

EPPO Datasheet: *Fusarium euwallaceae*

Last updated: 2024-05-17

IDENTITY

Preferred name: *Fusarium euwallaceae*

Authority: S. Freeman, Z. Mendel, T. Aoki & O'Donnell

Taxonomic position: Fungi: Ascomycota: Pezizomycotina:

Sordariomycetes: Hypocreomycetidae: Hypocreales: Nectriaceae

Other scientific names: *Neocosmospora euwallaceae* (S. Freeman, Z. Mendel, T. Aoki & O'Donnell) Sandoval-Denis, L. Lombard & Crous

Common names: Fusarium dieback, Fusarium wilt

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EPPO Categorization: A2 list, Alert list (formerly)

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EU Categorization: A1 Quarantine pest (Annex II A)

EPPO Code: FUSAEW

Notes on taxonomy and nomenclature

Fusarium euwallaceae (Freeman *et al.*, 2013), within the *Fusarium solani* species complex (O'Donnell *et al.*, 2008), is characterized as a fungal symbiont, vectored by the ambrosia beetle *Euwallacea fornicatus* Eichhoff (polyphagous shot hole borer), inciting Fusarium dieback on many host plants. Molecular phylogenetic analyses of multilocus DNA sequence data (Kasson *et al.*, 2013) indicate that the symbiont of *E. fornicatus* constitutes a novel subclade within Clade 3 of the *Fusarium solani* species complex (O'Donnell *et al.*, 2008). Furthermore, *F. euwallaceae* was resolved as an independent evolutionary lineage that exhibits a distinct ecology (Freeman *et al.*, 2013). There is a dispute regarding the nomenclature of the genus *Fusarium* (O'Donnell *et al.*, 2020; 2022), whereby certain reports have preferred the designation *Neocosmospora* (Crous *et al.*, 2021), based on monophyletic vs polyphyletic conclusions. In this report we have maintained the *Fusarium* option since the dispute has not yet been settled.

HOSTS

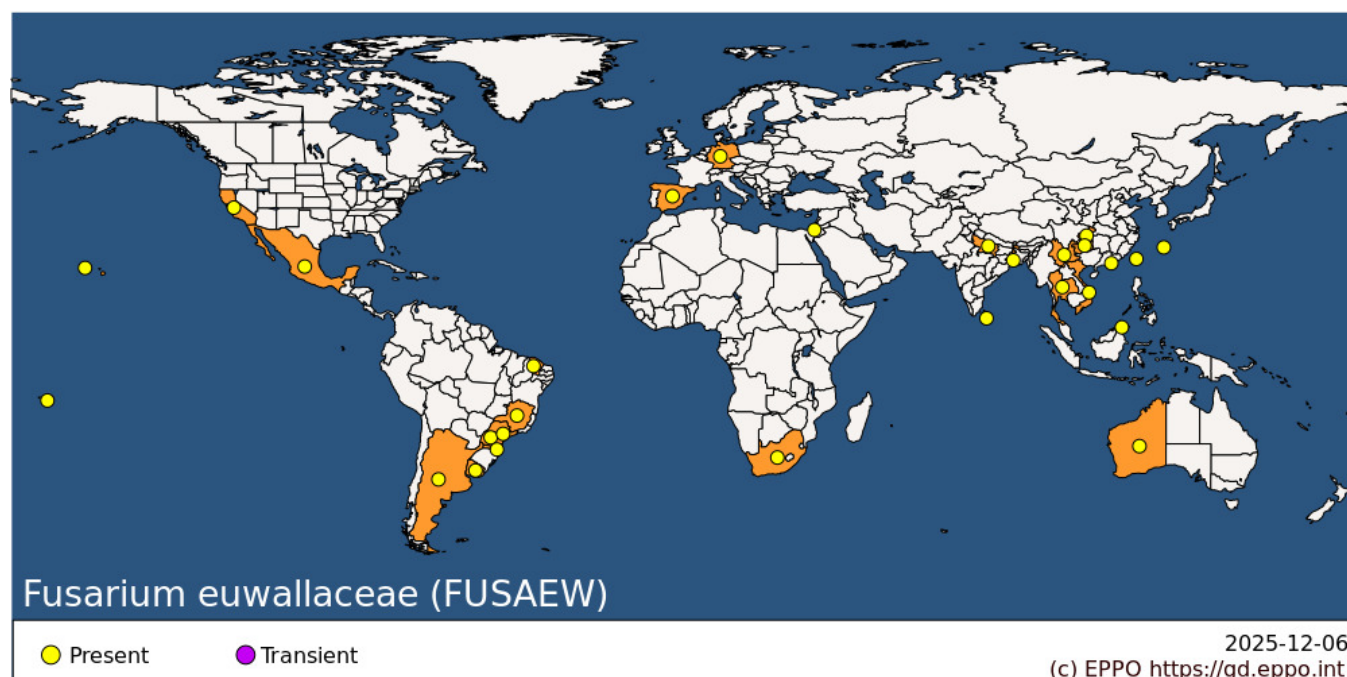
Fusarium euwallaceae is completely dependent on the botanical host range of its vector *Euwallacea fornicatus*, which is very broad. The host range reported by Gomez *et al.* (2019) includes 412 botanical species in 75 families; 109 are reported as breeding hosts, 95 are commercial timber tree species and 43 are fruit trees/shrubs. Initially, the avocado industry was the major concern, however, later it was found that the beetle/fungus complex causes serious damage on native and exotic trees in urban landscapes as well as in native forests (Mendel *et al.*, 2021; O'Donnell *et al.*, 2015; Boland, 2016; Mendel *et al.*, 2017; Paap *et al.*, 2018). The beetle's reproductive success rate, as well as the long list of botanical species belonging to the 'non-reproductive host' category, is the outcome of interactions between *F. euwallaceae* and sapwood of the attacked tree (Mendel *et al.*, 2021). Thus, the host tree selected by *E. fornicatus* may be grouped into: (i) those that do not allow *F. euwallaceae* to develop, (ii) those that reduce fungal development, and (iii) those that permit *F. euwallaceae* proliferation. In summary, the host range suitable for beetle reproduction is determined by development of *F. euwallaceae* (Mendel *et al.*, 2021).

Host list: *Acer buergerianum*, *Acer macrophyllum*, *Acer negundo*, *Acer palmatum*, *Acer paxii*, *Ailanthus altissima*, *Alangium chinense*, *Albizia julibrissin*, *Alectryon excelsus*, *Alnus rhombifolia*, *Banksia saxicola*, *Bauhinia x blakeana*, *Betula pendula*, *Bischofia javanica*, *Brachychiton acerifolius*, *Brachychiton australis*, *Brachychiton discolor*, *Brachychiton rupestris*, *Calpurnia aurea*, *Camellia reticulata*, *Camellia semiserrata*, *Camptotheca acuminata*, *Carya illinoensis*, *Cassia brewsteri*, *Castanospermum australe*, *Catalpa speciosa*, *Ceiba speciosa*, *Chionanthus retusus*, *Cinnamomum camphora*, *Citrus x aurantium* var. *sinensis*, *Cleyera japonica*, *Cocculus laurifolius*, *Cocculus orbiculatus*, *Cornus controversa*, *Corylus colurna*, *Corymbia ficifolia*, *Cussonia spicata*, *Diospyros lycioides*, *Dombeya cecuminum*, *Eriobotrya japonica*, *Erythrina corallodendron*, *Erythrina crista-galli*, *Erythrina humeana*, *Erythrina lysistemon*, *Erythrina x sykesii*, *Eucalyptus polyanthemus*, *Eucalyptus torquata*, *Fagus sylvatica*, *Fatsia japonica*

, *Ficus macrophylla*, *Ficus platypoda*, *Firmiana simplex*, *Fraxinus uhdei*, *Harpullia arborea*, *Heliocarpus donnellsmithii*, *Hymenosporum flavum*, *Ilex cornuta*, *Ilex latifolia*, *Inga feuillei*, *Juniperus chinensis*, *Liquidambar formosana*, *Liquidambar styraciflua*, *Livistona chinensis*, *Luehea divaricata*, *Lysiphylum carronii*, *Macadamia integrifolia*, *Machilus thunbergii*, *Magnolia grandiflora*, *Magnolia x veitchii*, *Malus domestica*, *Melianthus major*, *Metasequoia glyptostroboides*, *Morus alba*, *Neltuma articulata*, *Olea europaea*, *Parasenecalia visco*, *Parkinsonia aculeata*, *Parkinsonia florida*, *Parkinsonia x sonora*, *Persea americana*, *Pipturus argenteus*, *Pittosporum undulatum*, *Platanus mexicana*, *Platanus occidentalis*, *Platanus racemosa*, *Platanus wrightii*, *Platanus x hispanica*, *Populus fremontii*, *Populus trichocarpa*, *Prunus armeniaca*, *Prunus dulcis*, *Prunus mume*, *Prunus persica* var. *nucipersica*, *Prunus persica*, *Prunus serrula*, *Pyrus communis*, *Pyrus kawakamii*, *Quercus agrifolia*, *Quercus chrysolepis*, *Quercus engelmannii*, *Quercus ilex*, *Quercus lobata*, *Quercus macrocarpa*, *Quercus mexicana*, *Quercus robur*, *Quercus suber*, *Quercus virginiana*, *Ricinus communis*, *Salix babylonica*, *Salix gooddingii*, *Salix laevigata*, *Schinus terebinthifolia*, *Schotia brachypetala*, *Senna racemosa* var. *liebmannii*, *Tilia americana*, *Triadica sebifera*, *Ulmus americana*, *Ulmus parvifolia*, *Umbellularia californica*, *Ungnadia speciosa*, *Washingtonia filifera*, *Wisteria floribunda*, *Wisteria sinensis*, *Xylosma congesta*, *Zelkova serrata*, *Ziziphus jujuba*

GEOGRAPHICAL DISTRIBUTION

As mentioned within the host range section, geographical distribution of the fungal symbiont *Fusarium euwallaceae* is strictly dictated by the beetle vector *Euwallacea fornicatus*. Thus, the beetle/fungal symbiont species complex is native to Asia and Oceania (Smith *et al.*, 2019). *E. fornicatus* is reported to have originated from countries within the Far East: China, Japan, Malaysia, Sri Lanka, Taiwan, Thailand, and Vietnam, as well as Samoa (Oceania) and has been introduced into Argentina, Israel, South Africa, and the United States (California and Hawaii) (Ceriani-Nakamurakare *et al.*, 2023; Eskalen *et al.*, 2012; Mendel *et al.*, 2012; Paap *et al.*, 2018; Rugman-Jones *et al.*, 2020). In Europe, outbreaks of the fungus/beetle complex have been reported from protected greenhouse habitats in Poland (Poznan-2019), Italy (Merano-2020), the Netherlands and Germany (Berlin and Erfurt-2021) (Schuler *et al.*, 2022). Removal of the host plants resulted in eradication of the beetle and its fungal symbiont (EPPO, 2024).



EPPO Region: Germany, Israel, Spain (mainland)

Africa: South Africa

Asia: China (Chongqing, Guizhou, Xianggang (Hong Kong), Yunnan), India (Uttar Pradesh, West Bengal), Israel, Japan (Ryukyu Archipelago), Malaysia (Sabah), Sri Lanka, Taiwan, Thailand, Vietnam

North America: Mexico, United States of America (California, Hawaii)

South America: Argentina, Brazil (Ceara, Minas Gerais, Parana, Santa Catarina, Sao Paulo), Uruguay

Oceania: American Samoa, Australia (Western Australia)

BIOLOGY

The fungus *Fusarium euwallaceae* is an obligate symbiont of *Euwallacea fornicatus* and serves as a nutritional source for the ambrosia beetle (Mendel *et al.*, 2012). *F. euwallaceae* is considered nonpathogenic to host plants in its native environment, where most ambrosia beetle species attack only weakened or dying plants (Mendel *et al.* 2012). However, a few ambrosia species, including *E. fornicatus*, colonize healthy trees and cause damage through mass accumulation (Hulcr and Stelinski, 2017). Two more recently described symbiotic fungi (*Graphium euwallaceae* and *Paracremonium pembeum*), in addition to *F. euwallaceae*, are carried by the *E. fornicatus* beetle (Freeman *et al.*, 2016; Lynch *et al.*, 2016). However, the adult female beetle carries predominantly *F. euwallaceae* within the mycangia (Freeman *et al.*, 2016). It appears that *F. euwallaceae* is required for establishment in a new host, and this fungus allows the beetle to complete its life cycle. Thus, *F. euwallaceae* is involved in two major requirements of the vector: (i) overcoming the xylem tissue resistance for establishment of the beetles in galleries, and (ii) serving as a food source during the first phase of colonizing females, and likely throughout its adult life cycle. It has been suggested that the first food source for early larvae is *Graphium euwallaceae* while adult parent beetles consume predominantly *F. euwallaceae*. The role of *Paracremonium pembeum* has not yet been determined, although it may be postulated to serve as an antagonist of contaminant fungi, including the previous two symbionts (Freeman *et al.*, 2016).

DETECTION AND IDENTIFICATION

Symptoms

E. fornicatus female ambrosia beetles bore and tunnel into the trunk, stems and branches of healthy trees and cause damage through mass accumulation. Thereafter, the symbiont *F. euwallaceae* released from beetle mycangia colonizes the base of secondary branches, resulting in localized branch dieback (Mendel *et al.*, 2012). *F. euwallaceae* produces localized necrosis inciting a significant amount of damage when inoculated by a large number of beetles within the host tree galleries (Smith and Hulcr, 2015). Pathogenicity is manifested by invasion of the tree vascular system, causing cambial necrosis, sugar or gum exudation, branch dieback, and mortality of a wide spectrum of tree hosts (Eskalen *et al.*, 2013; Mendel *et al.*, 2021). In avocado, *F. euwallaceae* did not spread far from the beetle galleries and remained viable in live xylem for up to 25 months (Freeman *et al.*, 2019). Recovery of *F. euwallaceae* from heavily infested branches can be identified according to stained gallery tissues as was determined in naturally fungus-infected avocado.

Morphology

Fusarium euwallaceae forms ellipsoidal, blue to brownish-pigmented clavate, multiseptated macroconidia, a useful phenotypic character for distinguishing this species (Freeman *et al.*, 2013). Aerial conidia are mostly ellipsoidal, fusiform-ellipsoidal to short clavate, e.g. three-septate measuring on average $22.5\text{--}39 \times 6.5\text{--}11\text{ }\mu\text{m}$. Chlamydospores are formed abundantly in hyphae and in conidia, mostly subglobose to round ellipsoidal, intercalary or terminal, single, or often in chains, ordinary hyaline to pale-yellow, later becoming bluish to brownish when strongly pigmented, smooth to often rough-walled, measuring on average $6\text{--}12 \times 6\text{--}10\text{ }\mu\text{m}$; sclerotia are absent (Freeman *et al.*, 2013). Colonies of *F. euwallaceae* on PDA show radial mycelial growth rates of 4.5 to 4.8 mm/day at 25°C.

Detection and inspection methods

Susceptible tree hosts, such as box elder (*Acer negundo*) and/or avocado (*Persea americana*), should be surveyed periodically for tree mortality and/or branch dieback with signs of beetle attack at junctions of small and mid-size shaded branches, showing the presence of frass at exit holes accompanied by exudates described following infection (Eskalen *et al.*, 2013). From these infection sites, plant material can be plated on PDA and/or SNA media for *F. euwallaceae* identification according to morphology (Freeman *et al.*, 2013), and by molecular identification according to species-specific PCR amplification protocols of DNA extracted from *F. euwallaceae* (de Jager and Roets, 2022; Short *et al.*, 2017).

PATHWAYS FOR MOVEMENT

F. euwallaceae is vectored actively by the *E. fornicatus* ambrosia beetle which is the major means of dispersal of the pathogen. Therefore, over short distances, flight of female beetles carrying the fungus within their mycangia is one of the main means of movement to previously uninfected areas where susceptible host plant species prevail (EPPO, 2024). In addition, the movement and shipping of beetle and fungus-infected timber and wood packaging material, are also ways of spreading the fungal-vector complex, mainly at ports of entry to countries where the products are delivered. Movement of infested host plants for planting can also transport all stages of the fungal-vector complex.

PEST SIGNIFICANCE

Economic impact

Severe economic impacts have been reported in various countries and areas worldwide, including Argentina, California (USA), Israel and South Africa. In various host plants, the beetle bores and tunnels into trunks, stems and branches of healthy trees and causes damage through mass infestations. Female beetles usually colonize the base of secondary branches, release spores of *F. euwallaceae* resulting in localized branch dieback. Besides detrimentally affecting the health of host trees, beetle-pathogen colonization and establishment and weakened trees can also fall and cause damage and injury (EPPO, 2024).

In South Africa, the fungus-beetle complex causes serious damage to urban environments (Paap *et al.*, 2020), while in Israel, the complex has severely affected avocado crop cultivation and yields (Mendel *et al.*, 2012). In Argentina, the maple industry has been compromised, whereby branch dieback and complete tree mortality have been reported within a short period of time (Ceriani-Nakamurakare *et al.*, 2023). In Southern California in both urban and native stands, a wide range of ornamental and agriculturally important hardwood host species are threatened, and infestations are causing serious ecological and environmental damage (Chen *et al.*, 2020).

Control

Similar to management procedures for the beetle that vectors the pathogen *F. euwallaceae*, early detection, sanitation measures and preventive insecticide sprays should be implemented. Infested branches should be removed and destroyed (chipped, burned, buried or solarized by covering under a tarp under direct sun (Jones and Paine, 2015).

Management of the *F. euwallaceae*/beetle complex affecting sycamore trees in California has been reported using pesticide injection techniques. It was shown that the systemic fungicide propiconazole, alone or combined with the systemic insecticide emamectin benzoate, can significantly reduce the fungal infection after infestation by the beetle (Grosman *et al.*, 2019). Thus, emamectin benzoate alone or combined with propiconazole can significantly act as therapeutic and preventative treatments for management of the fungal/beetle complex in sycamore trees in southern California (Grosman *et al.*, 2019).

Phytosanitary risk

A broad spectrum of host plants has been recorded for the species *E. fornicatus* vectoring *F. euwallaceae*. For example, among 583 examined tree species, 13.8% were considered reproductive hosts, allowing the symbiotic fungus to survive and colonize plants (Mendel *et al.*, 2021). Therefore, any of this woody material of a suitable size and moisture content may be infested and thus, pose a direct risk of the beetle/fungal population establishing itself in areas outside the natural habitat of the complex (EPPO, 2024). In the EPPO region, and elsewhere, certain fruit crops such as avocado (Mendel *et al.*, 2012) and other ornamental trees can be a source of spread of the complex if not strictly monitored before being exported (EPPO, 2021).

PHYTOSANITARY MEASURES

Global movement of commodities has increased significantly over the years, thus the transport of *F. euwallaceae* and *E. fornicatus*

complex in timber and wood packaging material, such as pallets, crates and dunnage should be monitored, and/or treated to eliminate beetle/pathogen introduction (EPPO, 2024). Spread and establishment of potential beetle infestations and fungal infections via plants for planting may also take place, therefore, such plant material should originate from pest-free areas or pest-free production sites where plants are cultivated under physical isolation (EPPO, 2021).

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CABI resources used when preparing this datasheet

CABI Datasheet on *Euwallacea fornicatus*:
<https://www.cabidigitallibrary.org/doi/10.1079/cabicompendum.18360453>

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