Cytospora abietis Associated with Dwarf Mistletoe on True Firs in California

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ABSTRACT

Cytospora abietis was commonly found associated with dwarf mistletoe (*Arceuthobium campylopodum* f. sp. *abietinum*) parasitizing branches of white fir (*Abies concolor*) and red fir (*A. magnifica*). Twenty-two per cent of all branches bearing dwarf mistletoe were infected by *C. abietis*. Of 235 isolates of the fungus, only 9 (4%) were from branches not invaded by dwarf mistletoe. Both white and red fir are equally susceptible to infection by *C. abietis*. Geographic location in California and age of dwarf mistletoe were not important factors influencing infection by *C. abietis*. Phytopathology 59:1657-1658.

Cytospora abietis Sacc. attacks white fir (*Abies concolor* [Gord. & Glend.] Lindl.) and red fir (*A. magnifica* A. Murr.) in California and Nevada (6), and grand fir (*A. grandis* [Dougl.] Lindl.) in northern Idaho (4). In California, *C. abietis* infects firs of all ages. Occasionally, it assumes epidemic proportions when trees are weakened by environmental or other factors (6). For instance, in certain parts of California in 1966, a 9-month drouth weakened trees. The parasite intensified and killed limbs, tops, and even entire trees (1). In Idaho, the fungus occurs sporadically, causes a dieback of terminal and upper branches of young trees, and is primarily a problem to producers of Christmas trees.

A species of *Cytospora*, presumably *C. abietis*, has been reported to be commonly associated with branch swellings caused by dwarf mistletoe (*Arceuthobium campylopodum* Engelm. f. sp. *abietinum* [Engelm.] Gill) on red firs in California (2). Inoculations made by Wright (6) showed that *C. abietis* attacks and kills mistletoe-infected as well as noninfected branches on both red fir and white fir.

My field observations suggest that killing of dwarf mistletoe-infected fir branches by *C. abietis* is common and occurs every year. Branch flagging, often the result of *Cytospora* attack, is one of the best field symptoms of the occurrence of dwarf mistletoe, and possibly also of *C. abietis* on firs.

Because of the widespread annual flagging of fir branches and the potential impact this fungus may have on limiting dwarf mistletoe, a study was made to determine the following: (i) the amount of *Cytospora* infection in mistletoe-infected and noninfected branches; (ii) the difference in susceptibility between red fir and white fir to infection by the fungus; (iii) the proportion of dwarf mistletoe swellings attacked by *C. abietis*; (iv) differences in amount of fungus infection on firs growing in different geographic and climatic zones; (v) the relationship between fungus attack and mortality of dwarf mistletoe-infected branches; and (vi) the influence of age of dwarf mistletoe swellings on infection by *C. abietis*.

METHODS.—In 1967, 38 plots were established in dwarf mistletoe-infected red fir stands, and, in 1968, 20 plots were established in infected white fir stands on the eastern slope of the southern Cascades in the Lassen National Forest and on the western slope of the central Sierra Nevada in the Eldorado and Stanislaus National Forests. The one-tenth-acre plots were established in understory fir infected by dwarf mistletoe from surrounding heavily infected overstory firs. On each plot, 20 trees up to 4 m in height were selected at random, 5 from each height class, 0-1 m, 1-2 m, 2-3 m, and 3-4 m. The sample trees were cut, and their branches examined for infection by both dwarf mistletoe and *C. abietis*. Branch condition and the presence of *C. abietis* as indicated by canker development and sporulation were noted.

All dead branches, dwarf mistletoe swellings, and cankered portions of branches suspected of bearing *C. abietis* infection were brought into the laboratory for fungus isolation. To isolate *C. abietis*, several chips were taken from each specimen, surface-sterilized in 5% sodium hypochlorite (Clorox) for 15 min, and then placed on 2% water agar in petri dishes. The dishes were then incubated at room temperature for about 1 to 2 weeks. Fungal growth appearing from the chips was hyphal-tipped and transferred to potato-dextrose agar (PDA) in test tubes. All fungus isolates obviously not *C. abietis* were discarded.

The suspected isolates of *C. abietis* were transferred from PDA to sycamore twigs partially imbedded in agar in test tubes. *C. abietis* sporulates readily on this medium, and by this method the fungus was identified.

Age of dwarf mistletoe on red fir was determined by counting the number of swollen annual rings in a branch infected by dwarf mistletoe (5).

RESULTS.—Nearly all *C. abietis* infections on both fir species were associated with dwarf mistletoe swellings. Of 154 isolations of the organism from white fir, only 6 (4%) were from branches not infected by dwarf mistletoe. Similarly on red fir, only 3 of 81 (4%) isolations of the fungus were from branches without mistletoe. Thus, in the presence of abundant *C. abietis* associated with dwarf mistletoe, only a few mistletoe-free branches were infected.

Both fir species were equally susceptible to infection by *C. abietis* (Table 1). Slightly more than 20% of the dwarf mistletoe-invaded branches of both species were attacked by the fungus.

The occurrence of *C. abietis* on firs was not restricted to a particular geographic location. About the same amount of infection occurred on firs growing on the

TABLE 1. *Cytospora abietis* associated with dwarf mistletoe on red fir and white fir

Area	Branches with dwarf mistletoe	Dwarf mistletoe-infected branches with *Cytospora*	
White Fire	*no.*	*no.*	%
Southern Cascades	422	99	23
Central Sierra Nevada	209	49	23
Total	631	148	23
Red Fir			
Southern Cascades	159	31	20
Central Sierra Nevada	218	47	22
Total	377	78	21
Both Firs	1,008	226	22

eastern slopes of the southern Cascades as occurred on firs on the west slope of the central Sierra Nevada.

Identification of *C. abietis*, from field symptoms only, did not prove practical. Of 143 dwarf mistletoe-infected branches attacked by the fungus, only 41 (29%) showed any canker development, and only one (less than 1%) showed the presence of fruiting bodies or sporulation. Thus, only about a third of all *C. abietis*-infected dwarf mistletoe swellings was detected from field symptoms alone. The condition of the host branch bearing the mistletoe infection also did not indicate the presence of *Cytospora*.

C. abietis was isolated from 21% of 502 living mistletoe-infected white fir branches, 25% of 28 partially dead, and 33% of 101 dead mistletoe-infected branches.

Branches bearing young and old dwarf mistletoe plants on red fir were infected with approximately equal frequency. The per cent of branches infected with mistletoe of different ages is as follows: 0-5 years, 22% of 72 plants; 6-10 years, 19% of 103 plants; 11-15 years, 25% of 12 plants; and 16-20 years, 30% of 10 plants.

DISCUSSION.—*Cytospora* (*C. abietis*), reported by Gill (2) to be common on branches of red fir infected by dwarf mistletoe, was also common on dwarf mistletoe on white fir. Wright (6) suggested that possibly mistletoe-infected branches of white fir are more susceptible to infection by *C. abietis* than red fir. Results of the present study do not support this suggestion.

In the present studies, very little *C. abietis* was found attacking branches not infected by dwarf mistletoe. This relationship suggests, as reported by Wright (6), that only under certain climatic or other conditions does the fungus increase to epidemic levels on mistletoe-free trees. However, the rather high level of infection of mistletoe swellings by *C. abietis* would provide an ever-present source of inoculum of the pathogen for attacks on healthy trees when conditions favor the disease. This situation may, in part, explain why epidemic outbreaks of *C. abietis* occur whenever favorable conditions prevail.

Branches killed by dwarf mistletoe infection alone are the main cause of crown reduction. However, the influence *C. abietis* has in reducing the amount of tree crown on dwarf mistletoe-infected trees is no doubt significant. As the present study shows, about 20% of all mistletoe-infected branches are attacked by *C. abietis*, and it takes about 12 to 15 months for the fungus to girdle and kill a branch (6). Therefore, a continued reduction of the total dwarf mistletoe population and, ultimately, of a good portion of the tree crown takes place. Whether reduction of the level of dwarf mistletoe by progressive dying of the tree crown has a favorable or unfavorable net effect on the vigor of the tree is not known.

C. abietis grows readily from bark chips and is easily isolated. Therefore, it is not likely that the absence of *Cytospora* in a large proportion of dead and partially dead dwarf mistletoe swellings is the result of inadequate isolation techniques.

Age of dwarf mistletoe was not an important factor in infection of branches by *C. abietis*, but amount of infection appeared to increase slightly with age. Possibly higher percentage infection would occur in dwarf mistletoe populations older than those examined in the present study.

The reason why *C. abietis* was much more common on dwarf mistletoe-infected branches than on noninfected branches was not determined. For weak parasites like *Cytospora*, infection is often the result of host decline or reduced vigor. However, at least three factors may be responsible for the selective attack on dwarf mistletoe-infected fir branches: (i) dwarf mistletoe may weaken the branch, thus making it more susceptible to attack by the pathogen; (ii) bark cracks occur and basal cups of dwarf mistletoe shoots remain on infected branches; either may provide an entrance court for the fungus; and (iii) the swollen branch tissue and endophytic system of dwarf mistletoe are the site of carbohydrate accumulation (3). Consequently, these tissues may provide a particularly favorable substrate on which *C. abietis* can grow.

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