Biscogniauxia canker found on Valley oaks in Southern California

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Introduction

Robert Sartain, Oak Tree Specialist for the City of Santa Clarita sent me several images of some unusual cankers on dying Valley oaks (*Quercus lobata*) that he was concerned about. He explained that the oaks had been declining, or had died, since the recent severe drought. Although this year's rainfall in Southern California was near normal, it was unusually hot there this summer. He thought it might be Hypoxylon canker. (**Fig. 1**)

After studying the images and asking a few questions, I suspected that it might be *Biscogniauxia* canker, formerly Hypoxylon canker. I've seen similar cankers on oaks several times in Sonoma County, CA, and had read about it. About a year ago, I saw a report regarding dying oaks in southern California. The pathogen in that case was identified as *B. mediterranea*. I learned that it's an endophyte that colonizes the bark and wood of severely stressed and dying trees.

According to Dr. Ted Swiecki (Phytosphere Research), "Hypoxylon-like fungi are widely distributed in oak woodlands and forests in CA; they are usually associated with scattered declining and dead trees, so they usually don't attract much attention. The main exception has been the obvious association between *Annulohypoxylon thouarsianum* and sudden oak death. What we've seen over several decades of field observations is that in extreme stress events, including drought and fire, some of these fungi sporulate in abundance on populations of affected trees, and likely contribute to tree mortality. There hasn't been a lot of research on this group of fungi in California to date." (**Fig. 2**)

In the images that Robert Sartain sent of the cankers, I could see irregular-shaped areas where the bark had fallen away, exposing what appeared to be black, flat, spreading mat-like fruiting body. Some of the cankers were narrow and the fruiting bodies were more raised and charcoal-like in appearance. In several of the images, I noted large exit holes in the lower

> *Biscogniauxia canker is a secondary or opportunistic pathogen, affecting oaks and other species that are severely stressed.*

Figure 1. (Left) Dying valley oaks in an open space area of Santa Clarita. ***Photo: Robert Sartain***

Figure 2. (Right) Fruiting bodies of *Annulohypoxylon thourasianum*, a Hypoxylon-like canker fungus. They are dome-shaped and usually 1 to 1.5 inches across, not flat and sheet-like as is the case for *Biscogniauxia* canker. You can also see that the wood decay caused by the pathogen extends well into the sapwood. ***Photo: B. Hagen***

Figure 3. (Above left) Characteristic symptoms of *Biscogniauxia* canker (probably *B. mediterranea*) on a dead valley oak. The blackened surface where the bark has fallen away is the fruiting body which produces the sexual spores of the pathogen. *Photo: Robert Sartain*

Figure. 4. (Above right) Symptoms are quite variable. Cankers also vary in size and shapes. Some are initially small but in time, grow in both height and width. Sometimes the cankers are small and discreet and other times large and diffuse. *Photo: Robert Sartain*

trunk, probably caused by the California prionus beetle (*Prionus californica*), a round-headed borer that burrows in living and dead roots, as well as the outer sapwood around the lower trunk of a wide range of hosts. The larvae can girdle roots and damage areas of the lower trunk. The damage they cause undoubtedly causes additional stress in host plants. (**Figs. 3, 4**)

Robert indicated that he often sees signs of these borers in the local oaks. I suspect that these beetles typically colonize stressed trees and those whose root function has been impaired by root-loss injury or root disease. Close examination of some of the cankers revealed that a number of wood boring insects had also colonized the inner bark, cambial layer, and outer sapwood in or near areas where the fruiting bodies occurred. You would expect this, because severely stressed trees are quite susceptible to exploitation by secondary pests, such as bark beetles, ambrosia beetles, and wood borers. Although such pests directly contribute to dieback, and decline, they are not the proximate cause. (**Figs. 5, 6**)

Robert notified me later that a sample he'd sent to the UC Berkeley Forest Pathology and Mycology Laboratory, had been identified. Dr. Matteo Garbelotto, the lab's director, confirmed that the pathogen in the sample was *Biscogniauxia mediterranea*, rather than *B. atropunctum,* the species commonly found in California and elsewhere in North America. *B. mediterranea* has been reported in California and throughout North America, but apparently not from valley oaks in California. Dr. Garbelotto indicated high confidence in his confirmation, but added that possibly some previous IDs might have been wrong.

The National Fungus-Host Database (**https://nt.ars-grin.gov/fungaldatabases/index.cfm**) does not report this fungus as present on oaks in California. However, Dr. Swiecki pointed out that the CODA (Califor-

Figure 5. (Below left) The base of this dying valley oak showed signs of borer damage, in case, the California Prionus borer. Note the large exit holes. *Photo: Robert Sartain*

Figure 6. (Below right) In this image black fruit bodies seem to be disintegrating next to borer galleries along the surface of the wood and tunnels that penetrate the sapwood. This tree was predisposed by drought stress to colonization by the *Biscogniauxia* canker, perhaps others pathogens or saphropytes, as well as wood boring beetles. *Photo: Robert Sartain*

nia oak disease and arthropod) database (http://coda.phytosphere.com) shows that *B. mediterranea* has been reported in CA on *Q.* agrifolia, *Q. dumosa*, and *Quercus* sp. The records are from the USDA (1960) Index of Plant Diseases - Handbook 165 (for *Q. agrifolia* and *Q. dumosa*) and from Tim Tidwell's (CDFA) 1986 reported UCB Herbarium records search (*Q. agrifolia* and Q. species). The old *Q. dumosa* record (wide sense of this species) would almost certainly be from its Southern CA range. Unless those represent misidentifications, this fungus has been in CA for some time. Dr. Swiecki reports having seen a number of these resupinate 'hypoxyloid' fungi on oaks over many years. Resupinate is used to describe fungal fruiting bodies that lie flat against the wood surface, forming a sheet-like layer in which the reproductive cells (spores) are produced.

A point of interest here is that Bob Wallace, a consulting arborist in the Los Angeles area, reported seeing similar cankers on California Sycamore. Dr. Jim Downer reported seeing something on sycamores as well. This is certainly possible, as the pathogen has been reported on many species including oaks, and sycamores In North American. (**Fig. 7**)

According to Matteo, "the fungus is a common fungal pathogen of oaks in the Mediterranean basin where it can, in combination with severe heat and drought stress, cause mortality to cork oak (*Q. suber*), as well as other oak species. It is known there as causing charcoal disease because of the color and texture of the fruiting body. This disease is common in warmer areas, so it's not surprising I haven't encountered it in some of the colder coastal areas of Northern California. It probably occurs there but is fairly rare. It was very likely introduced into California."

Swiecki added that "the relationship between these California fungi and those elsewhere in the US or Europe have not been worked out. It may not be possible to determine whether these are native or introduced fungi, especially when their introduction could have occurred as early as a hundred years ago or more."

Nonetheless, *Biscogniauxia* canker is a secondary or opportunistic pathogen, affecting oaks and other species that are severely stressed. The disease primarily affects mature trees that have been sufficiently weakened by drought and high temperature, or other combination of unfavorable factors.

Biology

The fungus has two phases:

Endophytic: Most non-symptomatic oaks are infected with some species of *Biscogniauxia* or *Hypoxylon* and infections can occur on all parts of young trees, but in most cases, the fungus survives as an endophyte for decades in the woody tissue, without causing apparent injury. An endophyte is an endosymbiont, often a bacterium or fungus that lives within a plant for at least part of its life cycle without causing apparent disease. There is no practical way to test for endophytes. Endophytes are ubiquitous and have been found in all species of plants studied to date; yet, most of the endophyte/plant relationships are not well understood. However, according to Garbelotto, it's well known that the switch from endophytic to the pathogenic phase (see below) is associated with an increase in the gaseous component (mostly O_2 and CO_2) in the wood. This change is normally driven by drought, stem girdling, root diseases, root loss injury, or mechanical injury, such as fire or sunburn injury. The result is a decrease in water potential (water deficit) throughout the tree or affected portions. In healthy trees with high water potential these gases are absent, but in stressed

Figure 7. (Left) This is the image of what appears to be the fruiting bodies of *Biscogniauxia* canker on California sycamore. The host range for *B. mediterranea* is fairly wide so this definitely possible. *Photo: Bob Wallace*

Figure 8. (Right) *Biscogniauxia* canker causes a rapid decay of affected sapwood, often resulting in branch or whole tree failure. Note the black fruiting bodies on the large fallen limb. *Photo: Robert Sartain*

Figure 9. Remnants of the fruiting of *Biscogniauxia* canker are visible on the trunk of this long dead valley oak. Most of the bark has fallen away. *Photo: Robert Sartain*

trees their presence increases. It is the gradual increase in gases that triggers growth of decay agents and endophytes. Another way to look at this, according to Swiecki, is that the increase in the gaseous component is the normal result of embolism, i.e., the 'snapping of the water column' that occurs when water potential drops below critical values due to extreme water stress. The gases replace water in xylem tissue; if the vessels are not filled with water, they're filled with gas.

Pathogenic: This destructive phase is triggered by severe stress, typically—drought and heat. Other factors, such as repeated defoliation, root loss, restricted soil aeration, high soil salinity, etc., may also cause sufficient stress. The pathogen can then quickly colonize weakened or stressed woody tissue. When the host's natural defenses have been sufficiently weakened, the fungus in and around old (endophytic) infection sites begins to decay the sapwood, causing a white sap rot. Although growth is fast, it may take up to several years for the fruiting bodies to become visible. For this reason, and because the formation of fruit bodies is favored by wet weather, the association between water stress and the pathogenic phase of *Biscogniauxia* fungi may not be immediately apparent.. Stem cankers develop as the cambium and phloem are invaded and killed. Crown dieback occurs as the pathogen spreads and cankers merge, girdling infected stems. Trees with large cankers are unlikely to survive and may be or quickly become hazardous, due to the progressive loss of the sapwood. The outer cylinder of sapwood provides a significant amount of the trunk's resistance to failure. The risk increases if the heartwood is already decayed, as is common in old trees. (**Figs. 8, 9**)

Biscogniauxia cankers are elongate and range from several inches to several feet long. The fruiting body forms under the bark in affected areas. It is a flat, spreading, mat-like, spore-bearing surface called a *stroma*. This causes the bark above to fall away in patches, revealing the fruiting body. Pieces of bark can be seen at the base of the tree. When first formed, the stroma is light brown in color and produces asexual spores (conidia) that are wind-disseminated. They can infect other trees in the area. Gradually, the fruiting body turns light gray and ultimately jet black and begins to form sexual spores (genetic recombination). Sexual spores are wind-blown or rain-splashed to nearby trees. Often, fruit bodies are parasitized by *Trichoderma* fungi and as a result a *Biscogniauxia* stroma may appear greenish in color, due to the color of the fungus parasitizing them. (**Figs. 10, 11**)

Diagnosing this pathogen on the basis of its fruiting body can be unreliable because there are a number of different fungi that form resupinate fruiting bodies. These include Ascomycete fungi such as *B. mediterranea* and *B. atropunctum*, as well as some unrelated Basidiomycete fungi. Some of these fungi are pathogens, others are saprophytes decaying already dead wood. As resupinate fruiting bodies age the surface disintegrates, making recognition difficult. Incidentally, most of the wood decaying

Figure 10. (Left) A close up of the sheet-like fruiting body growing over the wood surface. At this early stage, its spore-bearing surface is rather bumpy. This was found on a declining California sycamore. *Photo: Bob Wallace*

Figure 11. (Right) Picture of an oak with stem cankers caused by *B. atropunctum*. This is the asexual stage of the fruiting body which produces conidia. *Photo: Molly Giesbrecht, Texas A&M AgriLife Extension Service, Bugwood.org*

fungi are in the family Basidiomycetes (*Basidiomycota*).

The pathogen colonizes host plants during wet periods through natural openings and injuries caused by wind, hail, frost, birds, animals, and human activity. Infections occur on young saplings during rainy periods. There is no practical way to prevent infections.

Conditions that can lead to generalized plant stress:

- severe drought and high temperatures
- root loss injury (**Fig. 12**)
- fire (heat) injury
- restricted soil aeration, severe soil compaction, and prolonged flooding
- impaired root function due to Armillaria root disease, or crown rot (*Phytophthora cinnamomi*) and others major canker diseases such as *Inonotus dryophilus, I. dryadeus* and, *I. andersonii,* and also *Phytophthora ramorum* (Black oaks).
- repeated defoliation

Management.

- The presence of large fruiting bodies, sometimes resembling charcoal or charring on the main stem, typically indicate that the tree is probably beyond recovery, and the tree should be considered hazardous. Thus, intervening before trees become severely stressed is the best management strategy. This can prevent the endophyte from becoming pathogenic.
- When branch and stem cankers appear to be associated with mechanical damage, recovery may occur if environmental conditions become favorable. If soil moisture improves, water content within its woody tissues increases along with resistance to the pathogen. Dead branches will, of course, fail in time.
- Although irrigating drought-stricken trees can help minimize damage, the most prudent approach is to prevent drought stress in the first place, in situations where this is feasible. Apply water to as much of the root zone as practical, water the area within about one-half the distance from the trunk to the dripline and at least 10 feet beyond. Most of the surface roots are concentrated there. This can be challenging when trees are surrounded by pavement. However, even a few hundred gallons of water can help minimize stress. During years with normal rainfall, native oaks seldom need supplemental irrigation. Oaks in urban settings, however, may benefit from judicious irrigation, particularly when their root zones have been compromised by pavement, buildings, soil compaction, etc. Oaks in irrigated settings may become severely stressed when the water they've had access to is scaled back or turned off. Such trees typically have a high water-demand because their leafy crowns are comparatively larger than their root systems. Water infrequently, no more than monthly during the summer and allow the water to penetrate to a depth of at least 8 inches. Allow the soil to dry between irrigation cycles. Too much water or frequent application can, however, encourage the development of root diseases.
- In general, fertilization of stressed trees should be avoided. Nitrogen, contained in many fertilizer preparations, is known to exacerbate insect and disease problems, and it may increase soil salinity.
- If practical, mulch the root zones of susceptible trees with a 2- to 3-inch layer of coarse wood-chips to conserve soil moisture, improve soil conditions, and retard weed growth. Avoid piling mulch against the base of the tree.
- Thin dense stands of oaks by removing some of the weaker trees to improve spacing. This reduces competition for soil moisture, and improves exposure to sunlight. Excessive thinning, though, can lead to water stress.
- Avoid removing branches in the lower crown that shade the soil surface in the root zone, effectively reducing evaporation from the soil surface.
- Pruning in areas where this pathogen is prevalent, other than to abate tree risk, should be done during the driest months of the year.
- Because the fungus remains active on standing dead trees and fallen branches, it's important to remove them to reduce the spore level in the area. In this manner, healthy trees are less likely to become infected (endophytically). Trees that are sufficiently stressed may be infected by wind-blown spores from more distant trees and subsequently develop cankers. This prescription may be relevant to urban parks and high value recreational areas, but it does not apply to infected trees in forested areas or at the urban-forest interface, due to the high levels of inoculum likely to be present in such areas.

Figure 12. The root loss injury in this valley oak caused severe stress. The tree was subsequently colonized by oak bark beetles and Pacific flatheaded bores, which contributed to the trees ultimate death. *Photo: B. Hagen*

- If you suspect that a tree has died of Armillaria and there are high value trees nearby, carefully remove the stump and large support roots to eliminate as much woody root mass practical. Large woody material serves as a reservoir and energy source for that pathogen, allowing it to spread more readily to adjoining plants.
- Disease progression and dieback is typically rapid in infected trees and ultimately they fail or progressively fall apart. Arborists should be concerned about trees with extensive sap rot. The stability of a tree's trunk or its branches is largely dependent on the strength of the outer layer of wood. If it is decayed, much of the stem's strength is lost. Trees with extensive heart rot, common in many older oaks, are particularly prone to failure if the sapwood is decayed as well.
- If you replant, use stock propagated from a local seed source to ensure that the replacement trees are adapted to survive the local environmental conditions.

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