CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

California Pest Rating Proposal for

Fusarium kuroshium (F. Na, J.D. Carrillo & A. Eskalen ex Sand.-Den. & Crous) O'Donnell, Geiser, Kasson & T. Aoki 2020

≡ ***Neocosmospora kuroshio*** **F. Na, J.D. Carrillo & Eskalen ex Sand.-Den. & Crous 2019**

Current Pest Rating: Z

Proposed Pest Rating: B

Kingdom: Fungi, Phylum: Ascomycota,
Subphylum: Pezizomycotina, Class: Sordariomycetes,
Subclass: Hypocreomycetidae, Order: Hypocreales,
Family: Nectriaceae

Comment Period: 11/02/2022 through 12/17/2022

Initiating Event:

This pathogen has not been through the current pest rating process. The risk to California from *Fusarium kuroshium* is described herein and a permanent rating is proposed.

History & Status:

Background:

Shot hole borers (SHB)-Fusarium dieback (FD) is a pest-disease complex affecting numerous tree species in California. SHB are ambrosia beetles that feed on symbiotic fungi that they carry in their mandibular mycangia to inoculate and cultivate inside living trees. Within beetle galleries, fungi grow and serve as a source of food for the beetles. There are two genetically distinct, but morphologically indistinguishable *Euwallacea* spp. nr. *fornicatus* beetles in California with independent evolutionary lineages (O'Donnell et al. 2015; Stouthamer et al. 2017). They are referred to as polyphagous shot hole borer (PSHB) (*Euwallacea fornicatus* [Eichhoff]) and Kuroshio shot hole borer (KSHB) (*Euwallacea kuroshio* Gomez and Hulcr), (Coleoptera: Curculionidae: Scolytinae: Xyleborini), and they are associated with separate species of symbiotic fungi. It is believed that polyphagous shothole borer (PSHB) and Kuroshio shothole borer (KSHB) were introduced to Southern California from Vietnam and Taiwan respectively. The beetles were presumably transported in infested wood products or shipping material.

These ambrosia beetles create galleries and cause damage to dozens of species of trees. PSHB was evaluated in 2015 and has a B rating (Leathers, 2015).

In 2013, beetle infestations were detected on sycamore trees located in El Cajon in San Diego County. This beetle infestation was initially considered to be an extension of the existing infestation of PSHB from Los Angeles County. Molecular analysis of the fungal symbionts (*Fusarium* spp. and *Graphium* spp.) revealed significant differences from the symbionts normally recovered from PSHB (Na et al., 2018). The beetle was subsequently named Kuroshio shot hole borer, and in 2014 was confirmed in commercial avocado groves and landscape trees in San Diego County. In 2015, a large-scale infestation was identified in the Tijuana River Valley. KSHB is currently also present in Orange and Santa Barbara Counties. A single beetle was caught in a trap in San Luis Obispo County in 2016. Today we have sympatric populations of both beetle species in San Diego, Orange, and southern Los Angeles counties. With two invasive SHB-FD complexes in California, it is important to distinguish between the fungi they vector to identify any differences in host range and pathogenicity, as well as to describe morphological and genetic differences for diagnostics. *Fusarium euwallaceae*, which is one of the plant pathogens carried by the PSHB, has previously gone through the pest rating system, and is rated B (Scheck, 2020).

The Ambrosia Fusarium Clade (AFC) is a monophyletic lineage within clade 3 of the *Fusarium solani* species complex. These fungi are known or predicted to be farmed by adult female *Euwallacea* ambrosia beetles as nutritional mutualism. *Fusarium kuroshium* was first isolated from the heads or galleries of KSHB in a California sycamore tree. Conidia formed by *F. kuroshium* vary widely in size and shape and are described as having multiseptate “dolphin shaped” conidia. Maximum likelihood and maximum parsimony analyses of a multi locus data set have shown that *F. kuroshium* is a phylogenetically distinct species based on genealogical concordance (Aoki et al., 2021)

Fusarium kuroshium was found to be the most abundant fungal species from macerated heads of Kuroshio shot hole borers that were recovered from sycamore (*Platanus racemosa*) and avocado (*Persea americana*) in California (Gomez et al., 2018; Na et al., 2018). A second beetle species, *E. interjectus* has an association with *F. kuroshium* in Japan and fig trees (*Ficus carica*), but pathogenicity has not been described (Jiang et al., 2021).

Hosts: Albizia julibrissin (Persian silk tree), *Dombeya cacuminum* (strawberry snowball tree), *Erythrina humeana* (dwarf coral tree), *Persea americana* (avocado), *Platanus racemosa* (California sycamore), coast live oak (*Quercus agrifolia*), *Quercus suber* (cork oak), *Ricinus communis* (castor bean) (Morse et al., 2017).

Symptoms: Trees will show different symptoms of SHB-FD depending on the response of the tree to the beetle-fungal infestation. Affected trees generally will have signs of ambrosia beetle attack. The typical entry-hole to a gallery is round and approximately 0.9 mm in diameter. The abdomen of the female beetle can sometimes be seen protruding from the entry-hole. The hole may also be plugged or covered by sap, exudate, or frass. Frass produced by the beetle's boring activity may be present on the host tree depending on the infestation level. Long "matchsticks" of frass have been observed on some tree species.

Symptoms caused by FD vary depending on the host tree's response to water stress because the xylem is affected. Staining may be visible on the exterior of branches or trunk and may be wet and dark or dry and light-colored. Light colored staining is more characteristic for sycamores. Sugary exudate from avocados is often in the form of white, powdery "volcanoes". Some of these symptoms may be washed away or obscured by rain or irrigation water. *Fusarium kuroshium* infection causes dark discoloration of the wood beneath the bark and around the beetle gallery.

Advanced infestations lead to branch dieback and overall decline. When beetle attacks are concentrated on a branch or in the branch collar, infestations can lead to limb failure. Some trees develop large branch cankers with distal dieback and defoliation. Some trees undergo a generalized wilt leading to mortality in severe cases (Eskalen et al., 2012).

Transmission: Only the female KSHB can fly. Females bore tunnels into a wide variety of host trees forming galleries where eggs, containing more females than males, are laid. Mature siblings mate with each other allowing females, ready to lay fertilized eggs, to leave and start new galleries. They are also capable of parthenogenesis; if a female fails to mate before leaving the gallery, she can lay unfertilized eggs and later mate with a son. Through flight and natural spread, the population expands. SHB will grow its colony within a single tree until the point it is no longer a suitable host. There can be 3-5 generations per year and trees can suffer the effects of thousands of SHB galleries. Long distance spread is possible with nursery stock, or infested firewood or other solid wood materials such as pallets (Morse et al., 2017).

Both PSHB and KSHB have a special structure in their mandibles called a mycangium. KSHB carries *Fusarium kuroshium* and *Graphium kuroshium*. The beetle grows these fungi in their galleries for food (Eskalen et al., 2012).

Damage Potential: Many ambrosia beetles and their associated fungi are ecologically constrained to dying or dead trees and usually remain relatively harmless even after establishment in non-native regions (Cognato et al., 2015). Some invasive symbioses have been found to shift from non-pathogenic saprotrophy in native ranges to prolific tree killing in invaded ranges and cause significant damage (Joseph and Keyhani, 2021). Eskalen (2022) reported that *F. kuroshium* and a second fungus associated with KSHB, *Graphium kuroshium,* are part of a complex and as confirmed by Koch's postulates, both fungi are capable of causing disease in healthy young avocado plants.

The main cause of branch loss or tree mortality is likely the disruption of water and nutrients in the phloem and xylem, which results from both fungal infection and extensive beetle boring (Coleman et al. 2019). High levels of colonization by female SHB and the ensuing action of the pathogen along the main stem and branches have led frequently to tree injury and mortality of certain hardwood species (Coleman et al. 2019). *Fusarium kuroshium* can produce several key metabolites with phytotoxicity properties. Among the metabolites identified in a fungal exo-metabolome project, fusaric acid (FA) was further studied due to its phytotoxicity and relevance as a virulence factor. Testing of FA and organic extracts from *F. kuroshium* at various dilutions in avocado foliar tissue was done by Gutiérrez-Sánchez et al., (2021) and was found to be the cause of necrosis and chlorosis, producing symptoms like those observed in FD.

Worldwide Distribution: Japan, Taiwan, United States (California).

Official Control: *Fusarium kuroshium* is a quarantine pest in Mexico

California Distribution: Los Angeles, Orange, San Diego, and Santa Barbara counties (CDFA PDR Database, 2022; Na et al., 2018). A single beetle was caught in a trap in San Luis Obispo County in 2016.

California Interceptions: none

The risk *Fusarium kuroshium* would pose to California is evaluated below.

Consequences of Introduction:

1) **Climate/Host Interaction:** To date, all detections of KSHB-FD have been in southern California. Since this is an exotic, invasive species, it is unclear if it will be able to continue to spread north from Santa Barbara into other parts of California. Low temperatures are a limiting factor with minimum temperatures for development of SHB measured at 13°C (Umida and Paine, 2018).

   Evaluate if the pest would have suitable hosts and climate to establish in California.

   Score: **2**
   - Low (1) Not likely to establish in California; or likely to establish in very limited areas.
   - **Medium (2) may be able to establish in a larger but limited part of California.**
   - High (3) likely to establish a widespread distribution in California.

2) **Known Pest Host Range:** The host range includes trees in multiple families.

   Evaluate the host range of the pest.

   Score: 2
   - Low (1) has a very limited host range.
   - **Medium (2) has a moderate host range.**
   - High (3) has a wide host range.

3) **Pest Reproductive Potential:** KSHB can fly and has the potential to produce multiple generations per year in southern California. It could move longer distances with infested nursery stock or with firewood. KSHB carries *F. kuroshium* in mycangia and inoculates it into its natal galleries inside suitable tree hosts.

   Evaluate the natural and artificial dispersal potential of the pest.

   Score: 3
   - Low (1) does not have high reproductive or dispersal potential.
   - Medium (2) has either high reproductive or dispersal potential.

- High (3) has both high reproduction and dispersal potential.

4) **Economic Impact:**

Damage has been reported from the pathogen on both known hosts. It is vectored by an ambrosia beetle which bores into trees.

Evaluate the economic impact of the pest to California using the criteria below.

Economic Impact: A, E

A. The pest could lower crop yield.
B. The pest could lower crop value (includes increasing crop production costs).
C. The pest could trigger the loss of markets (includes quarantines).
D. The pest could negatively change normal cultural practices.
E. The pest can vector, or is vectored, by another pestiferous organism.
F. The organism is injurious or poisonous to agriculturally important animals.
G. The organism can interfere with the delivery or supply of water for agricultural uses.

Economic Impact Score: 2

- Low (1) causes 0 or 1 of these impacts.
- Medium (2) causes 2 of these impacts.
- High (3) causes 3 or more of these impacts.

5) **Environmental Impact:** *Platanus racemosa*, California sycamore, is a native species in western North America. Its preferred habitat is on stream banks, and it occurs widely along the coast from San Diego to the Bay area, in the Sierra foothills, and the Sacramento valley (Calflora, https://www.calflora.org/app/taxon?crn=6633).

Evaluate the environmental impact of the pest to California using the criteria below

Environmental Impact: A, E

A. The pest could have a significant environmental impact such as lowering biodiversity, disrupting natural communities, or changing ecosystem processes.
B. The pest could directly affect threatened or endangered species.
C. The pest could impact threatened or endangered species by disrupting critical habitats.
D. The pest could trigger additional official or private treatment programs.
E. The pest significantly impacts cultural practices, home/urban gardening or ornamental plantings.

Environmental Impact Score: 3

- Low (1) causes none of the above to occur.
- Medium (2) causes one of the above to occur.
- High (3) causes two or more of the above to occur.

Consequences of Introduction to California for *Fusarium kuroshium:* Medium

Add up the total score and include it here. **11**
-Low = 5-8 points
-Medium = 9-12 points
-High = 13-15 points

6) **Post Entry Distribution and Survey Information**: Evaluate the known distribution in California. Only official records identified by a taxonomic expert and supported by voucher specimens deposited in natural history collections should be considered. Pest incursions that have been eradicated, are under eradication, or have been delimited with no further detections should not be included.

   Detections have been made in Orange County, and in the southern part of Santa Barbara County.

   Evaluation is 'low'.

   Score: -1
   -Not established (0) Pest never detected in California or known only from incursions.
   -Low (-1) Pest has a localized distribution in California or is established in one suitable climate/host area (region).
   -Medium (-2) Pest is widespread in California but not fully established in the endangered area, or pest established in two contiguous suitable climate/host areas.
   -High (-3) Pest has fully established in the endangered area, or pest is reported in more than two contiguous or non-contiguous suitable climate/host areas.

7) **The final score is** the consequences of introduction score minus the post entry distribution and survey information score: (Score)

   Final Score: *Score of Consequences of Introduction – Score of Post Entry Distribution and Survey Information* ***= 10***

Uncertainty:

It is difficult to distinguish between PSHB and KSHB. It is possible some infestations of PSHB are actually KSHB. The fungi they carry are also very closely related. The host list for this complex could expand over time.

Conclusion and Rating Justification:

Based on the evidence provided above the proposed rating for *Fusarium kuroshium* is B.

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Responsible Party:

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***Comment Period: 11/02/2022 through 12/17/2022**

***NOTE:**

You must be registered and logged in to post a comment. If you have registered and have not received the registration confirmation, please contact us at permits[@]cdfa.ca.gov.

Comment Format:

- Comments should refer to the appropriate California Pest Rating Proposal Form subsection(s) being commented on, as shown below.

  Example Comment:

  Consequences of Introduction: 1. Climate/Host Interaction: [Your comment that relates to "Climate/Host Interaction" here.]

- Posted comments will not be able to be viewed immediately.
- Comments may not be posted if they:

  Contain inappropriate language which is not germane to the pest rating proposal;

Contains defamatory, false, inaccurate, abusive, obscene, pornographic, sexually oriented, threatening, racially offensive, discriminatory or illegal material;

Violates agency regulations prohibiting sexual harassment or other forms of discrimination;

Violates agency regulations prohibiting workplace violence, including threats.

- Comments may be edited prior to posting to ensure they are entirely germane.
- Posted comments shall be those which have been approved in content and posted to the website to be viewed, not just submitted.

Proposed Pest Rating: B
