

SCYTINOSTROMA GALACTINUM AS A PATHOGEN OF WOODY PLANTS

by

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ABSTRACT

Scytinostroma galactinum (FR.) DONK is the fungus commonly known as *Corticium galactinum* (FR.) BURT. Although it occurs as a saprobe on woody plants and plant debris, it also has been considered by several authors as an active pathogen that causes a white root and butt or collar rot. During the summer of 1970, it was found near Baltimore and also in Montgomery County, Maryland, under circumstances that seemingly provide additional records of pathogenicity. Several other Maryland records are cited, and many Canadian studies have been reviewed. *S. galactinum* has a distinctive dextrinoid mycelium, which is characteristic enough to permit a tentative identification even in the absence of other features. Outstanding elements of the basidiocarp are the dextrinoid hyphae and slender gloeocystidia. In culture, dextrinoid fiber hyphae and papillate oil-bearing hyphae with clamp connections are characteristic. These and other features of the basidiocarp and culture serve in the characterization of this fungus, which is economically significant and widely distributed.

INTRODUCTION

Scytinostromagalactinum (FR.) DONK probably is more familiar as *Corticium galactinum* (FR.) BURT, although it is not well known by either name. Like many of the fungi commonly referred to as "Corticiums", it often is associated with decay of dead wood. ENGELHARDT, FOSTER, & CRAIG (1961), for example, found that this fungus causes deterioration in logs of white spruce³⁾ and alpine fir in British Columbia. BASHAM (1957) noted that *S. galactinum* incites root and butt rots of living conifers,⁴⁾ but he also (1957, 1958) called attention to its role in the saprobic deterioration of fire-killed pine trees in Ontario. BASHAM, MOOK & A. DAVIDSON (1953) discovered that *S. galactinum* causes a heart rot in living balsam firs, after which it may, in some instances, invade the sap wood and continue growth after the trees are dead. Thus, *S. galactinum* may be regarded as a facultative saprobe.

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³⁾ Latin names of host plants are listed in Appendix I.

⁴⁾ Reports of pathogenicity are summarized in Appendix II.

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Recent observations in Maryland parallel those in published reports implicating *S. galactinurn* as a pathogen in living plants. Early records of pathogenicity were based on examination of hardwood trees in the United States, but the majority of later studies have involved conifer decay in Canada. According to BASHAM & MORAWSKI (1964), the economic importance of *S. galactinurn* is shown by the fact that it is second of 23 listed fungi in causing loss of Crown stumpage revenue from major commercial tree species in Ontario. SMERLIS (1961) discovered that *S. galactinurn* represented 40.6 percent of 133 basidiomycete isolates from root and butt rot in Quebec. *S. galactinurn* also has been found in Europe, Asia, and the West Indies (BURT, 1926, 1931; ITO, 1929; WHITE, 1951; PARMASTO, 1971), but perhaps not as a recognized pathogen.

The only comprehensive accounts of *S. galactinurn* and of its significance as a pathogen (COOLEY & DAVIDSON, 1940; WHITE, 1951) were published essentially as pioneer reports. More than three-quarters of the publications on the pathogenicity of this fungus were issued during the past 20 years, but the work of this recent period has not been summarized. Descriptions of the basidiocarp (BURT, 1926; COOLEY & DAVIDSON, 1940; WHITE, 1951; PARMASTO, 1971) are somewhat less than adequate, for various reasons. Although WHITE'S description is comprehensive, it needs revision; PARMASTO'S probably is unavailable for many potential users.

The most detailed culture descriptions were written by FRITZ (1923) and BOIDIN (1958), but each author omitted some pertinent details. Moreover, FRITZ'S description was published without adequate taxonomic identification of the fungus that it characterized. DAVIDSON, CAMPBELL & BLAISDELL (1938) and DAVIDSON, CAMPBELL & VAUGHN (1942) provided significant culture data, but not a comprehensive description. BASHAM, MOOK & A. DAVIDSON (1953) stated that WHITE'S (1951) publication includes a thorough description of the culture characteristics, but the truth is quite to the contrary: WHITE'S discussion of his culture studies was limited to information concerned with interfertility. Thus - in reference to studies of pathogenicity, basidiocarp morphology, and culture characteristics - information is scattered, incomplete, or otherwise inadequate.

S. galactinurn was found in Maryland during the summer of 1970 under circumstances that gave presumptive evidence of its pathogenicity. Thus, a search was initiated for additional information concerning its occurrence there. Notations of occurrence in Maryland as a presumed pathogen were found in reports by COOLEY & DAVIDSON (1939, 1940) and COOLEY (1951), and also among unpublished records in the Forest Mycology Research Center. No published reference?, to appearance there after 1951 could be found. Moreover, reports of recent occurrence elsewhere in the United States are almost nonexistent. This paucity of records, in the light of continuing occurrence of *s. galactinurn* in Maryland, suggests that the fungus may also occur unrecognized as a pathogen elsewhere in the

United States. The following comprehensive account of pathogenicity and taxonomic characteristics is intended to direct additional attention to *S. galactinurn*.

Pathogenicity

Published records of pathogenicity, together with unpublished Maryland records, are summarized in Appendix 11. Apparently, only three records were based on inoculation studies. Others have resulted from observations of the fungus and associated host symptoms (Fig. 1) or from culture studies of decay isolations. The role of *S. galactinum* as a pathogen was first recognized by SCHRENK (1902), who wrote that, "The fungus was transferred from oak roots to young apple trees, killing the latter within a year". COOLEY & DAVIDSON (1940) found that *S. galactinurn* was able to attack inoculated apple trees and that controls were unaffected. Similarly, TOOLE (1967) caused infection of sycamore, sweetgum, oak, and ash seedlings by inoculating them with *S. galactinurn*. Mimosa [*Albizia julibrissin* DURAZZ.] was unaffected in TOOLE's studies.

After SCHRENK's early observations, other reports of pathogenicity were sparse, but SCHRENK & SPAULDING (1909) noted that *S. galactinum* attacked various forest trees and also parasitized fruit trees planted on newly cleared land in western Arkansas and surrounding areas. BURT (1926) mentioned that, "The mycelium of *C. galactinum* was collected as a parasitic root rot on the roots of young apple trees and blackberry bushes and developed mature fructifications". He listed five collections from apple roots and one from blackberry roots. At the same time, he gave records of 97 other collections, all of which presumably had grown under saprobic circumstances. Some reports, such as one by OVERHOLTS (1938), in Louisiana, do not adequately specify whether the fungus was living as a pathogen or as a saprobe. Records of this nature are omitted from Appendix II unless the probability seems great that the fungus killed the host.

As determined by SCHRENK (1902), *S. galactinum* spreads from one host to another through the soil. This was verified by the experimental work and observations of COOLEY & DAVIDSON (1940), COOLEY (1948, 1951), and others. According to WHITE (1951), disease may be transmitted not only by means of infected substratum but also through root graftings. COOLEY (1951) was able to eliminate *S. galactinum* from soil by removing diseased plants and then fumigating with chloropicrin. During a subsequent observation period of up to seven years, no infection occurred in replantings in the treated area.

When the pathogen reaches a new host, according to SCHRENK & SPAULDING (1909), ". . . long white strands . . . penetrate the bark of . . . trees until they reach the living tissues". CAMPANA (1954) was unable to isolate *S. galactinum* from small feeding rootlets of



Fig. 1. Crown and root rot of *Cornus florida*, F. P. 66274, $\times 1/3$.

Fig. 2. Basidiocarp from stump of *Prunus* sp. (ornamental cherry), P.L.L. 2402, $\times 3/4$

Fig. 3. Decay in butt of *Tsuda canadensis*. P.L.L. 2403, $\times 1$.

white pine seedlings, even though he had introduced the fungus into close association with the roots by inoculation into the soil or even into actual contact with wounded roots. In other studies this fungus has been recovered from the roots of various plants and several authors have stated that the root and butt rots both are initiated by root infection. According to COOLEY & DAVIDSON (1940), the infection starts at the collar or on the larger roots and advances rapidly outward on the smaller roots.

Penetration often is through wounds or dead roots, as noted by REDMOND (1957) for various butt rot infections in balsam fir. WHITNEY (1961) found that many entrance lesions are compression wounds such as stone bruises; and several pathologists also have shown that wounds very commonly are caused by insect attack. For example, larvae of root weevils such as *Pissodes* (KREBILL, 1963) and *Hylobius* (SMERLIS, 1961; WHITNEY, 1961) apparently are important avenues of infection. In many instances, trees are especially susceptible to attack after they have been either weakened or killed by insects, such as spruce budworm [*Choristoneura fumiferana* (CLEM.)] (A. DAVIDSON, 1951; QUIRKE, 1953; STERNER, 1970a, 1970b).

COOLEY & DAVIDSON (1940) described the initial formation of white infection strands and the development of a dense, white mycelial mass on the root surface, followed by penetration of the epidermis, cortex, cambium, and wood. During the initial stages, according to COOLEY (1946), the fungus kills the cambium in spots, so that zonate infection areas are visible on the wood surface of affected roots when the bark is removed. BASHAM & MORAWSKI (1964) found that the spring wood becomes disrupted by decay pockets that coalesce and cause separation of the annual rings. Then the wood deteriorates to form a loose, fibrous mass, which eventually may disintegrate and leave a central cavity in the butt of the tree. In some instances, the cavity is filled with a mass of fungus mycelium (Fig. 3). During their decay studies in four areas of eastern North America, BASHAM, MOOK & A. DAVIDSON (1953) observed that the average extent of decay above ground level was approximately four to six feet in the various areas.

On the basis of tests for extracellular oxidase, *S. galactinum* belongs in the white-rot group of Basidiomycetes. However, the actual color of the decay may range from white to yellowish or even brownish. In four individual samples, BASHAM, MOOK & A. DAVIDSON (1953) found a reddish trunk rot that they associated with *S. galactinum*.

Death, often early in the growing season and very soon after conspicuous symptoms appear, is the usual course of disease caused by *S. galactinum* (SCHRENK, 1902; COOLEY & DAVIDSON, 1940). According to SCHRENK (1902), apple trees that were planted on newly cleared land showed no evidence of disease until the year of death; and death often occurred early in the summer. This history may be inter-

preted as an indication that the roots were badly diseased during the preceding growing season and that they were unable to support the stress of renewed growth. In such instances, the role of *S. galactinum* as a pathogen may be obscured by the fact that its presence is not evident to casual observation until after the tree is dead. Eventually, a basidiocarp may develop at the base of the tree, on the roots, or even on the surrounding soil.

Basidiocarp Characteristics

Scytinostroma DONK (1956) [Type: *Corticium portentosum* BERK. & CURT.] was segregated from *Corticium* FR. and other corticioid fungi on the basis of basidiocarp structure. The special elements that permit the genus to be distinguished from all others are the thick-walled, sparsely septate or nonseptate hyphae, which are devoid of clamp connections, branch in a particular manner that is essentially dichotomous, and which become reddish brown in MELZER'S solution. These thick-walled hyphae are responsible for the characteristic tenacious consistency of the basidiocarp. They are more-or-less similar to some of the dichohyphidia in *Vararia*. According to CUNNINGHAM (1963), they are skeletal hyphae of the so-called "bovista" type. REID (1965) placed *Scytinostroma* in the family Lachnocladiaceae REID, characterized by dichophytic binding hyphae. Although the manner of branching is not incompatible with designation of the thick-walled hyphae as binding hyphae, these elements in *Scytinostroma* probably are more suitably regarded as branching skeletal hyphae. This also is the concept held by PARMASTO (1971), who described the hyphal system as: "dimitic (with generative hyphae and dextrinoid skeletal hyphae); in hymenium primitive skeletohyphidia or skeletodendrohyphidia".

The following description is based in part on one prepared by WHITE (1951), and also on descriptions by BURT (1926), COOLEY & DAVIDSON (1940), and on our own observations. PARMASTO'S (1971) account also was consulted.

Macroscopic Characteristics — Basidiocarp (Fig. 2) corticioid, adherent, becoming broadly effused, thickening to approximately 1mm or more, soft- but tough-coriaceous when fresh, becoming corky or woody when dry; hymenial surface smooth or papillate, dry or slightly waxy, white at first, becoming cream colored, often light buff or ochraceous when sporulating; margin thinning out.

Microscopic Characteristics — Context appearing densely homogeneous (Fig. 4); generative hyphae inconspicuous, thin walled, septate, with clamp connections (Fig. 6), (1.5-) 2—3(—3.5) μ in diameter; skeletal hyphae (skeletodendrohyphidia in the hymenium) conspicuous, thick walled, non-septate or sparsely septate, lacking clamp connections, branched more-or-less dichotomously (Fig. 5), fiber-like, contorted and tenaciously intertwined, colorless to pale yellow, turning reddish brown in MELZER'S solution (dextrinoid),

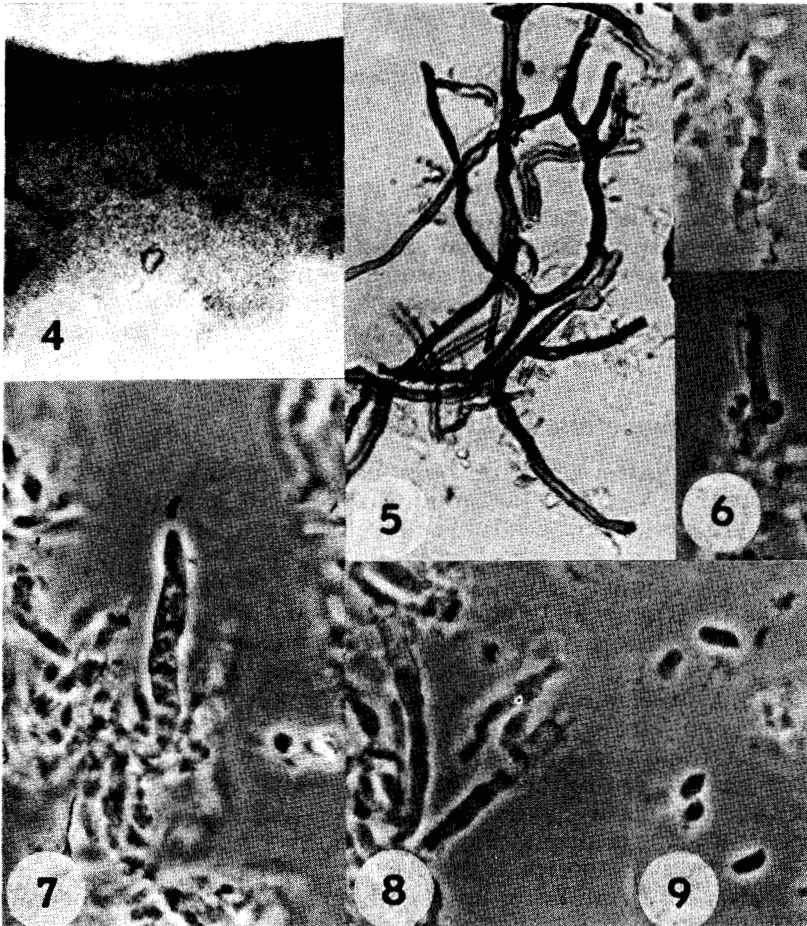


Fig. 4. Vertical section through basidiocarp from roots of *Aucuba*, Washington, D.C. $\times 90$.

Figs. 5-9. Microscopic elements of basidiocarp, P.L.L. 2402, $\times 875$.

Fig. 5. Dichotomously branched skeletal hyphae from context. Fig. 6. Segments of generative hyphae with clamp connections. Fig. 7. Gloeocystidium. Fig. 8. Basidia. Fig. 9. Basidiospores.

1—3 μ in diameter; gloeocystidia (Fig. 7) inconspicuous, thin walled, slender, flexuous, with clear or refractile contents, 40—55 (-120) \times 2—5 entirely immersed or protruding slightly, with apex rounded or tapered; basidia (Fig. 8) at first broad and obpyriform, then elongating apically by formation of a tubular outgrowth, 20—35 \times 2—3.5 μ , with four sterigmata; spores (Fig. 9) thin walled,

smooth, ellipsoid, flattened on the adaxial side, colorless, nonamyloid, $4-5.5 \times 2-3 \mu$

BURT (1926) wrote that *S. galactinurn* does not have gloeocystidia; COOLEY & DAVIDSON (1940) recognized specialized hymenial elements but called them "paraphyses"; and WHITE (1951) described the specialized elements as gloeocystidia but incorrectly gave the width range as 20-50 μ , probably as the result of a typographical error. WHITE also listed a maximum length of 120 μ , and this figure is included in our description as an exceptional limit. However, WHITE'S drawings, the size range given by COOLEY & DAVIDSON, and our own observations all show that most gloeocystidia are much shorter. Some of the spores in our collection from ornamental cherry were unusually long, up to 6.5 μ .

Culture Characteristics

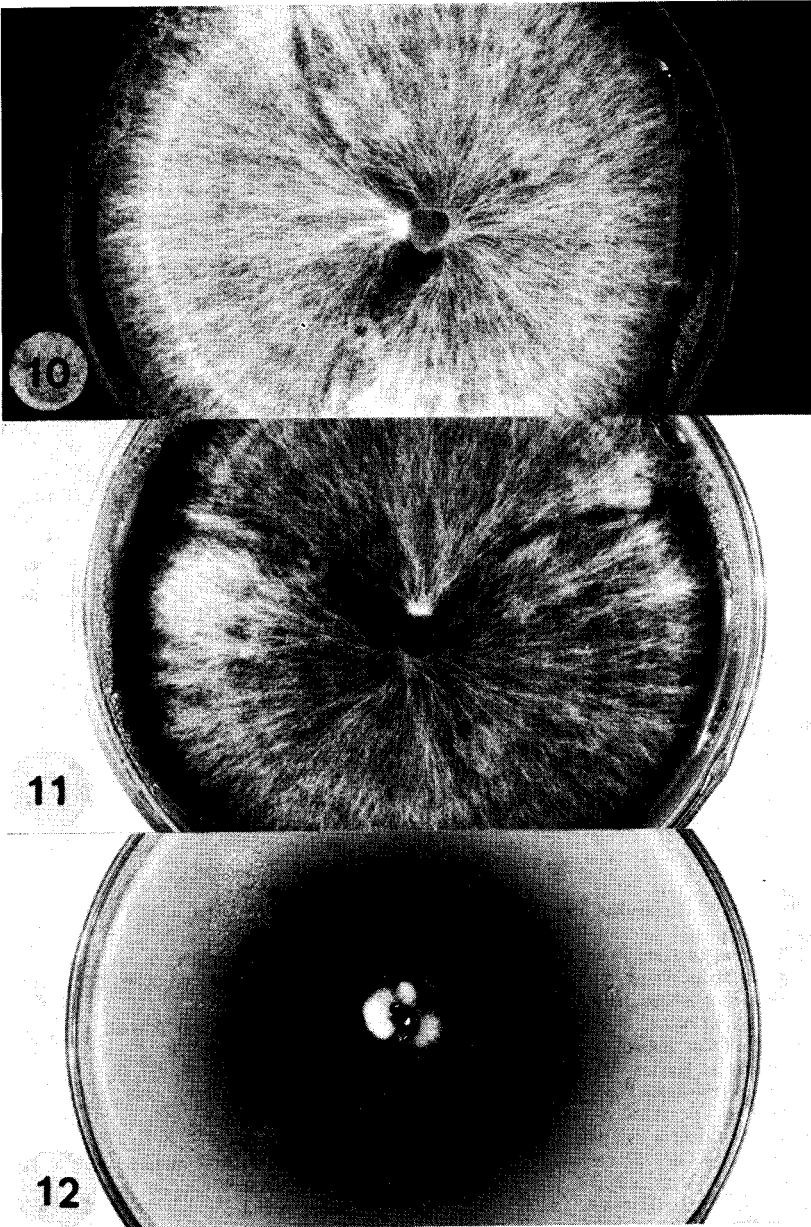
The key patterns for *S. galactinurn*, according to DAVIDSON, CAMPBELL & VAUGHN (1942), are: A-P-I-1-11-16 and B-P-I-1-11-16. They are based on methods of culture study currently in use at the Forest Mycology Research Center.

Growth Characteristics — Growth on 2.5 % diamalt agar (Fig. 10) at 25° C moderately rapid, forming a mat 90+ mm in diameter at 14 days, delicate, raised, loose-woolly, minutely floccose, collapsed in the center, zonate toward the margin, with the marginal region thin, translucent, adherent, fimbriate, very fragile; mat entirely white or with a tinge of light ochraceous buff to Naples yellow; agar beneath the mat not discolored; odor lacking or faintly sweet; oxidase reaction strongly positive on tannic (Fig. 11) and gallic (Fig. 12) acid agar media, with mycelial growth lacking or forming a mat up to 47 mm in diameter within seven days on gallic acid agar, 18-72 mm in diameter on tannic acid agar.

In test-tube cultures at 28 days, mat covering the diamalt agar slant and extending to base of agar cylinder, appearing as a loose, raised growth radiating from the inoculum block and forming a cottony-woolly growth over the agar surface; growth entirely white, or white with a light buff to tawny tinge in thicker areas; agar under the mat not discolored; tube culture odorless.

Microscopic Characteristics — Generative hyphae (Fig. 13b, d) thin walled, with clamp connections, branched, colorless, staining in phloxine, $(0.5-1.5-3-4 (-7))\mu$ in diameter, some modified as oil-filled segments or ends bearing lateral, tapering, knob-tipped papillae (Fig. 13a); fiber hyphae (Fig. 13c) with walls slightly to definitely thickened and refractile, apparently nonseptate, sparsely branched, nonstaining in phloxine, commonly becoming reddish brown in MELZER'S solution (dextrinoid), $0.5-2.5\mu$ in diameter.

Temperature Relations — According to COOLEY & DAVIDSON (1940), the optimum growth temperature is between 25 and 31° C, and the maximum apparently is slightly above 34°.



Figs. 10-12. Cultures photographed after 14 days, P. L.L. 2403, $\times 1$.
Fig. 10. Diamalt agar. Fig. 11. Tannic acid agar. Fig. 12. Gallic acid agar.

Cultures Studied — Cultures studied as the basis for the description of culture characteristics include: P. L. LENTZ 2402, on *Prunus* sp. (ornamental cherry), May 8, 1970, Elkridge, Md.; P. L. LENTZ 2403, on *Tsuga canadensis*, May 8, 1970, Elkridge, Md.; R. L. GILBERTSON 5485 sp, on *Pinus strobus*, Sept. 12, 1965, PAUL SMITH'S, N. Y.; R. L. GILBERTSON 5830 sp, on *Pinus ponderosa* LAWS., June 23, 1966, Flathead Lake, Mont.; M. J. LARSEN 266 sp, on *Fagus* sp. (beech), Aug. 7, 1963, Alfred, N. Y.

In culture, the oil-filled hyphal portions with knob-tipped papillae are the outstanding feature after approximately two weeks. Clamp connections and the development of dextrinoid fiber hyphae also are noteworthy. Clamps are not formed in monosporous cultures, and WHITE (1951) determined that *S. galactinurn* is heterothallic with tetrapolar interfertility. The clamp-bearing hyphae of cultures may be compared with generative hyphae of basidiocarps, and the dextrinoid fiber hyphae are probably homologous with dextrinoid skeletal hyphae of basidiocarps. According to NOBLES (1958), *S. galactinum* shows a positive reaction for extracellular oxidase when tested with gum guaiac, as well as with gallic and tannic acid.

Appendix I

Hosts Cited in Pathogenicity Records

Latin Name	Common Name
<i>Abies balsamea</i> (L.)MILL.	Balsam fir
<i>A. lasiocarpa</i> (HOOK.)NUTT.	Alpine fir, balsam
<i>Baptisia australis</i> R. BR.	False indigo (herb)
<i>Betula alleghaniensis</i> BRITT.	Yellow birch
<i>Cornus florida</i> L.	Flowering dogwood
<i>Exochorda racemosa</i> REHD.	Pearl bush (shrub)
<i>Fraxinus pennsylvanica</i> MARSH.	Red ash
<i>Hibiscus syriacus</i> L.	Rose of Sharon
<i>Ilex</i> sp.	Holly
<i>I. opaca</i> AIT.	Holly
<i>Iris</i> sp.	Iris (herb)
<i>Jasminum nudiflorum</i> LINDL.	Jasmine (shrub)
<i>Kalmia</i> sp.	Laurel
<i>Larix laricina</i> (DU ROI) KOCH	Larch, Tamarack
<i>L. occidentalis</i> NUTT.	Western larch, Western Tamarack
<i>Liquidambar styraciflua</i> L.	Sweet gum
<i>Lychnis alba</i> MILL.	Evening campion (shrub)
<i>Malus sieboldi</i> REGEL	Toringo crabapple
<i>M. sylvestris</i> MILL.	Apple
<i>Paeonia officinalis</i> L.	Peony (herb)
<i>Picea abies</i> (L.)KARST.	Norway spruce
<i>P. glauca</i> (MOENCH)VOSS	White spruce
<i>Picea glauca</i> var. <i>albertiana</i> (S. BROWN)SARG.	Western white spruce
<i>P. mariana</i> (MILL.) B.S.P.	Black spruce
<i>P. rubra</i> (DUROI)DIETR.	Red spruce
<i>Pinus banksiana</i> LAMB.	Jack pine
<i>P. resinosa</i> AIT.	Red pine
<i>P. strobus</i> L.	Eastern white pine
<i>Platanus occidentalis</i> L.	Sycamore, American planetree
<i>Populus trichocarpa</i> TORR. & GRAY	Black cottonwood

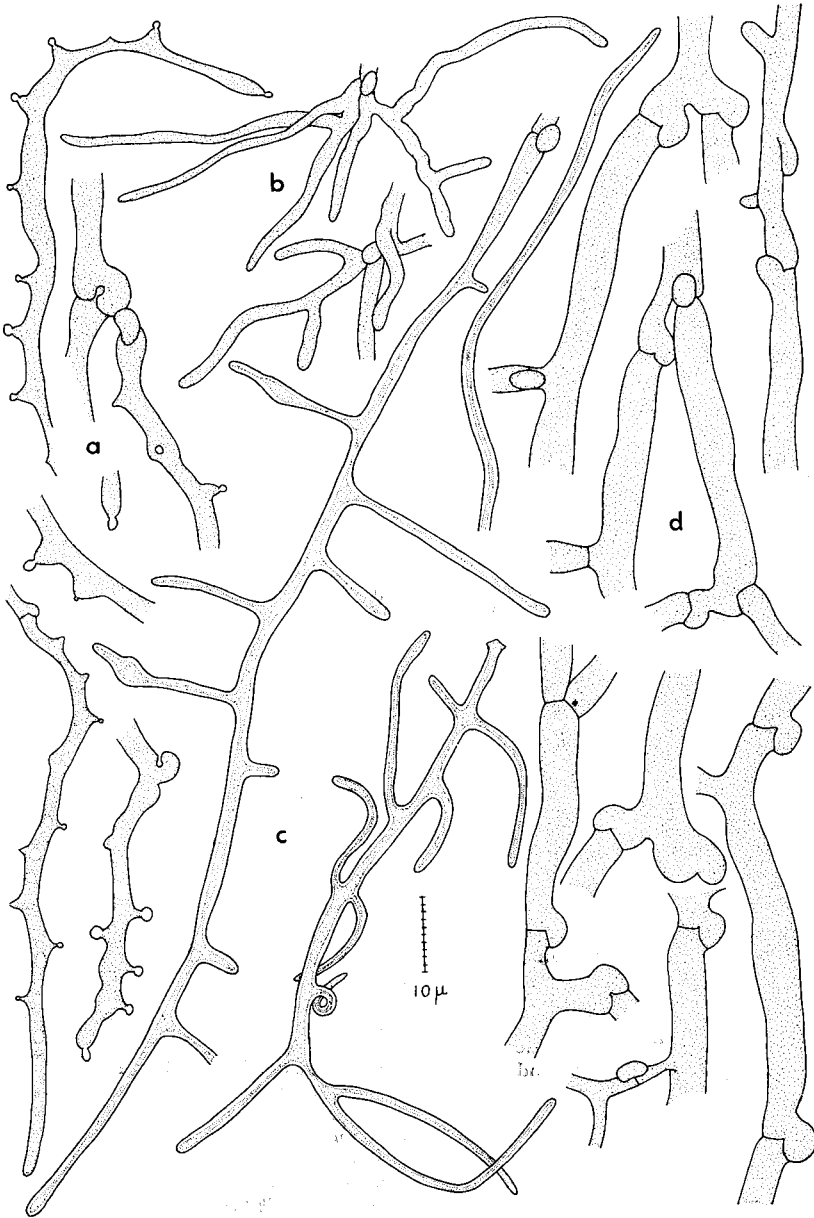


Fig. 13. Hyphal elements from diamalt agar culture, P.L.L. 2403, $\times 1000$. a: Papillate thin-walled hyphae. b: Slender, thin-walled hyphae. c: Fiber hyphae, one showing basal clamp connection. d: Broad, thin-walled hyphae with clamp connections.

<i>Prunus glandulosa</i> THUNB.	Flowering almond
<i>P. persica</i> (L.)BATSCH	Peach
<i>P. triloba</i> LINDL.	Flowering almond
<i>Pseudotsuga menziesii</i> (MIRB.)FRANCO	Douglas fir
<i>Quercus</i> spp.	Oak
<i>Q. alba</i> L.	White oak
<i>Q. nuttallii</i> PALMER	Nuttall oak
<i>Rhus glabra</i> L.	Smooth sumac
<i>Rubus</i> sp.	
<i>R. allegheniensis</i> PORTER	Allegheny blackberry
<i>R. flagellaris</i> WILLD.	Northern dewberry
<i>R. phoenicolasius</i> MAXIM.	Wineberry
<i>Spiraea thunbergii</i> SIEB.	Spiraea (shrub)
<i>Thuja occidentalis</i> L.	Arborvitae, Northern white cedar
<i>Tsuga canadensis</i> (L.)CARR.	Common hemlock
<i>T. heterophylla</i> (RAF.) SARG.	Western hemlock
<i>Viburnum carlesii</i> HEMSL.	Viburnum (shrub)

Appendix II

Records of Pathogenicity

Record	Locality	Host	Symptom
SCHRENK (1902)	Arkansas, Illinois Kentucky, Mis- souri, Oklahoma, W. Virginia	<i>Malus sylvestris</i>	Root rot
SCHRENK & SPAULDING (1909)	Arkansas and environs	<i>Quercus</i> spp., fruit trees	
FRITZ (1923, as Balsam rot Type B Fungus 2)	Ontario and Quebec	<i>Abies balsamea</i> . <i>Picea mariana</i>	Decayed wood
BURT (1926)	Arkansas, Missou- ri (*Arkansas only)	<i>Malus sylvestris</i> , <i>Rubus</i> (blackberry)*	Root rot
ARCHER (1927)	Alabama	<i>Malus sylvestris</i>	Root infection
COOLEY & DAVID- SON (abstr. 1939; 1940)	Delaware, Indiana, Maryland, Tennes- see, Virginia	<i>Cornus florida</i> , <i>Ilex</i> sp., <i>Kalmia</i> sp., <i>Lych- nis alba</i> , <i>Malus syl- vestris</i> , <i>Quercus</i> spp., <i>Rhus glabra</i> , <i>Rubus</i> <i>allegheniensis</i> , <i>R.</i> <i>flagellaris</i> , <i>R.</i> <i>phoenicolasius</i>	Collar rot
COOLEY (1946)	Eastern and Cen- tral United States	<i>Cornus florida</i> , <i>Ilex</i> <i>opaca</i> , <i>Malus sylves- tris</i> , <i>Rubus allegh- niensis</i>	White root rot
COOLEY (1948)	Virginia	<i>Malus sylvestris</i>	White root rot
MARSHALL (1948)	Connecticut	<i>Pinus strobus</i>	Root decay
COOLEY (1951)	Maryland	<i>Baptisia australis</i> , <i>Exochorda racemosa</i> , <i>Iris</i> sp., <i>Jasminum</i> <i>nudiflorum</i> , <i>Paeonia</i> <i>officinalis</i> , <i>Prunus</i> <i>glandulosa</i> , <i>P. tri- loba</i> , <i>Spiraea thun- bergii</i> , <i>Viburnum</i> <i>carlesii</i> (also listed as susceptible: <i>Malus sieboldi</i> , <i>Pru- nus persica</i>)	Root rot

Record	Locality	Host	Symptom
WHITE (1951)	Ontario	<i>Abies balsamea</i> , <i>A. lasiocarpa</i> , <i>Pinus strobus</i> , <i>Thuja occidentalis</i>	Root and butt rot
QUIRKE (1952)	Ontario	<i>Pinus</i> sp.; <i>P. strobus</i>	Heart rot; Root rot in young trees
RILEY, DENYER, & WHITNEY (1952)	Manitoba	<i>Picea mariana</i>	Heart rot
STILLWELL (1952)	New Brunswick	<i>Abies balsamea</i> , <i>Picea glauca</i>	Butt rot
BASHAM, MOOK & A. DAVIDSON (1953)	Ontario	<i>Abies balsamea</i>	White stringy butt rot; rarely a trunk rot
QUIRKE (1953)	Ontario	<i>Abies balsamea</i> , <i>Picea glauca</i> , <i>P. mariana</i> , <i>Pinus strobus</i>	White, stringy butt rot; red butt rot
STILLWELL (1953)	Maritime Provinces	<i>Betula alleghaniensis</i>	Decay
THOMAS & PODMORE (1953)	British Columbia	<i>Populus trichocarpa</i>	Decay
WHITE (1953)	Ontario	<i>Abies balsamea</i> , <i>Pinus strobus</i>	Root and butt rot
A. DAVIDSON, NEWELL, & COCHRANE (1954)	Maritime Provinces	<i>Abies balsamea</i>	
FOSTER, CRAIG, & WALLIS (1954)	British Columbia	<i>Tsuga heterophylla</i>	Decay
QUIRKE (1954)	Ontario	<i>Picea glauca</i> , <i>P. mariana</i>	Decay survey
STILLWELL & A. DAVIDSON (1954)	Maritime Provinces	<i>Larix laricina</i> , <i>Pinus banksiana</i> , <i>Thuja occidentalis</i> , <i>Tsuga canadensis</i>	Decay survey
QUIRKE & HORD (1955)	Ontario	<i>Abies balsamea</i> , <i>Picea mariana</i> , <i>Pinus banksiana</i>	Decay survey
POMERLEAU (1956)	Quebec	<i>Abies balsamea</i> , <i>Picea rubra</i>	Decay survey
A. DAVIDSON (1957)	Canadian Eastern Provinces	<i>Abies balsamea</i>	Butt decay
A. DAVIDSON & REDMOND (1957)	Maritime Provinces	<i>Picea glauca</i>	White butt rot
POMERLEAU & BENAZET (1957)	Quebec	<i>Abies balsamea</i> , <i>Picea rubra</i>	Decay survey
REDMOND (1957)	New Brunswick	<i>Abies balsamea</i>	Root decay
J. REID (1957)	Ontario	<i>Abies balsamea</i> , <i>Picea</i> spp.	Heart rot
POMERLEAU (1958)	Quebec	<i>Abies balsamea</i> ; <i>Picea mariana</i>	Butt rot; Decay survey
MOLNAR (1959)	British Columbia	<i>Larix occidentalis</i>	Culture isolate; first host record from Western North America
PARKER & JOHNSON (1960)	British Columbia	<i>Abies balsamea</i> , <i>Picea glauca</i> var. <i>albertiana</i>	Root and butt rot

Record	Locality	Host	Symptom
TOOLE (1960)	Arkansas	<i>Quercus alba</i>	Root isolate
OUELLETTE (1961)	Quebec	<i>Abies balsamea</i>	Culture isolate from broken tops
SMERLIS (1961)	Quebec	<i>Abies balsamea</i>	Root and butt rot
WHITNEY (1961)	Manitoba and Saskatchewan	<i>Picea glauca</i>	Root rot
FOSTER & JOHNSON (1963)	British Columbia	<i>Pseudotsuga menziesii</i>	Root rot
KREBILL (1963)	Wisconsin	<i>Pinus banksiana</i> , <i>P. resinosa</i>	Decay
BASHAM & MORAWSKI (1964)	Ontario	<i>Abies balsamea</i> , <i>Betula alleghaniensis</i> , <i>Picea glauca</i> , <i>P. mariana</i> , <i>Pinus banksiana</i> , <i>P. resinosa</i> , <i>P. strobus</i> , <i>Tsuga canadensis</i>	Decay; yellow stringy butt rot
OUELLETTE (1966)	Quebec	<i>Abies balsamea</i> , <i>Picea abies</i>	Butt rot
OUELLETTE (1967)	Quebec	<i>Abies balsamea</i>	Butt rot
TOOLE (1967)	Mississippi	<i>Liquidambar styraciflua</i> , <i>Platanus occidentalis</i> , <i>Quercus alba</i> , <i>Q. nuttallii</i>	Inoculation test infection
STERNER (1970a, 1970b)	New Brunswick	<i>Abies balsamea</i>	Butt decay
LENTZ & BURDSALL, 1970 (May), previously unpublished	Belmont Estate, vicinity Baltimore, Maryland	<i>Tsuga canadensis</i> (PLL 2403)	Basal heart rot; pure culture isolate obtained from mycelium in newly killed hedge plant
LENTZ & BURDSALL, 1970 (August), previously unpublished	Montgomery County, Maryland	<i>Quercus</i> spp. and various shade trees	Dead and dying trees with root and collar rot, with associated fungus mycelial masses
DAVIDSON, records from cultures and specimens in Forest Mycology Research Center, previously unpublished	Prince Georges County, Maryland	<i>Ilex</i> sp., <i>Kalmia</i> sp., <i>Cornus florida</i> (FP 86206)	
	Suburban District of Columbia (in Maryland)	<i>Hibiscus syriacus</i> (FP 105262)	
	Montgomery County, Maryland	<i>Cornus florida</i> and <i>Quercus</i> sp. (FP 105449); <i>C. florida</i> and <i>Ilex</i> sp. (FP 66274)	

References

- ARCHER, W. A. (1927) Diseases of fruit and nut crops in the United States in 1926. *Pl. Dis. Repr.*, Suppl. 52: 109 p.
- BASHAM, J. T. (1957) The deterioration by fungi of jack, red, and white pine killed by fire in Ontario. *Canad. J. Bot.* 35: 155—172.
- BASHAM, J. T. (1958) The pathological deterioration of fire-killed pine in the Missisagi region of Ontario. *Canad. Dept. Agric. Forest Biol. Div. Publ.* 1022. 38 p.
- BASHAM, J. T., MOOK, P. V. & DAVIDSON, A. G. (1953) New information concerning balsam fir decays in eastern North America. *Canad. J. Bot.* 31: 334—360.
- BASHAM, J. T. & MORAWSKI, Z. J. R. (1964) Cull studies, the defects and associated basidiomycete fungi in the heartwood of living trees in the forests of Ontario. *Canada Dept. Forestry Publ.* 1072. 69 p.
- BOIDIN, J. (1958) Essai biotaxonomique sur les Hydnes résupinés et les Corticiés. *Rev. Mycologie*, Mem. hors-ser. 6. 387 p.
- BURT, E. A. (1926) The Thelephoraceae of North America. XV. *Corticium*. *Missouri Bot. Gard. Annals* 13: 173—354.
- BURT, E. A. (1931) Hymenomycetous fungi of Siberia and Eastern Asia, mostly of wood-destroying species. *Missouri Bot. Gard. Annals* 18: 469—487.
- CAMPANA, R. J. (1954) *Corticium galactinum* does not cause white pine needle blight. *Pl. Dis. Repr.* 38: 297—303.
- COOLEY, J. S. (1946) Root diseases of deciduous fruit trees. *Bot. Rev.* 12: 83—100.
- COOLEY, J. S. (1948) Natural infection of replanted apple trees by white root rot fungus. *Phytopathology* 38: 110—113.
- COOLEY, J. S. (1951) Control of white root rot with chloropicrin in a border of ornamental plants. *Phytopathology* 41: 379—380.
- COOLEY, J. S. & DAVIDSON, R. W. (1939) White root rot of apple trees (*Corticium galactinum*). *Phytopathology* 29: 5. Abstr.
- COOLEY, J. S. & DAVIDSON, R. W. (1940) A white root rot of apple trees caused by *Corticium galactinum*. *Phytopathology* 30: 139—148.
- CUNNINGHAM, G. H. (1963) The Thelephoraceae of Australia and New Zealand. *N. Zeal. Dept. Sci. Industr. Res. Bull.* 145. 359 p.
- DAVIDSON, A. G. (1951) Decay of balsam fir in New Brunswick. *Dept. Agric. Canada Div. For. Biol. BiM. Progr. Rept.* 7(5): 1.
- DAVIDSON, A. G. (1957) Studies in forest pathology XVI. Decay of balsam fir, *Abies balsamea* (L.) MILL., in the Atlantic Provinces. *Canad. J. Bot.* 35: 857—874.
- DAVIDSON, A. G., NEWELL, W. R. & COCHRANE, R. H. (1954) Decay of balsam fir in the Maritime Provinces of Canada. *Pulp Pap. (Mag.) Canada* 55: 135—137, 141—142, 144.
- DAVIDSON, A. G. & REDMOND, D. R. (1957) Decay of spruce in the Maritime Provinces. *Forestry Chron.* 33: 373—380.
- DAVIDSON, R. W., CAMPBELL, W. A. & BLAISDELL, D. J. (1938) Differentiation of wood-decaying fungi by their reactions on gallic or tannic acid medium. *Agric. Res. J.* 57: 683—695.
- DAVIDSON, R. W., CAMPBELL, W. A. & VAUGHN, D. B. (1942) Fungi causing decay of living oaks in the eastern United States and their cultural identification. *U.S. Dept. Agric. Tech. Bull.* 785. 65 p.
- DONK, M. A. (1956) Notes on resupinate hymenomycetes — III. *Fungus* 26: 3—24.
- ENGELHARDT, N. T., FOSTER, R. E. & CRAIG, H. M. (1961) Studies in forest pathology XXIII. Pathological deterioration of wind-damaged white spruce and alpine fir in the Crescent Spur area of British Columbia. *Canada Dept. Forestry Publ.* 20 p.
- FOSTER, R. E., CRAIG, H. M. & WALLIS, G. W. (1954) Studies in forest pathology XII. Decay of western hemlock in the Upper Columbia region, British Columbia. *Canad. J. Bot.* 32: 145—171.
- FOSTER, R. E., & JOHNSON, A. L. S. (1963) Studies in forest pathology XXV. Assessments of pattern, frequency distribution, and sampling of forest disease in Douglas fir plantations. *Canada Dept. Forestry Publ.* 1011. 52 p.
- FRITZ, C. W. (1923) Cultural criteria for the distinction of wood-destroying fungi. *Royal Soc. Canada Proc. Trans.* 17: 191—288.

- Ito, T. (1929) Symbolae ad mycologiam Japonicam. III. *Corticium*, *Gloeocystidium*, et *Asterostroma*. *Bot. Mag. Tokyo* 43: 633—642.
- KREBILL, R. G. (1963) Etiology of a jack and red pine plantation decline characterized by root weevil injury and fungal deterioration. *Diss. Abstr.* 23: 1861.
- MARSHALL, R. F. (1948) A white root rot that merits study as a possible cause of white pine blight. *Bartlett Tree Res. Labs. Sci. Tree Topics* 1(9): 66—68.
- MOLNAR, A. C. (1959) Province of British Columbia Forest Disease Survey. p. 97—103. Canada Dept. Agric. Forest Insect Dis. Surv. Ann. Rept., 1958. 114 p.
- NOBLES, M. K. (1958) A rapid test for extracellular oxidase in cultures of wood-inhabiting hymenomycetes. *Canad. J. Bot.* 36: 91—99.
- OUELLETTE, G. B. (1961) Province of Quebec Forest Disease Survey. p. 41—44. Canada Dept. Agric. Forest Insect Dis. Surv. Ann. Rept., 1960. 121 p.
- OUELLETTE, G. B. (1966) Important Forest Diseases. p. 38—43. In MARTINEAU, R. & OUELLETTE, G. B. Quebec Region. p. 33—43. Canada Dept. Agric. Forest Insect Dis. Surv. Ann. Rept., 1965. 126 p.
- OUELLETTE, G. B. (1967) Important Forest Diseases. p. 41—50. In MARTINEAU, R. & OUELLETTE, G. B. Quebec Region. p. 34—50. Canada Dept. Agric. Forest Insect Dis. Surv. Ann. Rept., 1966. 142 p.
- OVERHOLTS, L. O. (1938) Notes on fungi from the lower Mississippi Valley. *Torrey Bot. Club Bull.* 65: 167—180.
- PARKER, A. K. & JOHNSON, A. L. S. (1960) Decay associated with logging injury to spruce and balsam in the Prince George region of British Columbia. *Forestry Chron.* 36: 30—45.
- PARMASTO, E. (1971) The Lachnociadiaceae of the Soviet Union. Acad. Sci. Estonian S.S.R. Instit. Zool. Bot. Publ. 168 p.
- POMERLEAU, R. (1956) Province of Quebec Forest Disease Survey. p. 32—34. Canada Dept. Agric. Forest Insect Dis. Surv. Ann. Rept., 1955. 106 p.
- POMERLEAU, R. (1958) Province of Quebec Forest Disease Survey. p. 29—31. Canada Dept. Agric. Forest Insect Dis. Surv. Ann. Rept., 1957. 94 p.
- POMERLEAU, R. & BENAZET J. (1957) Province of Quebec Forest Disease Survey. p. 35—38. Canada Dept. Agric. Forest Insect Dis. Surv. Ann. Rept., 1956. 95 p.
- QUIRKE, D. A. (1952). Province of Ontario Forest Disease Survey. p. 127—139. Canada Dept. Agric. Forest Insect Dis. Surv. Ann. Rept., 1951. 154 p.
- QUIRKE, D. A. (1953) Province of Ontario Forest Disease Survey. p. 67—78. Canada Dept. Agric. Forest Insect Dis. Surv. Ann. Rept., 1952. 154 p.
- QUIRKE, D. A. (1954) Province of Ontario Forest Disease Survey. p. 77—90. Canada Dept. Agric. Forest Insect Dis. Surv. Ann. Rept., 1953. 158 p.
- QUIRKE, D. A. & HORD, H. V. (1955) Province of Ontario Forest Disease Survey. p. 70—81. Canada Dept. Agric. Forest Insect Dis. Surv. Ann. Rept., 1954. 135 p.
- REDMOND, D. R. (1957) Infection courts of butt-rotting fungi in balsam fir. *Forest Sci.* 3: 15—21.
- REID, D. A. (1965) A monograph of the stipitate sterioid fungi. *Nova Hedwigia*, Beihefte 18. 388 p.
- REID, J. (1957) Province of Ontario Forest Disease Survey. p. 56—59. Canada Dept. Agric. Forest Insect Dis. Surv. Ann. Rept., 1956. 95 p.
- RILEY, C. G., DENYER, W. B. & WHITNEY, R. D. (1952) Prairie Provinces Forest Disease Survey. p. 140—146. Canada Dept. Agric. Forest Insect Dis. Surv. Ann. Rept., 1951. 154 p.
- SCHRENK, H. v. (1902) A root rot of apple trees caused by *Thelephora galactina* Fr. *Bot. Gaz.* 34: 65.
- SCHRENK, H. v. & SPAULDING, P. (1909) Diseases of deciduous forest trees. U.S. Dept. Agric. Bur. Pl. Ind. Bull. 149. 85 p.
- SMERLIS, E. (1961) Pathological condition of immature balsam fir stands of *Hylacomium-Oxalis* type in the Laurentide Park, Quebec. *Forestry Chron.* 37: 109—115
- STERNER, T. E. (1970a) Butt decay in balsam fir defoliated by the spruce budworm. *Canad. Forestry Serv. BiM. Res. Notes* 26: 17—18.
- STERNER, T. E. (1970b) Butt decay in balsam fir defoliated by the spruce budworm. *Canad. Forestry Serv. BiM. Res. Notes* 26: 38—39.
- STILLWELL, M. A. (1952) Maritime Provinces Forest Disease Survey. p. 119—123. Canada Dept. Agric. Forest Insect Dis. Surv. Ann. Rept., 1951. 154 p.

- STILLWELL, M. A. (1953) Maritime Provinces Forest Disease Survey. p. 18—21. Canada Dept. Agric. Forest Insect Dis. Surv. Ann. Rept., 1952. 154 p.
- STILLWELL, M. A. & DAVIDSON, A. G. (1954) Maritime Provinces Forest Disease Survey. p. 20—31. Canada Dept. Agric. Forest Insect Dis. Surv. Ann. Rept., 1953. 158 p.
- THOMAS, G. P. & PODMORE, D. G. (1953) Studies in forest pathology XI. Decay in black cottonwood in the Middle Fraser region, British Columbia. *Canad. J. Bot.* 31: 675—692.
- TOOLE, E. R. (1960) Root rot of white oak in Arkansas. *Pl. Dis. Rept.* 44: 783.
- TOOLE, E. R. (1967) Root rot of southern hardwood trees caused by *Corticium galactinum*. *Pl. Dis. Rept.* 51: 500—501.
- WHITE, L. T. (1951) Studies of Canadian Thelephoraceae VIII. *Corticium galactinum* (Fr.) Burt. *Canad. J. Bot.* 29: 279—296.
- WHITE, L. T. (1953) Studies in forest pathology X. Decay of white pine in the Timagami Lake and Ottawa Valley areas. *Canad. J. Bot.* 31: 175—200.
- WHITNEY, R. D. (1961) Root wounds and associated root rots of white spruce. *Forestry Chron.* 37: 401—411.