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).

<table>
<tr><th>Possible sibling species</th><th>Stouthamer et al. (2017)</th><th>O'Donnel et al. (2015): sibling species</th></tr>
<tr><td rowspan="4">E. fornicatus sensu stricto
tea shot hole borer, TSHB
(at least Clade 1B, possibly including also Clade 1A)</td><td>Clade 1A (some specimens from Malaysia, Singapore and Thailand)</td><td></td></tr>
<tr><td rowspan="3">Clade 1B (E. fornicatus sensu stricto, tea shot hole borer), specimens from Sri Lanka, India, Thailand, Australia, Papua New Guinea, Taiwan, Hawaii, Florida</td><td>Euwallacea sp. #2 found in Florida</td></tr>
<tr><td>Euwallacea sp. #3 from Queensland (Australia)</td></tr>
<tr><td>Euwallacea sp. #4 from Sri Lanka, potentially the true E. fornicatus</td></tr>
<tr><td>Kuroshio shot hole borer, KSHB</td><td>Clade 2 with specimen from Taiwan, Okinawa, California, Mexico</td><td>Euwallacea sp. #5 found in California: Kuroshio Shot Hole</td></tr>
</table>

		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[1] 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.

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

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).

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

	References	Comments
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 - Florida - Hawaii	EPPO Global database	- PSHB/Euwallacea sp. #1 and KSHB/#5. First reported 2003 (Kirkendall and Ødegaard, 2007) - 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)

	References	Comments
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*

Family	Genus/Species
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*)
Fabaceae	*Prosopis articulata*
Fabaceae	*Robinia pseudoacacia*
Fabaceae	*Tephrosia candida*
Fabaceae	*Tephrosia vogelii*
Fabaceae	*Wisteria floribunda*
Fagaceae	*Quercus agrifolia*

Family	**Genus/Species**
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 integer*
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.
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*

Family	**Genus/Species**
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*

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