathways are marked with '?'):

- *wood (round or sawn, with or without bark, incl. firewood) of hosts*
- *wood chips, hogwood, processing wood residues (except sawdust and shavings)*
- *wood packaging material if not treated according to ISPM 15*
- *plants for planting (except seeds) of hosts*
- *cut branches of hosts?*

Because of the large and uncertain host range, pathways may cover all non-coniferous species. The pathways may also cover the known coniferous hosts (incl. Christmas trees).

Spread (following introduction, i.e. within EPPO region)

X. crassiusculus may enter new countries in the EPPO region through natural spread. This may have happened from Italy (Friuli Venezia Giulia) to Slovenia. The outbreak in France is close only to Italy, and in Spain is far from any border. Spread to Switzerland is less likely due to the obstacle of the Alps. *X. crassiusculus* may also spread with wood commodities of potentially many deciduous trees. If *X. crassiusculus* entered nursery production in the EPPO region, plants for planting may also spread the pest. Human-assisted pathways may lead to multiple introductions from which local spread could occur.

Establishment

X. crassiusculus has already established in several EPPO countries of the Mediterranean Basin, and may establish throughout the Mediterranean area, although it is not known if the most arid areas would also be at risk. In the North, Smith and Hulcr (2015) note that in colder temperate zones with more extensive freezing, *X. crassiusculus* is often replaced by *X. germanus*. However, it is present in North America to Ontario and

Washington State. The climate types where it occurs are present in a large part of the EPPO region, throughout Europe to the South of Scandinavia and into European Russia.

Given its wide host range, *X. crassiusculus* is likely to find hosts throughout that area. However, in Southern Europe, it has been found so far on a limited number of species, including *Ceratonia siliqua* (carob), *Cercis siliquastrum*, which have a limited distribution in the EPPO region, as well as on *Castanea sativa*, which is grown more widely for fruit, wood production and as ornamental tree.

Areas with suitable climates and host plants are available in the EPPO region, and establishment in areas where it does not already occur is possible.

Potential impact (including consideration of host plants)

So far in the EPPO region, there are few indications of damage. *X. crassiusculus* has been found in natural areas or on few ornamental species that have a limited use in the region. However, attacks on *Castanea sativa* in plantations, including mortality have been observed in Piemonte, Italy in 2018. Mortality of *Ceratonia siliqua* trees has also been reported from Italy and France. Many woody plants attacked by *X. crassiusculus* are important fruit crops, forest trees or woody ornamentals in the EPPO region. *X. crassiusculus* has occasionally become a significant and aggressive pest. *X. crassiusculus* has the potential to cause damage to chestnut plantations, to be a pest in nurseries (as reported from the USA), and possibly in orchards and plantations of other hosts. Data is lacking on its potential impact in forests and wood production, although impact on logs have been reported from the USA.

Table 1. Distribution

	Reference	**Comments (with references)**
EPPO region		
France	EPPO, 2018b	First found in 2014 in Alpes Maritimes
Italy	EPPO, 2018b	First found in 2003 in Toscana, later in Liguria, Veneto, Friuli Venezia Giulia, Lazio, Piemonte (EPPO, 2018b; Faccoli *et al.*, 2011; Francardi *et al.*, 2017; Gallego *et al.*, 2017; M. Faccoli, pers. obs., 2018)
Spain	EPPO, 2018b	First found in 2016 (Gallego *et al.*, 2017). Benifaió municipality, Comunidad Valenciana
Slovenia: transient, actionable, under surveillance	EPPO RS, 2018	Based on pest notification by the NPPO
Netherlands: transient: non-actionable, under surveillance	NPPO of the Netherlands, 2018	Pest notification by the NPPO
Absent: Belgium (no pest record); Lithuania (confirmed by survey)	EPPO, 2018b	
Unconfirmed: Israel	NPPO of Israel, 2018	Reported by Buse *et al*. (2013) as trapped during surveys in a stand of old oaks (*Quercus calliprinos*) in northern Israel. Possibly a misidentification, not represented in the Israelian collection of Scolytinae, never collected by Israelian specialists (NPPO of Israel, 2018).
Africa		
Cameroon	EPPO, 2018b	
Congo Dem. Rep.	EPPO, 2018b	
Cote d'Ivoire	EPPO, 2018b	
Equatorial Guinea	EPPO, 2018b	
Gabon	EPPO, 2018b	
Ghana	EPPO, 2018b	
Kenya	EPPO, 2018b	
Madagascar	EPPO, 2018b	
Mauritania	EPPO, 2018b	

	Reference	**Comments (with references)**
Mauritius	EPPO, 2018b	
Nigeria	EPPO, 2018b	
Seychelles	EPPO, 2018b	
Sierra Leone	EPPO, 2018b	
Tanzania	EPPO, 2018b	
Asia		
Bhutan	EPPO, 2018b	
China (Fujian, Hunan, Sichuan, Xianggang (Hong Kong), Xizhang, Yunnan)	EPPO, 2018b	
India	EPPO, 2018b	
India (Andaman and Nicobar Islands, Assam, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Tamil Nadu, Uttar Pradesh, West Bengal)	EPPO, 2018b	
Indonesia	EPPO, 2018b	
Japan -Hokkaido, Honshu, Kyushu, Shikoku -Also Ryukyu Islands	-EPPO, 2018b -Ito and Kajimura, 2009	
Korea Dem. Rep.	EPPO, 2018b	
Korea Rep.	EPPO, 2018b	
Malaysia	EPPO, 2018b	
Myanmar	EPPO, 2018b	
Nepal	EPPO, 2018b	
Pakistan	EPPO, 2018b	
Philippines	EPPO, 2018b	
Sri Lanka	EPPO, 2018b	
Taiwan	EPPO, 2018b	
Thailand	EPPO, 2018b	
Vietnam	EPPO, 2018b	
North America		
Canada (Ontario)	EPPO, 2018b	
USA - Alabama, Arkansas, Delaware, Florida, Georgia, Hawaii, Indiana, Kansas, Louisiana, Maryland, Michigan, Mississippi, Missouri, Nebraska, New Jersey, New York, North Carolina, Ohio, Oklahoma, Oregon, South Carolina, Tennessee, Texas, Virginia, Washington - Kentucky	- EPPO, 2018b - Gomez *et al.*, 2018	first record in 1974 in South Carolina on a dying graft of *Liquidambar styraciflua* (EPPO, 2018a) Reported as eradicated from Oregon in LaBonte (2010)
Central America		
Guatemala	EPPO, 2018b	
Honduras	Storer *et al.* 2017	Citing unpublished collection by the author in 2013
Panama	EPPO, 2018b	First record 2003 (Kirkendall and Ødegaard, 2007)
South America		
Argentina	EPPO, 2018b	First record in Landi *et al.* (2017)
Brazil (Amapa, Pernambuco,	EPPO, 2018b	2012

	Reference	Comments (with references)
Rio de Janeiro, Sao Paulo)		
Costa Rica	EPPO, 2018b	First record 1996 (Kirkendall and Ødegaard, 2007)
French Guiana	EPPO, 2018b	2009
Uruguay	EPPO, 2018b	First record in Landi *et al.* (2017)
Oceania		
Australia (Queensland)	EPPO, 2018b	
New Caledonia	EPPO, 2018b	
New Zealand (absent, intercepted only)	EPPO, 2018b	
Palau	EPPO, 2018b	
Papua New Guinea	EPPO, 2018b	
Samoa	EPPO, 2018b	

Table 2. Host genera (all from Atkinson, 2018, except * from Horn and Horn, 2006 and other sources)

Family	Genus
Adoxaceae	*Sambucus*
Adoxaceae	*Viburnum*
Altingiaceae	*Liquidambar*
Anacardiaceae	*Gluta*
Anacardiaceae	*Holigarna*
Anacardiaceae	*Lannea*
Anacardiaceae	*Pistacia*
Anacardiaceae	*Swintonia*
Annonaceae	*Annona*
Annonaceae	*Sageraea*
Apocynaceae	*Alstonia*
Apocynaceae	*Amoora*
Apocynaceae	*Plumeria*
Apocynaceae	*Wrightia*
Arecaceae	*Neodypsis*
Asparagaceae	*Dracaena*
Asparagaceae	*Ruscus*
Betulaceae	*Ostrya**
Burseraceae	*Aucoumea*
Burseraceae	*Canarium*
Calophyllaceae	*Calophyllum*
Calophyllaceae	*Kayea*
Cannabaceae	*Cannabis*
Combretaceae	*Terminalia*
Convolvulaceae	*Ipomoea*
Cornaceae	*Cornus*
Cucurbitaceae	*Luffa*
Cupressaceae	*Juniperus**
Dilleniaceae	*Dillenia*
Dipterocarpaceae	*Dipterocarpus*
Dipterocarpaceae	*Hopea*
Dipterocarpaceae	*Shorea*
Dipterocarpaceae	*Vateria*
Ebenaceae	*Diospyros*
Eleaocarpaceae	*Elaeocarpus*
Euphorbiaceae	*Hevea*
Euphorbiaceae	*Lasiococca*
Fabaceae	*Cercis*
Fabaceae	*Dalbergia*
Fabaceae	*Erythrina*
Fabaceae	*Erythrophleum*
Fabaceae	*Gleditsia*
Fabaceae	*Gliricidia*
Fabaceae	*Ougeinia*
Fabaceae	*Scorodophloeus*
Fabaceae	*Ceratonia*
Fagaceae	*Castanea*
Fagaceae	*Castanopsis*
Fagaceae	*Lithocarpus*
Fagaceae	*Quercus*
Juglandaceae	*Carya*
Lamiaceae	*Vitex*
Lamiaceae	*Tectona*
Lauraceae	*Cinnamomum*
Lauraceae	*Laurus*
Lauraceae	*Machilus*
Lauraceae	*Persea*
Lauraceae	*Phoebe*
Lythraceae	*Lagerstroemia*
Magnoliaceae	*Liriodendron*
Magnoliaceae	*Magnolia*
Malvaceae	*Sterculia*
Malvaceae	*Theobroma*
Melastomataceae	*Swietenia*
Melastomataceae	*Topoboea*
Meliaceae	*Cedrela*
Meliaceae	*Guarea*
Meliaceae	*Khaya*
Mimosaceae	*Albizzia*
Moraceae	*Artocarpus*
Moraceae	*Castilla*
Moraceae	*Cecropia*
Moraceae	*Ficus*
Moraceae	*Pachytrophe*
Moraceae	*Pourouma*
Myristicaceae	*Myristica*
Myristicaceae	*Pycnanthus*
Myrtaceae	*Syzygium*
Olacaceae	*Ongokea*
Oleaceae	*Olea**
Phyllanthaceae	*Bischofia*
Pinaceae	*Pinus*
Poaceae	*Saccharum*
Proteaceae	*Grevillea*
Rosaceae	*Malus*
Rosaceae	*Prunus*
Rosaceae	*Pyrus*
Rosaceae	*Sorbus*
Rutaceae	*Chloroxylon*
Rutaceae	*Murraya*
Rutaceae	*Zanthoxylum*
Salicaceae	*Populus*
Sapindaceae	*Koelreuteria*
Sapindaceae	*Ungnadia*
Sapotaceae	*Pouteria*
Styracaceae	*Styrax*
Ulmaceae	*Doonia*
Ulmaceae	*Ulmus*
Vitaceae	*Leea*
Vochysiaceae	*Vochysia*

References

Atkinson TH, Foltz JL, Wilkinson RC, Mizell RF. 2014. Granulate Ambrosia Beetle, *Xylosandrus crassiusculus* (Motschulsky) (Insecta: Coleoptera: Curculionidae: Scolytinae). EENY131. University of Florida, IFAS Extension.

Atkinson T. 2018. Bark and Ambrosia Beetles. Online database. http://www.barkbeetles.info/index.php

Beaver R, Sittichaya W, Liu L-Y. 2014. Synopsis of the Scolytine Ambrosia Beetles of Thailand (Coleoptera: Curculionidae: Scolytinae). Zootaxa 3875 (1): 001–082.

Brockerhoff EG, Knízek M, Bain J. 2003. Checklist of indigenous and adventive bark and ambrosia beetles (Curculionidae: Scolytinae and Platypodinae) of New Zealand and interceptions of exotic species (1952-2000). New Zealand Entomologist 26: 29-44.

Browne FG. 1963. Notes on the habits and distribution of some Ghanaian bark beetles and ambrosia beetles (Coleoptera: Scolytidae And Platypodidae). Bulletin of Entomological Research, 54(2):229-266.

Buse J, Assmann T, Friedman All, Rittner O, Pavlicek T. 2013. Wood-inhabiting beetles (Coleoptera) associated with oaks in a global biodiversity hotspot: a case study and checklist for Israel. Insect Conservation and Diversity, 6:687–703.

Defra. 2015. Rapid Pest Risk Analysis (PRA) for: *Xylosandrus crassiusculus*, Department for environment, food and rural affairs. UK.

DSF 2018. Plan de surveillance des foyers de *Xylosandrus crassiusculus* et *Xylosandrus compactus* en région PACA 2018. Prefecture de la Région Provence-Alpes-Cote d'Azur.

EPPO. 2018a. *Xylosandrus crassiusculus*. Alert List. Available at www.eppo.int

EPPO. 2018b. EPPO Global Database. gd.eppo.int

EPPO RS. 2018. 2018/028 First report of *Xylosandrus crassiusculus* in Slovenia. EPPO Reporting Service. February 2018.

Europhyt. 2016. Interceptions of harmful organisms in commodities imported into the EU Member States and Switzerland. Reported to Europhyt during 2016. Available at: https://ec.europa.eu/food/plant/plant_health_biosecurity/europhyt/interceptions_en

Europhyt. 2017. Interceptions of harmful organisms in commodities imported into the EU Member States and Switzerland. Reported to Europhyt during 2017. Available at: https://ec.europa.eu/food/plant/plant_health_biosecurity/europhyt/interceptions_en

Faccoli M, Petrucco Toffolo E, Vettorazzo M, Narduzzo G. 2011. Segnalazioni di *Xylosandrus crassiusculus* (Coleoptera, Curculionidae, Scolytinae) in Italia Nord Orientale. Sessione IV - Entomologia forestale. Presentazioni Posters XXIII Congresso Nazionale Italiano di Entomologia Genova, 13-16 giugno 2011.

Flechtmann CAH, Atkinson TH. 2016. First Records of *Xylosandrus crassiusculus* (Motschulsky) (Coleoptera: Curculionidae: Scolytinae) from South America, with Notes on its Distribution and Spread in the New World. The Coleopterists Bulletin, 70(1):79–83.

Francardi V, Noal A, Francescato S, Pinto R, Bruni A, Loffredi L, Bucini D, Guarnieri D, Bellantuono M, Esposito N, Nuccitelli L, Binazzi F, Vitale S, di Giambattista G, Roversi PF, Pennacchio F, 2017: Coexistence of *Xylosandrus crassiusculus* (Motschulsky) and *X. compactus* (Eichhoff) (Coleoptera Curculionidae Scolytinae) in the National Park of Circeo (Lazio, Italy), Redia, 100: 149-155.

Frank SD, Sadof CS. 2011. Reducing Insecticide Volume and Nontarget Effects of Ambrosia Beetle Management in Nurseries. J. Econ. Entomol. 104(6): 1960-1968.

Gallego D, Lencina JL, Mas H, Ceveró J, Faccoli M. 2017. First record of the Granulate Ambrosia Beetle, *Xylosandrus crassiusculus* (Coleoptera: Curculionidae, Scolytinae), in the Iberian Peninsula. Zootaxa 4273(3): 431-434.

Gill S. 2014. What Happened with Ambrosia Beetles in 2014? Stanton Gill, Extension Specialist in Nursery and Greenhouse IPM, Central Maryland Research and Education Center, University of Maryland Cooperative Extension Sgill@umd.edu. www.Extensioin.umd.edu/IPM

Gomez DF, Rabaglia RJ, Fairbanks KEO, Hulcr J. 2018. North American Xyleborini north of Mexico: a review and key to genera and species (Coleoptera, Curculionidae, Scolytinae). ZooKeys 768: 19–68.

Grégoire J-C, Piel F, De Proft M, Gilbert M. 2001. Spatial distribution of ambrosia-beetle catches: A possibly useful knowledge to improve mass-trapping. Integrated Pest Management Reviews 6: 237–242.

Haack RA, Rabaglia RJ. 2013. Exotic bark and ambrosia beetles in the USA: potential and current invaders. Potential invasive pests of agricultural crops. CAB International, Wallingford, 48-74.

Harrington TC, McNew D, Mayers C. 2014. *Ambrosiella roeperi* sp. nov. is the mycangial symbiont of the granulate ambrosia beetle, *Xylosandrus crassiusculus*. Mycologia, 106(4):835–845

Horn S, Horn G. 2006. New Host Record for the Asian Ambrosia Beetle, *Xylosandrus crassiusculus* (Wlotschulsky) (Coleoptera: Curculionidae). J. Entomol. Sci. 41(1): 90-91.

Hulcr J, Black A, Prior K, Chen CY, Li HF. 2017. Studies of ambrosia beetles (Coleoptera: Curculionidae) in their native ranges help predict invasion impact. Florida Entomologist, 100(2), 257-261.

Keshavareddy G, Verghese A. 2008. Relationship between the Levels of Infestation of *Xylosandrus crassiusculus* Motschulsky (Coleoptera: Scolytidae) and Growth Parameters of Grape. Pest Management in Horticultural Ecosystems, 14(1): 74-80.

Khuhro RD, Nizamani SM, Jiskani MM, Talpur MA. 2017. AAB monitoring device, cultural practices and chemicals for management of mango tree mortality. www.pakissan.com

Kirkendall LR, Ødegaard F. 2007. Ongoing invasions of old-growth tropical forests: establishment of three incestuous beetle species in Central America (Curculionidae, Scolytinae). Zootaxa 1588: 53-62.

Kovach J, Gorsuch CS. 1985. Survey of ambrosia beetle species infesting South Carolina peach orchards and a taxonomic key for the most common species. J. Agric. Entomol. 2(3): 238-247.

LaBonte JR. 2010. Eradication of an exotic ambrosia beetle, *Xylosandrus crassiusculus* (Motschulsky), in Oregon. 2010 USDA Research Forum on Invasive Species.

Landi L, Gómez D, Braccini CL, Pereyra VA, Smith SM. Marvaldi AE. 2017. Morphological and Molecular Identification of the Invasive *Xylosandrus crassiusculus* (Coleoptera: Curculionidae: Scolytinae) and its South American Range Extending into Argentina and Uruguay. Ann. Entomol. Soc. Am. 110(3): 344-349.

Lightle DM, Gandhi KJK, Cognato AI, Mosley BJ, Nielsen DG, Herms DA. 2007. New Reports of Exotic and Native Ambrosia and Bark Beetle Species (Coleoptera: Curculionidae: Scolytinae) from Ohio. The Great Lakes Entomologist Vol. 40, Nos. 3 & 4.

MAF NZ. 2011. Import Health Standard: Woodware from All Countries. MAF Biosecurity New Zealand standard.

Mani M, Shivaraju C, Kulkarni NS. 2013. The Grape Entomology. Springer Science & Business Media, 26. nov. 2013 - 202 pages

Mizell RF, Riddle TC. 2004. Evaluation of Insecticides to Control the Asian Ambrosia Beetle, *Xylosandrus crassiusculus*. SNA Research Conference - Vol. 49.

Nageleisen LM, Bouget C, Noblecourt T. 2015. Les Scolytes du genre *Xylosandrus* en France (Coleoptera Curculionidae Scolytinae). L'Entomologiste, 71(4):267-271.

NPPO of the Netherlands. 2018. First finding of *Xylosandrus crassiusculus* (EPPO Alert List) in kairomone traps surrounding three import locations of wood packaging material (municipalities Venlo, Nuth and Moerdijk). February 2018 Pest report – The Netherlands. Netherlands Food and Consumer Product Safety Authority.

Oliver JB, Mannion CM. 2001. Ambrosia Beetle (Coleoptera: Scolytidae) Species Attacking Chestnut and Captured in Ethanol-Baited Traps in Middle Tennessee. Environmental Entomology Vol. 30, no. 5.

Pennacchio F, Roversi PF, Francardi V, Gatti E. 2003. *Xylosandrus crassiusculus* (Motschulsky) a bark beetle new to Europe (Coleoptera Scolytidae). Redia, LXXXVI, 2003: 77-80

Ranger CM, Reding ME, Schultz PB, Oliver JB, Frank SD, Addesso KM, Chong JH, Sampson B, Werle C, Gill S, Krause C. 2016. Biology, Ecology, and Management of Non-native Ambrosia Beetles (Coleoptera: Curculionidae: Scolytinae) in Ornamental Plant Nurseries. Journal of Integrated Pest Management, 7(1), 9, 1-23.

Reddy GK, Verghese A. 2006. Management of Shot Hole Borer, *Xylosandrus crassiusculus* (Motschulsky) (Coleoptera: Scolytidae) on Grapes. Pest Management in Horticultural Ecosystems, 12(2):107-115.

Reding ME, Ranger CM, Oliver JB, Schultz PB, Youssef NN, Bray AM. 2017. Ethanol-injection induces attacks by ambrosia beetles (Coleoptera: Curculionidae: Scolytinae) on a variety of tree species. Agricultural and Forest Entomology, 19, 34–41.

Reding ME, Schultz PB, Ranger CM, Oliver JB. 2011. Optimizing Ethanol-Baited Traps for Monitoring Damaging Ambrosia Beetles (Coleoptera: Curculionidae, Scolytinae) in Ornamental Nurseries. J. Econ. Entomol. 104(6): 2017-2024.

Slovenian Forestry Institute. 2017. Pest Risk Analysis for the Asian Ambrosia Beetle (*Xylosandrus crassiusculus* (Motschulsky, 1866)).

Smith SM, Hulcr J. 2015. Morphology, taxonomy, and phylogenetics of bark beetles. In: Vega FE, Hofstetter RW (Eds.), Bark Beetles Biology and Ecology of Native and Invasive Species Academic Press, London, pp. 495–531.

Soné K, Mori T, Ide M. 1998. Spatial Distribution Pattern of Attack of the Oak Borer, *Platypus quercivorus* (Murayama) (Coleoptera: Platypodidae), and Scolytid Ambrosia Beetles (Coleoptera: Scolytidae) on Fresh Logs. J. For. Res. 3:225-229.

Sreedharan K, Balakrishnan MM, Samuel SD, Bhat PK. 1991. A note on the association of wood boring beetles and a fungus with the death of silver oak trees on coffee plantations. Journal of Coffee Research 21(2), 145-148.

Storer C, Payton A, McDaniel S, Jordal B, Hulcr J. 2017. Cryptic genetic variation in an inbreeding and cosmopolitan pest, *Xylosandrus crassiusculus*, revealed using ddRADseq. Ecology and Evolution, 7:10974–10986.

Thu PQ, Griffiths M, Pegg GS, McDonald J, Wylie R, King J, Lawson SA. 2010. Healthy plantations. A field guide to pests and pathogens of Acacia, Eucalyptus and Pinus in Vietnam. The State of Queensland, Department of Employment, Economic Development and Innovation, Brisbane.

VanDerLaan NR, Ginzel MD. 2013. The capacity of conophthorin to enhance the attraction of two *Xylosandrus* species (Coleoptera: Curculionidae: Scolytinae) to ethanol and the efficacy of verbenone as a deterrent. Agricultural and Forest Entomology, 15, 391-397.

Werle CT, Sampson BJ, Oliver JB. 2012. Diversity, Abundance and Seasonality of Ambrosia Beetles (Coleoptera: Curculionidae) in Southern Mississippi. Midsouth entomologist, 5, 1-5.

ANNEX 3. Non-coniferous woody plants in EPPO region

As per the adopted Specification, the present study focuses on 'non-coniferous wood', and the EWG was tasked to identify the 'tree species and genera' covered, in relation to the wood commodities considered. The present annex provides an overview of non-coniferous woody plants in the EPPO region. Available data on trade is dealt with in Annex 5. The EWG analysis of species and genera that could or should be covered by horizontal measures is in Section 2.

1. What are non-coniferous woody plants

'Conifer' belongs to the Gymnosperms, but the understanding of the term depends on the taxonomic classification and on the source (see Box 1). The study was launched to focus on woody angiosperms.

The study aimed to discuss horizontal measures for wood, and therefore 'trees' are the most relevant. However, the wood of some other types of plants may be traded, that would generally be called 'shrubs' such as *Buxus*. In addition, species of bark and ambrosia beetles were studied irrespective of the type and form of their host plants, as long as those were non-coniferous woody plants. Host ranges therefore contain 'trees', 'shrubs' and sometimes woody plants that would generally be called 'vines' (such as *Actinidia*). Finally, woody plants other than trees need to be considered in relation to the potential risks presented by a bark or ambrosia beetle, should it be introduced.

Nevertheless, small bushes, sometimes called 'dwarf bushes', are not covered in this study (e.g. *Vaccinium myrtilloides*). Most bark and ambrosia beetles need a certain diameter in order to successfully colonize plants. No strict threshold was applied for this.

2. Non-coniferous woody plants in the EPPO region

Non-coniferous woody plants are important components of many types of habitats in the EPPO region, with an overall very high economic, environmental and social importance. It is not realistic to provide in this study an inventory of non-coniferous trees and bushes in the EPPO region, nor of all habitats. Considered at the scale of the EPPO region, such an inventory would include a huge number of species in very many genera and families. However, some major habitats are outlined below.

2.1 Forests

Forests may be undisturbed, semi-natural and plantation forests (EEA, 2006). Forests may be economically, environmentally or socially important depending on their use. Wood production is of major economic importance. A complete overview of forests, their uses, and ecosystem services is provided in De Rigo *et al.* (2016), written for the EU but that would presumably apply to most of the EPPO region. In arid areas such as North Africa, forests play a role against desertification and erosion (Mhirit and Blérot, 1999). In the North of the EPPO region, including Russia through to the Far-East, conifer species dominate. Non-coniferous forests are present throughout the region, but are more concentrated South of 60° North to European Russia, and in the Southern part of Siberia and the Far-East.

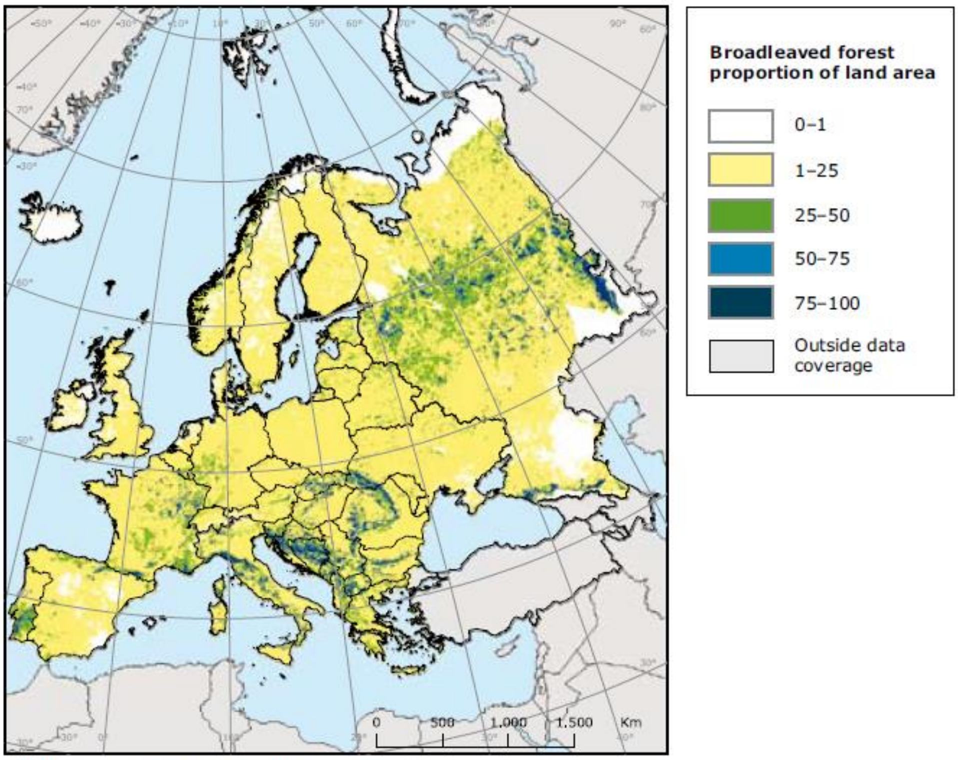
In North Africa, woodlands and forest occur from the coastal plains to the hills of northern Morocco, Algeria and Tunisia, and around the Atlas Mountains. Non-coniferous forest species include *Quercus ilex* (holm oak), *Q. suber* (cork oak), *Olea europaea* subsp. *sylvestris* (wild olive) and *Ceratonia siliqua* (carob) (WWF, 2018). In Morocco, forests cover over 5 million ha, and are dominated by oaks (*Q. ilex*, *Q. suber*, *Q. canariensis*), *Argania spinosa* and Saharan acacias (Mhirit and Blérot, 1999).

In the Near East, forest covers a small proportion of EPPO countries. In Jordan, natural or planted forests cover ca. 87 000 ha (FAO, no date). In Israel, natural forests cover ca. 40 000 ha and reforestation occupied another 90 000 ha (Israel Ministry of Foreign Affairs, 2018). Natural non-coniferous species include oaks (*Q. calliprinos*, *Q. boissieri* and *Quercus ithaburensis*), *Ceratonia siliqua*, *Pistacia palestina* and *Cercis siliquastrum*. *Ziziphus*, tamarisks and acacias are also present. Afforestation relied initially on conifers, but also on other species such as eucalyptus, acacias and tamarisks, and led to new forests, woodlands or oases.

A special feature of Central Asia is its fruit and nuts forests (see under Fruit trees below).

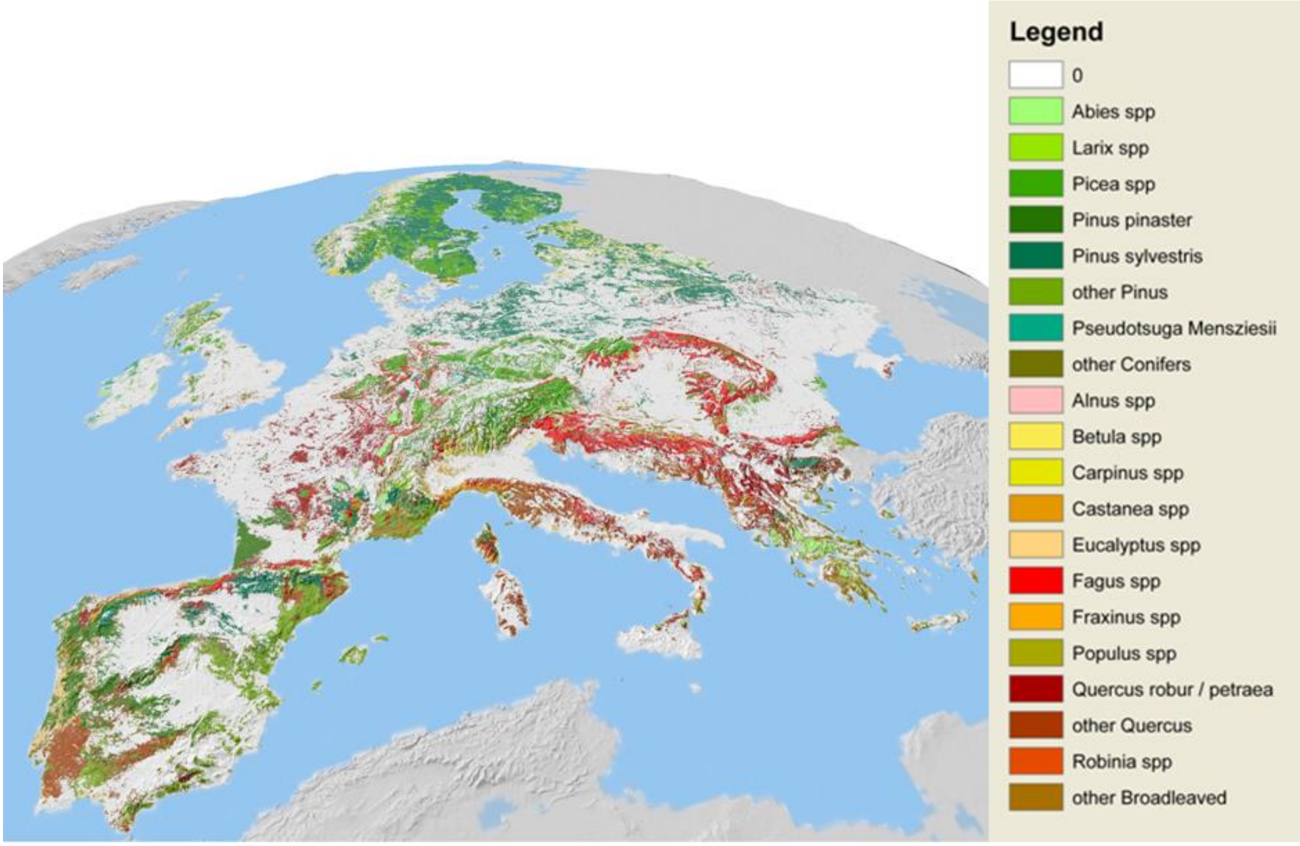
In Russia, EPPO (2000) provides a list of trees reported in the former-USSR, including their natural and cultivated distribution. A detailed map of Russian forest is available (Yaroshenko *et al.*, 2004). A detailed analysis of forests in Far-East Russia is provided by Krestov (2013). 75% of the total forest area is occupied by conifers, but the main non-coniferous trees (12 species in the genera *Acer*, *Alnus*, *Betula*, *Fraxinus*, *Populus*, *Quercus*, *Salix*, *Tilia* and *Ulmus*) cover ca. 28000 million ha. Their complete analysis of the different vegetation zones of Far-East Russia names ca. 40 non-coniferous trees, 30 bushes and 10 vines.

For Europe, a complete map of the natural vegetation (extending to the Caucasus region and European Russia) can be found in Bohn *et al.* (2007). The maps below illustrate broadleaved forests for part of the EPPO region.



Source: European Forest Institute (EFI), 2005.

Map 1. Broadleaved forest proportion of land area (EFI, 2005)



Map 2. Forest dominant species (broadleaved) (EFI, 2011)

In Europe[25], forests cover 33 % of the total land area (215 million ha) and other wooded lands an additional 36 million ha (De Rigo *et al.*, 2016). 26 tree genera have been listed in Europe as important forestry species based on the proportion of land surface they occupy (De Rigo *et al.*, 2014; http://www.cost.eu/COST_Actions/fps/FP1401), of which the following 18 non-coniferous genera: *Acer, Alnus, Betula, Carpinus, Castanea, Corylus, Crataegus, Fagus, Fraxinus, Ostrya, Populus, Prunus, Quercus, Robinia, Salix, Sorbus, Tilia and Ulmus*. The EU Atlas of Forest Tree species details on trees belonging to 38 genera, of which 29 are non-coniferous, in addition to the above: *Aesculus*, *Ailanthus*, *Celtis*, *Cornus*, *Eucalyptus*, *Euonymus*, *Frangula*, *Ilex*, *Juglans*, *Olea*, *Sambucus*, *Tamarix*. The species detailed include native and exotic species. Finally, the European forest genetics programme (EUFORGEN) lists 110 species, of which about 70 non-coniferous (and provides maps for a number of species). The analyses above are restricted to the main species and do not mention other woody plants in forests.

The following is from EC (2013) and maps of distribution of various species can be seen in the European Atlas of Forest Species (EU, 2016). Several species of *Quercus* and *Fagus* are major components of non-coniferous forests in Europe. *F. sylvatica* is present to from plains to higher mountains, in some areas mixed with species such as *Acer pseudoplatanus*, *Ilex*, *Quercus*, *Taxus*; *Fagus moesiaca* is also present. Regarding *Quercus*, major species in Mediterranean forests are *Q. suber*, *Q. ilex*, *Q. rotundifolia* or *Q. macrolepis*, but there are many others such as *Q. faginea, Q. canariensis, Q. afares, Q. trojana, Q. cerris, Q. petraea, Q. frainetto* or *Q. virgiliana*, *Q. alnifolia* , *Q. infectoria*. Towards the north, *Q. robur* and *Q. petraea* dominate. Natural mixed forests with *Quercus* may include *Carpinus betulus*, *Tilia cordata*, *Betula pendula*, *B. pubescens*, *Sorbus aucuparia*, *Populus tremula*, *Frangula alnus*. In Euro-Siberian steppic woods of the South-East *Q. robur*, *Q. cerris*, *Q. pedunculiflora* and *Q. pubescens* dominate. The hemiboreal natural old broadleaved deciduous forest, situated between the Western Taiga and more temperate deciduous forests, comprises species such as *Q. robur*, *Ulmus*, *Fraxinus excelsior*, *Tilia cordata* or *Acer platanoides*.

Examples of other types of forests present in Europe are: mixed forests of *Acer pseudoplatanus*, *Fraxinus excelsior*, *Ulmus glabra*, *Tilia cordata*; mixed forests dominated by *Tilia tomentosa*; supra- and sub-Mediterranean *Castanea sativa*-dominated forests and old established plantations with semi-natural

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[25] This publication covers Europe as per foresteurope.org, i.e. 46 countries, extending to European Russia and Turkey.

undergrowth; Macaronesian laurel forests (Laurus, Ocotea); *Phoenix theophrasti* and *Phoenix canariensis* palm groves in Crete or the Canary Islands.

Other types of forested environments

Trees or shrubs dominate in many other types of environments. The transition areas between grasslands and forests are generally rich in shrub vegetation. This section focuses a bit more on Mediterranean environments, as they include the climatic zones that have been found to be generally suitable for tropical and subtropical bark and ambrosia beetles, and have supported the establishment of some species.

The Mediterranean maquis (see *Xylosandrus compactus*) occupies areas with irregular annual precipitation, with rainfall in late autumn and winter, and aridity in summer. It is dominated by shrubby, stiff-leaved, evergreen species adapted to summer drought. The maquis' composition depends on especially precipitation and soils. Areas with more precipitation are more favourable to tree growth (e.g. *Q. ilex* or *Arbutus unedo*), while shrubs dominate in areas with long dry summers (e.g. *Pistacia lentiscus* or *Rhamnus alaternus*). Some important species in the Mediterranean maquis are for example: *Q. suber, Laurus nobilis, Fraxinus ornus, Pistacia terebinthus, Olea europaea* var. *sylvestris, Ceratonia siliqua, Quercus coccifera, Q. calliprinos, Chamaerops humilis, Cytisus* spp. (Gaudenzio and Peccenini, 2003).

Between the sub-Mediterranean area and temperate areas, stable xerothermophilous and calcicolous scrubs dominated by *Buxus sempervirens* occur in hills and mountains, associated with calcareous grasslands, or dry forests with for example oak, beech or pine (EC, 2013). Native evergreen oaks (*Quercus suber, Q. ilex, Q. rotundifolia, Q. coccifera*) formations in crops, pastures or shrub formations are a typical feature of the Iberian Peninsula.

In the North, *Salix* is present in subarctic and boreo-alpine areas and in the mountains. Small groups of deciduous trees and shrubs and patches of open meadows (with *Fraxinus excelsior, Betula pendula, B. pubescens, Quercus robur, Tilia cordata, Ulmus glabra* or *Alnus incana*) are a feature of Scandinavia.

Riparian environments are rich in trees and shrubs, with species such as various *Salix* and *Populus*; *Alnus incanae* in mountains; mixed forests of *Fraxinus excelsior* and *Alnus glutinosa* in temperate and boreal Europe; mixed forests of *Quercus, Ulmus* and *Fraxinus*; mixed forests of *Populus, Ulmus, Salix, Alnus, Acer, Tamarix, Juglans regia, Q. robur, Q. pedunculiflora, Fraxinus angustifolia, F. pallisiae, Populus. Rhododendron ponticum, Salix, Frangula* in Mediterranean areas; forest with *Platanus orientalis* and *Liquidambar orientalis*.

Trees may be planted for many purposes, including erosion control, flood management, energy production, recreation, landscaping etc. This includes genera such as *Robinia, Salix, Eucalyptus, Populus*, etc.

Within a country, trees are present in many different types of environments that cannot all be described here. In a study on trees outside forests, the different types of environments supporting trees and shrubs were cited for Sweden: fruit orchard cultivation, grazing, enclosure for reindeer, berry bush cultivation, vegetation strips, solitary trees, biotope islets with trees and shrubs, mound of stones/boulder/bedrock outcrop with trees and shrubs, ponds with trees and shrubs, wetlands in agricultural land (de Foresta *et al.*, 2013).

Fruit trees and bushes

Major fruit trees grown commercially in the EPPO region belong to the genera *Malus, Pyrus, Prunus, Vitis, Citrus, Morus, Olea, Actinidia, Ficus, Persea, Punica*, as well as bushes such as *Ribes, Rubus, Vaccinium*. Subtropical or tropical species are grown to a lesser extent, such as *Mangifera*. Nut trees and bushes include *Juglans, Castanea, Prunus* and *Corylus*. These genera and many others are also cultivated in gardens. Analysis of various fruit and nut trees and bushes in the EPPO region can be found in many EPPO PRAs produced in recent years for tree pests, to name a few of the most recent: '*Candidatus* Phytoplasma phoenicium', *Aromia bungii, Oemona hirta, Apriona* spp., thousand cankers disease, etc. (all available at www.eppo.int). An analysis of fruit production in the EU was conducted in the framework of the EU-funded project DROPSA (EPPO, 2017).

A unique feature in the EPPO region are the fruit and nut trees of Central Asia. Central Asia is the centre of origin and of diversity for many globally significant fruit and nut trees. In particular, Central Asia includes wild populations of walnut, apple and apricot (Bioversity International, 2017). Only 4% of the Kyrghyz territory is occupied by forests, but it hosts the unique pure walnut forests (jicajfm.aknet.kg, 2018; EPPO thousand cankers PRA). Eastwood *et al.* (2009) had attracted attention on the large number of endangered trees in that region. Fruit trees are an important component of income generation and nutrition. Bioversity International has launched projects on the conservation and use of traditional fruit trees in Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan, with over 50 fruit tree nurseries, and farmer training (Bioversity International, 2018).

Urban trees

Trees in urban areas can be found in urban forests and woodlands, public spaces, gardens, along waterways or as street trees (Davies *et al.*, 2017). They are sometimes considered as being at the frontline of invasions because they are close to points of entry, such as harbours, airports or companies receiving commodities. Ecosystem services of urban forests are detailed in Davies *et al.* (2017) and include cultural services (e.g. health, education, nature connection), regulating services (e.g. carbon sequestration, air purification, noise mitigation), provision services (food, fuel and wood). Other benefits are listed for Turkey in Gul *et al.* (2012), including reduced urban traffic speed or improved business. The species may be similar to those found in forests, but the range of species used is broader and extends to many exotic species. In particular, botanical gardens host a wide diversity of trees, including numerous exotic species.

Green planning has become a common component of urban management, and may detail the exact rules and guidelines around the presence of trees in cities, such as the desirable number of trees per area or the planification of green spaces (e.g. Royaume du Maroc, 2008), including the species that may be used. In Italy (chosen here as example because several bark and ambrosia species from this study have established), municipalities can establish “green regulations” (regolamento del verde), which in some cases lists species. A few examples of species composition in EPPO cities are given below. In addition, Pauleit *et al.* (2002) reported on the result of a European survey.

- In Bologna, 24 species were selected as suitable for planting, in the framework of a project for urban afforestation with environmental focus, gathering public, private and non-profit stakeholders (GAIA, 2018). The list is a mix of native and exotic species of the following genera: *Catalpa*, *Cercis*, *Crataegus*, *Diospyros*, *Gingko*, *Juglans*, *Koelreuteria*, *Laurus*, *Ligustrum*, *Photinia*, *Prunus*, *Quercus*, *Sophora*, *Sorbus*, *Tilia*, *Viburnum*, *Zelkova*, *Ziziphus*. The Regolamente del verde of the Bologna cities contains a much longer list of trees present or possible for the town (Bologna, 2016).
- In Moscow (Makarova, 2003), an inventory found 15 tree species (45 000 trees for ca. 270 sites had been counted in past surveys), of which the following non-coniferous, also a mix of native and exotic species: *Aesculus hippocastanum*, *Tilia cordata*, *Populus balsamifera*, *Fraxinus pennsylvanica*, *Acer negundo*, *Acer platanoides*, *Betula pendula*, *Fraxinus excelsior*, *Sorbus aucuparia*. *Pinus sylvestris*, *Ulmus laevis*, *Quercus robur, Malus pumila*.
- in northern Morocco, well-represented species in the town of Oujda were: *Sophora japonica*, *Ceratonia siliqua*, *Schinus molle*, *Citrus aurantium*, *Phoenix canariensis*, *Schinus terebinthifolia*, *Washingtonia filifera* and *Jacaranda mimosifolia* (Merimi and Boukroute, 1996).
- An inventory of street and park trees in 5 Nordic cities found that *Tilia*, *Sorbus* and *Betula* were dominating in various cities, and other non-coniferous genera were *Acer*, *Aesculus*, *Alnus*, *Betula*, *Carpinus*, *Crataegus*, *Fagus*, *Fraxinus*, *Malus*, *Platanus*, *Populus*, *Prunus*, *Quercus*, *Robinia*, *Salix*, *Ulmus* (Östberg, 2013).
- In observations in several Central Asian cities, species such as *Morus alba*, *Cercis griffithii*, *Platanus orientalis*, *Malus*, *Sambucus*, *Ulmus* were present (Whitehead, 1982).

Individual checks made when preparing EPPO PRAs on specific tree pests consistently show that most host species are available commercially. One interesting example is *Liquidambar styraciflua* a North American tree, which has become host for several Asian ambrosia species when those were introduced into the USA. *L. styraciflua* was introduced to Europe in the 19th century (Hsu and Andrews, 2004) and is a popular ornamental tree with many varieties available, also in the EPPO region (general Internet search). Other *Liquidambar* spp., such as *L. orientalis* (native to Turkey and Rhodos) and *L. formosana* (from Asia) are also used (Hsu and Andrews, 2004).

Finally, trees and bushes are widely used for ornamental purposes and sold to the public. Most trees and bushes mentioned as hosts of selected bark and ambrosia beetles in this study are expected to be available in nurseries in the EPPO region, possibly except the most tropical trees species. Trees may be produced locally or imported. There is a huge trade of plants for planting into the EPPO region.

Box 1. Coniferous versus non-coniferous

The coverage of 'conifers' is extensively discussed in Farjon *et al.* (2010), which consider that 'conifers' are the members of 8 families: Pinaceae (containing the highest number of species), Araucariaceae, Cephalotaxaceae, Cupressaceae, Phyllocladaceae, Podocarpaceae, Sciadopityaceae, Taxaceae. This approach is also followed in EPPO Global Database, where these 8 families are under the Order Pinales, Class Pinophyta. An alternative classification was proposed by Christenhusz *et al.* (2011), dividing gymnosperms into sub-classes, with 'conifers' corresponding to the sub-class Pinidae, comprising 6 families (2 of the 8 above being considered as synonyms of others). While these two alternative classifications vary at the higher taxonomic levels, they assign the same families and genera to the 'conifers'. 'Non-coniferous' woody plants therefore include the remaining Gymnosperms as well as woody Angiosperms.

Classification of gymnosperms according to Christenhusz *et al.* (2011)

Subclass	**Order**	**Family**
Cycadidae	Cycadales	Cycadaceae, Stangeriaceae, Zamiaceae
Ginkgoidae	Ginkgoales	Ginkgoaceae
	Welwitschiales	Welwitschiaceae
Gnetidae	Gnetales	Gnetaceae
	Ephedrales	Ephedraceae
Pinidae ► **'conifers'**	Pinales	Pinaceae
	Araucariales	Araucariaceae, Podocarpaceae (incl. Phyllocladaceae)
	Cupressales	Sciadopityaceae, Cupressaceae, Taxaceae (incl. Cephalotaxaceae)

The EU Directive uses the terms 'coniferous (Coniferales)'. 'Coniferales' is considered as a synonym of 'Pinales' in EPPO Global Database (i.e. including the 8 'conifer' families mentioned above). Christenhurtz *et al.* (2011) noted however that the names based on 'Conifer-' (e.g. Coniferopsida, Coniferidae, Coniferales etc.) should be avoided.

Other interpretations broader than those above were not retained here, e.g.:

- Conifers has sometimes been understood as covering all cone-bearing gymnosperms, leading to the inclusion of plants such as *Gingko* spp. (Farjon *et al.*, 2010).
- The term 'Coniferae' has been used but is out-dated, and corresponds to earlier classifications (Farjon *et al.*, 2010)
- The European Forest Institute's Compilation of Forestry Terms and Definition (Schultz *et al.*, 2002) defines 'coniferous' as 'all trees classified botanically as Gymnospermae, they are sometimes referred as «softwoods».

Finally, the term 'broadleaved' is often used in contrast to the word 'conifers'. It covers species that shed their leaves during part of the season ('deciduous') and those that do not ('evergreen'). The latter terms possibly also apply to the 'non-coniferous' gymnosperms. Some authors use the word 'small-leaved' to apply to some species of angiosperms. To avoid ambiguities or misinterpretation, the word 'non-coniferous' was used throughout this study.

References

Bioversity International. 2017. Fruit tree genetic diversity in Central Asia: A spatial threat analysis.

Bioversity International. 2018. Central Asia fruit trees.

Bohn U, Zazanashvili N, Nakhutsrishvili G. 2007. The Map of the Natural Vegetation of Europe and its application in the Caucasus Ecoregion. Bulletin of the Georgian National Academy of Sciences, 175.

Bologna. 2016. Regolamento Comunale del Verde Pubblico e Privato. Comune di Bologna.

Christenhusz MJM, Reveal JL, Farjon A, Gardner MF, Mill RR, Chase MW. 2011. A new classification and linear sequence of extant gymnosperms. Phytotaxa 19: 55–70.

Davies H, Doick K, Handley P, O'Brien L, Wilson J. 2017. Delivery of ecosystem services by urban forests. Forest Research, UK.

de Foresta H, Somarriba E, Temu A, Boulanger D, Feuilly H, Gauthier M. 2013. Towards the Assessment of Trees Outside Forests. A Thematic Report Prepared in the Framework of the Global Forest Resources Assessment. IRD and FAO.

de Rigo D, Bosco C, San-Miguel-Ayanz J, Houston Durrant T, Barredo JI, Strona G, Caudullo G, Di Leo M, Boca R. 2016. Forest resources in Europe: an integrated perspective on ecosystem services, disturbances and threats. In: San-Miguel-Ayanz J, de Rigo D, Caudullo G, Houston Durrant T, Mauri A (Eds.), European Atlas of Forest Tree Species. Publ. Off. EU, Luxembourg.

de Rigo *et al*., 2014; http://www.cost.eu/COST_Actions/fps/FP1401).

Eastwood A, Lazkov G & Newton A. 2009. The Red List of Trees of Central Asia. Fauna & Flora International, Cambridge, UK. http://www.globaltrees.org/downloads/RedListCentralAsia.pdf

EC. 2013. Interpretation Manual of European Union Habitats. Eur 28. April 2013. European Commission DG Environment Nature ENV B.3

EEA. 2006. European forest types. Categories and types for sustainable forest management reporting and policy. EEA Technical report No 9/2006.

EFI. 2005. Forest maps. https://www.efi.int/knowledge/maps/forest

EFI. 2011. Tree species maps for European Forests. https://www.efi.int/knowledge/maps/treespecies

EPPO. 2000. Distribution of the main forest trees and shrubs on the territory of the former USSR. Working document for the Panel on Quarantine Pests for Forestry. 00/7806.

EPPO. 2017. PART 2 - Analysis of fruit production and imports in the EU to select species for pathway studies. DROPSA Work package 1. Pathways of introduction of fruit pests and pathogens Deliverable 1.3. Available at https://www.eppo.int

EU. 2016. European Atlas of Forest Species. eds San-Miguel-Ayanz, J., de Rigo, D., Caudullo, G., Houston Durrant, T., Mauri, A. Publ. Off. EU, Luxembourg, pp. e01aa69+. https://w3id.org/mtv/FISE-Comm/v01/e01aa69

FAO. no date. Forests, Rangelands and Climate Change in Jordan Near East Region. Country Reports.

Farjon A. 2010. A Handbook of the world's conifers. First edition. Brill.

GAIA. 2018. GAIA per le cittaà. Linee guida per la replicabilità della partnershipGAIA forestazione urbana.

Gaudenzio P, Peccenini S. 2003. Vegetation. In: *The Mediterranean maquis evergreen coastal formations.* edited by Alessandro Minelli. Ministero Dell'ambiente E Della Tutela Del Territorio, Museo Friulano Di Storia Naturale. Comune di Udine.

Gul A, Orucu OK, Eraslan S. 2012. Design of the Urban Street Trees and Problems in Turkey. Miestų želdynų formavimas 1(9):43–53.

Hsu E, Andrews S. 2004. Liquidambar. Tree of the year. International Dendrology Society. http://www.dendrology.org/publications/tree-of-the-year

Israel Ministry of Foreign Affairs. 1997. Conservation Of Biological Diversity In Israel. Israel Environment Bulletin Autumn, 20(4).

jicajfm.aknet.kg. 2018. The Project for the Support for Joint Forest Management in the Kyrgyz Republic. http://jicajfm.aknet.kg/index.php?act=view_material&id=53

Krestov PV. 2003. Forest Vegetation of Easternmost Russia (Russian Far East). In: Kolbek J., Šrůtek M., Box E.O. (eds) Forest Vegetation of Northeast Asia. Geobotany, vol 28. Springer, Dordrecht

Makarova. 2003. Soil technological and other ecological aspects of state of trees in Moscow. PhD thesis, Wageningen University.

Merimi J, Boukroute A. 1996. Inventaire et état sanitaire des arbres d'alignement dans la ville d'Oujda (Maroc Oriental). Actes Inst. Agron. Veto (Maroc), 16(1):41-47.

Mhirit O, Blérot P. 1999. Le grand livre de la forêt marocaine] Sprimont (Belgique): Mardaga, cop.

Östberg J. 2013. Tree inventories in the urban environment - Methodological development and new applications. PhD Thesis, Acta Universitatis Agriculturae Sueciae.

Pauleit S, Jones N, Garcia-Martin G, Garcia-Valdecantos JL, Rivière LM, Vidal-Beaudet L, Bodson M, Randrup TB. 2002. Tree establishment practice in towns and cities – Results from a European survey. Urban For. Urban Green. 1: 83–96

Royaume du Maroc. 2008. Guide d'élaboration des plans verst urbains au Maroc. Edition 2008. 91 pages.

Schuck A, Paivinen R, Hytonën T, Pajari B. 2002. Compilation of forestry terms and definitions. European Forest Institute Internal Report No. 6, 2002.

Whitehead MJ. 1982. Trees of Soviet Central Asia. Journal of Arboriculture 8(2).

WWF. 2018. Northern Africa: Morocco, Algeria, and Tunisia. https://www.worldwildlife.org/ecoregions/pa1214

Yaroshenko A, Bartalev S, Ershov D & Isaev AS, Potapov P, Turubanova S. 2004. Russia's Forests Dominating Forest Types and Their Canopy Density.

ANNEX 4. Commodities covered

Different wood commodities were used for the purpose of indicating commodities the bark and ambrosia beetles studied could be associated with, and for the consideration of horizontal measures. In addition, the Specification provided that "if possible, other significant pathways than wood commodities should also be identified".

For the purpose of this study, the wood commodities were organized as proposed below. The EPPO 'Study on wood commodities other than round wood, sawn wood and manufactures items' (EPPO, 2015) defines commodities that are different from the categories of commodities documented in trade data or in regulations, and they are therefore regrouped below. These very broad categories may need to be sub-divided later for the purpose of identifying horizontal measures. However at the stage of gathering information on representative species, broad categories were considered sufficient (with any more detailed information when available (e.g. with or without bark etc.). Definitions of terms are provided in Table 1 below.

- **Wood** (all commodities of round wood and sawn wood, with or without bark)
- **Wood chips, hogwood, processing wood residues (except sawdust and shavings)**, i.e. sometimes called in previous EPPO documents: 'Particle wood and wood waste' (EPPO does not recommend now to use the term 'wood waste' which cannot be a commodity).
- **Bark** (including for mulch, and other intended uses)

It should be noted that these commodities can be used as firewood.

Other wood

Wood packaging material (which is not a commodity) was excluded from the scope of the study, because measures are covered in ISPM 15. The study did not consider measures for wood packaging material. However, when collecting information on individual representative species, any known association was noted.

The wood commodities *sawdust and shavings*, *processed wood material*, *post-consumer scrap wood*, are generally considered to present a negligible risk in the EPPO study on wood commodities. Two previous EPPO PRAs on bark beetles (*Pityophthorus juglandis* and *Polygraphus proximus*-the latter on coniferous species) considered articles made of wood (incl. those still carrying bark, e.g. wagons made of wood, furniture, gunstocks) as very unlikely pathways. Association of bark and ambrosia beetles with such commodities is not likely, because they would require a certain humidity, although there are occasional exceptions, such as *Hypothenemus eruditus*.

Other possible pathways

The Specification detailed that other major pathways should be recorded, but the study would not propose measures on pathways other than wood. The following pathways were identified in relation to various species studied:

- Plants for planting (including e.g. potted plants, plants with bare roots, scion wood for grafting, etc. but except seeds, tissue cultures)
- Cut branches
- Natural spread into the EPPO region (if native distribution is close enough) or to other countries of the region (if already present with a limited distribution).

Regarding contaminating pests, the PRA report for *Euwallacea fornicatus* (EPPO, 2017) mentioned that according to two sources, ambrosia beetles may contaminate shipments of cut flowers and fruits. However, no specific indication of contamination was found for the species studied.

No other potential pathway was identified in the detailed consideration of species. In particular, the following which had been considered as very unlikely in three EPPO PRAs on bark beetles (*Pityophthora juglandis*, *Euwallacea fornicatus* and *Polygraphus proximus* (the latter on conifers)): fruits and seeds of host plants (except palm seeds); soil and growing medium; tissue cultures; movement of individuals, shipping of live beetles, e.g. traded by collectors.

Table 1. Definitions used in the EPPO Study on wood commodities (EPPO, 2015) TD 1071 – in the order in which they appear in the text above
Including existing definitions from ISPM 5 *Glossary of Phytosanitary Terms* for wood commodities and definitions developed as part of the Study

Commodity	**Definition**	**Origin of definition**
Round wood	Wood not sawn longitudinally, carrying its natural rounded surface, with or without bark	Glossary (ISPM 5)
Firewood except sawn wood, processing wood residues, wood chips, hogwood, processed wood material and post-consumer scrap wood	See 'round wood' definition	
Sawn wood	Wood sawn longitudinally, with or without its natural rounded surface with or without bark	Glossary (ISPM 5)
Wood chips	Wood with or without bark in the form of pieces with a definable particle size produced by mechanical treatment with sharp tools	Proposed under the Study TD 1071
Hogwood	Wood with or without bark in the form of pieces of varying particle size and shape, produced by crushing with blunt tools such as rollers, hammers, or flails	Proposed under the Study TD 1071
Processing wood residues	Parts of wood and bark that are left after the process of transforming round wood into sawn wood and further transformation of sawn wood	Proposed under the Study TD 1071
Harvesting residues	Wood material consisting of any parts of trees left on the site after round wood harvesting	Proposed under the Study TD 1071
Bark (as a commodity)	Bark separated from wood	Glossary (ISPM 5)
Processed wood material	Products that are a composite of wood constructed using glue, heat and pressure, or any combination thereof	Glossary (ISPM 5)
Post-consumer scrap wood	Wide variety of wood material from ex-commercial, industrial and domestic use made available for recycling	Proposed under the Study TD 1071
Manufactured wood items	To be added when defined under the ISPM (under development) on 'International movement of wood products and handicrafts made of wood'	

References

EPPO. 2015. EPPO Technical Document No. 1071, EPPO Study on wood commodities other than round wood, sawn wood and manufactured items. EPPO Paris. Available at https://www.eppo.int

EPPO. 2017. Report of a Pest Risk Analysis for *Euwallacea fornicatus sensu lato* and *Fusarium euwallaceae*. Available at https://www.eppo.int

ANNEX 5. Trade of non-coniferous wood into the EPPO region

1. Data on wood and trade into the EPPO region

There is a wide diversity of species used for their wood. The 'working list of commercial timber tree species' lists 1575 non-coniferous species, integrated from lists available from 17 different sources (Mark *et al*., 2014). Many references provide details on species used as wood, such as the wood database (http://www.wood-database.com/wood-identification/by-scientific-name/) or, for tropical species, CIRAD (https://tropix.cirad.fr/fiches-disponibles). In particular, the Wood Database gives details on the wood of over 410 non-coniferous species (listed in Table 1 as examples), including species also planted for other uses than wood, such as fruits or nuts, and both trees and bushes.

There is no source providing complete data on which species or genera are traded as wood commodities into EPPO countries.

FAOSTAT is the only source that provides some data for wood imports covering most EPPO countries and data is therefore analysed in Section 1, 2.3. These data relate to general wood commodities (and not to tree species or genera), of 'industrial non-coniferous non-tropical roundwood', 'industrial non-coniferous tropical roundwood', 'non-coniferous sawn wood', and 'hardwood wood chips and particles'.

Some other sources are useful to identify some species or genera that must be traded into the EPPO region, but surely provide a very partial overview of all traded woods, also because they relate only to the EU. The EPPO region is wider than the EU, and other woods are surely imported for different purposes in different parts of the region.

- Trade statistics in Eurostat. The categories for round wood and sawn wood cover some genera (listed below), as well as categories for 'other'. For tropical sawn wood, a large number of 'other' woods are mentioned[26].
- Europhyt, in relation to non-compliance for "wood and bark" in 2010-2017, mentions a number of non-coniferous species, genera and families, which are therefore traded at least into the EU. This only represents wood that has been inspected (i.e. possibly targeting origins and wood), but points to a wide diversity of imported wood.
- In addition, individual articles published in non-EU EPPO countries may also give indications of species traded.

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[26] The category of 'other' tropical sawn wood include the following (scientific names have not been sought): abura, acajou d'Afrique, afrormosia, ako, andiroba, aningré, avodiré, azobé, balau, bossé clair, bossé foncé, cativo, cedro, dabema, dibétou, doussié, framiré, freijo, fromager, fuma, geronggang, ilomba, ipé, jaboty, jelutong, jequitiba, jongkong, kapur, kempas, keruing, kosipo, kotibé, koto, limba, louro, maçaranduba, makoré, mandioqueira, mansonia, mengkulang, merawan, merbau, merpauh, mersawa, moabi, niangon, nyatoh, obeche, okoumé, onzabili, orey, ovengkol, ozigo, padauk, paldao, palissandre de Guatemala, palissandre de Para, palissandre de Rio, palissandre de Rose, pau Amarelo, pau marfim, pulai, punah, quaruba, ramin, saqui-saqui, sepetir, sipo, sucupira, suren, tauari, teak, tiama, tola.

Genus/Species	**Source**
Acer	Non-trop. Sawn wood, Eurostat
Acer macrophyllum	Europhyt, non-compliance
Acer rubrum	Europhyt, non-compliance
Acer saccharinum	Europhyt, non-compliance
Acer saccharum subsp. *nigrum*	Europhyt, non-compliance
Afzelia bipindensis	Europhyt, non-compliance
Alnus	Europhyt, non-compliance
Amphimas pterocarpoides	Europhyt, non-compliance
Aucoumea klaineana	Europhyt, non-compliance
Betula	Non-trop. Round wood, sawn wood, Eurostat
Betula alleghaniensis	Europhyt, non-compliance
Caesalpinia	Europhyt, non-compliance
Chlorophora excelsa	Europhyt, non-compliance
Chrysophyllum	Europhyt, non-compliance
Copaifera religiosa	Europhyt, non-compliance
Copaifera salikounda	Europhyt, non-compliance
Dimorphandra	Europhyt, non-compliance
Diospyros	Europhyt, non-compliance
Entandrophragma (sapelli)	Tropical, Eurostat
Entandrophragma candollei	Europhyt, non-compliance
Entandrophragma cylindricum	Europhyt, non-compliance
Entandrophragma utile	Europhyt, non-compliance
Eperua sp.	Europhyt, non-compliance
Eucalyptus	Non-trop. Round wood, Eurostat
Fagus	Non-trop. round wood, sawn wood, Eurostat
Fagus	Europhyt, non-compliance
Fraxinus	Europhyt, non-compliance
Fraxinus americana	Europhyt, non-compliance
Guarea cedrata	Europhyt, non-compliance
Guibourtia sp.	Europhyt, non-compliance
Juglans	Europhyt, non-compliance
Juglans nigra	Europhyt, non-compliance
Juglans regia	Europhyt, non-compliance
Khaya	Europhyt, non-compliance
Khaya anthotheca	Europhyt, non-compliance
Khaya grandifoliola	Europhyt, non-compliance
Laurelia sempervirens	Europhyt, non-compliance
Leguminosae	Europhyt, non-compliance
Liriodendron	Europhyt, non-compliance
Liriodendron tulipifera	Europhyt, non-compliance
Lovoa trichilioides	Europhyt, non-compliance
Magnoliaceae	Europhyt, non-compliance
Microberlinia	Europhyt, non-compliance
Milicia (iroko)	Tropical, Eurostat
Milicia excelsa	Europhyt, non-compliance
Nothofagus obliqua	Europhyt, non-compliance
Ochroma (balsa)	Tropical, Eurostat
Ocotea (=*Phoebe*; imbuia)	Tropical, Eurostat
Parashorea (white seraya)	Tropical, Eurostat
Populus	Non-tropical Round wood, sawn wood, Eurostat
Populus	Europhyt, non-compliance
Prunus	Non-trop. Sawn wood, Eurostat
Prunus	Europhyt, non-compliance
Prunus avium	Europhyt, non-compliance
Quercus	Non-trop. round wood[27], sawn wood, Eurostat
Quercus	Europhyt, non-compliance
Quercus alba	Europhyt, non-compliance
Quercus rubra	Europhyt, non-compliance
Shorea (merantis, lauan, alan)	Tropical, Eurostat
Swietenia (mahogany)	Tropical, Eurostat
Tectona grandis	Europhyt, non-compliance
Tetraberlinia bifoliata	Gümüs and Ergün, 2015
Triplochiton scleroxylon	Europhyt, non-compliance
Ulmus	Europhyt, non-compliance
Ulmus rubra	Europhyt, non-compliance
Virola	Tropical, Eurostat

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[27] in Eurostat, ‘wood in the rough, whether or not stripped of bark or sapwood, or roughly squared’

2. Interceptions in wood commodities

In Europhyt for 2010-2017, cases of non-compliance due to the presence of organisms, where the family was indicated (there were also identifications as insect or Coleoptera, and one at the species level, *Xyleborus volvulus*), showed interceptions of Scolytinae and Platypodinae from non-EPPO origins, as listed below.

Platypodinae

Species	Origin
Populus	USA
Quercus alba	USA
Aucoumea klaineana	Congo, Equatorial Guinea
Caesalpinia	Cameroon
Chlorophora excelsa	Central Af. Rep., Congo, Congo Dem. Rep.
Copaifera religiosa	Gabon
Copaifera salikounda	Congo
Entandrophragma candollei	Central African Rep., Congo
Entandrophragma cylindricum	Cameroon, Central Af. Rep., Congo Congo Dem. Rep.
Guarea cedrata	Cameroon Central Af. Rep.
Guibourtia sp.	Central Af. Rep. Gabon
Khaya anthotheca	Congo Dem. Rep.
Leguminosae	Cameroon Congo Dem. Rep.
Magnoliaceae	Congo
Microberlinia sp.	Gabon

Scolytinae

Species	origin
Juglans sp.	USA
Juglans regia	USA
Juglans nigra	USA
Liriodendron sp.	USA
Populus sp.	USA
Prunus avium	USA
Prunus sp.	USA
Afzelia bipindensis	Congo
Aucoumea klaineana	Congo, Equatorial Guinea
Caesalpinia sp.	Cameroon
Chlorophora excelsa	Central African Rep., Congo, Congo Dem. Rep.
Copaifera religiosa	Congo, Gabon
Copaifera salikounda	Congo
Diospyros sp.	Congo Dem. Rep.
Entandrophragma candollei	Central Af. Rep., Congo
Entandrophragma cylindricum	Cameroon, Central Af. Rep., Congo, Congo Dem. Rep.
Entandrophragma utile	Central Af. Rep., Congo
Guarea cedrata	Cameroon, Central Af. Rep., Congo
Guibourtia sp.	Central Af. Rep., Gabon
Khaya anthotheca	Congo Dem. Rep.
Khaya grandifoliola	Congo
Leguminosae	Cameroon, Congo, Congo Dem. Rep.
Magnoliaceae	Congo
Microberlinia sp.	Gabon
Triplochiton scleroxylon	Cameroon

3. Analysis of FAOSTAT trade data

Considering the whole EPPO region and the fact that most bark and ambrosia beetles considered in this study are polyphagous, the general trade data available for most EPPO countries in FAOSTAT was analysed here. It was not considered useful to analyse Eurostat data on specific wood genera traded into the EU.

The categories of commodities used in FAOSTAT do not correspond exactly to commodities as proposed in the EPPO Study (EPPO, 2015), and differences are outlined below.

Round wood

FAOSTAT provides trade data for several categories of round wood.

- *Industrial round wood-wood in the rough*, defined as (Year Book of Forestry, 2015 - http://www.fao.org/3/a-i7304m.pdf) *'Roundwood that will be used in the production of other goods and services (except as a source of fuel). It includes: all roundwood except wood fuel. In the production* *statistics, it represents the sum of: sawlogs and veneer logs; pulpwood, round and split; and other industrial roundwood. ....It is reported in cubic metres underbark (i.e. excluding bark).'* Trade data for non-coniferous industrial roundwood is divided in two categories, tropical and non-tropical, and imports into the EPPO region are detailed below. However, this division is not clear: there are imports of tropical wood recorded from non-tropical countries (e.g. Canada) and imports of non-tropical wood from tropical countries (e.g. Indonesia). It is not clear whether this relates to re-export, misclassification of woods, or because some wood genera are attributed to a category but may include trees of the other.

- *Wood fuel*: '*Roundwood that will be used as fuel, including wood harvested from main stems, branches and other parts of trees (where these are harvested for fuel) and wood that will be used for charcoal production (e.g. in pit kilns and portable ovens), wood pellets and other agglomerates'*. However, the trade data does not separate coniferous and non-coniferous wood, and this category is not useful here.

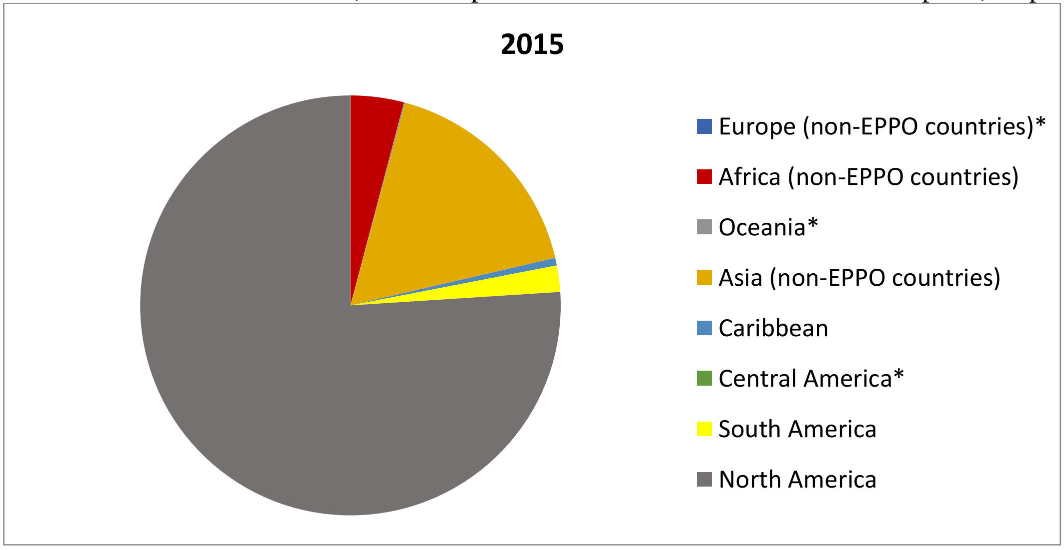
A category of *Wood residues*, is defined as '*The volume of roundwood that is left over after the production of forest products in the forest processing industry (i.e. forest processing residues) and that has not been reduced to chips or particles. It includes: sawmill rejects, slabs, edgings and trimmings, veneer log cores, veneer rejects, sawdust, residues from carpentry and joinery production, etc. It excludes: wood chips made either directly (i.e. in the forest) from roundwood or made from residues (i.e. already counted as pulpwood, round and split or wood chips and particles). It is reported in cubic metres solid volume excluding bark*'. Part of this may also fall under other EPPO categories, but no detailed trade data is given.

Consequently only the data for industrial roundwood (non-coniferous, non-tropical and tropical) is presented below and represents only part of imported non-coniferous roundwood.

***Imports of <u>non-tropical</u> non-coniferous industrial roundwood (FAOSTAT)* (detailed data in Table 2)**

Over the period 2013-2015, imports were recorded from all regions: Africa (25 countries), Asia (16), North America (all 3), South America (13), Caribbean (4), Central America (4), Oceania (2) and Iceland. Many tropical countries in South America and Africa are represented, which introduces some doubts about the data.

In 2015, the total import volume reached over 1 020 000 m^3 from 63 countries, and the largest volumes came from North America and Asia, which represented over 75% and 17% of all imports, respectively.



* The total volume for this region is small and not visible in the diagram.

Two countries accounted for over 90% of the total volume: USA and China (73% and 17 % respectively). Countries with exports over 100 m^3 to EPPO countries are listed below. Countries located in a tropical area are marked with *

Country	2015, m^3
Angola*	665
Australia	903
Benin	141

Country	2015, m^3
Brazil*	232
Cameroon*	23704
Canada	18910

Country	2015, m^3
Central African Rep.*	599
Chile*	141

Country	2015, m^3
China	174163
Congo*	954
Côte d'Ivoire*	112
Dem. Rep. Congo*	4899
Dominican Republic*	5863

Country	2015, m^3
Gabon*	447
Guyana*	1321
India	561
Liberia*	4131
Malaysia*	548
Mexico	5559

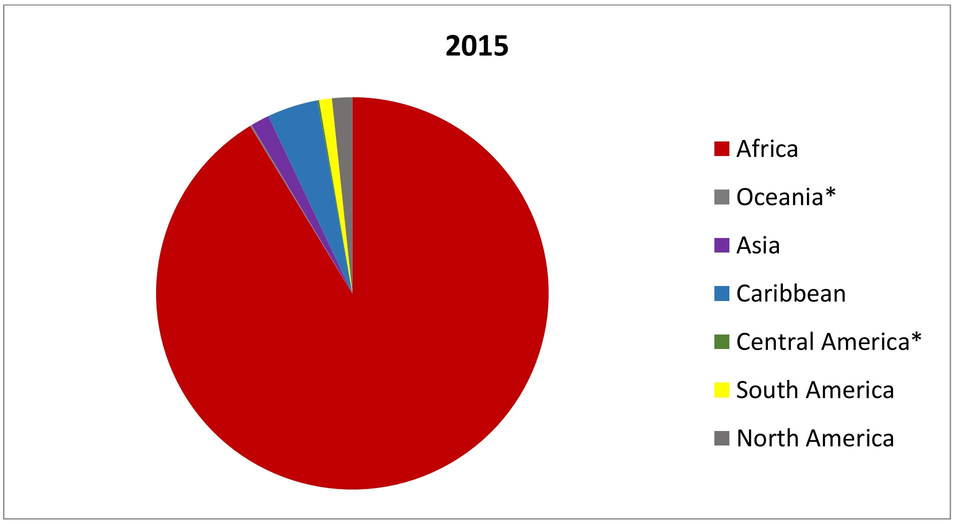
Country	2015, m^3
Nigeria*	132
South Africa	6014
Suriname*	18488
Uruguay	228
USA	752933
Vietnam*	105

33 EPPO countries imported such wood in 2015, including 24 EU members. Netherlands, Italy and Portugal accounted for over 50% of the total, and over 90% together with Germany, Spain, Belgium, Sweden, Turkey, Denmark, France and Czech Republic. The issue detailed above with regards to tropical countries also applies here: for example imports to the 3rd importer, Portugal, came from 9 countries, only 2 (USA and China) not (entirely) in tropical areas.

***Imports of <u>tropical</u> non-coniferous industrial roundwood (FAOSTAT)* (detailed data in Table 3)**

Over the period 2013-2015, imports were recorded from all regions: Africa (20 countries), Asia (11), North America (all 3), South America (9), Caribbean (2), Central America (2), Oceania (3). Some non-tropical countries are represented (such as Canada), but not certain tropical countries that are included in the data for non-tropical wood, which introduces some doubts about the data.

In 2015, the total import volume reached over 190 000 m^3 from 38 countries. Africa represented over 90% of total imports.



* The total volume for this region is small and not visible in the diagram.

The two Congos accounted for over 45% of the total volume, and together with 3 other African countries (Central African Rep., Cameroon, Liberia) and the Dominican Republic, over 93%. Countries with exports over 100 m^3 to EPPO countries are listed below. Countries located in a tropical area are marked with *

Country	2015, m^3
Angola	505
Brazil	1271
Cameroon	28046
Central Af. Rep.	32160
China	155
Congo	55887
Congo Dem. Rep.	34461
Costa Rica	460

Country	2015, m^3
Côte d'Ivoire	1196
Dominican Rep.	8000
Equatorial Guinea	11459
Fiji	173
Gabon	1003
Ghana	231
Liberia	9679
Malaysia	1875

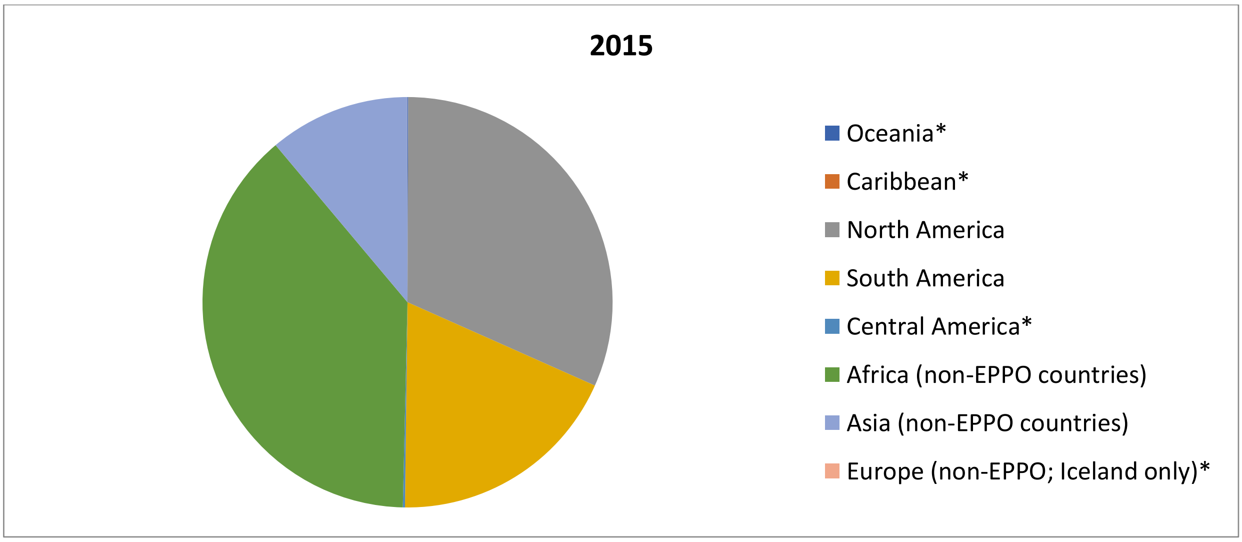
Country	2015, m^3
Mexico	1755
Myanmar	546
Panama	279
Singapore	203
Uruguay	126
USA	1422

27 EPPO countries imported such wood in 2015, including 20 EU members. France and Turkey accounted for ca. 50% of the total, and over 90% together with Belgium, Portugal, Italy, Slovenia, Austria, Germany. As many tropical countries are listed for non-tropical wood, this may not represent the correct ranking of imports for tropical wood. For example, Portugal would take the second rank before Turkey if counting imports from tropical countries in the category of non-tropical wood.

Sawn wood (detailed data in Table 4)
FAOSTAT provides trade data for non-coniferous sawn wood.

Over the period 2013-2015, imports were recorded from all regions: Africa (33 countries), Asia (28), North America (all 3), South America (13), Caribbean (3), Central America (6), Oceania (5). Imports from Iceland were also recorded.

In 2015, the total import volume reached over 1304 000 m^3 from 72 countries. Imports were more spread over continents than for other wood commodities, with Africa, Asia, North and South America representing over 99% of total imports.



* The total volume for this region is small and not visible in the diagram.

The USA, Cameroon and Brazil accounted for over 60% of the total volume. Countries with exports over 100 m^3 to EPPO countries are listed below.

Country	2015 (m^3)
USA	366231
Cameroon	237013
Brazil	183253
Côte d’Ivoire	102297
Malaysia	85278
Congo	52286
Canada	45788
Gabon	39757
Dem. Rep. Congo	23332
Central African Rep.	22539
Ghana	19187
Suriname	18319
India	16537

Country	2015 (m^3)
Ecuador	14677
Indonesia	12150
China	10358
Guyana	8887
Peru	8354
Myanmar	7108
Singapore	7064
Uruguay	3810
Vietnam	3511
Bolivia	1962
Thailand	1647
Nigeria	1492
Chile	1362
Madagascar	1004
Guatemala	869

Country	2015 (m^3)
South Africa	735
Mozambique	581
Angola	562
Belize	560
Guinea	556
Honduras	417
Paraguay	350
Panama	324
Papua New Guinea	316
Equatorial Guinea	305
Costa Rica	292
Iran	289
Nicaragua	279

Country	2015 (m^3)
Tanzania	254
Lao PDR	229
Australia	227
Benin	202

Country	2015 (m^3)
Rep. Korea	165
Colombia	154
Argentina	143
UAE	132

Country	2015 (m^3)
Japan	113
Armenia	112
Mauritius	110

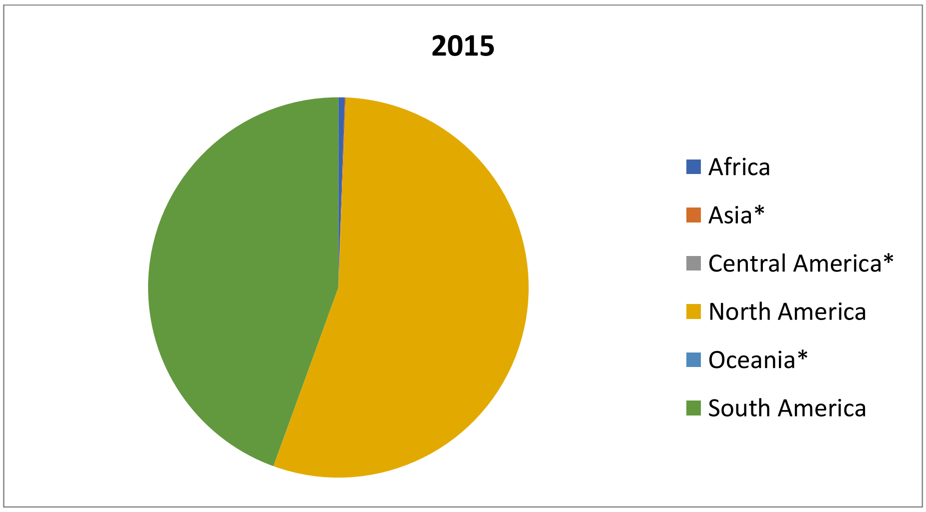
Most EPPO countries imported sawn wood in 2015 from outside the EPPO region (46 out of 51, including all EU members). Belgium, Italy, Netherlands and UK represented over 55% of imports, and over 80% together with Germany, France, Spain and Turkey (all the EPPO countries with imports over 100 000 m^3).

Wood chips, hogwood, processing wood residues (except sawdust and shavings) (data in Table 5)
Trade data is not available as such for these EPPO commodities. However, FAOSTAT provides data that may partly cover them, and would represent part of the imports of these commodities:

'Wood chips and particles' is defined as *'Wood that has been deliberately reduced to small pieces during the manufacture of other wood products and is suitable for pulping, for particle board and fibreboard production, for use as a fuel, or for other purposes. It excludes: wood chips made directly (i.e. in the forest) from roundwood (i.e. already counted as pulpwood or wood fuel). It is reported in cubic metres solid volume excluding bark.*'. The fact that it excludes wood chips made directly (i.e. in the forest) from roundwood excludes part of the imports, but no separate data is available for this category. Detailed data on 'wood chips and particles' is given in Table 5.

Over the period 2013-2015, imports were recorded from all regions except the Caribbean: Africa (11 countries), Asia (11), North America (all 3), South America (8), Central America (1), Oceania (2).

In 2015, the total import volume reached over 4.1 million m^3 from 27 countries. North and South America accounted for over 99% of imports (54 and 44 % respectively), which was due to USA and Brazil accounting for ca. 44 and 39 % of the total volume, respectively.



* The total volume for this region is small and not visible in the diagram.

Countries with exports over 100 m^3 to EPPO countries are listed below.

Country	2015, m^3
UAE	114
Chile	241
China	270
Egypt	285
Thailand	305

Country	2015, m^3
Rep. Korea	373
Japan	2172
South Africa	22081
Uruguay	53009

Country	2015, m^3
Venezuela	173372
Canada	462486
Brazil	1602016
USA	1796837

24 EPPO countries imported such wood in 2015, including 18 EU members. Turkey accounted for over 70% of the total, and over 95% together with Germany.

References

CIRAD. Tropix 7. The main technological characteristics of 245 wood species. https://tropix.cirad.fr/fiches-disponibles.

Eurostat. European Statistics. Online database. http://ec.europa.eu/eurostat.

FAOSTAT. Food and agriculture data. Online database. FAO, Rome, Italy. http://www.fao.org/faostat/en/#home.

Mark J, Newton AC, Oldfield S, Rivers M. 2014. International Timber Trade: A working list of commercial timber tree species Botanic Gardens Conservation International, Richmond, UK.

The wood database. Explore wood. Online database: http://www.wood-database.com/wood-identification/by-scientific-name/.

Table 1. List of woods in the Wood Database (http://www.wood-database.com/wood-identification/by-scientific-name/)

Acacia acuminata
Acacia cambagei
Acacia galpinii
Acacia koa
Acacia mangium
Acacia mearnsii
Acacia melanoxylon
Acer campestre
Acer macrophyllum
Acer negundo
Acer nigrum
Acer pensylvanicum
Acer platanoides
Acer pseudoplatanus
Acer rubrum
Acer saccharinum
Acer saccharum
Aesculus falva
Aesculus glabra
Aesculus hippocastanum
Afzelia spp.
Ailanthus altissima
Albizia ferruginea
Albizia lebbeck
Albizia julibrissin
Allocasuarina luehmannii
Allocasuarina spp.
Alnus glutinosa
Alnus nepalensis
Alnus rubra
Amphimas pterocarpoides
Anadenanthera colubrina
Andira inermis
Apuleia leiocarpa
Arbutus menziesii
Arctostaphylos pungens
Aspidosperma megalocarpon
Aspidosperma polyneuron
Astronium fraxinifolium
Astronium graveolens
Atherosperma moschatum
Aucoumea klaineana
Bagassa guianensis
Baikiaea plurijuga
Baillonella toxisperma
Bambusa spp.
Berchemia zeyheri
Berlinia bracteosa
Berlinia confusa
Berlinia grandiflora
Berlinia auriculata
Betula alleghaniensis
Betula alnoides
Betula lenta
Betula neoalaskana
Betula nigra
Betula papyrifera
Betula pendula
Betula populifolia
Betula pubescens
Bobgunnia fistuloides
Bobgunnia madagascariensis
Borassus flabellifer
Brosimum paraense
Brosimum rubescens
Brosimum spp.
Brosimum guianense
Bulnesia arborea
Bulnesia sarmientoi
Buxus sempervirens
Caesalpinia echinata
Caesalpinia paraguariensis
Caesalpinia platyloba
Calycophyllum candidissimum
Calycophyllum multiflorum
Carapa guianensis
Cardwellia sublimis
Carpinus betulus
Carpinus caroliniana
Carya aquatica
Carya cordiformis
Carya glabra
Carya illinoinensis
Carya laciniosa
Carya myristiciformis
Carya ovata
Carya tomentosa
Castanea dentata
Castanea sativa
Casuarina spp.
Catalpa bignonioides
Catalpa speciosa
Cedrela odorata
Cedrelinga catenaeformis
Celtis occidentalis
Centrolobium spp.
Cercocarpus ledifolius
Chlorocardium rodiei
Chloroxylon swietenia
Chrysolepis chrysophylla
Cinnamomum camphora
Cocos nucifera
Colophospermum mopane
Combretum imberbe
Copaifera mildbraedii
Copaifera salikounda
Cordia alliodora
Cordia dodecandra
Cordia glabrata
Cordia spp.
Cordia goeldiana
Cordia megalantha
Cornus florida
Corymbia citriodora
Corymbia gummifera
Corymbia maculata
Cynometra spruceana
Dalbergia baronii
Dalbergia cearensis
Dalbergia cultrata
Dalbergia decipularis
Dalbergia frutescens
Dalbergia latifolia
Dalbergia maritima
Dalbergia melanoxylon
Dalbergia nigra
Dalbergia olivera
Dalbergia retusa
Dalbergia sissoo
Dalbergia stevensonii
Dalbergia cochinchinensis
Dalbergia spruceana
Dalbergia tucurensis
Dendrocalamus asper
Diospyros celebica
Diospyros crassiflora
Diospyros ebenum
Diospyros ebonasea
Diospyros mun
Diospyros virginiana
Diospyros embryopteris
Diospyros peregrina
Dipterocarpus spp.
Dipteryx odorata
Distemonanthus benthamianus
Dracontomelon dao
Dracontomelon mangiferum
Dyera costulata
Ebenopsis ebano
Elaeagnus angustifolia
Endiandra palmerstonii
Entandrophragma cylindricum
Entandrophragma utile
Enterolobium cyclocarpum
Erica arborea
Erythroxylon mexicanum
Eucalyptus camaldulensis
Eucalyptus coolabah
Eucalyptus deglupta
Eucalyptus diversicolor
Eucalyptus dumosa
Eucalyptus grandis
Eucalyptus marginata
Eucalyptus melliodora
Eucalyptus moluccana
Eucalyptus obliqua
Eucalyptus oleosa
Eucalyptus regnans
Eucalyptus robusta
Eucalyptus socialis
Eucalyptus urograndis
Eucalyptus viridis
Eucalyptus leucoxylon
Euxylophora paraensis
Fagus grandifolia
Fagus sylvatica
Flindersia brayleyana
Fraxinus americana
Fraxinus excelsior
Fraxinus latifolia
Fraxinus mandshurica
Fraxinus nigra
Fraxinus pennsylvanica
Fraxinus profunda
Fraxinus quadrangulata
Gleditsia triacanthos
Gluta spp.
Gonystylus spp.
Grevillea robusta
Grevillea striata
Guaiacum officinale
Guaiacum sanctum
Guarea cedrata
Guarea thompsonii
Guibourtia demeusei
Guibourtia ehie
Guibourtia hymenaeifolia

Guibourtia pellegriniana
Guibourtia tessmannii
Gymnocladus dioicus
Handroanthus guayacan
Handroanthus serratifolius
Hardwickia binata
Hevea brasiliensis
Hymenaea courbaril
Ilex mitis
Ilex opaca
Ilex aquifolium
Intsia bijuga
Intsia palembanica
Juglans californica
Juglans cinerea
Juglans hindsii
Juglans neotropica
Juglans nigra
Juglans olanchana
Juglans regia
Juglans x *paradox*
Julbernardia pellegriniana
Khaya anthotheca
Khaya grandifoliola
Khaya ivorensis
Khaya senegalensis
Koompassia malaccensis
Krugiodendron ferreum
Laburnum anagyroides
Lagerstroemia spp.
Liquidambar styraciflua
Liriodendron tulipifera
Lonchocarpus spp.
Lophira alata
Lovoa trichilioides
Loxopterygium sagotti
Lysiloma bahamense
Lysiloma latisiliquum
Macadamia integrifolia
Machaerium spp.
Maclura pomifera
Maclura tinctoria
Magnolia acuminata
Magnolia grandiflora
Magnolia virginiana
Malus domestica
Malus sieversii
Malus sylvestris
Mangifera indica
Manikara bidentata
Mansonia altissima
Melanorrhoea spp.
Melia azedarach
Metopium brownei
Metrosideros collina
Metrosideros polymorpha
Microberlinia brazzavillensis
Milicia excelsa
Milicia regia
Millettia laurentii
Millettia stuhlmannii
Mitragyna ciliata
Mora excelsa
Mora gonggrijpii
Morus alba
Morus nigra
Morus rubra
Myroxylon balsamum
Myroxylon peruiferum
Nothofagus cunninghamii
Notholithocarpus densiflorus
Nyssa aquatica
Nyssa sylvatica
Ochroma pyramidale
Ocotea porosa
Olea europaea
Olea hochstetteri
Olneya tesota
Ostrya virginiana
Oxandra lanceolata
Palaquium spp.
Panopsis spp.
Paulownia tomentosa
Payena spp.
Peltogyne spp.
Pericopsis elata
Pericopsis mooniana
Phyllostachys spp.
Piptadenia spp.
Pistacia vera
Platanus occidentalis
Platanus x *acerifolia*
Platymiscium ulei
Platymiscium pinnatum
Platymiscium trinitatis
Populus alba
Populus balsamifera
Populus deltoides
Populus grandidentata
Populus nigra
Populus tremula
Populus tremuloides
Populus trichocarpa
Pouteria adolfi-friederici
Pouteria altissima
Pouteria sapota
Pouteria dombeyi
Pouteria robusta
Prosopis africana
Prosopis glandulosa
Prosopis juliflora
Prosopis kuntzei
Prosopis nigra
Prunus avium
Prunus domestica
Prunus serotina
Prunus armeniaca
Pterocarpus angolensis
Pterocarpus dalbergioides
Pterocarpus indicus
Pterocarpus macrocarpus
Pterocarpus santalinus
Pterocarpus soyauxii
Pterogyne nitens
Pterygota macrocarpa
Pyrus communis
Quercus alba
Quercus bicolor
Quercus cerris
Quercus coccinea
Quercus falcata
Quercus garryana
Quercus ilex
Quercus kelloggii
Quercus laurifolia
Quercus lyrata
Quercus macrocarpa
Quercus michauxii
Quercus mongolica
Quercus nigra
Quercus pagoda
Quercus palustris
Quercus petraea
Quercus phellos
Quercus prinus
Quercus robur
Quercus rubra
Quercus shumardii
Quercus stellata
Quercus velutina
Quercus virginiana
Rhamnus cathartica
Rhamnus purshiana
Rhus typhina
Robinia pseudoacacia
Roseodendron donnell-smithii
Roupala spp.
Salix alba
Salix fragilis
Salix nigra
Salix bebbiana
Samanea saman
Sassafras albidum
Schinopsis spp.
Senna siamea
Shorea acuminatissima
Shorea assamica
Shorea cochinchinensis
Shorea contorta
Shorea faguetiana
Shorea hypochra
Shorea kalunti
Shorea leprosula
Shorea leptoclados
Shorea negrosensis
Shorea smithiana
Spirostachys africana
Swartzia benthamiana
Swartzia cubensis
Swartzia spp.
Swietenia macrophylla
Swietenia mahogani
Syncarpia glomulifera
Syringa vulgaris
Talipariti elatum
Tamarindus indica
Tectona grandis
Terminalia amazonia
Terminalia bialata
Terminalia elliptica
Terminalia ivorensis
Terminalia superba
Tieghemella africana
Tieghemella heckelii
Tilia americana
Tilia vulgaris
Tilia x *europaea*
Toona ciliata
Triplochiton scleroxylon
Turraeanthus africanus
Ulmus × hollandica
Ulmus alata
Ulmus americana
Ulmus crassifolia
Ulmus glabra
Ulmus procera
Ulmus rubra
Ulmus thomasii
Umbellularia californica
Vachellia erioloba
Vachellia seyal
Vouacapoua americana
Weinmannia trichosperma
Zanthoxylum flavum
Zollernia paraensis
Zygia racemosa
Zygia cataractae

Table 2. FAOSTAT – Industrial roundwood, non-coniferous, non-tropical in m^3 (imports by EPPO countries)

Origin	Destination	2013	2014	2015
Afghanistan	France			6
Angola	Italy	122	72	
Angola	Portugal		505	665
Angola	Russia	223		
Angola	Spain		70	
Argentina	Netherlands			2
Argentina	Turkey	6		
Australia	France	24	32	11
Australia	Germany	15	2	2
Australia	Netherlands			4
Australia	Sweden		9	
Australia	UK	342	469	886
Bangladesh	Netherlands			3
Belize	Italy			56
Belize	Spain			22
Belize	UK			4
Benin	Italy			141
Benin	Turkey		18	
Bolivia	Italy	41	44	
Brazil	Czech Rep.	240	63	
Brazil	Germany	25	52	1
Brazil	Ireland		17	
Brazil	Italy		2	16
Brazil	Luxembourg	28	42	
Brazil	Morocco			117
Brazil	Netherlands			9
Brazil	Poland		6	17
Brazil	Portugal			54
Brazil	Spain			18
Brazil	Sweden	1443	2670	
Cabo Verde	Austria			16
Cameroon	Algeria			2478
Cameroon	Czech Rep.		18	15
Cameroon	Finland	136	93	
Cameroon	France	1028	948	1837
Cameroon	Germany	149	31	30
Cameroon	Italy	4073	1390	959
Cameroon	Luxembourg	3823	5918	8823
Cameroon	Morocco		1894	3392
Cameroon	Netherlands			2
Cameroon	Norway		154	
Cameroon	Poland			45
Cameroon	Portugal	918	972	1752
Cameroon	Spain	52	102	
Cameroon	Switzerland	4		
Cameroon	Tunisia	102		206
Cameroon	Turkey	4890	3734	4165
Cameroon	UK	185		
Canada	Austria			1000
Canada	Belgium		106	1000
Canada	Czech Rep.		179	4000
Canada	Estonia	316		
Canada	France	1000		6
Canada	Germany	4000	2015	7000
Canada	Ireland	4	18	34
Canada	Italy	8		
Canada	Netherlands			3
Canada	Norway			1100
Canada	Poland	58		
Canada	Slovenia		20	43
Canada	Sweden	1000	7	4000
Canada	Switzerland		2	16
Canada	Turkey	1000		
Canada	UK	1066	1130	708
Canada	Ukraine		68	
Central Af. Rep.	France	344	341	349
Central Af. Rep.	Germany	28	33	122
Central Af. Rep.	Italy	216	39	
Central Af. Rep.	Portugal			105
Central Af. Rep.	Spain		118	
Central Af. Rep.	Turkey	16		23
Chile	France	12	1	
Chile	Germany	51	46	97
Chile	Netherlands			3
Chile	Portugal	68		
Chile	Slovenia			16
Chile	Spain	29	43	25
Chile	Turkey		67	
China	Albania	4		
China	Algeria		3	
China	Austria		6	11
China	Belgium	57	25	54
China	Bulgaria	25		
China	Croatia	42	14	18
China	Denmark	1		
China	Estonia	26		
China	Finland		2	
China	France	153	89	400
China	Germany	143	79	117
China	Israel	10	2	
China	Italy	37	28	30
China	Jordan	1		
China	Kyrgyzstan	36		
China	Lithuania		9	
China	Luxembourg			2
China	Morocco		1	
China	Netherlands	2762	3625	171931
China	Norway	349	18	336
China	Poland	63	45	180
China	Portugal			4
China	Romania	20	21	
China	Russia		3	
China	Slovenia	20	40	205
China	Spain	2		
China	Sweden			54
China	Switzerland	25	12	7
China	Tunisia			24
China	Turkey	5	4	
China	UK	395	561	790
China	Ukraine	7	3	
Colombia	France	48	22	
Colombia	Germany	15	59	
Colombia	Israel	20		
Colombia	Italy			36

Origin	Destination	2013	2014	2015
Colombia	Netherlands	8		
Colombia	UK	19		
Congo	France	1996	170	181
Congo	Germany	54	273	228
Congo	Italy	852	345	147
Congo	Netherlands		53	32
Congo	Portugal		108	14
Congo	Tunisia	131		344
Congo	Turkey	198		
Congo	UK	277		8
Costa Rica	Austria		25	
Costa Rica	Germany	44	107	44
Costa Rica	Italy			5
Costa Rica	Netherlands	113		3
Costa Rica	Spain			23
Côte d’Ivoire	Belgium		76	
Côte d’Ivoire	France	33		
Côte d’Ivoire	Germany		18	5
Côte d’Ivoire	Italy		41	41
Côte d’Ivoire	Netherlands		4	
Côte d’Ivoire	UK			66
Cuba	Netherlands			2
Dem. Rep. Congo	France	874	449	1047
Dem. Rep. Congo	Germany	52		14
Dem. Rep. Congo	Italy	110		
Dem. Rep. Congo	Netherlands		18	
Dem. Rep. Congo	Portugal	2034	1663	3484
Dem. Rep. Congo	Spain	172	204	120
Dem. Rep. Congo	Switzerland	1		
Dem. Rep. Congo	Tunisia	116		
Dem. Rep. Congo	Turkey			34
Dem. Rep. Congo	UK	126		200
Dominican Rep.	France		13	
Dominican Rep.	Netherlands			3
Dominican Rep.	Turkey		2811	5860
Ecuador	Germany	36		
Ecuador	Italy	22		
Ecuador	Netherlands	23		2
Ecuador	Portugal			93
Ecuador	Spain	23		
Ecuador	Sweden	11		
Ecuador	Tunisia	21		
Egypt	Algeria			1
El Salvador	Turkey	9		
Equatorial Guinea	France	93	66	
Equatorial Guinea	Netherlands			1
Equatorial Guinea	Portugal		113	
Gabon	Denmark	41		
Gabon	Germany	106		
Gabon	Luxembourg			442
Gabon	Morocco			5
Ghana	Belgium	1		
Ghana	Germany	159		
Ghana	Israel	2		
Ghana	Italy	336	17	
Ghana	Lithuania	16		
Ghana	Netherlands	14		
Ghana	Poland			20
Ghana	UK	3		
Guatemala	Netherlands			2
Guatemala	Turkey	18	42	46
Guinea	Poland			2
Guyana	Belgium		22	21
Guyana	Denmark	23	113	121
Guyana	France	59	41	6
Guyana	Germany	178	68	80
Guyana	Italy	323	86	497
Guyana	Netherlands	188	241	596
Guyana	UK	188	2	
Haiti	France	2		
Iceland	Denmark	20		
Iceland	Netherlands			4
Iceland	Switzerland	7		
India	Belgium	13		2
India	Bulgaria	14		
India	Czech Rep.	12	1	43
India	Denmark	12		
India	Finland	15	2	
India	Ireland	43	44	7
India	Israel	3		
India	Italy	20	2	341
India	Netherlands		86	2
India	Russia		12	
India	Spain	131		159
India	Switzerland		6	
India	Turkey			1
India	UK		2	6
Indonesia	Austria			2
Indonesia	Denmark		2	
Indonesia	France			4
Indonesia	Germany	16	18	18
Indonesia	Italy	2	2	
Indonesia	Lithuania			10
Indonesia	Luxembourg		2	2
Indonesia	Netherlands	18	12	38
Indonesia	Norway		17	
Indonesia	Switzerland	17	18	4
Indonesia	UK		3	1
Iran	Czech Rep.	14		
Iran	Germany			7
Jamaica	France		16	44
Jamaica	Portugal	2		
Japan	France	31		
Japan	Germany	99	14	13
Japan	Netherlands			24
Kenya	Netherlands			5
Liberia	France	424	516	827
Liberia	Germany	83	57	381
Liberia	Netherlands	22		
Liberia	Turkey	2846		2923
Madagascar	Belgium	500		
Madagascar	France		39	
Madagascar	Slovenia	21		
Madagascar	Switzerland	46		
Malaysia	Austria		2	11
Malaysia	Belgium	1		
Malaysia	Czech Rep.	21	11	29
Malaysia	France	10	33	63

Origin	Destination	2013	2014	2015
Malaysia	Germany	209	298	284
Malaysia	Italy	24	10	
Malaysia	Luxembourg		38	6
Malaysia	Netherlands	8		41
Malaysia	Norway		13	
Malaysia	Poland	31	43	83
Malaysia	Portugal		1	2
Malaysia	Switzerland	8	1	
Malaysia	Turkey	16	8	
Malaysia	UK	80	27	29
Mauritius	Portugal	6		
Mexico	France	2262	2378	176
Mexico	Germany	137	234	422
Mexico	Italy	174	201	231
Mexico	Netherlands			3
Mexico	Slovenia	16	771	38
Mexico	Spain	645	17	4601
Mexico	Turkey	41	47	88
Mozambique	Germany	61		12
Mozambique	Netherlands		29	
Mozambique	Portugal		35	
Mozambique	Sweden	8		
Mozambique	UK			3
Myanmar	France		36	
Myanmar	Italy	32	17	16
Myanmar	Netherlands		30	
New Zealand	Italy	25		
New Zealand	Netherlands			3
New Zealand	Norway	375		
New Zealand	Switzerland	14		
New Zealand	UK	2	4	1
Nicaragua	Germany			13
Nigeria	Germany	81	126	110
Nigeria	Italy		148	
Nigeria	Poland			22
Oman	Netherlands			2
Pakistan	Czech Rep.		20	
Pakistan	Netherlands			3
Pakistan	Slovakia			57
Panama	Austria	22		
Panama	Netherlands		9	
Panama	Spain	42		1
Paraguay	France	1095	547	37
Paraguay	Germany			17
Paraguay	Lithuania	428		
Paraguay	Spain	28	28	
Peru	Germany	11	2	
Peru	Netherlands			3
Peru	UK	82	24	
Philippines	Greece		3	
Philippines	Netherlands			3
Philippines	Spain	2		
Philippines	UK		2	2
Rep. Korea	Germany	8		6
Rep. Korea	Netherlands			9
Sierra Leone	Albania	23		
Singapore	France	11		
Singapore	Netherlands		4	4
Singapore	UK	85	25	10
South Africa	Austria	2	2	7
South Africa	Belarus	2		2
South Africa	Belgium	102	1	3
South Africa	Czech Rep.		1	1
South Africa	Denmark	29	105	237
South Africa	Estonia		3	
South Africa	France	30	24	63
South Africa	Germany	2472	424	385
South Africa	Ireland	26		11
South Africa	Italy	26	67	47
South Africa	Luxembourg		1	2
South Africa	Netherlands	2139	3866	4801
South Africa	Norway	8	6	401
South Africa	Slovenia		60	
South Africa	Switzerland	10	2	
South Africa	UK	28	24	54
Sri Lanka	Denmark	13		
Sri Lanka	Germany	15	11	8
Sri Lanka	Netherlands			1
Sri Lanka	UK	23		
Suriname	Bulgaria		106	
Suriname	Denmark		7	265
Suriname	France		11	26
Suriname	Germany	4	65	42
Suriname	Italy		95	
Suriname	Netherlands	347	84	17596
Suriname	Spain		23	21
Suriname	Turkey		20	538
Suriname	UK	26		
Tanzania	Italy	20		
Tanzania	Netherlands			2
Tanzania	UK	1		
Thailand	Czech Rep.	2		
Thailand	Germany	11	8	
Thailand	Israel		13	
Thailand	Lithuania		27	28
Thailand	Netherlands			11
Thailand	Sweden		6	32
Thailand	UK		6	
Togo	France			13
Uganda	Estonia	56		
Uganda	Netherlands			1
Uganda	Poland		110	
Uruguay	France	250	141	228
Uruguay	Spain	21394		
Uruguay	UK	93		
USA	Albania	111		
USA	Algeria	198	882	501
USA	Austria	514	4000	8000
USA	Azerbaijan	64		
USA	Belarus	563		
USA	Belgium	48000	127000	37000
USA	Bulgaria	820		
USA	Cyprus	48	20	
USA	Czech Rep.	1000	459	15000
USA	Denmark	26000	57000	23000
USA	Estonia		6720	13275
USA	Finland	9000	28000	6000
USA	France	31000	31000	17000

Origin	Destination	2013	2014	2015
USA	Georgia	199		
USA	Germany	151000	143000	128000
USA	Greece	1259	1727	1299
USA	Ireland	378	159	173
USA	Israel	13	8	5759
USA	Italy	261000	231000	189000
USA	Lithuania	1000	101	7000
USA	Luxembourg		15	
USA	Malta	2681	1628	2448
USA	Morocco	1000	2060	1758
USA	Netherlands	4156	33	1572
USA	Norway	6772	9497	6374
USA	Poland	5000	2000	9000
USA	Portugal	90000	189000	143000
USA	Romania			1000
USA	Russia		2	366
USA	Slovenia	41000	1000	888
USA	Spain	44000	145000	95000
USA	Sweden	23000	51000	30000
USA	Switzerland	34		25
USA	Turkey	39000	9864	10168
USA	UK	1427	412	327
USA	Ukraine	23	61	
Vietnam	Germany	27	34	27
Vietnam	Netherlands			5
Vietnam	Spain			71
Vietnam	Sweden			2
Vietnam	Switzerland	9	5	
Zambia	Netherlands			3

Table 3. FAOSTAT – Industrial roundwood, non-coniferous, tropical in m^3 (imports by EPPO countries)

Origin	Destination	2013	2014	2015
Angola	France	461		
Angola	Italy	249	237	310
Angola	Poland	12		
Angola	Portugal	589		27
Angola	Slovenia			112
Angola	Spain	40		56
Angola	Turkey	188		
Australia	Netherlands	1		
Bolivia	Belgium	89		
Bolivia	Morocco		10	
Brazil	Belgium	2101	290	904
Brazil	Czech Rep.	164	32	54
Brazil	Germany		77	
Brazil	Ireland		2	
Brazil	Italy			37
Brazil	Luxembourg	80		271
Brazil	Morocco			5
Brazil	Slovenia		49	
Brazil	Switzerland		46	
Cameroon	Algeria		34	96
Cameroon	Belgium	3000	2000	2000
Cameroon	Bosn. &Her.	2	2	
Cameroon	Czech Rep.	76		
Cameroon	Denmark	23		43
Cameroon	France	6000	3000	2000
Cameroon	Germany	4000	767	532
Cameroon	Greece	839	1826	3339
Cameroon	Ireland			115
Cameroon	Italy	2000	5000	9000
Cameroon	Luxembourg	12		
Cameroon	Malta			24
Cameroon	Morocco		54	52
Cameroon	Netherlands		1000	
Cameroon	Norway	157	24	4
Cameroon	Poland			9
Cameroon	Portugal	1000	2000	2000
Cameroon	Romania	13		
Cameroon	Slovenia	108		
Cameroon	Spain	1000	163	200
Cameroon	Switzerland	194		115
Cameroon	Tunisia	181	442	113
Cameroon	Turkey	9000	11000	8000
Cameroon	UK	726	840	404
Canada	Belgium		111	
Canada	Czech Rep.			5
Canada	Norway			5
Central Af. Rep.	Austria		2446	8384
Central Af. Rep.	Belgium	177	1254	1736
Central Af. Rep.	Czech Rep.	177		
Central Af. Rep.	Denmark	44	1086	2395
Central Af. Rep.	France	5000	13000	9169
Central Af. Rep.	Germany	1000	4000	1524
Central Af. Rep.	Greece			135
Central Af. Rep.	Ireland			87
Central Af. Rep.	Italy	442	104	568
Central Af. Rep.	Morocco		37	
Central Af. Rep.	Portugal	1000	1000	2676
Central Af. Rep.	Romania	108		180
Central Af. Rep.	Slovenia			183
Central Af. Rep.	Spain	1000	211	597
Central Af. Rep.	Turkey	4000	3000	4526
China	Belgium		1	
China	Denmark	44	5	5
China	France		6	
China	Kyrgyzstan	35		
China	Netherlands		36	39
China	Norway		5	86
China	Poland			24
China	UK			1
Colombia	Germany	15	25	
Colombia	Israel			11
Colombia	Italy	26		
Colombia	Moldova	48		
Colombia	Portugal		372	
Colombia	Spain	10		18
Congo	Algeria	211	321	727
Congo	Belgium	14000	14000	13000
Congo	Czech Rep.	1000	699	1130
Congo	Denmark	14		
Congo	Estonia	4	2	
Congo	France	18000	22000	28000
Congo	Germany	2000	2000	2000
Congo	Greece	271	378	214
Congo	Italy	1000	1000	1000
Congo	Morocco		3	
Congo	Netherlands	1000	1000	
Congo	Portugal	1000	3000	5000
Congo	Slovenia	288	94	855
Congo	Spain	3000	222	421
Congo	Switzerland	2	20	
Congo	Tunisia	774		188
Congo	Turkey	3000	7000	3000
Congo	UK	196	460	352
Costa Rica	Austria	78	47	
Costa Rica	Germany	25		40
Costa Rica	Italy	14		30
Costa Rica	Netherlands		107	75
Costa Rica	Poland			40
Costa Rica	Spain			275
Côte d’Ivoire	Belgium	89	40	17
Côte d’Ivoire	Czech Rep.		13	23
Côte d’Ivoire	France		29	251
Côte d’Ivoire	Germany	21	44	
Côte d’Ivoire	Ireland		34	53
Côte d’Ivoire	Slovenia			739
Côte d’Ivoire	Turkey			49
Côte d’Ivoire	UK	147	22	64
Dem.Rep. Congo	Belgium	6000	2000	3596
Dem.Rep. Congo	Czech Rep.	2		60
Dem.Rep. Congo	France	20000	12000	13177
Dem.Rep. Congo	Germany	1000	397	
Dem.Rep. Congo	Greece	88	351	314
Dem.Rep. Congo	Ireland		76	
Dem.Rep. Congo	Italy	1000	52	336
Dem.Rep. Congo	Morocco		25	
Dem.Rep. Congo	Portugal	9000	7000	10290

Origin	**Destination**	**2013**	**2014**	**2015**
Dem.Rep. Congo	Slovenia	3918	3858	4884
Dem.Rep. Congo	Spain	3000	2546	1016
Dem.Rep. Congo	Switzerland	24		23
Dem.Rep. Congo	Turkey	1000	370	
Dem.Rep. Congo	UK	235	287	765
Dominican Rep.	Spain		4	
Dominican Rep.	Turkey			8000
Ecuador	Belgium			7
Ecuador	France		21	
Ecuador	Netherlands	23		
Ecuador	Romania		17	
Ecuador	Russia	22		
Ecuador	Spain		48	
Ecuador	Sweden	26		
Ecuador	UK	12		
El Salvador	Turkey	3		
Equat. Guinea	Belgium		215	
Equat. Guinea	France	5000	8000	11000
Equat. Guinea	Greece	354	299	149
Equat. Guinea	Italy	288	245	
Equat. Guinea	Portugal		82	
Equat. Guinea	Spain		84	109
Equat. Guinea	Turkey	39	302	201
Eritrea	Portugal	3		
Fiji	Czech Rep.			10
Fiji	France		67	30
Fiji	Slovenia			133
Gabon	Belgium	767	79	134
Gabon	France	1511	286	241
Gabon	Greece		1	575
Gabon	Portugal			53
Gabon	Turkey	819		
Gabon	UK	223	59	
Ghana	Belgium	85	96	65
Ghana	Germany		92	19
Ghana	Ireland	260	90	109
Ghana	Netherlands			2
Ghana	Poland			19
Ghana	Turkey			17
Ghana	UK	81		
Guinea	Belgium			8
Guinea-Bissau	Russia	24		
Guyana	Italy			25
India	Netherlands		9	
India	UK			56
Indonesia	Germany		90	65
Indonesia	Ireland			2
Indonesia	Netherlands		15	3
Indonesia	Poland			4
Indonesia	Slovakia	2	31	18
Indonesia	Slovenia			5
Indonesia	UK	45	56	
Kenya	Italy	56		
Lao PDR	Slovenia	24		
Liberia	France	6000	2218	4066
Liberia	Germany	2000	4504	3384
Liberia	Greece	412	721	544
Liberia	Poland		18	
Liberia	Turkey	4000	5628	1685
Malaysia	Belgium	1000	58	24
Malaysia	Bosnia & Her.			3
Malaysia	Denmark	5	6	11
Malaysia	France	1000	1000	1000
Malaysia	Germany	2000		
Malaysia	Italy		1000	
Malaysia	Netherlands	19	486454	9
Malaysia	Norway	181	1	
Malaysia	Poland	590	457	752
Malaysia	Spain		10	8
Malaysia	Turkey		1000	
Malaysia	UK	157	41	68
Mexico	Italy			3
Mexico	Russia	4		
Mexico	Slovenia	1073	1817	1698
Mexico	Spain			35
Mexico	Turkey	32		19
Mongolia	Italy		57	
Mozambique	France			26
Myanmar	Belgium		280	92
Myanmar	Germany	1000	1000	64
Myanmar	Italy	1000	1000	352
Myanmar	Netherlands	35	26	
Myanmar	Poland	1	6	
Myanmar	Slovenia		300	
Myanmar	Spain	21	72	38
Myanmar	Turkey	415	1000	
Nigeria	Poland		12	23
Panama	Germany			279
Papua N. Guinea	Belgium			62
Papua N. Guinea	Germany			16
Peru	Belgium	38		
Philippines	UK			2
Sierra Leone	Italy	22		
Singapore	France			18
Singapore	Greece			183
Singapore	Turkey		525	
Singapore	UK		22	2
South Africa	France	5		83
South Africa	Ireland		165	
South Africa	Luxembourg	34		
South Africa	Netherlands		16	
Suriname	Belgium	154		96
Suriname	Netherlands	100		
Suriname	Turkey		157	
Tanzania	Belgium	6		
Tanzania	Germany		12	
Tanzania	Poland	4		
Tanzania	Russia	6		
Tanzania	Spain		25	
Tanzania	UK	15		
Thailand	Netherlands			17
Togo	France			25
Trinidad&Tobago	Belgium	29		
Uruguay	Poland		11	126
USA	Belgium	91		
USA	Germany			21
USA	Ireland	8	9	
USA	Italy	151	27	150

Origin	**Destination**	**2013**	**2014**	**2015**
USA	Netherlands		19	5
USA	Norway			2
USA	Portugal	21		
USA	Spain			1244
USA	Turkey	31		
USA	UK	10		
Vietnam	Norway			3
Zambia	Ireland		3	

Table 4. FAOSTAT – Sawn wood, non coniferous in m^3 (imports by EPPO countries)

Origin	Destination	2013	2014	2015
Afghanistan	France	2		44
Angola	Austria	7		
Angola	Belgium	78		
Angola	France		121	6
Angola	Germany	17		
Angola	Portugal	458	107	351
Angola	Spain	94		74
Angola	Turkey	96		110
Angola	UK			21
Argentina	Belgium		11	7
Argentina	France	13	38	
Argentina	Germany		2	
Argentina	Israel	109	129	
Argentina	Italy	262	224	135
Argentina	Netherlands			1
Argentina	Turkey	8		
Armenia	Austria	9	22	3
Armenia	Czech Rep.	64	38	50
Armenia	France			9
Armenia	Germany	17	18	40
Armenia	Italy	25	55	
Armenia	Russia		2	
Armenia	Spain			10
Australia	Belarus	4		
Australia	Denmark	14	12	24
Australia	France	124	77	36
Australia	Germany	7	2	5
Australia	Israel	1		
Australia	Italy		34	5
Australia	Lithuania			24
Australia	Netherlands	1		3
Australia	Norway	401		
Australia	Poland	218		
Australia	Sweden	36	15	126
Australia	Switzerland	2		
Australia	UK		7	4
Bahrain	Greece			23
Bahrain	Switzerland	1		
Bangladesh	Germany		18	8
Bangladesh	Netherlands			1
Belize	Belgium		25	
Belize	Germany	41	11	
Belize	Netherlands	125	1006	512
Belize	Spain			48
Benin	Czech Rep.			28
Benin	Denmark	44		
Benin	France		40	22
Benin	Germany	52		
Benin	Italy		158	67
Benin	Russia			14
Benin	Spain		46	14
Benin	Turkey		40	57
Bhutan	Italy		22	
Bolivia	Belarus	24		22
Bolivia	Belgium	342	197	189
Bolivia	Bosnia & Her.		24	57
Bolivia	Croatia		54	77
Bolivia	Czech Rep.	5		
Bolivia	Denmark	42		
Bolivia	France	1193	275	122
Bolivia	Germany	71	64	97
Bolivia	Ireland		18	
Bolivia	Israel		56	
Bolivia	Italy	326	281	200
Bolivia	Lithuania		25	
Bolivia	Morocco			22
Bolivia	Netherlands	542	995	970
Bolivia	Poland	28		
Bolivia	Portugal	64	19	26
Bolivia	Romania	736	682	
Bolivia	Russia	1	39	37
Bolivia	Spain	199	520	143
Bolivia	Switzerland		21	
Bolivia	UK	22		
Brazil	Austria	586	487	393
Brazil	Belarus	66		19
Brazil	Belgium	17000	20000	23239
Brazil	Bosnia & Her.	26		153
Brazil	Bulgaria	3		
Brazil	Croatia	100	27	252
Brazil	Cyprus	97	267	70
Brazil	Czech Rep.	456	455	769
Brazil	Denmark	4469	4194	6435
Brazil	Estonia	64	75	
Brazil	Finland		26	
Brazil	France	35000	41000	41298
Brazil	Georgia			307
Brazil	Germany	3000	4000	6811
Brazil	Greece		52	
Brazil	Hungary	20		
Brazil	Ireland	47	9	45
Brazil	Israel	1000	2000	1170
Brazil	Italy	3000	2000	1662
Brazil	Jordan		536	81
Brazil	Lithuania	109	103	203
Brazil	Luxembourg	55	12	12
Brazil	Morocco			26
Brazil	Netherlands	48000	60000	69508
Brazil	Norway	1113	1031	1658
Brazil	Poland	2000	1000	444
Brazil	Portugal	11650	13939	13878
Brazil	Moldova	20	3	
Brazil	Romania		24	
Brazil	Russia	53	58	24
Brazil	Slovakia	4		46
Brazil	Slovenia	395	408	500
Brazil	Spain	8506	7000	12645
Brazil	Sweden	326	357	342
Brazil	Switzerland	1194	1097	536
Brazil	Turkey	322	42	83
Brazil	UK	6000	5000	604
Brazil	Ukraine	6	1	40
Brunei Daruss.	Slovenia	19		
Burkina Faso	Greece		27	
Burundi	France		1	
Cabo Verde	Spain		21	

Origin	Destination	2013	2014	2015
Cambodia	Netherlands		1	
Cameroon	Albania	20		
Cameroon	Algeria	108	395	999
Cameroon	Austria	226	181	107
Cameroon	Belarus	306		17
Cameroon	Belgium	14000	107000	104000
Cameroon	Bosnia & Her.	21	23	30
Cameroon	Bulgaria	139	233	34
Cameroon	Croatia	185	196	58
Cameroon	Cyprus	118	146	382
Cameroon	Czech Rep.	442	282	201
Cameroon	Denmark	1043	418	678
Cameroon	Estonia	26	168	109
Cameroon	Finland	246	445	257
Cameroon	France	52000	27000	10000
Cameroon	Germany	2000	7000	1000
Cameroon	Greece	625	1425	1177
Cameroon	Ireland	4631	18464	9899
Cameroon	Israel		32	
Cameroon	Italy	35000	64000	57000
Cameroon	Jordan	138	110	51
Cameroon	Latvia		129	
Cameroon	Lithuania	322	96	110
Cameroon	Luxembourg	118	82	70
Cameroon	Malta	281	1042	279
Cameroon	Morocco		461	364
Cameroon	Netherlands	2000	14000	1000
Cameroon	Norway	43	103	225
Cameroon	Poland	428	1000	311
Cameroon	Portugal	5633	10358	7567
Cameroon	Rep. Moldova		3	
Cameroon	Romania	234	340	
Cameroon	Russia	358	617	367
Cameroon	Slovakia	21	106	
Cameroon	Slovenia	102	21	1
Cameroon	Spain	19825	24000	3000
Cameroon	Sweden	21		
Cameroon	Switzerland	137	180	203
Cameroon	Tunisia	3356	2950	5824
Cameroon	Turkey	16324	24193	29536
Cameroon	UK	25719	18000	2000
Cameroon	Ukraine	80	109	157
Canada	Algeria	48	47	290
Canada	Austria	358	390	316
Canada	Belarus	63		
Canada	Belgium	1000	1000	1000
Canada	Bosnia & Her.			9
Canada	Bulgaria	212	85	
Canada	Croatia	10	72	52
Canada	Cyprus	95	38	23
Canada	Czech Rep.	19	78	
Canada	Denmark	485	415	433
Canada	Estonia	1163	1628	318
Canada	Finland	161	171	123
Canada	France	1000	1000	1000
Canada	Germany	12000	11000	10000
Canada	Greece	336	82	52
Canada	Ireland	936	773	834
Canada	Israel	1000	2000	919

Origin	Destination	2013	2014	2015
Canada	Italy	3000	2000	2000
Canada	Jordan	11213	8676	3000
Canada	Lithuania	345	628	279
Canada	Malta	53		76
Canada	Morocco	2140	2420	1594
Canada	Netherlands	1000	1000	1000
Canada	Norway	1348	1670	3825
Canada	Poland	1000	1000	192
Canada	Portugal	495	338	181
Canada	Russia	207	100	14
Canada	Slovakia	5	11	23
Canada	Slovenia	5	55	42
Canada	Spain	359	2000	1000
Canada	Sweden	369	535	246
Canada	Switzerland	103	126	162
Canada	Tunisia	41	65	3
Canada	Turkey	1272	1915	1782
Canada	UK	16000	16000	15000
Canada	Ukraine	21	6	
Central Af. Rep.	Austria			527
Central Af. Rep.	Belarus	18		
Central Af. Rep.	Belgium	1338	1289	1491
Central Af. Rep.	Bosnia & Her.		12	
Central Af. Rep.	Denmark	79		22
Central Af. Rep.	Finland	34	6	
Central Af. Rep.	France	408	11613	9198
Central Af. Rep.	Germany	598	6192	3677
Central Af. Rep.	Italy		47	57
Central Af. Rep.	Morocco		6080	6885
Central Af. Rep.	Netherlands	1128		
Central Af. Rep.	Portugal		64	
Central Af. Rep.	Russia	12	28	3
Central Af. Rep.	Slovakia	20	21	21
Central Af. Rep.	Spain	37		226
Central Af. Rep.	Switzerland	252	158	39
Central Af. Rep.	Turkey	333	396	393
Chile	Belgium	65	43	35
Chile	Denmark	46	47	
Chile	France	21	25	
Chile	Georgia	35	33	51
Chile	Germany	29	27	28
Chile	Israel		22	
Chile	Italy	66	22	47
Chile	Jordan	45		
Chile	Lithuania		13	
Chile	Malta			24
Chile	Morocco		45	
Chile	Netherlands	807	966	1057
Chile	Russia	1		
Chile	Spain	42	32	75
Chile	Sweden	18	8	
Chile	UK	43	47	45
China	Albania	7	54	16
China	Algeria		4	72
China	Austria		61	71
China	Azerbaijan	98	65	
China	Belarus	7		
China	Belgium	1172	582	420
China	Bosnia &		18	20

Origin	**Destination**	**2013**	**2014**	**2015**
	Herze.			
China	Bulgaria	8		
China	Croatia	160	139	153
China	Cyprus	109	19	3
China	Czech Rep.	98	90	122
China	Denmark	328	128	95
China	Estonia		1	1
China	Finland	1	1	21
China	France	1075	425	744
China	Georgia			18
China	Germany	1819	1641	1351
China	Greece	37		
China	Hungary	34	8	
China	Ireland	453	45	118
China	Israel	107	551	740
China	Italy	1645	1320	1265
China	Jordan	577	621	317
China	Kazakhstan	20	26	13
China	Latvia	17	2	
China	Lithuania			3
China	Luxembourg	2	3	9
China	Malta	23	23	22
China	Morocco		2	32
China	Netherlands	5720	2622	2288
China	Norway	181	207	28
China	Poland	89	85	15
China	Portugal	2	17	28
China	Romania	10	12	
China	Russia	45	141	162
China	Slovakia		5	8
China	Slovenia	646	255	334
China	Spain	83	167	94
China	Sweden	38	117	238
China	Switzerland	42	42	94
China	Tunisia			9
China	Turkey		38	29
China	UK	1958	2397	1368
China	Ukraine	35		37
Colombia	Czech Rep.	59		
Colombia	Denmark			22
Colombia	France	25	12	
Colombia	Germany	96	35	
Colombia	Israel	252	346	99
Colombia	Netherlands		60	
Colombia	Spain	57	32	33
Colombia	Switzerland	2		
Congo	Albania	98		
Congo	Algeria	443	769	3583
Congo	Austria		47	175
Congo	Belarus	164		10
Congo	Belgium	26360	61141	11939
Congo	Bosnia & Her.		2	2
Congo	Bulgaria	113	30	121
Congo	Croatia	35	130	50
Congo	Cyprus		47	20
Congo	Czech Rep.	123	279	
Congo	Denmark	1626	2147	639
Congo	Estonia			20
Congo	Finland	68		61
Congo	France	21948	98055	10723
Congo	Germany	14717	25605	6375
Congo	Greece	71	122	20
Congo	Ireland	632	1316	261
Congo	Israel	206	556	76
Congo	Italy	2936	9949	2181
Congo	Jordan	44	90	101
Congo	Kyrgyzstan			55
Congo	Lithuania		3	42
Congo	Malta	21	174	61
Congo	Morocco	1880	935	60
Congo	Netherlands	2190	2638	
Congo	Poland	1434	1446	451
Congo	Portugal	4351	10775	5057
Congo	Romania		31	63
Congo	Russia	145	96	86
Congo	Slovakia		2	3
Congo	Slovenia	41	404	8
Congo	Spain	2171	6369	2350
Congo	Switzerland		258	596
Congo	Tunisia	929	2219	1297
Congo	Turkey	2986	1076	1359
Congo	UK	17099	46643	4436
Congo	Ukraine	8	25	5
Costa Rica	Austria		42	2
Costa Rica	Bulgaria	16		
Costa Rica	Denmark	16		
Costa Rica	Estonia	10		
Costa Rica	Finland	42		
Costa Rica	France	25		
Costa Rica	Germany	58		39
Costa Rica	Ireland	4		
Costa Rica	Israel	12	13	8
Costa Rica	Italy	28		63
Costa Rica	Netherlands		437	2
Costa Rica	Poland			40
Costa Rica	Russia	8		
Costa Rica	Spain		21	136
Costa Rica	Switzerland	3		2
Côte d’Ivoire	Albania		75	81
Côte d’Ivoire	Algeria	188		22
Côte d’Ivoire	Austria	189	166	11
Côte d’Ivoire	Belarus	53		
Côte d’Ivoire	Belgium	11193	33462	28234
Côte d’Ivoire	Bosnia & Her.		5	8
Côte d’Ivoire	Bulgaria	26	98	27
Côte d’Ivoire	Croatia	10		104
Côte d’Ivoire	Cyprus	48	218	105
Côte d’Ivoire	Czech Rep.	25	19	
Côte d’Ivoire	Denmark	203	202	
Côte d’Ivoire	Estonia	20	20	
Côte d’Ivoire	France	5943	7532	5824
Côte d’Ivoire	Germany	11920	15483	12445
Côte d’Ivoire	Greece	1195	4415	3864
Côte d’Ivoire	Ireland	332	881	654
Côte d’Ivoire	Israel		96	16
Côte d’Ivoire	Italy	12198	27494	28357
Côte d’Ivoire	Jordan	135	197	59
Côte d’Ivoire	Lithuania	73	28	

Origin	Destination	2013	2014	2015
Côte d’Ivoire	Malta	23	201	144
Côte d’Ivoire	Morocco		274	70
Côte d’Ivoire	Netherlands	2681	5599	3651
Côte d’Ivoire	Poland	282	159	109
Côte d’Ivoire	Portugal	1836	1559	1300
Côte d’Ivoire	Romania		54	75
Côte d’Ivoire	Russia	264	183	125
Côte d’Ivoire	Slovakia	3	5	5
Côte d’Ivoire	Slovenia	3		45
Côte d’Ivoire	Spain	2817	7157	4308
Côte d’Ivoire	Switzerland	57	57	30
Côte d’Ivoire	Tunisia	486	193	41
Côte d’Ivoire	Turkey	1103	1162	1333
Côte d’Ivoire	UK	5414	12344	11250
Côte d’Ivoire	Ukraine	18	89	
Dem. Rep. Congo	Algeria			20
Dem. Rep. Congo	Belarus			1
Dem. Rep. Congo	Belgium	12965	12170	11794
Dem. Rep. Congo	Croatia		19	
Dem. Rep. Congo	Cyprus	63	53	198
Dem. Rep. Congo	Czech Rep.	50	6	
Dem. Rep. Congo	Denmark	242	215	133
Dem. Rep. Congo	Estonia	12		
Dem. Rep. Congo	France	1082	823	1091
Dem. Rep. Congo	Germany	850	1991	1373
Dem. Rep. Congo	Greece		46	
Dem. Rep. Congo	Ireland	55	121	48
Dem. Rep. Congo	Italy	1037	345	137
Dem. Rep. Congo	Lithuania		27	7
Dem. Rep. Congo	Malta	66		41
Dem. Rep. Congo	Morocco		433	688
Dem. Rep. Congo	Netherlands	9728	2669	
Dem. Rep. Congo	Poland	169	36	87
Dem. Rep. Congo	Portugal	1051	1636	1639
Dem. Rep. Congo	Russia	57	23	2
Dem. Rep. Congo	Slovenia	40	57	178
Dem. Rep. Congo	Spain	353	796	1145
Dem. Rep. Congo	Switzerland	562	1203	575
Dem. Rep. Congo	Turkey	929	1778	924
Dem. Rep. Congo	UK	1125	1484	3250
Dem. Rep. Congo	Ukraine	208		1
Djibouti	Poland	14		
Dominican Rep.	Netherlands			2
Dominican Rep.	Turkey	211	27	
Ecuador	Austria	15	19	10
Ecuador	Belgium		26	28
Ecuador	Bulgaria	10	8	26
Ecuador	Czech Rep.	47	14	
Ecuador	Denmark	1900	1882	2103
Ecuador	Finland	234	212	204
Ecuador	France	817	632	925
Ecuador	Germany	2752	3498	3373
Ecuador	Hungary	6		
Ecuador	Israel	3		2
Ecuador	Italy	50	34	39
Ecuador	Latvia	14		
Ecuador	Lithuania	652	774	1117
Ecuador	Morocco	8		
Ecuador	Netherlands	472	1392	2851
Ecuador	Poland	932	994	1714
Ecuador	Russia	4	6	4
Ecuador	Slovenia	10		
Ecuador	Spain	394	729	2014
Ecuador	Switzerland	34	50	45
Ecuador	Turkey			16
Ecuador	UK	238	170	206
Egypt	Belgium	1		
Egypt	Spain		23	
El Salvador	France	5		20
El Salvador	Turkey	6		
Equatorial Guinea	France	95		
Equatorial Guinea	Italy	274	92	70
Equatorial Guinea	Morocco			36
Equatorial Guinea	Portugal			139
Equatorial Guinea	Spain	37	9	60
Eritrea	Portugal	24		
Fiji	France		21	30
Fiji	Israel		42	21
Fiji	Switzerland		7	
Gabon	Albania	188		169
Gabon	Algeria			21
Gabon	Austria		2	
Gabon	Belgium	19000	16000	19000
Gabon	Bosnia & Her.	8		81
Gabon	Cyprus		812	
Gabon	Czech Rep.	4		
Gabon	Denmark	22		21
Gabon	France	9000	7000	5000
Gabon	Germany	3000	1000	2000
Gabon	Greece	33	80	125
Gabon	Ireland	2		
Gabon	Italy	8000	5000	5000
Gabon	Jordan	42		57
Gabon	Malta	45	22	
Gabon	Morocco		169	50
Gabon	Netherlands	11000	1000	1000
Gabon	Poland	67	173	215
Gabon	Portugal	2969	2239	3943
Gabon	Russia	53	23	21
Gabon	Spain	1377	1708	1000
Gabon	Switzerland	45	70	55
Gabon	Tunisia	1451		311
Gabon	Turkey	676	1198	1414
Gabon	UK	142	175	272
Gabon	Ukraine		1	
Ghana	Algeria		147	22
Ghana	Austria	111	105	58
Ghana	Belarus	9		
Ghana	Belgium	3284	1238	1696
Ghana	Bosnia & Her.	542	860	1133
Ghana	Bulgaria	76	19	25
Ghana	Croatia	75		
Ghana	Cyprus	11		41
Ghana	Czech Rep.	1	13	23
Ghana	Denmark	538	308	627
Ghana	Estonia	55		
Ghana	Finland	24	2	
Ghana	France	2995	2526	2230

Origin	Destination	2013	2014	2015
Ghana	Germany	12901	7070	7480
Ghana	Greece	126	253	396
Ghana	Ireland	192	40	87
Ghana	Israel	1373	853	418
Ghana	Italy	1138	1667	1745
Ghana	Jordan	73	111	21
Ghana	Lithuania	77	48	46
Ghana	Malta	71	73	
Ghana	Morocco	101	336	424
Ghana	Netherlands	739	1480	210
Ghana	Poland	283	218	242
Ghana	Portugal	182	47	64
Ghana	Russia	325	380	115
Ghana	Slovenia	60	38	31
Ghana	Spain	117	318	194
Ghana	Switzerland	117	107	51
Ghana	Turkey	11	535	178
Ghana	UK	3492	3094	1620
Ghana	Ukraine	19	5	10
Guatemala	Austria		1	3
Guatemala	Germany	37	56	183
Guatemala	Netherlands		64	384
Guatemala	Poland	1	2	
Guatemala	Spain	73	63	251
Guatemala	Switzerland			2
Guatemala	Turkey		40	46
Guinea	Belgium			57
Guinea	Czech Rep.			20
Guinea	France			1
Guinea	Germany			182
Guinea	Greece	22		
Guinea	Morocco		25	
Guinea	Netherlands		6	
Guinea	Spain		51730	122
Guinea	Turkey		43	174
Guinea-Bissau	Morocco		50	
Guinea-Bissau	Portugal	79		
Guinea-Bissau	Spain	23		
Guyana	Belgium		320	125
Guyana	Bulgaria		65	
Guyana	Cyprus		25	
Guyana	Denmark	40		17
Guyana	France	72	48	67
Guyana	Germany	253	21	15
Guyana	Italy	47	47	339
Guyana	Netherlands	2853	2577	1961
Guyana	UK	3229	6438	6363
Honduras	Denmark	8		
Honduras	Germany		17	
Honduras	Portugal	18		
Honduras	Spain	32	18	
Honduras	UK	587	1691	417
Iceland	Ireland			40
Iceland	Israel			32
Iceland	Netherlands	2		2
Iceland	Norway	5	1	1
India	Austria	60	50	58
India	Belgium	4420	6805	7692
India	Croatia	88	173	15
India	Czech Rep.	7		
India	Denmark	104	106	296
India	Estonia	2		
India	Finland	218	302	171
India	France	958	1560	1824
India	Germany	595	393	60
India	Greece	194	480	131
India	Israel		53	44
India	Italy	2821	2274	2784
India	Moldova	3		
India	Netherlands	4276	6873	3274
India	Norway	37	5	61
India	Poland		35	4
India	Portugal	6		4
India	Russia	10	9	2
India	Slovenia	7	67	
India	Spain	38	39	32
India	Sweden	11	15	9
India	Switzerland	25		31
India	Turkey	179	88	12
India	UK	36	26	33
India	Ukraine	33		
Indonesia	Austria	91	512	346
Indonesia	Azerbaijan	2		7
Indonesia	Belarus	13		
Indonesia	Belgium	1683	2000	1567
Indonesia	Bosnia & Her.			3
Indonesia	Cyprus	23	18	35
Indonesia	Czech Rep.	168	25	24
Indonesia	Denmark	56		110
Indonesia	Estonia	77	183	121
Indonesia	Finland	16	69	
Indonesia	France	1000	2000	1000
Indonesia	Germany	892	1000	657
Indonesia	Greece	163	220	161
Indonesia	Hungary			2
Indonesia	Ireland	57	26	48
Indonesia	Italy	497	1000	1000
Indonesia	Jordan	51		211
Indonesia	Kazakhstan	8		
Indonesia	Lithuania	253	172	209
Indonesia	Luxembourg	9	4	52
Indonesia	Morocco		2	
Indonesia	Netherlands	1000	1000	2000
Indonesia	Norway		25	18
Indonesia	Poland	2973	1879	3000
Indonesia	Moldova	38	22	33
Indonesia	Romania	126		12
Indonesia	Russia	18	33	22
Indonesia	Slovakia	80	60	7
Indonesia	Slovenia	49	160	274
Indonesia	Spain	82	29	10
Indonesia	Sweden	38	192	61
Indonesia	Switzerland	108	18	18
Indonesia	Turkey	591	176	139
Indonesia	UK	1536	2000	1000
Indonesia	Ukraine	61	2	3
Iran	France			39
Iran	Georgia	105	176	83

Origin	Destination	2013	2014	2015
Iran	Italy		39	
Iran	Kazakhstan		20	
Iran	Romania		24	
Iran	Turkey	115	125	167
Iraq	Turkey		1	
Jamaica	Portugal		22	
Japan	Czech Rep.			2
Japan	France			18
Japan	Germany	13	11	47
Japan	Netherlands	189	12	15
Japan	Norway			5
Japan	Romania			3
Japan	Slovenia			18
Japan	Spain			4
Japan	UK			1
Kenya	Denmark	4		
Kenya	Italy			5
Kenya	Netherlands			4
Kenya	Switzerland		23	
Kenya	UK		8	
Lao PDR	Denmark		24	
Lao PDR	Germany			14
Lao PDR	Russia	19		49
Lao PDR	Slovenia	42	109	166
Liberia	Czech Rep.			15
Liberia	France	70		
Liberia	Ireland	9	5	
Liberia	Israel		13	
Liberia	Jordan			42
Liberia	Netherlands	59	204	
Liberia	Russia	44		
Madagascar	France	53	788	992
Madagascar	Germany		34	12
Malaysia	Austria	52	141	267
Malaysia	Belarus	16		30
Malaysia	Belgium	10000	10000	9000
Malaysia	Bosnia & Her.	47		18
Malaysia	Cyprus	30	55	53
Malaysia	Czech Rep.	85	238	232
Malaysia	Denmark	1080	930	1038
Malaysia	Finland			27
Malaysia	France	8000	8000	6000
Malaysia	Germany	8000	9000	8000
Malaysia	Greece	1750	2534	2174
Malaysia	Ireland	26	94	246
Malaysia	Israel		22	
Malaysia	Italy	3000	3000	3000
Malaysia	Jordan	1119	527	700
Malaysia	Lithuania	14	60	
Malaysia	Luxembourg	383	325	418
Malaysia	Malta			20
Malaysia	Netherlands	25000	37000	39000
Malaysia	Norway	4131	2833	3437
Malaysia	Poland	3000	3000	1000
Malaysia	Portugal		28	
Malaysia	Moldova	2	9	8
Malaysia	Romania	15		
Malaysia	Russia	17	42	21
Malaysia	Slovakia	46	18	
Malaysia	Slovenia	135	58	36
Malaysia	Spain	17	99	35
Malaysia	Sweden		21	
Malaysia	Switzerland	48	9	107
Malaysia	Turkey	128	626	411
Malaysia	UK	12000	12000	10000
Malaysia	Ukraine	6		
Mali	Norway		48	
Mauritius	France		59	39
Mauritius	Jordan			71
Mauritius	Spain	68		
Mexico	Denmark		58	
Mexico	Germany	75	14	31
Mexico	Israel	9		
Mexico	Netherlands			2
Mexico	Norway		1	1
Mexico	Russia		3	3
Mexico	Spain	2	2	1
Mexico	UK		11	8
Mozambique	Belgium			171
Mozambique	Czech Rep.	36	423	
Mozambique	France	129	122	286
Mozambique	Germany	35	142	96
Mozambique	Italy	34		
Mozambique	Netherlands		65	
Mozambique	Poland	31	18	
Mozambique	Portugal	30		
Mozambique	UK		23	28
Myanmar	Austria	13		144
Myanmar	Belgium	72	144	127
Myanmar	Croatia	45	29	34
Myanmar	Czech Rep.			5
Myanmar	Denmark	340	249	397
Myanmar	Finland	67	49	79
Myanmar	France	20	134	176
Myanmar	Germany	489	205	1020
Myanmar	Greece		11	11
Myanmar	Israel	139	441	151
Myanmar	Italy	636	790	696
Myanmar	Netherlands	5301	4070	2723
Myanmar	Norway	287	224	952
Myanmar	Poland		83	59
Myanmar	Portugal			12
Myanmar	Russia	27	20	20
Myanmar	Slovenia	33	30	34
Myanmar	Spain		27	23
Myanmar	Sweden	43	48	48
Myanmar	Switzerland	11	6	13
Myanmar	Turkey	810	624	360
Myanmar	UK	67	41	20
Myanmar	Ukraine			4
Nepal	Denmark		2	
New Zealand	Belgium			14
New Zealand	Denmark		38	25
New Zealand	Germany		4	22
New Zealand	Italy	9	2	
New Zealand	Netherlands		177	9
New Zealand	Norway	294		
Nicaragua	Belgium		21	35

Origin	Destination	2013	2014	2015
Nicaragua	Bosnia & Her.		2	
Nicaragua	Germany	21	25	15
Nicaragua	Israel	17		21
Nicaragua	Netherlands			172
Nicaragua	Spain			19
Nicaragua	Turkey			17
Niger	Ireland	64	17	
Niger	Turkey	20		
Nigeria	Belgium	26		
Nigeria	Czech Rep.	82	55	
Nigeria	Germany	40	3	
Nigeria	Ireland			1
Nigeria	Italy	37	115	45
Nigeria	Lithuania	18		
Nigeria	Netherlands		26	
Nigeria	Russia		11	
Nigeria	Spain	32	89	
Nigeria	Turkey	408	391	1406
Nigeria	Ukraine	4		40
Oman	Morocco			3
Pakistan	Austria			27
Pakistan	Czech Rep.			17
Pakistan	Greece		4	
Pakistan	Netherlands			2
Panama	Belgium	94	17	
Panama	Denmark	11	48	
Panama	France		103	50
Panama	Germany	98	53	27
Panama	Israel	405	115	168
Panama	Italy	22		3
Panama	Netherlands	11		1
Panama	Portugal	49	52	
Panama	Russia	23		
Panama	Sweden			43
Panama	UK		9	32
Papua N. Guinea	Belgium	36		50
Papua N. Guinea	Bulgaria		3	8
Papua N. Guinea	Czech Rep.	20		
Papua N. Guinea	Finland	17		
Papua N. Guinea	Germany	22	43	69
Papua N. Guinea	Italy			25
Papua N. Guinea	Lithuania	25		
Papua N. Guinea	Netherlands			108
Papua N. Guinea	Poland	240	25	25
Papua N. Guinea	Turkey	3		
Papua N. Guinea	UK	41		31
Paraguay	Austria			17
Paraguay	Belarus	15		
Paraguay	France	26	54	50
Paraguay	Germany	19	35	14
Paraguay	Israel	42		
Paraguay	Italy	48	148	70
Paraguay	Lithuania	2		
Paraguay	Netherlands	28	3	
Paraguay	Russia		1	106
Paraguay	Slovenia			56
Paraguay	Spain	22	9	22
Paraguay	Switzerland		1	
Paraguay	UK	18		15

Origin	Destination	2013	2014	2015
Peru	Algeria	34		
Peru	Austria			25
Peru	Belgium	289	58	337
Peru	Bulgaria			26
Peru	Czech Rep.			18
Peru	Denmark	160	723	727
Peru	France	172	210	72
Peru	Germany	24	63	68
Peru	Greece			27
Peru	Israel	34	80	
Peru	Italy	126		
Peru	Lithuania		67	
Peru	Netherlands	5455	6077	6052
Peru	Norway			228
Peru	Poland		31	
Peru	Portugal			40
Peru	Russia	22		4
Peru	Slovakia		6	
Peru	Spain	51	98	131
Peru	Sweden	24	158	140
Peru	Switzerland	21		
Peru	UK	100	344	459
Peru	Ukraine	1		
Philippines	Belgium	105		
Philippines	Czech Rep.	739		15
Philippines	France	1000		
Philippines	Germany	3000		
Philippines	Italy	6		
Philippines	Kazakhstan	6		
Philippines	Netherlands	1000		1
Philippines	UK	1000	47	37
Rep. Korea	Algeria			50
Rep. Korea	Austria			46
Rep. Korea	Hungary	4	3	
Rep. Korea	Israel			56
Rep. Korea	Kazakhstan		2	
Rep. Korea	Latvia			5
Rep. Korea	Netherlands			7
Rep. Korea	Spain			1
Saudi Arabia	UK			26
Senegal	France		5	
Senegal	UK		42	
Sierra Leone	Belgium	19		
Sierra Leone	Finland	23		
Sierra Leone	France	165		
Sierra Leone	Italy	99	18	
Sierra Leone	Turkey	130		
Singapore	Belgium	155	896	313
Singapore	Denmark	568	478	139
Singapore	Finland	79	24	18
Singapore	France	88	47	26
Singapore	Germany	1260	106	991
Singapore	Ireland			23
Singapore	Israel	389	356	440
Singapore	Italy	200	361	19
Singapore	Kazakhstan	1		
Singapore	Lithuania	23		
Singapore	Netherlands	1460	328	4364
Singapore	Norway	1602	378	243

Origin	Destination	2013	2014	2015
Singapore	Portugal		197	
Singapore	Russia	19		
Singapore	Sweden		33	15
Singapore	Switzerland			40
Singapore	Turkey	17		
Singapore	UK	408	287	433
Solomon Islands	Austria			75
Solomon Islands	Belgium		16	14
South Africa	Austria	141		
South Africa	Bosnia & Her.		22	
South Africa	Bulgaria		19	
South Africa	Czech Rep.	19	15	
South Africa	France	4	1465	424
South Africa	Jordan	5		
South Africa	Netherlands	1198	165	169
South Africa	Norway			30
South Africa	Russia		1	
South Africa	Slovenia		2	4
South Africa	Spain	26	37	50
South Africa	Sweden			3
South Africa	Switzerland	128	27	31
South Africa	Turkey	36		
South Africa	UK	23		24
Sri Lanka	France	4	3	11
Sri Lanka	Germany	5		16
Sri Lanka	Netherlands	178		
Sri Lanka	Portugal			39
Sri Lanka	Sweden			1
Sri Lanka	Switzerland			3
Suriname	Belarus	64		
Suriname	Belgium	3574	2613	5647
Suriname	Bulgaria	20	23	24
Suriname	Denmark		575	117
Suriname	France	1042	1271	747
Suriname	Germany	4267	1174	5186
Suriname	Israel	399	496	440
Suriname	Italy	68	130	150
Suriname	Luxembourg			7
Suriname	Netherlands	6659	4306	5896
Suriname	Norway			1
Suriname	Spain			54
Suriname	Switzerland	159		
Suriname	Turkey		49	
Suriname	UK	208	24	50
Syrian Arab Rep.	Belgium	139		
Syrian Arab Rep.	Jordan	22		
Syrian Arab Rep.	UK		28	
Tanzania	Austria			28
Tanzania	France	122	121	51
Tanzania	Germany	16	38	48
Tanzania	Spain	10	25	41
Tanzania	Sweden			3
Tanzania	Turkey			66
Tanzania	UK	39	3	17
Thailand	Austria			17
Thailand	Belgium			57
Thailand	Czech Rep.			54
Thailand	Denmark	87		26
Thailand	Estonia	6	2	

Origin	Destination	2013	2014	2015
Thailand	France	12	847	1000
Thailand	Georgia	42		
Thailand	Germany	74		
Thailand	Greece		22	
Thailand	Israel	88	1	104
Thailand	Italy			24
Thailand	Jordan		1	
Thailand	Netherlands	1239	1000	47
Thailand	Norway	172	297	313
Thailand	Poland	28	88	
Thailand	Slovenia	25		
Thailand	Sweden	6	6	5
Thailand	Switzerland		3	
Thailand	Turkey	303		
Thailand	UK	23		
Togo	Morocco		16	
Togo	Spain	58		
Trinidad & Tobago	Italy			2
Trinidad & Tobago	UK	23		17
UAE	Austria		70	
UAE	Azerbaijan			14
UAE	France		25	4
UAE	Jordan	10	16	13
UAE	Malta			29
UAE	Netherlands	27	15	72
Uruguay	Belgium	369	197	195
Uruguay	Czech Rep.	1		
Uruguay	Denmark			25
Uruguay	France	316	818	980
Uruguay	Germany		24	74
Uruguay	Israel			27
Uruguay	Italy	195	176	79
Uruguay	Latvia			25
Uruguay	Lithuania	25	24	25
Uruguay	Netherlands	109	214	152
Uruguay	Poland		39	
Uruguay	Romania			19
Uruguay	Slovenia	26		
Uruguay	Spain	417		
Uruguay	Sweden			26
Uruguay	UK	1914	3502	2183
USA	Albania	136	131	159
USA	Algeria	101	87	345
USA	Austria	1000	1000	1000
USA	Azerbaijan	41		
USA	Belarus	339	18	246
USA	Belgium	11000	10000	11000
USA	Bosnia & Her.	54	3	25
USA	Bulgaria	232	256	120
USA	Croatia	30	34	20
USA	Cyprus	463	473	516
USA	Czech Rep.	642	826	136
USA	Denmark	3895	3656	2702
USA	Estonia	6588	8967	5637
USA	Finland	2525	2449	1643
USA	France	6000	4000	5000
USA	Georgia	188	113	266
USA	Germany	44000	50000	45000
USA	Greece	2943	3137	2076

Origin	Destination	2013	2014	2015
USA	Hungary			79
USA	Ireland	6404	7477	7078
USA	Israel	12000	11000	8501
USA	Italy	147000	73000	59000
USA	Jordan	3753	5112	2518
USA	Kazakhstan		29	
USA	Kyrgyzstan			16
USA	Latvia	159	271	143
USA	Lithuania	2190	2287	3000
USA	Luxembourg	57		
USA	Malta	1822	1766	1316
USA	Morocco	1836	2364	3988
USA	Netherlands	8000	7000	7000
USA	Norway	16269	20391	21037
USA	Poland	2000	3000	3000
USA	Portugal	20125	16374	13087
USA	Romania	148	117	150
USA	Russia	1826	1427	548
USA	Slovakia	43	63	6
USA	Slovenia	46	21	90
USA	Spain	19155	36000	45000
USA	Sweden	6295	8464	8123
USA	Switzerland	1067	966	1114
USA	Tunisia	108	28	
USA	Turkey	10835	10184	10542
USA	UK	120000	106000	95000
USA	Ukraine	48	26	4
Venezuela	Russia	8		
Vietnam	Austria			100
Vietnam	Czech Rep.			44
Vietnam	France	2135	2322	3000
Vietnam	Germany	8	112	
Vietnam	Israel	1		
Vietnam	Italy		24	43
Vietnam	Jordan		43	
Vietnam	Netherlands	105	21	4
Vietnam	Norway	2		
Vietnam	Russia	11		
Vietnam	Slovenia		25	12
Vietnam	Sweden			50
Vietnam	Switzerland			258
Vietnam	Ukraine		19	
Zambia	Netherlands			1
Zambia	Russia		79	
Zimbabwe	Netherlands			1

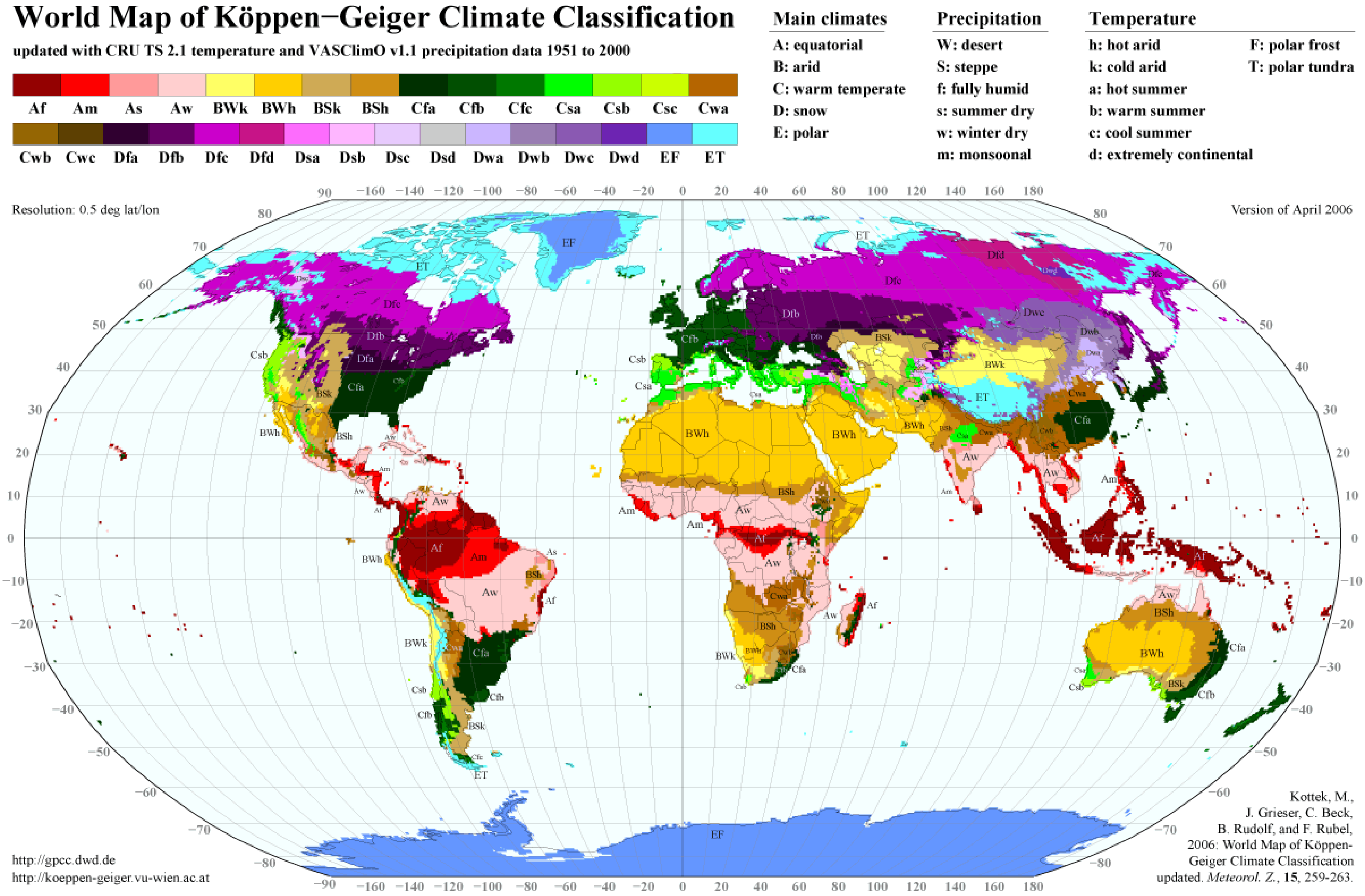
Table 5. FAOSTAT – Wood chips and particles in m^3 (imports by EPPO countries)

Origin	Destination	2013	2014	2015
Argentina	France	14		9
Australia	Czech Rep.	7000		
Australia	France	8	21	80
Australia	Italy	4	4	
Australia	Sweden	13		
Brazil	Denmark	3	5	12
Brazil	France		4	
Brazil	Germany	811000	835000	913000
Brazil	Italy			4
Brazil	Netherlands	6		
Brazil	Portugal	506000	20000	13000
Brazil	Spain	175000	125000	
Brazil	Sweden	26	3000	
Brazil	Turkey	586000	987000	676000
Burkina Faso	France			2
Cameroon	Italy		4	
Canada	Austria			1
Canada	Belgium	1	91	20
Canada	Czech Rep.		7	
Canada	Finland		27	24
Canada	Germany		1000	1000
Canada	Greece		4	
Canada	Hungary		1	
Canada	Israel		1	
Canada	Italy	6	27000	11
Canada	Netherlands	7	24	1000
Canada	Norway		31	
Canada	Poland	21	6	
Canada	Spain	1		84
Canada	Sweden	101	77	206
Canada	Switzerland		2	
Canada	Turkey	512000	528000	460000
Canada	UK	6	86	140
Canada	Ukraine		1	
Chile	France	8	18	16
Chile	Germany	2	11	2
Chile	Italy	75	123	223
Chile	Portugal		11000	
Chile	Spain		11	
China	Austria	451	1	1
China	Belgium		36	
China	Denmark	1		6
China	Estonia		1	1
China	Finland	11	20	3
China	France		5	8
China	Hungary		2	
China	Ireland		2	6
China	Italy		14	
China	Netherlands	35	18	33
China	Norway	66		125
China	Russia			1
China	Slovakia	3	2	
China	Sweden	8	13	70
China	Switzerland		2	7
China	Turkey	2117		
China	UK	2		9
Congo	Portugal	35479		
Congo	Spain	38729		
Congo	Turkey	33801	36171	
Costa Rica	Italy	19		
Costa Rica	Switzerland			38
Côte d’Ivoire	Lithuania		101	
Côte d’Ivoire	Tunisia	23		
Ecuador	Netherlands	1		
Egypt	Belgium		2	
Egypt	Cyprus	7	2	
Egypt	Denmark	19		
Egypt	Germany	100		
Egypt	Greece	18		
Egypt	Israel		34	
Egypt	Italy	155	399	78
Egypt	Malta		21	
Egypt	Morocco	27		
Egypt	UK	19	48	207
Gabon	Ireland		3	
Ghana	Belgium		5	
Ghana	Denmark	75973	45815	
Ghana	France		84	
Ghana	Ireland			20
Ghana	Portugal		6	
Honduras	France			16
Honduras	UK		1	
India	Czech Rep.			42
India	Israel			4
India	Italy		1	
India	Netherlands	10	5	
India	UK		1	
Indonesia	Sweden	3		
Japan	Belgium	4		
Japan	France			2159
Japan	Russia			5
Japan	Sweden	2		8
Liberia	Italy	32531		
Malaysia	Denmark	2223		
Mexico	Austria	1		
Mexico	Poland			92
New Zealand	Denmark	2		
New Zealand	Germany			4
New Zealand	Russia			22
New Zealand	UK	2		
Nigeria	Belgium		15891	
Nigeria	Germany		2967	
Nigeria	Portugal		389	
Nigeria	UK			10
Philippines	Netherlands	24	35	
Philippines	Switzerland			1
Rep. Korea	Belgium	86	112	246
Rep. Korea	Italy			2
Rep. Korea	Norway			125
South Africa	Belgium		2	
South Africa	France	9		22000
South Africa	Netherlands		26	
South Africa	Sweden		3	
South Africa	UK	40	21	81
Sri Lanka	France	4	4	5
Sri Lanka	Netherlands			1

Origin	**Destination**	**2013**	**2014**	**2015**
Suriname	Czech Rep.			32
Thailand	France		62000	
Thailand	Israel		46	301
Thailand	Norway	37		
Thailand	Sweden		42	4
UAE	France		17	114
UAE	Ireland	4		
Uruguay	Norway	136000		
Uruguay	Portugal	489000	105000	53000
Uruguay	Spain	293000	186000	
Uruguay	Sweden			9
USA	Austria	89	18	86
USA	Azerbaijan	1	3	
USA	Belgium	1164	34	59
USA	Bulgaria	30		
USA	Czech Rep.	5	5	15
USA	Denmark	8000	4000	11000
USA	Finland	1000	13	23
USA	France	56000	37000	38000
USA	Georgia		22	19
USA	Germany	48000	55000	18000
USA	Hungary			13
USA	Ireland			16
USA	Israel	289	345	409
USA	Italy	89000	95000	15000
USA	Netherlands	23000	27	9000
USA	Norway	158	2369	415
USA	Poland	11	10	1000
USA	Russia	18	8	10
USA	Slovenia	1		18
USA	Spain	5000	14000	390
USA	Sweden	3000	4553	173
USA	Switzerland	1000	5	27
USA	Turkey	2063000	1826000	1703000
USA	UK	174	133	164
Venezuela	Austria		35799	
Venezuela	Italy		35568	
Venezuela	Turkey	243234	303970	173372
Vietnam	Denmark		100	
Vietnam	Germany		4	
Vietnam	Sweden			16
Zambia	Austria		158	

ANNEX 6. Köppen Geiger maps

Kottek M, Grieser J, Beck C, Rudolf B, Rubel F. 2006. World Map of the Köppen-Geiger climate classification updated Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263



Updated Köppen-Geiger Climate Classification (Kottek *et al*., 2006) showing only the distribution of the specific climate types that occur in the EU (courtesy R. Baker, Fera, UK)