

PEST ALERT

Walnut Twig Beetle and Thousand Cankers Disease of Black Walnut

For at least the past decade, an unusual decline of black walnut (*Juglans nigra*) has been observed in several western states. Initial symptoms involve a yellowing and thinning of the upper crown, which progresses to include death of progressively larger branches (Figure 1). During the final stages large areas of foliage may rapidly wilt. Trees often are killed within three years after initial symptoms are noted. Tree mortality is the result of attack by the walnut twig beetle (*Pityophthorus juglandis*) and subsequent canker development around beetle galleries caused by a fungal associate (*Geosmithia morbida*) of the beetle (Figure 2). The name for this insect-disease complex is *thousand cankers disease* (TCD) of walnut.



Figure 1. Rapidly wilting black walnut in the final stage of thousand cankers disease.



Figure 2. Outer bark peeled from a log to expose coalescing branch cankers produced by *Geosmithia morbida*.

Walnut Twig Beetle

Distribution. The walnut twig beetle is native to North America being originally described in 1928 from specimens collected in 1896 in the area of “Lone Mountain”, New Mexico (Grant County). In the 1992 catalog of Bark and Ambrosia Beetles by Wood and Bright the primary range of the insect was listed to include New Mexico, Arizona, and Chihuahua, Mexico (Figure 3). This range appears to coincide largely with the distribution of Arizona walnut (*J. major*), a presumed original native host. There is also good evidence that walnut twig beetle may be native to southern California, where it would have been associated with southern California walnut, *Juglans californica*. In Arizona walnut the insect functions as a “typical” twig beetle, confining its development to overshadowed or injured small diameter limbs and functioning as a

natural pruning agent. The association and injury potential of the walnut twig beetle in southern California walnut is still being evaluated.

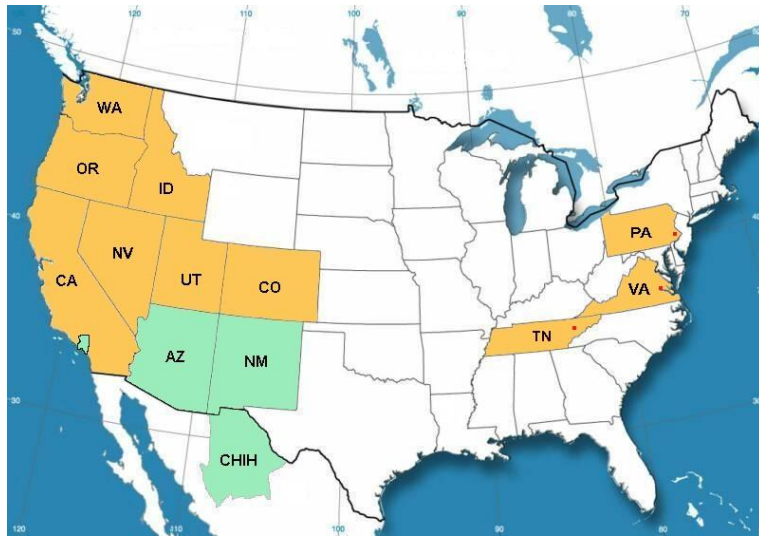


Figure 3. Distribution of the walnut twig beetle and thousand cankers disease. In green are states and the California county of Los Angeles with records of the species prior to 1960. States in orange have reported the insect since 1988. The recent (2010-2011) records from states east of the Mississippi are presently known only from limited areas: Tennessee/Knox County and surrounding areas; Virginia/Richmond; and Pennsylvania/Bucks County.

The first published record of black walnut mortality associated with the walnut twig beetle was in the Espanola Valley of northern New Mexico where large numbers of mature black walnut died in 2001. However, this may have been preceded in Utah where undetermined black walnut mortality occurred in the early 1990s along the Wasatch Front; a Utah record of the beetle dates to 1988. Similar widespread decline also occurred about this time in the Boise-Meridian area of Idaho where the twig beetle was first confirmed present in 2003.

Black walnut mortality has been noted in some Front Range

communities in Colorado since 2001 and the twig beetle has been confirmed present in the state since 2004. Thousand cankers disease has since been recorded from 13 counties, on both sides of the Continental Divide, and has largely eliminated black walnut from many communities in recent years.

Elsewhere in the western US walnut twig beetle has been recorded from Oregon (Portland) since 1997, has been commonly captured in funnel traps in The Dalles since 2004, and is suspected of being associated with recent widespread death of *Juglans* spp. in the Willamette Valley of Oregon. Mortality of walnut associated with the presence of walnut twig beetle was reported from the Prosser area of Washington in 2008.

Within California recent detections of walnut twig beetle have greatly increased the known range of the insect in the state and it had been found over a wide area, including much of the Central Valley. Issues with decline of walnut have been associated with northern California walnut, *J. hindsii*, as well as black walnut and hybrids with *J. nigra* parentage (e.g., Paradox root stock).

In July 2010, the walnut twig beetle and *Geosmithia morbida* were found in Knoxville, TN. This is a highly significant discovery because it is the first report of TCD appearing within the native range of black walnut. Upon initial detection, the outbreak in the Knoxville area was found over an extensive area, indicating the introduction of TCD-infective walnut twig beetles occurred well over a decade ago. Subsequently, in 2011, TCD infestations in the eastern US were found in Richmond, Virginia and Bucks County, Pennsylvania.

Prior to these recent reports, walnut twig beetle had never been associated with *Juglans* mortality. In most areas in the western US where the die-offs of black walnut were originally noted, drought was originally suspected as the cause of the decline and death of trees, with the beetle as a secondary pest. The widespread area across which *Juglans* spp. die-off have since been reported, the documented presence of an associated canker-producing fungal pathogen (*Geosmithia morbida*) carried by the twig beetle, and the occurrence of black walnut death in irrigated sites not sustaining drought, all suggested an alternate underlying cause – thousand cankers disease.

Description. The walnut twig beetle *Pityophthorus juglandis* is a minute (1.5-1.9 mm) yellowish-brown bark beetle, about 3X long as it is wide. It is the only *Pityophthorus* species associated with *Juglans* in the western US but can be readily distinguished from other members of the genus by several physical features (Figures 4, 5). Among these are 4 to 6 concentric rows of asperities on the prothorax, usually broken and overlapping at the median line. The declivity at the end of the wing covers is steep, very shallowly bisulcate, and at the apex it is generally flattened with small granules. (In the eastern US another species of *Pityophthorus* that is associated with several hardwoods, *P. lauta*, has also been reported from black walnut.)



Figure 4. Walnut twig beetle, side view. Photograph by Jim LaBonte, Oregon Department of Agriculture.



Figure 5. Walnut twig beetle, top view. Photograph by Jim LaBonte, Oregon Department of Agriculture.

Life History and Habits. Despite its small size - and common name - attacks by adult *P. juglandis* and larval development in black walnut rarely occur in twigs. Instead tunneling is almost always confined to branches greater than 2 cm diameter. Very large branches and even the trunk can be colonized during advanced stages of TCD.

The life history is imperfectly understood. In areas with cold winters such as Colorado, winter is spent primarily in the adult stage. However, all developmental stages can be observed in logs during the winter months, suggesting continuously breeding overlapping generations. Adults resume activity by late-April in Colorado – as early as March in California. Males initiate tunneling and produce pheromones that are attractive to females. Mating occurs within an excavated chamber under the bark, and females initiate egg gallery tunnels (Figure 6). With warm weather, larvae feed for 4-6 weeks under the



Figure 7. Walnut twig beetle tunneling under bark of large branch.

bark in meandering tunnels that run roughly perpendicular to the egg gallery (Figure 7). Pupation occurs at the end of the tunnel and the adults emerge through minute, round exit holes.

Adults emerge to produce a second generation, beginning in early summer. Peak flight activity of adults in Colorado occurs from mid-July through late August and declines by early fall as the beetles enter hibernation sites. However, more limited breeding may extend well into autumn. Normally 2-3 generations are likely produced, which overlap considerably. Biology will likely vary considerably in different regions due to climatic differences

Cankers caused by *Geosmithia*

The walnut twig beetle, normally and perhaps invariably, carries spores of *Geosmithia morbida*



Figure 6. Walnut twig beetle and associated staining around tunnel.



Figure 8. Teneral adults and pupae of walnut twig beetle with sporulating *Geosmithia* exposed from under bark.

as an external contaminant on its body (Fig 8). The benefits, if any, of this fungus to the beetle are unknown; mutualistic associations are possible but presently unproven.

Regardless, when the beetle tunnels into limbs, the fungus also colonizes the gallery walls and adjacent bark tissue. The extent of subsequent colonization of the bark and associated and necrosis, called a canker, is dependent on the susceptibility of the host.

In Arizona walnut, a native host of the beetle, cankers are limited and superficial. The tree's defenses quickly seal off tissue damaged by the fungus and very little branch injury occurs. In contrast, black walnut is highly susceptible to canker formation by this *Geosmithia* and trees can be killed from the accumulated effects of large, coalescing cankers that develop on this species. The susceptibility of other native walnuts, including northern (*J. hindsii*) and southern (*J. californica*) California walnuts, and little walnut (*J. microcarpa*) as well as the cultivated nut-producing species English walnut (*Juglans regia*) appear to show various levels of intermediate resistance to the *Geomithia*

fungus and subsequent development of thousand cankers disease. Other kinds of nut-bearing trees, such as hickories and pecan, are immune to thousand cankers disease.

In black walnut, dark brown to black cankers develop around each beetle gallery. These cankers are initially small, but expand rapidly and soon coalesce (Figs 2 and 9). The depth of the cankering in the bark is variable; some cankers only kill tissue (phloem) next to the outer bark whereas others extend deep into the inner bark to the wood. As a result, the inner bark develops

a marbled appearance of healthy and dead phloem. Eventually all of the inner bark is killed and the branch dies. The number of cankers that are formed on branches and the trunk is enormous; hence the name *thousand cankers* to describe the disease.

Unlike many open-faced canker diseases such as butternut canker and *Nectria* cankers, the outer bark on black walnut affected by TCD remains largely intact and doesn't slough off. Thus the extent of canker development isn't readily apparent until the outer bark is mechanically removed (Fig 9).



Figure 9. Cankers developing in black walnut around tunnels produced by walnut twig beetles in black walnut.

Many other insects and fungi can be found in bark macerated by the walnut twig beetle and *Geosmithia* during the final stages of the disease. Several insect fungivores and lesser numbers of predators are commonly recovered from TCD-affected wood. Ambrosia beetles and the fungus *Fusarium solani* also may be found in the wood of severely damaged trees. *Fusarium solani* is pathogenic to black walnut and may contribute to tree mortality. No other insects, aside from walnut twig beetle, appear to have the close association with the *Geosmithia* fungus and a cambium tunneling habit that allow significant involvement in the

development of thousand cankers disease.

The exact mechanism of how thousand cankers ultimately produces tree death is not known but appears to result from progressive depletion of energy reserves of the plant. It is speculated that the cankers disrupt movement of nutrients through the plant and subsequent storage of starches. Photosynthetic efficiency may also be affected. As energy reserves become exhausted during end stages of the disease the trees rapidly decline and dieback accelerates. The depletion of energy from root reserves is indicated by the observation that often TCD-killed trees when removed will produce few, if any, sprouts.

Detection of Thousand Cankers Disease

Detection of thousand cankers is very difficult in early stages of the disease. At present detection is generally possible only if external symptoms are expressed, which occurs several years after the tree is initially infested.

Initial symptoms most often appear as yellow flagging of smaller branches. These may often be in the upper crown but may be scattered (Figure 8). The crown may also



Figure 10. Flagging symptom in crown of black walnut in SE Colorado. Picture taken in July 2009; tree was dead the following year.

show a general thinning and limbs with symptomatic flagging later die. During end stages of the disease there may be extensive areas of foliage wilting. In the Rocky Mountain states black walnut trees will typically be dead within 2-3 years after initial foliar symptoms are observed.



Figure 11. Crown dieback and bushy growth in lower canopy observed among dying black walnut in Knoxville, Tennessee.

Some differences in symptoms progression may occur with thousand cankers disease in higher rainfall areas where growing conditions for black walnut are more favorable. There, initial dieback may be more confined to the upper crown and dense bushy growth may develop in the lower canopy before the disease ultimately progresses to tree death. It is also likely that trees growing under more optimum conditions will see slower progression of disease symptoms than trees in less favorable sites.

Confirmation of the disease requires examination of symptomatic limbs for the presence of either walnut twig beetle activity (e.g., live stages, tunneling, exit holes) or *Geosmithia morbida*. Perhaps the easiest means of detection is to sample flagging or recently killed limbs and examine them for the minute exit holes of the walnut twig beetle. Shallow peeling of the bark at these sites will also reveal the characteristic tunneling of the beetles. Despite the common name *Pityophthorus juglandis* does not colonize the smaller diameter twigs of black walnut; limbs

ranging between 2-5 cm diameter with smooth bark are probably easiest for locating evidence of the insect.

Detecting cankers produced by *Geosmithia morbida* requires examining live branches where TCD symptoms are present; wood becomes generally discolored on older dead branches and cankers cannot be distinguished. *Geosmithia morbida* also is readily cultured and produces distinctive colonies when cultured from wood chips, walnut twig beetles, or beetle frass (Figure 12).



Figure 12. Exit holes produced by walnut twig beetles and shallow tunnels exposed under the bark.



Figure 13. Typical colony formation of *Geosmithia morbida* growing out of bark chips placed on a Petri plate.

Detection surveys are best done during July and August. Earlier in the season flagging symptoms may not yet become expressed and develop only later with higher temperatures and more environmental stress. Late in the season limb flagging may become common on many limbs compromised by other factors, such as mechanical injuries and overshadowing. Also distracting in surveys will be leaf yellowing and premature leaf drop that can have many biotic (e.g., mites, aphids) or abiotic (e.g., drought) causes. However, these produce crown thinning broadly through the canopy whereas thousand cankers disease typically produces more limited symptoms affecting individual limbs.

Several compounds attractive to walnut twig beetle have been identified by USFS researchers. The first of these (Compound X) is being made commercially available in 2012 to be used with either small Lindgren funnel traps or sticky cards. The use of these traps should greatly aid studies into the life history of the insect and be useful in helping to detect infestations.

Management

Effective controls for TCD have not yet been identified and their development will require substantially better understanding of the biology of the walnut twig beetle and the canker-producing *Geosmithia* fungus.

The ability of insecticides to help manage TCD appears to be limited. Although the beetles are very susceptible to many commonly used bark beetle insecticides (e.g., carbaryl, various pyrethroids) there is an extended period when adult beetles are active and during colonization large areas of the tree may be points of attack. Because use of trunk/branch applications of insecticides will require thorough application, applied repeatedly throughout a season to maintain coverage, their effectiveness for suppressing TCD will likely be limited; arborists that have attempted to control TCD with trunk sprays have not been able to prevent progression of thousand cankers in trees showing early symptoms. Furthermore, colonization of the bark and cambium by *Geosmithia* may continue even if adult beetles or larvae are killed by the insecticide. The involvement of the fungus, that colonizes areas ahead of beetle tunneling, also will likely limit the ability of systemic insecticides to effectively move in plants in a manner to kill beetles. Furthermore, the use of insecticides, or any other pesticides, is limited by the regulatory status of black walnut, which is regulated as a nut-bearing food crop.

Similarly, sanitation practices, such as those used so effectively in control of Dutch elm disease, have more modest effectiveness in management of TCD. This is due in large part to the long lag time (years) between when trees are initially infested by twig beetles and visual symptoms appear that allow detection. During this period the beetles likely will have spread widely within a TCD-infested area, preventing effective containment. Control is also made difficult since all walnut twig beetles likely carry the *Geosmithia* fungus.

However a vigorous program to identify black walnuts showing early stage symptoms and then removing them to prevent further spread of walnut twig beetles may be useful in slowing the spread of thousand cankers with an affected community. The wood from TCD-infected trees should be removed as soon as possible and all wood handled in a way to prevent further spread of walnut twig beetles. Chipping is considered the best management approach, as it accelerates

the speed of wood material becoming unsuitable for walnut twig beetle breeding, although some beetles will survive this treatment on larger fragments. Alternately the wood may be buried or held in a secure location that is well isolated from areas where TCD is not present.

These management limitations make it extremely critical that the walnut twig beetle not be allowed to spread from infested areas. The most likely means of long-distance spread is through human movement of salvaged TCD-infected logs or firewood that contain walnut twig beetles. Dying trees and recently cut walnut wood produce enormous numbers of walnut twig beetles each contaminated with the *Geosmithia* fungus. Even a small scrap of walnut with bark intact can support developing walnut twig beetles that can start new infestations.

Since early 2010 several states have established quarantines that prevent the movement of certain walnut products. It is likely that many more will follow. These all regulate raw walnut wood material with bark intact although details may differ regarding accepted means of disinfestation. Most do allow transport of wood that has been milled to remove all bark and wood that had been incorporated into finished products. Also, nuts do not harbor walnut twig beetles and are not regulated by quarantines.

For further information concerning thousand cankers disease of walnut, contact Ned Tisserat (Ned.Tisserat@ColoState.EDU) or Whitney Cranshaw (Whitney.Cranshaw@ColoState.EDU), Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO 80523. An associated web site that provides additional information can be found at: <http://www.colostate.edu/Depts/bspm/extension%20and%20outreach/thousand%20cankers.html>

Revision made July 12, 2012

