Information for pest management professionals and pesticide applicators

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Invasive Shot Hole Borers Threatening Trees in Southern California

The 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 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).

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

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Fig. 2. Dead sycamore tree.

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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Management on Landscape Trees

If you think PSHB or KSHB is affecting trees in a landscape or area you manage, please contact your local Agricultural Commissioner's or UC Cooperative Extension before making any treatments or removing 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.

Preliminary results from ongoing pesticide experiments on sycamore trees suggest that a combination of emamectin benzoate (4%) and propiconazole (14.3%) applied as trunk injections in the wood (2-3" in the xylem), lead to a reduction in new beetle attacks over time on low-level infested trees. An earlier study also suggests that a combination of emamectin benzoate (4%) and tebuconazole (16%) applied as trunk injections in the wood were able to reduce new beetle attacks over time on infested trees.

If the infestation level on a host is moderate to heavy, we also found some level of control with trunk sprays of bifenthrin (23.4%), and a soil drench application of the systemic insecticide imidacloprid (75%). It is important to note that the chance of saving a moderate to heavily infested tree is very low. **Note: These pesticides are only registered on landscape trees.** [The mention of these pesticides does not constitute a recommendation.]

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Fig. 3. Beetle gallery formation on box elder.

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Fig. 4. Sugar volcano symptoms on avocado.

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Fig. 5. Staining symptoms on coast live oak.

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Fig. 6. Gumming symptoms on Calpurnia aurea.

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 lasolepis*)*
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 corallodendon*)
24. Blue palo verde (*Cercidium floridum*)*
25. Palo verde (*Parkinsonia aculeata*)*
26. Moreton Bay Chestnut (*Castanospermum australe*)
27. Brea (*Cercidium sonorae*)
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 goddingii*)*
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**

Invasive Shot Hole Borers *...continued from p.2*

Cultural/Sanitation Practices

The removal of 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 branches are 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 preferably be 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 moving 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 at eskalenlab.ucr.edu or pshb.org.

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Fig. 7. Frass symptoms on avocado.

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