

## Invasive Shot Hole Borers Threatening Trees in Southern California

**T**he Polyphagous shot hole borer (PSHB) (Fig. 1) and Kuroshio shot hole borer (KSHB) are invasive wood-boring beetles that attack dozens of tree species in Southern California, including commercial avocado groves, common landscape trees, and native species in urban and wildland environments. Both beetles spread a disease called Fusarium Dieback (FD), which is caused by pathogenic fungi. Trees that are FD-susceptible may experience branch dieback, canopy loss, and tree mortality (Fig. 2).

### Insect Vector

PSHB carries three fungi: *Fusarium euwallaceae*, *Graphium euwallaceae* and *Paracremonium pembeum*. KSHB carries two new species of fungi: *Fusarium* sp. and *Graphium* sp. Mature females of both species are black and 0.07 to 0.1 inches (1.8–2.5 mm) long, whereas males are brown and smaller than females at 0.06 inches (1.5 mm) long. The female attacks a wide variety of host trees forming galleries (Fig. 3), where she lays her eggs. Mature siblings inbreed inside galleries and the pregnant females leave to establish new galleries in the same host or nearby hosts; most wingless males, however, remain in maternal galleries.

The tiny beetles tunnel into host trees and spread the fungi that cause FD disease. Beetle larvae within the gallery in



Fig. 1. Adult female Polyphagous shot hole borer (*Euwallaceae* sp.).



Fig. 2. Dead box elder tree.



Fig. 3. Beetle gallery formation on box elder.

infected trees feed on the fungus, forming a symbiotic relationship between the fungus and beetle. Fusarium Dieback stops the flow of water and nutrients in over 48 susceptible tree species, which can lead to the death of individual branches or, in severe cases, an entire tree (Fig. 2).

### Symptoms

**External:** A host tree's visible response to disease varies among host species. Sugary exudate (also called a sugar volcano) (Fig. 4), staining (Fig. 5), gumming (Fig. 6), and frass (Fig. 7) are among symptoms that may be noticeable before the tiny beetles are found. The beetle's entry holes, which are approximately 0.03 inches (0.85 mm) in diameter, can be located beneath or near the symptoms. Advanced fungal infections will eventually lead to branch dieback.

**Internal:** The fungi interrupt the transport of water and nutrients in branches of affected trees, leading to wood discoloration which can vary in color from brown to black. Shaving outer layer bark with a clean knife around beetle entry holes reveals obvious wood discoloration. Cross-sections of cut branches around affected areas show the extent of infection (Fig. 8).

### Wide range of hosts

These two beetles and their symbiotic fungi have a wide variety of suitable hosts. See list on page 2. This wide host range makes landscape, native riparian, oak woodland, and mixed evergreen communities highly susceptible to invasion and mortality by PSHB/KSHB-FD.

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# Invasive Shot Hole Borers ...continued from page 1



Fig. 4. Sugar volcano symptoms on avocado.

Fig. 5. Staining symptoms on coast live oak.

Fig. 6. Gummy symptoms on *Calpurnia aurea*.

Fig. 7. Frass symptoms on avocado.

Fig. 8. Fungal colonization on a box elder tree trunk.

## Management on Landscape Trees

Chemical and biocontrol management strategies are currently being investigated for this pest-disease complex. Early detection of infestation and removal of the infested branches will help reduce vector populations and the spread of this pest-disease complex.

If you or your customers suspect PSHB or KSHB is affecting trees in your area, please contact your local Agricultural Commissioner's office or UC Cooperative Extension office.

## Cultural/Sanitation Practices

The removal of the heavily infested reproductive hosts will help reduce vector populations and the spread of this pest-disease complex.

- Chip infested wood onsite to a size of one inch or smaller. If the branch is too large to chip, solarize them under a clear tarp:
  - ✦ **July – August:** cover chips/logs with sturdy plastic for at least 6 weeks. Temperatures during these months should be regularly above 95°F (35°C)

✦ **September – June:** cover chips/logs with sturdy plastic for at least 6 months

- Have wood chips composted at a professional composting facility that has earned the U.S. Composting Council's Seal of Testing Assurance at: <http://compostingcouncil.org/participants/>. Sterilize pruning tools with either 5% household bleach, Lysol cleaning solution, or 70% ethyl alcohol to prevent the spread of the pathogens through pruning tools
- Avoid movement of infested wood and chipping material out of infested areas unless the material is covered or contained during transport.
- Transport wood or chips to a biogeneration facility (biogeneration facilities burn green waste and convert it into energy).
- Transport wood or wood chips to a landfill where it will be used as Alternative Daily Cover.

For more information, visit the UC Riverside Eskalen Lab website (<http://eskalenlab.ucr.edu>) or [pshb.org](http://pshb.org).

## Current reproductive host list of Shot Hole Borers

1. Box elder (*Acer negundo*)\*
2. Big leaf maple (*Acer macrophyllum*)\*
3. Evergreen Maple (*Acer paxii*)
4. Trident maple (*Acer buergerianum*)
5. Japanese maple (*Acer palmatum*)
6. Castorbean (*Ricinus communis*)
7. California Sycamore (*Platanus racemosa*)
8. Mexican sycamore (*Platanus mexicana*)
9. Red Willow (*Salix laevigata*)\*
10. Arroyo willow (*Salix lasiolepis*)\*
11. Avocado (*Persea americana*)
12. Mimosa (*Albizia julibrissin*)
13. English Oak (*Quercus robur*)
14. Coast live oak (*Quercus agrifolia*)\*
15. London plane (*Platanus x acerifolia*)
16. Cottonwood (*Populus fremontii*)\*
17. Black cottonwood (*Populus trichocarpa*)\*
18. White Alder (*Alnus rhombifolia*)\*
19. Titoki (*Alectryon excelsus*)
20. Engelmann Oak (*Quercus engelmannii*)\*
21. Cork Oak (*Quercus suber*)
22. Valley oak (*Quercus lobata*)\*
23. Coral tree (*Erythrina corallodendron*)
24. Blue palo verde (*Cercidium floridum*)\*
25. Palo verde (*Parkinsonia aculeata*)\*
26. Moreton Bay Chestnut (*Castanospermum australe*)
27. Brea (*Cercidium sonora*)
28. Mesquite (*Prosopis articulata*)\*
29. Weeping willow (*Salix babylonica*)
30. Chinese holly (*Ilex cornuta*)
31. Camelia (*Camellia semiserrata*)
32. Acacia (*Acacia spp.*)
33. Liquidambar (*Liquidambar styraciflua*)
34. Red Flowering Gum (*Eucalyptus ficifolia*)
35. Japanese wisteria (*Wisteria floribunda*)
36. Goodding's black willow (*Salix gooddingii*)\*
37. Tree of heaven (*Ailanthus altissima*)
38. Kurrajong (*Brachychiton populneus*)
39. Black mission fig (*Ficus carica*)
40. Japanese beech (*Fagus crenata*)
41. Dense logwood (*Xylosma congestum*)
42. Mule Fat (*Baccharis salicifolia*)\*
43. Black Poplar (*Populus nigra*)\*
44. Carrotwood (*Cupaniopsis anacardioides*)
45. California buckeye (*Aesculus californica*)\*
46. Canyon Live oak (*Quercus chrysolepis*)\*
47. Kentia Palm (*Howea forsteriana*)
48. King Palm (*Ptychosperma elegans*)

\*Native species to California

# Phytophthora tentaculata: A New Exotic and Invasive Disease

A new plant pathogen in the genus *Phytophthora* (pronounced Fie-TOF-ther-uh) has recently been found in several California native plant nurseries and habitat restoration sites. The pathogen, *Phytophthora tentaculata*, poses a risk of disease in wildlands, gardens and landscapes that use susceptible California native and non-native plants. Once introduced in these areas, the pathogen can generate disease for years to come, potentially causing lasting environmental and economic impacts. Because both native and non-native California plants from nurseries can carry new pathogens and other pests, it is important to remember that only healthy plant material should be used for planting.

## What is Phytophthora?

Phytophthoras are microscopic, fungus-like organisms called water molds that produce spores and hyphae. Many are soilborne, attack plant roots and stems, and spread by the movement of infested soil, including soil stuck to tools, containers, or shoes. The genus *Phytophthora* is large, with over 100 described species, including the Sudden Oak Death pathogen and other destructive

pathogens of agricultural, ornamental, and forest plants.

Similar to other members of the *Phytophthora* genus, *P. tentaculata* releases swimming spores that move through water and are attracted to plant root exudates. Once infected, the pathogen can cause disease in susceptible plant roots. If susceptible stems are contacted, infection can occur there following water movement or splash, and stem disease can also result from the pathogen growing into the stem from the roots. *Phytophthora tentaculata* cannot be seen with the naked eye unless grown in a laboratory. However, it usually produces visible symptoms – stem cankers and root rots – on host plants.

## Hosts, symptoms and detection

The pathogen was first described in 1993 from a nursery in Germany. In the United States, it was first found in 2012 in a nursery in Monterey County, and to date is present only in central California. Currently, seventeen plant species and two additional genera worldwide are thought to be susceptible to *P. tentaculata*, but the list may expand as we learn more. In California, eight native plant

species and one additional genus have been found infected, all common in the native plant nursery trade and in wildlands. These include *Artemisia douglasiana* (mugwort), *A. dracuncululus* (tarragon), *A. californica* (California sagebrush), *Salvia* species (sage), *Ceanothus cuneatus* (buck brush), *Frangula californica* (California coffeeberry), *Monardella villosa* (coyote-mint), and *Heteromeles arbutifolia* (toyon).

In California, *P. tentaculata* was first isolated from *Diplacus aurantiacus* (orange bush monkeyflower) where it was observed causing aboveground symptoms (Fig. 1a) that included stunted growth, sparse and chlorotic foliage, stem collar lesions (Fig. 1b) and plant death. Root system symptoms included necrotic, sunken lesions, and few roots (Fig. 1c). Soon after, *P. tentaculata* was detected in the nursery trade in the U. S., the pathogen was recovered in central California wildlands, presumably having been released into the landscape via contaminated nursery plants used in restoration plantings. It has now been found in Alameda, Butte, Monterey, Placer, and Santa Cruz Counties.

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[IMAGES: (A) L. SIMS; (B-C) S. ROONEY-LATHAM, CDFW]

**Figure 1.** (a) Dying and dead *Diplacus aurantiacus* (orange bush monkeyflower) with advanced above ground symptoms, typical of *Phytophthora* disease. The infected plants has chlorotic (yellowing and browning) foliage. (b) The inner stem and root crown of a diseased *D. aurantiacus* was discolored and advanced up the stem from the roots. (c) *Artemisia douglasiana* (mugwort) plant infected with *P. tentaculata* had a sparse root system a result of severe root rot.

## *P. tentaculata* ...continued from page 3

Germany, Italy, Spain, and China have reported disease from *P. tentaculata* on several plant species including *Apium graveolens* (celery), *Saussurea costus* (costus root), *Cichorium intybus* (chicory), *Chrysanthemum* species (hybrids, marguerite, and oxeye daisy), *Consolida ajacis* (rocket larkspur), *Gerbera jamesonii* (Barberton daisy), *Origanum vulgare* (oregano), *Santolina chamaecyparissus* (lavender cotton), and *Verbena* species (vervain hybrids). Many of the above species are grown in California and should be considered at risk to disease.

### Prevention and Management

**Prevention:** By far, prevention is the best possible method for dealing with any *Phytophthora* pathogen. Consider planting from seed as *Phytophthora* in general is rarely transmitted this way. If buying container stock of any of the above plant species, find out if the nursery is following best management practices for preventing *Phytophthora* (for example: [tinyurl.com/zvmjyt3](http://tinyurl.com/zvmjyt3)). Purchase plant material that has been grown in pasteurized soil and under proper sanitation procedure. Do not use/buy plants or material that has been in the nursery for an extended time, these can become contaminated with *Phytophthora* and other pathogens.

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**Avoidance:** Avoid buying known host-plant container stock and do not purchase plants that appear unhealthy or otherwise potentially contaminated. At more advanced stages of disease, plants may exhibit symptoms as outlined above, but nearby plants may still look healthy even though they have been contaminated through soil or water movement. If a number of plants in the nursery block show symptoms of infection, do not buy those plants or their neighbors. The host species list is a work in progress; be aware that other, unlisted species may also be susceptible.

**Quarantine:** If you purchase host plants (or closely related species), consider setting them aside before planting. Give the plants time (4 - 6 weeks) to develop symptoms before planting them in your yard, and be sure soil and excess water from these plants does not flow into your garden soil. If symptoms develop, dispose of the plant, soil, and container according to disposal guidelines for your area. Do not home-compost this pathogen, as it may not be killed.

**Remediation:** If plants are already in the ground and exhibiting symptoms such as stunted growth and/or chlorotic foliage, check the root collar and stem for necrotic sunken lesions and/or stem rots.

If possible, check root systems for abnormally large numbers of dead and dying roots, few healthy new roots, and necrotic spotting on roots that are still living. If the roots appear to be infected, do not move soil from the garden bed and nearby infected plants to other parts of the garden.

Change irrigation practices to reduce the potential for *Phytophthora* growth, as outlined in the UC IPM Pest Note: *Phytophthora Root and Crown Rot in the Garden* at [ipm.ucanr.edu/PMG/PEST-NOTES/pn74133.html](http://ipm.ucanr.edu/PMG/PEST-NOTES/pn74133.html). Clean your tools and boots before working another area of your garden. You may wish to contact your local Agricultural Commissioner or UC Cooperative Extension office to see if they can offer updates or further advice.

For more information, including references to original research and related articles, see the pages covering this pathogen at [www.suddenoakdeath.org/diagnosis-and-management/nursery-information/phytophthora-tentaculata/](http://www.suddenoakdeath.org/diagnosis-and-management/nursery-information/phytophthora-tentaculata/).

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