



**NEW PEST ADVISORY GROUP (NPAG)**  
**Plant Epidemiology and Risk Analysis Laboratory**  
**Center for Plant Health Science & Technology**

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## NEW PEST ADVISORY GROUP (NPAG) Plant Epidemiology and Risk Analysis Laboratory Center for Plant Health Science & Technology

### NPAG Report

#### ***Euwallacea fornicatus* Eichhoff: Tea shot-hole borer**

Coleoptera: Curculionidae, Scolytinae, Xyleborini

DA Approval Date: February 19, 2013



Left: *Euwallacea fornicatus* (Eichhoff), Photo by G. Arakelian (UCCE 2012); Center: *Fusarium* sp. white powdery exudate surrounded by wet discoloration in association with a single beetle exit hole, cortex and wood under beetle hole; Right: brown discolored necrosis caused by fungus (Eskalen and Stouthamer, 2012)

**Initiating Event and Pest Identification:** On April 20, 2012, Mark Nakhla (PPQ CPHST Beltsville) concurred with the identification of an unnamed *Fusarium* species collected (on or about April 12, 2012) from a residential avocado (*Persea americana*) tree in Los Angeles County, CA (Nakhla, 2012), a new U.S. record for this pathogen. The fungus was analyzed at the University of California, Riverside, the California Department of Food and Agriculture (CDFA), and the CPHST Beltsville Laboratory; the sequencing results match and confirm the pathogen is the same as a new undescribed *Fusarium* species recently documented as causing dieback on avocado trees in Israel (Floyd, 2012; Mendel et al., 2012). The unnamed *Fusarium* sp. is vectored by *Euwallacea* (formerly *Xyleborus*) *fornicatus* (Eichhorn) (Mendel et al., 2012), an Asian ambrosia beetle present in three states in the United States (CA, FL, HI) (Browne, 1968; FDACS, 2003; Rabaglia et al., 2006). Both the fungus and the beetle were found on several backyard avocado trees in February and March 2012 (Eskalen and Stouthamer, 2012). On April 26, 2012, David Kaplan, PPQ EDP, notified NPAG of the detection and requested a review (Bertone, 2012).

There is a complication with the identity of the ambrosia beetle. The population in California has been identified as *Euwallacea fornicatus* (Rabaglia et al., 2006), however, molecular diagnostics show substantial differences in DNA sequences between *E. fornicatus* in California and Israel and *E. fornicatus* invading Sri Lanka and Florida (Stouthamer et al., 2012). There is no genetic difference between the specimens collected in California in 2006 (see Prior NPAG History below) and those collected in 2012. The genetic makeup of the beetle in Hawaii is currently under review (Leathers, 2012). Stouthamer et al. (2012) believe that the ambrosia beetle in California and Israel is a new *Euwallacea* species and refer to it as the 'polyphagous shot hole borer.' Specimens from California, Israel, Florida, Hawaii and Sri Lanka were recently sent to Roger Beaver, an expert on this group, to compare with specimens from south and east Asia and the Pacific Islands; Dr. Beaver agrees that all specimens are morphologically indistinguishable and are *E. fornicatus* (Rabaglia, 2012b). Drs. Stouthamer, Rabaglia and Beaver will collaborate to work out the systematics of the species complex (Rabaglia, 2012c). The fungus will be formally named once the identity of the vector has been sorted out (Mendel, 2012b).

**Prior NPAG History:** In 2003, following the detection of *E. fornicatus* (under the synonym *Xyleborus fornicatus*) emerging from a *Delonix regia* (royal poinciana) tree in Florida, NPAG conducted a full review. At the time, Florida was monitoring the area of detection using ethanol-baited traps and planned to continue monitoring for at least one more year. NPAG recommended no change in the regulatory status (reportable/ actionable) (NPAG, 2003).

In 2006, EPPO reported that *E. fornicatus* had been collected in California from the trunks of live trees within the genera *Acer*, *Alnus*, *Platanus*, and *Robinia* (EPPO, 2006; Haack, 2006). NPAG updated its information on this scolytid by conducting a pre-assessment. The file was not re-opened because *E. fornicatus* was apparently established in Florida, and neither Florida nor California were attempting to control *E. fornicatus* (NPAG, 2007).

**Synonyms:** *Xyleborus fornicatus* Eichhoff 1868; *Euwallacea fornicator* Eggers 1923; *Euwallacea whitfordiendrus* Schedl 1942; *Euwallacea perbrevis* (Schedl 1951; *Euwallacea schultzei* Schedl 1951; *Euwallacea tapatapaoensis* Schedl 1951 (Rabaglia, 2012b).

**Current PPQ Port Policy:** The synonym *Xyleborus fornicatus* is listed as reportable/actionable in PestID (queried 4/26/2012). The genus *Euwallacea* is listed as reportable/actionable (PestID queried 9/18/2012).

#### **Pest Situation Overview:**

**Exotic status:** *Euwallacea fornicatus* is established in the United States in Hawaii (Browne, 1968; Samuelson, 1981), Florida (Dade County) (Thomas, 2005), and California (Rabaglia et al., 2006) (Orange and Los Angeles Counties).

**Known pest status:** *Euwallacea fornicatus* is the most important pest of tea (*Camellia sinensis*) in most regions of Asia (Karunaratne et al., 2009; Kumar et al., 2011), particularly Sri Lanka and India (Walgama et al., 2007; Walgama and Zalucki, 2006). Infestation is a combined attack of the beetle and its associated ambrosia fungus, *Monacrosporium ambrosium* (Karunaratne et al., 2009). The damage reduces yields (Sivapalan, 1977) and leads to death of young shoots of the tea bush (Karunaratne et al., 2008). It has become a major pest of pomegranate (*Punica granatum*) in India by making innumerable pin or shot holes in the collar region (base) of the plant, disrupting the conduction of water and ultimately resulting in the desiccation of the upper portion or entire plant (Balikai et al., 2011) and by vectoring a wilt disease, *Ceratocystis fimbriata* (Somasekhara et al., 2000). It is a new pest of som (*Persea bombycina*), a tree important both economically and culturally in India; the damage on som appears to be physical and is currently associated with tunneling that weakens branches and allows the entrance of secondary invasives (e.g., pathogens) (Kumar et al., 2011). It is a common pest of fruit and nut trees in Hawaii (Mitchell and Maddox, 2010). This beetle has recently been detected on avocado (*Persea americana*) in Australia, causing branch death, either from tunneling or due to plant response from associative fungi (*Fusarium ambrosianum*) (Campbell and Geering, 2011). It has been reported attacking both healthy (Karunaratne et al., 2008) and dying or diseased (Mitchell and Maddox, 2010) plants.

Most recently, *E. fornicatus* has been found vectoring a new *Fusarium* species that is damaging avocado and other woody species in California (Eskalen and Stouthamer, 2012; Nakhla, 2012) and Israel (Mendel et al. 2012). The new *Fusarium* species is thought to be a relatively weak pathogen and, while it can move within the vascular system of a susceptible host to a certain extent, it appears to require high populations of the beetle and multiple inoculations to kill trees (Hulcr, 2012). This beetle-fungus complex 'has become a serious threat to the future of the avocado industry in Israel' (Mendel et al., 2011). The avocado industry and other stakeholders in California are concerned about its potential for damage (e.g., Stouthamer et al., 2012). The complex is widely distributed in urban and landscape areas in two counties in southern California (Los Angeles and Orange), between two major avocado-producing areas. The complex does not appear to have spread into major avocado production areas (Newton, 2012).

**Biology:** *Euwallacea fornicatus* females (1.8 – 2.5 mm in length) bore galleries into host stems and infest these with spores of the associated ambrosia fungus. The spores, carried in specialized pouches (mycangia) on their heads, form a fungal mat on the gallery walls (Beaver, 1990; Fernando, 1959).

Females<sup>1</sup> oviposit eggs (15-20) in the galleries over a period of 10-20 days; larvae hatch in three to four days and both larvae and adults feed on the ambrosia fungal mycelia (Beaver, 1990). The life cycle takes five to six weeks for completion and breeding is continuous with overlapping generations; thus, in suitable environments, the species is active at all times and in all stages of development (Mathew, 2004). In its native range, this beetle often attacks relatively small stems and branches (e.g., 1 – 4 cm) of healthy plants (Karunaratne et al., 2008; Rai and Bhandary, 1973). This beetle has recently been detected on avocado in Queensland Australia, also on small branches between 1.5 and 3 cm in diameter (Campbell and Geering, 2011). Pest status is affected directly by elevation and this scolytid is essentially absent in cool areas (elevations above 1400 m) with mean temperatures around 15 °C (Walgama and Zalucki, 2007). The lower developmental threshold (below which no measurable development occurs) has been reported to be around 15 °C for eggs, 15-16 °C for larvae, 13-16 °C for pupae, with degree days for development at  $70 \pm 4.4$ ,  $95 \pm 8.5$ , and  $72 \pm 5.1$  DD, respectively (Walgama and Zalucki, 2007). The optimum temperature for development at all stages is around 30 °C (Walgama and Zalucki, 2007). Intraspecific competition may limit population development to some extent (Cranham, 1966; Karunaratne et al., 2008).

*Euwallacea fornicatus* has been associated globally with a number of symbiotic fungi<sup>2</sup>. Its primary associate on tea is *Monacrosporium ambrosium* (Karunaratne et al., 2008), but *Fusarium timidum* has also been isolated (Mouli and Kumar, 1988). A pomegranate wilt, *Ceratocystis fimbriata*, is vectored by this beetle in India (Somasekhara et al., 2000). The fungus isolated from surface-sterilized detached beetle heads collected from avocado (*P. americana*) in Australia is *Fusarium ambrosianum* (Campbell and Geering, 2011). It is not clear yet whether the damage to avocado branches in Australia is from beetle activity or a pathogenic response to the fungus (Campbell and Geering, 2011).

In addition to the new *Fusarium* species (comprising 99%), multiple fungal species<sup>3</sup> have been found associated with *E. fornicatus* in California, including the new *Fusarium* sp., two strains of *F. solani*, another unidentified *Fusarium* sp., *Graphium* sp., yeast, and 10 other species at low concentrations (Eskalen et al., 2012). The new *Fusarium* species vectored by *E. fornicatus* (in California and Israel) was first observed on avocado in Israel in 2005. Symptoms include discoloration of the outer bark surrounding the beetle penetration site, brownish staining of the xylem under the infested spot, wilting of branches and discoloration of leaves, branches broken at the site of beetle galleries, and death of both young and mature trees (Mendel et al., 2012). The new *Fusarium* species is thought to be a relatively weak pathogen and, while it can move within the vascular system of a susceptible host to a certain extent, it appears to require high populations of the beetle and multiple inoculations to kill trees (Hulcr, 2012).

**Prevalence and global distribution:** **Africa** – Madagascar, Reunion; **Asia** – Bangladesh, Bon Islands, Burma, Cambodia, Ceylon, India, Indonesia, Laos, Malaysia, Philippines, Sri Lanka, Thailand, Taiwan, Vietnam (north); **Australasia and Pacific Islands** – Australia, Caroline Islands, Fiji, Micronesia, New Hebrides, Papua New Guinea, Solomon Islands; **Central America** – Costa Rica, Panama; **Middle East** – Israel; **North America** – United States (CA [Los Angeles and Orange Counties], FL, HI) (Balikai et al., 2011; Browne, 1968; Karunaratne et al., 2008; Kirkendall and

<sup>1</sup> In ambrosia beetles, offspring groups are produced by a single foundress (female originating a population) (Peer and Taborsky 2004). These beetles are haplodiploid with fertilized (diploid) eggs developing into females and unfertilized (haploid) eggs developing into males. Males are flightless and mating most often takes place among siblings within the natal gallery (Kirkendall and Ødegaard, 2007; Peer and Taborsky, 2004). Females have functional wings and leave the galleries after mating; the males remain and die in the galleries (Karunaratne et al., 2008).

<sup>2</sup> *M. ambrosium* is not listed in PestID, nor are *F. timidum* and *F. ambrosianum*; *Ceratocystis fimbriata* is listed in PestID and is nonreportable/nonactionable (queried 9/20/2012).

<sup>3</sup> The genus *Fusarium* is listed in PestID as both reportable and nonreportable; the genus *Graphium* is listed in PestID and is nonreportable/nonactionable. Other species and their port policies, are as follows: (Listed in PestID with a port policy): *Fusarium lateridium* (nonreportable); *F. oxysporum* (reportable); *Bionectria ochroleuca* (nonreportable); *Epicoccum nigrum* (nonreportable); *Exophiala mesophyla* (nonreportable); (Not listed in PestID): *Neofusicoccum parvum*; *N. arbuti*; *N. austral*; *Phaeoacremonium* sp.; *Aerobasidium proteae*; *Cosmospora cymosa* (queried 9/20/2012).

Ødegaard, 2007; Kumar et al., 2011; Mendel et al., 2012; Rabaglia, 2012a; Rabaglia et al., 2006; Samuelson, 1981; Schedl, 2009; Thomas, 2005; Wood, 1982).

**Host range:** (Note: Ambrosia beetles bore galleries into and through the bark of twigs, branches, and stems of woody plants, developing only in wood [xylem]). The following species represent reproductive hosts for *E. fornicatus* (worldwide; those hosts with a footnote are specific to the beetle in California): **Aceraceae** – *Acer negundo*<sup>4</sup> (boxelder), *A. praxii*<sup>4</sup> (evergreen maple); **Anacardiaceae** – *Schinus terebinthifolius*<sup>4</sup> (Brazilian pepper-tree); **Betulaceae** – *Alnus rubra* (red alder); **Burseraceae** – *Protium panamense* (copal, chuttra); **Euphorbiaceae** – *Ricinus communis*<sup>4</sup> (castor bean); **Fabaceae** – *Albizia falcata* [Syn. *A. falcateria*, *Paraserianthes falcateria*] (albizia, batai), *Delonix regia* (royal poinciana), *Erythrina lithosperma* (dapdap), *Gliricidium sepium* (madreado), *Robinia pseudoacacia* (black locust); **Fagaceae** – *Quercus agrifolia*<sup>4</sup> (Coast live oak), *Q. robur*<sup>4</sup> (English oak); **Hamamelidaceae** – *Liquidambar styraciflua*<sup>4</sup> (sweetgum); **Lauraceae** – *Persea american*<sup>4</sup> (avocado), *P. bombycina* (som); **Meliaceae** – *Cedrela odorata* (Spanish cedar); **Moraceae** – *Atrocarpus altilis* (breadfruit); **Platanaceae** – *Platanus racemosa*<sup>4</sup> (California sycamore); **Proteaceae** – *Macadamia integrifolia* (macadamia); **Punicaceae** – *Punica granatum* (pomegranate); **Sapindaceae** – *Litchi chinensis* [Syn. *L. sinensis*] (litchi, lychee); **Theaceae** – *Camellia sinensis* (tea); **Verbenaceae** – *Gmelina arborea* (gumhar, gmelina); (Campbell and Geering, 2011; Eskalen et al., 2012; Hulcr et al., 2007; Judenko, 1961; Karunaratne et al., 2008; Kirkendall and Ødegaard, 2007; Kumar et al., 2011; Nair and Mathew, 1988; Rai and Bhandary, 1973; Sivapalan, 1977; Stouthamer, 2012; Wang and Yuan, 2003).

*Euwallacea fornicatus* is highly polyphagous in its native and introduced ranges and other hosts are reported (e.g., CABI, 2012), but it is unclear whether these are reproductive hosts or not. This beetle has been associated with (but is not breeding in) the following species in California, all of which appear to be suitable hosts for the new *Fusarium* species: **Fabaceae** – *Senna racemosa* var. *lichmannii* (limestone senna); **Oleaceae** – *Olea europea* (olive); **Platanaceae** – *Platanus racemosa* (California sycamore); **Sapindaceae** – *Alectryon excelsus* (titoki), *Koelreuteria elegans* (Chinese rain tree); **Vitaceae** – *Vitis vinifera* (grape) (Newton, 2012). Eskalen et al. (Eskalen et al., 2012) have identified over 200 species with symptoms of beetle damage (entrance holes, ‘tasting’); of these 108 are infested with *Fusarium* sp. nov.

It is important to note that the complex has been found on three citrus species in southern California (orange, lime, and kumquat). The beetle is not reproducing on the citrus species but the fungus has been isolated (Eskalen, 2012). A comprehensive host list is in press and will be made available on the University of California-Riverside’s Center for Invasive Species Research (CISR) website ([http://cistr.ucr.edu/tea\\_shot\\_hole\\_borer.html](http://cistr.ucr.edu/tea_shot_hole_borer.html)).

**Potential pathways of introduction:** Ambrosia beetles move on wood products (logs, firewood, wood chips, wood packaging materials, etc.) (Brockerhoff et al., 2006; Haack, 2006; Haack et al., 2010) and may also hitchhike on cut flowers and fruit. There are no port interception records specific to *Xyleborus fornicatus* (synonym of *E. fornicatus*), but port interceptions of *Xyleborus* sp. (since 2006) include wood packaging material (dunnage, pallets, crating), fruit, cut flowers, and plant parts; interceptions were primarily on general or permit cargo (AQAS, 2012). This beetle has been intercepted in Australia in sea cargo containers (Stanaway et al., 2001). *Euwallacea fornicatus* develop in the base of young avocado trees in Israel (Freeman et al., 2012b). In California, the green waste industry may provide an important pathway for movement of infested material and infested nursery stock or infested rootstock may also move this disease complex.

**Potential distribution in the United States and spread:** Based on its native range and its known biology, *Euwallacea fornicatus* would be expected to establish in tropical and subtropical areas of the United States. There are no indications that this scolytid has spread into areas outside Hawaii, Florida,

<sup>4</sup> These species have been noted as reproductive hosts for the California/Israeli strain of *E. fornicatus*.



or California. However, it may not have reached its potential distribution. The tribe Xyleborini is widely distributed; their cryptic nature, polygamous, sib-mating system, and wide host range enable these beetles to travel through commerce and establish in new areas (Rabaglia et al., 2006). Information from its native range suggests that *E. fornicatus* does not develop at temperatures below 15 °C, so cold temperatures may limit its dispersal potential. Natural spread is likely. *Euwallacea fornicatus* females fly (in Ceylon from 8 a.m. to 5 p.m., at approximately 0.3 to 0.6 meters per second, duration less than one hour) (Calnaido, 1965). Additionally, ambrosia beetles can be caught by the wind and carried distances up to 15 km or more (Rudinsky, 1962; Wood, 1982).

Once a susceptible tree is inoculated with the new *Fusarium* sp., the pathogen can remain in the tree and spread to a certain extent (it appears not very far) within the vascular system of the tree regardless of whether the beetle remains to breed within the tree (Freeman et al., 2012b). Thus, an infected tree, moved into a non-infected area, may provide a pathway by which the pathogen could spread into a new area. In addition to *E. fornicatus*, other ambrosia beetles may be capable of vectoring the pathogen; for example, although the primary vector for laurel wilt disease in Florida is *Xyleborus glabratus*, there are now other ambrosia beetles associated with the causal agent *Raffaelea lauricola*, including *Xyleborus volvulus*, *X. ferrugineus* and *Xyleborinus gracilis* (Carrillo et al., 2012).

**Detection and control:** Description: Because this beetle has a very typical Xyleborine appearance, confirmation of its identity requires an expert in scolytid identification (Thomas, 2005). *Euwallacea fornicatus* is about 2.5 mm in length and rather stout. It is brownish or blackish in color with reddish legs and antennae. There are four rounded teeth on the anterior margin of the pronotus, and apical declivity is evenly rounded to the apex, which is sharply margined. The body is covered sparsely with long and slender pale setae (Thomas, 2005).

Trapping: There is no effective lure for this beetle in California; both ethanol and manuka oil have been tested and neither works efficiently (Paine, 2012). In the past, these beetles have been collected using Malaise traps (Kirkendall and Ødegaard, 2007), sticky traps (Kirkendall and Ødegaard, 2007), flight intercept traps (Kirkendall and Ødegaard, 2007), Lindgren funnel trap (unbaited, Thomas, 2005), aphid-sampling suction trap (Thomas, 2005), and others. In a study focused on the efficiency of different traps, the most effective was a multiple funnel trap with synthetic attractants added to the first funnel (James et al., 2007).

Control:

Chemical: To date, no effective chemical controls have been found for managing *E. fornicatus* and its symbiotic fungus in avocado plantations in Israel, although many different agents have been tested (Mendel, 2012a). Emamectin benzoate has shown promise (Freeman et al., 2012a). Various chemicals have been utilized over the years to provide control for *E. fornicatus* in tea plantations, although some (e.g., dieldrin) have been abandoned because of unintended effects (e.g., increased populations of other pests) (Cranham, 1966; Danthanarayana, 1966). Most recently, insecticides include deltamethrin, quinalphos, lambda-cyhalothrin, chlorpyrifos; increased doses of potassium are added to the soil to induce physiological resistance against this beetle (Mathew and Shanmugapriyan, 2011). Fenthion is also utilized as a prophylactic treatment (Walgama et al., 2008), but it is no longer registered for use in the United States.

Biological control: In a study focused on the natural enemies of tea pests in India, there were no natural enemies recorded for *E. fornicatus* (Muraleedharan et al., 1988).

Host resistance: Some cultivars of tea show resistance to damage by *E. fornicatus* and the use of resistant varieties is employed in production areas (Walgama et al., 2007). It has been suggested that resistance to establishment of the ambrosia fungus culture plays an important role (Karunaratne et al., 2009; Kumar et al., 1995). Caffeine is a prominent secondary metabolite in tea plant chemistry and has been shown to accumulate in tea stems after beetle attack; it inhibits the ambrosia fungus *M. ambrosium*, reduces oviposition, and disrupts normal development of the beetle (Kumar et al., 1995).

**Diversionary hosts:** A number of plant species that may serve as diversionary hosts (plants that attract beetles away from tea (*Camellia sinensis*) have been tested in Sri Lanka (Amarasinghe and Devy, 2003).

**Proper disposal of infested material:** Stakeholders in California are in the process of developing recommendations for the best way to dispose of infested material. At a public meeting, concerned citizens were advised to refrain from moving firewood, other raw wood, nursery stock, and mulch from infested counties. Proper disposal may include grinding and chipping (the most efficacious size has not yet been determined), tarping or enclosing infested material (solar radiation), seasoning wood on site, heat treatments (71° C for 75 minutes), fumigation, or burning the wood (Coleman, 2012a).

**Potential economic impacts:** Because of its large host range and the potential for new fungal associations, it is not possible to predict all economic impacts this beetle may have. We know that *Euwallacea fornicatus* is a notorious pest of tea in most tea-growing regions and infestation has immediate economic impacts (Karunaratne et al., 2008; Sivapalan, 1977). However, tea production in the United States is limited to small production areas in Hawaii and South Carolina (The Associated Press State & Local Wire, September 10k, 2007). In India, crops of pomegranate (*Punica granatum*) are severely affected by a pathogen (*Ceratocystis fimbriata*) vectored by this beetle (Somasekhara et al., 2000). The 2007 Agricultural Census identifies 55 counties in the United States with pomegranate acreage; the largest area of pomegranate production is in the San Joaquin Valley in California. The pathogen *Ceratocystis fimbriata* is already present in the United States and is not considered a quarantine pest (PestID queried 9/20/2012).

Although no dollar values have been suggested, this beetle and its symbiotic fungus are reported to have become a serious threat to the future of the avocado industry in Israel; there, 'Hass' avocado appears to be the most susceptible cultivar (Mendel et al., 2012). Infestations in avocado plantations cause loss of yield and premature dropping of fruit; heavy infestations lead to tree mortality, although farmers rarely allow infested trees to remain in the avocado orchards (Freeman et al., 2012b). California produces more than 90% of U.S.-grown avocados and last year's crop was valued at \$460 million; the California avocado growers are very concerned about the situation and the California Avocado Commission has provided \$100,000 in emergency funds to UC-Riverside to research the scope of the infestation (Dickerson, 2012). Additional funding is being sought.

**Trade implications:** There is relatively little trade in avocado propagative material; last year (2011), United States sent bud stems to Japan, stems to Mexico, and plants to Peru (CA exports, PCIT queried 9/14/2012). There were no records of avocado propagative material sent to or received from Israel (PCIT queried 9/14/2012; PestID queried 10/15/2012). Avocado fruit has not been suggested as a possible pathway for the movement of either the vector or the pathogen, so the presence of this complex in California is not likely to close foreign or domestic markets for the movement of fruit. There may be domestic trade issues that arise from the potential movement of nursery stock or rootstock of host material, both reproductive hosts for the vector and hosts for the pathogen.

**Potential environmental impacts:** *Euwallacea fornicatus* has been causing the decline of *Delonix regia* (royal poinciana), an exotic tree now naturalized in Florida, for a number of years (Thomas 2005). The beetle in California attacks many tree species, some exotic and utilized in urban landscape settings, and some native species. Because dry conditions are not considered the ideal environment for ambrosia beetles in general (Hulcr, 2012), the areas most at risk in southern California are those near sources of water. Urban landscapes and gardens are likely to be impacted, as are riparian areas. The U.S. Forest Service has begun conducting surveys on public lands, concentrating in riparian corridors; native species at risk include *Acer macrophyllum* (big leaf maple), *Alnus rhombifolia* (white alder), *Quercus agrifolia* (coast live oak), and *Platanus racemosa* (California sycamore) (Coleman, 2012b).

**NPAG teleconferences:** NPAG has not held any teleconferences, but we have been included in two conference calls (6/26/2012 and 8/3/2012) organized by the California Department of Food and

Agriculture (CDFA). Attendees included representatives from CDFA, APHIS, and the University of California-Riverside. Updates were given on the identity of the beetle, where the beetle had been found in California, potential hosts, and activities associated with the situation in California (Condos, 2012; Murphy, 2012).

**Past regulatory response and activities:** When *E. fornicatus* was detected in Florida, the State planned to continue surveying for the pest for at least one more year; the port policy remained reportable/actionable (NPAG, 2003).

**Current regulatory response and activities:** Surveys are currently being conducted in California by CDFA and PPQ (Kreger, 2012; Stone-Smith, 2012). *Euwallacea fornicatus* is a Q-rated pest in California; if it is found on nursery stock during inspections the plants would be placed on hold for treatment or destruction (the *Fusarium* sp. has been found in one nursery and the plants were destroyed); (Leathers, 2012; Stone-Smith, 2012). To move live beetles or the fungus, a permit is required (Leathers 2012).

Activities discussed during the CDFA conference calls include the following: CDFA and PPQ have been working together to obtain *E. fornicatus* specimens from Hawaii for analysis by UC-R scientists; the Hawaiian specimens have been sent to UC-Riverside for genetic testing; USDA and CDFA have coordinated with UC-Riverside regarding the PCR they are using to identify the vector and *Fusarium* species – the protocol has been passed to Normal Barr at CPHST in Texas; CDFA, UC-Riverside, and LA County will send GIS survey points to USDA for coordination; PPQ will coordinate with CAPS staff to ensure that any suspect *E. fornicatus* detected during the 2012 National Exotic Wood Boring Beetle Surveys are identified to species if possible (Condos, 2012; Leathers, 2012; Murphy, 2012; Stone-Smith, 2012).

Other activities: Koch's postulates have been completed on avocado and a manuscript to name the *Fusarium* sp. is being prepared by scientists at UC-Riverside (Bullock 2012). A 3-day conference was held 8/12-14/2012 in Riverside, CA, bringing together international experts in ambrosia beetles (see trip report, Newton 2012). The U.S. Forest Service is surveying national forested lands surrounding the infested counties. The University of California Cooperative Extension Service is in the process of obtaining documented locations of *Acer negundo* (box elder, a preferred host for the vector) to conduct field surveys (Kreger, 2012).

#### **Need for new technology or knowledge:**

- Critical research needs include:
  - clarification of the systematics of both the beetle and the pathogen
  - definitive host list for both beetle and pathogen
  - detection, monitoring and control strategies, particularly an effective lure for the vector

**Forest Service consultation:** Dr. Bob Rabaglia (2012b) provided a complete list of synonyms for *E. fornicatus* (see Synonyms) and the following caveat regarding the beetle's identity:

(There is) the possibility that what is being reported as genetically different in California and Israel may in fact be a population or even a species that was previously described and is now considered a synonym. In your report you mention what is currently accepted as *E. fornicatus* has many different hosts in different countries. Until we have a better understanding of the genetics of these populations of beetles as well as the associated *Fusarium* species, it will be hard to say what is being moved around and impacting different hosts.

Morphologically, I think these are all fairly indistinguishable. I sent specimens of what I have called *E. fornicatus* to Roger Beaver, an expert on this group, in Thailand. Roger compared the specimens I



had from California, Israel, Florida, Hawaii and Sri Lanka to specimens he has from south and east Asia and the Pacific Islands. Roger agrees that all of the specimens I sent him are morphologically indistinguishable and are *E. fornicatus*.

**National Plant Board consultation:** None.

**Recent updates (from October 2012 – January 2013):** The beetle/pathogen complex has now expanded east into San Bernardino County (Stone Smith, 2013) and has also been found on the Angeles National Forest on white alder, castor bean, California sycamore, and willow (Rabaglia, 2013). There were indications that the new *Fusarium* sp. had been found associated with *E. fornicatus* in Florida, however, this is not correct. There is a new *Fusarium* sp. that has been found associated with a congener (*E. interjectus*) on box elder in northeastern Florida, and while the pathogen is very similar to the one in California, it is not the same *Fusarium* species (Smith, 2013). *Euwallacea fornicatus* and a new *Fusarium* species has been found in Spain, damaging avocado (Floyd, 2013), but it is unknown currently whether it is the same *Fusarium* sp. as that in Israel and California.

**LT Approved NPAG Recommended PPQ Port Policy:** NPAG recommends no change in port policy; retain *Euwallacea fornicatus* (currently listed under its old name *Xyleborus fornicatus*) as reportable/actionable.

**LT Approved Recommendations (31 January 2013):**

1. NPAG recommends no change in port policy; retain *Euwallacea fornicatus* (currently listed under its old name *Xyleborus fornicatus*) as reportable/actionable because this beetle is of limited distribution in the United States and is vectoring a new pathogen that damages agricultural and landscape trees. **Action Leader: Joe Cavey (PPQ PM PHP).**
2. NPAG recommends that the name *Xyleborus fornicatus* be changed to *Euwallacea fornicatus* in all PPQ databases to reflect current nomenclature. **Action Leaders: Joe Cavey (PPQ PM PHP), John Bowers (PPQ PM PHP), and John Payne (BISSM).**
3. NPAG recommends that *Euwallacea fornicatus* and the new *Fusarium* sp. be considered for addition to the CAPS list. **Action Leader: John Bowers (PPQ PM PHP).**
4. NPAG recommends that the three PPQ Core Functional Areas work with California and other states to assess the options available to stakeholders affected by *Euwallacea fornicatus* and the new *Fusarium* species. **Action Leader: Scott Pfister (PPQ PM PHP).**
5. NPAG recommends that PPQ forward research needs identified in the “Needs for new technology and knowledge” section of this report to the appropriate research groups. **Action Leader: David Kaplan (PPQ S&T).**

**Referred to LT on 31 January 2013.**

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NEW PEST ADVISORY GROUP (NPAG)  
Plant Epidemiology and Risk Analysis Laboratory  
Center for Plant Health Science & Technology

NPAG Report

*Euwallacea fornicatus* Eichhoff: Tea shot-hole borer

Coleoptera: Curculionidae, Scolytinae, Xyleborini

LT Approval Date: January 31, 2013

*[Handwritten signature]*  
2/19/2013



Left: *Euwallacea fornicatus* (Eichhoff), Photo by G. Arakelian (UCCE 2012); Center: *Fusarium* sp. white powdery exudate surrounded by wet discoloration in association with a single beetle exit hole, cortex and wood under beetle hole; Right: brown discolored necrosis caused by fungus (Eskalen and Stouthamer, 2012)

**Initiating Event and Pest Identification:** On April 20, 2012, Mark Nakhla (PPQ CPHST Beltsville) concurred with the identification of an unnamed *Fusarium* species collected (on or about April 12, 2012) from a residential avocado (*Persea americana*) tree in Los Angeles County, CA (Nakhla, 2012), a new U.S. record for this pathogen. The fungus was analyzed at the University of California, Riverside, the California Department of Food and Agriculture (CDFA), and the CPHST Beltsville Laboratory; the sequencing results match and confirm the pathogen is the same as a new undescribed *Fusarium* species recently documented as causing dieback on avocado trees in Israel (Floyd, 2012; Mendel et al., 2012). The unnamed *Fusarium* sp. is vectored by *Euwallacea* (formerly *Xyleborus*) *fornicatus* (Eichhorn) (Mendel et al., 2012), an Asian ambrosia beetle present in three states in the United States (CA, FL, HI) (Browne, 1968; FDACS, 2003; Rabaglia et al., 2006). Both the fungus and the beetle were found on several backyard avocado trees in February and March 2012 (Eskalen and Stouthamer, 2012). On April 26, 2012, David Kaplan, PPQ EDP, notified NPAG of the detection and requested a review (Bertone, 2012).

There is a complication with the identity of the ambrosia beetle. The population in California has been identified as *Euwallacea fornicatus* (Rabaglia et al., 2006), however, molecular diagnostics show substantial differences in DNA sequences between *E. fornicatus* in California and Israel and *E. fornicatus* invading Sri Lanka and Florida (Stouthamer et al., 2012). There is no genetic difference between the specimens collected in California in 2006 (see Prior NPAG History below) and those collected in 2012. The genetic makeup of the beetle in Hawaii is currently under review (Leathers, 2012). Stouthamer et al. (2012) believe that the ambrosia beetle in California and Israel is a new *Euwallacea* species and refer to it as the 'polyphagous shot hole borer.' Specimens from California, Israel, Florida, Hawaii and Sri Lanka were recently sent to Roger Beaver, an expert on this group, to compare with specimens from south and east Asia and the Pacific Islands; Dr. Beaver agrees that all specimens are morphologically indistinguishable and are *E. fornicatus* (Rabaglia, 2012b). Drs. Stouthamer, Rabaglia and Beaver will collaborate to work out the systematics of the species complex (Rabaglia, 2012c). The fungus will be formally named once the identity of the vector has been sorted out (Mendel, 2012b).

**Prior NPAG History:** In 2003, following the detection of *E. fornicatus* (under the synonym *Xyleborus fornicatus*) emerging from a *Delonix regia* (royal poinciana) tree in Florida, NPAG conducted a full review. At the time, Florida was monitoring the area of detection using ethanol-baited traps and planned to continue monitoring for at least one more year. NPAG recommended no change in the regulatory status (reportable/ actionable) (NPAG, 2003).