Fusarium dieback: A new and serious insect-vectored disease of landscape trees

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A NEW, SERIOUS, INSECT-vectored disease, *Fusarium* dieback, has been discovered in southern California on landscape trees and *Persea americana* (avocado). The latter is typically an orchard tree but, because of the popularity of its fruit, it frequently appears in the landscape. A new, yet unnamed species of *Fusarium* causes the disease. A type of ambrosia beetle tentatively identified as the tea shot hole borer (TSHB) is the vector although the beetle, morphologically identical to the TSHB, might also be a new species. The host list includes many common landscape trees and avocado and other fruit trees. Here we provide a brief overview of the disease and its vector.

Disease symptoms

Symptoms of *Fusarium* dieback include dark, dry or water-soaked or oily-looking, sometimes weeping lesions surrounding beetle entry/exit holes on the trunk and branches (**Figs. 1-3**); discolored wood; leaf discoloration and chlorosis; wilting; branch dieback (**Fig. 4**); and, in some cases, death of the tree (**Fig. 5**). In *Acer negundo* (box elder), *Persea americana*, and some other species, a white, sometimes crusty ring or halo of sugary exudate surrounds the entry/exit hole (**Figs. 6**). Scraping the bark down to the wood behind the entry/exit hole reveals brown necrotic tissue (**Fig. 7**). Staining may be found beneath the outermost layers of sapwood to a depth of up to 1.5 to 2 inches. So far the disease has only been found in Israel and California.

Figure 1. (Left) On this old *Acer negundo* in Long Beach, CA initial symptoms of *Fusarium* dieback include dark, discolored, dry or water-soaked or oily-looking, sometimes weeping bark lesions surrounding beetle entry/exit holes on the trunk and branches. (D. R. Hodel).

Figure 2. (Right) Extensive areas of discolored, dry or water-soaked or oily-looking lesions, which give the bark a somewhat stained appearance, are symptoms of *Fusarium* dieback on this young, severely attacked *Acer negundo* in Long Beach, CA. Note the chlorotic leaves. (D. R. Hodel).

Tea Shot Hole Borer

The TSHB (*Euwallacea fornicatus*) is native to southern Asia. Initially it was collected and described from Ceylon (Sri Lanka) in 1868. It has been found in Bangladesh, Cambodia, China, Japan, India, Indonesia, Malaysia, Myanmar, Taiwan, Thailand, Vietnam, New Guinea, Philippine Islands, Fiji, Samoa, Reunion Island, Micronesia, Australia, Israel, Madagascar, Panama and, the United States, including Florida, Hawaii, and, most recently, California. The TSHB favors tropical and subtropical climates, where it produces multiple generations per year, but has been found at elevations of up to 15,000 feet. It is considered an aggressive pest and can attack healthy, vigorous trees as well as weakened or stressed trees.

An unusually small beetle, female TSHBs are 0.07 to 0.1 inch long and dark brown to black (**Fig. 8**) while males are even smaller, about 0.05 inch long and brown (**Fig. 9**). The female TSHB is the primary disperser and, once landing on a new host tree, it makes tunnels by burrowing through the bark and into the wood, penetrating about 0.5 to 1.5 inches. Entry/exit holes in avocadoes are about 0.033 inch in diameter. Larvae are about 0.14 inch long and 0.04 inch wide. In heavy, severe infestations,

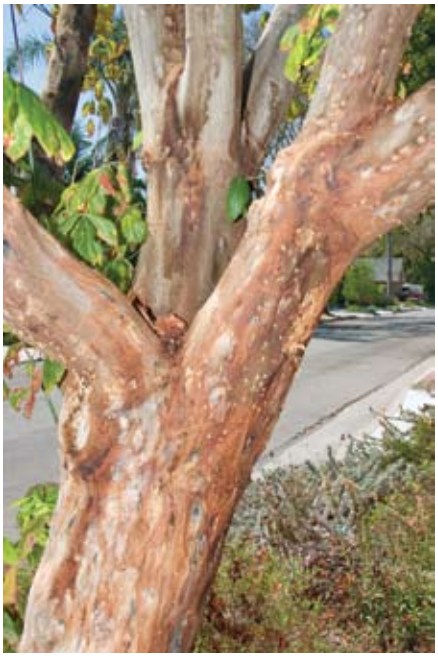


Figure 3. (Left) Extensive areas of discolored, dry or water-soaked or oily-looking lesions, which give the bark a somewhat stained appearance, are symptoms of *Fusarium* dieback on this young, severely attacked *Acer negundo* in Long Beach, CA. Note the grayish halo surrounding beetle entry/exit holes. Barely discernable "toothpick" frass (right center and upper right) is likely from a secondary invader, probably another species of ambrosia beetle (D. R. Hodel).

Figure 4. (Right) Advanced symptoms of *Fusarium* dieback include branch death (*Acer negundo*, Long Beach, CA). (D. R. Hodel).

TSHBs can be seen at the entry/exit hole openings (**Fig. 10**) or on freshly cut wood.

The TSHB closely resembles many other ambrosia beetles. These beetles can be extremely challenging to differentiate. Other species of ambrosia beetles, including several species in the genera *Monarthrum*, *Xyleborus*, and *Xyleborinus*, are easily mistaken for the TSHB, and their host lists can overlap with that of the TSHB. These other species can produce distinctive, solidified frass resembling short, round toothpicks protruding from the bark but, because this frass dissolves readily in water, it might be unobserved. Nonetheless, field identification of the TSHB should be considered tentative until confirmed by a specialist.

Natural history

The disease is the result of the symbiotic relationship between the TSHB and the *Fusarium* fungus, a type of relationship found in many ambrosia beetles with different fungi. The female TSHB, which disperses to other parts of the host tree or to new host trees, carries the fungus from tree to tree in specialized sacs in its head. It secretes the fungal spores into its mouth and uses its mandibles to deposit spores on the walls of the tunnels it creates. Egg laying and hatching are timed to coincide with development of the *Fusarium* within the tunnel walls. Larvae remain in the tunnels, feeding on the fungus, pupating, and emerging as adults within about 40 days. Male TSHBs, which occur at lower rates than females, are flightless but may crawl out from the tunnel in which they were reared in order to mate.

The host list includes many common landscape trees and avocado and other fruit trees.

The fungus, which is likely dependent on the TSHB for dispersal, attacks the vascular tissue, disrupting water, carbohydrate, and mineral flow within the tree, and eventually causing branch die back or, in some cases, death of the entire tree. Some potential host species seem capable of plugging entry holes with sap and other plant exudates, which may repel or severely limit movement of the beetle and spread of the disease. Adult tunneling activity can weaken branches and provide entry points for secondary pests and diseases.

The TSHB might be associated with a second fungus, *Ceratocystis fimbriata*, which was found on *Punica granatum* (pomegranate) in India but has not been discovered in California. (*C. fimbriata*, a vascular wilt disease affecting a wide range of hosts, has

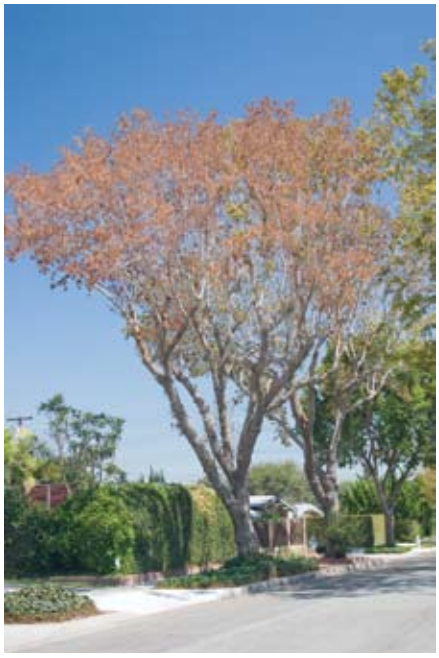


Figure 5. Eventually *Fusarium* dieback will kill the tree (*Acer negundo*, Long Beach, CA). (D. R. Hodel).

forms or strains with limited host ranges that may ultimately prove to be distinct species. One such form, *C. fimbriata* f. sp. *platani*, is found in parts of California but only affects trees of the genus *Platanus*.)

Host List

The host list of the TSHB is over 100 species in 36 families and will likely become longer. The TSHB is a generalist (polyphagous), as opposed to having a limited host preference, and, therefore, has increased potential for inflicting greater economic and environmental harm to a wider range of hosts. Table 1 lists some of the more commonly attacked species. Preferred or unusually susceptible hosts include *Persea americana*, *Acer negundo*, and *Ricinus communis* (castor bean). The latter, especially because it frequently occurs as a wild plant along water courses and in unkempt or abandoned areas, might serve as a source of the fungus and vector for spreading the disease to nearby landscapes and orchards.

Of tremendous concern, of course, is the potential for damage to avocado trees and that industry in California.

Table 1. Selected Host Species of the Tea Shot Hole Borer

BOTANICAL NAME	COMMON NAME
Acer negundo	box elder
Acer saccharinum	silver maple
Ailanthus altissima	tree-of-heaven
Albizia julibrissin	silk tree
Alnus rubra	red alder
Bixa orellana	lipstick tree, annatto
Chamaedorea seifrizii	bamboo palm
Camellia sinensis	tea
Castanopsis spp.	chinkapin
Ceiba pentandra	kapok
Citrus spp.	citrus
Cupaniopsis anacardioides	carrot wood
Delonix regia	royal poinciana
Durio zibethinus	durian
Gmelina arborea	beechwood, gamhar
Grevillea robusta	silk oak
Hevea brasiliensis	rubber tree
Koelreuteria elegans	goldenrain tree
Litchi chinensis	lychee, litchi
Macadamia integrifolia	macadamia nut
Mangifera indica	mango
Persea americana	avocado, alligator pear
Persea bombycina	som
Platanus racemosa	California sycamore
Platanus × hispanica (Platanus × acerifolia)	London plane tree
Psidium guajava	guava
Punica granatum	pomegranate
Ricinus communis	castor bean
Robinia pseudoacacia	black locust
Shorea spp.	meranti
Tectona grandis	teak
Terminalia catappa	tropical almond
Theobroma cacao	cacao tree
Wisteria spp.	wisteria

Figure 6. (Left) In some species, a white ring or halo of sugary exudate surrounds the TSHB entry/exit hole (*Acer negundo*, Long Beach, CA). (D. R. Hodel).

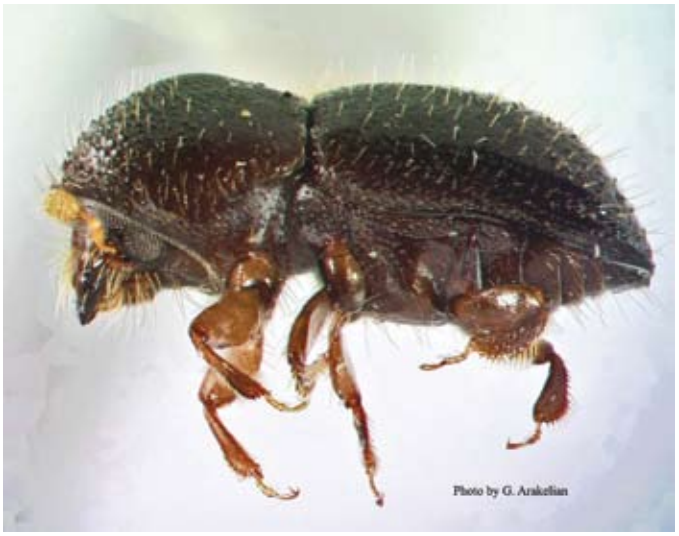
Figure 7. (Right) On trees with *Fusarium* dieback, scraping of the bark down to the wood behind the TSHB entry/exit hole typically reveals brown necrotic tissue (*Persea americana*). (A. Eskalen).

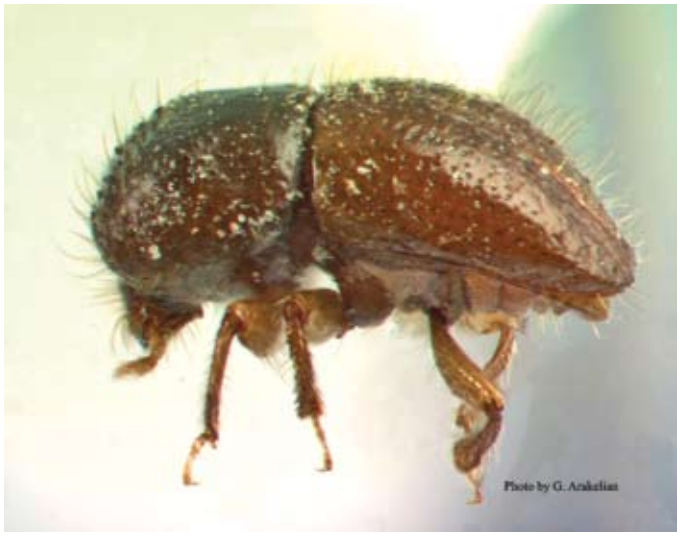
However, because of the wide host range of the TSHB, potential damage to landscape trees is of equal concern. University of California, Riverside (UCR) researchers have confirmed the disease on various landscape trees in Los Angeles County. In Israel, TSHB and its *Fusarium* symbiont have already caused significant economic harm. Current research at UCR also found that although there are no known occurrences of TSHB and *Fusarium* dieback on the California native *Umbellularia californica* (California bay laurel) in the landscape or wild, the species was tested and found to be highly susceptible to the fungus (*U. californica* and *Persea* are in the Lauraceae family).

In a spectacularly devastating case in Long Beach, California in 2010, where *Fusarium* dieback severely damaged or destroyed an entire city block of *Acer negundo* street trees, necessitating their removal and replacement, the TSHB or similar beetle attacked several other nearby, common landscape trees although there was little or no disease development. These other landscape trees, some of which are listed as hosts of the TSHB, included *Afrocarpus falcatus* (*Podocarpus gracilior*) (fern pine), *Albizia julibrissin* (silk tree), *Cupaniopsis anacardioides* (carrotwood), *Geijera parviflora* (Australian willow), *Grevillea robusta* (silk oak), *Koelreuteria elegans* (goldenrain tree), *Liquidambar styraciflua* (American sweet gum), *Magnolia grandiflora* (southern magnolia, bull bay), *Platanus* × *hispanica* (*P.* × *acerifolia*) (London plane tree), *P. racemosa* (California sycamore), *Robinia pseudoacacia* (black locust), and *Ulmus parvifolia* (evergreen or Chinese elm).

Figure 8. (Left) Female TSHBs are 0.07 to 0.1 inch long and black. (G. Arakelian).

Figure 9. (Right) Male TSHBs are 0.05 inch long and brown. (G. Arakelian).





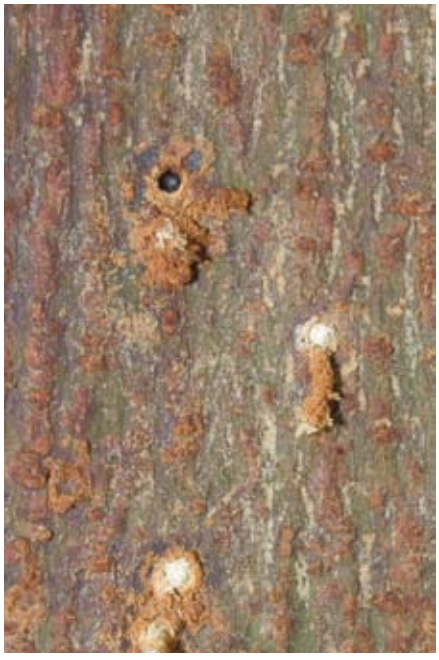
History

The TSHB was first reported in California in 2003, when it was captured in Lindgren funnel traps in South El Monte. Since 2010 University of California and Los Angeles County Agricultural Commissioner/Weights and Measures researchers have detected or identified it and *Fusarium* dieback on *Persea americana* and *Acer negundo* in southeastern Los Angeles County. The TSHB has been found mostly along or in the vicinity of the Rio Hondo and San Gabriel Rivers, from El Monte to Long Beach. More recently it has been found in Hacienda Heights and La Habra Heights, also in southeastern Los Angeles County, and in a nursery on *Litchi chinensis* (lychee) in San Diego. The TSHB has been in Hawaii since 1975 but the disease has not been detected there.

Current research

Research is focused on creating a better understanding of TSHB and its *Fusarium* symbiont in order to develop management strategies. Because the beetle breeds in the tunnels and on the trees where they are hatched, it may be possible to disrupt their breeding with anti-aggregation pheromones. Consideration is also being given to finding a parasitoid or other targeted biological control mechanism.

Figure 10. TSHBs can sometimes be seen at the entry/exit hole openings (*Acer negundo*, Long Beach, CA). (D. R. Hodel).



Management

Although the TSHB will attack healthy, unstressed trees, maintaining trees in optimal health is likely the best strategy against TSHB and *Fusarium* dieback. Healthy, vigorous trees might be less attractive to the beetle, are more likely to repel attacks, and would recover from an attack more quickly. For optimal tree health select species that are well adapted to the site and intended use and plant and care for them properly. Provide appropriate culture, including irrigation, mulch, and, if necessary, fertilizer. Avoid practices that can stress trees, such as excessive pruning, disturbance of the root zone, and too much or too little water. Avoid pruning or otherwise wounding trees when the weather is warming up and the beetle becomes active, as they may be attracted to fresh wounds.

Generally, systemic insecticides applied to soil or injected into roots or trunks do not control or prevent attack by ambrosia bark beetles. Insecticides will not kill the wood-boring stages of most insects. Furthermore, unless a tree is monitored regularly, timing of insecticide application is likely to be too late and ineffective. Correctly timed prophylactic bark spraying, though, using a persistent insecticide, might protect a tree from further attack although more work is needed on this strategy. Because TSHB colonizes all branch and trunk sizes, the whole tree could be subject to bark treatment. It is currently unknown how fungicides may work against the *Fusarium*.

Avoid movement of infested wood out of infested areas. Scout the area for other cultivated host species and any wild-growing susceptible hosts, such as *Ricinus communis* and *Ailanthus altissima*. Because the TSHB is currently a Q-rated pest in California, removal of infested wood from the site is prohibited. Although not thoroughly evaluated, chipping infested wood or cutting it into 18-inch lengths, placing it in a sunny location at the site, and tightly covering it with clear, heavy plastic for at least three months until the wood is thoroughly dried and the pest and fungus are unable to survive might prove to be an acceptable management strategy. Prune out any infested or infected wood at least six inches below symptomatic areas and sterilize pruning and other tools with 25% household bleach or 70% ethyl alcohol between cuts.

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