Root and Butt Rot Fungi on Balsam Fir and Red Spruce in the White Mountains, New Hampshire

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ABSTRACT

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Sixteen species of hymenomycetes were isolated and identified from decay in roots or butt sections of 103 balsam fir and 25 red spruce trees in the White Mountains, New Hampshire. *Resinicium bicolor*, an unidentified species of Corticiaceae related to *Resinicium*, and *Scytinostroma galactinum* were the most frequently isolated fungi from trees in the subalpine zone (above 800 m elevation). *Armillaria* sp. (probably *A. obscura*) was the most commonly isolated fungus at lower elevations.

Root and butt rot fungi cause considerable losses in softwood production by causing direct mortality (25), predisposing trees to secondary mortality agents such as bark beetles (6), causing cull and degrade (3), reducing growth rates of infected trees (26), and predisposing trees to windthrow and windsnap (25). Information on root and butt rot fungi of balsam fir (*Abies balsamea* (L.) Mill.) and red spruce (*Picea rubens* Sarg.) in the northern Appalachian Mountains is very limited, but our observations suggest that the losses can be substantial, particularly for balsam fir. Comprehensive surveys of decay of these species in Canada have been made (2,3,7,8,21), but these surveys were conducted at low elevation sites and in forest types that are not directly comparable to the montane forests of the northern Appalachians. Our survey was conducted to identify the most common root and butt rot fungi on spruce and fir in the major forest types of the White Mountains, New Hampshire.

MATERIALS AND METHODS

Isolations for root and butt rot fungi were attempted from decayed wood collected in 1984 and 1985 from root- or butt-rotted spruce and fir trees at a variety of elevations in four areas of the White Mountains: the northwest slope of Wildcat Mountain (44° 15′ N, 71° 20′ W), the northeastern slope of Mt. Moosilauke (44° 01′ N, 71° 51′ W), the western slopes of the Presidential Range (44° 10′–44° 20′ N, 71° 20′ W), and the east side of Kancamagus Pass (44° 00′–44° 05′ N, 71° 30′–71° 12′ W). Elevations at the first three areas ranged from 600 to 1,200 m and included stands in the northern hardwoods and subalpine zones (18). The elevations east of Kancamagus Pass ranged from 200 to 850 m, where the lowest elevation sites (below 600 m) may be classified as softwood flats (12) and comprise primarily red spruce, balsam fir, eastern hemlock (*Tsuga canadensis* (L.) Carr.), eastern white pine (*Pinus strobus* L.), and several hardwood species. Other samples collected near the summit of Kancamagus Pass were from subalpine forest types.

Most of the decay samples were obtained from butt-rotted trees (81 fir and 11 spruce) whose stems had recently snapped at approximately 1 m or less above ground level; only a few of the sampled butt-rotted trees had been uprooted. At each of the four sites, all snapped or uprooted fir and spruce trees with green foliage remaining on the crown were sampled along hiking trails and roadways. These samples were classified as "butt-rotted." The butt-rotted fir trees ranged from 6 to 30 cm in diameter at 1.4 m above ground and spruce trees ranged from 12 to 35 cm in diameter. In addition, samples were collected from decay in roots of living fir (22 trees) and spruce (14 trees) that were encountered during other, unrelated field studies. In contrast to the butt rot samples, these "root rot" samples were collected from only a few locations.

Isolations from decayed wood were made in the laboratory. Samples were split, and chips of decayed wood not previously exposed were axenically removed and plated on a semiselective medium for hymenomycetes (13) consisting of 15 mg/ml malt extract, 15 mg/ml agar, 100 μg/ml streptomycin sulfate, and 4 μg/ml benomyl 50WP; streptomycin sulfate and benomyl were added after autoclaving. Incubation was at room temperature (22–26 C). Subcultures of hymenomycetes were transfered to MEA (15 mg/ml malt extract and 15 mg/ml agar) and identified on the basis of cultural characteristics (16,17,23). Occasionally, positive identifications were based solely on microscopic examination of distinctive mycelium growing within the decayed wood, and isolations were not attempted.

RESULTS AND DISCUSSION

Sixteen species of hymenomycetes were isolated and identified from root or butt rots of 103 balsam fir (Fig. 1) and 25 red spruce trees (Fig. 2). Common white rot fungi identified on both fir and spruce were *Resinicium (Odontia) bicolor* (Fr.) Parm. (21 fir and two spruce trees), an unidentified species of Corticiaceae (perhaps a species of *Resinicium*) (10 fir and two spruce trees), *Scytinostroma (Corticium) galactinum* (Fr.) Donk (10 fir and three spruce trees), *Perenniporia (Poria) subacida* (Pk.) Donk (nine fir and two spruce trees), and *Armillaria* sp. (11 fir and five spruce trees). *Amylostereum (Stereum) chailletii* (Fr.) Boidon was isolated from one fir tree. Common brown rot fungi were *Serpula himantioides* (Fr.) Karst. (four fir and four spruce trees), *Coniophora puteana* (Schum.:Fr.) Karst. (three fir and three spruce trees), *Tyromyces (Polyporus) balsameus* (Pk.) Murrill (seven fir trees), and *Sistrotrema brinkmanii* (Bres.) J. Erikss. (five fir trees). *Fomitopsis (Fomes) pinicola* (Fr.) Karst., *Phaeolus (Polyporus) schweinitzii* (Fr.) Pat., *Polyporus subcartilagineus* Overh., and *Poria cocos* (Schw.) Wolf were each isolated once (from fir). Three fir trees with white rot yielded unidentified hymenomycetes (three different species), and an unidentified hymenomycete was isolated from brown rot in a spruce tree. Approximately 15% of the isolation attempts from butt-rotted trees were unsuccessful in recovering a hymenomycete. Unsuccessful isolation attempts were evenly divided between brown rots and white rots.

Each of the above fungi appeared to be the primary cause of root and butt rot, but two decay fungi, *Xeromphalina campanella* (Fr.) Kuhner & Maire and *Hyphoderma praetermissum* (Karst.) Erikss. & Strid., isolated from 10 and seven fir trees and from one and two spruce trees, respectively, may have been

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secondary colonizers. Fine rhizomorphs of *X. campanella* often were found on the surface of decay from which other fungi were isolated; the fungus was isolated from both white stringy-rots and laminated rots (wood separating along the annual rings). *H. praetermissum*, reported to cause a white rot (9), was isolated from both brown rots and white rots.

We were not able to identify two important fungi to species, *Resinicium* sp. and *Armillaria* sp. Basidiocarps of a corticiaceous hymenomycete with cystidia typical for species of *Resinicium* (apical halo of resinous material over a swollen apex [9]) were found on decayed roots of red spruce at two locations. Single-basidiospore isolates from one of these basidiocarps were compatible in di-mon matings with isolates from root and butt rots of the unidentified fungus listed in Figures 1 and 2 as *Resinicium* sp. Neither the basidiocarps nor the cultures match those of the described species of *Resinicium* (9,14) or that of an unknown root and butt rot fungus from a Canadian study (3).

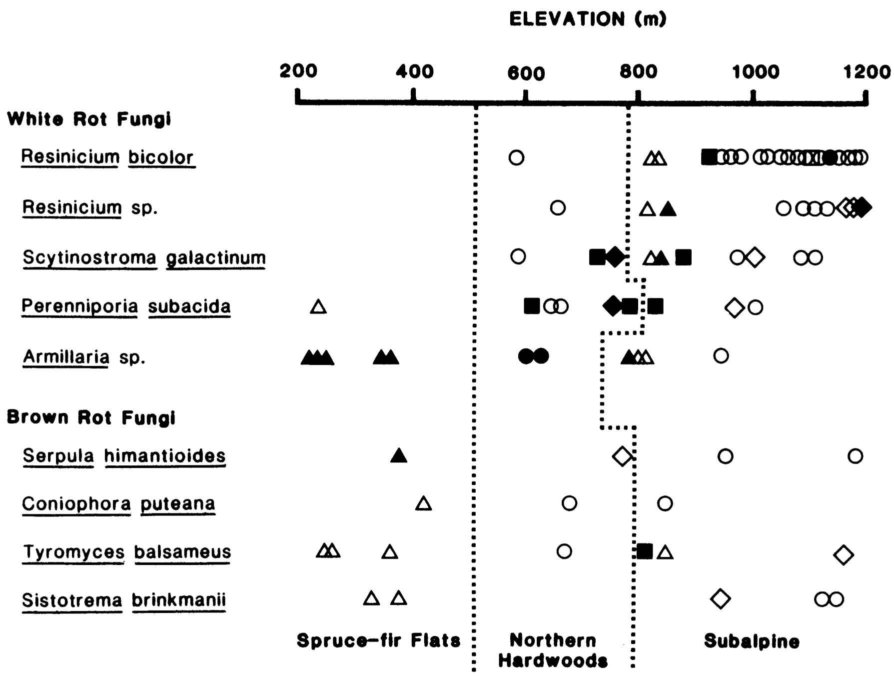

Fig. 1. Elevations, sites, and forest types in the White Mountains at which different species of root and butt rot fungi were isolated from balsam fir. Sites: o = Wildcat Mountain, ◇ = Mt. Moosilauke, Δ = Kancamagus Pass, and □ = western slopes of the Presidential Range. Open symbols represent isolations from butt rots found in wind-snapped or uprooted trees; solid symbols represent isolations from roots of living trees.

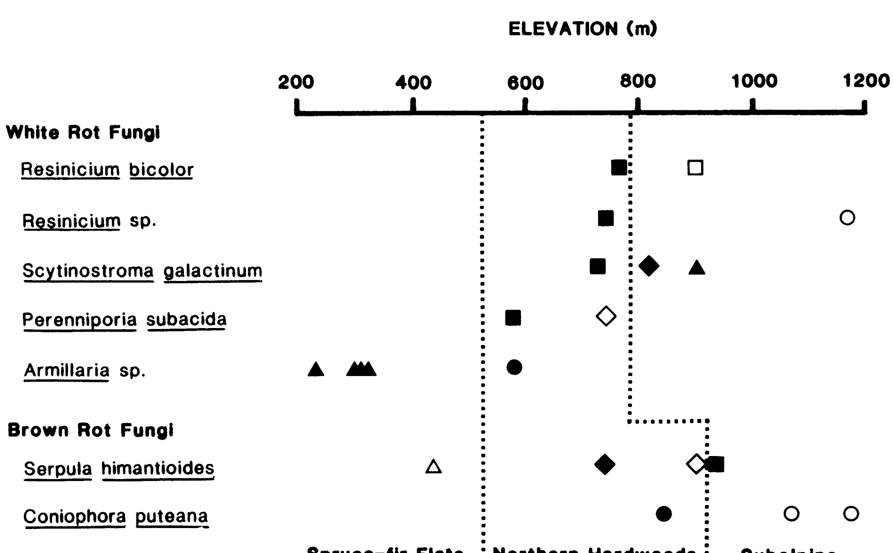

Fig. 2. Elevations, sites, and forest types in the White Mountains at which different species of root and butt rot fungi were isolated from red spruce. Sites: o = Wildcat Mountain, ◇ = Mt. Moosilauke, Δ = Kancamagus Pass, and □ = western slopes of the Presidential Range. Open symbols represent isolations from butt rots found in wind-snapped or uprooted trees; solid symbols represent isolations from roots of living trees.

The *Armillaria* sp. encountered in our survey appears to be *A. obscura* (Pers.) Herink (= *A. ostoyae* (Rom.) Herink). Each of 22 *Armillaria* isolates from diseased fir and spruce in the White Mountains (including some from our survey) were compatible with *A. obscura* in haploid-diploid pairings in another study (10).

The diversity of hymenomycetes encountered contrasts sharply with a 1944 report (22) that *Perenniporia subacida* and *Tyromyces balsameus* were responsible for 95% of root and butt rot of balsam fir in New England. In this earlier study, however, the authors do not clearly indicate if isolations from decayed wood were used to determine the identity of the fungi. With the exception of *Resinicium* sp., the fungi we identified were similar to those identified from fir and spruce species in surveys conducted in eastern Canada (2,3,7,8,21).

Several decay fungi important on spruce and fir in other regions were not found in our survey. For instance, *Haematostereum sanguinolentum* (Fr.) Pouz. is the most common trunk rot of balsam fir in Canada and may cause root and butt rot (2). We have occasionally observed *H. sanguinolentum* as a trunk rot in the White Mountains, but it was not found in the root and butt rot survey. In a survey of red spruce in New Brunswick, Davidson and Redmond (8) found *Inonotus (Polyporus) tomentosus* (Fr.) Gilbn. to be one of the two most common root and butt rot fungi. *I. tomentosus* is also a major pathogen of black and white spruce in Canada (25). We have observed *I. tomentosus* in wind-snapped red spruce on spruce-fir flats in northern New Hampshire (north of the White Mountains), but this fungus was not found in our survey. *Abortiporus (Polyporus) borealis* (Fr.) Sing. has been described as causing a butt rot of overmature red spruce in the Green Mountains of Vermont (15) and in New York (1). Although we have observed *A. borealis* fruiting on large, living, old-growth red spruce throughout the northern Appalachians, old-growth forests were not extensively sampled in our survey. *Heterobasidion (Fomes) annosum* (Fr.) Bref. is a major root pathogen on spruce and fir in Europe and western North America but was not found in our study. This may be due to the absence of the spruce intersterility group of this fungus (5,11) in the White Mountains.

Basham et al (2) reported that *Armillaria* decay rarely extended more than 0.5 m into the butt section of balsam fir, whereas butt rot by other fungi usually extended over 1 m above ground level. In our survey, *Armillaria* sp. was found causing butt rot only on three occasions. Thus, based only on the survey of snapped trees, *Armillaria* sp. would have appeared to be rare in the

White Mountains. Similarly, the importance of other root rot fungi that do not predispose trees to wind-snap may have been underestimated by our survey.

Root and butt rot was encountered much more often in fir than in spruce, which may reflect the relative susceptibility to root and butt rot between spruce and fir (19). Davidson and Redmond (8) found decay (both butt and trunk) in only 18% of the living red spruce trees examined, but over 50% of fir trees older than 60 yr had some form of decay in other surveys (3,7).

Three forest types were sampled in the present survey: subalpine (above 800 m elevation), northern hardwoods (600–800 m), and softwood flats (below 600 m) (18). *Resinicium bicolor, Resinicium* sp., and *Scytinostroma galactinum* were found mostly above 800 m elevation in the subalpine zone (Figs. 1 and 2). *R. bicolor* was by far the most common fungus isolated at Wildcat Mountain, where most of the subalpine samples were collected. These three fungi were found only a few times below 800 m. However, fewer samples were taken from the northern hardwoods zone because of a lower incidence of spruce and fir and the scarcity of wind-snapped trees.

Perenniporia subacida and *Armillaria* sp. were more common below than above 800 m (Figs. 1 and 2). When these two fungi were found in the subalpine zone, it was in stands with a large proportion of hardwoods, mostly paper birch (*Betula papyrifera* var. *cordifolia* (Regel) Fern.). Basham et al (2) noted that *P. subacida* was more common in Ontario on "mixedwood slopes" (perhaps analogous to the northern hardwoods zone of the White Mountains [20]) than on softwood flats. At the low-elevation (below 600 m) softwood flats east of Kancamagus Pass, we found that *Armillaria* was common as a root rot but not as a butt rot, and mortality of trees due to cambial killing by this fungus was occasionally observed. Similarly, Basham et al (2) reported that *Armillaria* was more common in Canada on softwood flats than on mixedwood slopes. Two recent surveys (4,24) also found a decrease in the incidence of *Armillaria* spp. on red spruce with increasing elevation.

With the exception of *Armillaria* sp. and one isolation of *Perenniporia subacida*, all root and butt rots encountered on softwood flats were caused by brown rot fungi (Figs. 1 and 2). *X. campanella* and *Hyphoderma praetermissum*, which we considered secondary colonizers, were isolated from samples evenly distributed in the subalpine and northern hardwoods zones.

As in eastern Canada, a number of hymenomycetes cause root and butt rots on balsam fir and red spruce in the White Mountains. A few species important on spruce and fir in other regions were not found in our survey, and an unidentified species (*Resinicium* sp.) important in the White Mountains has evidently not been reported previously. The prevalence of a few of the fungi varied with elevation and forest type. On the previously unsurveyed subalpine forest type, *Resinicium* sp., *R. bicolor*, and *Scytinostroma galactinum* appear to be the most important causes of root and butt rot.

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