Twig Blight of California Oaks, Should There Be Concern?

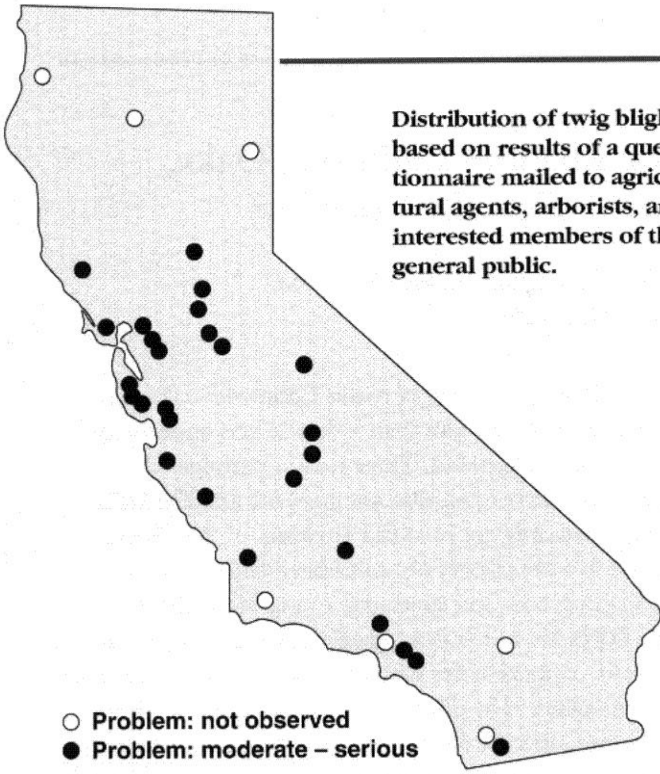
Eva Hecht-Poinar, Fields Cobb and Robert D. Raabe

Twig blight, a disease of native California oaks, has been recognized for more than a decade and appears to have become widespread. Three fungus pathogens, *Cryptocline cinerescens*, *Discula quercina* and *Diplodia mutila*, apparently are involved as causes of the disease. The first two are commonly considered to be anthracnose fungi causing both leaf spots and young branchlet die-back. *Diplodia mutila* is a typical canker-causing fungus which can colonize older woody tissue and cause death of larger branches. The disease may be associated with insects as well, specifically a pit scale, *Asterolecanium minus*, which is a native of Europe.

The disease often renders oaks unsightly and occasionally will kill them. Thus, a project was initiated to gain knowledge of the fungi involved in twig blight, environmental factors associated with disease incidence, disease management through integrated control, and interactions with insects and other pathogens. Our studies involved an assessment of the distribution and severity of the disease, control through application of fungicides, pruning and host resistance, and interactions with the pit scale and with root pathogens, *Armillaria mellea* and *Phytophthora* species.

Distribution of Oak Twig Blight

There has been no extensive effort to determine the distribution and severity of oak twig blight in California. To obtain an estimate of the extent of the problem, a questionnaire was mailed in 1986-87 with the cooperation of the Nature Conservancy and *Sunset Magazine* to horticulturists, other professionals and the general public. Of 210 respondents, 52 percent considered the disease moderate to serious, 20 percent observed the disease but considered it not a problem, and 18 percent had not observed it. The accompanying map of California shows where the problem is considered moderate to serious (practically all areas of the State) and where it has not been observed, possibly because fewer oaks occur in those areas. One third of the respondents believed that the disease was increasing in severity.



Distribution of twig blight based on results of a questionnaire mailed to agricultural agents, arborists, and interested members of the general public.

Oak twig blight was reported on all eight of the oak species listed on the questionnaire, but reports were most common on coast live oak (*Q. agrifolia*) and valley white oak (*Q. lobata*). Moderate numbers of reports were made of the disease on interior live oak (*Q. wislizenii*) and black oak (*Q. kellogii*), and fewer than 10 percent reported the disease on blue oak (*Q. douglasii*), mountain live oak (*Q. chrysolepis*), Oregon oak (*Q. garryana*) and mesa oak (*Q. engelmanii*).

Respondents were also asked whether they had observed an association with pit-scale insects. Although a majority did not respond, of those who reported observations, twice as many had seen an association with scales as had not.

Control Treatments

Treatments to control or manage oak twig blight were continued during 1987, and data were taken and analyzed during 1988. In the Stanford University Arboretum mature coast live oaks with visible symptoms of twig blight were treated with the fungicide Benlate alone, Benlate plus pruning, or pruning alone. Benlate was applied by grounds personnel at the rate of 1 pound or 4 pounds per 100 gallons of water. Pruning involved removal of all blighted branches and dead wood.

The results indicated that twig blight of live oak can be reduced to a visually acceptable level (20 percent or less of the crown affected) for at least a year by pruning alone, by the Benlate solutions, or by pruning plus Benlate. Disease reduction by the stronger Benlate solution carried over to a second year, and re-treatment in the second year was also effective. Assessment of second-year effects was complicated by the generally low level of natural infection in 1987, a relatively dry year. In July, 1990, three years after treatment was terminated, effects of the 4-pounds-Benlate-plus-pruning application were still in evidence on at least two of the five trees that received this treatment.

Choice of treatment depends on cost-benefit considerations. Pruning is time-consuming and difficult in large trees. Spraying requires special equipment, and Benlate is currently registered for use only at 1 pound per 100 gallons for oaks. Trees vary in the degree to which they are damaged by twig blight, and the extent of blight varies from year to year. People with oaks may want to keep records of which trees are highly susceptible and to restrict control applications to those trees in which unacceptable disease buildup is imminent. Pruning versus spraying may depend on initial levels of infection, especially when disease is so severe that pruning would have to be extensive.

Grafting to Obtain Potentially Resistant Oaks

Based on numerous observations in Northern California, oaks appear to vary greatly in their susceptibility to twig blight. Commonly in neighboring coast live oak trees, one will show severe blight and the other only a negligible amount. In early phases of our studies, results of inoculations of potted oak seedlings indicated further that in some trees there may be a high degree of resistance which could be useful to arborists. In a June, 1989, field test, multiple branches of six apparently resistant, mature trees were inoculated with *Diplodia mutila*. Branches that were in total shade had very low infection whether in apparently susceptible or resistant trees, a phenomenon possibly related to a high temperature optimum for the fungus. In spite of the shade effect, results showed a trend toward differences in resistance.

To take advantage of resistance in coast live oak, a study was initiated to develop rooting and grafting techniques for this species. Using adaptations of commercial techniques used in the Netherlands to graft *Q. robur fastigiata* and *Q. frainetto*, we successfully grafted well over one hundred plants. Twelve, produced from scion material collected from mature, apparently resistant coast live oaks, were outplanted in March, 1989, in a wildlands setting with minimal watering. Those had grown to a height of three to six feet by summer, 1990, and had no apparent twig blight. Twelve other grafted plants were outplanted in January, 1990, in an urban setting. To date, they also show no symptoms of blight.

Approximately 60 grafted plants are being kept in a lathhouse for production of scion material. Grafts made from young, "rejuvenated" wood are much more successful (70-75 percent) than those made from wood of mature trees (10-15 percent), as the Dutch have learned from long-term experience. Their success rate is 95-98 percent with rejuvenated scion material. We hope that the horticultural industry will use this knowledge to provide the public with twig-blight-resistant plants.

Associations Between Pit Scale and Twig Blight

Early in our studies, we observed an apparent association between the occurrence of twig blight and the pit-scale insect, *Asterolecanium minus*, which was introduced from Europe. The nature of the association is still unknown. The pit scale could be serving as a vector for the fungus pathogen, as a wounding agent that provides a means of entry into the plant for the fungus, or as an incidental organism that has no role in relation to the fungus. Spore forming bodies of *C. cinerescens* have also been observed next to natural wounds, such as leaf scars. Similar associations between scale and disease have been noted on oaks in Pennsylvania and on tan oaks in California, especially in early stages of a disease epidemic; in those cases, the pit scale appears to have had an important role in the disease complex.

We have continued to study the association, partly in cooperation with Pam Elam of the UC Agricultural Extension Service, Fresno. Branches of valley white oak collected near Fresno in September, 1989, had no scales or lesions (dead tissue usually around the scales) on woody tissue produced in 1989. A relatively small number of scales and lesions occurred on 1988 summer growth, and many more scales and lesions occurred on growth produced in spring, 1988, and in 1987. Of the scales on wood produced in 1988 and summer, 1987, about 30 percent occurred on necrotic lesions. Isolations were made from a sample of the lesions, and fungi were obtained from 76 percent of them, with *Diplodia mutila* the most common (over 30-percent incidence). Samples from a coast live oak in Lafayette in Contra Costa County yielded similar results.

(left) Four-month-old grafted coast live oak, *Quercus agrifolia*.

(below) Spore forming bodies of *Cryptocline cinerescens* around embedded oak pit scales may serve as entry points for the fungus.

Ten branches from each of five coast live oaks near Napa were sampled in October, 1989. The trees had twig blight ratings from 0 (none) to 3, which is moderately severe. One tree with a rating of 0 had only one scale and no lesions, but a second tree rated 0 had a moderate number of scales, one half of which were associated with lesions. In the latter tree, fungi had not grown from the localized lesions to colonize adjacent tissue. There were relatively large numbers of scales on the three trees rated 1, 2 or 3, with 46 percent of them associated with dead tissue. These data and those from Fresno suggest that the pit-scale insects usually are not acting alone to cause branch mortality, but that they are somehow enhancing the activities of twig blight fungi, especially *Diplodia mutila*.

In a related study, a variety of methods was used to determine if crawlers (immature pit scales) could vector *Diplodia* spores. None were successful. When isolations were made directly from the crawlers, they were always contaminated with bacteria or yeast-like fungi. Isolations from water used to rinse branches with and without scales also were not successful in obtaining *Diplodia* or any of the other fungi associated with twig blight. On the other hand, *Diplodia mutila*, *Discula quercina*, *Cryptocline cinerescens*, *Dothiorella* sp. and three unidentified fungi were commonly isolated from young scales beyond the crawler stage, from dead areas beneath scales, and from margins of infected tissue adjacent to the scales.

Interactions Between Root Pathogens and Twig Blight

Observations of twig blight on chestnut oak in Pennsylvania and tan oak in California have suggested that the disease may predispose those species to root pathogens, especially *Armillaria* species. On the other hand, many twig blight or canker-causing fungi infect woody plants that have been stressed by various factors. If such interactions occur in the California oaks, the implications could be increased disease severity and losses.

We initiated a series of inoculations in 1988 and 1989, to test for possible interactions between *A. mellea* and *Phytophthora cinnamomi* and the twig blight organism *Diplodia mutila*. In one test, two-year-old plants of coast live oak were inoculated with *D. mutila* and approximately one month later with *A. mellea* and *P. cinnamomi*. However, the roots were apparently already infected by one or more root pathogens (*Pythium, Rhizoctonia, Phytophthora*) prior to the inoculations with *Diplodia*. Thus, the data in Table 1 show the correlation between percentage girdling by *D. mutila* and diseased condition of the roots which is not necessarily caused by *A. mellea* or the *Phytophthora* with which we inoculated. The results summarized here indicated that severe twig blight and severe root disease tend to occur together and that there may be a threshold effect, that is, the effect is pronounced only when both diseases are severe.

Table 1: Relationship between severity of root diseases[1] in two-year-old potted *Quercus agrifolia* seedlings and circumference girdling of stems by *Diplodia mutila.*

% Roots Diseased	0-35	36-65	66-100
# Plants	10	23	14
Average % girdling	32	37	67

[1] Seedlings were inoculated with *D. mutila* first by inoculations with *A. mellea* and *Phytophthora*. Root disease was also associated with unidentified preexisting root disease species.

Table 2: Interaction between root disease and severity of girdling by *Diplodia mutila* on coast live oak seedlings, incoculated with *Armillaria mellea* from 4 to 9 months before inoculation with *D. mutila.*

% Roots Diseased	0-35	36-65	66-100
# Plants	9	29	41
Average % Girdling	42	40	39

In a second test, the coast live oak seedlings were inoculated first with *A. mellea* followed by inoculations with *Diplodia mutila* four, five-and-a-half and nine months later. The test was terminated approximately 15 months after the initial inoculation with *A. mellea.* Almost all seedlings had evidence of *A. mellea* infection, but there was no evidence of a correlation between *A. mellea* infection ratings and severity of girdling by *D. mutila*. Nor was there evidence of a correlation between percentage of roots diseased as a result of any factor and severity of girdling (see Table 2).

If we consider the results of the two tests, there may be some evidence suggesting that infection by the twig blight fungus, *Diplodia mutila*, may increase conditions favorable for root disease pathogens. However, more research is necessary before conclusions should be drawn.

Implications

There appears to have been somewhat less twig blight during the past 2-3 years, probably due to lack of water essential for infection by some of the fungi involved in the disease complex. However, reports from throughout California indicate that the disease is having an impact on several of our important oaks and may be increasing.

On valuable individual trees, the disease can be managed to an acceptable level with pruning and Benlate applications, but these are labor intensive and costly. Use of resistance in the hosts may be a more effective approach in the long term. While breeding is a possibility, rooting cuttings and/or grafting scions from resistant trees may be a more practical approach for the ornamental and shade tree industry.

While the native oaks of California may have coexisted with the fungi that cause twig blight for many, many years and have survived, they have not evolved with the pit scale. Nor have they evolved with insecticides and other human factors that could be interacting to enhance the activities of the pit scale and fungi. If, as some of our results suggest, severe twig blight leads to increased root disease, the complex known as oak twig blight bears close scrutiny. At this point, we still know too little to predict its future impact.

Eva Hecht-Poinar is Specialist, Fields Cobb is Professor, and Robert D. Raabe is Professor, Plant Pathology, University of California, Berkeley.