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[1] 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.

[1] 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) - South Carolina - Ohio	Atkinson, 2018 - Coyle *et al.*, 2005 - Lightle *et al.*, 2007	New York (1976) (Cognato *et al.*, 2015) - first report - 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	

EUWALLACEA INTERJECTUS	References	Comments
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*
Fabaceae	*Dalbergia hupeana*
Fagaceae	*Castanea crenata*
Fagaceae	*Fagus japonica* var. *multinervis*
Fagaceae	*Fagus* sp.
Fagaceae	*Quercus grosseserrata*
Fagaceae	*Quercus velutina*
Juglandaceae	*Juglans* sp.
Lauraceae	*Machilus* sp.
Magnoliaceae	*Magnolia obovata*
Malvaceae	*Tilia amurensis*

Family	Genus/Species
Moraceae	*Ficus carica*
Pinaceae	*Abies firma*
Pinaceae	*Pinus densiflora*
Pinaceae	*Pinus massoniana*
Pinaceae	*Pinus parvifolia*
Pinaceae	*Pinus sylvestris*
Pinaceae	*Pinus taiwanensis*
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*

Family	Genus/Species	Family	Genus/Species
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.
Malvaceae	*Bombax ceiba*
Malvaceae	*Bombax insigne* (as *Salmalia insignis)*
Malvaceae	*Kydia calycina*
Malvaceae	*Pterygota alata* (*Sterculia alata*)
Malvaceae	*Pterocymbium tinctorium* (*Sterculia campanulata*)

Family	Genus/Species
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*

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