

# Foliar Fungi of Western Trees

A. Funk



**Cover Photo:**

Rhabdocline needle cast of Douglas-fir: early spring condition.

**Cover Inset:**

Ascomata of *Rhabdocline pseudotsugae* and *Phaeocryptopus gaeumannii* on Douglas-fir needle.

# **Foliar Fungi of Western Trees**

**A. Funk**

Canadian Forestry Service  
Pacific Forest Research Centre

BC-X-265

1985

Canadian Forestry Service  
Pacific Forest Research Centre  
506 West Burnside Road  
Victoria, B.C.  
V8Z 1M5

© Minister of Supply & Services Canada, 1985  
ISSN 0705-3274  
ISBN 0-662-14054-0  
Cat. No. Fo46-17/265E

## **Abstract**

The descriptions of the foliar fungi of principal western trees and some shrubs are presented. These fungi are all from the Ascomycetes and Deuteromycetes. The diseases induced by the fungi are needle casts, needle blights, leaf spots, tar spots, sooty moulds and mildews. Approximately two hundred species are described. Notes on host range, disease symptoms and taxonomy are included. The descriptions are arranged alphabetically by genus name. Keys for identification appear in the front of the book. An appendix listing the foliar rusts, a glossary, references, host index and general index appears in the back.

## **Résumé**

Nous présentons les descriptions des champignons aux feuillage des arbres de l'ouest. Ces champignons font tous partie des Ascomycètes et des Deuteromycètes. Les maladies provoquées par ces champignons sont les tache des feuilles, rouges, anthracnoses, blancs et fumagines. Inclues aussi sont des notes sur la zone d'hôte, les symptômes de maladies et la taxonomie. Environ 200 espèces de champignon sont incluses. Les descriptions sont arrangées en ordre alphabétique selon le nom du genre du champignon. Au début du livre se trouvent les clefs d'identification; à la fin se trouvent l'appendix des rouille des feuilles, les références littéraires, le lexique, l'index d'hôtes et l'index général.



# Contents

	Page
Preface.....	7
Introduction.....	9
Keys for Identification of foliar fungi .....	14
Key to the genera of Hemiphacidiaceae .....	14
Key to the genera of Hypodermataceae.....	15
Key to the genera of Discomycetes .....	15
Key to the genera of Pyrenomycetes.....	16
Key to the genera of Loculoascomycetes .....	17
Key to the genera of Sphaeropsidales.....	18
Key to the genera of Melanconiales .....	18
Key to the genera of Hyphomycetes .....	19
Descriptions of Species (all species arranged alphabetically by genus) .....	20
List of Secondary Fungi of Conifer Needles.....	117
Appendix. List of foliar rusts (Uredinales).....	118
Glossary.....	125
References.....	131
Host Index .....	140
General Index.....	145





## Preface

Two descriptive works dealing specifically with the parasitic fungi of western trees have appeared recently. In 1974, W.G. Ziller in his book **Tree Rusts of Western Canada** described all the known rusts affecting western trees. In 1981, I described the ascomycetes and deuteromycetes associated with stem diseases in a book entitled **Parasitic Microfungi of Western Trees**. The present volume deals with the fungi attacking foliage or acting as secondary saprophytes and epiphytes of leaves of the principal western trees and some shrubs (Hosie 1969). The records are based largely on collections held in the herbaria of this research centre and of the Northern Forest Research Centre in Edmonton (see HOST INDEX). These fungi are also ascomycetes and deuteromycetes. Many rusts (Uredinales) also attack foliage, but these were treated by Ziller in the above mentioned work, and are merely listed here under their host genera in the Appendix. This period has also seen the appearance of several excellent handbooks that describe forest diseases in the west (Peterson and Smith 1975; Bega 1978; Holsten *et al.* 1980).

This research centre has produced two notable workers in the foliar fungi: A.K. Parker (1922-1974) who worked on the physiology and taxonomy of *Rhabdocline* and *Dothistroma*; and W.G. Ziller, who in addition to the work on the rusts described many new species and elucidated life cycles. It was my privilege, on occasion, to cooperate with these experts on specific studies, but the foliar fungi were not my area of research. However, my frequent travels and discussions with them enhanced my understanding and appreciation of the many problems and have greatly helped me in the preparation of this book.

The mycologists of the Biosystematics Research Institute, Ottawa, have also contributed immeasurably to this work by identifying many of the species and offering useful comments on them.

Many members of this research centre have helped to make this book possible. Drs. R.S. Hunt and J.C. Hopkins offered much direct assistance and advice in identification. Mrs. D.P. Lowe did proof-reading and checked the references. Mr. J. Wiens arranged and presented the manuscript and artwork. Mr. E.J. Chatelle did much of the photographic work. Members of the Forest Insect and Disease Survey made many of the disease collections. My sincere thanks to all!



## Introduction

The foliar fungi form a large and diverse group that has interested taxonomists for nearly two hundred years. Despite the vast amount of knowledge that has accumulated about these fungi, certain problems persist that lead to misunderstanding in diagnosis of disease problems. Only in recent years has extensive life history study combined with close microscopic scrutiny resolved some of these enigmas. For instance, the needle blight of pines, so long attributed to *Lophodermium pinastri*, was shown to be caused largely by a hitherto unrecognized species, *L. seditiosum*, and *L. pinastri* was shown to be a symptomless endophyte (Minter 1981). Certain fungi thought to be primary pathogens were shown to be merely secondary invaders that prevented fruiting of the causal fungus and thereby exerted a degree of natural control (Darker 1964). In the area of taxonomy, the enigma of *Rhabdocline pseudotsugae* was resolved by Parker and Reid (1969) who showed that, instead of a single species, there existed two species with five subspecies, each with a slightly different morphology, life cycle or symptomatology. Even with the recent advances in knowledge, close scrutiny and the practiced eye are necessary for correct identification of many of the foliar fungi.

Life cycles of some foliar fungi, especially the Hypodermataceae and *Rhabdocline*, are strongly regulated to coincide with phenology of the trees and may require up to three years to complete their development. Spore discharge and infection by these fungi is frequently restricted to a specific season. If infection is restricted to newly developing needles then sporulation is timed to coincide with spring budbreak, but successful infection may still be dependent on the right weather conditions occurring in that period. Many other foliar fungi do not appear to be so strongly regulated and could be considered opportunistic or climate-regulated in their sporulation, which often occurs in the same year as the initial infection, or may develop on the cast leaves.

Needle cast diseases are capable of causing tremendous damage, as in the year of writing (1983) when large tracts of interior B.C. forests were absolutely red with various needle diseases. Tree mortality is usually rare, except possibly in the case of young trees that cannot survive repeated defoliation. In older trees, loss of growth increment is the chief result. However, certain foliage diseases may limit planting of exotic trees as in the case of *Dothistroma* blight which will kill *Pinus radiata* in a few years if planted in coastal British Columbia.

The secondary fungi of the needle cast diseases form an interesting group from their physiological aspect. Once thought to be primary parasites, they are now considered to be beneficial by limiting spore production of the parasites. Darker (1964) considered the secondary fungi to be competitors for the food supply in the needles, rather than mycoparasites of the primary fungi. As evidence of the secondary nature, Darker noted that many occurred only in the year during which the primary fungus would have matured. The destruction of the primary invader may be so complete that there is no evidence of their ascocarps, and only the remains of

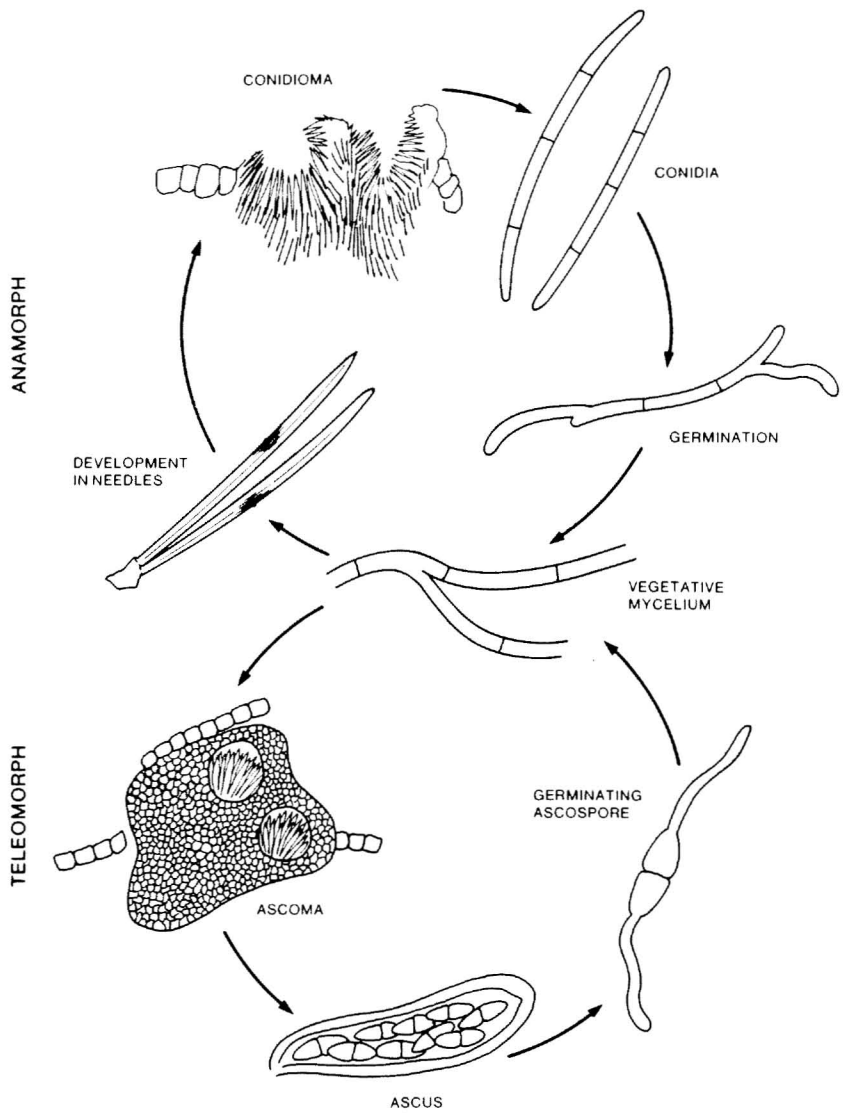


Fig. 1. Life cycle diagram of *Scirrhia pini*, the cause of red-band needle blight of pines.

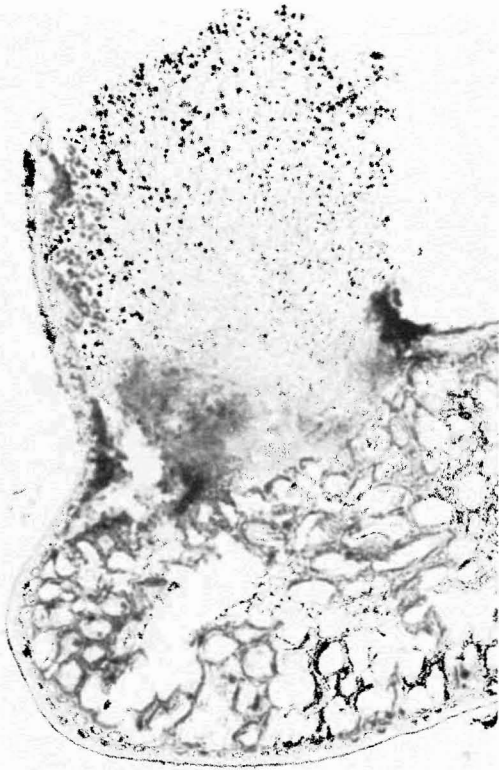


Fig. 2. *Pseudostypella (Tremella) translucens*, a mycoparasite, attacking the ascoma of *Lophodermium decorum*.

pycnidia give an indication of the original causal fungus. The known and suspected secondary fungi that exert natural control of some needle diseases are listed in Table 5. In contrast to the secondary fungi, *Pseudostypella (Tremella) translucens* (Gordon) Reid & Minter is a basidiomycetous mycoparasite that attacks the ascomata of *Lophodermium* and *Meloderma* (Fig. 2). Secondary fungi as a distinct group appear to be lacking in the broadleaf diseases.

Foliar symptoms also develop from causes other than fungal infections: climate (frosts, drying winds, drought, etc.), air pollution, mineral deficiencies, root diseases and insect attack. The symptoms of the abiotic diseases usually lack the randomness and the associated fungal fruit bodies present in infectious diseases. The publication by Malhotra and Blauel (1980) is an excellent diagnostic tool in determining the causes of these symptoms.

“Red belt” or winter drying is a climatological cause of needle killing that affects large tracts of coniferous forests. The affected areas are often in the form of narrow, horizontal “belts” on a mountainside. Severe tree mortality has resulted

from these occurrences that are associated with warm winds in winter. It is sometimes explained as increased transpiration when the ground is frozen resulting in desiccated needles, but Robins and Susut (1974) present evidence that a rapid drop in temperature following a thaw might explain this sudden damage to conifer foliage.

The work of G.C. Carroll and his co-workers has revealed a group of hitherto unknown fungi that inhabit leaves as symptomless endophytes (Carroll and Carroll 1978). The same workers have also examined the epiphytic fungal flora of leaves, visible only by epifluorescence and scanning electron microscopy (Bernstein and Carroll 1977). These fungi have not been included in the present work, but they represent a very important contribution to our knowledge of the association and interaction of fungi and their host trees, as well as a data base for the effects of air pollutants on phyllosphere fungi (Rossman and Lu 1980).

Many foliar saprophytes increase dramatically as leaves senesce. Although the living leaves all have phylloplane fungi, with senescence the primary saprophytes such as *Cladosporium* predominate, and invade the still living leaves. On dead leaf litter the secondary saprophytes, which include basidiomycetes as well as many microfungi, complete the decomposition (Hudson 1968). This type of successional study is of great interest to the ecologist but is not of immediate concern to the pathologist.

## **Control of Foliage Diseases**

Control of foliage diseases on a forest wide basis is seldom practical or possible. In New Zealand, young stands of Monterey pine are protected by aerial spraying against *Dothistroma* blight (Red-band disease) (Gibson 1974) and this involves relatively large areas. But in western Canada control practices center chiefly on nurseries, seed orchards, special plantings such as Christmas tree farms, and shelterbelts. The vast stretches of forest that sometimes become infected by foliar parasites may be helped only by natural biological control, such as secondary fungi, and by climatic conditions that hinder sporulation and spread of the fungi.

Chemical control of agricultural foliage diseases has been practiced for more than a hundred years. Since the accidental discovery of the effects of copper sulfate and lime on mildew of grape leaves in 1882, much progress has been made in this field, although the original mixture is still widely used to control fungal diseases under the name of Bordeaux Mixture. Copper in various forms continues to be a useful control chemical but the organic fungicides such as benomyl and daconil are also in wide use. Mercurial fungicides are now largely restricted because of environmental dangers.

Proper timing of fungicidal treatments is very important in controlling foliage diseases. Limited periods of susceptibility occur in some hosts and protective spraying should precede these periods. Spore dispersal in some fungi may also be seasonal or climate-controlled so that host protection must be planned to coincide with the spore showers. In some diseases of conifer needles only the new are susceptible; in others, all ages may be attacked.

Sanitation, i.e., removal of infected fallen leaves, may be a practical form of control in gardens and plantations where the source of inoculum is from fungal fruiting bodies that develop in dead leaves. However, in the case of certain fungi such as *Sirococcus strobilinus* and *Diplodia pinea*, the fungus can also fruit in dead cones or twigs, so that sanitation would require the removal of these parts from the tree.

Phyllosphere fungi, i.e. foliage saprophytes, have also been considered as biological control agents that can limit the severity of infection by foliar parasites. Bier (1965) applied aqueous suspensions of foliar saprophytes to leaves of poplars and obtained decreased infection by the leaf rust *Melampsora*. He also showed that removal of the saprophytes gave increased infection. Etheridge (1965) attempted to control *Dothistroma* blight of pines in East Africa by artificially increasing foliage saprophytes through spraying a nutrient solution on the leaves. A 5% aqueous solution of molasses was used without significant results, but a principle was established that deserves further attention.

### **Note on Arrangement of Text**

All species, regardless of classification, are arranged alphabetically by genus. Taxonomic relationships may be deduced from the keys.

Most species are listed under the name of the teleomorph, i.e., the perfect or sexual state, if it occurs. However, if the anamorph, i.e., the imperfect or asexual state, is more prominent, then it appears under that name. In either case the corresponding state is listed in the general index. Some synonyms are also included in the index.

# Keys for identifying the foliar fungi

Foliage diseases are identified chiefly by the fruiting bodies of the fungi found on the affected leaves. These fungi are classified according to their morphology in the following nine groups. A key to the genera of each group follows, but all genera of all groups are arranged alphabetically in the text. Identification of species is by reference to the text. In genera with many species the main features are listed in a table.

## ASCOMYCETES

1. A mere film of asci covering the leaf surface ..... *Taphrina*  
(a single genus)
2. Ascocarp an apothecium, excipular tissue sparse ..... *Hemiphacidiaceae*
3. Ascocarp an apothecium, excipular tissue  $\pm$  developed ..... *Discomycetes*
4. Ascocarp hysterioid, ascospores in gelatinous sheath ..... *Hypodermataceae*  
(*Rhytismataceae*)
5. Ascocarp a perithecium, asci unitunicate ..... *Pyrenomycetes*
6. Ascocarp an ascostroma, asci bitunicate ..... *Loculoascomycetes*

## DEUTEROMYCETES

7. Conidia produced within a pycnidium ..... *Sphaeropsidales*
8. Conidia produced in an acervulus ..... *Melanconiales*
9. Conidia produced on conidiophores or hyphae ..... *Hyphomycetes*

## UREDINALES (RUSTS)

Fruit bodies usually tongue-like or horn-like projections from leaves, orange or white in color. Rusts are listed in an Appendix at the back of the book under host genus.

### 2. Key to the genera of *Hemiphacidiaceae* (Korf 1962) (excipular tissue of apothecia lacking)

1. Ascospores with a distinct constriction near the middle ..... 2.
  2. Asci 8-spored, on *Pseudotsuga* ..... *Rhabdocline*
  2. Asci 4-spored, on *Tsuga* ..... *Fabrella*



1. Ascospores not constricted in the middle .....3.
3. Asci J-, 4-spored; ascospores 2-celled, pitted; on *Thuja*..... *Didymascella*
3. Asci J-, 8-spored; ascospores clavate..... *Hemiphacidium*
3. Asci J-, 8-spored; ascospores filiform, septate..... *Naemacyclus*
3. Asci J+, 8-spored; ascospores clavate ..... *Sarcotrochila*
3. Asci J+, 8-spored; ascospores broadly fusoid..... *Lophophacidium*

### 3. Key to the genera of Discomycetes

(asci unitunicate, ascocarp an apothecium)

1. Ascospores colored at maturity ..... *Stegopezizella*
1. Ascospores hyaline or faintly colored .....2.
2. Ascospores nonseptate .....3.
3. Apothecia on a sclerotium ..... *Ciborinia*
3. Apothecia on Cupressaceae only ..... *Chloroscypha*
3. Apothecia opening by longitudinal split ..... *Darkera*, *Lophophacidium*
3. Apothecia opening by teeth ..... *Phacidium*
3. Apothecia with lid of epidermis ..... *Nothophacidium*
3. Apothecia orange, ascospores sphaerical ..... *Pithya*
2. Ascospores 1-septate ..... *Diplocarpon*
2. Ascospores multiseptate ..... *Gremmeniella*

### 4. Key to the genera of Hypodermataceae

(ascospores in gelatinous sheath, ascocarp a hysterothecium)

(Figs. 3, 4)

1. Ascocarps linear, often nervisequious, dark brown to black; pycnidia continuous or in broken lines .....2.
2. Ascospores rod-shaped ..... *Virgella*
2. Ascospores bifusiform ..... *Isthmiella*
2. Ascospores clavate..... *Lirula*
1. Ascocarps elliptical, concolorous to black; pycnidia scattered or unknown .....3.
3. Asci clavate.....4.
4. Ascospores clavate, ascocarps subcuticular..... *Hypodermella*
4. Ascospores clavate, ascocarps subepidermal ..... *Davisomycella*
4. Ascospores clavate, ascocarps subhypodermal ..... *Lophodermella*
4. Ascospores elongate-fusiform, 1-septate ..... *Elytoderma*
4. Ascospores bifusiform, pycnidia large ..... *Bifusella*
3. Asci cylindrical .....5.
5. Ascospores rod-shaped to fusiform ..... *Meloderma*
5. Ascospores filiform, nonseptate ..... *Lophodermium*
5. Ascospores filiform, septate ..... *Lophomerum*

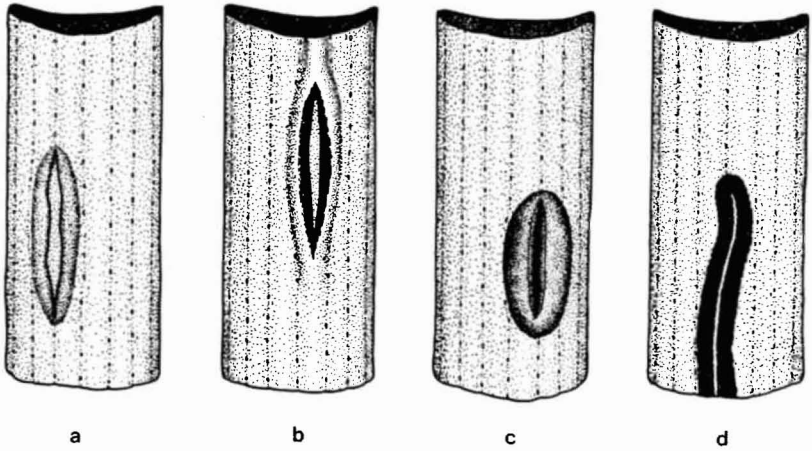


Fig. 3. Ascocarpia in the Hypodermataceae.

- a) concolorous as in *Lophodermella*
- b) narrow, black as in *Elytroderma*
- c) ellipsoid as in *Lophodermium*
- d) nervisequious as in *Lirula*

- 1. Ascocarps circular to polyhedral .....6.
- 6. Stroma simple ..... *Coccomyces*
- 6. Stroma polycarpous ..... *Rhytisma*

### 5. Key to the genera of Pyrenomyces (asci unitunicate, ascocarp a perithecium)

- 1. Ascospores hyaline .....2.
- 2. Ascospores ovoid to ellipsoid ..... *Phyllactinia*, *Uncinula*
- 2. Ascospores fusiform ..... *Gnomonia*
- 2. Ascospores filiform ..... *Linospora*
- 1. Ascospores colored .....3.
- 3. Ascospores nonseptate ..... *Rosellinia*
- 3. Ascospores multiseptate .....4.
- 4. Perithecia in "black mildew," rough ..... *Asteridiella*
- 4. Perithecia in "black mildew," appendaged ..... *Appendiculella*
- 4. Perithecia in needles attacked by hypodermataceous fungi ..... *Leptosphaeria*

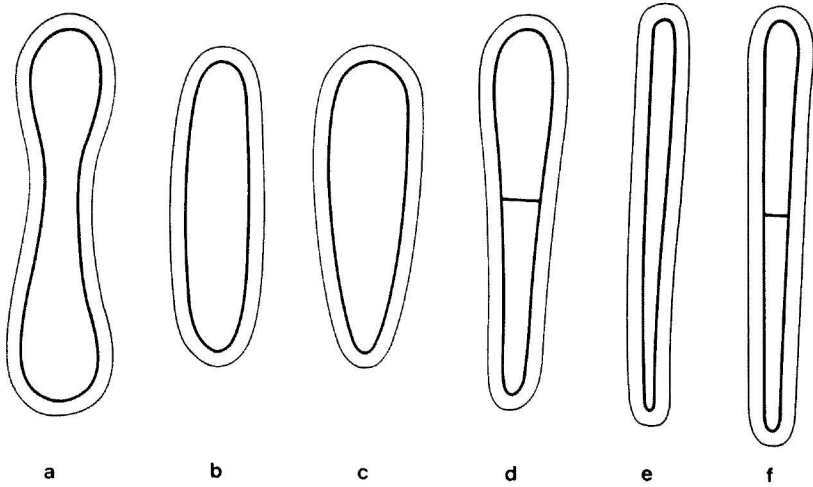


Fig. 4. Ascospore types in the Hypodermataceae (after Darker).

- a) bifusiform as in *Bifusella*, *Isthmiella*
- b) symmetric as in *Meloderma*, *Virgella*
- c) clavate as in *Davisomycella*, *Hypodermella*, *Lirula*, *Lophodermella*
- d) clavate-septate as in *Elytroderma*
- e) filiform as in *Lophodermium*, *Coccomyces*, *Rhytisma*
- f) filiform-septate as in *Lophomerum*

## 6. Key to the genera of Loculoascomycetes

(asci bitunicate, ascocarps ascostromatic)

- 1. Ascospores hyaline or faintly colored .....2.
- 2. Ascospores nonseptate ..... *Botryosphaeria*
- 2. Ascospores 1-septate .....3.
- 3. Ascospores fusoid ..... *Delphinella*, *Stomiopeltis*, *Mycosphaerella*
- 3. Ascospores cuneate ..... *Scirrha*
- 3. Ascospores clavate ..... *Phaeocryptopus*
- 3. Ascospores ovoid, medianly septate ..... *Epipolaenum*
- 3. Ascospores ellipsoid, pale green ..... *Venturia*
- 3. Ascospores ellipsoid, septum in upper third ..... *Atopospora*
- 2. Ascospores 3-5-septate .....4.
- 4. Ascocarp discoid ..... *Cyanodiscus*
- 4. Ascocarp sphaeroid ..... *Dothiora*
- 2. Ascospores muriform ..... *Sydowia*

1. Ascospores colored ..... 5.
5. Ascospores 1-septate ..... 6.
6. Thyrothecia on chlorotic spots..... *Thyriopsis*
6. Thyrothecia in “black mildew” ..... *Maurodothia*
6. Pseudothecia in brown felt blight ..... *Herpotrichia*
5. Ascospores multiseptate ..... 7.
7. Pseudothecia in sooty mould ..... *Capnodium, Limacinia*
7. Pseudothecia in brown felt blight ..... *Herpotrichia*

## 7. Key to the genera of Sphaeropsidales

(conidia produced within a pycnidium)

1. Conidia hyaline ..... 2.
2. Conidia nonseptate ..... 3.
3. Conidia ovoid to ellipsoid ..... *Sclerophoma, Phyllosticta, Phyllostictina*
3. Conidia rectangular, larger than 10  $\mu\text{m}$  ..... *Rhizosphaera*
3. Conidia rod-shaped, plain ..... *Leptostroma*
3. Conidia rod-shaped, appendaged ..... *Tiarospora*
3. Conidia allantoid ..... *Cytospora, Melasmia*
3. Conidia fusoid, biguttulate ..... *Phomopsis A*
3. Conidia pyriform ..... *Leptothyriella*
3. Conidia filiform, curved ..... *Phomopsis B*
2. Conidia 1-septate ..... *Sirococcus*
2. Conidia 3-septate ..... 4.
4. Conidia broadly fusoid ..... *Rhizothyrium*
4. Conidia falcate ..... *Brunchorstia*
4. Conidia elongate, curved ..... *Septoria*
2. Conidia 3-5-septate, elongate ..... *Dothistroma*
2. Conidia muriform, large ..... *Dichomera*
1. Conidia colored ..... 5.
5. Conidia 0-1-septate ..... *Diplodia*
5. Conidia mostly 3-septate ..... *Didymosporium, Hendersonia, Lecanosticta, Phaeoseptoria*
5. Conidia 15-septate ..... *Phaeoxyphiella*
5. Conidia muriform, large ..... *Camarosporium, Dichomera*

## 8. Key to the genera of Melanconiales

(conidia produced in acervuli)

1. Conidia hyaline ..... 2.
2. Conidia nonseptate ..... 3.
3. Conidia oval to rectangular ..... *Gloeosporium*
3. Conidia long, cylindric ..... *Colletotrichum*
3. Conidia rhomboid, in chains ..... *Cercoseptoria*
3. Conidia naviculate ..... *Rhabdogloeopsis*

- 3. Conidia peanut-shaped, plain ..... *Meria*
- 3. Conidia peanut-shaped, appendaged ..... *Rhabdogloeum*
- 2. Conidia 1-septate ..... *Marssonina*
- 2. Conidia multiseptate ..... 4.
- 4. Conidia filiform ..... *Linodochium*
- 4. Conidia insect-like ..... *Entomosporium*
- 1. Conidia colored ..... 5.
- 5. Conidia 1-septate ..... *Pollaccia*
- 5. Conidia 3-septate, appendaged ..... *Truncatella*
- 5. Conidia 4-septate, appendaged ..... *Pestalotiopsis*
- 5. Conidia 5-septate ..... *Seiridium, Leptomelanconium*
- 5. Conidia 6-8-septate ..... *Cercospora*

## 9. Key to the genera of Hyphomycetes

(conidia on hyphae or specialized conidiophores)

- 1. Conidiophores simple ..... 2.
- 2. Conidia hyaline, nonseptate ..... *Hormisciomyces*
- 2. Conidia hyaline, in chains ..... *Oidium*
- 2. Conidia hyaline, complex ..... *Cristulariella*
- 2. Conidia dark, 1-septate ..... *Pirozynskia*
- 2. Conidia dark, muriform ..... *Epicoccum*
- 1. Conidiophores sporodochial ..... 3.
- 3. Conidia hyaline, nonseptate ..... *Kabatina*
- 3. Conidia hyaline, triradiate ..... *Vanterpoolia*
- 3. Conidia dark, multiseptate ..... *Stigmina*

# Descriptions of species

(all species arranged alphabetically by genus)

***Apiosporina collinsii*** (Schw.) Hoehn. Sitzb. K. Akad. Wiss. Wien 119: 439 (1910).

ANAMORPH: *Cladosporium*

Systemic in twigs, where thick, black, mycelial subicula are formed. Ascostromata black, hypophyllous on a subiculum, gregarious, globose, ostiolate, tapered at the base, 125-250  $\mu\text{m}$  diameter, collapsing when dry. Asci clavate, bitunicate, 40-70  $\times$  9-12  $\mu\text{m}$ . Ascospores pale green to yellowish brown, elliptic-fusoid, 1-septate near the base, 12-15  $\times$  4-6  $\mu\text{m}$ .

Conidiophores covering subiculum early in the season, erect, single or branched, septate, brown, up to 225  $\mu\text{m}$  long and 4  $\mu\text{m}$  wide. Conidia ellipsoid, denticulate, brown, nonseptate, 8-18  $\times$  5-8  $\mu\text{m}$ .

HOST: *Amelanchier alnifolia*

DISEASE: Causes a mild brooming of Saskatoon where it is systemic in the twigs, and a blackening and curling of the leaves.

***Apostrasseria lunata*** (Shear) Nag Raj Can. J. Bot. 61: 19 (1983).

TELEOMORPH: *Phacidium lunatus* DiCosmo, Nag Raj & Kendrick

Pycnidia stromatic, dark brown, ostiolate, often with a conical neck, immersed, globose to subglobose, 170-500  $\times$  120-300  $\mu\text{m}$  deep, locule convoluted or irregularly divided; wall up to 40  $\mu\text{m}$  thick, of brown *textura angularis*. Conidiogenous cells annellides, ampulliform or lageniform, 4-12  $\times$  2-5  $\mu\text{m}$ . Conidia blastic, hyaline, nonseptate, lunate, apex rounded, base truncate, 5-13  $\times$  2-3  $\mu\text{m}$ , with conical, mucoid, apical appendage.

HOST: *Larix occidentalis*

DISEASE: Found on necrotic primary needles of stored larch seedlings.

***Appendiculella pinicola*** (Dearn.) Pirozynski & Shoemaker Can. J. Bot. 48: 1321 (1970).

Colonies amphigenous on the needles, dense, smooth black. Mycelium superficial, reticulate, branching; hyphae dark brown, septate, anastomosing, straight to flexuous, 6-10  $\mu\text{m}$  wide, bearing capitate and mucronate hyphopodia.

Ascomata black, globose, appendages larviform, up to 250  $\mu\text{m}$  diameter Ascospores dark brown, thick-walled, ellipsoid, curved, 3-septate, 46-58  $\times$  15-21  $\mu\text{m}$ .

HOST: *Picea sitchensis*

NOTE: Epiphytic on living needles, causing "black mildew."

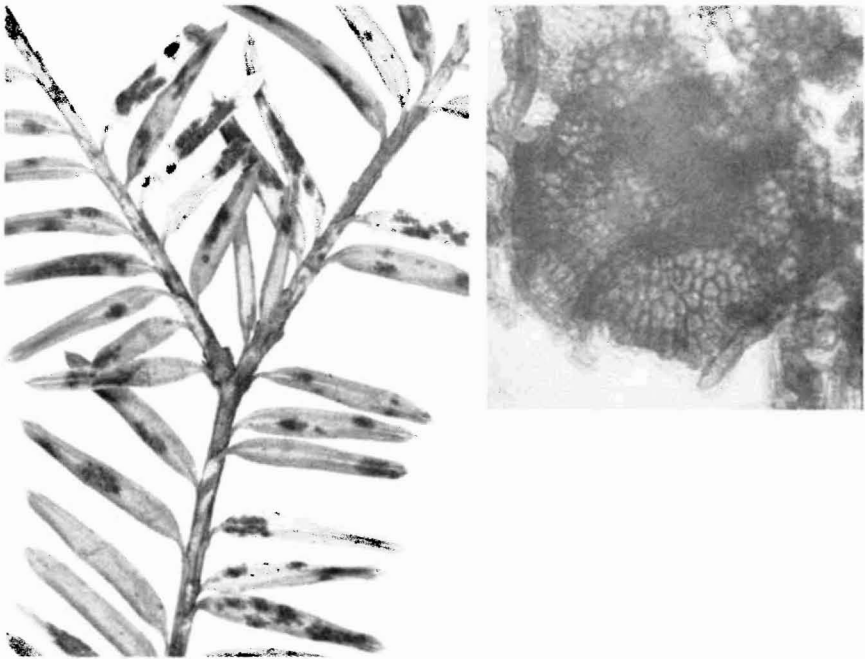


Fig. 5. *Asteridiella pitya*. "Black mildew" on yew leaves. Colony and ascoma.

***Asteridiella pitya*** (Sacc.) Hansf. Sydowia 10:49 (1957).

Colonies amphigenous on the needles, discrete, approximately 2 mm diameter, or confluent, smooth, black. Mycelium superficial, reticulate; hyphae dark brown, thick-walled, flexuous, bearing capitate hyphopodia.

Ascomata globose, roughened by protruding surface cells which are conic, dark brown, up to 300  $\mu\text{m}$  diameter. Ascospores dark brown, thick-walled, ellipsoid, curved, 3-septate, 43-52  $\times$  16-20  $\mu\text{m}$  (Fig. 5).

HOST: *Taxus brevifolia*

NOTE: Epiphytic on living needles, causing "black mildew" characteristic of the largely tropical order Meliolales (Pirozynski and Shoemaker 1970).

***Atichia glomerulosa*** (Ach. ex Mann) Stein Krypt. Fl. Schlesiens 2: 356 (1879).

TELEOMORPH: *Seuratia millardetii* (Racib.) Meeker

Stromatic colonies superficial on living or dead bark, irregular, dark brown, hard when dry, swelling and becoming cartilaginous when moistened. Tissue consists of torulose cells in a gelatinous matrix, inner cells subhyaline. Colonies at maturity with subglobose swellings approximately 100  $\mu\text{m}$  diameter, total size rarely exceeding 1 mm (Fig. 6).

HOSTS: *Pseudotsuga menziesii*, *Abies grandis*

NOTES: A common epiphyte in the wet coastal areas, usually only in the vegetative form. This fungus is common on subtropical vegetation (Meeker 1975).

***Atopospora betulina*** (Fr.) Petrak Ann. Mycol. 23:101 (1925).

Stromata black, shiny, pulvinate, subcuticular, 0.3-1.5 mm diameter, 45-85  $\mu\text{m}$  high, multiloculate, pseudoparenchymatous. Locules in a single layer, 60-80  $\mu\text{m}$  diameter, opening by a pore. Asci cylindrical, 8-spored, 36-54  $\times$  9-14  $\mu\text{m}$ , bitunicate. Ascospores elliptical, yellowish to greenish, septate in upper third, 10-15  $\times$  4-6  $\mu\text{m}$  (Fig. 7).

HOSTS: *Betula* spp.

DISEASE: Shiny tar spot in green leaves.

NOTE: Stromata form in living leaves but ascospores mature after overwintering.

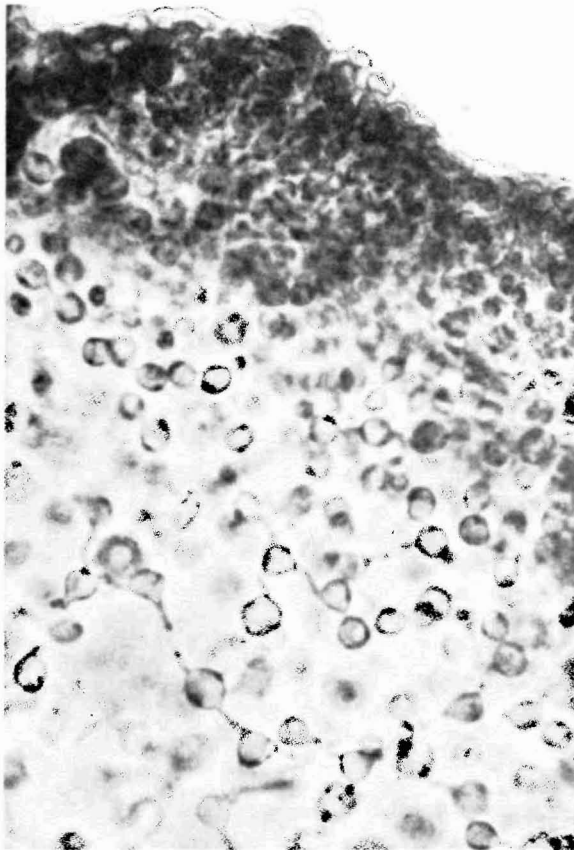


Fig. 6. *Atichia glomerulosa*. Cells of vegetative stroma.



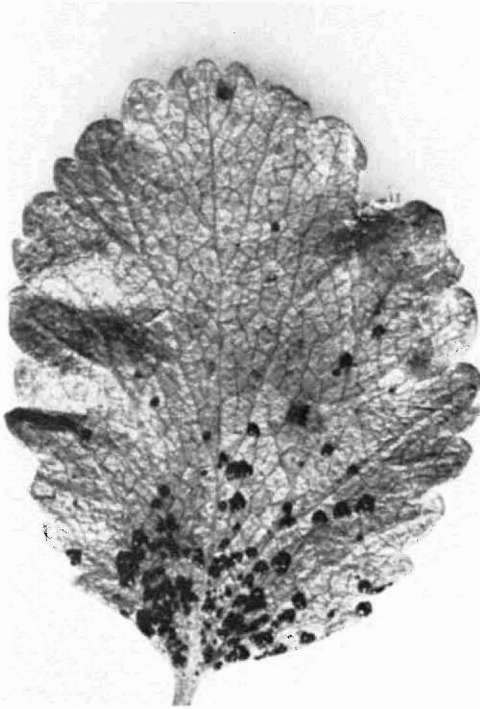


Fig. 7. *Atopospora betulina*. Stromata on birch leaf causing "tar spot."

***Bifusella*** Hoehn. Ann. Mycol. 15: 318 (1917).

Hysterothecia black, elliptical, subcuticular; hymenium flat, subhymenial layer thin. Asci clavate. Paraphyses absent or tending to disappear at maturity. Ascospores bifusiform or rod-like and tending toward bifusiform (Fig. 4).

Pycnidia large or coalescing into large areas, covered by a thin pseudoparenchymatous layer attached to the cuticle. Spermata relatively large, rod-shaped.

1) ***Bifusella linearis*** (Peck) Hoehn. is common on needles of *Pinus monticola* and *P. albicaulis*. Hysterothecia are shiny black, subcuticular, elliptical, 0.4 — 0.9 mm long. Asci are clavate,  $130-190 \times 19-28 \mu\text{m}$ . Ascospores are bifusiform,  $41-60 \times 3-4 \mu\text{m}$ . Often followed by *Hemiphacidium planum* (q.v.) which inhibits *Bifusella* fruiting.

2) ***Bifusella saccata*** (Darker) Darker occurs on *Pinus albicaulis* and has hysterothecia black, subcuticular,  $4-8 \times 0.6-0.9 \text{ mm}$ . Asci  $160-185 \times 27-33 \mu\text{m}$ , clavate. Ascospores more rod-shaped,  $24-36 \times 4-6 \mu\text{m}$ . On dead tips of green needles.

3) ***Bifusella pini*** (Dearn.) Darker on *Pinus cembroides* var. *monophylla* has large cylindrical ascospores measuring  $36-69 \times 7-14 \mu\text{m}$ .

***Botryosphaeria abietina*** (Prill. & Delacr.) Maubl. Bull. Soc. Mycol. Fr. 23: 169 (1907).

Pseudothecia black, subglobose, subepidermal, immersed in mesophyll, 250-350  $\mu\text{m}$  diam, wall of thick-walled, black pseudoparenchyma, becoming hyaline inwards and thinner walled near the opening, 25-35  $\mu\text{m}$  thick. Asci cylindrical-clavate, 8-spored, 100-140  $\times$  16-25  $\mu\text{m}$ , immersed in interthecial tissue (paraphysoids). Ascospores hyaline, nonseptate, ellipsoid, 22-30  $\times$  8-11  $\mu\text{m}$ .

HOST: *Abies grandis*

DISEASE: Needle blight of grand fir. Apparently occurs chiefly on needles of understory branches.

NOTE: Arx and Müller (1954) apparently made the same combination as Maublanc for this fungus and it is their description that is given here.

***Botrytis cinerea*** Pers. Syn. Meth. Fung. 690 (1801).

TELEOMORPH: *Sclerotinia fuckeliana* (de Bary) Fckl.

Conidiophores arising within shoots and leaves, forming a grey weft over them, up to 2 mm long and 15-30  $\mu\text{m}$  wide, with a stipe and open head of branches, smooth, clear brown below, paler near the apex, ends of branches almost hyaline. Conidiogenous cells polyblastic, terminal on the branches or growing out of subterminal cells. Conidia holoblastic, ellipsoid to obovate, colorless to pale brown, with a slight frill or hilum at point of attachment, 6-18  $\times$  4-11  $\mu\text{m}$ . Small, black, irregular sclerotia may also be present on the host or in culture. The ascigerous stage is rarely found (Fig. 8).

HOSTS: Most conifers and many broad-leaved species.

DISEASE: Causes blight or rot (Gray mould) of nursery seedlings and stored planting stock of conifers.

***Camarosporium strobilinum*** Bomm., Rouss. & Sacc. Syll. Fung. 10: 344 (1892).

Pycnidia dark brown, glabrous, globose, sessile, superficial, 300-500  $\mu\text{m}$  diameter; ostiolate, not beaked; walls of brown *textura globulosa*, grading to hyaline, compressed cells toward interior. Conidia at first clavate, becoming globose, brown with lighter colored basal cells when young, muriform, 21-35  $\times$  17-20  $\mu\text{m}$  exuding in a slime drop. Conidiophores mostly simple annellophores, 15-40  $\times$  2-4  $\mu\text{m}$  (Fig. 9).

HOSTS: *Abies lasiocarpa*, *Picea glauca*

DISEASE: Parasitic on buds and shoots of subalpine fir and white spruce, causing necrosis and dieback (Shoemaker 1967). Epidemic outbreaks sometimes occur.

***Capnodium walteri*** Sacc. Hedwigia 32: 58 (1893).

ANAMORPH: *Phaeoxyphiella morototoni* Bat. & Cif.

Colonies composed of an irregular network of loose, brown, repent hyphae. Ascstromata black, ovoid, sessile, ostiolate, nonsetose. Asci bitunicate, 8-spored. Ascospores brown, 3-septate, ovoid, constricted at middle septum.

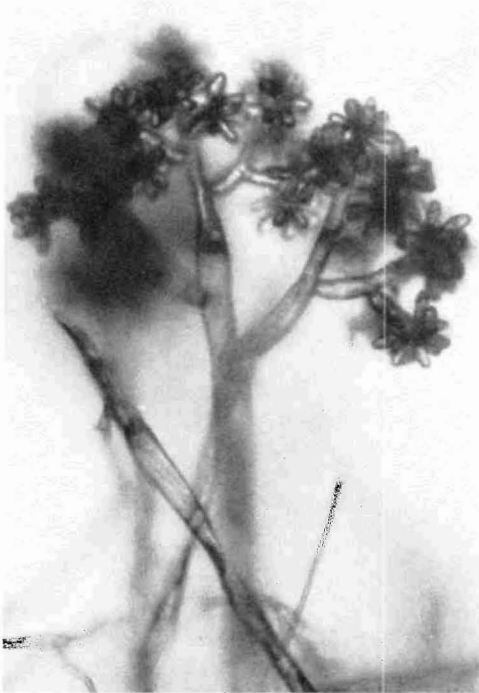
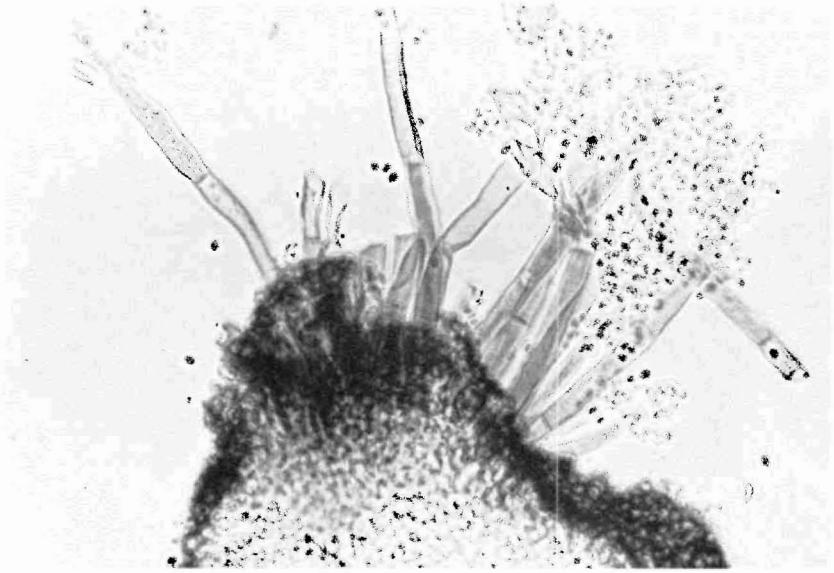


Fig. 8. *Botrytis cinerea*. Conidiophores arising from a sclerotium. Conidiophore and conidia.

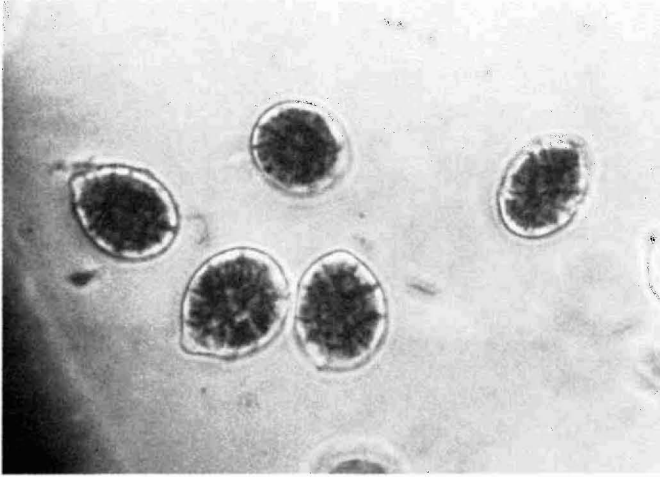


Fig. 9. *Camarosporium strobilinum*. Conidia.

Pycnidia flask-shaped, barely stalked, neck tapered and terminating in an ostiole surrounded by blunt ends of hyphae. Conidia fusoid, straight, reddish brown, acute apex and flat basal scar, 15-septate.

HOST: *Arbutus menziesii*

DISEASE: Sooty mould of arbutus leaves.

NOTE: Associated with infestation of scale insects on the lower surface of the leaves. The mould is nourished by the "honey dew" deposited on them from above (Hughes 1976).

***Cenangium acuum*** Cooke & Peck Grevillea 7: 40 (1878).

SYNONYM: *Mollisia pinastri* Sacc.

Apothecia reddish-brown, circular with an irregularly toothed margin, up to 1 mm diam, hymenium plane, lighter in color than excipulum, erupting through epidermis. Asci clavate with abrupt, stem-like base, 8-spored,  $80-100 \times 8-10 \mu\text{m}$ . Ascospores fusoid, nonseptate, hyaline,  $12-14 \times 3-4 \mu\text{m}$ . Paraphyses filiform, tips enlarged.

HOST: *Pinus monticola*

NOTE: Probably saprophytic.

***Cercospora sequoiae*** Ell. & Ev. J. Mycol. 3: 13 (1887).

Conidiomata stromatic acervular, black, erumpent, amphigenous. Conidiophores dark, simple, septate, geniculate, with thickened scars, borne in fascicles, slightly roughened,  $50-125 \times 4-6 \mu\text{m}$ . Conidia tapered toward the tip, straight or curved, yellowish-brown, 0-8-septate, often constricted at the septa, slightly echinulate,  $25-80 \times 4-8 \mu\text{m}$ .

HOSTS: *Juniperus*, *Sequoia*, *Cupressus*

DISEASE: Foliage necrosis of lower branches adjacent to the stem; spreads upward and outward. May kill seedlings or cause mild cankering of stems (Hodges 1962).

***Cercospora alni*** Dearn. and Barth *Mycologia* 9: 362 (1917).

Conidia consisting of tufts of filamentous, hyaline appendages, densely fasciculated, often collapsing into a mop-like mass when wet, bound together by a stromatic base. Filaments 250-400  $\times$  5-7  $\mu\text{m}$ , 2-6-septate, cylindrical with obtuse apices. (Fig. 10)

HOST: *Alnus rubra*

DISEASE: Brown leaf blotch and early abscission.

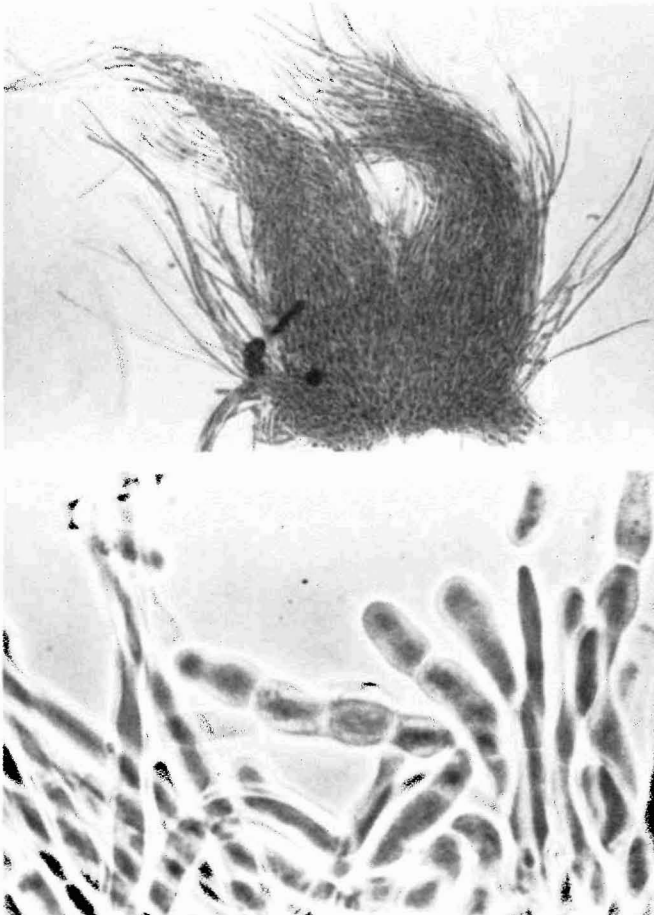


Fig. 10. *Cercospora alni*. Propagule from alder leaf. Conidial filaments.

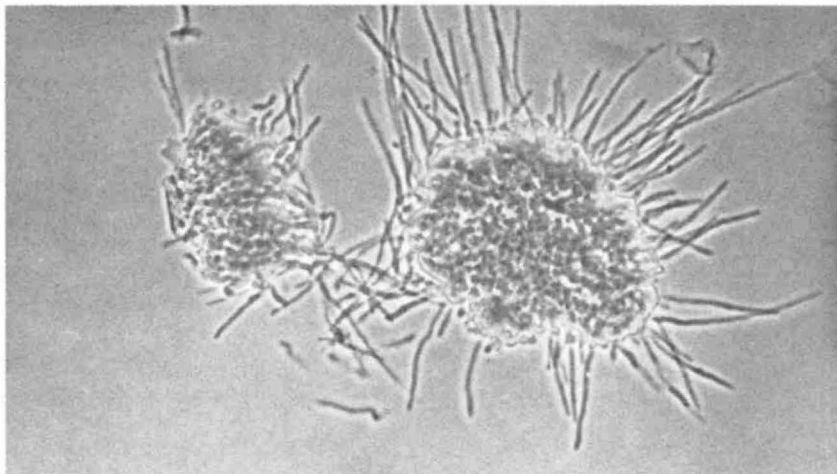


Fig. 10a. *Cercospora aceris*. Propagules from maple leaf.

NOTES: A species on broadleaf maple is *Cercospora aceris* Dearn. and Barth. with smaller filaments ( $100-300 \times 5-6 \mu\text{m}$ ) and causing zonate leaf spots (Fig. 10a).

Both species of *Cercospora* are being revised to a new genus, *Mycopappus* (S.A. Redhead, Can. J. Botany 1985) (in press).

***Chloroscypha sabinae*** (Fckl.) Dennis Kew Bull. 410 (1954).

SYNONYM: *Kriegeria juniperi* (Ellis) Seaver

Apothecia short-stalked, round, black, 0.4-0.5 mm diameter, glabrous. Asci clavate, 8-spored, rounded apex blued by iodine,  $150 \times 20 \mu\text{m}$  maximum. Ascospores hyaline, nonseptate, ellipsoid-fusiform,  $15-20 \times 8-9 \mu\text{m}$ . Paraphyses branched, thickened at the tips, forming a brown epithecium.

HOSTS: *Juniperus* spp.

***Chloroscypha seaveri*** Seaver Mycologia 23: 249 (1931).

SYNONYM: *Kriegeria seaveri* (Rehm) Seaver

Apothecia single or in small clusters, short-stipitate, turbinate, greenish black to black, less than 0.5 mm diameter. Asci clavate, 8-spored,  $100-135 \times 25-30 \mu\text{m}$ . Ascospores yellowish, granular, 2-seriate, fusoid, nonseptate,  $20-30 \times 8-10 \mu\text{m}$ . Paraphyses filiform, forming a brown epithecium where united at the tips.

HOSTS: *Thuja plicata*, *Chamaecyparis lawsoniana*

***Ciborinia foliicola*** (Cash & Davidson) Whetzel Mycologia 37: 668 (1945).

Sclerotia surrounding the midribs of overwintering leaves or formed in the blade,  $10-20 \times 1-1.5 \text{mm}$ .

Apothecia arising singly from the sclerotia, with rhizoidal tufts, stalked, light brown, cupulate to discoid, 2-6 mm diameter; stalks 2-5 mm long. Asci cylindrical, 8-spored, pore staining blue in iodine,  $125-150 \times 7-9 \mu\text{m}$ . Ascospores ellipsoid, biguttulate, nonseptate, hyaline,  $9-12 \times 6-7 \mu\text{m}$ . Paraphyses slightly clavate, simple, light brown above,  $1-2 \mu\text{m}$  broad.

HOSTS: *Salix*

DISEASE: Black rib of willows. Leaf necrosis is accompanied by formation of light brown zones of discoloration.

NOTES: Another species on *Salix*, *Ciborinia wisconsinensis* Batra lacks the rhizoidal tufts and appears to favor the lanceolate-leaved willows; *Ciborinia foliicola* favors the broad-leaved willows (Sutton and Lawrence 1969).

***Ciborinia pseudobifrons*** Whetzel Can. J. Bot. 33: 583 (1955).

Sclerotia formed in living leaves and remaining after leaf fall, black, oval or elongate,  $10-15 \times 3-5 \text{ mm}$  (Fig. 11).

Apothecia occurring on sclerotia in leaves lying on the ground, stalked, brown, cupulate to discoid, 1-3 mm diameter; stalks up to 12 mm long. Asci slender, clavate, 8-spored, pore staining blue in iodine (J+),  $110-130 \times 7-9 \mu\text{m}$ . Ascospores uniseriate, ovoid, hyaline, nonseptate,  $7-10 \times 3-4 \mu\text{m}$ . Paraphyses  $2 \mu\text{m}$  wide, slightly enlarged at the tips.

HOST: *Populus tremuloides*

DISEASE: "Inkspot" of leaves.

NOTES: Sclerotia of *C. pseudobifrons* occur mostly on veins and petioles and remain attached, whereas sclerotia of *C. whetzelii* are in the blade of the leaf and drop out in late summer (Baranyay and Hiratsuka 1967).

***Ciborinia whetzelii*** (Seaver) Seaver N. Am. Cup Fungi (Inoperculates) 70 (1951).

Sclerotia formed in living leaves, black, circular to irregular, 2-8 mm diam, usually dropping out in late summer leaving "shotholes" in the leaf.

Apothecia occurring on sclerotia lying on the ground, stalked, brown, cupulate to discoid, 2-10 mm diameter, stalks 5-25 mm long. Asci clavate,  $160-180 \times 11-12 \mu\text{m}$ , pore staining blue in iodine. Ascospores uniseriate, ellipsoid, nonseptate, hyaline,  $12-15 \times 6-9 \mu\text{m}$ . Paraphyses numerous.

HOSTS: *Populus tremuloides*, *P. balsamifera*

DISEASE: "Inkspot" and "Shothole" of poplars (Fig. 11).

NOTES: Another species on western aspen is *Ciborinia seaveri* Groves & Bowerman which has much smaller asci ( $46-65 \times 6-7 \mu\text{m}$ ) and much smaller ascospores ( $7-10 \times 2-4 \mu\text{m}$ ); but sclerotia are similar to *C. whetzelii*. Apparently rare. (Groves and Bowerman 1955).

***Coccomyces arbutifolius*** Sherwood Occ. Papers Farlow Herb. No. 15: 22 (1980).

Apothecia subepidermal, dark brown, densely gregarious, irregular to elongate, opening irregularly by splitting of the dark covering layer, 0.2-1.0 mm diam. Asci  $120-150 \times 15-20 \mu\text{m}$ , clavate, long-stalked, 8-spored. Ascospores



Fig. 11. *Ciborinia whetzeli*. Sclerotia in aspen leaves.

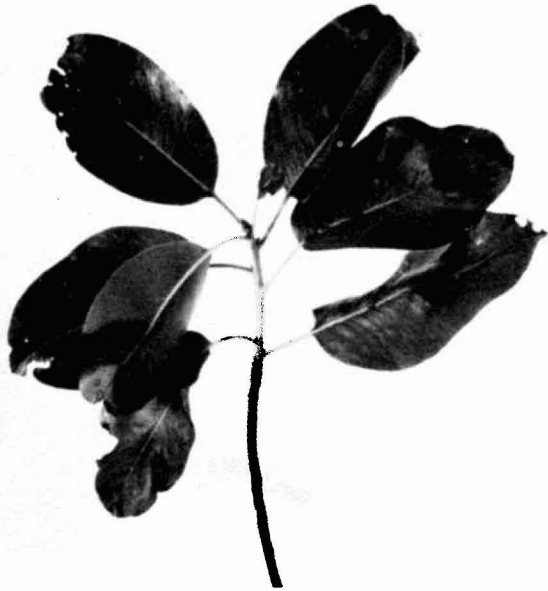


Fig. 12. *Coccomyces arbutifolius*. Leaf spot of *Arbutus*.



hyaline,  $75-100 \times 2.5 \mu\text{m}$ , nonseptate, in mucilaginous sheath. Paraphyses filiform, simple or branched, enlarged at the tips. Subhymenium colorless (Fig. 12).

HOST: *Arbutus menziesii*

DISEASE: Leaf spot of arbutus. Discolored spots marked by a faint whitish bloom.

NOTES: *Coccomyces dentatus* (Fr.) Sacc. sometimes found on dead leaves of *Arbutus*, has shiny black hexagonal to quadrate apothecia with preformed opening splits; ascospores measure  $45-65 \times 2 \mu\text{m}$ .

*Rhytisma arbuti* Phillips described from *Arbutus* leaves in California (Grevillea 7: 13 (1878-79)) might be synonymous with *C. arbutifolius*, but no measurements are given.

***Colletotrichum acutatum*** Simmonds ex Simmonds Queensland J. Agric. Animal Sci. 25:178 (1968).

Acervuli superficial or subcuticular, pink to pale orange when fresh, drying dark brown, up to 0.5 mm diameter. Setae absent or present occasionally, brown, smooth, septate, tapered, up to  $85 \mu\text{m}$  long and  $3-4 \mu\text{m}$  wide. Conidiophores arising from upper cells of basal pseudoparenchyma, phialidic, simple or branched near the base, short. Conidia hyaline, fusiform, nonseptate, straight,  $8-16 \times 2.5-4 \mu\text{m}$ , salmon pink in mass (Fig. 13).

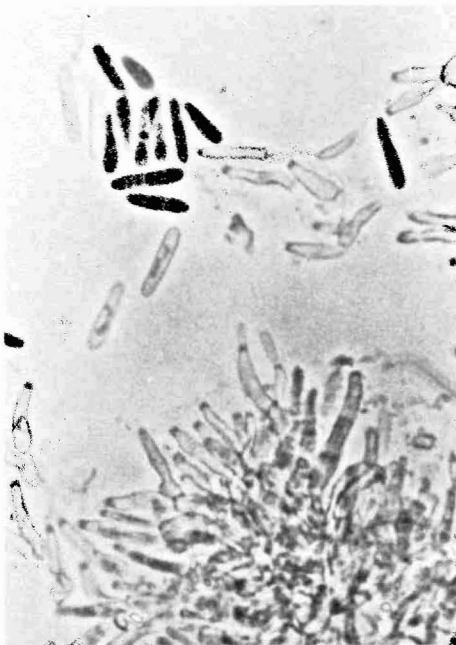


Fig. 13. *Colletotrichum acutatum*. Conidiophores and conidia.

Colonies in culture characteristically carmine red, then greyish or black, effuse. Conidia produced in great numbers, usually enclosed in large droplets of mucus on colony surface.

HOST: *Tsuga heterophylla*

DISEASE: Terminal crook of hemlock seedlings in nursery.

NOTES: The *forma specialis pinea* of *C. acutatum* causes terminal crook of *Pinus* spp. in New Zealand, Australia and Kenya and may have been introduced to Canada where it appeared in 1981 in a forest nursery on the West Coast. The disease has been studied by Dingley and Gilmour (1972), Nair and Corbin (1981) and Nair *et al.* (1983).

***Colletotrichum gloeosporioides*** (Penz.) Penz. & Sacc. Fungi Agrum. 2:6 (1882).

TELEOMORPH: *Glomerella cingulata* (Stonem.) Spauld. & Schrenk

Acervuli on both sides of leaf, pulvinate, yellowish, 0.5-2 mm diameter, setae not observed, parenchymatous base. Conidiogenous cells enteroblastic, phialidic, hyaline, cylindrical, borne on short, cylindrical conidiophores that arise from upper cells of acervuli. Conidia hyaline, cylindrical to slightly clavate, nonseptate, 12-20 × 4-5 μm (Fig. 14).

Perithecia immersed, brown, subglobose, 100-350 μm diameter, ostiole beaked with external hairs. Asci cylindrical, 35-80 × 8-14 μm. Ascospores ellipsoid, hyaline, nonseptate, 12-28 × 4-7 μm. Paraphyses filiform, evanescent.

HOSTS: *Tsuga heterophylla*, *Salix* spp.

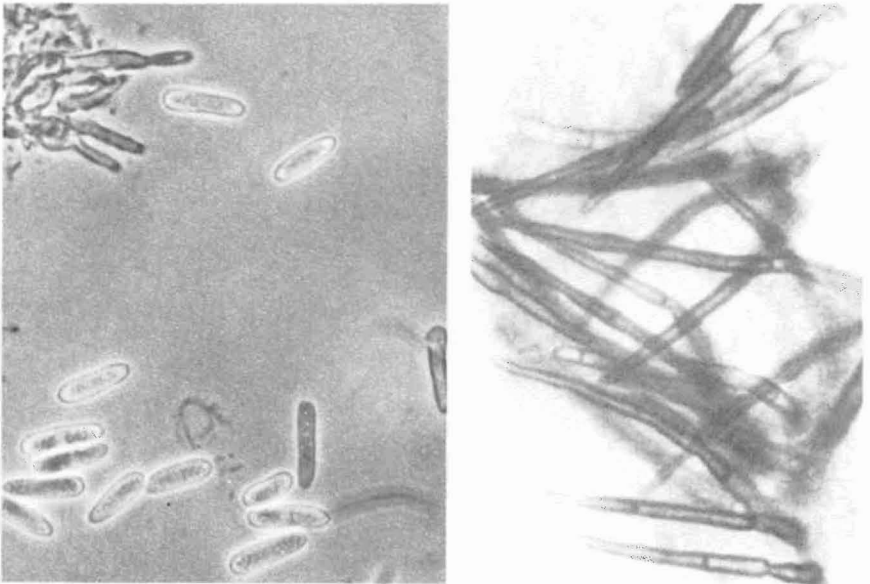


Fig. 14. *Colletotrichum gloeosporioides*. Conidiophores, conidia. Setae.

DISEASE: Leaf blight and terminal crook of western hemlock seedlings, similar to damage caused by *C. acutatum* (q.v.). Cultures lack the carmine red pigment produced by *C. acutatum*.

NOTES: Description given here is for the fungus as it occurred on hemlock seedlings. As Sutton (1980) has stated "it is clear that *C. gloeosporioides* shows excessively wide variation and for this reason it is meaningless to provide a standardized description." The teleomorph was also found on hemlock.

***Cristulariella depraedans*** (Cooke) Hoehn. Fragmente z. Mykol. 997: 98 (1916).

Macroconidia (propagules) borne singly on apex of conidiophores in necrotic area of leaf. Macroconidia multicellular, subglobose to discoid, hyaline to brown in age, 100-160  $\mu\text{m}$  diameter. Conidiophore erect, septate, solitary, uniseriate, hyaline, unbranched, tapering apically, 100-250  $\times$  8-16  $\mu\text{m}$ . Black sclerotia may form along major leaf veins (Fig. 15).

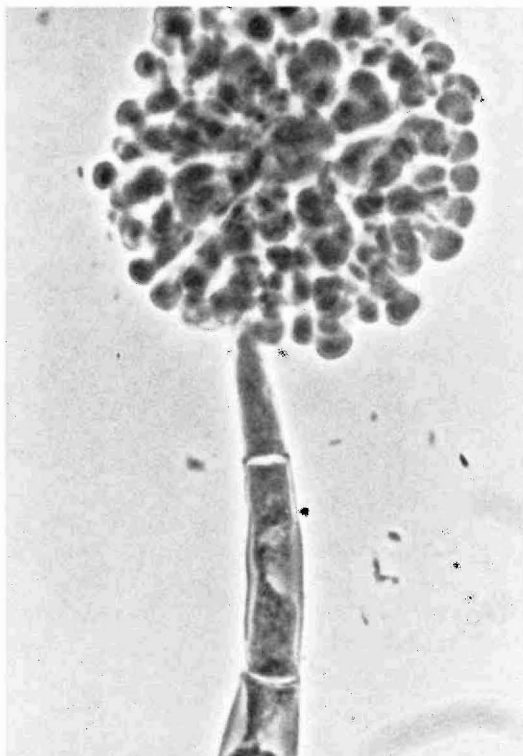


Fig. 15. *Cristulariella depraedans*. Conidiophore with propagule (conidium).

HOSTS: *Acer circinatum*, *A. glabrum* var. *douglasii*

DISEASE: Leaf spot of maple.

NOTE: A zonate leaf spot of broadleaf maple has been found on Vancouver Island that closely resembles that produced by *Cristulariella moricola* (Hino) Red-head but identity of fungus not confirmed.

***Cyanodiscus occidentalis*** E. Muller and Farr Mycologia 63: 1083 (1971).

Ascocarps superficial, discoid, sessile, blue-green, 215-235  $\mu\text{m}$  diameter, about 80  $\mu\text{m}$  high; wall pseudoparenchymatous with seta-like appendages, flaking away above. Asci bitunicate, ellipsoid to subcylindric, 8-spored, 34-58  $\times$  8-10  $\mu\text{m}$ . Ascospores hyaline to subhyaline, fusiform to clavate, 3-5-septate, not constricted, 12-19  $\times$  3-4  $\mu\text{m}$ . Paraphyses numerous, hyaline, filiform. Free mycelium present, superficial, blue-green.

HOST: *Chamaecyparis nootkatensis*

NOTE: Epiphytic on leaves of yellow cedar (Müller and Farr 1971). Has also been found on bark of *Pinus contorta*.

***Darkera abietis*** Whitney, Reid & Pirozynski Can. J. Bot. 53: 3052 (1975).

Apothecia hypophyllous, subepidermal, shiny black, ovoid to elongate, up to 1 mm long or if coalescing then up to 2 mm  $\times$  0.5 mm, opening by a longitudinal split, covering layer 30  $\mu\text{m}$  thick, of dark pseudoparenchyma; hymenium dull orange, subhymenium pale brown plectenchyma 30  $\mu\text{m}$  thick. Asci clavate, broadest below apex or near the base, short-stalked, pore structure lacking, dehiscing by a bilabiate split, 85-100  $\times$  17-22  $\mu\text{m}$ , usually 8-spored but occasionally 4- to 7-spored. Ascospores hyaline, nonseptate, broadly ellipsoid to reniform, 18-28  $\times$  10-14  $\mu\text{m}$ . Paraphyses about as long as the asci, simple, slightly swollen at the tips. Associated with *Tiarosporella abietis* anamorph (q.v.) but relationship not proven.

HOSTS: *Abies* spp.

NOTES: On *Picea* spp. there is ***Darkera parca*** Whitney, Reid & Pirozynski with ascospores 20-35  $\times$  8-14  $\mu\text{m}$  and associated with the anamorph ***Tiarosporella parca*** (q.v.) (Fig. 15a).

***Davisomycella*** Darker Can. J. Bot. 45: 1423 (1967).

Ascomata black, conspicuous, innate, short, elliptical to oblong or elongate, subepidermal, with longitudinal slit, parenchymatous. Asci clavate or saccate, 4- or 8-spored. Paraphyses filiform, simple. Ascospores clavate, nonseptate, hyaline, with mucilaginous sheath, at base + attenuated (Figs. 3,4,16). Pycnidia, if present, small, flat, concolorous with needle.

NOTES: *Davisomycella* is represented by six species occurring only on *Pinus* (Table 1). *Lophodermella*, like *Davisomycella*, has clavate, nonseptate ascospores but the ascocarps are concolorous and subhypodermal.

*Davisomycella ampla* is the most important species. The fruiting bodies occur in straw-colored segments of green needles (Hunt 1981) (Fig. 16). The segments may be separated from the green portions by an orange

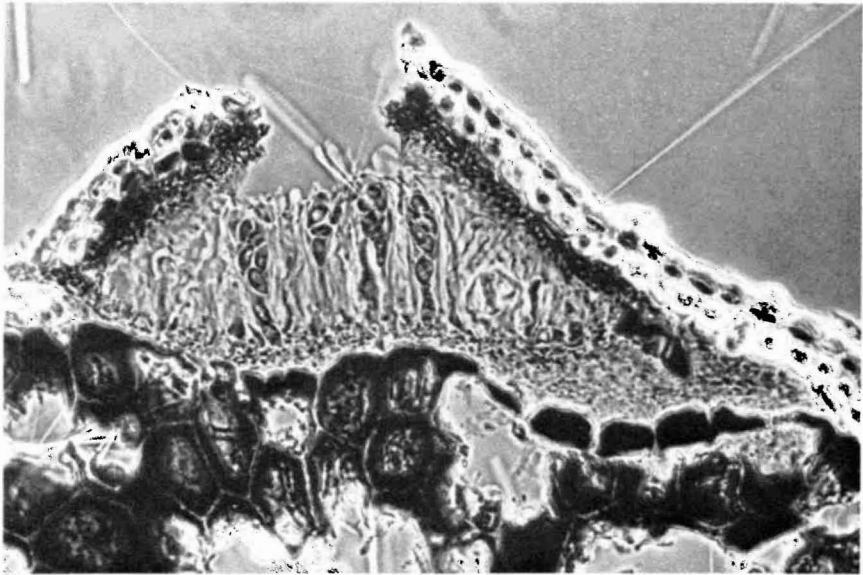


Fig. 15a. *Darkera parca*. Apothecium in spruce needle. (photo by J. Reid).

band. It is subject to secondary invasion by *Sarcotrichila macrospora* in coastal areas preventing ascoma development. (Ziller and Funk 1973).

***Delphinella abietis*** (Rostr.) E. Muller    Beitr. Krypt. Schweiz 11:26 (1962).  
ANAMORPH: *Sclerophoma*

Ascstromata subepidermal, becoming erumpent, on shoots and needles, single or rarely aggregated, black, globose, pseudoparenchymatous, 150-200  $\mu\text{m}$  diameter. Asci cylindric-clavate, bitunicate, 50-90  $\times$  18-22  $\mu\text{m}$ , multisporied (16-24), paraphysate. Ascospores ellipsoid, uniseptate, hyaline, 11-21  $\times$  4-7  $\mu\text{m}$ .

Pycnidia resembling ascostromata, conidia fusiform, hyaline, aseptate, 10-16  $\times$  4-7  $\mu\text{m}$ , produced from cells of inner wall.

HOST: *Abies lasiocarpa*

DISEASE: Parasitic on shoots and leaves of true firs, causing typical reddening of new growth.

NOTES: A closely related species, *Delphinella balsameae* (Waterm.) E. Muller, has much larger asci (80-140  $\times$  33-41  $\mu\text{m}$ ), and ascospores (30-50  $\times$  7-12  $\mu\text{m}$ ), and also occurs on alpine fir. This species was described and studied under the name *Rehmiellopsis* (Waterman 1945).

*Delphinella* is very similar to the genus *Sydowia*, differing only in that *Sydowia* may have muriform ascospores. Conidial states are also similar in the two genera, and referable to the genus *Sclerophoma*.

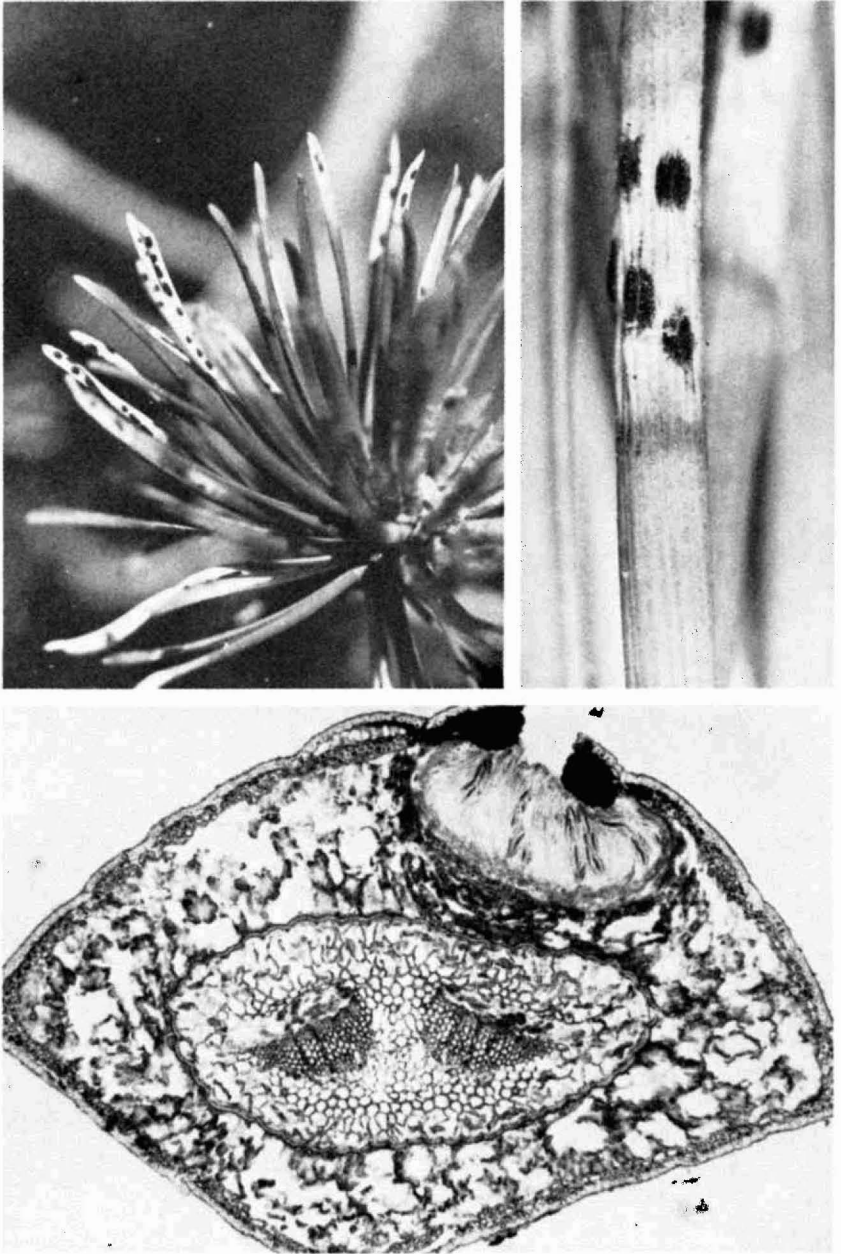


Fig. 16. *Davisomycella ampla*. Ascomata on straw-colored segment which is bordered by dark orange-brown band. *D. medusa*. Vertical section of ascoma on ponderosa pine.

Table 1. *Davisiomycella* species (Darker 1967) (Fig. 16)

Species	Hysterothecia	Special Characteristics	Asci	Ascospores	Age of needles	Hosts
<i>D. ampla</i> (Davis) Darker	0.7-1.3 × 0.3-0.6 mm black subepidermal	followed by <i>Sarcotrichila</i> , pycnidia concolorous, ascospores not attenuated at base	120-225 × 20-35 μm 8-spored	60-140 × 3-8 μm	1 + yrs living or dead	<i>Pinus contorta</i> , <i>P. banksiana</i>
<i>D. lacrimiformis</i> (Darker) Darker	0.6-3.5 × 0.2-0.6 mm black subepidermal	asci rarely 4-spored	150-195 × 18-23 μm 8-spored	24-38 × 4.5-6 μm	1 + yrs brown area in green needles	<i>Pinus attenuata</i>
<i>D. limitata</i> (Darker) Darker	0.8-2.5 × 0.3-0.5 mm black subepidermal	aborted ascospores present	125-160 × 14-15 μm 4-spored	33-45 × 4-4.5 μm	1 + yrs brown area in green needles	<i>Pinus radiata</i>
<i>D. medusa</i> (Dearn.) Darker	0.7-21 × 0.4-0.5 mm black subepidermal to subhypodermal		130-180 × 18-27 μm 8-spored	66-80 × 3-6 μm attenuated in lower half	on browned needles	<i>Pinus ponderosa</i> (Fig. 16), <i>P. contorta</i> , <i>P. jeffreyi</i>
<i>D. montana</i> (Darker) Darker	1-7.5 × 0.4-0.8 mm black subepidermal	very close to <i>D. ampla</i>	180-240 × 30-33 μm 8-spored	70-105 × 5-6 μm clavate	2 + yrs	<i>Pinus contorta</i>
<i>D. ponderosae</i> (Staley) Dubin	1-45 × 0.5-1.1 mm black subepidermal	ascomata sinuous to bifurcate	150-210 × 14-22 μm 8-spored	120-170 × 3-4.5 μm filiform	2 + - 5 + yrs on green needles	<i>Pinus ponderosa</i>

***Dichomera gemmicola*** Funk & Sutton Can. J. Bot. 50: 1514 (1972).

Pycnidia stromatic, unilocular or multilocular, black or dark brown, each locule with a papillate ostiole, outer wall of dark brown to medium brown pseudoparenchyma, inner layer hyaline, thin-walled; unilocular pycnidia  $350\ \mu\text{m}$  by  $450\ \mu\text{m}$  high, multilocular pycnidia proportionately larger. Conidiogenous cells holoblastic, annellidic, ampulliform to short-cylindric, unbranched,  $8\text{--}11 \times 5\text{--}7\ \mu\text{m}$ , produced all around stomatal cavities. Conidia blastospores, produced singly from apex of conidiophore, pale brown, muriform, with 11-17 transverse septa, most cells with several longitudinal septa, cylindric, curved,  $70\text{--}85 \times 12\text{--}17\ \mu\text{m}$  (Fig. 17).

HOSTS: *Pseudotsuga menziesii*, *Picea sitchensis*, *P. glauca*, *P. engelmannii*

DISEASE: Causing bud necrosis of *Pseudotsuga* and *Picea*, resulting in deformation, or death of the tree in severe cases.



Fig. 17. *Dichomera gemmicola*. Pycnidia on necrotic buds. Damage from severe attack on Douglas-fir.



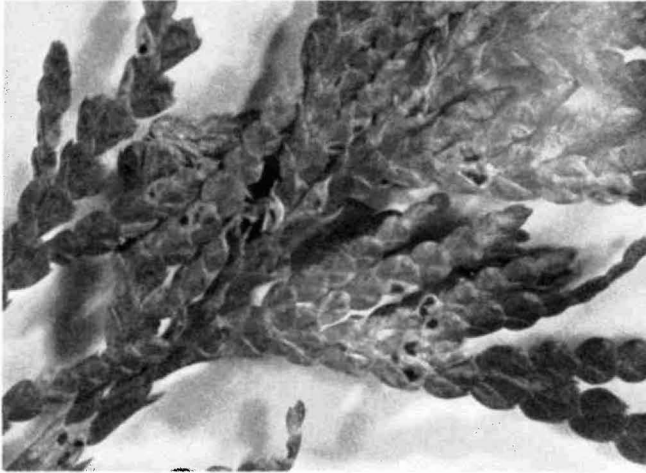


Fig. 18. *Didymascella thujina*. Ascomata on western red cedar.

***Didymascella thujina*** (Durand) Maire Bull. Soc. Hist. Nat. Afr. Nord 18: 120 (1927).

SYNONYM: *Keithia thujina* Durand

Ascomata chiefly on upper surface of needles, subepidermal, roughly circular in outline, olive brown, up to 1 mm diameter; hymenium not covered by fungal tissue, exposed by rupture of overlying epidermis. Ascomata may fall out entirely when spent, leaving a pit in the leaf. Asci clavate, 2-spored, pore not bluing in iodine (J-),  $100 \times 20 \mu\text{m}$ . Ascospores ellipsoid, thick-walled, 1-septate near the upper end, walls pitted, brown,  $22-25 \times 15-16 \mu\text{m}$ , with a gelatinous sheath. Paraphyses filiform, branched, thickened at the tips.

HOST: *Thuja plicata*

DISEASE: Needle blight of red cedar (Fig. 18).

LIFE CYCLE: Infection of current year's foliage occurs in spring or summer from ascospores produced in the previous year's infected foliage (Porter 1957).

***Didymosporium arbuticola*** Zeller Mycologia 26:303 (1934).

Acerveli hypophyllous, erumpent through epidermis, circular,  $130-240 \mu\text{m}$  diam. Conidiophores simple, short, hyaline. Conidia acrogenous, oblong-ellipsoid, light brown, 1-(3-)septate, slightly constricted at septum,  $19-29 \times 7-8 \mu\text{m}$  (Fig. 19).

HOST: *Arbutus menziesii*

DISEASE: Leaf spot of arbutus. Spots are brown with purplish to reddish margins, 3-6 mm diam, in living leaves (Hunt and Funk 1983). A somewhat similar spot on arbutus leaves is produced by the rust fungus *Pucciniastrum sparsum* (Wint.) E. Fischer whose urediniospores are  $26-45 \times 12-20 \mu\text{m}$  (Ziller 1974).

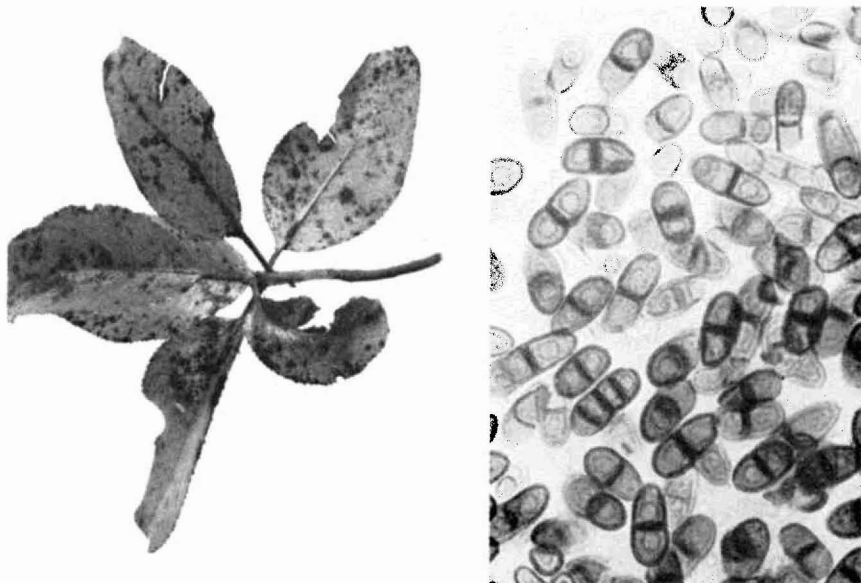


Fig. 19. *Didymosporium arbuticola*. Leaf spot on *Arbutus*. Conidia.

***Diplodia pinea*** (Desm.) Kickx Fl. Flandres 1:397 (1867).

SYNONYM: *Sphaeropsis sapinea* (Fr.) Dyko & Sutton

Pycnidia black, ovoid, immersed then erumpent, solitary or gregarious, with apical ostioles; pycnidial wall thickened around the top, 0.5 mm diameter. Conidiophores simple, subulate, about half as long as the conidia. Conidia (blastoconidia) yellow to dark brown, wall roughened, oblong to clavate, apex rounded, base blunt, aseptate to tardily 1-septate,  $30-45 \times 10-16 \mu\text{m}$  (Fig. 20).

HOSTS: *Pinus* spp. chiefly, but also many other conifers

DISEASE: May cause browning of needles. Rare in western Canada.

***Dothiora taxicola*** (Peck) Barr Contr. Univ. Mich. Herb. 9:575 (1972).

ANAMORPH: *Cytospora*

Ascomata densely scattered, epiphyllous, subepidermal, subglobose with erumpent apex,  $130-240 \times 145-165 \mu\text{m}$ ; wall pseudoparenchymatous, black,  $14-30 \mu\text{m}$  thick, apical region paler. Asci clavate, bitunicate, 8-spored,  $60-96 \times 9-15 \mu\text{m}$ . Ascospores hyaline, ellipsoid, 1-3-septate,  $13-18 \times 3-5 \mu\text{m}$  (Fig. 21).

Pycnidia immersed, subglobose, approximately  $400 \mu\text{m}$  diameter. Conidiophores  $7-15 \times 2 \mu\text{m}$ . Conidia hyaline, nonseptate,  $3-5 \times 1 \mu\text{m}$ .

HOST: *Taxus brevifolia*

DISEASE: Needle- and shoot-blight of yew.

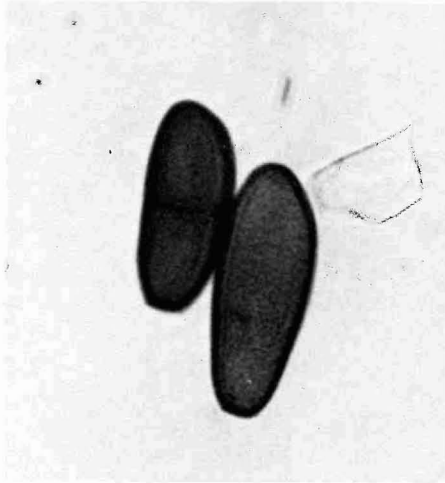


Fig. 20. *Diplodia pinea*. Conidia.

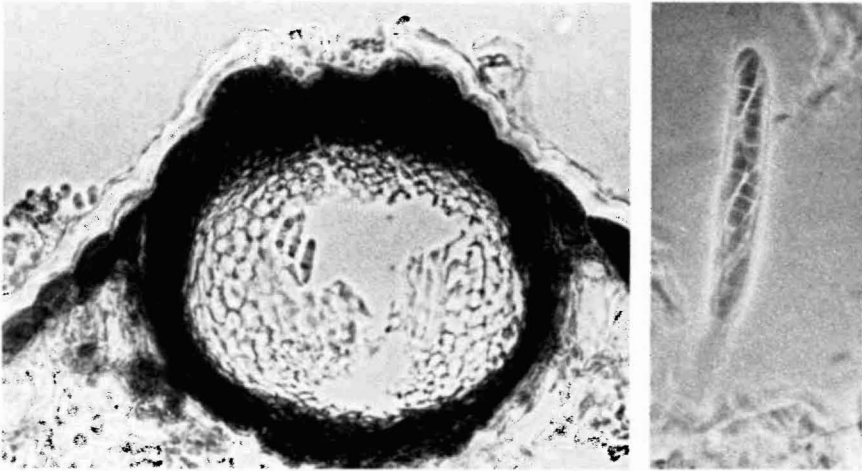


Fig. 21. *Dothiora taxicola*. Ascoma, vertical section. Ascus with ascospores.

*Elytroderma deformans* (Weir) Darker Contr. Arnold Arbor. 1: 62 (1932).

ANAMORPH: *Leptostroma*

Ascomata appear as narrow, black lines (slits) of varying lengths, chiefly on the abaxial surface of the browned needles, up to 10 mm long; opening by a longitudi-

nal split to expose the pale brown hymenium. The subepidermal clypeus of black cells covers only the central part of the hymenium. The subhymenium is hyaline and thin. Asci saccate to fusiform-clavate, 8-spored,  $140-240 \times 30-45 \mu\text{m}$ . Ascospores hyaline, cylindrical, 1-septate,  $90-120 \times 6-9 \mu\text{m}$ , with thick gelatinous sheath. Paraphyses filiform, simple, septate (Figs. 3, 4, 22).

Conidiomata concolorous with needle, subepidermal, up to 1.2 mm long, blister-like. Conidiophores  $12-15 \mu\text{m}$  long, arising from a thin basal layer, ampulliform, simple. Conidia terminal, hyaline, bacillar,  $6-8 \times 1 \mu\text{m}$ .

HOSTS: *Pinus ponderosa*, *P. contorta* and other 2- and 3-needle pines.

DISEASE: Causes browning of needles; may enter shoots and cause brooming of branch ends by a systemic, perennial infection of the bark (Fig. 22).

LIFE CYCLE: Current year needles are infected by ascospores shot in mid to late summer or by mycelium from perennial infections in bark of twigs. Infected needles gradually discolor (parts may remain green); conidiomata form in the following spring and ascomata begin to form in June, with ascospores maturing in late summer. (Childs 1959, 1968; Scharpf and Bega 1981).

***Entomosporium mespili*** (DC. ex Duby) Sacc. *Michelia* 2: 115 (1880).

TELEOMORPH: *Diplocarpon mespili* (Sorauer) Sutton

SYNONYM: *Fabraea maculata* Atk.

Acervuli circular, single or confluent, subcuticular, up to  $200 \mu\text{m}$  diameter. Conidiophores septate, cylindrical, straight or flexuous, branched at the base, hyaline,  $15 \times 3-4 \mu\text{m}$ . Conidiogenous cells holoblastic, terminal, with a single conidium. Conidia resembling an insect, consisting of basal and upper cells with two or more lateral, smaller cells, all subglobose, apical and lateral cells with simple, single, flexuous appendages,  $15-22 \times 5-10 \mu\text{m}$  long (Fig. 23).

Apothecia cupulate, dark brown, pseudoparenchymatous. Asci clavate-cylindrical, 8-spored, pore J+,  $60-95 \times 18-24 \mu\text{m}$ . Ascospores narrowly ovoid, 1-septate, hyaline,  $16-24 \times 6-10 \mu\text{m}$ .

HOSTS: *Crataegus*, *Amelanchier*, *Sorbus*

DISEASE: Leaf spot and blight or scald.

NOTES: Transmission chiefly by rain-splashed conidia. Overwinters as mycelium in cast leaves, producing conidia in the spring. Defoliation occurs in mid-summer (Sivanesan and Gibson 1976; Horie and Kobayashi 1980).

***Epicoccum nigrum*** Link *Mag. Ges. naturf. Fr. Berl.* 7: 32 (1815).

Sporodochia black, pulvinate, up to 2 mm diameter. Mycelium mostly immersed, stromata present. Conidiophores densely packed on stromata, mostly simple,  $5-15 \times 3-6 \mu\text{m}$ . Conidiogenous cells monoblastic, terminal, cylindrical. Conidia solitary, dry, acrogenous, globose to pyriform, brown, often with a pale basal stalk cell, muriform but septa obscured by rough, opaque wall,  $15-25 \mu\text{m}$  diameter, occasionally to  $50 \mu\text{m}$ . (Fig. 24).

HOSTS: Conifers and hardwoods

DISEASE: Colonizes leaves and needles. Saprophytic or weakly parasitic.

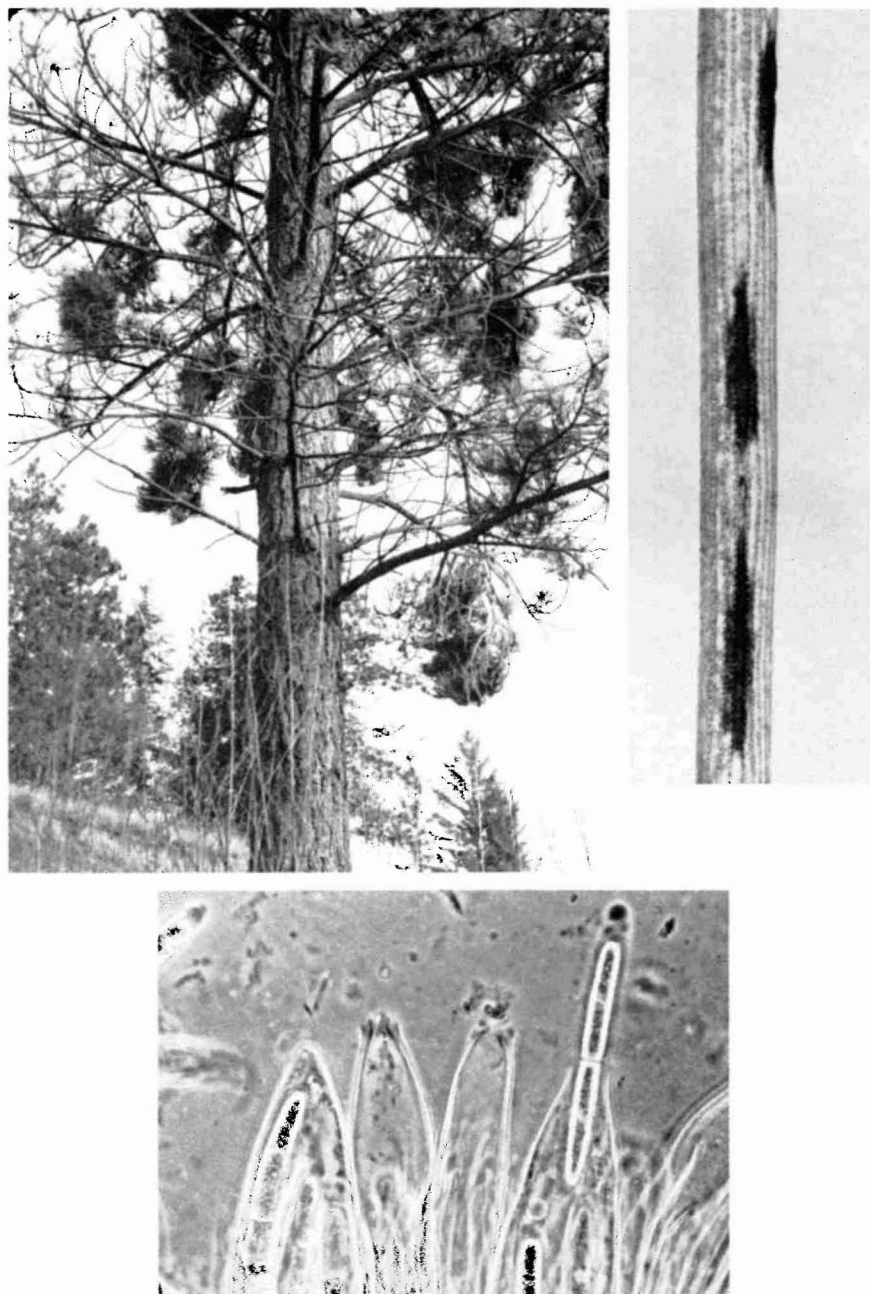


Fig. 22. *Elytroderma deformans*. Brooming produced in ponderosa pine. Ascospores emerging from asci.



Fig. 23. *Entomosporium mespili*. Conidia.



Fig. 24. *Epicoccum nigrum*. Sporodochium and conidia.

***Epipolaem abietis*** (Dearn.) Shoemaker    Can. J. Bot. 43: 634 (1965).

SYNONYM: *Dimerosporium abietis* Dearn.

Perithecia hypophyllous, clustered on radiating, superficial mycelium that enters needle only at stomata and bears orange crystals, globose, setose, 120-180  $\mu\text{m}$  diameter, with a short yellowish beak lined with periphyses. Asci in a basal cluster, bitunicate, saccate, 8-spored, 50-70  $\times$  20-36  $\mu\text{m}$ . Paraphyses absent. Ascospores ovoid, hyaline to light brown, 1-septate at the middle, upper cell broader, 24-36  $\times$  6-9  $\mu\text{m}$  (in age rarely 3-septate and finely roughened).

HOSTS: *Abies amabilis*, *A. grandis*, *A. lasiocarpa*

DISEASE: "Black mildew." Conspicuous black colonies on needles (Fig. 25).

NOTE: On living or dead needles.

***Epipolaem tsugae*** (Dearn.) Shoemaker    Can. J. Bot. 43: 635 (1965).

SYNONYM: *Dimeriella tsugae* (Dearn.) Petr.

Perithecia hypophyllous, clustered on superficial, radiating mycelium that enters needle only at stomata and bears orange crystals, globose, setose, 70-100  $\mu\text{m}$  diam, ostiolar area yellowish, with inner periphyses. Asci in basal cluster, bitunicate, saccate, 8-spored, 36-50  $\times$  9-15  $\mu\text{m}$ . Paraphyses absent. Ascospores hyaline, ovoid, 1-septate at the middle, upper cell broader, 18-21  $\times$  3-5  $\mu\text{m}$ .

HOSTS: *Tsuga heterophylla*, *Picea glauca*

DISEASE: "Black mildew." Conspicuous black colonies under leaves (Fig. 25).

NOTES: On living or dead needles. *E. pseudotsugae* (V.M. Miller & Bonar) Shoem. occurs on Douglas-fir needles, is similar to the above but has smaller asci (30-40  $\times$  6-10  $\mu\text{m}$ ) and ascospores (9-12  $\times$  3  $\mu\text{m}$ ).

***Fabrella tsugae*** (Farlow) Kirschst. subsp. *grandispora* Ziller    Mycologia 54: 28 (1962).

Ascumata subepidermal, yellowish-red to dark yellowish-brown, ellipsoid, exposing hymenium by rupturing the epidermis. Asci cylindric, 4-spored, 70-95  $\mu\text{m}$  long. Ascospores at first hyaline, 1-celled, becoming 2-celled and greenish-brown at maturity, constricted at the septum, 16-21  $\times$  8-10  $\mu\text{m}$ .

HOST: *Tsuga heterophylla*

DISEASE: Needle blight of western hemlock. Rare and usually sparse infections.

### ***Gloeosporium "corni"***

Acervuli brown, pulvinate, small, irregular, often along leaf veins. Conidiophores phialidic, subulate, simple or branched, pointed at the tips, hyaline. Conidia hyaline, nonseptate, ellipsoid-fusiform, guttulate, mostly 8  $\times$  2  $\mu\text{m}$  (Fig. 27).

HOST: *Cornus nuttallii*

DISEASE: Leaf blotch of flowering dogwood. Blotches frequently centered on mid-vein giving a wedge-shaped appearance (Fig. 26) (anthracnose).

NOTES: *Phyllosticta cornicola* has also been linked to leaf blotch of dogwood in the west (q.v.).

Arx (1970) considered *Gloeosporium corni* Greene and *G. corni* Woron. to be the same as *Colletotrichum gloeosporioides* which has much larger conidia than the *Gloeosporium* described here.

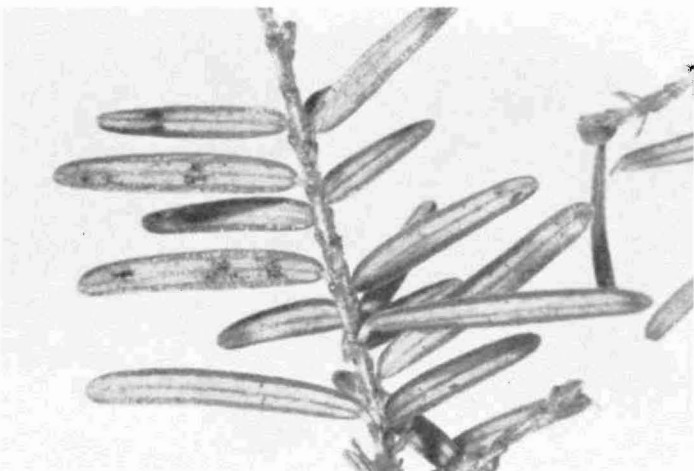


Fig. 25. *Epipolaeum abietis*. "Black mildew" on grand fir. *E. tsugae*, colonies on western hemlock.





Fig. 26. *Gloeosporium* "corni". Leaf blotching of flowering dogwood.

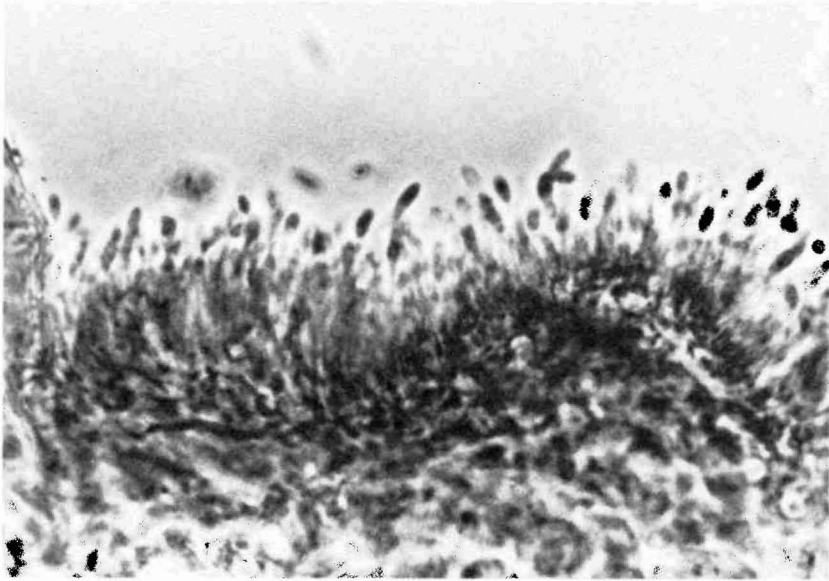


Fig. 27. *Gloeosporium* "corni". Sporodochium and conidia.

***Gnomonia setacea*** (Pers.) Ces. & de Not. Mycol. Europ. 5 & 6: 27 (1869).

Perithecia mainly hypophyllous, black, immersed in leaf, 200-300  $\mu\text{m}$  diam; ostiole more than 500  $\mu\text{m}$  long, 25-40  $\mu\text{m}$  thick at the base, protruding from leaf. Asci 35-45  $\times$  6-8  $\mu\text{m}$ , clavate, 8-spored. Ascospores hyaline, fusiform, straight, 1-septate, 14-16  $\times$  2  $\mu\text{m}$ .

HOSTS: *Alnus*

DISEASE: Leaf browning and early abscission (anthracnose).

NOTES: The recent revision of Gnomoniaceae (Monod 1983) places some doubt on the identification of this fungus. One specimen identified as *G. setacea* had ascospores up to 35  $\times$  4  $\mu\text{m}$ .

*G. campylostyla* Auers. causes a similar disease in *Betula glandulosa*.

*Gnomonia quercina* Kleb. is reported on *Quercus macrocarpa*. *G. veneta* Kleb. that attacks *Platanus* leaves is common some years in the ornamental plantings; its conidial state only is usually present (conidia 10-14  $\times$  4-6  $\mu\text{m}$ , oozing out of acervuli in white masses). Refer to Monod (1983) for revised names.

***Gremmeniella abietina*** (Lagerberg) Morelet Bull. Soc. Sci. Nat. Arch. Toulon 183:9 (1969).

ANAMORPH: *Brunchorstia pinea* (Karst.) Hoehn.

Apothecia dark brown, short-stalked, erumpent, cup-shaped, folded when dry, inrolled margin, 1 mm diameter; excipulum of *textura angularis*; hymenium pale to cream-colored; hypothecium hyaline. Asci cylindric, 8-spored, J-, 110-120  $\times$  8-10  $\mu\text{m}$ . Ascospores hyaline, 4-celled, ellipsoid, 15-22  $\times$  3-5  $\mu\text{m}$ . Paraphyses hyaline, filiform, forming an epithecium.

Pycnidia dark brown, erumpent, subglobose to irregular, thick-walled, 0.4-0.5 mm diameter; conidiophores simple, short, probably phialidic, lining inner wall; conidia curved to sickle-shaped, fusoid, hyaline, up to 4-celled, 25-50  $\times$  3-4  $\mu\text{m}$  (Fig. 28).

HOSTS: *Pinus contorta*, *P. ponderosa*, *P. albicaulis*

DISEASE: Foliar symptoms in early summer are yellowing or reddening of needle bases. Later the entire needle turns brown. The fungus infects through the needles but then may invade branches causing dieback and "Scleroderris Canker" of stems. It is usually the pycnidial state that is found on the needles. The disease has been found only at a few scattered locations in western Canada and impact so far has been negligible. See reports by Dorworth (1970, 1972).

***Hemphacidium longisporum*** Ziller & Funk Can. J. Bot. 51: 1960 (1973).

Apothecia amphigenous, sessile, subepidermal then erumpent to produce a circumscissile lid of epidermis, circular to polygonal, 200-500  $\times$  300-600  $\mu\text{m}$ ; excipulum poorly developed, dark reddish-brown, 20-30  $\mu\text{m}$  thick, of short-celled hyphae. Hymenium olive-brown, without covering layer. Asci cylindrical to

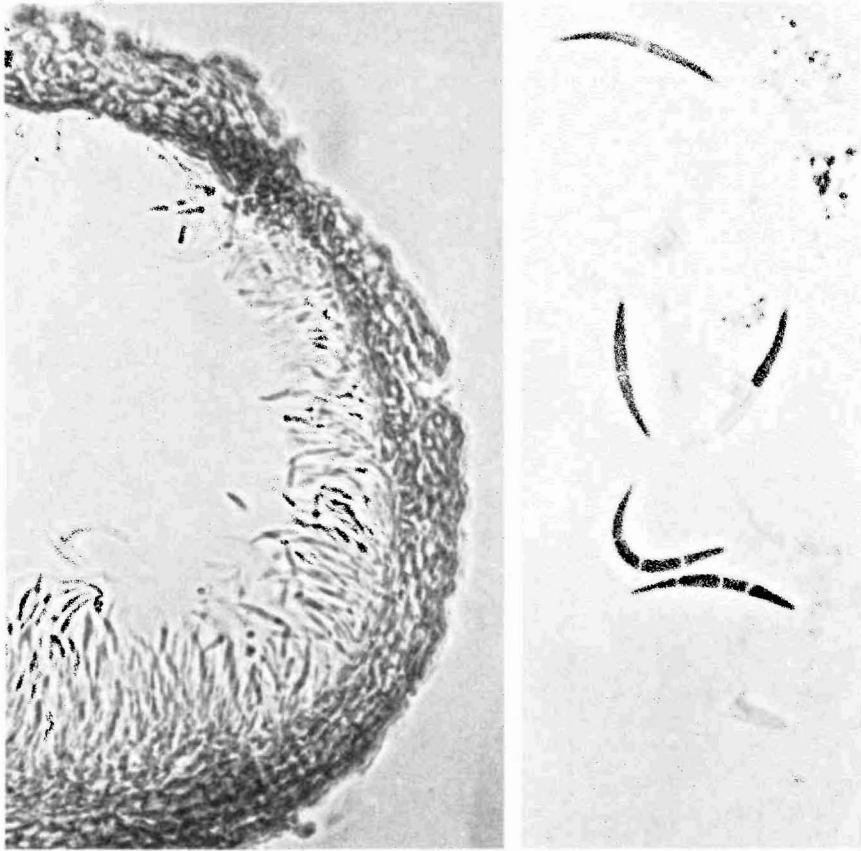


Fig. 28. *Gremmeniella abietina*. *Brunchorstia* anamorph and conidia.

clavate, 8-spored, pore of apex not staining in iodine (J-),  $60-100 \times 10-14 \mu\text{m}$ . Ascospores narrowly clavate, hyaline, nonseptate,  $45-70 \times 2-3 \mu\text{m}$ , basal end  $1.5 \mu\text{m}$ , frequently with knob. Paraphyses filiform, septate, sometimes branched, swollen at the apex (Fig. 29).

HOST: *Pinus contorta*

DISEASE: Secondary invader of needles attacked by *Lophodermella concolor* (Table 5).

NOTE: This fungus was found only on 1-year-old needles on trees growing not more than 1.6 km from the seashore.

***Hemiphacidium planum*** (Davis) Korf Mycologia 54:27 (1962).

Apothecia sessile, subepidermal then erumpent to produce a lid of epidermis, irregular in outline, 1-2 mm long; excipulum poorly developed, of hyaline hyphae.

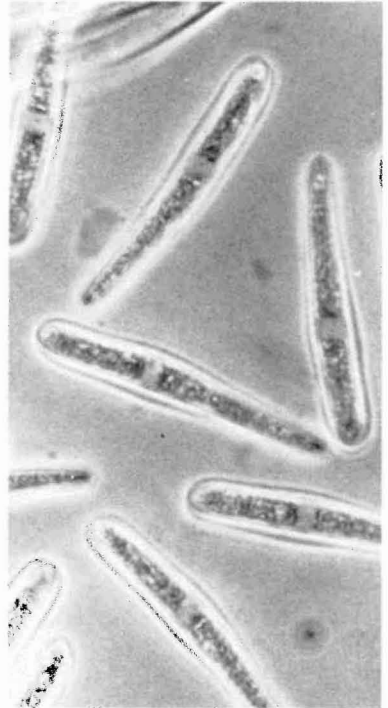
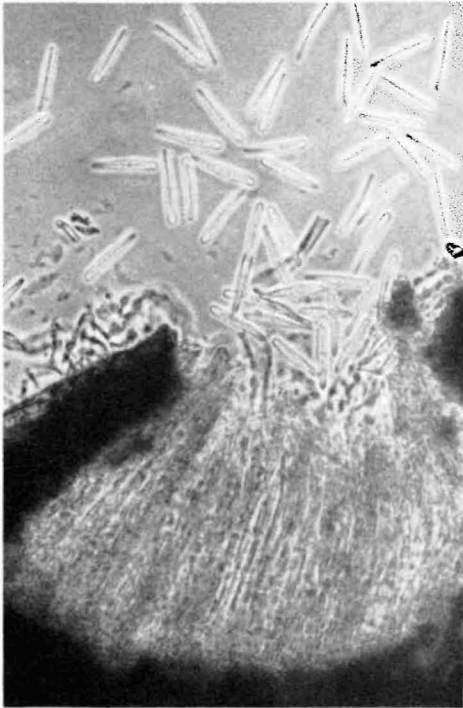
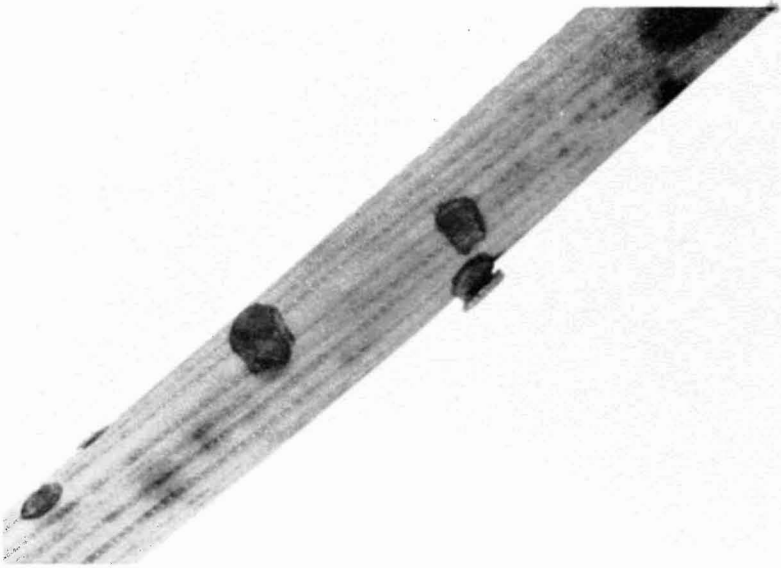


Fig. 29. *Hemiphacidium longisporum*. Apothecia on lodgepole pine. *Hemiphacidium planum*. Ascospores.

Hymenium brown, plane, without covering layer. Asci clavate, 8-spored,  $80-110 \times 14-18 \mu\text{m}$ , J-. Ascospores fusoid-clavate, hyaline, nonseptate,  $25-40 \times 4-6 \mu\text{m}$ . Paraphyses filiform (Fig. 29).

HOSTS: *Pinus* spp.

DISEASE: Secondary invader of pine needles attacked by various hypodermataceous needle fungi (Table 5).

NOTE: Differs from *H. longisporum* chiefly in its shorter ascospores and wider distribution.

***Hendersonia pinicola*** Wehmeyer Mycologia 38: 312 (1946).

Pycnidia black, subglobose, immersed, wall prosenchymatous,  $100-150 \mu\text{m}$  diam, with apical pore. Conidiophores absent. Conidiogenous cells hyaline, lining inner wall. Conidia dark brown, fusoid-ellipsoid, 3-septate at maturity, not constricted at septa,  $12-20 \times 4-7 \mu\text{m}$ , oozing out in a black, irregular cirrhous (Fig. 30).

HOSTS: *Pinus*

DISEASE: Secondary invader of pine needles attacked by hypodermataceous needle parasites, especially *Lophodermella concolor* (Table 5), and believed to act as a biological control agent.

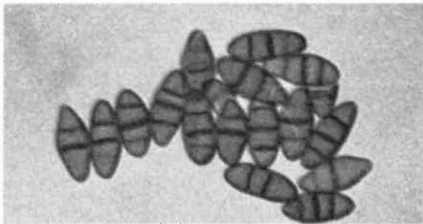


Fig. 30. *Hendersonia pinicola*. Conidia.

***Herpotrichia coulteri*** (Peck) Bose Phytopath. Z. 41: 195 (1961).

SYNONYM: *Neopeckia coulteri* (Peck) Sacc.

Pseudothecia globose, dark brown, single or in small groups, formed on a subiculum of felty brown hyphae,  $250-500 \mu\text{m}$  diameter, with a distinctly papillate pore, wall of thick-walled pseudoparenchyma, covered by brown hyphae. Asci cylindrical, short-stalked, bitunicate, 8-spored,  $140-210 \times 14-20 \mu\text{m}$ . Ascospores monostichous, elliptical, dark brown, 1-septate, constricted, with a dark epispore,  $10-28 \times 7-10 \mu\text{m}$ . Pseudoparaphyses hyaline, septate, filiform, sparsely branched.

HOSTS: Chiefly on *Pinus*, rarely on *Picea*

DISEASE: Causes snow mould, invading and killing foliage when it is covered by snow, therefore affecting lower branches or very young trees, especially in nurseries. A brown, felt-like mycelium covers the branches, penetrating the cuticle, and producing microsclerotia. Branch dieback or death of seedlings may result. Also called "brown felt-blight."

Fungicides maneb and zineb applied before first snowfall control the disease.



Fig. 31. *Herpotrichia juniperi*. Snow mould of alpine fir.

***Herpotrichia juniperi*** (Duby) Petr. Ann. Mycol. 23: 43 (1925).

SYNONYM: *Herpotrichia nigra* Hartig

Pseudothecia dark brown, globose, sparsely gregarious, partly hidden in a felt-like subiculum of dark brown hyphae, 200-450  $\mu\text{m}$  diameter, with a definite apical pore, wall of polygonal cells 20-40  $\mu\text{m}$  thick, covered with brown, septate hyphae. Asci cylindrical to subclavate, 8-spored, bitunicate, 115-190  $\times$  12-18  $\mu\text{m}$ . Ascospores monostichous or obliquely distichous, hyaline and 1-septate at first, becoming brown and 3-4-septate, elliptical, constricted at median septum, with a mucus sheath, 25-34  $\times$  8-12  $\mu\text{m}$ . Pseudoparaphyses filiform, hyaline.

HOSTS: *Abies*, *Chamaecyparis*, *Juniperus*, *Picea*, *Pinus*, *Tsuga*

DISEASE: Brown felt blight or snow mould. Similar to *H. coulteri* (Fig. 31).

NOTE: After snowmelt, fruit bodies form on mycelium and release spores.

***Hormonema merioides*** Funk, Woods and Hopkinson Can. J. Botany 63 (1985) (in press)

Sporodochia hypophyllous, sessile in stomates, columnar, brown, 50-110  $\mu\text{m}$  diameter, enclosed in mucus. Conidiophores simple, septate, emerging from stomates in a fascicle, 2-3  $\mu\text{m}$  diameter. Conidiogenous cells in chains of four, monophialidic, at first promycelial, then becoming subglobose or rectangular, sometimes branching, 8-13  $\times$  8-10  $\mu\text{m}$ . Conidia hyaline, ellipsoid, to ovoid, nonseptate, 0-2 guttulate, 6-11  $\times$  4-6  $\mu\text{m}$ ; at germination becoming brown and 1-septate.

HOST: *Pseudotsuga menziesii*, *Abies grandis*

DISEASE: Associated with needle blight under conditions of very high moisture.

A brick red discoloration of the distal half of the needle with a clear separation between living and infected tissue is the chief symptom (Fig. 31a).

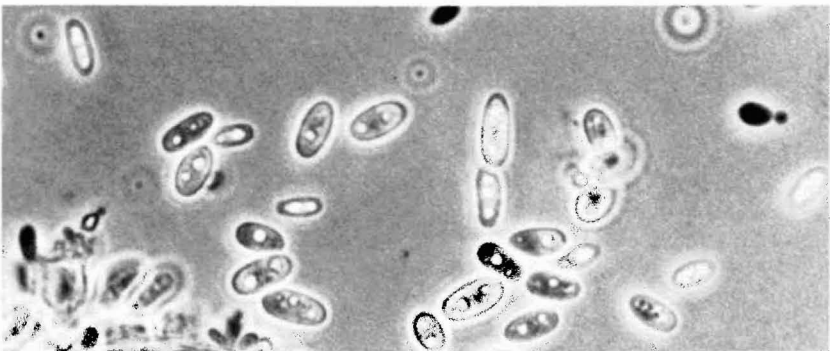
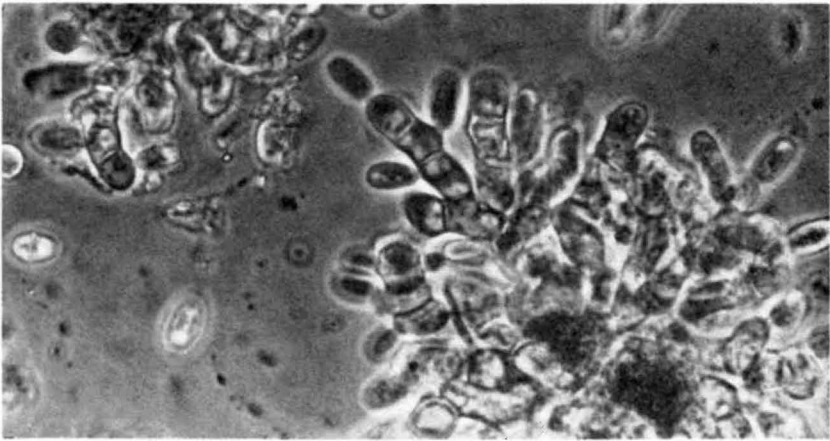
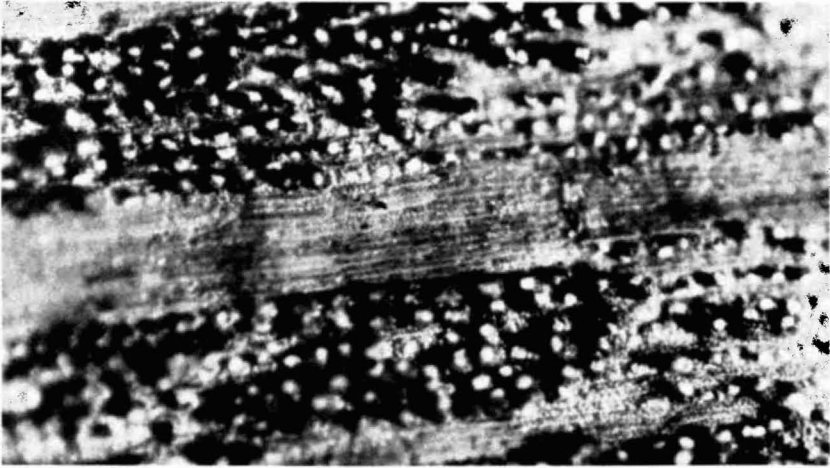


Fig. 31a. *Hormonema merioides*. Sporodochia in blighted needle. Sporodochium. Conidia.



Fig. 32. *Hypodermella laricis*. Blighted needles on western larch.

***Hypodermella laricis*** Tub. Bot. Centralbl. 61: 49 (1895).

ANAMORPH: *Leptothyriella laricis* Dearn.

Hysterothecia black, elliptical, subcuticular, more or less in a continuous row,  $0.5-0.8 \times 0.2-0.3$  mm; a basal layer of brown pseudoparenchyma subtends a plectenchymatous layer  $10-15 \mu\text{m}$  thick below the hymenium; covering layer dark without evident opening mechanism. Asci clavate, 4-spored usually, acutely pointed at maturity,  $80-112 \times 20-24 \mu\text{m}$ . Ascospores clavate tapering to an acute base, hyaline, nonseptate, with gelatinous sheath  $5 \mu\text{m}$  thick,  $70-105 \times 6 \mu\text{m}$ . Paraphyses shorter than the asci, filiform, slightly swollen at the tips (Figs. 3,4).

Pycnidia black, numerous,  $120-300 \times 80-120 \mu\text{m}$ . Conidia hyaline, elongated pyriform,  $4-5 \times 1 \mu\text{m}$ .

HOSTS: *Larix occidentalis*, *L. laricina*, *L. lyallii*

DISEASE: Needle blight. Diseased needles retained after normal needle drop (Fig. 32). All needles on a spur turn reddish-brown. Only newly flushed needles are susceptible.

NOTE: Benomyl and maneb fungicides applied repeatedly during flushing will protect needles.

***Isthmiella abietis*** (Dearn.) Darker Can. J. Bot. 45: 1420 (1967).

SYNONYM: *Bifusella abietis* Dearn.

Hysterothecia usually continuous along lower surface midrib of needle, intraepidermal but becoming subepidermal at the sides, black,  $420-455 \mu\text{m}$  wide,  $210-280 \mu\text{m}$  deep, basal layer of plectenchyma  $30-35 \mu\text{m}$  thick continuing up the sides in a narrow band. Asci clavate, thin-walled, rounded at the tip, 8-spored,  $115-160 \times 28-30 \mu\text{m}$ . Ascospores bifusiform with narrow connecting isthmus, hyaline, with thick gelatinous sheath,  $40-50 \times 4-6 \mu\text{m}$ . Paraphyses filiform, hyaline, with thin gelatinous sheath,  $110-120 \times 1 \mu\text{m}$  (Fig. 4).

Pycnidia epiphyllous, intraepidermal, concolorous with needle, along both



wings of needle, 140-240  $\mu\text{m}$  wide.

HOST: *Abies lasiocarpa*

DISEASE: Needle blight of 1+ -yr-old needles.

NOTE: The secondary fungi *Leptosphaeria faullii*, *Lophomerum autumnale* and *Stegopezizella balsameae* may invade the needles and prevent maturation of *Isthmiella* ascospores.

*Lirula abietis-concoloris* sometimes occurs in same trees.

***Isthmiella crepidiformis*** (Darker) Darker Can. J. Bot. 45: 1420 (1967).

Hysterothecia black, conspicuous, hypophyllous, narrowly ellipsoid, opening longitudinally, 0.5-3.0  $\times$  0.3-0.6 mm, intraepidermal; basal layer plectenchymatous, 20-40  $\mu\text{m}$  thick; covering layer dark pseudoparenchyma, with epidermis 40-63  $\mu\text{m}$  thick. Asci clavate-truncate, 8-spored, 145-165  $\times$  24-28  $\mu\text{m}$ . Ascospores bifusiform, slightly constricted in the middle, hyaline with thick gelatinous sheath, 60-75  $\times$  8-8.5  $\mu\text{m}$  (Fig. 4).

HOSTS: *Picea engelmannii*, *P. glauca*, *P. mariana*

DISEASE: Needle blight.

NOTE: This disease is more common north of latitude 62°. Ascomata found only on needles older than two years, at which age many needles drop naturally. Ascomata outwardly resemble *Lirula macrospora*.

***Isthmiella quadrispora*** Ziller Can. J. Bot. 46: 1378 (1968).

Ascomata maturing in yellow, dead needles still attached, chiefly hypophyllous, nervisequious along entire needle or interrupted, black, subcuticular at first, but becoming subepidermal at the sides, 300-400  $\mu\text{m}$  wide, opening by a conspicuous slit with lips 40-60  $\mu\text{m}$  thick. Hymenium pale yellow. Basal layer 15-30  $\mu\text{m}$  thick. Asci 4-spored, truncate-clavate tapering to long stipe, 90-140  $\times$  14-18  $\mu\text{m}$ . Ascospores unequally bifusiform, nonseptate, isthmus 2-3  $\mu\text{m}$  diam, basal part longer and narrower than upper part, hyaline, in gelatinous sheath 1-5  $\mu\text{m}$  thick, 40-55  $\times$  3-6  $\mu\text{m}$ . Paraphyses filiform, septate, slightly swollen at tips, sheathed, approximately 130  $\times$  1  $\mu\text{m}$  (Fig. 33).

Pycnidia absent.

HOST: *Abies lasiocarpa*

DISEASE: Needle blight.

NOTES: The fungus has a two-year life cycle, i.e., it takes two years from infection to production of ascospores, resulting in alternate year's needles being infected, since only new needles susceptible (Fig. 33).

Secondary fungi *Stegopezizella balsameae* and *Lophomerum autumnale* may prevent maturation of *I. quadrispora*.

***Kabatina thujae*** Schneider & Arx Phytopath. Z. 57: 180 (1966).

Acervuli erumpent, brown, up to 150  $\mu\text{m}$  diameter, separate or confluent, pulvinate, formed of brown, thick-walled pseudoparenchyma, often vertically elongated and cylindrical towards top. Conidiophores pale brown or hyaline, branched at the base. Conidiogenous cells enteroblastic, phialidic, dolioform or



Fig. 33. *Isthmiella quadrispora*. Blighted needles on alpine fir. Ascoma on needle. Ascoma, vertical section, showing subcuticular development and mature position.

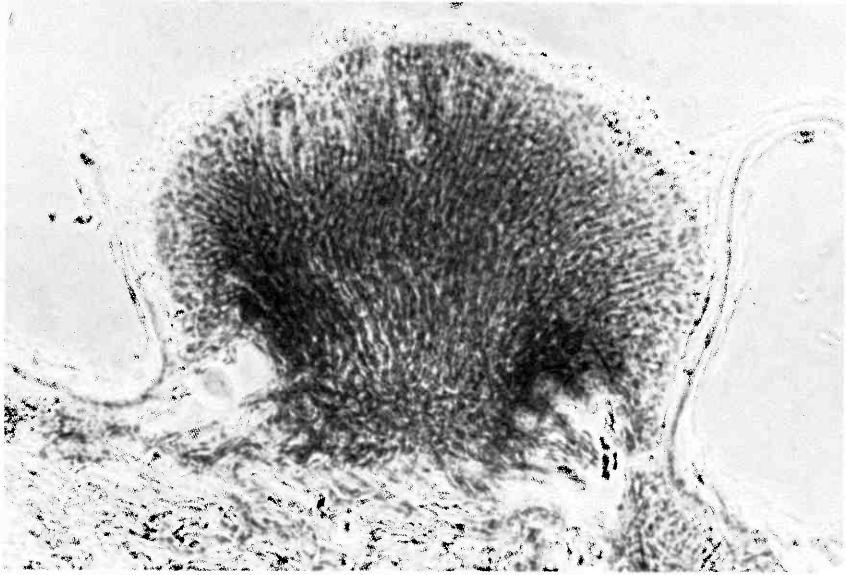


Fig. 34. *Kabatina thujae*. Conidioma in bark of yellow cedar. Conidia.

ampulliform, terminal or lateral,  $6-8 \times 4-5 \mu\text{m}$ . Conidia hyaline, nonseptate, ellipsoid,  $5-8 \times 2-3 \mu\text{m}$  (Fig. 34).

In agar culture almost black; conidia less than  $8 \mu\text{m}$  long produced directly from the dark, septate hyphae (*Hormonema*-like).

HOST: *Chamaecyparis nootkatensis*

DISEASE: Causes leaf and shoot blight of yellow cedar. An epidemic on ornamental varieties was reported in Fraser Valley nurseries by Funk and Molnar (1972). Cultural characteristics were described by Hermanides-Nijhof (1977).

NOTES: A closely related species, *K. juniperi* Schneider & Arx, is found on *Juniperus* spp. in the Great Plains (Ostrofsky and Peterson 1981) that differs slightly in cultural characteristics.

***Leptomelanconium cinereum*** (Dearn.) Morgan-Jones Can. J. Bot. 49: 1012 (1971).

SYNONYM: *Gloeocoryneum cinereum* (Dearn.) Weindl., *L. pini* (B. & C.) Hunt

Acervuli hypodermal then erumpent, black, irregular to circular in outline, up to  $600 \mu\text{m}$  diameter, composed of hyaline to subhyaline isodiametric pseudoparenchyma. Conidiophores hyaline, smooth-walled, short, cylindrical to subulate. Conidiogenous cells long, cylindrical,  $15-30 \times 3 \mu\text{m}$ , without annellations. Conidia brown, ovoid to ellipsoid, thick-walled, verrucose, 3-(5-) septate, obtuse at the apex narrowing to a truncate base which bears a marginal frill,  $20-25 \times 6-12 \mu\text{m}$  (Fig. 35).

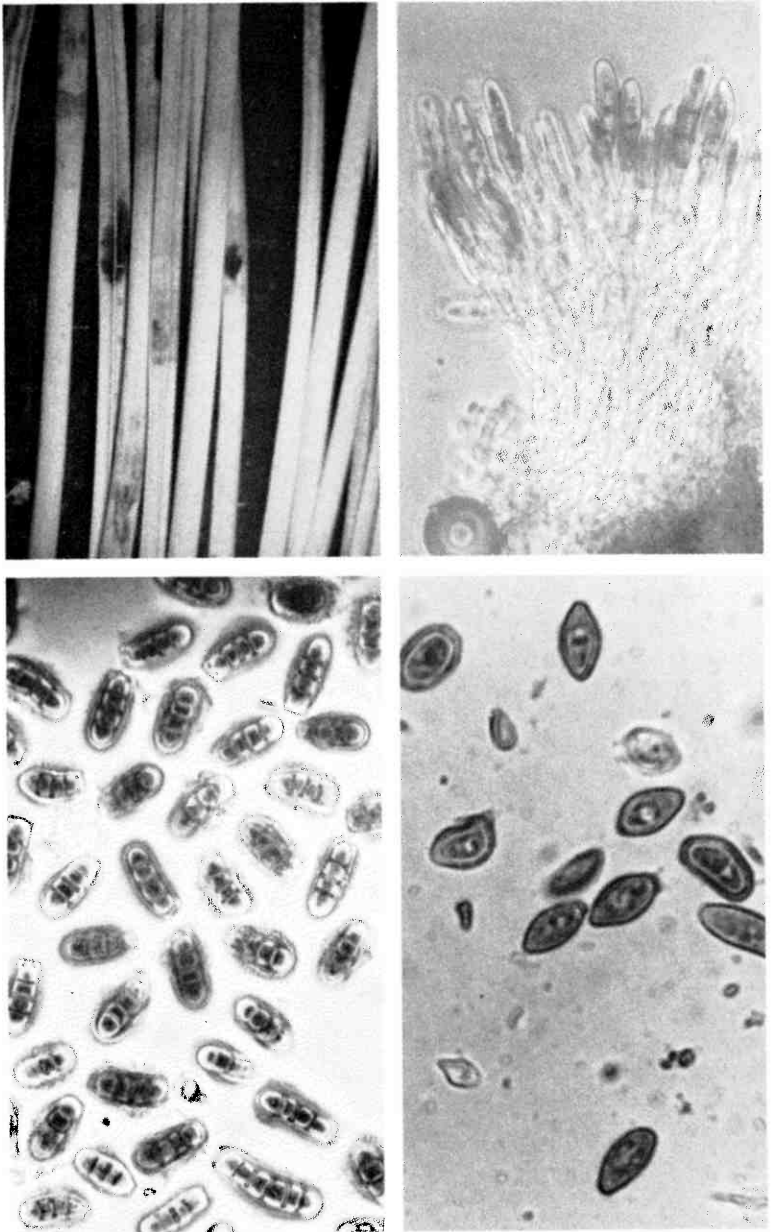


Fig. 35. *Leptomelanconium cinereum*. Conidiomata in pine needles.  
Conidia. *L. allescheri*, conidia.

HOSTS: *Pinus* spp.

DISEASE: Appears to cause needle blight of pines on needles of all ages but causal relationship is not proven.

NOTES: The long conidiogenous cells without annellations and 3-septate conidia favor *Gloeocoryneum* for this fungus (Sutton 1980).

A rare species on needles of white pine is *L. allescheri* (Schnabl) Petr. with nonseptate, verruculose, navicular conidia,  $8-12 \times 4-5 \mu\text{m}$  (Sutton and Chao 1970) (Fig. 35).

***Leptosphaeria faullii*** Darker Can. J. Bot. 42: 1006 (1964).

ANAMORPH: *Coniothyrium faullii* Darker

Perithecia scattered in needles attacked by hypodermataceous fungi of the nervequious habit, subepidermal, subglobose, wall of dark pseudoparenchyma, ostiolate to upper surface of needle,  $260-280 \times 170-235 \mu\text{m}$ . Asci clavate, 8-spored, cytoplasm reddish-brown in iodine, tip J-,  $80-110 \times 9-15 \mu\text{m}$ . Paraphyses simple, septate, filiform, hyaline, thinly sheathed. Ascospores biseriate to uniseriate, fusoid-ellipsoid, yellowish brown, 3-septate, slightly constricted at septa, with gelatinous sheath,  $15-23 \times 4-6 \mu\text{m}$ .

Pycnidia resembling perithecia in form and habit. Conidiophores simple, septate or occasionally branched, up to  $45 \mu\text{m}$  long. Conidiogenous cells phialidic at apex or below septa. Conidia ellipsoid, dark brown,  $5-8 \times 4-6 \mu\text{m}$ .

HOST: *Abies lasiocarpa*

NOTE: Secondary invader of needles attacked by *Isthmiella abietis*. An agent of biological control of needle parasites; may prevent fruiting of primary invader. Occurs only on needles of the year the primary invader would have matured (Darker 1964) (Table 5).

***Limacinia alaskensis*** Sacc. & Scalia Smithsonian Inst. Publ. 1994: 13-64 (1910).

ANAMORPH: *Hormisciomyces*

Sooty, black mycelium covering leaves. Ascomata superficial or immersed in the black subiculum, black, globose,  $100-200 \mu\text{m}$  diameter, wall of polygonal cells, with pore, appendaged. Asci ellipsoid, sessile or with knob-like stalk, bitunicate, 8-spored,  $48-112 \times 15-36 \mu\text{m}$ . Ascospores ellipsoid, 3-septate, slightly constricted at the septa, brown, guttulate,  $20-37 \times 8-13 \mu\text{m}$  (Fig. 36).

Phialophores arising from the cells of the subicular hyphae, 1-3-septate, cells barrel-shaped, giving rise to phialides. Conidia minute, globose, hyaline, nonseptate.

HOSTS: *Thuja plicata*, *Abies* spp., *Pseudotsuga*

DISEASE: "Sooty mould," a black, superficial growth (Barr 1955).

NOTE: Hughes (1974) indicated a complex of species under this name that should be in the genus *Euantennaria*.

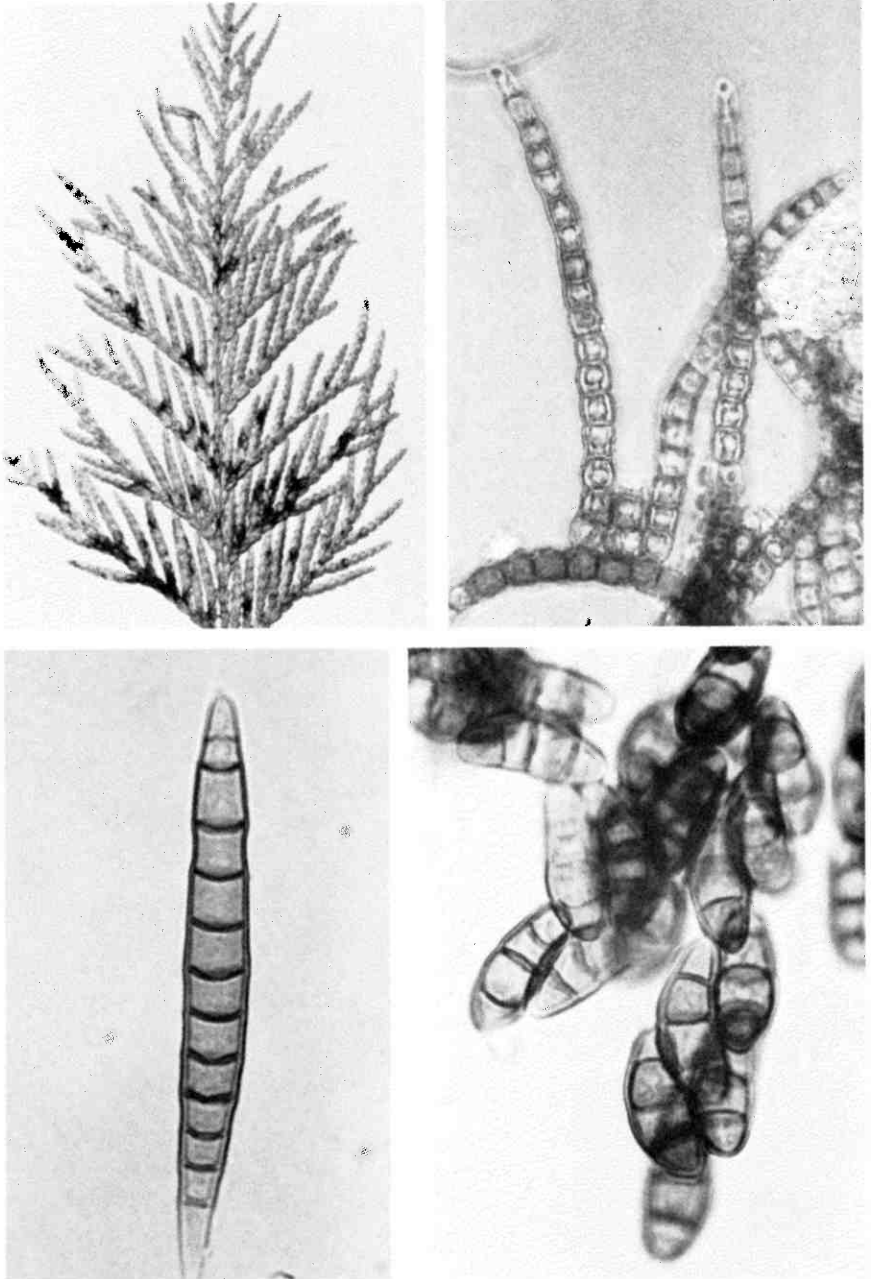


Fig. 36. *Limacinia alaskensis*. Sooty mould mycelium. Conidium. Ascospores.

***Linodochium hyalinum*** (Lib.) Hoehn. Sitzb. K. Akad. Wiss. Wien 118: 83 (1909).

TELEOMORPH: *Pseudohelotium pineti* (Batsch: Fr.) Fckl.

Sporodochia cream to yellowish, gelatinous when moist, hard when dry, separate to confluent, flat, or rarely pulvinate, round to oval with irregular margin, up to 1.2 mm diameter, tissues of hyaline *textura angularis* grading into *textura porrecta*, more or less gelatinized, hypostromata in stomata of host. Conidiophores hyaline, irregularly branched, septate, smooth, arising from upper cells of sporodochium,  $4-20 \times 2-3 \mu\text{m}$ . Conidiogenous cells sympodially proliferating, occasionally annellidic, integrated, cylindrical, terminal,  $6-14 \times 2 \mu\text{m}$ . Conidia holoblastic, hyaline, filiform, subulate, straight or slightly curved, 2-4-septate, base truncate, apex acute,  $36-88 \times 1.5 \mu\text{m}$  (Fig. 36a).

Apothecia superficial, whitish, up to 1 mm diameter, short-stipitate. Asci cylindrical, J+,  $70 \times 9 \mu\text{m}$ . Ascospores needle-like, 3-septate, hyaline,  $30-40 \times 2 \mu\text{m}$ .

HOST: *Pinus monticola*

DISEASE: Associated with needle blight.

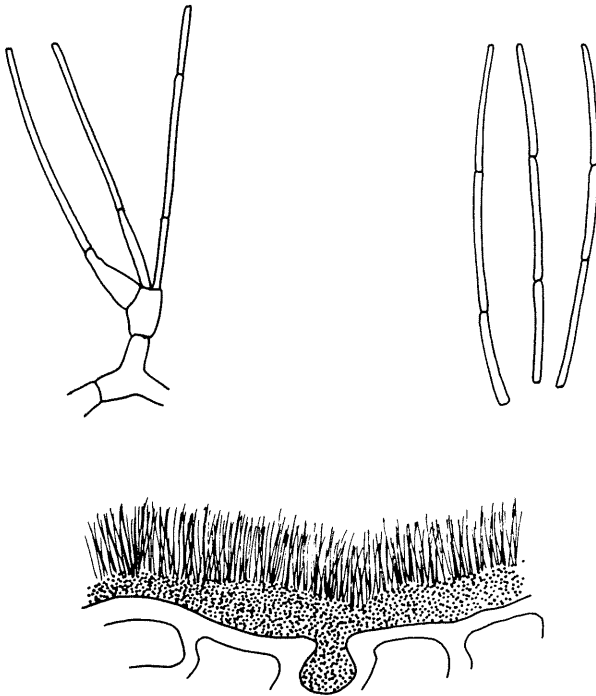


Fig. 36a. *Linodochium hyalinum*. Conidioma and conidia (after Sutton).

NOTES: Recently re-described by Dyko and Sutton (1979).

Soaking needles in water helps to make sporodochia more visible. The teleomorph was connected recently by Minter and Holubova-Jechova (1981) on the basis of cultural work by Gremmen (1960).

***Linospora tetraspora*** G.E. Thompson    Can. J. Res. C, 17: 236 (1939).

ANAMORPH: *Melasmia*-like

Perithecia immersed in stromatized leaf tissue, globose to pyriform, single, 175-270 × 110-175 μm; beak lateral, curved, exerted; covered by a black clypeus. Stromatic tissues are prosenchymatous mixed with host cells; clypeus is parenchymatous, epiphyllous. Asci cylindrical, 4-spored, 175-230 × 6-9 μm. Ascospores filiform, hyaline, straight or curved, 5-8-septate, 155-200 × 1-2 μm.

Acervuli epiphyllous, intraepidermal, round or irregular, 125-250 μm diameter. Conidiophores hyaline, 9-13 × 2-3 μm. Conidia (spermatia?) globose, hyaline, nonseptate, 2.5-3 μm diameter.

HOSTS: *Populus trichocarpa*, *P. balsamifera*

DISEASE: Leaf blight, spreads along veins to form irregular lesions; may cover entire leaf (Fig. 36b).

***Lirula abietis-concoloris*** (Mayr ex Dearn.) Darker    Can. J. Bot. 45: 1421 (1967).

SYNONYM: *Hypodermella abietis-concoloris* (Mayr) Dearn.

Hysterothecia mostly hypophyllous, usually nervisequious, black or with bluish-black lustre, continuous along full or part length of needle, 0.5-1.0 mm wide, intraepidermal in center, subepidermal at sides, basal layer hyaline plectenchyma, 15-25 μm thick, covering layer dark pseudoparenchyma, 60-120 μm thick. Asci

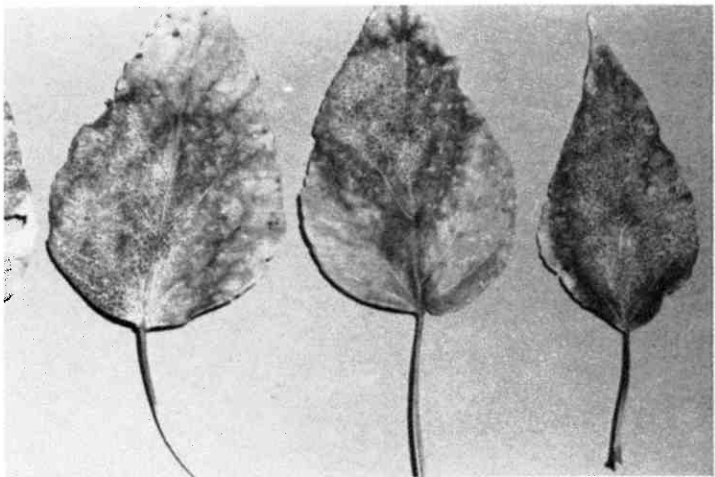


Fig. 36b. *Linospora tetraspora*. Leaf blight of poplar.



clavate, 8-spored,  $150-180 \times 16-20 \mu\text{m}$ . Ascospores clavate, hyaline, nonseptate,  $70-104 \times 4-5 \mu\text{m}$ , with thin gelatinous sheath. Paraphyses simple, filiform,  $135 \times 1 \mu\text{m}$ , conspicuous (Fig. 4).

Pycnidia epiphyllous, continuous or interrupted in groove of needle, or in double interrupted rows, brown to light brown after spore discharge, up to 0.2 mm wide. Conidia rod-like, hyaline,  $4-6 \times 1 \mu\text{m}$ .

HOSTS: *Abies amabilis*, *A. grandis*, *A. lasiocarpa*

DISEASE: Needle blight

NOTES: Fruits on 1+ to several-year-old needles. Often followed by the secondary invader *Nothophacidium phyllophilum* that causes a bluish mottling, and by *Stegopezizella balsameae*. *Phaeocryptopus nudus* often colonizes the killed needles.

***Lirula punctata*** (Darker) Darker also occurs on the balsam firs but the asci are 4-spored with rudiments of four additional ascospores; otherwise it is quite similar to *L. abietis-concoloris* (Fig. 37).

Scharpf *et al.* (1970) reported ***L. nervisequia*** (DC.: Fr.) Darker var. *conspicua* Darker on *Abies bracteata* in California with ascospores  $40-65 \times 2.5-3.5 \mu\text{m}$ .

***Lirula macrospora*** (Hartig) Darker Can. J. Bot. 45:1422 (1967).

SYNONYM: *Lophodermium macrosporum* (Hartig) Rehm

ANAMORPH: *Hypodermina hartigii* Hilitzer

Hysterothecia amphigenous, length varying up to full length of needle, 0.45-0.56 mm wide, shiny black, lips conspicuous, intraepidermal, basal layer of hyaline plectenchyma, 25-30  $\mu\text{m}$  thick, covering layer of dark pseudoparenchyma and epidermis, 55-68  $\mu\text{m}$  thick. Asci clavate-cylindric, tip abruptly tapered,  $100-132(180) \times 14-16 \mu\text{m}$ , 8-spored. Ascospores clavate, hyaline, nonseptate, with gelatinous sheath 3-4  $\mu\text{m}$  thick,  $56-68(125) \times 2.5-3.0 \mu\text{m}$ . Paraphyses simple, filiform, swollen at the tips,  $120 \times 1.5-2.0 \mu\text{m}$  (Figs. 3, 37).

Pycnidia concolorous with leaf surface, conspicuous, applanate.

HOSTS: *Picea* spp.

DISEASE: Needle blight. Considered the most damaging of spruce needle blights. Infected needles are not cast.

NOTES: Another species on spruce, and that occurs often with *L. macrospora*, is ***L. brevispora*** Ziller. This species has smaller asci ( $80-100 \times 11-15 \mu\text{m}$ ) and smaller ascospores ( $25-35 \times 3-3.5 \mu\text{m}$ ) but otherwise resembles *L. macrospora* (Ziller 1969b). Rare. (Fig. 37).

*Lirula macrospora* has a two-year life cycle although the anamorph appears one-year after infection.

***Lophodermella*** Hoehn. Ber. Deutsch. Bot. Gesell. 35:247 (1917).

Hysterothecia concolorous with needle surface, elliptical, short to elongate, subhypodermal, circular in cross-section. Hymenium cupulate; subhymenium thin. Asci clavate. Paraphyses simple, filiform. Ascospores clavate, nonseptate, hyaline, with gelatinous sheath. Pycnidia, if present, small, flask-like (Figs. 3, 4, 37a).

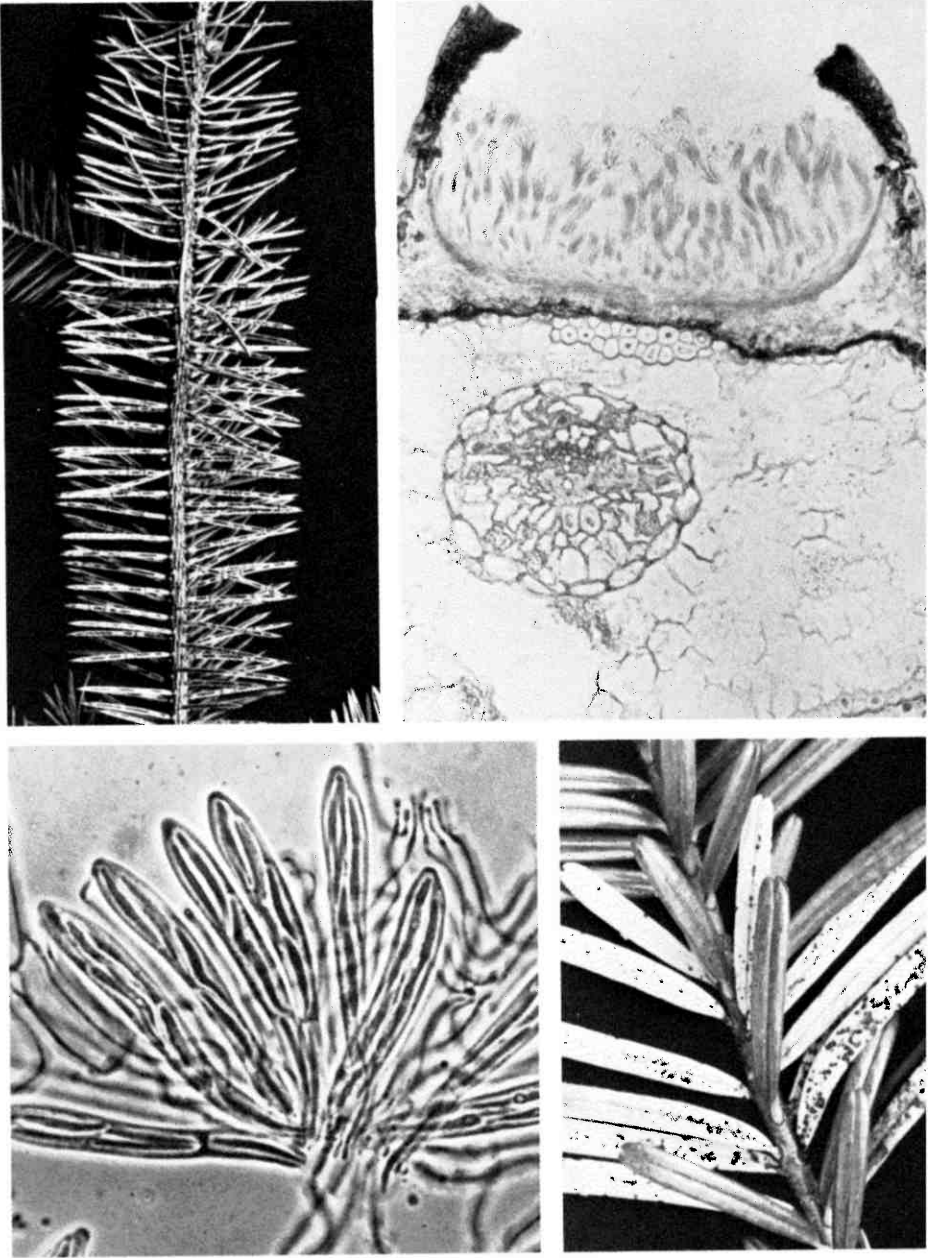


Fig. 37. *Lirula macrospora*. Ascomata on spruce needles. Ascoma, vertical section. *Lirula brevispora*. Asci and spores. *L. punctata*. Anamorph on balsam fir needles.

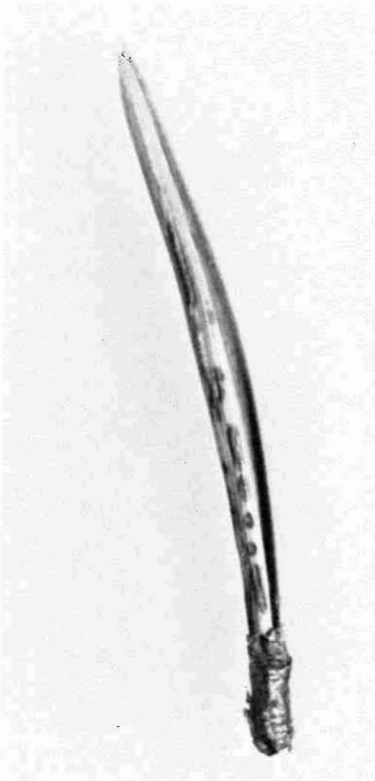


Fig. 37a. *Lophodermella montivaga*. Ascomata on pine needles. Note light-colored slits.

NOTES: *Lophodermella* is represented by seven species occurring only on *Pinus* (Table 2). *Lophodermella concolor* is subject to secondary invaders *Hemiphacidium* and *Hendersonia* (q.v.) that prevent development of ascomata. *Lophodermella* has ascospores similar to *Davisomycella*, but is distinguished by its concolorous, subhypodermal ascomata.

*Lophodermella concolor* is the most important species in the southern half of British Columbia with a one-year life cycle; needles are cast in mid-summer after sporulation of the fungus. *Lophodermella montivaga* is the most important species in northern British Columbia and the Yukon. Both fungi attack needles of the current year only.

The disease may be controlled with Bordeaux Mixture applied to needles when half-developed and when growth stops.

***Lophodermium*** Chev. Flor. Gen. Paris 1: 435 (1826).

Ascomata ellipsoid, blackish, immersed and then erumpent, covered with a clypeus that splits at maturity to reveal the hymenium; zone of the split may be lined with lip cells that may be colored. Asci clavate to cylindrical, stalked, apical pore not

Table 2. *Lophodermella* species (Darker 1967)

Species	Hysterothecia	Special Characteristics	Asci	Ascospores	Age of needles	Hosts
<i>L. arcuata</i> (Darker)	0.4-3.1 × 0.2-0.5 mm concolorous subhypodermal		110-160 × 14-18 μm clavate	42-50 × 4-6 μm clavate		<i>Pinus monticola</i> , <i>P. lambertiana</i> , <i>P. albicatulis</i>
<i>L. cerina</i> (Darker)	0.6-2.7 × 0.3-0.6 mm concolorous subhypodermal		160-225 × 17-21 μm fusiform	68-78 × 3.5 μm clavate		<i>Pinus contorta</i> , <i>P. ponderosa</i>
<i>L. concolor</i> (Dearn.)	0.4-0.8 × 0.3-0.4 mm concolorous subhypodermal	- needles red-brown becoming straw-colored - may form shallow depressions - followed by <i>Hendersonia</i> and <i>Hemiphacidium</i>	120-225 × 15-17 μm subcylindric	45-60 × 4-8 μm clavate		<i>Pinus contorta</i> , <i>P. banksiana</i>
<i>L. conjuncta</i> (Darker)	0.5-3.75 × 0.2-0.3 mm light brown subhypodermal	- mostly on tips of green needles - ascomata may fuse laterally	110-160 × 15-16 μm cylindric-fusiform	75-90 × 3-3.5 μm filiform-clavate	1 + yrs	<i>Pinus sylvestris</i>
<i>L. montivaga</i> Petr.	0.75-8 × 0.3-0.4 mm light brown to concolorous subhypodermal	- very similar to <i>L. sulcigena</i> - slit is light-colored	120-160 × 12-15 μm clavate	40-50 × 3-4 μm clavate	1 + yrs	<i>Pinus contorta</i> (Fig. 37a), <i>P. banksiana</i>
<i>L. sulcigena</i> (Rostr.) Hoehn.	2-20 × 0.3-0.4 mm concolorous subhypodermal	- very similar to <i>L. montivaga</i> - followed by <i>Hendersonia</i>	110-140 × 13-15 μm clavate 4-8-spored	27-35 × 4-5 μm clavate	on brown portions of green needles	<i>Pinus mugo</i> , <i>P. sylvestris</i> , <i>P. halepensis</i> (Europe)
<i>L. morbida</i> Staley & Bynum	1-6 mm long concolorous to brown subhypodermal	- occasionally up to 22 mm long	95-162 × 11-14 μm	23-53 × 2.5-3.5 μm clavate		<i>Pinus ponderosa</i> , <i>P. attenuata</i> (Staley & Bynum 1972)

Table 3. *Lophodermium* species (Darker 1932, Minter 1981) (Figs. 38, 39)

Species	Host Relation	Zone Lines	Ascomata	Asci	Ascospores	Host
<i>L. consociatum</i> Darker	intra-epidermal	—	0.4-0.6 × 0.6-1.7 mm	150-180 × 15-18 μm	95-120 × 2-2.5 μm	<i>Abies amabilis</i>
<i>L. decorum</i> Darker	sub-epidermal	—	0.3-0.6 × 0.5-1.2 mm	140-184 × 16-18 μm	55-75 × 3-4 μm	<i>Abies grandis</i> , <i>A. lasiocarpa</i>
<i>L. juniperi</i> (Grev.) Darker	sub-cuticular	—	0.3-0.4 × 0.5-0.9 mm	110-130 × 15-17 μm	70-90 × 2-3 μm	<i>Juniperus</i>
<i>L. lacurum</i> Darker	intra-epidermal	—	0.5-0.75 × 0.3-0.4 mm	100-125 × 12-16 μm	60-80 × 1.5-2.5 μm	<i>Abies balsamea</i> , <i>A. grandis</i>
<i>L. laricinum</i> Duby	sub-cuticular	—	0.5-0.6 × 0.2-0.4 mm	100-125 × 9-11 μm	80-115 × 1.5-2 μm	<i>Larix occidentalis</i> , <i>L. laricina</i> , <i>L. lyallii</i> (Ziller 1969)
<i>L. nitens</i> Darker	sub-cuticular	black abundant	0.6-0.85 × 0.35-0.5 mm	95-135 × 11-13 μm	80-120 × 2-3 μm	<i>Pinus flexilis</i> , <i>P. albicaulis</i> , <i>P. monticola</i>
<i>L. piceae</i> (Fckl.) Hoehn.	intra-peridermal	—	0.6-1.9 × 0.4-0.8 mm	110-140 × 10-14 μm	60-95 × 1.5-2 μm	<i>Picea</i> , <i>Abies</i>
<i>L. pinastri</i> (S. ex H.) Chev.	partly sub-epidermal	black abundant	0.7-1.2 × 0.3-0.7 mm	110-155 × 9-12 μm	70-110 × 2 μm	<i>Pinus</i> spp. (2, 3 & 5-needle)
<i>L. seditosum</i> Minter, Staley & Millar	sub-epidermal	absent or brown	0.8-1.6 mm	140-170 × 11-14 μm	90-120 × 2 μm	<i>Pinus</i> spp. (2, 3-needle)
<i>L. uncinatum</i> Darker	sub-cuticular	—	0.5-2.25 × 0.2-0.5 mm	105-135 × 13-15 μm	50-75 × 1.5-2 μm	<i>Abies amabilis</i> , <i>A. lasiocarpa</i>



Fig. 38. *Lophodermium pinastri*. Ascomata interspersed with smaller pycnidia on pine needles, showing black zone lines. *Lophodermium* sp. Asci and ascospores.

coloring in iodine, 8-spored. Ascospores hyaline, filiform, nonseptate, with a mucilaginous sheath. Paraphyses filiform, simple, hooked or swollen at the apex (Figs. 3, 4, 38).

*Leptostroma* anamorph: conidiomata immersed, circular to ellipsoid, dark to concolorous, opening by one or several splits, upper dark wall one cell thick, lower hyaline wall several cells thick. Conidiogenous cells covering lower wall, subulate, holoblastic, sympodial. Conidia rod-like to filiform (Minter 1980).

NOTES: *Lophodermium* is represented by 12 species, on *Pinus*, *Abies*, *Larix*, *Picea*, and *Juniperus* (Table 3). *Lophodermium molitoris* Minter is a subcuticular species on pine that resembles *L. nitens* but differs in having lip cells lining the split (Minter 1980). *Lophodermium baculiferum* Mayr is a rare species on Jeffrey pine with strongly curved tips on paraphyses (Minter 1980), but otherwise it resembles *L. pinastri*.

Two species are fully described.

***Lophodermium pinastri*** (Schrad.: Hook.) Chev. Fl. Gén. Env. Paris 1: 436 (1826).

ANAMORPH: *Leptostroma pinastri* Desm.

Ascumata amphigenous on needles, black, ellipsoid, 700-1200  $\mu\text{m}$  long, covered by host epidermis on sides, but above epidermis in the center, clypeus not extending to basal wall, opening by single split, lips often red to orange. Asci cylindrical, 8-spored, 110-155  $\times$  9-12  $\mu\text{m}$ . Ascospores filiform, nonseptate, 70-110  $\times$  2  $\mu\text{m}$ , in gelatinous sheath. Paraphyses filiform, simple. Zone lines black, abundant in needles (Fig. 38).

Conidiomata subepidermal, 300-400  $\mu\text{m}$  long. Conidia rod-like, 4-6  $\times$  1  $\mu\text{m}$ .

HOSTS: *Pinus*

DISEASE: May inhabit pine needles without producing symptoms. Most reports of damage by *L. pinastri* probably are attributable to *L. seditiosum*.

LIFE CYCLE: Inhabits green needles without producing symptoms. When needles senesce and fall apothecia are produced. Ascospores are released in wet weather (Minter 1981).

***Lophodermium seditiosum*** Minter, Staley & Millar Trans. Br. Mycol. Soc. 71: 300 (1978).

ANAMORPHS: *Leptostroma rostrupii* Minter (on secondary needles)

*Leptostroma austriacum* Oud. (on primary needles)

Ascumata amphigenous on needles, grey, surrounded by a black line sometimes, ellipsoid, 800-1500  $\mu\text{m}$  long, totally subepidermal, clypeus opening by a single median split, lips often green or blue. Asci cylindrical, 8-spored, 140-170  $\times$  11-13  $\mu\text{m}$ . Ascospores filiform, nonseptate, 90-120  $\times$  2  $\mu\text{m}$ , in a gelatinous sheath. Paraphyses filiform, simple, occasionally swollen or hooked. Zone lines in needles absent, or brown and diffuse (Figs. 3, 4).

Conidiomata subepidermal on secondary needles, subcuticular on primary needles. Conidia rod-like, 6-8  $\times$  1  $\mu\text{m}$ .

HOSTS: *Pinus*

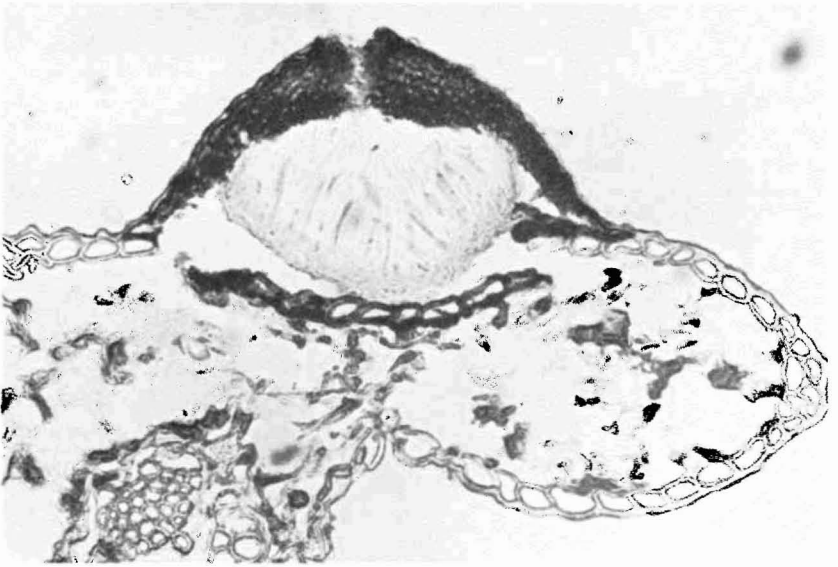


Fig. 39. *Lophodermium laricinum*. Ascoma, vertical section.

**DISEASE:** Needle cast of pines. Severe attacks may kill young trees. Reports of damage by *L. pinastri* usually can be attributed to *L. seditiosum* (Minter 1981).

**LIFE CYCLE:** Ascospores are released in late summer and early autumn during wet weather. The ascomata form on two-year-old needles still attached to the tree. The ascomata may also form on needles and cones of trash. Control programs in British Columbia require three spray applications between late July and mid-September (Ormrod 1976).

***Lophomerum autumnale*** (Darker) Magasi Mycologia 58:275 (1966).

Ascomata amphigenous, scattered or crowded and frequently confluent, elliptical, shiny black, subcuticular,  $0.4-0.8 \times 0.3-0.4$  mm, covering layer pseudoparenchymatous,  $45-50 \mu\text{m}$  thick. Asci clavate, 8-spored, J-,  $110-160 \times 12-15 \mu\text{m}$ . Ascospores filiform, 3-septate at maturity,  $85-95 \times 1.5-2.0 \mu\text{m}$ , with thick gelatinous sheath. Paraphyses filiform, septate, recurved at the tips, sometimes branched (Fig. 40).

**HOSTS:** *Abies lasiocarpa*, *A. amabilis*

**NOTES:** Secondary invader of needles attacked by *Isthmiella* spp. (Table 5). Fruits during summer and fall on needles of the third growing season. Another species, ***Lophomerum darkeri*** Ouellette, is found occasionally on needles of white spruce; its ascospores are  $70-118 \times 1-2 \mu\text{m}$  and up to 5-septate. Its status as a secondary invader to *Lirula macrospora* is suspected.





Fig. 40. *Lophomerum autumnale*. Ascoma, vertical section.

***Lophohacidium hyperboreum*** Lagerb. Svensk Bot. Tidsk. 43: 420 (1949).

Apothecia elongate, from half to full length of the needle, reddish-brown, intrahypodermal, opening lengthwise, 250-500  $\mu\text{m}$  wide, or covering face of needle entirely, up to 250  $\mu\text{m}$  high. Hymenium colorless, subtended by subhymenium up to 40  $\mu\text{m}$  deep, covered by black upper stromatic layer that may not be visible. Asci clavate, 8-spored, pore bluing in iodine, tip rounded, 80-125  $\times$  12-20  $\mu\text{m}$ . Ascospores hyaline, broadly fusiform, nonseptate, 15-25  $\times$  4-8  $\mu\text{m}$ . Paraphyses septate, filiform, simple or branched.

HOSTS: *Picea*

DISEASE: Cause of needle blight of spruce. Smerlis (1966) showed that *L. hyperboreum* attacked *Pinus strobus* and *Abies balsamea* as well as all native spruces in eastern Canada. Chemical control methods were devised (Smerlis 1979).

***Marssonina balsamiferae*** Y. Hiratsuka Mycotaxon 19: 133 (1984).

Acervuli hypophyllous, subcuticular on brown spots up to 5 mm diameter, and often confluent. Conidiophores simple, phialidic. Conidia hyaline, lunate, 1-septate, upper cell larger with pointed end, lower smaller cell with flat basal scar, 18-21  $\times$  4.5-5.5  $\mu\text{m}$ .

HOST: *Populus balsamifera*

DISEASE: Leaf spot (Hiratsuka 1984).

***Marssonina brunnea*** (Ell. & Ev.) Magn. Hedwigia 45: 89 (1906).

TELEOMORPH: *Drepanopeziza tremulae* Rimpour

Acervuli amphigenous but mostly hypophyllous, intraepidermal, up to 400  $\mu\text{m}$  diameter, conidia accumulating and lifting host cuticle to form yellow-orange blisters. Conidiogenous cells phialidic, cylindrical and often twisted, 6-13  $\times$  2  $\mu\text{m}$ . Conidia hyaline, granular, obovoid, straight or curved, 1-septate, lower cell smaller, with basal scar, larger cell rounded at apex, 11-21  $\times$  4-7  $\mu\text{m}$ . Microconidia sometimes present, hyaline, ellipsoid, nonseptate, 3-5  $\times$  1-2  $\mu\text{m}$  (Fig. 41).

HOST: *Populus tremuloides*

DISEASE: Leaf spot of aspen. Spots brown, angular, discrete, approximately 1 mm diameter.



Fig. 41. *Marssonina brunnea*. Conidia.

***Marssonina castagnei*** (Desm. & Mont.) Magn. Hedwigia 45: 89 (1906).

TELEOMORPH: *Drepanopeziza populi-albae* (Kleb.) Nannf.

Acervuli amphigenous but mostly epiphyllous, intraepidermal, up to 400  $\mu\text{m}$  diameter, conidial accumulation lifting host cuticle to form yellowish-white blisters. Conidiogenous cells phialidic, ampulliform, usually twisted, 6-10  $\times$  4-5  $\mu\text{m}$ . Conidia hyaline, obovoid to pyriform, straight or curved, 1-septate, lower cell smaller with flat scar on the base, upper cell rounded, 15-23  $\times$  5-8  $\mu\text{m}$ . Microconidia hyaline, nonseptate, ellipsoid, approximately 3-6  $\times$  2  $\mu\text{m}$ .

HOST: *Populus alba*

DISEASE: Leaf spot of white poplar.

***Marssonina populi*** (Lib.) Magn. Hedwigia 45:89 (1906).

TELEOMORPH: *Drepanopeziza populorum* (Desm.) Hoehn.

Acervuli epiphyllous, intraepidermal, 200-400  $\mu\text{m}$  diameter, accumulated conidia lifting host cuticle to form greyish blisters. Conidiogenous cells phialidic, cylindrical, 7-12  $\times$  4-5  $\mu\text{m}$ . Conidia hyaline, obovoid to pyriform, curved, 1-septate, lower cell smaller with flat, basal scar, upper cell rounded, 17-27  $\times$  8-13  $\mu\text{m}$ . Microconidia hyaline, nonseptate, obovoid, approximately 3-5  $\times$  2  $\mu\text{m}$ .

HOSTS: *Populus tremuloides*, *P. trichocarpa*

DISEASE: Leaf spot of poplars. Spots orange-brown, diffuse, irregular, 2-5 mm diameter, coalescing into vein-limited blotches (Harniss and Nelson 1984).

NOTE: The marssoninas on poplars all have a *Drepanopeziza* teleomorph, but these are rarely if ever found in Canada.

The common species causing leaf spot of willow is *M. kriegeiana* Magn. with typical conidia measuring 14-18  $\times$  5-7  $\mu\text{m}$ .

***Maurodothina farriae*** Pirozynski & Shoemaker Can. J. Bot. 48: 1327 (1970).

ANAMORPH: *Pirozynskia farriae* Subram.

Colonies epiphyllous on living needles, effused, black. Mycelium superficial and immersed; superficial hyphae densely interwoven, dark brown, thick-walled, up to 8.5  $\mu\text{m}$  wide, radiating from the ascوماتа, bearing conidiogenous hyphopodia and conidia. Hyphopodia broadly ellipsoid, producing a solitary conidium through apical pore. Conidia dark brown, tetric, thick-walled, verrucose, becoming 1-septate, 11-18  $\times$  6-8  $\mu\text{m}$ ; immersed hyphae forming plectenchymatous, subcuticular stromata.

Ascomata (thyrothecia) roughly circular, crust-like, up to 200  $\mu\text{m}$  diameter, composed of dark brown, radiating cells, opening by stellate cracks. Asci bitunicate, ellipsoid, 8-spored, 25-40  $\times$  12-20  $\mu\text{m}$ , with deliquescing paraphysoids. Ascospores brown, ovoid, 1-septate, 9-13  $\times$  5-6  $\mu\text{m}$ .

HOSTS: *Abies amabilis*, *A. grandis*

DISEASE: "Black mildew." Conspicuous black colonies on needles that resemble the colonies of *Epipolaeum abietis* shown in Fig. 25.

NOTE: Epiphytic on living needles.

***Meloderma desmazierii*** (Duby) Darker Can. J. Bot. 45:1429 (1967).

ANAMORPH: *Leptostroma strobicola* Hiltizer

Hysterothecia elliptical, often in a row, black surrounded by a grayish zone, 0.5-1  $\times$  0.25-0.4 mm, subepidermal but subcuticular near lips; lips bordered by a palisade row of colorless cells; covering layer of dark pseudoparenchyma 30-60  $\mu\text{m}$  thick; basal layer of plectenchyma 8-24  $\mu\text{m}$  thick. Asci cylindrical, round tips, 8-spored, 130-150  $\times$  16-17  $\mu\text{m}$ . Ascospores short-fusiform, hyaline, nonseptate, guttulate, in a gelatinous sheath 4  $\mu\text{m}$  thick, 27-38  $\times$  5  $\mu\text{m}$ . Paraphyses filiform, variously hooked at the tips, sometimes swollen and branched, 125  $\times$  1.5  $\mu\text{m}$  (Fig. 42).

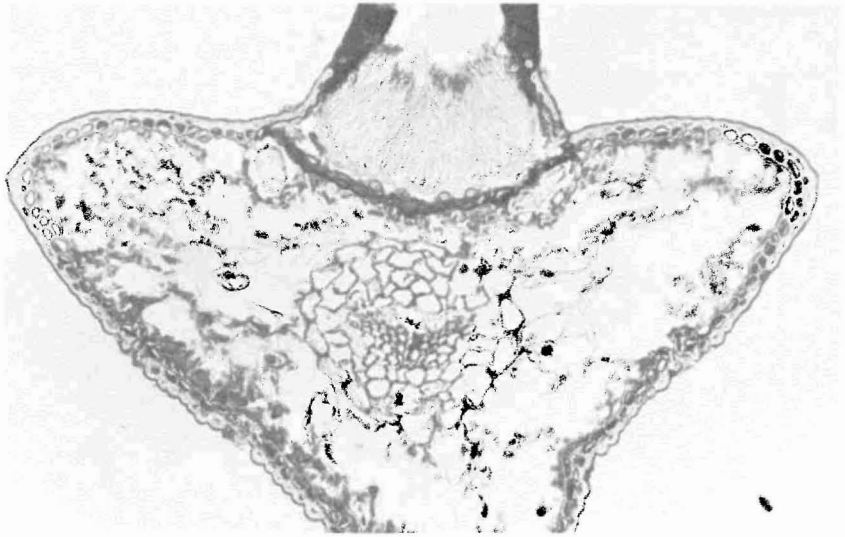


Fig. 42. *Meloderma desmazierii*. Ascoma, vertical section.

Pycnidia simple, flat, no ostiole. Conidia  $5-8 \times 1 \mu\text{m}$ .

HOST: *Pinus monticola*

DISEASE: Needle blight. Rare.

***Meria laricis*** Vuillemin Bull. Soc. Sci. Nancy Ser. II. 14: 15-67 (1896).

Conidiophores originating from substomatal mycelial masses and emerging from the stomates in dense tufts, simple or dichotomously branched, hyaline, septate, frequently curved, up to  $45 \mu\text{m}$  long,  $2-3 \mu\text{m}$  wide. Conidiogenous cells monophialidic, apical or intercalary, indeterminate, + cylindrical, apertures typically produced immediately below the septa on a short sterigma. Conidia hyaline, cylindrical with a median constriction (hence, peanut- or dumb-bell-shaped), non-septate but becoming 1-septate at germination,  $9-13 \times 3-4 \mu\text{m}$  (Fig. 43).

HOSTS: *Larix*, *Pseudotsuga menziesii*

DISEASE: Needle cast of larch. Needles turn yellow, then brown, and are shed after they die (Dubreuil 1982). The disease developed on Douglas-fir orchard trees under special sprinkler regime and wet spring weather.

NOTES: The fungus is almost invisible on the needle unless stained with cotton blue; it overwinters in the dead needles. Control by fungicides maneb and benomyl applied at bud swell and one month later, then at three-week intervals until weather becomes dry.

***Mycosphaerella arbuticola*** (Peck) Barr Contr. Univ. Mich. Herb. 9: 587 (1972).

SYNONYM: *Sphaerella arbuticola* Peck

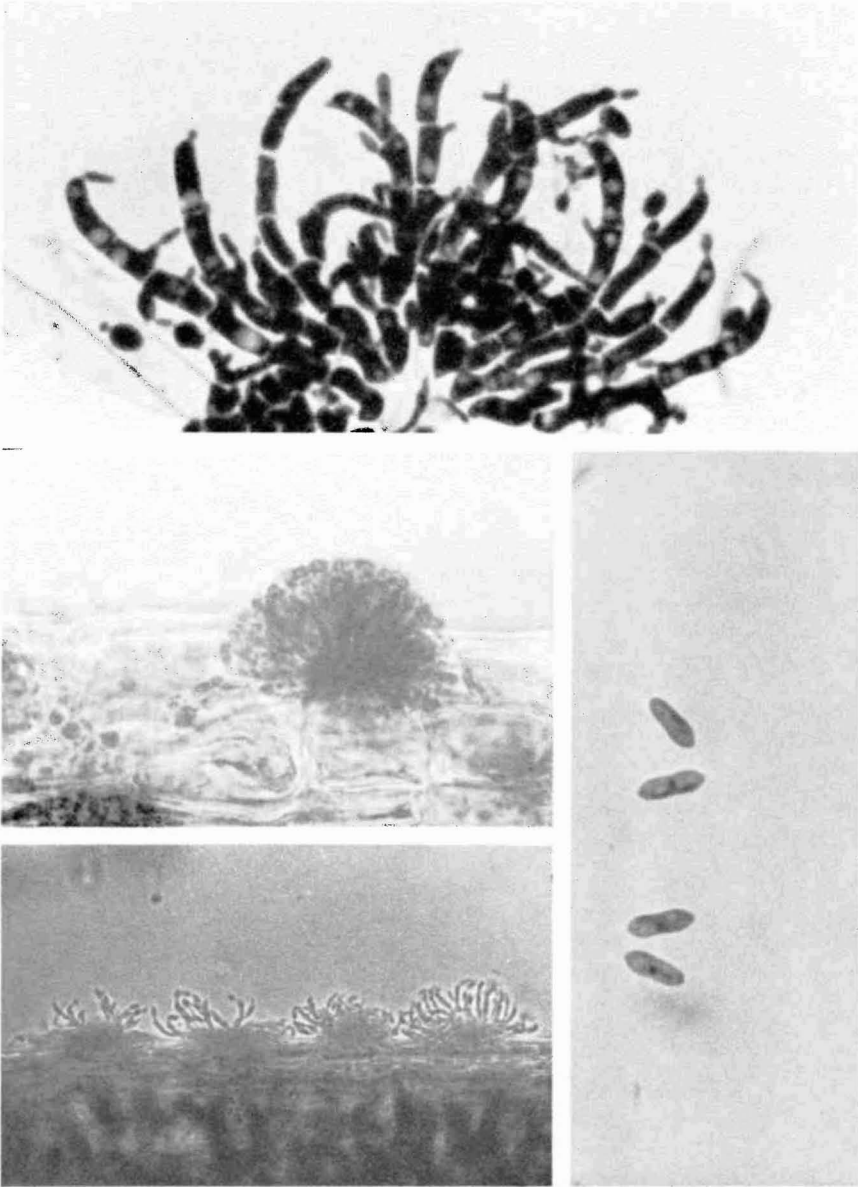


Fig. 43. *Meria laricis*. Sporodochia. Conidiophores and conidia.

Ascomata black, globose, epiphyllous, scattered or grouped, thin-walled, pseudoparenchymatous, 75-128  $\mu\text{m}$  diameter. Asci 40-58  $\times$  9-13  $\mu\text{m}$ , bitunicate. Ascospores 13-19  $\times$  3.5-5  $\mu\text{m}$ , hyaline, elliptic or narrowly obovate, straight or slightly curved, obliquely uniseriate or biseriata in the ascus.

HOST: *Arbutus menziesii*

DISEASE: Leaf spot of *Arbutus*. Spots are brown with dark brown, raised margin, 2-8 mm diameter (Barr 1972).

***Mycosphaerella dearnessii*** Barr Contr. Univ. Mich. Herb. 9: 587 (1972).

SYNONYM: *Scirrhia acicola* (Dearn.) Siggers

ANAMORPH: *Lecanosticta acicola* (Thuem.) Syd.

Ascocarps multiloculate, elliptic, 285-400  $\times$  80-110(300)  $\mu\text{m}$ , sometimes confluent to 2.5 mm long, up to 190  $\mu\text{m}$  high, immersed and erumpent; locules 50-80  $\mu\text{m}$  diameter, often in a single row. Asci 35-42  $\times$  6-9  $\mu\text{m}$ , bitunicate. Ascospores hyaline, fusoid, straight to inequilateral, 1-septate, 9-14  $\times$  2.5-3  $\mu\text{m}$ . Paraphyses absent.

Conidiomata elongate, erumpent, locules opening widely, the bases lined with short hyaline conidiophores. Conidia brown, elongate, bent, 3-septate, tapered at apex, blunt at base, rough-walled, 20-28  $\times$  2.5-3  $\mu\text{m}$ . Microconidia rod-like, 2-3  $\times$  1  $\mu\text{m}$  (Fig. 44).

HOSTS: *Pinus contorta*, *P. banksiana*

DISEASE: Brown spot needle blight of pines. Found in Manitoba (Laut *et al.* 1966). Rare in the west, but very destructive in southeastern U.S.A. A related fungus on *Larix*, ***Mycosphaerella laricina*** Hartig, apparently introduced from Europe, has come west as far as Iowa (Patton and Spear 1983). Conidia are hyaline, 1-4-septate, rounded at the tip, truncate base, 25-45  $\times$  2-4  $\mu\text{m}$ . It causes necrosis of needles and premature defoliation.

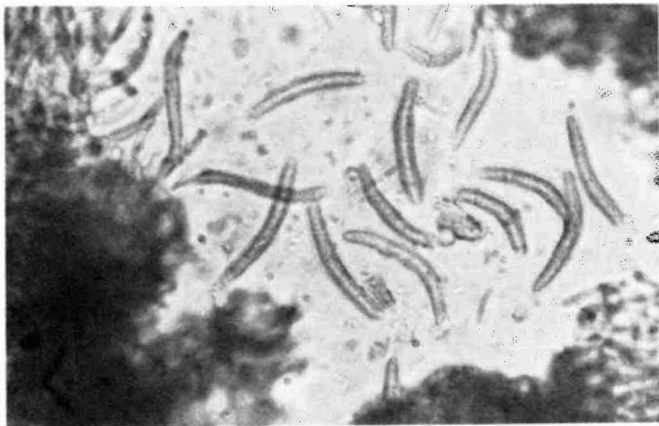


Fig. 44. *Mycosphaerella dearnessii*. *Lecanosticta* anamorph, conidia.

***Mycosphaerella populorum*** G.E. Thompson    Phytopathology 31: 246 (1941).

ANAMORPH: *Septoria musiva* Peck

Pseudothecia scattered or aggregated, partly erumpent, black, globose, wall pseudoparenchymatous, papillate, 64-106  $\mu\text{m}$  diameter. Asci bitunicate, cylindrical-clavate, fasciculate, 8-spored, 54-70  $\times$  13-16  $\mu\text{m}$ . Ascospores hyaline, ellipsoid, 1-septate, slightly constricted at the septum, 16-28  $\times$  4-6  $\mu\text{m}$ . Paraphyses absent.

Pycnidia immersed, globose to subglobose, ostiolate, 48-128  $\mu\text{m}$  diameter. Conidia cylindrical, straight or curved, hyaline, 1-4-septate, 28-54  $\times$  4  $\mu\text{m}$ . In humid conditions, conidia ooze out in a pink tendril.

HOSTS: *Populus* spp.

DISEASE: Causes cankers and leaf spot of native, exotic and hybrid poplars.

NOTES: Another related species, ***M. populicola*** G.E. Thompson (ANAMORPH: *Septoria populicola* Peck), produces similar diseases in poplars, but is somewhat larger in all respects: pseudothecia 96-160  $\mu\text{m}$  diameter; asci 64-90  $\times$  13-16  $\mu\text{m}$ ; ascospores 22-32  $\times$  6  $\mu\text{m}$ ; conidia 45-80  $\times$  3.5-4.5  $\mu\text{m}$  (Bier 1939; Zalasky 1978). Control methods of poplar leaf spots in nurseries were outlined by Carlson (1972).

***Naemacyclus minor*** Butin    Eur. J. For. Path. 3: 160 (1975).

ANAMORPH: *Phomopsis*-like

Ascomata concolorous with the needle, elliptical, 200-600  $\mu\text{m}$  long, subhypodermal, opening by a single longitudinal split to produce two flaps of leaf tissue and expose the white hymenium. Asci cylindrical, J-, 8-spored, 80-120  $\times$  10-12  $\mu\text{m}$ . Ascospores hyaline, filiform, with two septa about 8  $\mu\text{m}$  apart near the middle, bent in the middle, 65-100  $\times$  2.5-3  $\mu\text{m}$ . Paraphyses filiform, branched toward the apex. Broad, reddish-brown zone lines may occur across the needle at maturity.

Pycnidia immersed, globose, walls of hyaline pseudoparenchyma, 150-250  $\mu\text{m}$  diameter. Conidiogenous cells subulate, phialidic. Conidia bacillar, 6-10  $\times$  1  $\mu\text{m}$ .

HOST: *Pinus contorta*

DISEASE: Needle cast of pines.

NOTES: Butin (1975) showed that *N. minor* should be recognized as distinct from *N. niveus* on the basis of smaller ascomata, ascospores and conidia. *Naemacyclus minor* is also considered to be the more virulent pathogen (Millar and Minter 1980). See note under *N. niveus*.

LIFE CYCLE: Ascospores may be released from mid-summer to the following spring from fallen or attached needles. Needles of any age may be infected. Symptoms first appear a year or more later as a light green spot developing into a yellow band with zone lines interspersed. Ascomata develop in fall or spring and are preceded by pycnidia (Peterson 1981).

***Naemacyclus niveus*** (Pers.: Fr.) Sacc.    Bot. Zentralblatt 18: 251 (1884).

ANAMORPH: *Phomopsis*-like

Ascomata concolorous with needle, elliptical, up to 1 mm long, opening by a

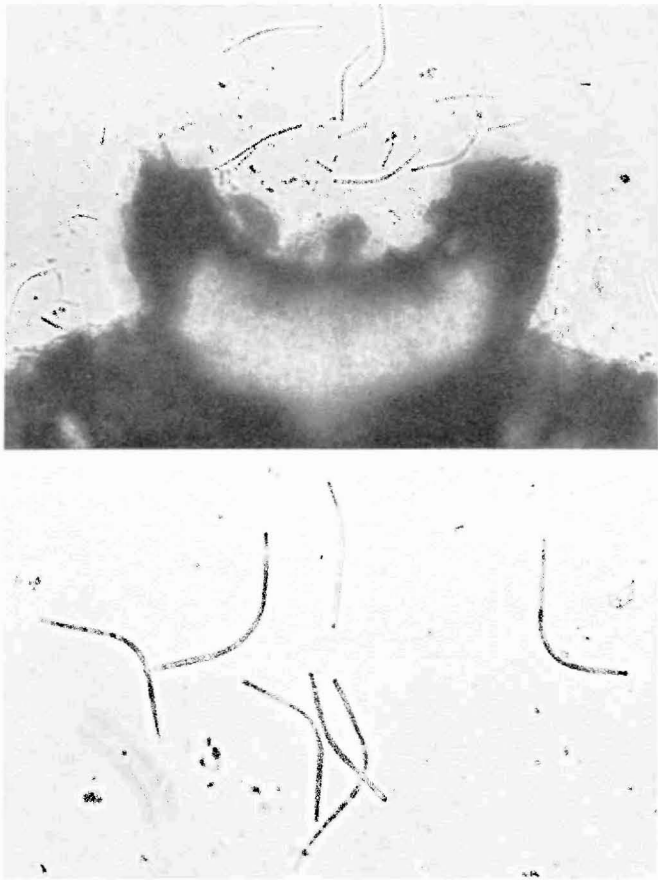


Fig. 45. *Naemacyclus niveus*. Ascoma, vertical section. Ascospores.

single longitudinal split to expose a white hymenium, subhypodermal. Covering flaps composed of needle tissue only. Asci J-, cylindric, 8-spored,  $100-130 \times 11-13 \mu\text{m}$ . Ascospores hyaline, filiform, with two septa approximately  $8 \mu\text{m}$  apart near the middle, frequently bent in the middle,  $75-120 \times 2.5-3.5 \mu\text{m}$ . Paraphyses filiform, branched near the apex. Broad, reddish-brown zone lines may be present in the needle (Fig. 45).

Pycnidia immersed, globose, walls of hyaline parenchyma,  $100-220 \mu\text{m}$  diam. Conidiogenous cells subulate, phialidic. Conidia curved, elongate,  $12-16 \times 1 \mu\text{m}$ .

HOSTS: *Pinus contorta*, *P. radiata*, *P. flexilis*

DISEASE: A weak parasite of pine needles.

NOTE: The revision of DiCosmo *et al.* (1983) has placed both species of *Naemacyclus* in the new genus *Cyclaneusma* of the Rhytismataceae (Hypodermataceae), the ascospores having gelatinous caps.



***Nothopacidium phyllophilum*** (Peck) Smerlis Can. J. Bot. 44: 563 (1966).

Apothecia sessile, cupulate, hymenium colorless, subepidermal, becoming erumpent, epidermis often remaining as a lid, excipulum of dark brown pseudoparenchyma with hair-like cells on the margins, 0.5-0.8 mm wide, 0.25 mm high, scattered or in rows up to 5 mm long. Asci cylindrical or slightly clavate, very short stipe, 8-spored, thickened at the rounded apex, pore not staining in iodine, 60-75  $\times$  9-14  $\mu$ m. Paraphyses filiform, slightly swollen at the tips, longer than the asci. Ascospores oval to broadly ellipsoid, hyaline or pale brown, nonseptate, 5.5-8.5  $\times$  4.5-6.5  $\mu$ m.

HOST: *Abies lasiocarpa*

DISEASE: Secondary invader of needles parasitized by *Lirula abietis-concoloris* (Table 5). Considered a snow-mould by Reid and Cain (1962a), Smerlis (1966) gave evidence that it was not a primary pathogen. Characteristically causes blue mottling of needles.

***Pestalotiopsis funerea*** (Desm.) Steyaert Bull. Jard. Bot. Brux. 19: 340 (1949).

Acervuli lenticular to globose, rupturing the epidermis, 1-2 mm diameter. Conidiogenous cells annellidic, formed from upper cells of acervular stroma, cylindrical to obovoid, 5-15  $\times$  2-4  $\mu$ m. Conidia fusiform, straight or curved, 4-euseptate, slightly constricted at the septa, three median cells olive-brown, apical and basal cells hyaline, 22-32  $\times$  7-13  $\mu$ m; with 2-6 apical appendages hyaline, 5-28  $\mu$ m long; basal appendage single, endogenous, hyaline, straight, 2-11  $\mu$ m long (Fig. 46).

HOSTS: Cupressaceae

DISEASE: Causes stem and leaf blight of conifers, especially Cupressaceae. Also saprophytic on dead material. Often in association with other fungi in dis-

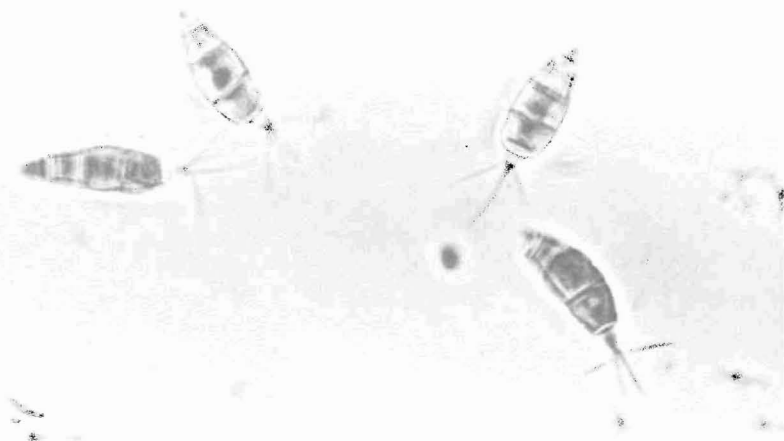


Fig. 46. *Pestalotiopsis funerea*. Conidia.

eased trees. Not considered a serious pathogen in good growing conditions.

NOTES: The genus *Pestalotiopsis* has 4-euseptate conidia, separating it from *Pestalotia* which has 5-distoseptate conidia (Sutton 1969). See note under *Truncatella truncata*.

***Phacidium abietis*** (Dearn.) Reid & Cain Mycologia 54:482 (1962).

Apothecia embedded in the hypodermis, erumpent through epidermis at maturity, in series on each side of midrib of lower surface of needle, oval to circular, often with a central papilla; roof black, opening by several irregular teeth; 300-500  $\mu\text{m}$  diameter, 120-225  $\mu\text{m}$  high; hymenium pale yellow, subhymenium white. Asci clavate, long-stalked with a basal foot, tip rounded, pore bluing in iodine, 90-125  $\times$  13-15  $\mu\text{m}$ , 8-spored. Ascospores oval, fusoid or flattened on one side, hyaline, nonseptate, 18-25  $\times$  6-7.5  $\mu\text{m}$ . Paraphyses filiform, nonseptate.

HOSTS: *Pseudotsuga menziesii*, *Abies lasiocarpa*, *A. balsamea*, *A. grandis*

DISEASE: Snow-blight; the fungus invades the foliage while covered with a layer of snow, spreading by a profuse web-like, white mycelium. Chemical control methods were devised (Smerlis 1979).

NOTES: In Europe, the related fungus *Phacidium infestans* Karsten causes snow-blight of conifers but this species is unknown in North America.

***Phacidium pini-cembrae*** (Rehm) Terrier is occasionally found on Douglas-fir. This species has two sizes of asci, the larger being 8-spored, measuring 85-125  $\times$  8-12  $\mu\text{m}$  and the smaller being 40-70  $\times$  8-12  $\mu\text{m}$  and 1-5-spored. Ascospores in the smaller asci are occasionally 1-3-septate.

***Phacidium dearnessii*** DiCosmo, Nag Raj & Kendrick (1983) has been found on needles of western yew with ascospores 6-11  $\times$  3-5  $\mu\text{m}$ . The anamorph is *Apostrasseria robusta* Nag Raj with lunate conidia 5-9  $\times$  3-4  $\mu\text{m}$  (Nag Raj 1983).

***Phacidium sherwoodiae*** DiCosmo, Nag Raj & Kendrick (1983) has been reported on dead leaves of western red cedar; ascospores are subfusiform, 9-11  $\times$  3-4  $\mu\text{m}$ . The anamorph is *Ceuthospora* with rod-shaped, appendaged conidia (DiCosmo *et al.* 1983) that I have found on needles of Douglas-fir and Noble fir (Fig. 47).

***Phaeocryptopus gaeumannii*** (Rohde) Petrak Ann. Mycol. 36: 22 (1938).

SYNONYM: *Adelopus gaeumannii* Rohde

Pseudothecia black, globose, smooth, developing from a knot of dark cells within the stoma of the leaf and becoming superficial, wall of dark, subglobose cells one or two layers thick, 50-80  $\mu\text{m}$  diameter. Asci bitunicate, clavate or slightly ventricose, 8-spored, 30-40  $\times$  8-15  $\mu\text{m}$ . Ascospores slightly clavate, hyaline to pale yellow, 10-15  $\times$  3.5-5  $\mu\text{m}$ , close to centrally 1-septate (Fig. 48).

HOST: *Pseudotsuga menziesii*

DISEASE: Causes the "Swiss Needle Cast" of Douglas-fir. Locally or generally severe at the coast and interior when climatic conditions favor spread (Hood 1982). Damage to Christmas tree plantations by needle discolora-

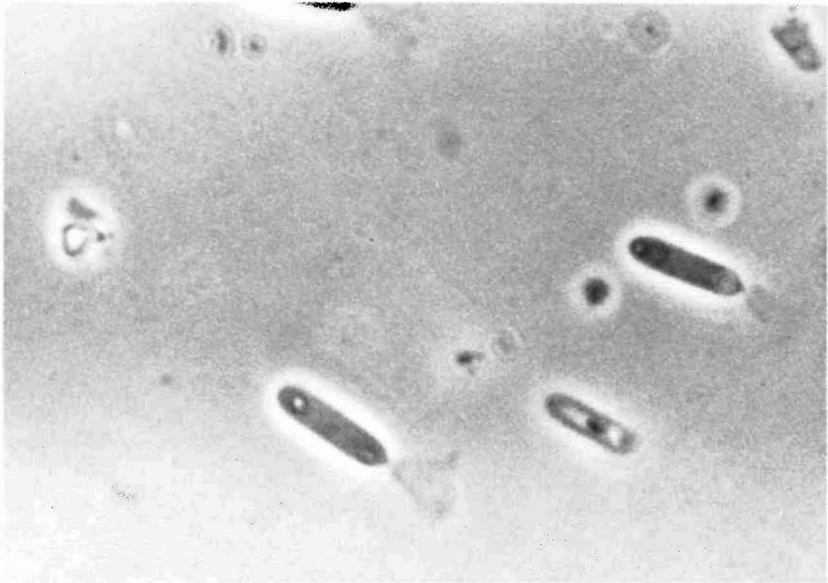
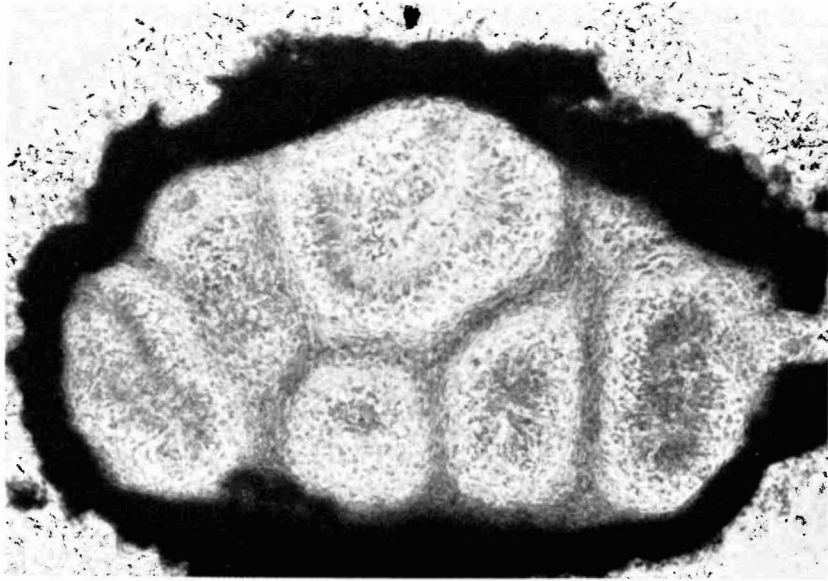


Fig. 47. *Phacidium sherwoodiae*. *Ceuthospora* anamorph. Conidia.

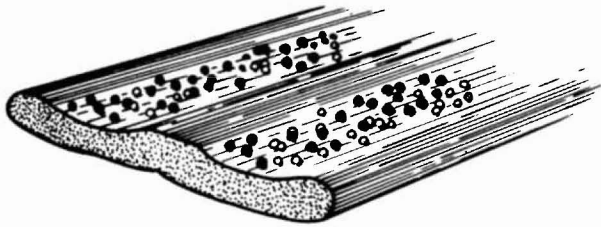
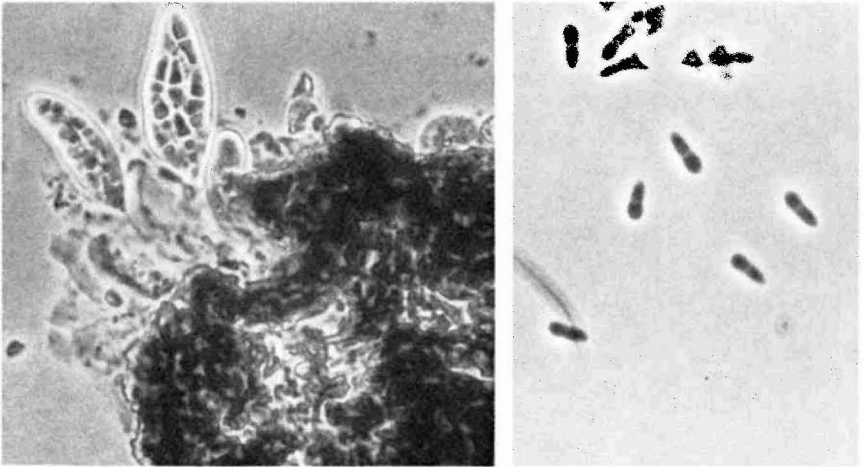


Fig. 48. *Phaeocryptopus gaeumannii*. Ascomata on Douglas-fir needle (after Butin).

tion to yellow or brown; loss of one- and two-year-old needles in summer.

NOTES: Hood (1979, 1982) has worked on infection, control and life cycle of *P. gaeumannii* in New Zealand and Canada; Chastagner and Byther (1983 a, b) studied infection and control in Washington state, U.S.A. Ascospores mature in April and May on one-year-old needles.

***Phaeocryptopus nudus*** (Peck) Petrak Ann. Mycol. 36: 15 (1938).

SYNONYM: *Adelopus nudus* (Peck) Theiss.

Pseudothecia black, globose, smooth, superficial on the needle, attached by a peg of tissue inserted in the stoma and continuous with the intercellular hyphae, walls of dark, subglobose cells, one or two layers thick, opening by a small pore, 80-155  $\mu\text{m}$  diameter. Asci bitunicate, clavate to ventricose, 32-56  $\times$  11-15  $\mu\text{m}$ , surrounded by deliquescing paraphysoids, 8-spored. Ascospores slightly clavate, hyaline to pale brown, near centrally 1-septate, 10-15  $\times$  4-5  $\mu\text{m}$ , biseriate.

HOSTS: *Abies amabilis*, *A. balsamea*, *A. lasiocarpa*, *Picea sitchensis*

DISEASE: Mildly parasitic or saprophytic. Causes browning of needles. Often colonizes needles killed by *Lirula abietis-concoloris*.

***Phaeoseptoria contortae*** Parmelee & Hiratsuka Can. J. Bot. 48: 1003 (1970).

Pycnidia immersed, black, globose, amphigenous, 150-200  $\mu\text{m}$  diameter with short neck. Conidiophores short, simple, lining interior wall of pycnidium. Conidiogenous cells acrogenous. Conidia fusoid to falcate, pale brown, 3-4-septate, 25-45  $\times$  3-4  $\mu\text{m}$ , oozing out in brown tendrils (Fig. 49).

HOST: *Pinus contorta*

DISEASE: Appears to cause blight of one-year-old pine needles, but pathogenicity not proved. In the type specimen associated with *Davisiomycella ampla*.

NOTE: *Periperidium acicola* Darker has conidia of similar form but is found on black spruce needles in Ontario. Its teleomorph is the phacidiaceous discomycete, *Micraspis acicola* (Darker 1963).

***Phoma glomerata*** (Corda) Wr. & Hochapf. Z. Parasit Kde. 8: 592 (1936).

Pycnidia globose to pyriform or elongated, with long necks and often with more than one ostiole, dark brown, 50-300  $\mu\text{m}$  in diameter; wall of dark pseudopa-

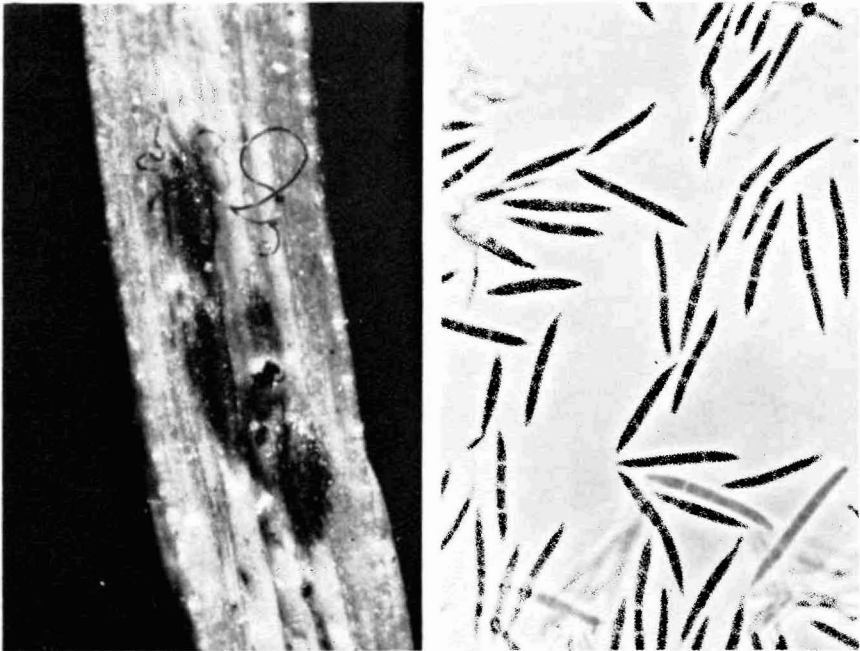


Fig. 49. *Phaeoseptoria contortae*. Conidiomata on leaves. Conidia.

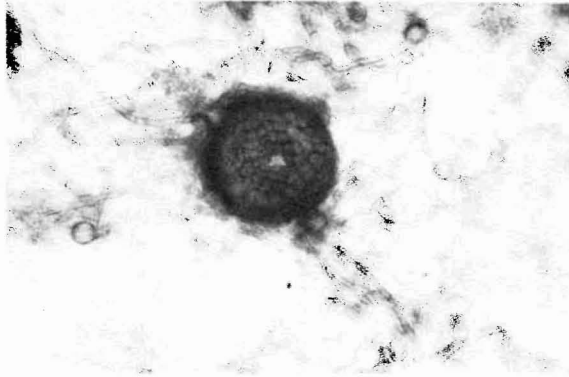


Fig. 50. *Phoma* sp. Pycnidium, top view.

renchyma outside, of subhyaline, thin-walled cells inside, bearing conidiophores. Conidia unicellular, rarely 1-septate, ellipsoid to oblong or obovate, guttulate, subhyaline, smooth, pale olive-brown with minutely roughened wall,  $5-10 \times 2.5-4 \mu\text{m}$ .

Dictyochlamydospores brown, in chains sometimes branched, irregularly ovate, up to 9 transverse septa and 3-6 longitudinal septa (produced in culture).

HOSTS: Conifers

DISEASE: Causes damping-off of conifer seedlings.

NOTES: *Phoma pomorum* Thuem. (= *P. prunicola* (Opiz.) Wr. & Hochapf.) is also found on conifer seedlings, but this species produces chlamydospores terminally and singly, not in chains (Fig. 50).

***Phomopsis lokoyae*** Hahn Mycologia 25:369 (1933).

TELEOMORPH: *Diaporthe lokoyae* Funk

Pycnidia erumpent, black, lenticular to subglobose, 300-600  $\mu\text{m}$  diameter, 200-300  $\mu\text{m}$  high. Conidiophores lining the single locule, flexuous, subulate, 5-20  $\mu\text{m}$  long; conidiogenous cells phialidic. Conidia of 2 types: A-spores hyaline, elliptic-fusoid (irregular), nonseptate, biguttulate,  $6-10 \times 2-4 \mu\text{m}$ ; B-spores hyaline, elongate-fusiform, nonseptate, minutely guttulate,  $10-12 \times 1.5-2.5 \mu\text{m}$  (Fig. 51).

HOSTS: *Pseudotsuga menziesii*, occasionally on *Tsuga heterophylla* and *Thuja plicata*

DISEASE: Top-killing of nursery seedlings.

NOTES: Only pycnidia are found on needles. A weak parasite, ***Phomopsis occulta*** Trav., occurs on needles of nursery seedlings of many conifers; A-conidia are ellipsoid,  $6-9 \times 2-3 \mu\text{m}$ , B-conidia filiform, curved,  $20-30 \times 1 \mu\text{m}$ ; some conidia may be intermediate in shape and size (Fig. 52).

***Phomopsis conorum*** (Sacc.) Died. has also been found on needles of blighted conifer seedlings. It is distinguished by its relatively large A-conidia ( $6-15 \times 3-5 \mu\text{m}$ ) and its strongly curved (horseshoe-shaped) B-conidia that measure  $10-35 \times 1 \mu\text{m}$ .

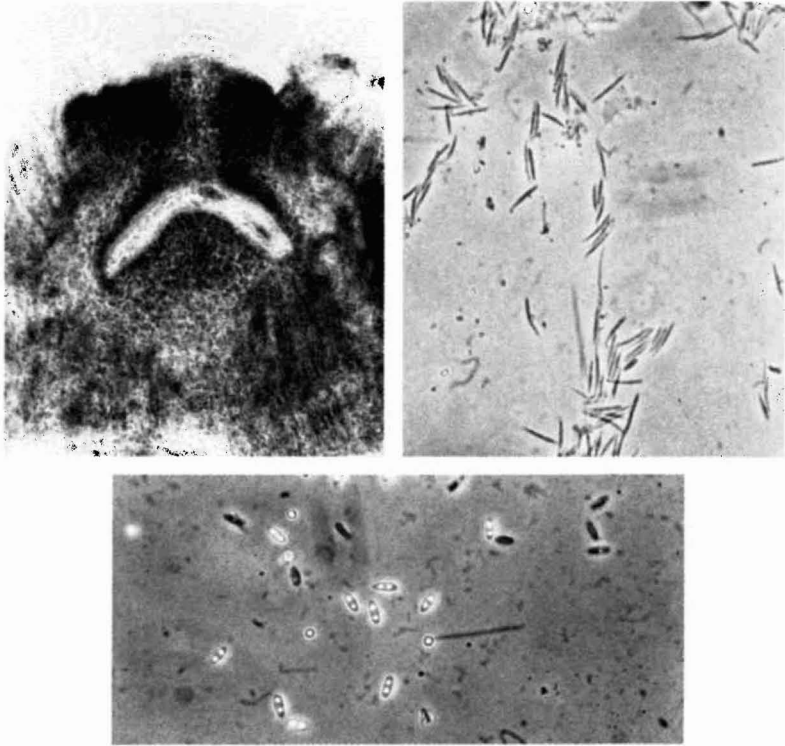


Fig. 51. *Phomopsis lokoyae*. Pycnidium, vertical section. Conidia of two types.

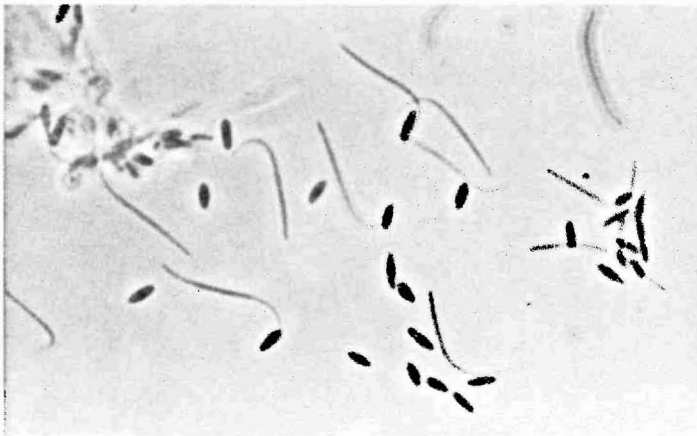


Fig. 52. *Phomopsis occulta*. Conidia of two types.

***Phyllactinia guttata*** (Fr.) Lév. Ann. Sci. Nat. Bot. III, 15: 144 (1851).

ANAMORPH: *Oidium*

Perithecia superficial, subglobose, black, up to 175  $\mu\text{m}$  diameter, nonostiolate, bearing around the equator a ring of 5-18 stiff, pointed, hyaline setae, 200-600  $\mu\text{m}$  long, with a subglobose swelling at the base; the apex of the perithecium bears a tuft of short setae. Asci numbering up to 45, ovoid, more or less stalked, 60-100  $\times$  25-40  $\mu\text{m}$ , usually 2-spored. Ascospores ovoid, 30-40  $\times$  16-25  $\mu\text{m}$ .

Conidiophores 1-4-septate, 100-500  $\times$  8-9  $\mu\text{m}$ . Conidia clavate or rhomboid, 75  $\times$  25  $\mu\text{m}$ .

HOSTS: *Alnus*, *Amelanchier*, *Betula*, *Cornus*

DISEASE: Powdery mildew of leaves.

***Phyllosticta cornicola*** (DC.) Rabenh. Kl. Herb. Myc. No. 454 (1855).

Pycnidia epiphyllous, sparse, punctiform, lenticular, with apical pore, 150-200  $\mu\text{m}$  diameter. Conidiophores subulate, simple or branched, phialidic. Conidia hyaline, nonseptate, ellipsoid-fusiform, biguttulate, 7-9  $\times$  3-4  $\mu\text{m}$ .

HOST: *Cornus nuttallii*

DISEASE: Leaf blotch of flowering dogwood (Fig. 27). The blotches are typically brown, wedge-shaped at the leaf tips, less frequently from the edges. Infections occur in spring and may cause early leaf fall, but most trees produce a second set of leaves. *Gloeosporium* "corni" has also been linked to leaf blotch (q.v.).

***Phyllosticta*** sp.

Pycnidia black, globose, erumpent, hypophyllous, approximately 150  $\mu\text{m}$  diameter. Conidiogenous cells lining inner wall of pycnidium, awl-shaped, phialidic. Conidia globose, hyaline, thick-walled, 8-10  $\mu\text{m}$  diameter, without appendages (Fig. 52a).

HOST: *Abies grandis*

DISEASE: Needle blight of grand fir in Christmas tree plantations. Tips or segments of needles become bright red. Reported only from Idaho, U.S.A.

***Phyllostictina hysterella*** (Sacc.) Petr. Trans. Brit. Mycol. Soc. 22: 102 (1938-39).

TELEOMORPH: *Physalospora gregaria* Sacc.

Pycnidia immersed, subgregarious, dark brown, subglobose to ovoid, 185-210  $\times$  140-180  $\mu\text{m}$ , ostiole indistinct, wall of dark brown elongated cells, young pycnidia filled with parenchymatous cells. Conidiophores straight, cylindrical, tapered at the tip, 5-11  $\times$  2-3  $\mu\text{m}$ . Conidia in mucilage, oval to elliptical, unicellular, hyaline, filled with granular cytoplasm, 10-16  $\times$  8-10  $\mu\text{m}$ .

HOST: *Taxus brevifolia*

DISEASE: Causes shoot and leaf blight of western yew.

NOTES: The teleomorph has not been found in the range of western yew.



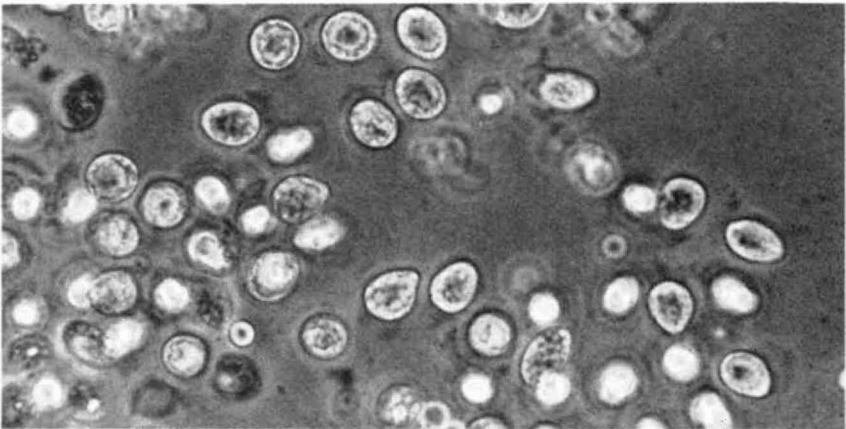
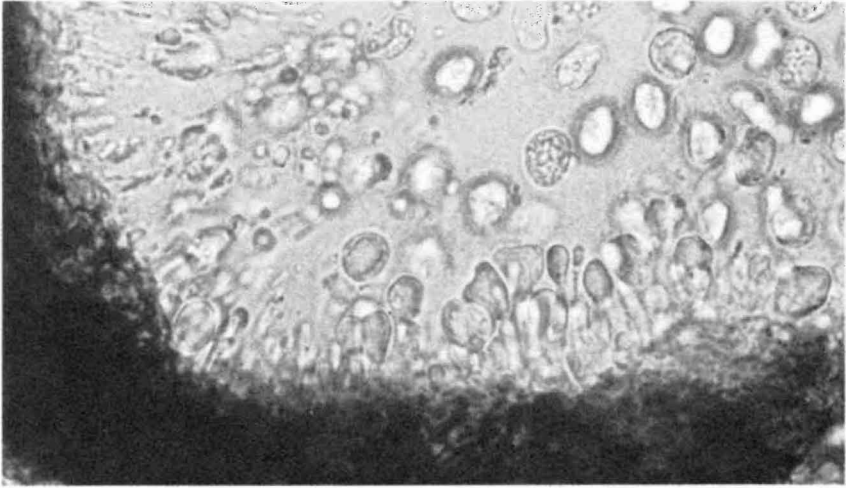
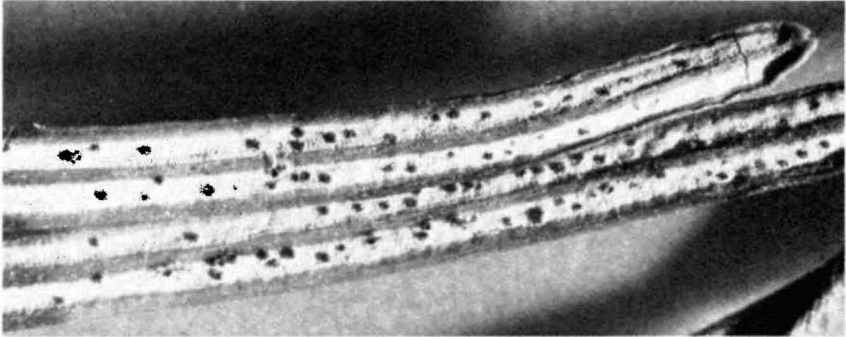


Fig. 52a. *Phyllostica* sp. Pycnidia in balsam fir needle. Conidiophores.  
Conidia

***Pithya cupressina*** (Fr.) Fckl. Jahrb. Nass. Naturk 23-24: 317 (1870).

Apothecia bright orange, approx 1 mm diameter, disc flat, short-stalked, excipulum paler orange. Asci 8-spored,  $210 \times 12 \mu\text{m}$ . Ascospores uniseriate in the ascus, globose, hyaline, nonseptate, 9-10  $\mu\text{m}$  diameter. Paraphyses cylindrical, slightly enlarged at the tip to 4  $\mu\text{m}$ .

HOSTS: *Thuja*, *Juniperus*

NOTE: Saprophytic.

### Key to *Rhabdocline* (Parker & Reid 1969)

1. Ascus pore lacking, not bluing in iodine (Melzer's Reagent)
  - A. Apothecia hypophyllous, rarely epiphyllous; paraphyses filamentous or slightly swollen at tips; sometimes associated with *Rhabdogloeum hypophyllum*..... *R. pseudotsugae* subsp. *pseudotsugae*
  - B. Apothecia epiphyllous; paraphyses with swollen tips to 10  $\mu\text{m}$ ; on one-year-old needles only; absent from interior dry belt .....  
..... *R. pseudotsugae* subsp. *epiphylla*
2. Ascus with pore, bluing in iodine
  - A. Ascospores oblong to slightly constricted at the middle; apothecia hypophyllous, on one-year-old or older needles.
    1. Apothecia varying in size and shape; on 1-yr-old and older needles; associated with *Rhabdogloeum pseudotsugae* ..... *R. weirii* subsp. *weirii*
    2. Apothecia rectangular, occupying width of needle; on 1-yr-old needles ....  
..... *R. weirii* subsp. *oblonga*
  - B. Ascospores obovate, 1- or 2-celled, apothecia hypophyllous, on 2-year-old and older needles ..... *R. weirii* subsp. *obovata*

***Rhabdocline pseudotsugae*** Syd. Ann. Mycol. 20: 194 (1922).

ANAMORPH: ? *Rhabdogloeum hypophyllum* Ell. & Gill

Apothecia chiefly hypophyllous orange to red-brown, on one or both sides of needle midrib; erumpent by median splitting of overlying epidermis, or by circumscissile or lateral splitting when apothecia small; hypothecium poorly developed, no epithelial tissue, excipulum of marginal paraphyses only; situated in necrotic spots that are roughly circular, band-like or extending up to entire length of needle, discrete or confluent in the necrotic spots, 0.5-1.0  $\times$  0.3-0.6 mm. Asci clavate, broadest below apex which is flattened, 8-spored, opening by a pseudooperculum or a bilabiate split of the apex, does not stain with iodine (J-), 120-160  $\times$  16-22  $\mu\text{m}$ . Ascospores at first hyaline and 1-celled, becoming 2-celled with one cell turning dark brown, oblong with obtuse ends, slightly constricted at the middle, 13-19  $\times$  5-8  $\mu\text{m}$ , with a thick, gelatinous sheath. Paraphyses septate, up to 2.5  $\mu\text{m}$  thick, sometimes slightly swollen at the tips, extending beyond the asci to form an epithecium (Fig. 53).

HOST: *Pseudotsuga menziesii*

DISEASE: Needle cast of Douglas-fir. Apothecia mature in May-June on one-

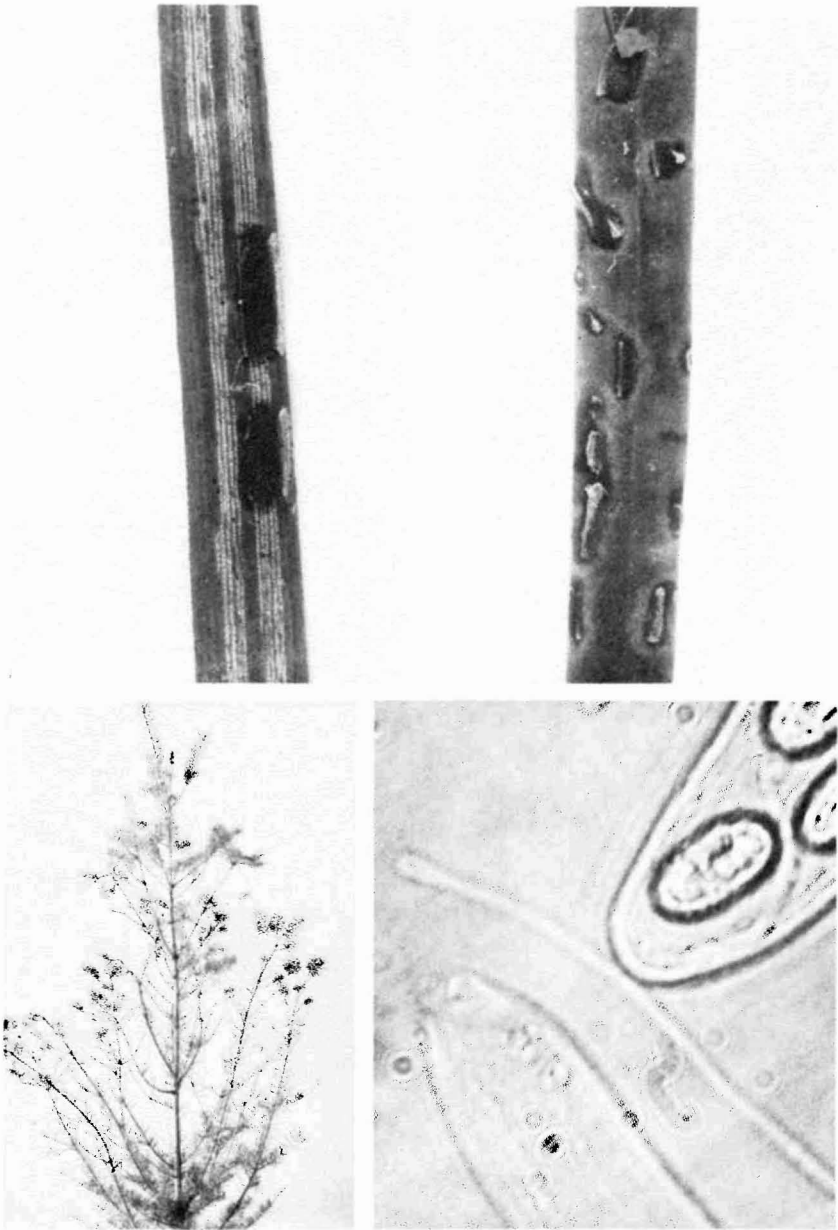


Fig. 53. *Rhabdocline pseudotsugae*. Ascomata in needles, subsp. *pseudotsugae* (left), subsp. *epiphylla* (right). Typical defoliation pattern in young Douglas-fir. Ascus tip showing thin wall and split. (Photos by Parker and Reid).

year-old needles and ascospores infect only current season's needles. There is much variation in susceptibility to this disease. Needles are usually cast right after ascospore discharge (June, July) (Parker 1970).

NOTES: *R. pseudotsugae* subsp. *epiphylla* Parker & Reid is basically similar with J- asci, but differs in that apothecia are chiefly epiphyllous, and less than 4 mm long; asci measure  $80-120 \times 18-22 \mu\text{m}$ ; ascospores broadly ellipsoid,  $14-21 \times 6-9 \mu\text{m}$ ; paraphyses swollen at the tips to  $10 \mu\text{m}$  wide and pale brown; occurs on one-year-old needles only. Absent from interior dry-belt of British Columbia.

Chemical control of Rhabdocline needle blight is practical with organic fungicides as well as copper (Morton and Miller 1982).

***Rhabdocline weirii*** Parker & Reid Can. J. Bot. 47: 1540 (1969).

ANAMORPH: *Rhabdogloeum pseudotsugae* Syd.

Apothecia hypophyllous, orange to red-brown, on one or both sides of needle midrib, erumpent by lateral splitting of overlying epidermis; hypothecium poorly developed, pseudoparenchymatous; excipulum of marginal paraphysis-like elements; situated in necrotic bands of tissue of varying length which may extend across entire width of the needle, irregular, circular or rectangular, 1-10 mm long, orange to red-brown. Asci clavate, broadest below the flattened apex, 8-spored, opening by a pore, the pore staining blue in iodine (J+),  $100-130 \times 15-20 \mu\text{m}$ . Ascospores at first hyaline and 1-celled, becoming 2-celled and one cell turning dark brown, oblong, slightly constricted in the middle,  $13-19 \times 4-8 \mu\text{m}$ , with a thick gelatinous sheath. Paraphyses septate, up to  $2.5 \mu\text{m}$  thick, sometimes slightly swollen at the tips (Fig. 54).

Acervuli abundant, scattered, gregarious or confluent, amphigenous, linear, up to 2 mm long,  $200-250 \mu\text{m}$  wide, at first covered, later exposed by the rupture of the epidermis and cuticle. Stroma pseudoparenchymatous, immersed in the substratum, subepidermal, composed of hyaline cells. Conidiogenous cells arising from the upper cells of the stroma, compactly arranged, phialidic, cylindrical to ampulliform, short, hyaline, smooth-walled, with a small collarete, sometimes proliferating percurrently once or twice,  $9-20 \times 4-6.5 \mu\text{m}$ . Conidia formed in succession from phialides, solitary, cylindrical or dumb-bell-shaped, unicellular, guttulate, hyaline, smooth-walled, obtuse at the apex, truncate at the base,  $14-17 \times 4-6 \mu\text{m}$ , with an apical or subapical, filiform, erect or flexuous, mucoid appendage,  $3-5.5 \times 1.5-2 \mu\text{m}$ .

HOST: *Pseudotsuga menziesii*

DISEASE: Needle cast of Douglas-fir.

NOTES: *R. weirii* subsp. *obovata* Parker & Reid is basically similar with J+ asci, but differs in that the ascospores are obovate in shape and it is not associated with a *Rhabdogloeum*; apothecia usually on both sides of midrib, linear; asci  $90-145 \times 16-20 \mu\text{m}$ ; ascospores obovate, with upper part broader,  $16-22 \times 6-9 \mu\text{m}$ ; occurs on two-year-old and older needles.

*R. weirii* subsp. *oblonga* Parker & Reid is very similar to *R. weirii* subsp. *weirii* but is not associated with a *Rhabdogloeum* and apothecia occur chiefly on one-year-old needles. Has not been found in British Columbia.

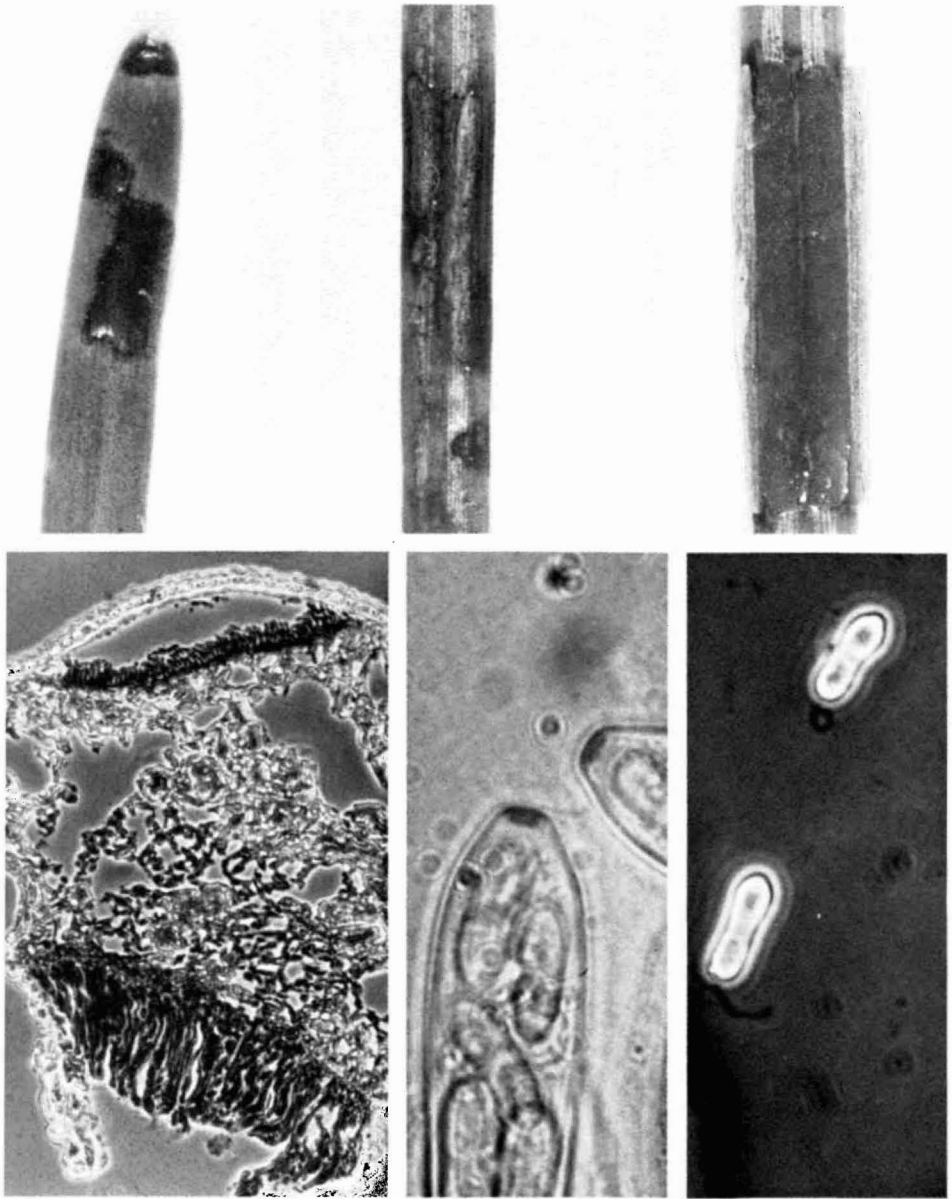


Fig. 54. *Rhabdocline weirii*. *Rhabdogloeum* state on upper surface of needle (left). Ascomata of subsp. *oblonga* (mid) and of subsp. *obovata* (right). Needle section of subsp. *weirii* showing *Rhabdogloeum* state above, ascoma below. Ascus tips showing iodine positive pore. Conidia of *Rhabdogloeum pseudotsugae*.

***Rhizosphaera kalkhoffii*** Bub. Ber. Deutsch. Bot. Gesell. 32: 188 (1914).

IN CULTURE: *Hormonema*

Pycnidia black, globose, smooth, lacking an ostiole, emerging from stomata in regular rows, carrying the waxy stomatal plug on top,  $45-75 \times 30-85 \mu\text{m}$ , with a stalk of mycelial strands, pycnidial wall one cell thick. Conidiophores absent. Conidiogenous cells monophialidic in the pycnidial wall. Conidia nonseptate, hyaline, elliptic to ovoid, rounded at the ends,  $5-10 \times 3-5 \mu\text{m}$ .

HOSTS: *Abies*, *Pinus*, *Pseudotsuga*

DISEASE: Needle blight (Kumi and Lang 1979; Tanaka and Chiba 1971).

NOTES: Waterman (1947) reported the disease in eastern North America, but it is widespread in the west at a moderate level. *R. oudemansii* Maubl., with conidia  $9-16 \times 5-9 \mu\text{m}$ , has been reported on *Tsuga* needles from Alaska (Sutton 1980).

***Rhizosphaera pini*** (Corda) Maubl. Bull. Soc. Mycol. France 23: 171 (1907).

Pycnidia black, subglobose, smooth, with a small apical ostiole, emerging from stomata in regular rows, carrying the waxy stomatal plug on top,  $50-65 \times 55-125$

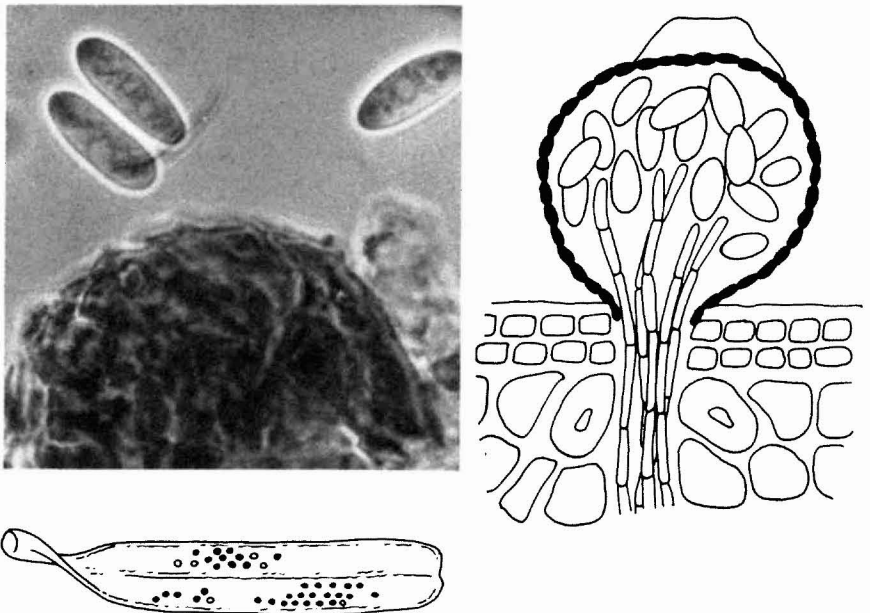


Fig. 55. *Rhizosphaera pini*. Pycnidia on needle. Pycnidium emerging from stomate. Conidia (after Diamandis and Minter).

$\mu\text{m}$ , supported by a stalk-like mycelial strand, pycnidial wall one cell thick. Conidiophores absent. Conidiogenous cells monophialidic in pycnidial wall. Conidia hyaline, nonseptate, elliptic to ovoid, rounded at the ends,  $15\text{-}32 \times 7\text{-}12 \mu\text{m}$  (Fig. 55).

HOSTS: *Picea sitchensis*, *Pinus monticola*, *Abies lasiocarpa*

DISEASE: Needle blight.

NOTES: In culture *R. pini* produces rudimentary pycnidia (Gourbiere and Morelet 1980).

***Rhizothyrium abietis*** Naum. Bull. Soc. Mycol. France 30: 423 (1915).

TELEOMORPH: *Rhizocalyx abietis* Petrak

Conidiomata superficial, with clypeus of dark brown radiating filaments, supported by a central columella or hyphal mass; inner tissue hyaline, flaring outward parallel to the clypeus, terminating in the conidiophores. Conidiomata  $70\text{-}200 \mu\text{m}$  diameter,  $20\text{-}40 \mu\text{m}$  thick. Conidiophores  $6\text{-}10 \mu\text{m}$  long. Conidiogenous cells phialidic, terminal. Conidia hyaline, elliptic, 3-septate,  $16\text{-}23 \times 5\text{-}6 \mu\text{m}$  (Fig. 56).

Apothecia superficial, stalked, black, smooth,  $100\text{-}320 \mu\text{m}$  diameter,  $190\text{-}250 \mu\text{m}$  high. Asci clavate, thickened at the apex, pore stained blue in iodine, 8-spored,  $65\text{-}115 \times 10\text{-}16 \mu\text{m}$ . Paraphyses filiform, colored at the tips. Ascospores hyaline, elliptic to clavate, 0-4-septate, guttulate,  $9\text{-}28 \times 4\text{-}6 \mu\text{m}$ .

HOST: *Abies lasiocarpa*

DISEASE: Weakly parasitic on needles, frequently associated with other pathogens such as *Phaeocryptopus nudus* and *Nothophacidium phyllophilum* (q.v.) (Darker 1965).

NOTES: The relationship of the teleomorph of *Rhizothyrium abietis* was proven by Smerlis (1967); it appears to be rare in the west.

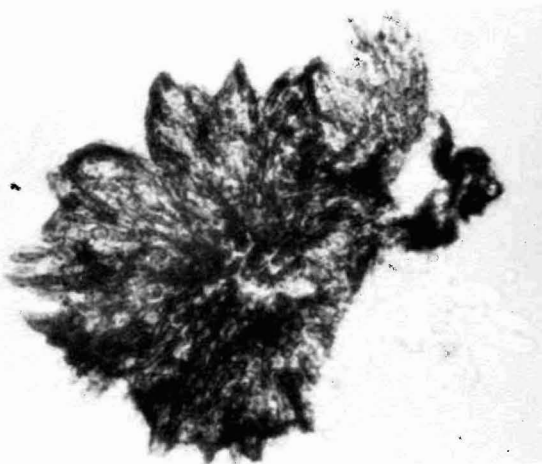


Fig. 56. *Rhizothyrium abietis*. Conidioma and conidia.

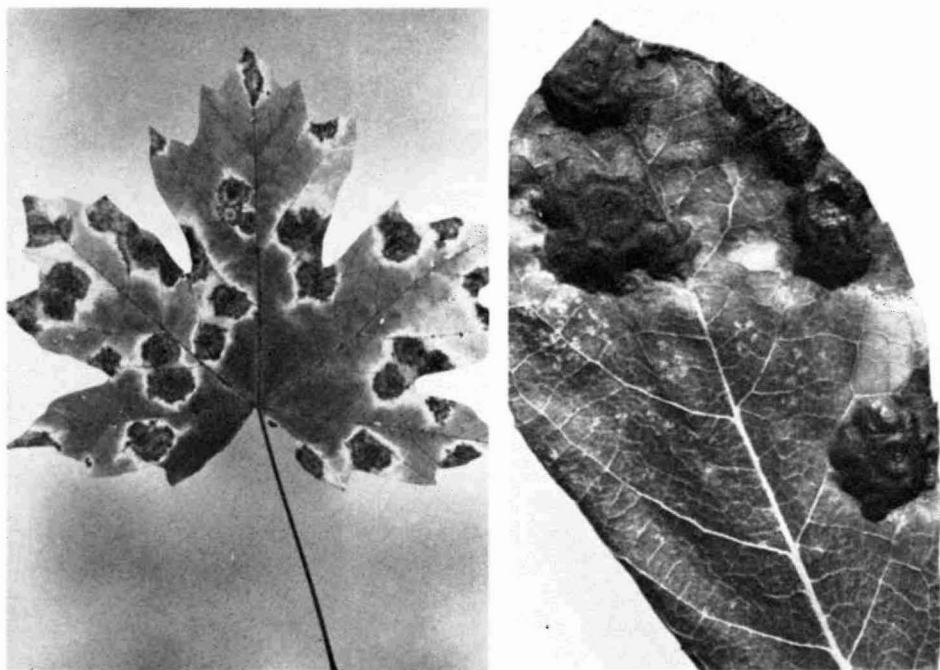


Fig. 57. *Rhytisma punctatum*. Ascomata on broadleaf maple. *R. salicinum*, stromata on willow.

***Rhytisma punctatum*** (Pers.) Fr. Syst. Mycol. 2:569 (1823).

ANAMORPH: *Melasmia punctata* Sacc. & Roum.

Stromata black, punctate or speck-like, circular, approximately 1 mm diameter, 20-30 aggregated in infected area of leaf, each containing a single apothecium or hymenial area. Asci clavate,  $70-80 \times 9-10 \mu\text{m}$ , 8-spored. Ascospores filiform, slightly broader above, nonseptate, guttulate, hyaline,  $30-36 \times 1.5-2 \mu\text{m}$ . Paraphyses filiform (Fig. 57).

Pycnidia forming in stromata singly. Conidiophores cylindric, simple or branched. Conidia allantoid, hyaline,  $4-6 \times 1 \mu\text{m}$ . Conidiogenous cells enteroblastic, phialidic.

HOSTS: *Acer macrophyllum*, *A. spicatum*

DISEASE: Speckled tar spot of maple leaves.

NOTE: Apothecia develop in the stromata of the fallen leaves and the ascospores are released in spring.

***Rhytisma salicinum*** (Pers.) Fr. Syst. Mycol. 2:568 (1823).

ANAMORPH: *Melasmia salicina* Lev.

Stromata black, circular, raised in the center approximately 2-5 mm diameter on the upper surfaces of leaves, containing numerous hymenial areas or apothecia



which become exposed by fissures in the crust, disc grey. Asci clavate, 8-spored,  $120-150 \times 10-15 \mu\text{m}$ . Ascospores filiform, hyaline,  $60-90 \times 1.5-3 \mu\text{m}$ , nonseptate, guttulate. Paraphyses filiform.

Pycnidia forming in the stromata, 2-3 in number,  $130-160 \mu\text{m}$  diam. Conidiophores densely crowded on basal stratum,  $16-23 \times 1-2 \mu\text{m}$ . Conidia cylindrical, hyaline,  $5-6 \mu\text{m}$  long. Conidiogenous cells enteroblastic, phialidic (Sutton 1980).

HOST: *Salix*

DISEASE: Tar spot of willow leaves (Fig. 57).

NOTES: The pycnidial state forms first. The apothecia form in the same stromata after leaves have fallen.

*Rhytisma arbuti* Phillips was reported on tar spot of *Arbutus menziesii* (madrone) on the west coast (see discussion under *Coccomyces arbutifolius*).

***Rosellinia herpotrichioides*** Hept. & Davidson *Phytopathology* 27: 307 (1937).

Subiculum a light gray mycelial mat, forming under leaves and branches. Perithecia embedded in subiculum, black, carbonaceous, wrinkled, papillate, gregarious, globose,  $500-900 \mu\text{m}$  diameter. Asci cylindrical, with gelatinous pore at the apex, 8-spored,  $185-210 \times 11-14 \mu\text{m}$ . Ascospores uniseriate, dark brown, unicellular, inequilaterally ovate, with longitudinal germ slit,  $23-26 \times 9-10 \mu\text{m}$  (Fig. 58).

Botrytis-like conidial state produced in subiculum, conidia hyaline, ovoid,  $5-8 \times 3-5 \mu\text{m}$ .

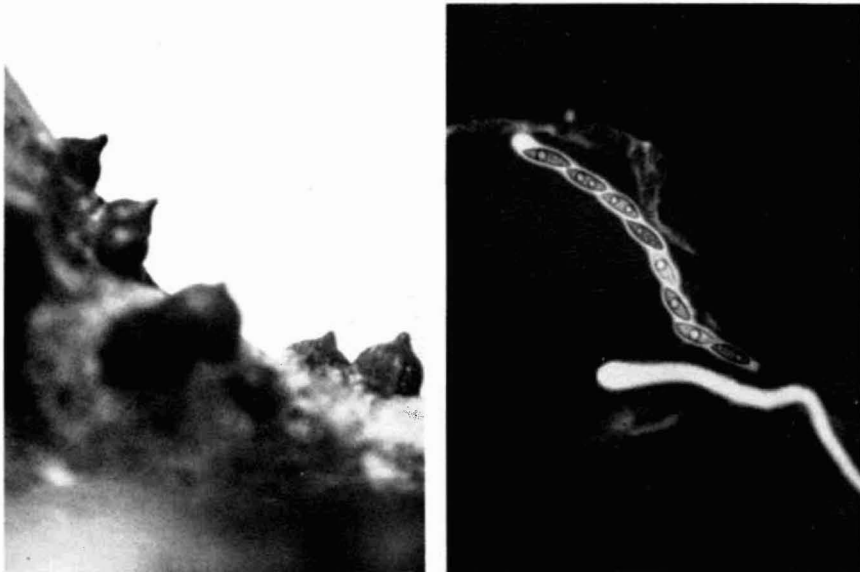


Fig. 58. *Rosellinia herpotrichioides*. Perithecia. Ascus and ascospores.

HOST: *Pseudotsuga menziesii*

DISEASE: Causing twig and leaf blight (smothering-disease) of young Douglas-fir seedlings in nurseries.

NOTES: This species on seedlings in British Columbia has smaller spores than the type, and is considered a new species by S.M. Francis (personal communication).

***Sarcotrochila alpina*** (Fckl.) Hoehn. Sitzb. K. Akad. Wiss. Wien 126: 310 (1917).

SYNONYMS: *Naemacyclus alpinus* Fckl., *Stegia alpina* (Fckl.) Rehm

Apothecia amphigenous, sessile, subepidermal and then erumpent, dehiscing laterally producing a lid of epidermis, irregularly rectangular, 0.4-0.8 mm long; covering layer lacking; hymenium yellowish-brown. Asci clavate, 8-spored, pore bluing in iodine (J+), 45-55 × 10-12 μm. Ascospores fusiform, hyaline and non-septate at first, but may become light brown and 1-3-septate in age. Paraphyses simple, septate, up to 9 μm wide above, far exceeding length of asci.

HOST: *Larix lyallii*

DISEASE: Needle blight of young trees (Ziller 1969a).

NOTES: The fungus fruited on red-brown attached needles. Occasionally associated with *Lophodermium laricinum*. Rare.

***Sarcotrochila macrospora*** Ziller & Funk Can. J. Bot. 51: 1960 (1973).

Apothecia amphigenous, sessile, subepidermal and then erumpent producing a circumscissile lid of epidermis, subcircular to polygonal, 200-500 × 300-800 μm; excipulum poorly developed, reddish-brown, 20-30 μm thick; covering layer lacking; hymenium flat, brownish. Asci cylindrical to truncate-clavate, 8-spored, pore staining blue in iodine (J+), 90-145 × 10-15 μm. Ascospores hyaline, clavate, nonseptate, 50-100 × 2-4 μm, sometimes with a knob at lower end. Paraphyses filiform, septate, swollen at the apex, sometimes branched (Fig. 59).

HOST: *Pinus contorta*

DISEASE: Secondary invader of needles attacked by *Davisiomycella ampla*.

NOTE: Found on two- to three-year-old needles on trees growing not more than 8 km from the seashore.

***Sarcotrochila piniperda*** (Rehm) Korf Mycologia 54: 30 (1962).

SYNONYM: *Naevia piniperda* Rehm

Apothecia amphigenous, intraepidermal, erumpent, pushing a flap of epidermis up. Excipulum of parallel rows of dark walled, septate hyphae, free at the tips. Asci clavate, 8-spored, pore blue in iodine (J+), 55-90 × 6-9 μm. Ascospores hyaline, nonseptate, ellipsoid, 9-14 × 3.5-6 μm. Ascospores in overwintered apothecia may become brown, 1-2-septate. Paraphyses filiform, slightly swollen at the apex.

HOSTS: *Picea sitchensis*, *P. glauca*

DISEASE: Secondary to *Lirula macrospora*. Reid and Cain (1962) considered it the cause of snow-blight of spruce but this does not appear to occur in the west (Table 5).

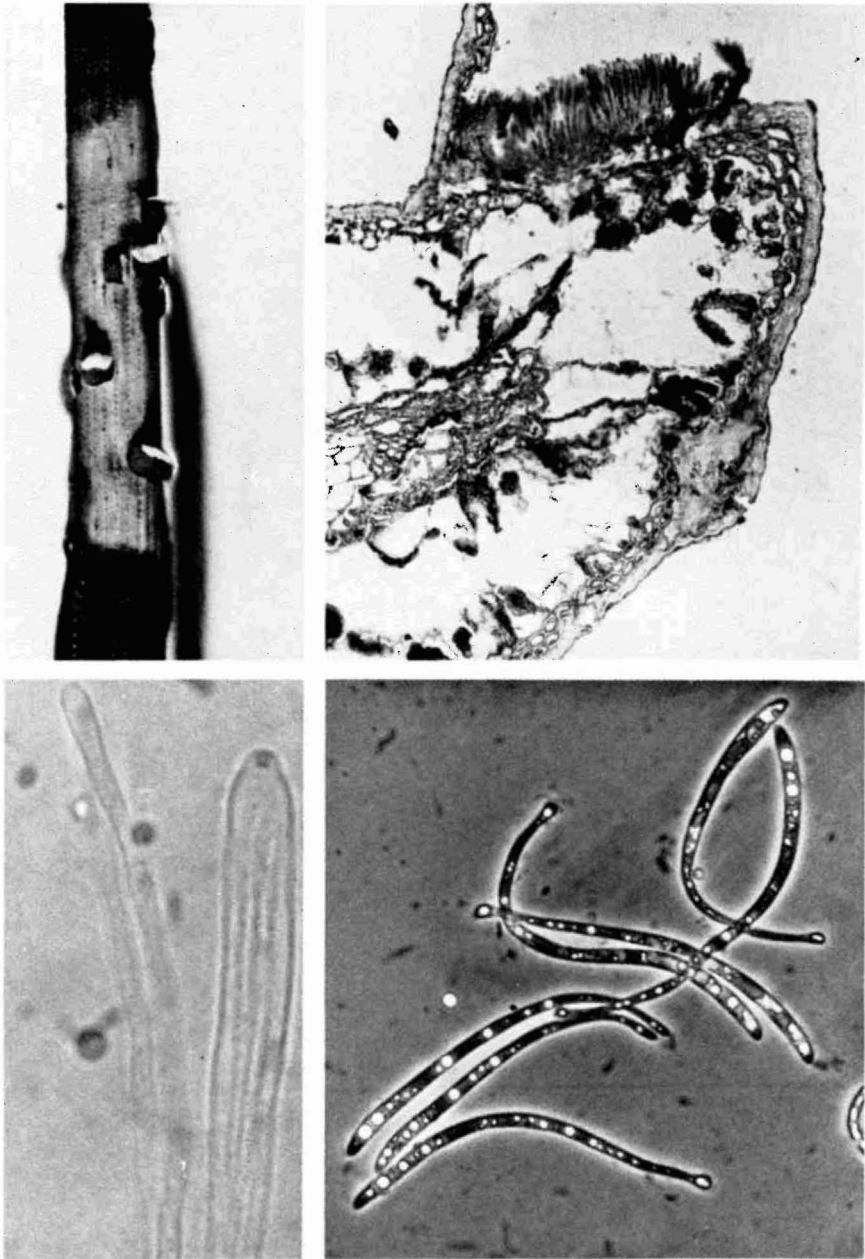


Fig. 59. *Sarcotrochila macrospora*. Ascomata on pine needle. Vertical section, ascoma. Ascus and paraphyses showing J+ ascus pore. Ascospores.

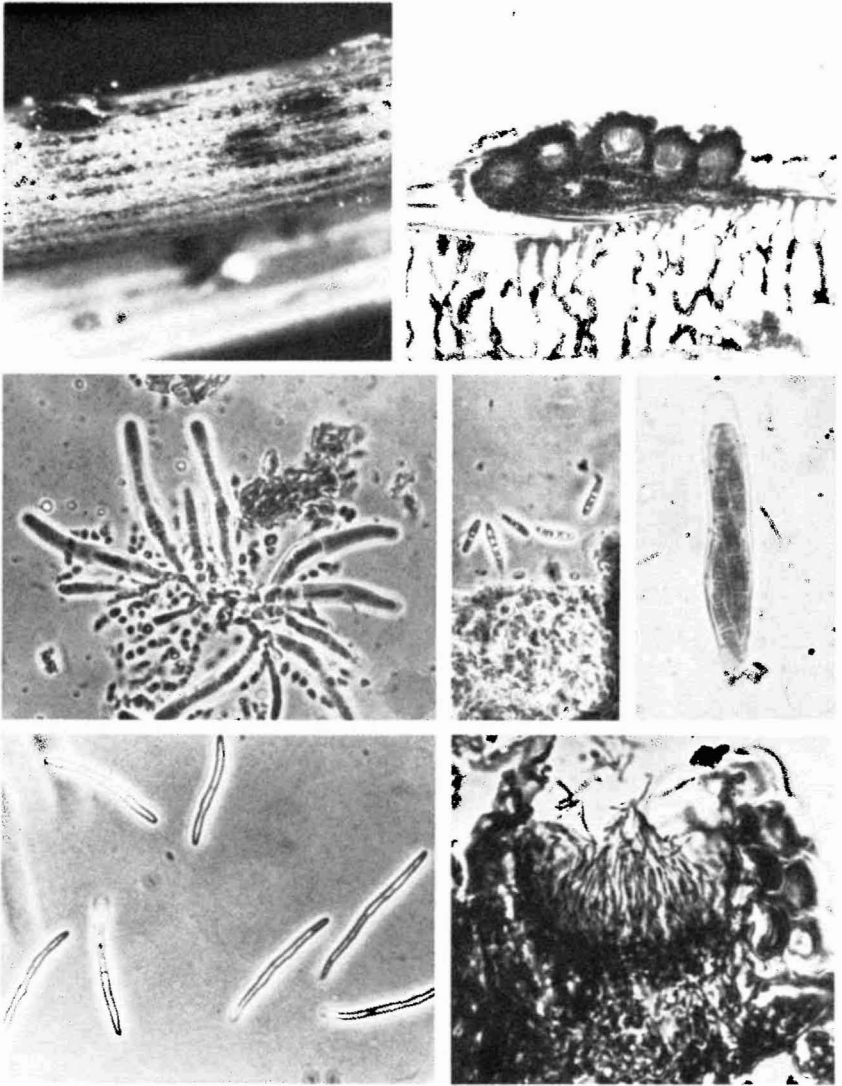


Fig. 60. *Scirrhia pini*. Ascomata in pine needle. Ascoma, vertical section. Ascus and ascospores. *Dothistroma* anamorph, vertical section. Conidium.

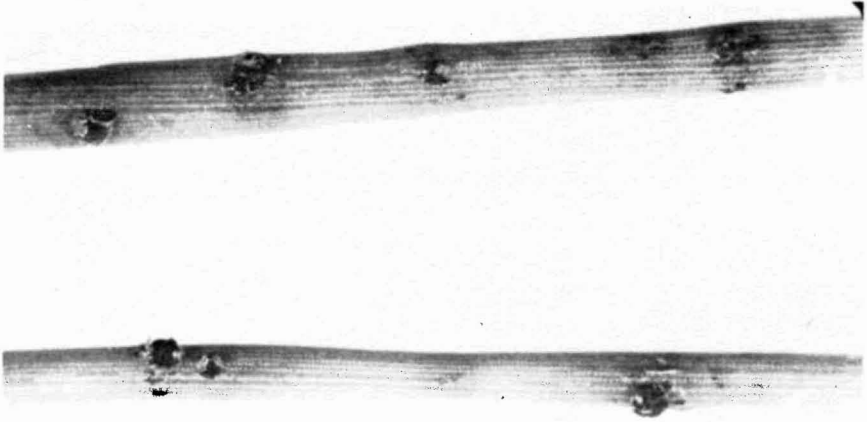


Fig. 61. *Scirrhia pini*. Needle blight of pine showing fruiting bodies in red bands.

*Scirrhia pini* Funk & Parker Can. J. Bot. 44: 1171 (1966).

ANAMORPH: *Dothistroma pini* Hulbary

SYNONYM: *Dothistroma septospora* (Dorog.) Morelet

Ascstromata black, linear, multiloculate, subepidermal, erumpent, 200-600  $\times$  95-150  $\mu\text{m}$ ; tissues pseudoparenchymatous, cells 7-14  $\mu\text{m}$  diameter; locules globose, in longitudinal order, 40-86  $\mu\text{m}$  diameter. Asci cylindric or clavate, bitunicate, apex rounded, 8-spored, 46-52  $\times$  8-10  $\mu\text{m}$ , separated by pseudoparaphysoids. Ascospores hyaline, 1-septate, fusiform to cuneate, 13-16  $\times$  3-4  $\mu\text{m}$  (Figs. 1, 60, 61).

Conidial stromata linear, subepidermal, erumpent, dark brown or black, 125-1500  $\mu\text{m}$  long, 50-450  $\mu\text{m}$  wide, up to 600  $\mu\text{m}$  high. Conidial locules parallel to the longitudinal axis of stroma, without a distinct wall. Conidia hyaline, scoleciiform, 1- to 5- but usually 3-septate, blunt at the ends, straight, slightly curved, or bent, 16-64  $\times$  3.5  $\mu\text{m}$ . Conidiophores numerous, approximately the same size as the conidia, hyaline or amber, dense, unbranched, producing conidia at their tips.

HOSTS: *Pinus*

DISEASE: Red band needle blight of pines. Universal and potentially very damaging (Gibson 1974; Parker 1972; Shaw and Leaphart 1960).

NOTES: Three varieties of the anamorph are recognized, based primarily on conidial length. *D. pini* var. *linearis* Thyr & Shaw, the longest spore form, is found in western North America (syn. *D. septospora* var. *lineare* (Thyr & Shaw) Sutton).

The life cycle is completed in one-year at the coast but requires two-years in most other parts of the west (Peterson and Graham 1974).

A purplish-red stain is given off by fruit bodies mounted in dilute KOH that fades in a few minutes.

Fruiting bodies form in the red bands and split the epidermis. Spores are released from April to November and may infect needles of all ages (Funk and Parker 1966; Parker and Collis 1966).

Copper fungicides effectively control the disease and should be applied just before and shortly after the new needles emerge.

***Sclerophoma pithyophila*** (Corda) Hoehn. *Fragmente z. Mykol.* 402: 1234 (1909).

TELEOMORPH: *Sydowia polyspora* (Bref. & Tav.) E. Muller

CULTURE: *Hormonema dematioides* Lagerb. & Melin

Pycnidia immersed, then erumpent, black, globose to irregular, separate or gregarious, unilocular or imperfectly divided, walls of dark brown parenchyma, rather thick, without ostiole, upper wall disintegrating, 150-300  $\mu\text{m}$  diameter. Inner hyaline cells becoming dolioform and producing a single phialidic aperture. Conidia hyaline, ovate to obovate, with central guttule, 4-8  $\times$  2-3  $\mu\text{m}$ . A bright red pigment is often produced in the locule (Fig. 62).

Pseudothecia immersed, then partially erumpent, black, glabrous, frequently grooved on the top, subglobose, up to 150  $\mu\text{m}$  diameter of dark parenchyma. Asci cylindrical, thickest below, bitunicate, 70-100  $\times$  22-26  $\mu\text{m}$ , 16-spored. Ascospores hyaline, oval with 1-6 transverse septa, constricted at the center septum, sometimes muriform with 1-3 longitudinal septa, 10-25  $\times$  3-8  $\mu\text{m}$ .

HOSTS: *Pinus* spp., *Pseudotsuga*, *Abies* spp., *Picea* spp., *Tsuga heterophylla*, *Larix*, *Thuja*

DISEASE: Follows drought, frost damage and other injuries in most conifers, causing canker, dieback and needle blight. The ascigerous stage is very

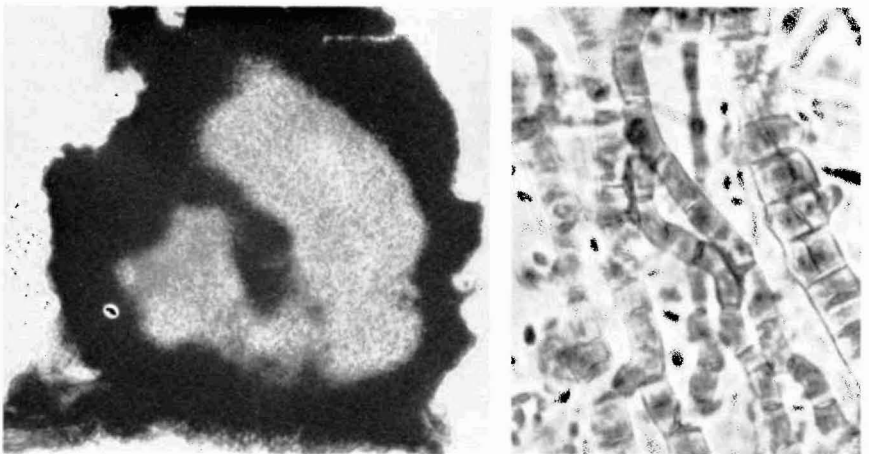


Fig. 62. *Sclerophoma pithyophila*. Pycnidium.

rare, but the pycnidial stage is produced abundantly in bark or needles.

NOTES: In culture, this fungus produces a dark *Hormonema* state characterized by an appressed colony with metallic sheen (Hermanides-Nijhof 1977) and conidia produced basipetally from a single locus in an undifferentiated cell.

***Seiridium cardinale*** (Wagener) Sutton & Gibson C.M.I. Descriptions of Pathogenic Fungi and Bacteria 326 (1972).

SYNONYM: *Coryneum cardinale* Wagener

Acervuli black, peridermal to subperidermal, of pale brown irregular pseudoparenchyma, more hyaline in the conidiogenous region, 200-300  $\mu\text{m}$  diameter. Conidiophores cylindrical, branched, septate, hyaline, up to 25  $\mu\text{m}$  long, 2  $\mu\text{m}$  wide, frequently intermingled with hyphae up to 50  $\mu\text{m}$  long that may be paraphyses. Conidiogenous cells holoblastic, annellidic, determinate, hyaline, 8-17  $\times$  2  $\mu\text{m}$ . Conidia formed at the tips, 5-euseptate, broadly fusiform, constricted slightly at the equidistant septa, smooth, 21-30  $\times$  8-9  $\mu\text{m}$ . Median cells equally dark brown; apical cell hyaline, conic with a short appendage 1  $\mu\text{m}$  long; basal cell hyaline, truncate with marginal frill, with or without an endogenous appendage 1  $\mu\text{m}$  long. (Fig. 63).

HOST: *Thuja plicata*

DISEASE: The cause of a serious shoot and leaf blight of native *Thuja* and ornamental Cupressaceae.

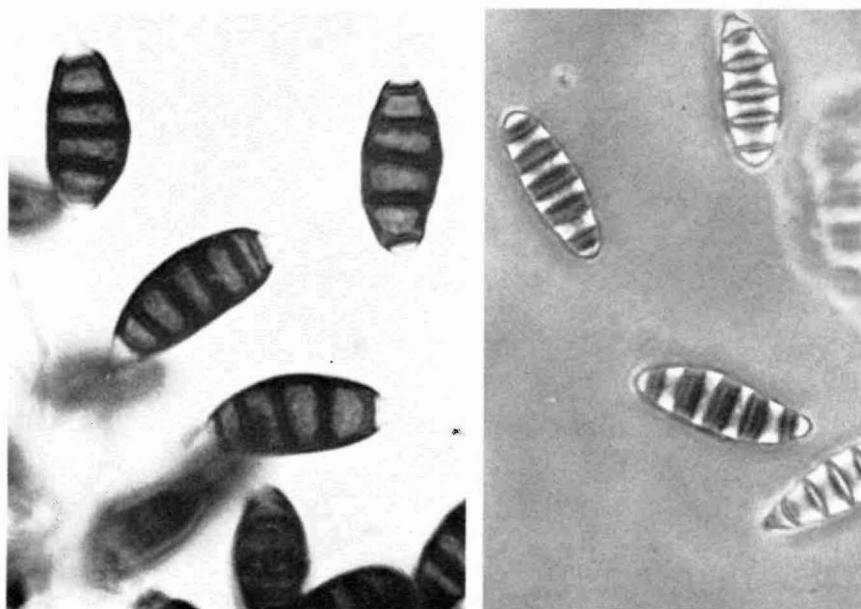


Fig. 63. *Seiridium cardinale*. Conidia. *Seimatosporium berckmansii*. Conidia.

NOTES: Swart (1973) considers this fungus to be a variant of *Monochaetia unicornis* (Cooke & Ell.) Sacc., having the teleomorph *Lepteutypa cupressi* (Natrass, Booth & Sutton) Swart, but this has not been confirmed in Canada. Sutton (1975) transferred *M. unicornis* to *Seiridium unicorne* (Cooke & Ell.) Sutton because the genus *Monochaetia* is characterized by 4-euseptate conidia (Sutton 1969).

*Seimatosporium (Coryneum) berckmansii* (Milb.) Sutton attacks ornamental Cupressaceae and has 5-septate conidia  $29-32 \times 9-10 \mu\text{m}$  with collapsed periclinal walls (Fig. 63).

***Septoria aceris*** (Lib.) Berk. & Br. Ann. N. Hist. No. 432 ? (1850).

Pycnidia dark, subglobose, clustered in leaf spot, approx.  $300 \mu\text{m}$  diameter, ostiole single, central, circular. Conidiophores absent. Conidiogenous cells holoblastic, sympodial. Conidia hyaline, 3-septate, filiform, smooth,  $55-65 \times 1.5-2 \mu\text{m}$  (Fig. 64).

HOST: *Acer glabrum* var. *douglasii*

DISEASE: Leaf spot of maple. Spots are 3-5 mm diameter, irregular, yellowish.

NOTE: For Septorias on poplar, see *Mycosphaerella*, the teleomorph.

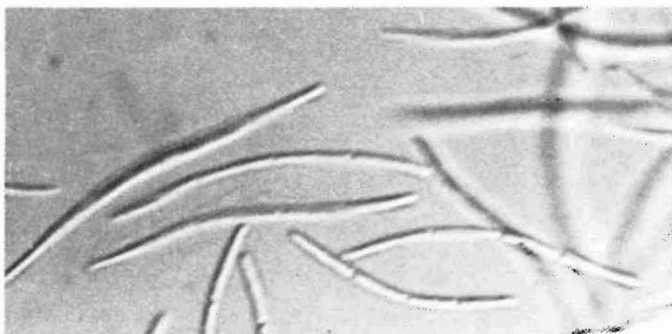


Fig. 64. *Septoria aceris*. Conidia.

***Septoria alni*** Sacc. Michelia 1:177 (1879).

Pycnidia epiphyllous, thin-walled, black, approx.  $200 \mu\text{m}$  diameter, ostiole single, central. Conidiophores absent. Conidiogenous cells holoblastic, sympodial.

Conidia hyaline, continuous, guttulate, filiform, curved,  $30-40 \times 1.5-2.5 \mu\text{m}$ .

HOST: *Alnus sinuata*

DISEASE: Leaf spot of alder. Spots are small (5 mm) irregular, brownish.

NOTES: Another similar species on alder leaves is *Septoria alnifolia* Ell. & Ev. with larger conidia ( $40-65 \times 2 \mu\text{m}$ ). *Cylindrosporium alni* Dearn. is a *nomen nudum*. It is probable that both of these names are referable to *S. alni*.

In a recent revision Constantinescu (T.B.M.S. 83: 383-398) shows conidia multiseptate in both species and  $10-15 \mu\text{m}$  longer than given here.



***Sirococcus strobilinus*** Preuss    Linnaea 26: 716 (1854).SYNONYM: *Ascochyta piniperda* Lindau

Pycnidia erumpent on shoots and needles, grayish green to black, subconical to spherical, ostiolate, 0.3-1.0 mm diameter; peridium of dark prosenchyma, lined with hyaline interwoven hyphae, 30-50  $\mu\text{m}$  thick, cavity simple. Conidiophores simple or branched, septate, each cell with a single phialide at the tip or just below the septum, 10-45  $\mu\text{m}$  long; phialides tapering, sharply pointed, 6-12  $\times$  2  $\mu\text{m}$ . Conidia hyaline, medianly 1-septate, tips acute, slightly constricted at the septum, acerose to fusiform, 13-15  $\times$  2-2.5  $\mu\text{m}$  (Fig. 65).

HOSTS: *Tsuga heterophylla*, *Pinus* spp., *Picea* spp., *Pseudotsuga menziesii*

DISEASE: Causes shoot and leaf blight of various conifers, but is most serious on western hemlock regeneration, in pine nursery stock and spruce germinants in British Columbia.

NOTES: This fungus often fruits on cones and spores may become seedborne. Killing of spruce germinants has been shown by the seedborne spores from natural sources (Sutherland *et al.* 1981).

***Stegopezizella balsameae*** (Davis) Syd.    Ann. Mycol. 22: 392 (1924).SYNONYM: *Sarcotrochila balsameae* (Davis) KorfANAMORPH: *Gloeosporium balsameae* DavisSYNONYM: *Rhabdogloeopsis balsameae* (Davis) Petrak

Apothecia circular, erumpent through the epidermis and pushing up a circular flap of host tissue, less than 1 mm diameter; excipulum of parallel, brown, gelatinized hyphae, hypothecium of small polygonal cells. Asci clavate, long-stalked, 8-spored, pore bluing in iodine especially after pretreatment with dilute KOH, 85-125  $\times$  15-20  $\mu\text{m}$ . Ascospores at first hyaline and nonseptate, (10-25  $\mu\text{m}$  long), broadly ellipsoid to ovoid, becoming brown and 3-septate, 24-30  $\times$  7-10  $\mu\text{m}$ . Paraphyses filiform, simple or branched, tips swollen (Fig. 66).

Conidiomata acervular, subepidermal, basal layer of brown polygonal cells. Conidiophores densely covering base, hyaline, septate, branched, with acropleurogenous conidia. Conidiogenous cells holoblastic, sympodial, indeterminate, cylindrical, with 1-3 sympodial proliferations on the apices. Conidia hyaline, nonseptate, fusiform, straight or curved, 20-35  $\times$  4-6  $\mu\text{m}$ .

HOSTS: *Abies amabilis*, *A. lasiocarpa*, *A. grandis*, *A. concolor*, *A. balsamea*

DISEASE: Unresolved differences of opinion exist on pathogenicity: Reid and Cain (1962b) and Bonar (1962) considered it the cause of needle death but Ziller (1968) and Darker (1932) considered it to be secondary to the hypodermataceous needle pathogens, *Isthmiella* and *Lirula* (Table 5).

***Stigmina thujina*** (Dearn.) Sutton    C.M.I. Mycol. Paper 138: 175 (1975).

Acervuli or sporodochia occurring on a pseudoparenchymatous, dark brown stroma that is immersed in the leaf but ruptures the cuticle and measures 150-230  $\times$  70-120  $\mu\text{m}$ . Conidiophores short, giving rise to cylindrical, light brown conidiogenous cells. Conidiogenous cells annellidic with up to five percurrent proliferations, 16-20  $\times$  3-4  $\mu\text{m}$ . Conidia brown, curved-cylindrical to obclavate,

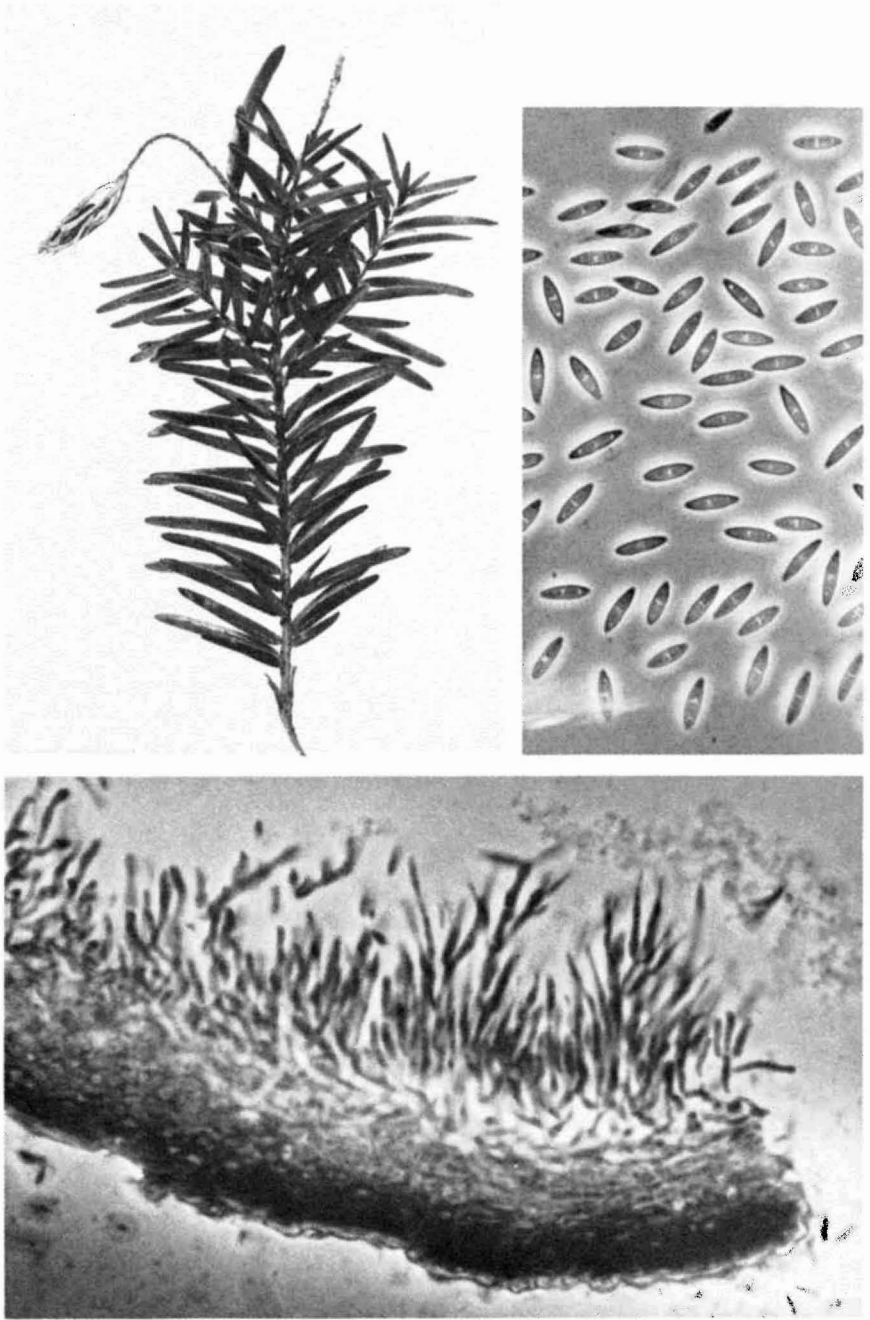


Fig. 65. *Sirococcus strobilinus*. Leaf and shoot blight of hemlock. Pycnidial wall with conidiophores. Conidia.

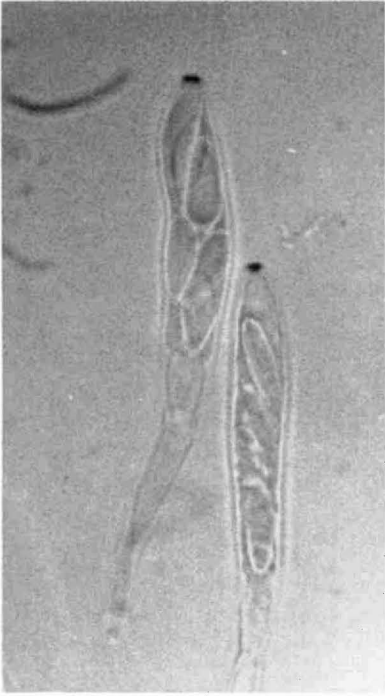


Fig. 66. *Stegopezizella balsameae*. Asci and ascospores (note ascus pore bluing in iodine after treatment with dil. KOH).

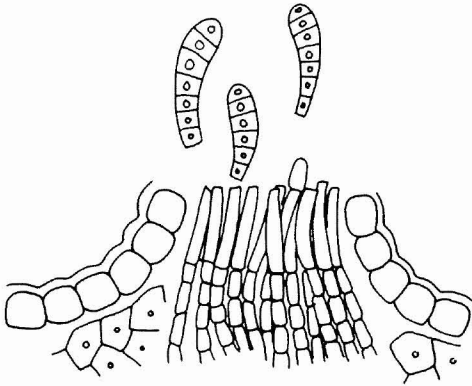


Fig. 67. *Stigmina thujina*. Sporodochium and conidia. (after Morgan-Jones)

truncate with basal frill, guttulate, smooth-walled, 5-10-septate,  $40-52 \times 6-8 \mu\text{m}$ ,  $3-5 \mu\text{m}$  wide at the base (Fig. 67).

HOST: *Thuja plicata*

DISEASE: Parasitic on western red cedar leaves.

NOTE: *Stigmina verrucosa* (Morgan-Jones) Sutton causes yellow spots on spruce needles; the obclavate conidia are verrucose, 5-7-septate and measure  $40-45 \times 5-8 \mu\text{m}$ . Morgan-Jones (1971) gives full descriptions of the *Stigmina*s under the name *Sciniatosporium*.

***Stomiopeltis pinastri*** (Fckl.) Arx Beitr. Krypt. Schweiz 11: 545 (1962).

Ascomata shield-like (thyriothecia), flattened on leaf surface, circular, brown,  $85-175 \mu\text{m}$  diameter, with central pore, composed of radially oriented hyphae. Asci cylindric to ellipsoid,  $15-18 \times 4-7 \mu\text{m}$ , bitunicate. Ascospores hyaline, 1-septate in the middle, bitunicate, fusoid-ellipsoid,  $6-8 \times 1.5-2 \mu\text{m}$ .

HOST: *Pinus monticola*

DISEASE: "Black mildew" or "fly speck" of living needles.

NOTE: An undescribed *Stomiopeltis* is common on living needles of Douglas-fir causing "fly speck."

***Taphrina*** Fr. Syst. Orbis Veg. 1: 317 (1825).

Asci formed in palisade layer on living plant surface, usually seated on small basal cells. No fruiting body is produced, and there are no paraphyses. Ascospores hyaline, globose to ellipsoid, often budding in the ascus to give large numbers of similar secondary spores; growth in culture is yeast-like, and budding also occurs on the host to form infectious secondary spores.



Fig. 68. *Taphrina americana*. Broom and leaf spot in birch.

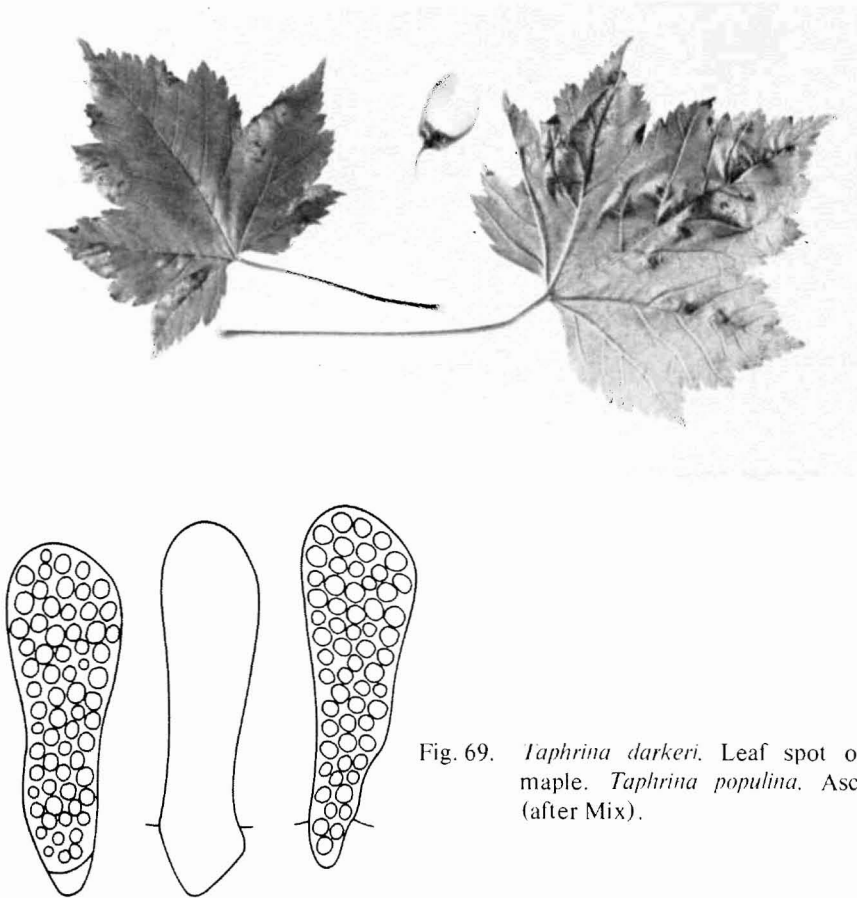


Fig. 69. *Taphrina darkeri*. Leaf spot of maple. *Taphrina populina*. Asci (after Mix).

Infection causes malformation of the host, such as blister-like swellings on leaves, swollen stems, malformed carpels, witches' brooms (Figs. 68, 69).

About twenty species are known on leaves of western trees (all angiosperms) and are listed in Table 4.

The *Taphrina* monograph by Mix (1949) is a standard reference.

***Thyriopsis halepensis*** (Cooke) Theiss. & Syd. Ann. Mycol. 13: 369 (1915).

Thyriothecia black, amphigenous, subcuticular, elongate to roundish, covering layer of brown, isodiametric cells, opening by splits,  $90-600 \times 60-180 \mu\text{m}$ ,  $30-80 \mu\text{m}$  thick. Asci ovoid, bitunicate, 8-spored,  $25-45 \times 20-28 \mu\text{m}$ . Ascospores ellipsoid, medianly 1-septate, hyaline to brown at maturity, thick-walled,  $11-16 \times 4-8 \mu\text{m}$ .

Table 4. *Taphrina* species

Species	Symptoms	Asci	Ascospores	Hosts
<i>T. americana</i> Mix	leaf spot and witches' brooms	17-40 × 8-18 μm	3.5-5.5 × 4-6 μm	<i>Betula papyrifera</i> (Fig. 68)
<i>T. bacterio-</i> <i>sperma</i> Johans.	yellowing of leaves	33-80 × 14-20 μm	3-6 × 1-2 μm	<i>Betula glandulosa</i>
<i>T. boycei</i> Mix	leaf spots	30-60 × 20-36 μm	4-5 × 4 μm	<i>Betula occidentalis</i> <i>B. papyrifera</i>
<i>T. caerules-</i> <i>cens</i> (Desm.) Tul.	swollen leaf spots			<i>Quercus garryana</i>
<i>T. confusa</i> (Atk.) Gies.	deforming leaves	23-53 × 7-13 μm	4-7 × 3-6 μm	<i>Prunus virginiana</i>
<i>T. darkeri</i> Mix	leaf spots	16-33 × 8-13 μm	4 × 3.5 μm	<i>Acer glabrum</i> (Fig. 69)
<i>T. flava</i> Farlow	leaf spots (small)	30-63 × 15-33 μm	5-6 × 5 μm	<i>Betula papyrifera</i>
<i>T. flectans</i> Mix	leaf curl and witches' broom	20-43 × 7-12 μm	4-6 × 4-5 μm	<i>Prunus emarginata</i>
<i>T. japonica</i> Kusano	leaf curl with thickening	33-92 × 13-33 μm	4-5.5 × 4-5 μm	<i>Alnus rubra</i>
<i>T. nana</i> Johans.	leaf yellowing	13-30 × 8-15 μm	3.5-6 × 3.5-5 μm	<i>Betula glandulosa</i>
<i>T. populina</i> Fries	golden yellow leaf spots	30-122 × 13-30 μm	4-6.5 × 4-5 μm	<i>Populus</i> hybrids <i>P. nigra</i> <i>P. tremuloides</i> (Fig. 69)
<i>T. populi-</i> <i>salicis</i> Mix	golden yellow leaf spots	50-106 × 13-30 μm	1.5-5 × 0.5-4.5 μm	<i>Populus trichocarpa</i> <i>Salix</i> sp.

Conidia produced in same thyriothecium before the asci, hyaline, ovoid to cylindrical, nonseptate,  $4.5 \times 2 \mu\text{m}$ . Conidiophores clavate to cylindrical,  $15-30 \times 2-3 \mu\text{m}$ , sometimes persisting and appearing as paraphyses in between the asci.

DISEASE: Associated with chlorotic spots on living needles.

HOSTS: *Pinus*

NOTE: Ouellette (1966) described the conidial form and suggested that they may act as spermatia.

***Tiarosporella pseudotsugae*** Whitney, Reid & Pirozynski Can. J. Bot. 53: 3057 (1975).

Pycnidia hypophyllous, subepidermal, scattered, black, ovoid or elongate,  $600-1000 \times 300 \mu\text{m}$ , wall pseudoparenchymatous, ostiole lateral. Conidiophores of cells lining inner wall, conical, holoblastic, approximately  $10 \mu\text{m}$  high. Conidia hyaline, nonseptate, cylindrical, slightly swollen at the apex, with flattened scar at the base,  $42-65 \times 4-5 \mu\text{m}$ , at maturity with a mucilaginous, apical appendage of irregular shape (cf. Fig. 69a).

HOST: *Pseudotsuga menziesii*

NOTES: On *Abies* spp. there is ***Tiarosporella abietis*** Whitney, Reid & Pirozynski with conidia  $29-45 \times 5-8 \mu\text{m}$ ; on *Picea* spp. there is ***Tiarosporella parca*** (Berk. & Br.) Whitney, Reid & Pirozynski with conidia  $23-40 \times 4-6 \mu\text{m}$ . These species are both associated with *Darkera* spp. (q.v.) but relationships have not been proven (Fig. 69a).

***Truncatella truncata*** (Lev.) Steyaert Bull. Jard. Bot. Brux. 25: 191 (1955).

Acervuli black, erumpent, pseudoparenchymatous, up to  $350 \mu\text{m}$  diameter. Conidiophores simple or branched at the base, cylindrical,  $24 \times 2 \mu\text{m}$ . Conidiogenous cells holoblastic, annellidic,  $11-21 \times 2 \mu\text{m}$ . Conidia holoblastic, acrogenous, 3-euseptate, broadly fusiform or slightly bent, constricted at the septa,  $18 \times 8 \mu\text{m}$ ; median cells thick-walled, brown; end cells thin-walled, hyaline, the apical cell with a single irregularly branched appendage up to  $13 \mu\text{m}$  long (Fig. 70).

HOST: *Tsuga heterophylla*

DISEASE: Infects needles but may be secondary.

NOTES: The segregates of the genus *Pestalotia* display constancy in conidial septation: *Truncatella* is 3-septate, *Pestalotiopsis* and *Monochaetia* are 4-septate, *Pestalotia* and *Seiridium* are 5-septate (Sutton 1969).

***Uncinula bicornis*** (Fr.) Lev. Ann. Sci. Nat. Bot. III, 15: 153 (1851).

ANAMORPH: *Oidium aceris* Rab.

Perithecia superficial on leaf, subglobose, nonostiolate, black, up to  $170 \mu\text{m}$  diameter, on the upper half bearing many short (approximately  $150 \mu\text{m}$ ) spreading appendages forked at the tip, the branches recurved to form a double hook. Asci 4-12 in number, pear-shaped,  $70-95 \times 45-55 \mu\text{m}$ , 8-spored. Ascospores hyaline, nonseptate, ellipsoid,  $22-26 \times 13-15 \mu\text{m}$  (Fig. 71).

Conidia ellipsoid,  $25-35 \times 15-20 \mu\text{m}$ .

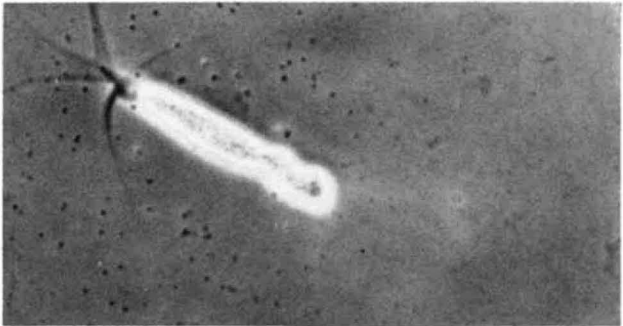
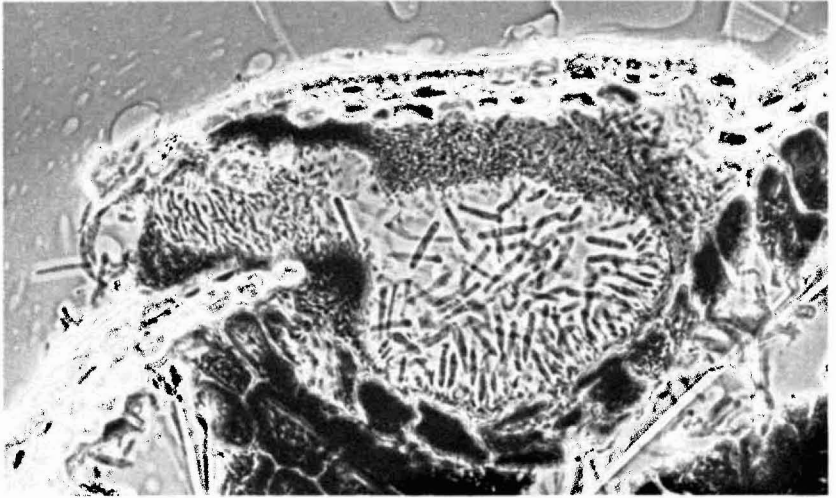
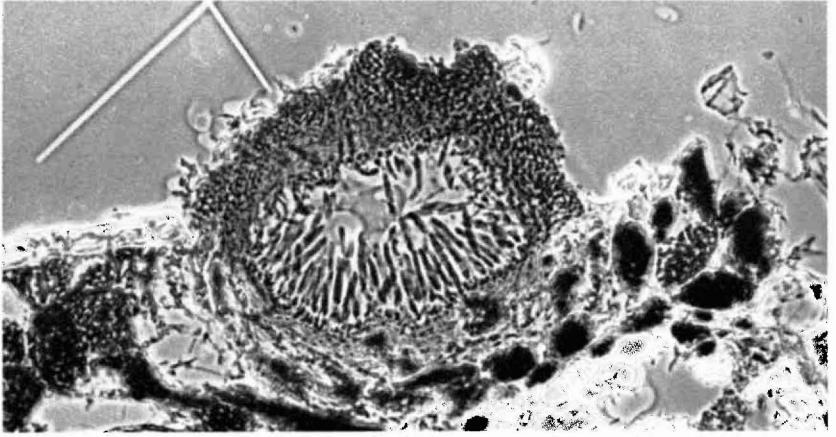


Fig. 69a. *Tiarosporella abietis*. Pycnidium. *Tiarosporella parca*. Pycnidium and conidia. (photos by J. Reid).



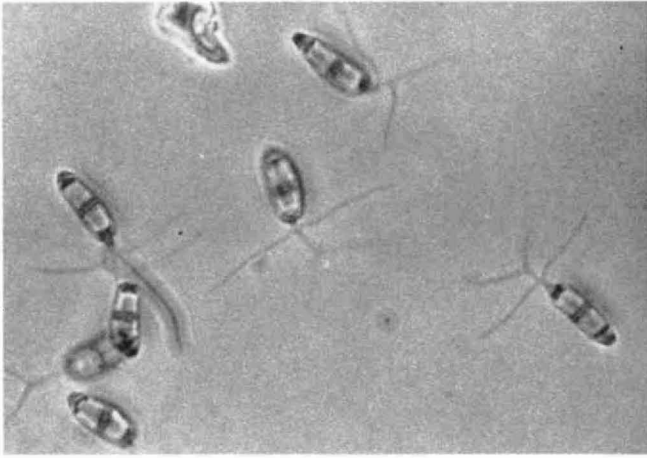


Fig. 70. *Truncatella truncata*. Conidia.

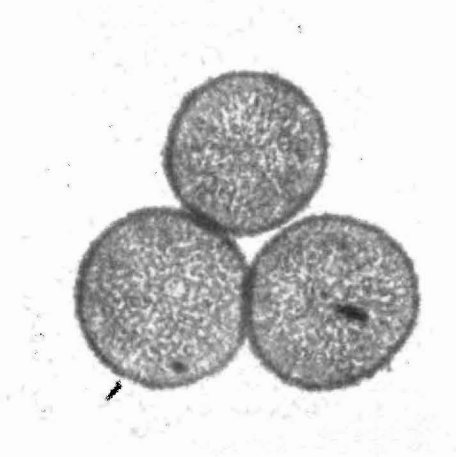


Fig. 71. *Uncinula bicornis*. Perithecia from powdery mildew of maple.



Fig. 72. Powdery mildew of broadleaf maple.

HOST: *Acer*

DISEASE: Powdery mildew of maple leaves (Fig. 72).

***Uncinula salicis*** (DC.) Winter Rab. Krypt. Fl. 1(2): 40 (1887).

SYNONYM: *Uncinula adunca* Lev.

ANAMORPH: *Oidium*

Perithecia superficial on leaf, subglobose, nonstiolate, dark brown, bearing many simple, hyaline appendages with recoiled tips around the equatorial zone. Asci pear-shaped, 8-12 in number,  $66-90 \times 38-52 \mu\text{m}$ , 4-5-spored. Ascospores broadly ellipsoid, hyaline,  $25-30 \times 15-19 \mu\text{m}$ .

Conidia ellipsoid,  $25-35 \times 11-20 \mu\text{m}$ .

HOSTS: *Populus*, *Salix*

DISEASE: Powdery mildew of leaves of poplar and willow.

***Vanterpoolia tsugae*** Funk Can. J. Bot. 60: 973 (1982).

Sporodochia semiglobose, sessile, reddish-orange, translucent, hard when dry, soft when moistened, up to 0.5 mm diameter. Conidiophores simple septate,  $75-105 \times 1.5-2.0 \mu\text{m}$ , arising in dense cluster from a scant pseudoparenchymatous base. Conidia triradiate or cylindric, blastopores, appendaged, produced in acropepal chains, hyaline, septate,  $30 \times 15 \mu\text{m}$  (Fig. 73).

HOST: *Tsuga heterophylla*

DISEASE: Found on necrotic, newly flushed needles. Pathogenicity not proved; apparently rare (Funk 1982).

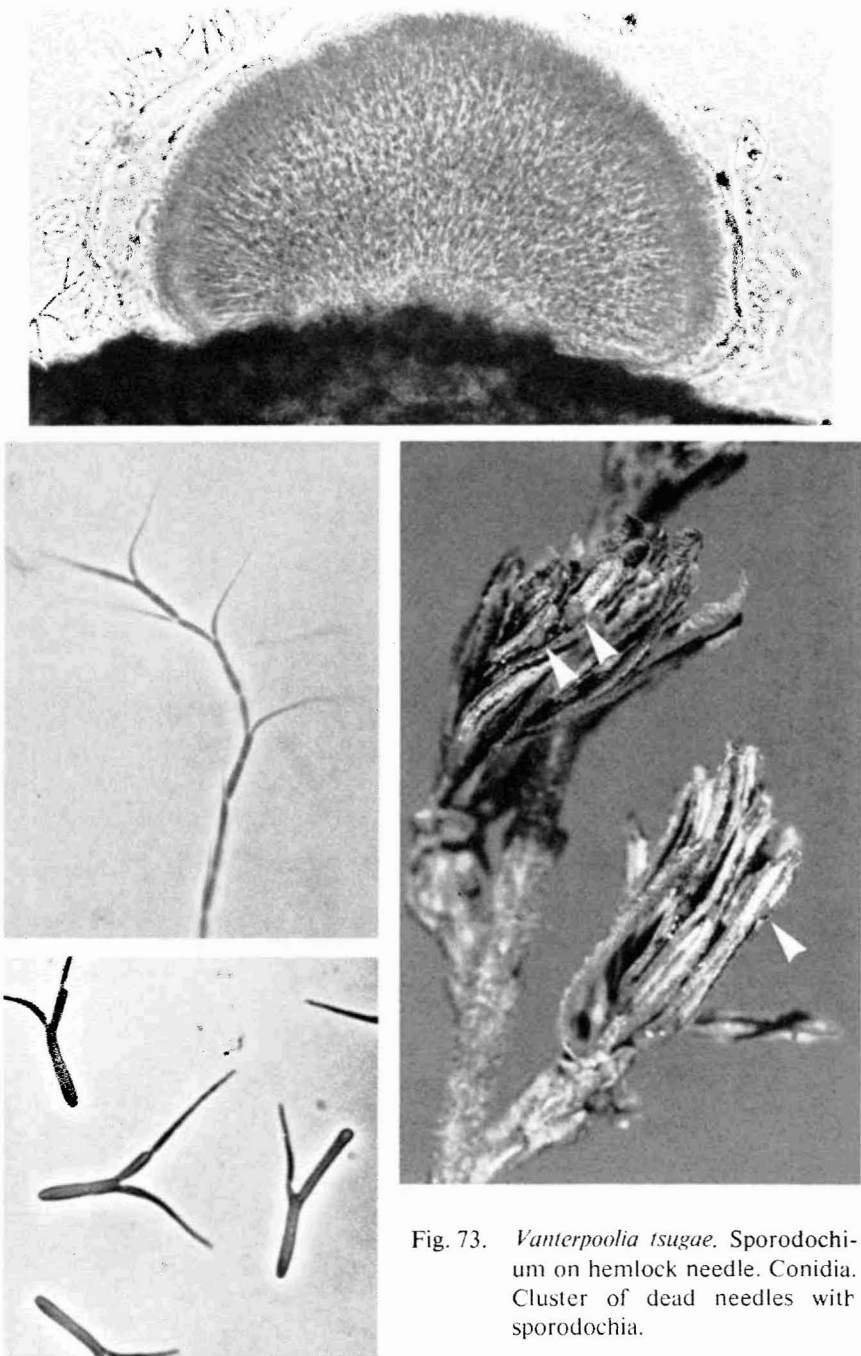


Fig. 73. *Venterpoolia tsugae*. Sporodochium on hemlock needle. Conidia. Cluster of dead needles with sporodochia.

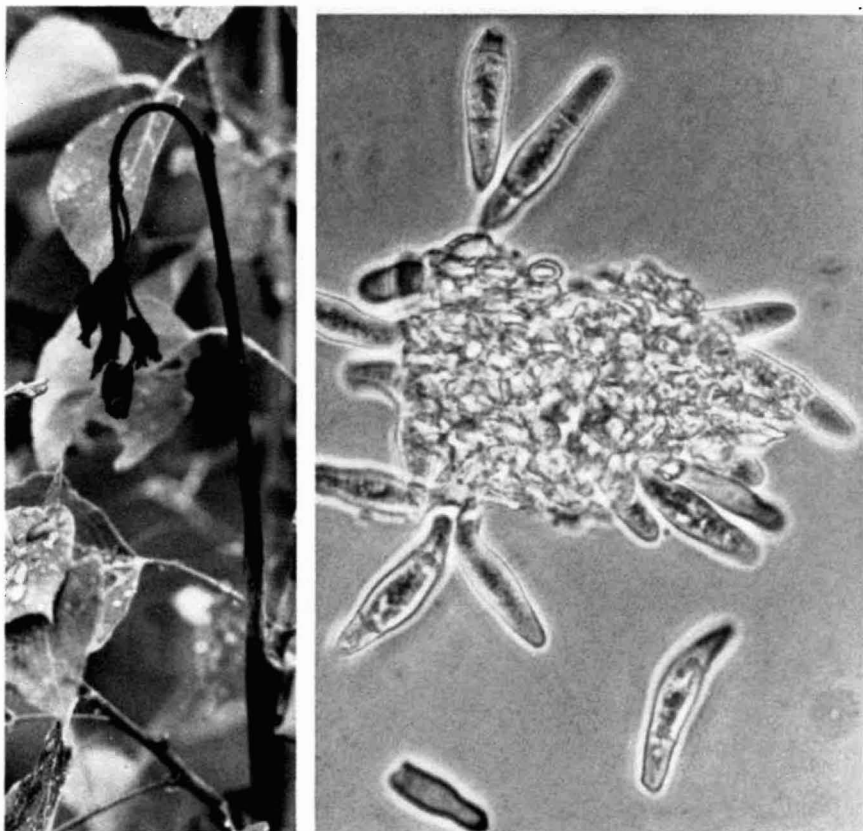


Fig. 74. *Venturia macularis*. Leaf and shoot blight of aspen. Conidia.

*Venturia macularis* (Fr.) E. Müller & Arx Ber. Schw. Bot. Gesell. 60: 366 (1950).

SYNONYM: *Venturia tremulae* Aderh.\*

ANAMORPHS: *Pollaccia americana* Ondrej

*Pollaccia radiosa* (Lib.) Bald. & Cif.

Ascomata immersed, globose to conical, erumpent, glabrous or setose, wall of brown polygonal cells, 80-140  $\mu\text{m}$  diameter, setae 30-50  $\mu\text{m}$  long, apical pore 25-50  $\mu\text{m}$  wide. Asci oblong to saccate, bitunicate, 2-4-8-spored, 42-63  $\times$  10-12  $\mu\text{m}$ . Ascospores greenish to brown, elliptical to clavate, straight or inequilateral, 1-septate in the middle or below, slightly constricted, sometimes finely roughened, sometimes with a gelatinous coating, 8-14  $\times$  4.5-6  $\mu\text{m}$ .

\* Barr (1968) synonymized *Venturia tremulae* Aderh. with *V. macularis* but Morelet (1983) considered *V. tremulae* distinct with three varieties.

Acervuli irregular, olive-green. Conidiophores brown, nonseptate,  $8-12 \times 4-6 \mu\text{m}$ . Conidia brown, ellipsoid to cylindrical, straight or bent, 0-2-septate,  $12-22 \times 6-7 \mu\text{m}$ .

HOST: *Populus tremuloides*

DISEASE: Causes leaf and shoot blight of poplars (Fig. 74).

NOTES: A closely related species attacks black and balsam poplars, viz., *V. populina* (Vuill.) Fabric. (ANAMORPH: *P. elegans* Serv.) which has larger ascospores ( $20-23 \times 11-13 \mu\text{m}$ ) and straight conidia ( $25-36 \times 8-14 \mu\text{m}$ ) (Fig. 74a) (Dance 1961).

Considerable variation has been noted in some *Venturia* species and it is possible that races exist. Pollaccias are also difficult to distinguish and the work of Ondrej (1972) has facilitated identification.

***Venturia saliciperda*** Nüesch Phytopath. Z. 39: 350 (1960).

ANAMORPH: *Pollaccia saliciperda* (Allesch. & Tub.) Arx

SYNONYM: *Fusicladium saliciperdatum* (Allesch. & Tub.) Lind

Ascomata immersed, globose to conical, papillate, setose,  $80-120 \mu\text{m}$  diameter, wall of two layers of brown cells. Asci oblong to saccate, bitunicate,  $35-55 \times 8-12 \mu\text{m}$ . Ascospores narrowly ellipsoid, 1-septate slightly above the middle, slightly greenish,  $11-14 \times 3-5 \mu\text{m}$ .

Conidial state developing on shoots and leaves, in brown irregular spots; conidiophores annellate, cylindrical to conic,  $8-15 \times 5-8 \mu\text{m}$ . Conidia ellipsoid to cylindrical, 1-2-septate, greenish-brown to olivaceous,  $16-23 \times 6-9 \mu\text{m}$ , base truncate.

HOSTS: *Salix* spp.

DISEASE: Cause of willow blight, often associated with *Glomerella cingulata* in this disease.

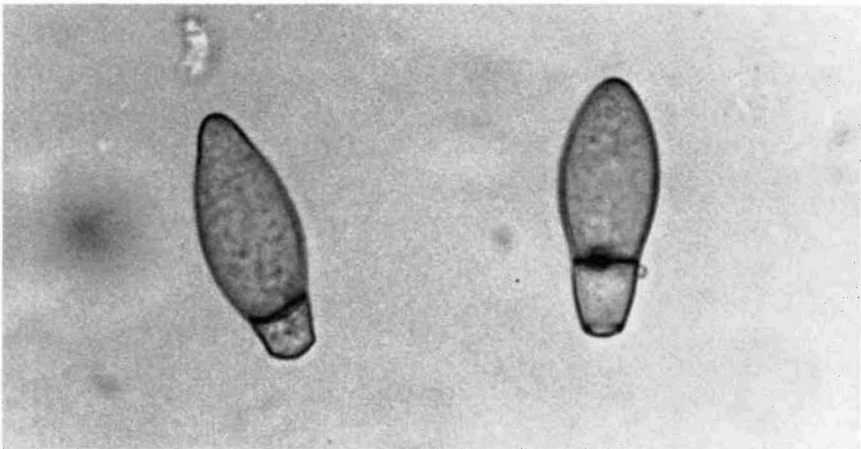


Fig. 74a. *Venturia populina*. Conidia.

***Virgella robusta*** (Tub.) Darker Can. J. Bot. 45: 1419 (1967).

SYNONYM: *Hypoderma robustum* Tub.

Hysterothecia hypophyllous, dark brown, innate, extending along full length of needle, up to 0.5 mm wide, nervisequious, opening by a longitudinal fissure, primordium of slit conspicuous, covering layer of dark pseudoparenchyma 30-40  $\mu\text{m}$  thick, basal layer of hyaline plectenchyma. Asci saccate-clavate, 8-spored, 138-192  $\times$  28-35  $\mu\text{m}$ . Ascospores rod-shaped, hyaline, nonseptate, 27-36  $\times$  4-8  $\mu\text{m}$ , with mucilaginous sheath up to 11  $\mu\text{m}$  thick that swells after discharge. Paraphyses filiform, simple, straight, hyaline, 120-150  $\times$  0.5  $\mu\text{m}$  (Fig. 4).

Pycnidia epiphyllous, in two rows on each wing of the reddish-brown needle, intraepidermal, maturing before the asci, continuous, concolorous at first, up to 280  $\mu\text{m}$  wide. Conidia hyaline, rod-shaped, 3-3.5  $\times$  0.5-0.7  $\mu\text{m}$ .

HOSTS: *Abies amabilis*, [*A. grandis*, *A. concolor*, *A. magnifica*]

DISEASE: Needle blight. One of the most important foliage diseases of balsam fir.

NOTES: *V. robusta* has a two-year life cycle and so is found on needles two-years old or older. It is often followed by *Lophodermium consociatum*.

Table 5. **Secondary fungi on conifer needles**

Secondary Fungus	Primary Fungus Followed	Host Tree
<i>Hemiphacidium longisporum</i>	<i>Lophodermella concolor</i>	<i>Pinus contorta</i>
<i>Hemiphacidium planum</i>	<i>Bifusella linearis</i> <i>Davisomycella medusa</i> <i>Elytroderma deformans</i> <i>Lophodermella concolor</i>	<i>Pinus monticola</i> <i>P. ponderosa</i> <i>P. ponderosa</i> <i>P. contorta</i>
<i>Hendersonia pinicola</i>	<i>Lophodermella concolor</i> <i>L. sulcigena</i>	<i>Pinus contorta</i>
<i>Leptosphaeria faullii</i>	<i>Isthmiella abietis</i> <i>I. quadrispora</i>	<i>Abies lasiocarpa</i>
<i>Lophomerum autumnale</i>	<i>Isthmiella abietis</i> <i>I. quadrispora</i>	<i>Abies amabilis</i> <i>Abies lasiocarpa</i>
<i>Lophomerum darkeri</i>	<i>Lirula macrospora</i>	<i>Picea glauca</i>
<i>Nothophacidium phyllophilum</i>	<i>Lirula abietis-concoloris</i>	<i>Abies lasiocarpa</i>
<i>Sarcotrichila macrospora</i>	<i>Davisomycella ampla</i>	<i>Pinus contorta</i>
<i>Sarcotrichila piniperda</i>	<i>Lirula macrospora</i> <i>P. glauca</i>	<i>Picea sitchensis</i>
<i>Stegopezizella balsameae</i>	<i>Isthmiella quadrispora</i> <i>I. abietis</i> <i>Lirula abietis-concoloris</i>	<i>Abies spp.</i>

# Appendix

## Uredinales (Rusts)

(ref. *The Tree Rusts of Western Canada* by W.G. Ziller)

The foliar rusts of western trees and their alternate hosts have been described by Ziller (1974). They are listed here under host genus of A) conifers, B) broad-leaved trees.

Fruit bodies are usually tongue-like or horn-like projections from non-necrotic leaves, orange, yellow or white in color. Spores are usually large, with thick, warted or sculptured walls, and brightly colored. The pycnial state, however, is a colorless, sunken fruit body with small, thin-walled spermatia (conidia) that could be confused with a coelomycete (Figs. 75-84).

In some cases the same rust is reported on both coniferous and broadleaved hosts. This is so because of host alternation in some rusts. The primary host is that on which the pycnial and aecial states are produced, and the alternate host is that on which the uredinial, telial and basidial states are produced. This is a unique characteristic among the parasitic fungi in that two unrelated hosts are required to complete the life cycle. Both conifers and broadleaved trees may be either primary or alternate hosts.

### 1) Rusts on conifer needles

***Abies*** Needle cast or blight or symptomless. Aecial states of the following rusts:

- Hyalopsora aspidiotus* P. Magn.
- Melampsora abieti-capraearum* Tub.
- Melampsora medusae* Thuem.
- Melampsora occidentalis* Jacks.
- Melampsorella caryophyllacearum* Schroet.
- Milesina laeviuscula* (Diet.) Hirat. f.
- Pucciniastrum epilobii* Outh
- Pucciniastrum goeppertianum* (Kuehn) Kleb.
- Uredinopsis hashiokai* Hirat. f.
- Uredinopsis longimucronata* Faull
- Uredinopsis phegopteridis* Arth.
- Uredinopsis pteridis* Diet. & Holw.
- Uredinopsis struthiopteridis* Stoerm.:Diet.

***Chamaecyparis*** Orange leaf spot. Uredinial and telial states of:

- Gymnosporangium nootkatense* Arth.



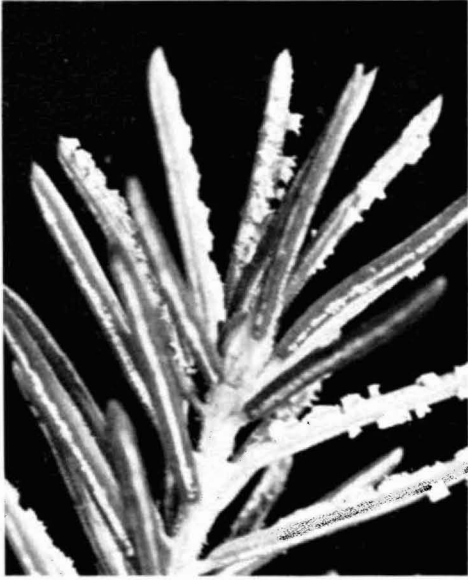


Fig. 75. *Chrysomyxa ledicola*. Aecia on spruce.



Fig. 76. *Coleosporium asterum*. Aecia on pine.



Fig. 77. *Melampsorella caryophyllacearum*. Aecia on alpine fir.



Fig. 78. *Milesina laeviuscula*. Aecia on grand fir.

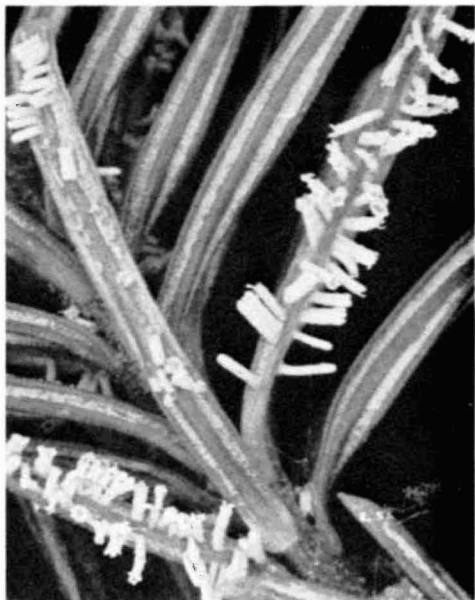


Fig. 79. *Pucciniastrum epilobii*. Aecia on alpine fir.



Fig. 80. *Gymnosporangium bethelii*, Roestelia on hawthorn.



Fig. 81. *Gymnosporangium fuscum*. Aecia on pear. Trellis-like aecia.



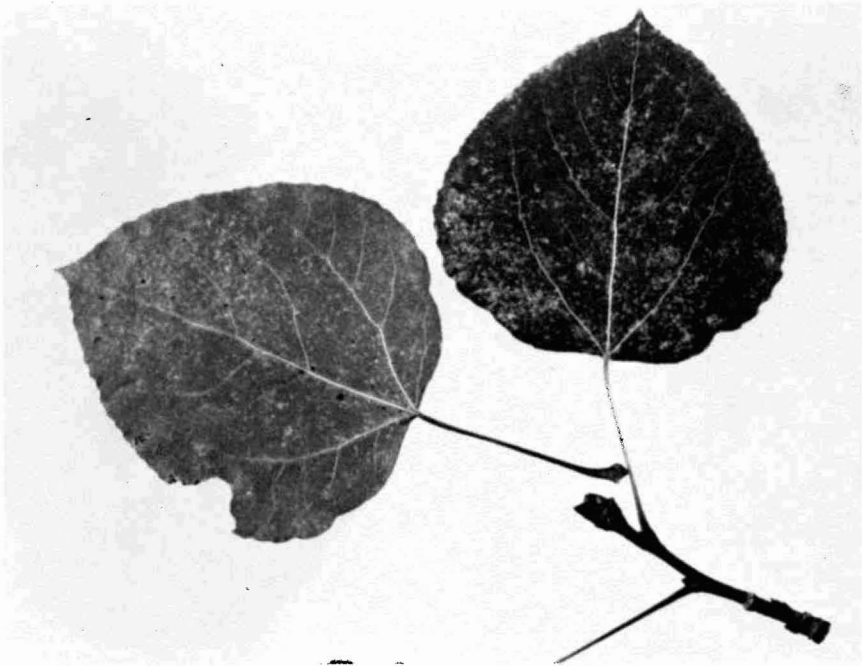


Fig. 82. *Melampsora medusae*. Uredinia on aspen.

**Juniperus** Leaf blight. Uredinial and telial states of:  
*Gymnosporangium cornutum* Arth.  
*Gymnosporangium gaeumannii* Zogg  
*Gymnosporangium haraeaeum* Syd.  
*Gymnosporangium inconspicuum* Kern

**Larix** Premature defoliation of larch. Aecial states of:  
*Melampsora medusae* Thuem.  
*Melampsora occidentalis* Jacks.  
*Melampsora paradoxa* Diet. & Holw.

**Picea** Premature defoliation. Aecial states of:  
*Chrysomyxa arctostaphyli* Diet.  
*Chrysomyxa empetri* Schroet. ex Cumm.  
*Chrysomyxa ledi* de Bary var. *ledi*  
*Chrysomyxa ledicola* Lagerh.  
*Chrysomyxa woroninii* Tranz.  
*Melampsora medusae* Thuem.  
*Melampsora occidentalis* Jacks.  
*Pucciniastrum americanum* (Farl.) Arth.

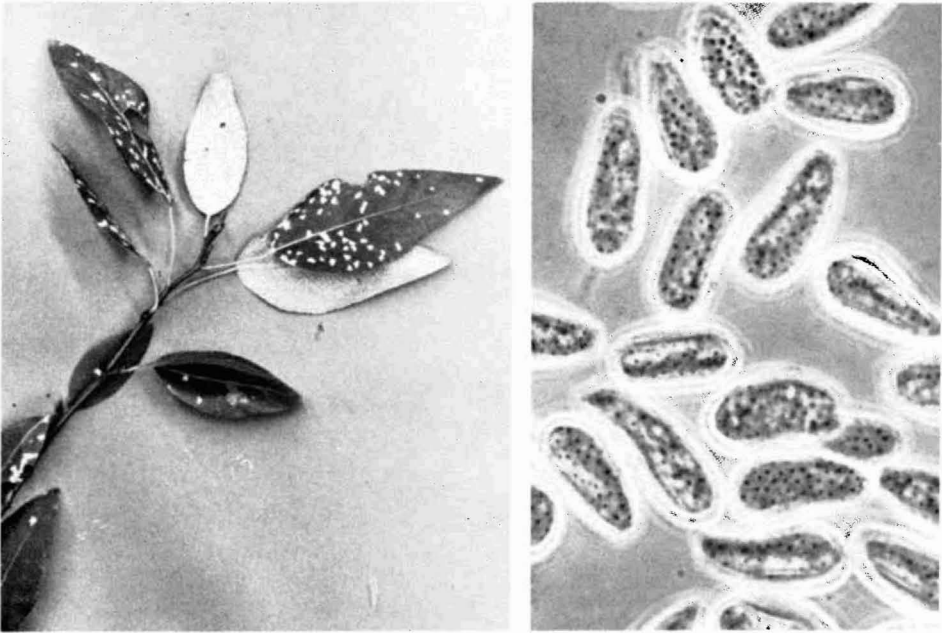


Fig. 83. *Melampsora occidentalis*. Uredinia on black cottonwood. Urediniospores.



Fig. 84. *Pucciniastrum sparsum*. Uredinia on Arbutus.

*Pucciniastrum arcticum* Tranz.  
*Pucciniastrum sparsum* (Wint.) E. Fischer

Telial state of:  
*Chrysomyxa weirii* Jacks.

**Pinus** Needle blight and defoliation. Aecial states of:  
*Coleosporium asterum* (Diet.) Syd.  
*Melampsora medusae* Thuem.  
*Melampsora occidentalis* Jacks.

**Pseudotsuga** Needle blight. Aecial states of:  
*Melampsora medusae* Thuem.  
*Melampsora occidentalis* Jacks.

**Tsuga** Needle discoloration and necrosis. Aecial states of:  
*Melampsora epitea* Thuem. f. sp. *tsugae* Ziller  
*Melampsora medusae* Thuem.  
*Pucciniastrum vaccinii* (Wint.) Joerst.

## 2) Rusts on broadleaf foliage

**Amelanchier** Yellow leaf spot. Aecial states (roestelia) of:  
*Gymnosporangium clavariiforme* (Pers.) DC.  
*Gymnosporangium nelsonii* Arth.  
*Gymnosporangium nidus-avis* Thaxt.

**Arbutus** Brown spot in purple areas of leaves. Uredinial and telial states of:  
*Pucciniastrum sparsum* (Wint.) E. Fischer

**Betula** Mottled yellowing of leaves. Uredinial and telial states of:  
*Melampsorium betulinum* Kleb.

**Crataegus** Yellow leaf spot. Aecial states of:  
*Gymnosporangium bethelii* Kern  
*Gymnosporangium clavariiforme* (Pers.) DC.

**Populus** Yellow leaf spot and premature defoliation of black cottonwood and aspen. Uredinial and telial states of:  
*Melampsora medusae* Thuem. (on aspen)  
*Melampsora occidentalis* Jacks. (on cottonwood)

**Pyrus** Orange-red leaf spot of pear. Aecial state of:  
*Gymnosporangium fuscum* Hedw. f. in DC.

**Rhamnus** Yellow leaf spot. Aecial state of:  
*Puccinia coronata* Corda

**Salix** Yellow leaf spot. Uredinial and telial states of:  
*Melampsora epitea* Thuem. complex of races.

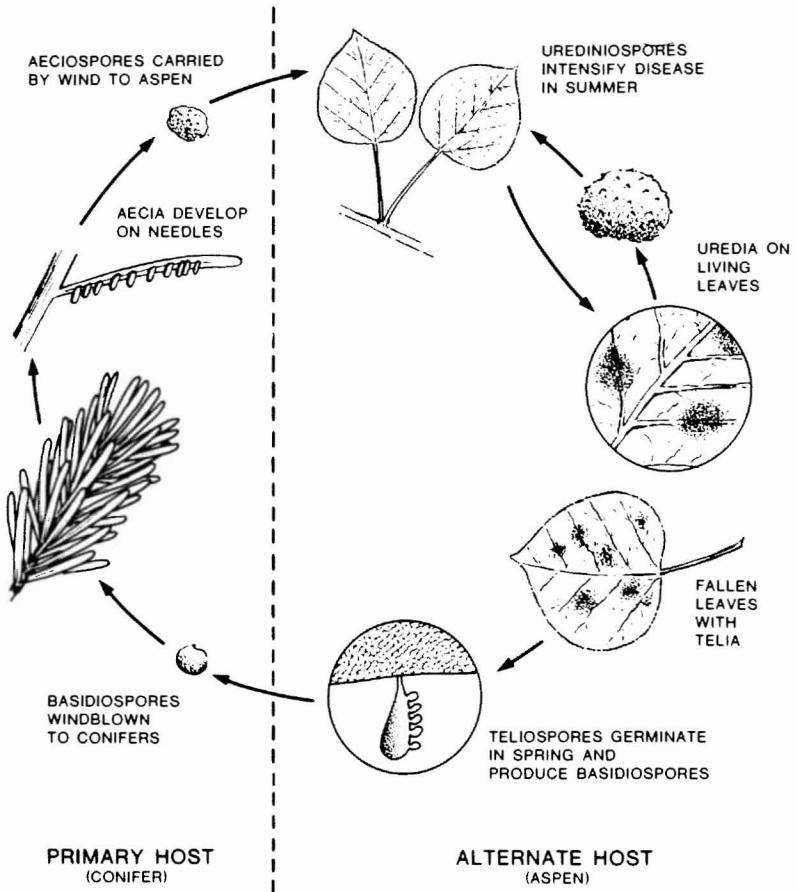


Fig. 85. Life cycle diagram of *Melampsora medusae*, a rust fungus that alternates from conifer to aspen.

## Glossary

- acervulus:** fruiting structure of certain Deuteromycotina, consisting of a shallow aggregation of hyphae and bearing conidiophores on the upper surface.
- acicular:** slender and pointed, needle-shaped.
- acrogenous:** at the tip, apical.
- acropleurogenous:** at the tip and sides.
- acuminate:** a narrowing to a point.
- acute:** pointed, less than a right angle.
- allantoid:** sausage-shaped, slightly curved with rounded ends.
- amphigenous:** growing all around or on both sides.
- ampulliform:** flask-shaped.
- amyloid:** stained blue black by Melzer's Iodine; symbol J+. (cf. dextrinoid).
- anamorph:** the imperfect state of a fungus; asexual, mitotic diasporic expression of a fungus.
- annellophore:** a conidiogenous cell with a series of ring-like scars left by succeeding blastoconidia (annellospores).
- anthracnose:** leaf necrosis caused by acervular fungi.
- apical:** at the tip.
- apothecium:** the cup- or saucer-shaped fruit body of the Discomycetes, containing asci.
- appendage:** a process or outgrowth.
- arthrospore:** spore produced from breaking up a hypha into separate cells.
- ascigerous:** having asci.
- ascocarp:** the ascus bearing fruit body of an Ascomycete.
- ascomyetes:** the Ascomycotina, or Sac fungi; typified by the ascus, within which are produced ascospores usually eight in number, but in some species more or less than eight.
- ascospore:** a spore produced within an ascus by free cell formation.
- ascostroma:** a stroma containing asci, as in the Loculoascomycetes.
- ascus:** a sac-like cell of an Ascomycete within which ascospores are produced.
- aseptate:** without crosswalls.
- asexual:** vegetative, without sex organs, imperfect, not involving nuclear fusion.
- basidiomycetes:** the Basidiomycotina, a large subdivision of the fungi characterized by presence of the basidium bearing basidiospores; includes the mushrooms, polypores, etc.
- basipetal:** development in direction of the base, making the apical part the oldest.
- bifusiform:** elongate with a narrow central isthmus.
- biseriate:** having two walls, as in the asci of Loculoascomycetes.
- blastospore:** a spore produced by blowing-out of the cell wall and enlarging before being delimited by a septum. (cf. holoblastic, enteroblastic).
- blight:** leaf damage that is sudden and serious (see also *needle blight*).

**botryose:** grouped like grapes.

**budding:** development of a spore from a small outgrowth.

**caespitose:** in groups or clusters, frequently arising from a common stroma.

**catenulate:** in chains, chain-like.

**cirrhous:** a tendril-like mass of forced-out spores.

**clavate:** club-like, narrowed at the base.

**cleistothecium:** an ascocarp having no special opening.

**clypeus:** a shield-like growth over a perithecium.

**coelomycete:** a division of the Deuteromycotina (Fungi Imperfecti) consisting of Sphaeropsidales and Melanconiales, q.v.

**concolorous:** of one color

**conidiogenous cell:** a cell from which a conidium is directly produced.

**conidioma:** general term for an asexual fruit body, i.e., the anamorphic phase.

**conidiophore:** a hypha bearing conidiogenous cells from which conidia are produced.

**conidium:** an asexual spore.

**continuous:** having no septa.

**cuneate:** wedge-like.

**dehiscent:** opening when mature by pores or by breaking up.

**deliquescent:** becoming liquid after maturing.

**dematiaceous:** more or less darkly pigmented.

**deuteromycetes:** Fungi Imperfecti; characterized by the absence of a sexual state.

**dextrinoid:** stained reddish-brown by Melzer's Iodine.

**dictyospore:** a spore having longitudinal and transverse septa; muriform.

**dieback:** death of the outermost twigs or extremities of the branches or leaders. Dieback can be caused by stress complexes or by invasion and girdling of stems by canker fungi.

**discomycetes:** the cup-fungi, with asci produced in an apothecium.

**distoseptate:** having each cell surrounded by a wall distinct from the common outer wall.

**ecto-:** outside.

**endo-:** inside.

**enteroblastic:** where only the inner wall, or no wall, contributes to the formation of conidia.

**epiphyllous:** on the upper surface of the leaf.

**epithecium:** the surface of the disc in certain Discomycetes.

**erumpent:** bursting through the bark.

**euseptate:** septa in which the diaphragm merges with the outside wall.

**evanescent:** soon disappearing, ephemeral.

**excipulum:** tissues of the apothecium; ectal-, forms outermost layers, including the margin, and medullary-, the zone enclosed by the ectal excipulum and the hypothecium.

**falcate:** curved like the blade of a sickle.

**filiform:** thread-like.

**floccose:** cottony.

**fruit body:** a general term for spore-bearing organs.



- gall:** a swelling or outgrowth produced by a plant as the result of fungus attack.
- glabrous:** smooth, not hairy.
- globose:** spherical or almost so.
- guttulate:** having one or more oil drops inside.
- holoblastic:** where both outer and inner walls contribute to the formation of a conidium.
- host:** a living organism harboring a parasite.
- hyaline:** transparent; colorless.
- hymenium:** the spore bearing layer of a fruit body.
- hyphae:** the vegetative, microscopic filaments of a mycelium (or spawn), forming the thallus (body) of a fungus.
- hyphomycetes:** the division of the Deuteromycotina in which conidia are borne on conidiophores not organized into a fruit body.
- hyphopodia:** a short branch on epiphytic mycelium of Meliolales.
- hypophyllous:** on the under surface of the leaf.
- hypothecium:** the hyphal layer under the hymenium of an apothecium.
- immersed:** embedded in the bark and covered by it.
- imperfect state:** the asexual spore state, the anamorph.
- innate:** embedded in or immersed.
- inoperculate:** without an apical lid, hence opening through a pore or a split at the tip of the ascus.
- intercalary:** between apex and base.
- interthecial:** between asci.
- ionomidotic:** releasing purple brown dye when immersed in dilute KOH. J+; iodine positive, giving a blue color with iodine (cf. J-).
- locule:** a cavity in a stroma.
- loculoascomycetes:** a class of the Ascomycotina characterized by bitunicate asci in an ascostroma.
- lunate:** like a new moon, crescentic.
- macroconidium:** the larger, diagnostic conidium of a fungus which also has microconidia.
- mazaedium:** a loose, powdery mass of ascospores free from asci.
- microconidium:** see macroconidium, sometimes functioning as a male sex cell.
- microfungi:** fungi having small fruit bodies, requiring magnification for observation.
- micron:** one-thousandth of a millimetre; approximately one 25,000th of an inch; symbol  $\mu\text{m}$ .
- moniliform:** having swellings at regular intervals, like a string of beads (=monilioid).
- mucronate:** the end is pointed.
- muriform:** see dictyospore.
- myc-, mycet-, myco-:** prefix meaning fungus.
- mycelium:** a mass of hyphae, the vegetative thallus of a fungus.
- mycology:** the study of the fungi.
- mycoparasite:** the parasitism of one fungus by another.
- needle blight:** fungal attack on foliage of any age and therefore active anytime

there is coincidence of high relative humidity and spores (cf. needle cast). Blighted foliage is also cast after spore release.

**needle cast:** loss of leaves by conifers caused by fungal attack (see *Rhabdocline*, *Lophodermium*, etc.). Only young needles of the current year are attacked.

**nervisequious:** living or occurring on veins of leaves.

**operculate:** opening by an apical lid.

**ostiole:** a pore through which spores are freed from a perithecium or pycnidium.

**ovate:** like a hen's egg.

**papilla:** a small rounded process.

**paraphysis:** upward growing hyphal element interspersed with the asci in the hymenium.

**parasite:** an organism living on and obtaining its nutrient from another living organism, frequently causing disease in the host.

**perfect state:** see teleomorph.

**periderm:** the outermost, corky layer of bark of a tree.

**perithecium:** the subglobose or flask-shaped ascocarp of the Pyrenomycetes.

**phialide:** an enteroblastic conidiogenous cell that produces conidia through a special opening where neither wall contributes toward formation of the conidium, often with a collarette surrounding the opening.

**phloem:** inner bark which functions in transport of elaborated foods from the leaves.

**phragmospore:** a spore having two or more transverse septa.

**plectenchyma:** tissue formed by hyphae becoming twisted and fixed together.

**primary needles:** in pine where single needles are produced in young stage.

**pruinose:** having a frost-like covering.

**pseudoparenchyma:** tissue composed of more or less isodiametric cells.

**pycnidium:** the globose or flask-shaped fruit body of the Sphaeropsidales containing conidia (pycnidiospores).

**pyrenomycetes:** the fungi producing unitunicate asci in perithecia.

**sclerotium:** a sterile mass of hyphae, usually rounded and firm.

**secondary needles:** in pine the normal needles (cf. primary needles).

**septum:** a cross wall forming a division, as in a spore or hypha.

**sessile:** having no stem.

**seta:** a stiff hair or bristle.

**sinuate:** wavy, curved.

**snow blight:** a blight disease of conifer foliage and twigs that develops under snow (see *Phacidium*).

**snow mould:** a smothering disease of conifer foliage that develops under snow (see *Herpotrichia*).

**sooty mould:** dark, superficial growth of a fungus.

**species:** in taxonomy, a division of a genus, usually based on morphological characters.

**spermatium:** a male sex cell, usually a microconidium in the Ascomycetes.

**spore:** the reproductive propagule in the fungi.

**sporodochium:** a conidial fruit body in which the spore mass is supported by a pul-

vinate body covered with short conidiophores.

**spot:** leaf disease characterized by numerous isolated circular or angular lesions.

**state:** a phase of the fungus life cycle; Ascomycetes generally have two states: 1)

Perfect state — the sexual or ascigerous state, also known as the *teleomorph*. 2) Imperfect state — the asexual or conidial state, also known as the *anamorph*. Sometimes a second asexual state is produced in culture.

**sterile:** 1) not producing spores, 2) free from living organisms.

**stipitate:** with a stalk.

**stroma:** a mass of fungus tissue on which perithecia or apothecia are produced, or in the Loculoascomycetes, in which ascigerous locules are formed.

**subiculum:** a net-like, or crust-like growth of mycelium under fruit bodies.

**subulate:** tapering to a point; awl-shaped.

**sympodula:** a conidiogenous cell characterized by continued growth of a succession of apices each of which originates below and to one side of the previous apex.

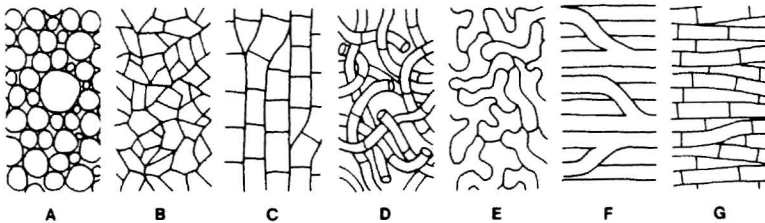
**syndrome:** a complex of symptoms constituting the picture of a disease.

**synnema:** a group of erect, fused conidiophores bearing conidia at the apex.

**synonym:** another name for a fungus, especially a later or illegitimate name.

**teleomorph:** the perfect or sexual state of a fungus, i.e., the form involved in producing meiotic spores.

**textura:** tissue of the Ascomycetes.



Short-celled tissue.

A) cells round: *textura globulosa*.

B) cells polyhedral: *textura angularis*.

C) cells rectangular: *textura prismatica*.

Long-celled tissue.

D) hyphae loose, not parallel: *textura intricata*.

E) hyphae united, not parallel: *textura epidermoidea*.

F) hyphae thick-walled, parallel: *textura oblita*.

G) hyphae thin-walled, parallel: *textura porrecta*.

**tomentose:** having a covering of soft, matted hairs.

**uncinate:** hooked.

**unitunicate:** of asci, having only one wall.

**valsoid:** groups of perithecia with convergent beaks.

**verrucose:** warty.

**verticillate:** whorled.

**viscid:** sticky.

## References

- Arx, J.A. von. 1970. A revision of the fungi classified as *Gloeosporium*. *Bibl. Mycol.* 24. J. Cramer.
- Arx, J.A. von and E. Müller. 1954. Die Gattungen der amersporen Pyrenomyceten. *Beitr. Kryptogamenflora Schweiz* 11: 1-434.
- Baranyay, J.A. and Y. Hiratsuka. 1967. Identification and distribution of *Ciborinia whetzellii* (Seaver) Seaver in western Canada. *Can. J. Bot.* 45: 189-191.
- Barr, M.E. 1955. Species of sooty moulds from western North America. *Can. J. Bot.* 33: 497-514.
- Barr, M.E. 1968. The Venturiaceae in North America. *Can. J. Bot.* 46: 799-864.
- Barr, M.E. 1972. Preliminary studies on the Dothideales in temperate North America. *Contr. Univ. Mich. Herb.* 9: 523-638.
- Bega, R.V. 1978. Diseases of Pacific coast conifers. U.S. Dep. Agric. For. Serv., Pacific Southwest Forest and Range Expmnt. Stn., Berkeley. *Agr. Hdbk.* No. 521.
- Bernstein, M.E. and G.C. Carroll. 1977. Microbial populations on Douglas-fir needle surfaces. *Microb. Ecol.* 4: 41-52.
- Bier, J.E. 1939. Septoria canker of introduced and native hybrid poplars. *Can. J. Res. C*, 17: 195-204.
- Bier, J.E. 1965. Some effects of foliage saprophytes in the control of *Melampsora* leaf rust on Black cottonwood. *For. Chron.* 41: 306-312.
- Bonar, L. 1962. *Stegopezizella balsameae* and *Gloeosporium balsameae*. *Mycologia* 54: 395-399.
- Butin, H. 1973. Morphologische und taxonomische Untersuchungen an *Nae-macyclus niveus* (Pers. ex Fr.) Fckl. ex Sacc. und verwandten Arten. *Eur. J. For. Pathol.* 3: 146-163.
- Carlson, L.W. 1972. Fungicidal control of poplar leaf spots in Alberta and Saskatchewan. *Can. Plant Dis. Surv.* 52: 99-101.

- Carroll, G.C. and F.E. Carroll. 1978. Studies on the incidence of coniferous needle endophytes in the Pacific Northwest. *Can. J. Bot.* 56: 3034-3043.
- Chastagner, G.A. and R.S. Byther. 1983a. Control of Swiss Needle Cast on Douglas-fir Christmas trees with aerial applications of Chlorothalonil. *Plant Dis.* 67: 790-792.
- Chastagner, G.A. and R.S. Byther. 1983b. Infection period of *Phaeocryptopus gaeumannii* on Douglas-fir needles in western Washington. *Plant Dis.* 67: 811-813.
- Childs, T.W. 1959. Elytroderma needle blight of ponderosa pine. U.S. Dep. Agric. For. Serv. F.P.L. 42.
- Childs, T.W. 1968. Elytroderma disease of ponderosa pine in the Pacific Northwest. U.S. Dep. Agric. For. Serv. Res. paper PNW-69.
- Dance, B.W. 1961. Leaf and shoot blight of poplars (section *Tacamahaca* Spach) caused by *Venturia populina* (Vuill.) Fabric. *Can. J. Bot.* 39: 875-890.
- Darker, G.D. 1932. The Hypodermataceae of conifers. *Contr. Arnold Arb. Harvard Univ.* 1: 1-131.
- Darker, G.D. 1963. A new genus of Phacidiaceae on *Picea mariana*. *Can. J. Bot.* 41: 1389-1393.
- Darker, G.D. 1964. A new *Leptosphaeria* species, an agent in the biological control of certain hypodermataceae. *Can. J. Bot.* 42: 1005-1009.
- Darker, G.D. 1965. The occurrence of *Rhizothyrium* on *Abies* and *Tsuga*. *Can. J. Bot.* 43: 11-14.
- Darker, G.D. 1967. A revision of the genera of the Hypodermataceae. *Can. J. Bot.* 45: 1399-1444.
- DiCosmo, F., T.R. Nag Raj and B. Kendrick. 1983. Prodrumus for a revision of the Phacidiaceae and related anamorphs. *Can. J. Bot.* 61: 31-44.
- DiCosmo, F., H. Peredo and D.W. Minter. 1983. *Cyclaneusma* gen. nov., *Naeomacyclus* and *Lasiostictis*, a nomenclatural problem resolved. *Eur. J. For. Pathol.* 13: 206-212.
- Dingley, J.M. and J.W. Gilmour. 1972. *Colletotrichum acutatum*: Simmds. f. sp. *pineae* associated with "Terminal Crook" disease of *Pinus* spp. *N.Z. J. For. Sci.* 2: 192-201.

- Dorworth, C.E. 1970. Scleroderris canker in Ontario forest nurseries. Can. For. Serv. Inf. Rept. 0-X-148.
- Dorworth, C.E. 1972. *Scleroderris lagerbergii* Gremmen in the boreal forest of Ontario. Can. For. Serv. Inf. Rept. 0-X-156.
- Dubreuil, S.H. 1982. Western larch needle blight and needlecast. U.S. Dep. Agric. For. Serv. North. Region Rept. No. 82-9.
- Dyko, B.J. and B.C. Sutton. 1979. A revision of *Linodochium*, *Pseudocenangium*, *Septopatella* and *Siroscyphella*. Can. J. Bot. 57: 370-385.
- Etheridge, D.E. 1965. Report to the Government of Tanzania on forest tree diseases. E.P.T.A. Report No. 2056, F.A.O., Rome.
- Funk, A. and A.K. Parker. 1966. *Scirrhia pini* n.sp., the perfect state of *Dothistroma pini* Hulbary. Can. J. Bot. 44: 1171-1176.
- Funk, A. and A.C. Molnar. 1972. *Kabatina thujae* on yellow cedar in British Columbia nurseries. Bi-monthly Res. Notes 28: 16-17.
- Funk, A. 1982. *Vanterpoolia*, a new genus of sporodochial hyphomycetes. Can. J. Bot. 60: 973-975.
- Gibson, I.A.S. 1974. Impact and control of dothistroma blight of pines. Eur. J. For. Pathol. 4: 89-100.
- Gourbiere, F. and M. Morelet. 1980. Le genre *Rhizosphaera* Mangin et Hariot. Cryptogam. Mycol. 1: 69-82.
- Gremmen, J. 1960. A contribution to the mycoflora of the pine forests in the Netherlands. Nova Hedwigia 1: 251-288.
- Groves, J.W. and C.A. Bowerman. 1955. The species of *Ciborinia* on *Populus*. Can. J. Bot. 33: 577-590.
- Harniss, R.O. and D.L. Nelson. 1984. A severe epidemic of *Marssonina* leaf blight on quaking aspen in Northern Utah. U.S. Dept. Agric. For. Ser. Res. Note INT-339.
- Hermanides-Nijhof, E.J. 1977. The black yeasts and allied hyphomycetes. Studies in Mycology No. 15. Centraalb. v. Schimmelcultures, Baarn.
- Hiratsuka, Y. 1984. A new leaf spot fungus, *Marssonina balsamiferae*, on *Populus balsamifera* in Manitoba and Ontario. Mycotaxon 19: 133-136.

- Hodges, C.S. 1962. Comparison of four similar fungi from *Juniperus* and related conifers. *Mycologia* 54: 62-69.
- Holsten, E.H. R.A. Werner and T.H. Laurent. 1980. Insects and diseases of Alaskan forests. U.S. Dep. Agric. For. Serv., Alaska Region. Report No. 75.
- Hood, I.A. 1979. Inoculation experiments with *Phaeocryptopus gaeumannii* on Douglas-fir seedlings. *N.Z. J. For. Sci.* 7: 77-82.
- Hood, I.A. 1982. *Phaeocryptopus gaeumannii* on *Pseudotsuga menziesii* in southern British Columbia. *N.Z. J. For. Sci.* 12: 415-424.
- Horie, H. and T. Kobayashi. 1980. *Entomosporium* leaf spot of Pomoideae (Rosaceae) in Japan. III. *Eur. J. For. Pathol.* 10: 225-235.
- Hosie, R.C. 1969. Native Trees of Canada. Can. For. Serv., Ottawa.
- Hudson, H.J. 1968. The ecology of fungi on plant remains above the soil. *New Phytol.* 67: 837-874.
- Hughes, S.J. 1974. New Zealand Fungi. 22. *Euantennaria* with *Antennatula* and *Hormisciomyces* states. *N.Z. J. Bot.* 12: 299-356.
- Hughes, S.J. 1976. Sooty Moulds. *Mycologia* 68: 693-820.
- Hunt, R.S. and W.G. Ziller. 1978. Host-genus keys to the Hypodermataceae of conifer leaves. *Mycotaxon* 6: 481-496.
- Hunt, R.S. 1981. Pine needle casts and blights in the Pacific region. Can. For. Serv. Pac. For. Res. Cent. For. Pest Leaflet. 43.
- Hunt, R.S. and A. Funk. 1983. Common pests of *Arbutus* in British Columbia. Can. For. Serv. Pac. For. Res. Cent. For. Pest. Leaflet.
- Korf, R.P. 1962. A synopsis of the Hemiphacidiaceae, a family of the Helotiales (Discomycetes) causing needle blights of conifers. *Mycologia* 54: 12-33.
- Kumi, J. and K.J. Lang. 1979. The susceptibility of various spruce species to *Rhizosphaera kalkhoffii* and some cultural characteristics of the fungus *in vitro*. *Eur. J. For. Pathol.* 9: 35-46.
- Laut, J.G., B.C. Sutton and J.I. Lawrence. 1966. Brown spot needle blight in Canada. *Plant Dis. Rep.* 50: 208.
- Malhotra, S.S. and R.A. Blauel. 1980. Diagnosis of air pollutant and natural stress



- symptoms on forest vegetation in western Canada. Can. For. Serv. North. For. Res. Cent. Inf. Rept. NOR-X-228.
- Millar, C.S. and D.W. Minter. 1980. *Naemacyclus minor*. C.M.I. Desc. of Path. Fungi and Bacteria. No. 659. Comm. Mycol. Inst., Kew.
- Minter, D.W., J.M. Staley and C.S. Millar. 1978. Four species of *Lophodermium* on *Pinus sylvestris*. Trans. Brit. Mycol. Soc. 71: 295-301.
- Minter, D.W. 1980. *Leptostroma* on pine needles. Can. J. Bot. 58: 906-917.
- Minter, D.W. 1981. *Lophodermium* on pines. Mycol. Paper No. 147. Comm. Mycol. Inst., Kew.
- Minter D.W. and V. Holubova-Jechova. 1981. New or interesting Hyphomycetes on decaying pine litter from Czechoslovakia. Folia Geobot. Phytotax., Praha 16: 195-217.
- Mix, A.J. 1949. A monograph of the genus *Taphrina*. Univ. Kans. Sci. Bull. 33: 1-167.
- Monod, M. 1983. Monographie taxonomique des Gnomoniaceae. Sydowia Ann. Mycol. IX Beiheft. 1-315.
- Morelet, M. 1983. Systematique et biologie des *Venturia* infeodes aux peupliers de la section *Leuce*. Doctoral Thesis, University of Nancy, France.
- Morgan-Jones, G. 1971. *Sciniatosporium* Kalchbr. and its synonyms *Marcosia* Syd., *Stigmia* Sacc., *Thyrostroma* Hoehnel, and *Thyrostromella* Syd., non Hoehnel. Can. J. Bot. 49: 993-1009.
- Morton, H.L. and R.E. Miller. 1982. Chemical control of Rhabdochline needle cast of Douglas-fir. Plant Dis. 66: 999-1000.
- Müller, E. and M.L. Farr. 1971. A new genus of the Schizothyriaceae from the Pacific Northwest. Mycologia 63: 1080-1083.
- Nag Raj, T.R. 1983. Genera coelomycetum. XXI. *Strasseria* and two new anamorph-genera, *Apostrasseria* and *Nothostrasseria*. Can. J. Bot. 61: 1-30.
- Nair, J. and J.B. Corbin. 1981. Histopathology of *Pinus radiata* seedlings infected by *Colletotrichum acutatum* f. sp. *pinæ*. Phytopathology 71: 777-783.
- Nair, J., F.J. Newhook and J.B. Corbin. 1983. Survival of *Colletotrichum acutatum* f.sp. *pinæ* in soil and pine debris. Trans. Br. Mycol. Soc. 81: 53-63.

- Ondrej, M. 1972. Ein Beitrag zur Kenntnis der parasitischen imperfekten Pilze der Gattung *Pollaccia* Bald. et Cif. an Pappeln (*Populus* spp.). Eur. J. For. Pathol. 2: 140-146.
- Ormrod, D.J. 1976. Control of Lophodermium needle cast of Scots pine Christmas trees in British Columbia. Can. Plant Dis. Surv. 56: 69-72.
- Ostrofsky, A. and G.W. Peterson. 1981. Etiologic and cultural studies of *Kabatina juniperi*. Plant Dis. 65: 908-910.
- Ouellette, G.B. 1966. On *Thyriopsis halepensis* and its conidial stage. Mycologia 58: 322-325.
- Parker, A.K. and D.G. Collis. 1966. Dothistroma needle blight of pines in British Columbia. For. Chron. 42: 160-161.
- Parker, A.K. and J. Reid. 1969. The genus *Rhabdocline* Syd. Can. J. Bot. 47: 1533-1545.
- Parker, A.K. 1970. Effect of relative humidity and temperature on needle cast disease of Douglas-fir. Phytopathology 60: 1270-1273.
- Parker, A.K. 1972. Artificial inoculation of *Pinus radiata* with *Scirrhia (Dothistroma) pine*: effect of relative humidity and temperature on incubation. Phytopathology 62: 1160-1164.
- Patton, R.F. and R.N. Spear. 1983. Needle cast of European larch caused by *Mycosphaerella laricina* in Wisconsin and Iowa. Plant Dis. 67: 1149-1151.
- Peterson, G.W. and D.A. Graham. 1974. *Dothistroma* needle blight of pines. U.S. Dep. Agric. For. Serv., Pest Leaflet No. 143.
- Peterson, G.W. and R.S. Smith, Jr. 1975. Forest Nursery Diseases in the United States. U.S. Dep. Agric. For. Serv., Agr. Hdbk. No. 470.
- Peterson, G.W. 1981. Pine and juniper diseases in the Great Plains. U.S. Dep. Agric. For. Serv., Gen. Tech. Rept. R.M. 86.
- Pirozynski, K.A. and R.A. Shoemaker. 1970. Some Asterinaceae and Meliolaceae on conifers in Canada. Can. J. Bot. 48: 1321-1328.
- Porter, W.A. 1957. Biological studies on western red cedar blight caused by *Keithia thujina* Durand. Interim Report, Pacific Forest Research Centre, Victoria, B.C.
- Reid, J. and R.F. Cain. 1962a. Studies on the organisms associated with

- “snow-blight” of conifers in North America. I. A new genus of the Helotiales. *Mycologia* 54: 194-200.
- Reid, J. and R.F. Cain. 1962b. Studies on the organisms associated with “snow-blight” of conifers in North America. II. Some species of the genera *Phacidium*, *Lophophacidium*, *Sarcotrochila* and *Hemiphacidium*. *Mycologia* 54: 481-497.
- Robins, J.K. and J.P. Susut. 1974. Red Belt in Alberta. Can. For. Serv. North. For. Res. Cent. Inf. Rept. NOR-X-99.
- Rossmann, A.Y. and K.C. Lu. 1980. Filamentous fungi associated with leaf surfaces of red alder and Douglas-fir seedlings in western Oregon. *Mycotaxon* 10: 369-371.
- Scharpf, R.F., J. Staley and F.G. Hawksworth. 1970. A needle cast, the first known disease of bristlecone fir in California. *Plant Dis. Rep.* 54: 275-277.
- Scharpf, R.F. and R.V. Bega. 1981. Elytroderma disease reduces growth and vigor, increases mortality of Jeffrey pines at Lake Tahoe basin, California. U.S. Dep. Agric. For. Serv. Res. paper PSW-155.
- Shaw, C.G. and C.D. Leaphart. 1960. Two serious foliage diseases of western white pine in the Inland Empire. *Plant Dis. Rep.* 44: 655-659.
- Shoemaker, R.A. 1965. Revision of some *Dimeriella* and *Dimerosporium* parasites of conifers. *Can. J. Bot.* 43: 631-639.
- Shoemaker, R.A. 1967. *Cucurbitaria piceae* and associated Sphaeropsidales parasitic on spruce buds. *Can. J. Bot.* 45: 1243-1248.
- Sivanesan, A. and I.A.S. Gibson. 1976. *Diplocarpon maculatum*, C.M.I. Desc. of Path. Fungi and Bacteria No. 481. Kew.
- Smerlis, E. and M. Saint-Laurent. 1966. Pathogenicity of *Lophophacidium hyperboreum* Lagerberg. *Plant Dis. Rep.* 50: 356-357.
- Smerlis, E. 1966. Notes on the nomenclature of *Nothophacidium phyllophilum* comb. nov., its pathogenicity and relationship to *Pezizella minuta*. *Can. J. Bot.* 44: 563-565.
- Smerlis, E. 1967. *Rhizocalyx abietis* Petrak, the perfect state of *Rhizothyrium abietis* Naumoff. *Can. J. Bot.* 45: 1715-1717.
- Smerlis, E. 1979. Chemical control of *Lophophacidium hyperboreum* and *Phacidium abietis*. Results of 1978 field assays. *Can. Centre Rech. For. Lauren-*

tides, Ste. Foy, Que. Rapp. Inf. LAU-X-42. 10 pp.

- Staley, J.M. and H.H. Bynum. 1972. A new *Lophodermella* on *Pinus ponderosa* and *P. attenuata*. *Mycologia* 64: 722-726.
- Stephan, B.R. 1973. Cytologische Untersuchungen zur Ascusentwicklung und Sporenkeimung bei *Rhabdocline pseudotsugae*. *Phytopath. Z.* 78: 336-343.
- Sutherland, J.R., W. Lock and S.H. Farris. 1981. Sirococcus blight: a seed borne disease of container-grown spruce seedlings in coastal British Columbia forest nurseries. *Can. J. Bot.* 59: 559-562.
- Sutton, B.C. and J.J. Lawrence. 1969. Black rib of willows—in Manitoba and Saskatchewan. *Plant Dis. Rep.* 53: 101-102.
- Sutton, B.C. and R.L.C. Chao. 1970. *Leptomelanconium*. *Trans. Br. Mycol. Soc.* 55: 37-44.
- Sutton B.C. 1969. Forest Microfungi. III. The heterogeneity of *Pestalotia* de Not. section *sexloculatae* Klebahn sensu Guba. *Can. J. Bot.* 47: 2083-2094.
- Sutton, B.C. 1975. Coelomycetes. V. *Coryneum*. C.M.I. Mycol. Paper No. 138. Kew.
- Sutton, B.C. 1980. The Coelomycetes. C.M.I., Kew, England. 696 pp.
- Swart, H.J. 1973. The fungus causing cypress canker. *Trans. Br. Mycol. Soc.* 61: 71-82.
- Tanaka, K. and O. Chiba. 1971. On a needle blight of pine caused by *Rhizosphaera kalkhoffii* Bubak. Life history, physiological characteristics and pathogenicity of the causal fungus. *J. Jpn. For. Soc.* 53: 279-286.
- Waterman, A.M. 1945. Tip blight of species of *Abies* caused by a new species of *Rehmiellopsis*. *J. Agric. Res.* 70: 315-337.
- Waterman, A.M. 1947. *Rhizosphaera kalkhoffii* associated with a needle cast of *Picea pungens*. *Phytopathology* 37: 507-511.
- Zalasky, H. 1978. Stem and leaf spot infections caused by *Septoria musiva* and *S. populicola* on poplar seedlings. *Phytoprotection* 59: 43-50.
- Ziller, W.G. 1968. Studies of hypodermataceous needle diseases. I. *Isthmiella quadrispora* sp. nov., causing needle blight of alpine fir. *Can. J. Bot.* 46: 1377-1381.

- Ziller, W.G. 1969a. *Sarcotrichila alpina* and *Lophodermium laricinum* causing larch needle blight in North America. *Plant Dis. Rep.* 53: 237-239.
- Ziller, W.G. 1969b. Studies of hypodermataceous needle diseases. II. *Lirula brevispora* sp. nov., causing needle blight of spruce. *Can. J. Bot.* 47: 261-262.
- Ziller, W.G. 1974. The tree rusts of Western Canada. *Can. For. Serv., Pub. No.* 1329, Dept. of Environ., Ottawa.
- Ziller, W.G. and A. Funk. 1973. Studies of hypodermataceous needle diseases. III. The association of *Sarcotrichila macrospora* n. sp. and *Hemiphacidium longisporum* n. sp. with pine needle cast caused by *Davisomycella ampla* and *Lophodermella concolor*. *Can. J. Bot.* 51: 1959-1963.

# Host Index

(refs. **Native Trees of Canada** by R.C. Hosie; Hunt and Ziller 1978)

## **ABIES AMABILIS (Dougl.)**

### **Forbes — Amabilis fir**

*Epipolaeum abietis*  
*Herpotrichia juniperi*  
*Limacinia alaskensis*  
*Lirula abietis-concoloris*  
*Lirula punctata*  
*Lophodermium consociatum*  
*Lophodermium uncinatum*  
*Lophomerum autumnale*  
*Maurodothina farriae*  
*Phacidium abietis*  
*Phaeocryptopus nudus*  
*Rhizosphaera kalkhoffii*  
*Stegopezizella balsameae*  
*Virgella robusta*

## **ABIES GRANDIS (Dougl.)**

### **Lindl. — Grand fir**

*Atichia glomerulosa*  
*Botryosphaeria abietina*  
*Epipolaeum abietis*  
*Hormonema merioides*  
*Limacinia alaskensis*  
*Lirula abietis-concoloris*  
*Lirula punctata*  
*Lophodermium decorum*  
*Lophodermium lacerum*  
*Lophodermium piceae*  
*Maurodothina farriae*  
*Phacidium abietis*  
*Phaeocryptopus nudus*  
*Phyllosticta* sp.  
*Stegopezizella balsameae*

## **ABIES LASIOCARPA**

### **(Hook.) Nutt. — Alpine fir**

*Camarosporium strobilinum*  
*Darkera abietis*  
*Delphinella abietis*  
*Delphinella balsameae*  
*Epipolaeum abietis*  
*Herpotrichia juniperi*  
*Isthmiella abietis*  
*Isthmiella quadrispora*  
*Leptosphaeria faulii*  
*Limacinia alaskensis*  
*Lirula abietis-concoloris*  
*Lirula punctata*  
*Lophodermium decorum*  
*Lophodermium piceae*  
*Lophodermium uncinatum*  
*Lophomerum autumnale*  
*Nothophacidium phyllophilum*  
*Phacidium abietis*  
*Phaeocryptopus nudus*  
*Rhizosphaera pini*  
*Rhizothyrium abietis*  
*Stegopezizella balsameae*  
*Tiarosporella abietis*

## **ACER CIRCINATUM**

### **Pursh — Vine maple**

*Cristulariella depraedans*

**ACER GLABRUM Torr. var.****douglasii (Hook.) Dipp.—****Douglas maple***Cristulariella depraedans**Septoria aceris**Taphrina darkeri***ACER MACROPHYLLUM****Pursh — Broadleaf maple***Cercospora aceris**Cristulariella depraedans**Rhytisma punctatum**Uncinula bicornis***ALNUS RUBRA Bong. —****Red alder***Cercosporaalni**Cylindrosporiumalni**Gnomonia setacea**Phyllactinia guttata**Taphrina japonica***AMELANCHIER****ALNIFOLIA (Nutt.)****Nutt. — Saskatoon berry***Apiosporina collinsii**Entomosporium mespili**Phyllactinia guttata***ARBUTUS MENZIESII****Pursh — Arbutus, Madrone***Capnodium walteri**Coccomyces arbutifolius**Coccomyces dentatus**Didymosporium arbuticola**Mycosphaerella arbuticola**Rhytisma arbuti***BETULA — Birch***Atopospora betulina**Gnomonia campylostyla**Phyllactinia guttata**Taphrina americana**Taphrina bacteriosperma**Taphrina boycei**Taphrina flava**Taphrina nana***CHAMAECYPARIS****NOOTKATENSIS (D. Don)****Spach — Yellow cedar***Chloroscypha seaveri**Cyanodiscus occidentalis**Kabatina thujae**Pestalotiopsis funerea***CORNUS NUTTALLII Aud.****— Western flowering****dogwood***Gloeosporium "corni"**Phyllactinia guttata**Phyllosticta cornicola***CRATAEGUS — Hawthorn***Entomosporium mespili***JUNIPERUS — Juniper***Cercospora sequoiae**Chloroscypha sabiniae**Herpotrichia juniperi**Kabatina juniperi**Lophodermium juniperi**Pithya cupressina***LARIX — Larch***Apostrasseria lunata**Hypodermella laricis*

*Lophodermium laricinum*  
*Meria laricis*  
*Mycosphaerella laricina*  
*Sarcotrochila alpina*

### **PICEA ENGELMANNII**

#### **Parry — Engelmann spruce**

*Dichomera gemmicola*  
*Herpotrichia coulteri*  
*Herpotrichia juniperi*  
*Isthmiella crepidiformis*  
*Lirula brevispora*  
*Lirula macrospora*  
*Sirococcus strobilinus*  
*Stigmia verrucosa*

### **PICEA GLAUCA (Moench)**

#### **Voss — White spruce**

*Camarosporium strobilinum*  
*Dichomera gemmicola*  
*Epipolaeum tsugae*  
*Isthmiella crepidiformis*  
*Lirula brevispora*  
*Lirula macrospora*  
*Lophodermium piceae*  
*Lophomerum darkeri*  
*Lophophacidium hyperboreum*  
*Sarcotrochila piniperda*  
*Sirococcus strobilinus*  
*Stigmia verrucosa*

### **PICEA MARIANA (Mill.)**

#### **B.S.P. — Black spruce**

*Isthmiella crepidiformis*  
*Lirula macrospora*  
*Stigmia verrucosa*

### **PICEA SITCHENSIS (Bong.)**

#### **Carr. — Sitka spruce**

*Appendiculella pinicola*  
*Dichomera gemmicola*

*Herpotrichia juniperi*  
*Lirula macrospora*  
*Lophodermium piceae*  
*Phaeocryptopus nudus*  
*Rhizosphaera pini*  
*Sarcotrochila piniperda*  
*Sirococcus strobilinus*

### **PINUS ALBICAULIS**

#### **Engelm. — Whitebark pine**

*Bifusella linearis*  
*Bifusella saccata*  
*Gremmeniella abietina*  
*Hemiphacidium planum*  
*Herpotrichia coulteri*  
*Lophodermella arcuata*  
*Lophodermium nitens*

### **PINUS BANKSIANA Lamb.**

#### **— Jack pine**

*Davisomycella ampla*  
*Lophodermella concolor*  
*Lophodermella montivaga*  
*Lophodermium molitoris*  
*Lophodermium pinastri*  
*Mycosphaerella dearnessii*  
*Thyriopsis halepensis*

### **PINUS CONTORTA Dougl.**

#### **— Lodgepole pine**

*Davisomycella ampla*  
*Davisomycella medusa*  
*Davisomycella montana*  
*Dothistroma pini*  
*Elytroderma deformans*  
*Gremmeniella abietina*  
*Hemiphacidium longisporum*  
*Hendersonia pinicola*  
*Herpotrichia coulteri*  
*Herpotrichia juniperi*  
*Leptomelanconium cinereum*  
*Lophodermella cerina*



Lophodermella concolor  
 Lophodermella montivaga  
 Lophodermium pinastri  
 Lophodermium seditiosum  
 Mycosphaerella dearnessii  
 Naemacyclus minor  
 Naemacyclus niveus  
 Phaeoseptoria contortae  
 Sarcotrochila macrospora  
 Scirrhia pini  
 Sclerophoma pithyophila  
 Sirococcus strobilinus

### **PINUS MONTICOLA Dougl.**

#### **— Western white pine**

Bifusella linearis  
 Cenangium acuum  
 Dothistroma pini  
 Hemiphacidium planum  
 Leptomelanconium allescheri  
 Linodochium hyalinum  
 Lophodermella arcuata  
 Lophodermium nitens  
 Lophodermium pinastri  
 Meloderma desmazierii  
 Rhizosphaera pini  
 Scirrhia pini  
 Stomiopeltis pinastri

### **PINUS PONDEROSA Laws.**

#### **— Ponderosa pine**

Davisomycella medusa  
 Davisomycella ponderosae  
 Diplodia pinea  
 Dothistroma pini  
 Elytroderma deformans  
 Gremmeniella abietina  
 Leptomelanconium cinereum  
 Lophodermella cerina  
 Lophodermella morbida  
 Lophodermium pinastri  
 Scirrhia pini  
 Sirococcus strobilinus

### **POPULUS BALSAMIFERA**

#### **L. — Balsam poplar**

Ciborinia whetzeli  
 Linospora tetraspora  
 Marssonina balsamiferae  
 Venturia populina

### **POPULUS TREMULOIDES**

#### **Michx. — Trembling aspen**

Ciborinia pseudobifrons  
 Ciborinia seaveri  
 Ciborinia whetzeli  
 Marssonina brunnea  
 Marssonina populi  
 Taphrina populina  
 Uncinula adunca  
 Venturia macularis

### **POPULUS TRICHOCARPA**

#### **Torr. & Gray —**

#### **Black cottonwood**

Linospora tetraspora  
 Marssonina populi  
 Mycosphaerella populicola  
 Mycosphaerella populorum  
 Taphrina populi-salicis  
 Uncinula adunca  
 Venturia populina

### **PSEUDOTSUGA**

#### **MENZIESII (Mirb.)**

#### **Franco — Douglas-fir**

Atichia glomerulosa  
 Botrytis cinerea  
 Dichomera gemmicola  
 Epipolaeum pseudotsugae  
 Hormonema merioides  
 Limacinia alaskensis  
 Meria laricis  
 Phacidium abietis

Phacidium pini-cembrae  
Phaeocryptopus gaeumannii  
Phomopsis lokoyae  
Rhabdocline pseudotsugae  
Rhabdocline weirii  
Rhabdogloeum hypophyllum  
Rhabdogloeum pseudotsugae  
Rhizosphaera kalkhoffii  
Rosellinia herpotrichioides  
Sclerophoma pithyophila  
Sirococcus strobilinus  
Stomiopeltis sp.  
Tiarosporella pseudotsugae

### **QUERCUS GARRYANA**

**Dougl. — Garry oak**

Taphrina caerulescens

### **QUERCUS MACROCARPA**

**Michx. — Bur oak**

Gnomonia quercina

### **SALIX — Willow**

Ciborinia foliicola  
Ciborinia wisconsinensis  
Marssonina kriegeriana  
Rhytisma salicinum  
Taphrina populi-salicis  
Uncinula salicis  
Venturia saliciperda

### **TAXUS BREVIFOLIA Nutt.**

**— Western yew**

Asteridiella pitya  
Dothiora taxicola  
Phacidium dearnessii  
Phyllostictina hysterella

### **THUJA PLICATA Donn —**

**Western red cedar**

Chloroscypha seaveri  
Didymascella thujina  
Limacinia alaskensis  
Phacidium sherwoodiae  
Phomopsis lokoyae  
Pithya cupressina  
Seiridium cardinale  
Stigmina thujina

### **TSUGA HETEROPHYLLA**

**(Raf.) Sarg. —**

**Western hemlock**

Colletotrichum acutatum  
Colletotrichum gloeosporioides  
Epipolaeum tsugae  
Fabrella tsugae  
Herpotrichia juniperi  
Phomopsis lokoyae  
Rhizosphaera oudemansii  
Sclerophoma pithyophila  
Sirococcus strobilinus  
Truncatella truncata  
Vanterpoolia tsugae

## General Index

### A

abietina, Botryosphaeria .....	24
abietina, Gremmeniella .....	48
abietis, Bifusella .....	54
abietis, Darkera .....	34
abietis, Delphinella .....	35
abietis, Dimerosporium .....	45
abietis, Epipolaeum .....	45
abietis, Isthmiella .....	54
abietis, Phacidium .....	80
abietis, Rhizothyrium .....	93
abietis-concoloris, Lirula .....	62
aceris, Cerosporella .....	28
aceris, Septoria .....	102
acicola, Lecanostica .....	76
acicola, Scirrhia .....	76
acutatum, Colletotrichum .....	31
acuum, Cenangium .....	26
Adelopus gaeumannii .....	80
Adelopus nudus .....	82
adunca, Uncinula .....	112
alaskensis, Limacinia .....	59
allescheri, Leptomelanconium .....	59
alni, Cercosporella .....	27
alni, Cylindrosporium .....	102
alni, Septoria .....	102
alnifolia, Septoria .....	102
alpina, Sarcotrochila .....	96
alpina, Stegia .....	96
alpinus, Naemacyclus .....	96
americana, Pollaccia .....	114
americana, Taphrina .....	108
ampla, Davisonmycella .....	34,37
Apiosporina collinsii .....	20
Apostrasseria lunata .....	20
Apostrasseria robusta .....	80
Appendiculella pinicola .....	20
arbuti, Rhytisma .....	31
arbuticola, Didymosporium .....	39

arbuticola, <i>Mycosphaerella</i> .....	74
arbutifolius, <i>Coccomyces</i> .....	29
arcuata, <i>Lophodermella</i> .....	66
<i>Ascochyta piniperda</i> .....	103
<i>Asteridiella pitya</i> .....	21
<i>Atichia glomerulosa</i> .....	21
<i>Atopospora betulina</i> .....	22,23
austriacum, <i>Leptostroma</i> .....	69
autumnale, <i>Lophomerum</i> .....	70

## B

bacteriosperma, <i>Taphrina</i> .....	108
baculiferum, <i>Lophodermium</i> .....	69
balsameae, <i>Delphinella</i> .....	35
balsameae, <i>Gloeosporium</i> .....	103
balsameae, <i>Sarcotrochila</i> .....	103
balsameae, <i>Stegopezizella</i> .....	103
balsamiferae, <i>Marssonina</i> .....	71
berckmansii, <i>Seimatosporium</i> .....	102
betulina, <i>Atopospora</i> .....	22,23
bicornis, <i>Uncinula</i> .....	109
<i>Bifusella abietis</i> .....	54
<i>Bifusella linearis</i> .....	23,117
<i>Bifusella pini</i> .....	23
<i>Bifusella saccata</i> .....	23
Black mildew .....	20,21,45,73,106
Black rib .....	28
<i>Botryosphaeria abietina</i> .....	24
<i>Botrytis</i> .....	95
<i>Botrytis cinerea</i> .....	24
boycei, <i>Taphrina</i> .....	108
brevispora, <i>Lirula</i> .....	63
brown felt blight .....	51,52
<i>Brunchorstia pinea</i> .....	48
brunnea, <i>Marssonina</i> .....	72

## C

caerulescens, <i>Taphrina</i> .....	108
<i>Camarosporium strobilinum</i> .....	24

campylostyla, Gnomonia .....	48
Capnodium walteri .....	24
cardinale, Seiridium .....	101
castagnei, Marssonina .....	72
Cenangium acuum .....	26
Cercospora sequoiae .....	26
Cercospora alni .....	27
Cercospora aceris .....	28
cerina, Lophodermella .....	66
Ceuthospora .....	80
Chloroscypha sabiniae .....	28
Chloroscypha seaveri .....	28
Chrysomyxa .....	121, 123
Ciborinia foliicola .....	28
Ciborinia pseudobifrons .....	29
Ciborinia seaveri .....	29
Ciborinia whetzellii .....	29
Ciborinia wisconsinensis .....	29
cinerea, Botrytis .....	24
cinereum, Leptomelanconium .....	57
cingulata, Glomerella .....	32
Cladosporium .....	12, 20
Coccomyces arbutifolius .....	29
Coccomyces dentatus .....	31
Coleosporium .....	123
Colletotrichum acutatum .....	31
Colletotrichum gloeosporioides .....	32
collinsii, Apiosporina .....	20
concolor, Lophodermella .....	66
confusa, Taphrina .....	108
Coniothyrium faullii .....	59
conjuncta, Lophodermella .....	66
conorum, Phomopsis .....	84
consociatum, Lophodermium .....	67
contortae, Phaeoseptoria .....	83
“corni,” Gloeosporium .....	45
cornicola, Phyllosticta .....	45, 86
Coryneum cardinale .....	101
coulteri, Herpotrichia .....	51
crepidiformis, Isthmiella .....	55
Cristulariella depraedans .....	33
cupressina, Pithya .....	88
Cyanodiscus occidentalis .....	34
Cyclaneusma .....	78
Cylindrosporium alni .....	102
Cytospora .....	40

## D

Darkera abietis .....	34
Darkera parca .....	34
darkeri, Lophomerum .....	70
darkeri, Taphrina .....	108
Davisomycella ampla .....	34,37,96,117
Davisomycella lacrimiformis .....	37
Davisomycella limitata .....	37
Davisomycella medusa .....	37,117
Davisomycella montana .....	37
Davisomycella ponderosae .....	37
dearnessii, Mycosphaerella .....	76
dearnessii, Phacidium .....	80
decorum, Lophodermium .....	11,67
deformans, Elytroderma .....	41
Delphinella abietis .....	35
Delphinella balsameae .....	35
dentatus, Coccomyces .....	31
depraedans, Cristulariella .....	33
desmazierii, Meloderma .....	73
Diaporthe lokoyae .....	84
Dichomera gemmicola .....	38
Didymascella thujina .....	39
Didymosporium arbuticola .....	39
Dimeriella tsugae .....	45
Dimerosporium abietis .....	45
Diplocarpon mespili .....	42
Diplodia pinea .....	13,40
Dothiora taxicola .....	40
Dothistroma pini .....	9,12,13,99
Dothistroma septospora .....	99
Drepanopeziza populi-albae .....	72
Drepanopeziza populorum .....	73
Drepanopeziza tremulae .....	72

## E

elegans, Pollaccia .....	115
Elytroderma deformans .....	41,117
Entomosporium mespili .....	42
Epicoccum nigrum .....	42
Epipolaeum abietis .....	45,73

Epipolaeum pseudotsugae .....	45
Epipolaeum tsugae .....	45
Euantennaria .....	59

## F

Fabraea maculata .....	42
Fabrella tsugae .....	45
farriae, Maurodothina .....	73
faullii, Coniothyrium .....	59
faullii, Leptosphaeria .....	59
felt blight .....	51
flava, Taphrina .....	108
flectans, Taphrina .....	108
Fly speck .....	106
foliicola, Ciborinia .....	28
funerea, Pestalotiopsis .....	79
Fusicladium saliciperdum .....	115

## G

gaeumannii, Adelopus .....	80
gaeumannii, Phaeocryptopus .....	80
gemnicola, Dichomera .....	38
Gloeocoryneum cinereum .....	57, 59
gloeosporioides, Colletotrichum .....	32
Gloeosporium .....	45
Gloeosporium balsameae .....	103
Gloeosporium "corni" .....	45, 86
glomerata, Phoma .....	83
Glomerella cingulata .....	32, 115
glomerulosa, Atichia .....	21
Gnomonia campylostyla .....	48
Gnomonia quercina .....	48
Gnomonia setacea .....	48
Gnomonia veneta .....	48
gregaria, Physalospora .....	86
Gremmeniella abietina .....	48
guttata, Phyllactinia .....	86
Gymnosporangium .....	118, 121, 123

## H

halepensis, Thyriopsis .....	107
Hemiphacidium longisporum .....	48,65,117
Hemiphacidium planum .....	23,49,117
Hendersonia pinicola .....	51,65,117
Herpotrichia coulteri .....	51
Herpotrichia juniperi .....	52
Herpotrichia nigra .....	52
herpotrichioides, Rosellinia .....	95
Hormisciomyces .....	59
Hormonema .....	57,92
Hormonema dematioides .....	100
Hormonema merioides .....	52
hyalinum, Linodochium .....	61
Hyalopsora .....	118
hyperboreum, Lophophacidium .....	71
Hypoderma rubustum .....	116
Hypodermella abietis-concoloris .....	62
Hypodermella laricis .....	54
Hypodermina hartigii .....	63
hypophyllum, Rhabdogloeum .....	88
hysterella, Phyllostictina .....	86

## I

Isthmiella abietis .....	54,59,117
Isthmiella crepidiformis .....	55
Isthmiella quadrispora .....	55,117

## J

japonica, Taphrina .....	108
juniperi, Herpotrichia .....	52
juniperi, Kabatina .....	57
juniperi, Lophodermium .....	67



## K

Kabatina juniperi .....	57
Kabatina thujae .....	55
kalkhoffii, Rhizosphaera .....	92
Keithia thujina .....	39
Kriegeria juniperi .....	28
Kriegeria seaveri .....	28
kriegeriana, Marssonina .....	73

## L

lacerum, Lophodermium .....	67
lacrimiformis, Davisomycella .....	37
laricina, Mycosphaerella .....	76
laricinum, Lophodermium .....	67
laricis, Hypodermella .....	54
laricis, Leptothyriella .....	54
laricis, Meria .....	74
Lecanosticta acicola .....	76
Lepteutypa cupressi .....	102
Leptomelanconium allescheri .....	59
Leptomelanconium cinereum .....	57
Leptosphaeria faullii .....	55,59,117
Leptostroma .....	41,69
Leptostroma austriacum .....	69
Leptostroma pinastri .....	69
Leptostroma rostrupii .....	69
Leptostroma strobicola .....	73
Leptothyriella laricis .....	54
Limacinia alaskensis .....	59
limitata, Davisomycella .....	37
linearis, Bifusella .....	23
Linodochium hyalinum .....	61
Linospora tetraspora .....	62
Lirula abietis-concoloris .....	55,62,79,83,117
Lirula brevispora .....	63
Lirula macrospora .....	63,70,96,117
Lirula nervisequia .....	63
Lirula punctata .....	63
lokoyae, Phomopsis .....	84
longisporum, Hemiphacidium .....	48
Lophodermella .....	63,65

Lophodermella arcuata .....	66
Lophodermella cerina .....	66
Lophodermella concolor .....	49,51,65,66,117
Lophodermella conjuncta .....	66
Lophodermella montivaga .....	65,66
Lophodermella morbida .....	66
Lophodermella sulcigena .....	66
Lophodermium .....	65
Lophodermium baculiferum .....	69
Lophodermium consociatum .....	67
Lophodermium decorum .....	67
Lophodermium juniperi .....	67
Lophodermium lacerum .....	67
Lophodermium laricinum .....	67,96
Lophodermium macrosporum .....	63
Lophodermium molitoris .....	69
Lophodermium nitens .....	67
Lophodermium piceae .....	67
Lophodermium pinastri .....	9,67,69
Lophodermium seditiosum .....	9,67,69
Lophodermium uncinatum .....	67
Lophomerum autumnale .....	55,70,117
Lophomerum darkeri .....	70,117
Lophophacidium hyperboreum .....	71
lunata, Apostrasseria .....	20
lunatus, Phacidium .....	20

## M

macrospora, Lirula .....	63
macrospora, Sarcotrochila .....	34,96
macularis, Venturia .....	114
maculata, Fabraea .....	42
Marssonina balsamiferae .....	71
Marssonina brunnea .....	72
Marssonina castagnei .....	72
Marssonina kriegeria .....	73
Marssonina populi .....	73
Maurodothina farriarum .....	73
medusa, Davisomyces .....	37
Melampsora .....	118,121,123,124
Melampsorella .....	118
Melampsoridium .....	123

Melasmia .....	62
Melasmia punctata .....	94
Melasmia salicina .....	94
Meliolales .....	21
Meloderma desmazierii .....	73
Meria laricis .....	74
merioides, Hormonema .....	52
mespili, Diplocarpon .....	42
mespili, Entomosporium .....	42
Micraspis acicola .....	83
Milesina .....	118
millardetii, Seuratia .....	21
minor, Naemacyclus .....	77
molitoris, Lophodermium .....	69
Mollisia pinastri .....	26
Monochaetia unicornis .....	102
montana, Davisonmycella .....	37
montivaga, Lophodermella .....	66
morbida, Lophodermella .....	66
musiva, Septoria .....	77
Mycopappus .....	28
Mycosphaerella arbuticola .....	74
Mycosphaerella dearnessii .....	76
Mycosphaerella laricina .....	76
Mycosphaerella populicola .....	77
Mycosphaerella populorum .....	77

## N

Naemacyclus alpinus .....	96
Naemacyclus minor .....	77
Naemacyclus niveus .....	77
Naevia piniperda .....	96
nana, Taphrina .....	108
Neopeckia coulteri .....	51
nervisequia, Lirula .....	63
nigra, Herpotrichia .....	52
nigrum, Epicoccum .....	42
nitens, Lophodermium .....	67
niveus, Naemacyclus .....	77
Nothopacidium phyllophilum .....	63, 79, 93, 117
nudus, Adelopus .....	82
nudus, Phaeocryptopus .....	82

## O

<i>occidentalis</i> , <i>Cyanodiscus</i> .....	34
<i>occulta</i> , <i>Phomopsis</i> .....	84
<i>Oidium</i> .....	112
<i>Oidium aceris</i> .....	109
<i>oudemansii</i> , <i>Rhizosphaera</i> .....	92

## P

<i>parca</i> , <i>Darkera</i> .....	34
<i>parca</i> , <i>Tiarosporella</i> .....	34
<i>Periperidium acicola</i> .....	83
<i>Pestalotiopsis funerea</i> .....	79
<i>Phacidium abietis</i> .....	80
<i>Phacidium dearnessii</i> .....	80
<i>Phacidium infestans</i> .....	80
<i>Phacidium lunatus</i> .....	20
<i>Phacidium pini-cembrae</i> .....	80
<i>Phacidium sherwoodiae</i> .....	80
<i>Phaeocryptopus gaumannii</i> .....	80
<i>Phaeocryptopus nudus</i> .....	63,82,93
<i>Phaeoseptoria contortae</i> .....	83
<i>Phaeoxyphiella morototoni</i> .....	24
<i>Phoma glomerata</i> .....	83
<i>Phoma pomorum</i> .....	84
<i>Phoma prunicola</i> .....	84
<i>Phomopsis</i> — like .....	77
<i>Phomopsis conorum</i> .....	84
<i>Phomopsis lokoyae</i> .....	84
<i>Phomopsis occulta</i> .....	84
<i>Phyllactinia guttata</i> .....	86
<i>phyllophilum</i> , <i>Nothophacidium</i> .....	79
<i>Phyllosticta</i> sp. ....	86
<i>Phyllosticta cornicola</i> .....	45,86
<i>Phyllostictina hysterella</i> .....	86
<i>Physalospora gregaria</i> .....	86
<i>piceae</i> , <i>Lophodermium</i> .....	67
<i>pinastri</i> , <i>Leptostroma</i> .....	69
<i>pinastri</i> , <i>Lophodermium</i> .....	67
<i>pinastri</i> , <i>Stomiopeltis</i> .....	106
<i>pineae</i> , <i>Brunchorstia</i> .....	48
<i>pineae</i> , <i>Diplodia</i> .....	40

pineti, Pseudohelotium .....	61
pini, Bifusella .....	23
pini, Dothistroma .....	99
pini, Rhizosphaera .....	92
pini, Scirrhia .....	99
pini-cembrae, Phacidium .....	80
pinicola, Appendiculella .....	20
pinicola, Hendersonia .....	51
piniperda, Ascochyta .....	103
piniperda, Naevia .....	96
piniperda, Sarcotrochila .....	96
Pinus cembrae .....	23
Pirozynskia farriae .....	73
Pithya cupressina .....	88
pithyophila, Sclerophoma .....	100
pitya, Asteridiella .....	21
planum, Hemiphacidium .....	49
Pollaccia americana .....	114
Pollaccia elegans .....	115
Pollaccia radiosa .....	114
Pollaccia saliciperda .....	115
pomorum, Phoma .....	84
ponderosae, Davisomycella .....	37
populi, Marssonina .....	73
populi-albae, Drepanopeziza .....	72
populicola, Mycosphaerella .....	77
populina, Taphrina .....	108
populina, Venturia .....	115
populi-salicis, Taphrina .....	108
populorum, Drepanopeziza .....	73
populorum, Mycosphaerella .....	77
Powdery mildew .....	86,112
pseudobifrons, Ciborinia .....	29
Pseudohelotium pineti .....	61
Pseudostypella translucens .....	11
pseudotsugae, Epipolaem .....	45
pseudotsugae, Rhabdocline .....	88
pseudotsugae, Rhabdogloeum .....	90
pseudotsugae, Tiarosporella .....	109
Puccinia .....	124
Pucciniastrum .....	118,121,123
punctata, Lirula .....	63
punctata, Melasmia .....	94
punctatum, Rhytisma .....	94

## Q

quadrispora, <i>Isthmiella</i> .....	55
quercina, <i>Gnomonia</i> .....	48

## R

radiosa, <i>Pollaccia</i> .....	114
Red band needle blight .....	9, 12, 99
Rehmiellopsis .....	35
Rhabdocline key .....	88
Rhabdocline pseudotsugae .....	9, 88
Rhabdocline weirii .....	90
Rhabdogloeopsis balsameae .....	103
Rhabdogloeum hypophyllum .....	88
Rhabdogloeum pseudotsugae .....	90
Rhizocalyx abietis .....	93
Rhizosphaera kalkhoffii .....	92
Rhizosphaera oudemansii .....	92
Rhizosphaera pini .....	92
Rhizothyrium abietis .....	93
Rhytisma arbuti .....	31, 94
Rhytisma punctatum .....	94
Rhytisma salicinum .....	94
robusta, <i>Virgella</i> .....	116
Rosellinia herpotrichioides .....	95
rostrupii, <i>Leptostroma</i> .....	69
Rusts .....	118

## S

sabinae, <i>Chloroscypha</i> .....	28
saccata, <i>Bifusella</i> .....	23
salicina, <i>Melasmia</i> .....	94
salicinum, <i>Rhytisma</i> .....	94
saliciperda, <i>Pollaccia</i> .....	115
saliciperda, <i>Venturia</i> .....	115
salicis, <i>Uncinula</i> .....	112
sapinea, <i>Sphaeropsis</i> .....	40
Sarcotrochila alpina .....	96
Sarcotrochila balsameae .....	103

Sarcotrochila macrospora .....	34,96,117
Sarcotrochila piniperda .....	96,117
Scale insects .....	26
Sciniatosporium .....	106
Scirrhia acicola .....	76
Scirrhia pini .....	10,99
Scleroderris canker .....	48
Sclerophoma .....	35
Sclerophoma pithyophila .....	100
Sclerotinia fuckeliana .....	24
seaveri, Chloroscypha .....	28
seaveri, Ciborinia .....	29
secondary fungi .....	117
seditiosum, Lophodermium .....	67
Seimatosporium berckmansii .....	102
Seiridium cardinale .....	101
Seiridium unicorne .....	102
Septoria aceris .....	102
Septoria alni .....	102
Septoria alnifolia .....	102
Septoria musiva .....	77
Septoria populicola .....	77
septospora, Dothistroma .....	99
sequoiae, Cercospora .....	26
setacea, Gnomonia .....	48
Seuratia millardetii .....	21
sherwoodiae, Phacidium .....	80
Sirococcus strobilinus .....	13,103
smothering disease .....	96
Snow blight .....	80,96
Snow mould .....	51,52
Sooty mould .....	26,59
Sphaerella arbuticola .....	74
Sphaeropsis sapinea .....	40
Stegia alpina .....	96
Stegopezizella balsameae .....	55,63,103,117
Stigmina thujina .....	103
Stigmina verrucosa .....	106
Stomiopeltis pinastri .....	106
strobilinum, Camarosporium .....	24
strobilinus, Sirococcus .....	103
sulcigena, Lophodermella .....	66
Swiss needle cast .....	80
Sydowia polyspora .....	35,100

## T

Taphrina .....	106, 107, 108
Taphrina americana .....	108
Taphrina bacteriosperma .....	108
Taphrina boycei .....	108
Taphrina caeruleascens .....	108
Taphrina confusa .....	108
Taphrina darkeri .....	108
Taphrina flava .....	108
Taphrina flectans .....	108
Taphrina japonica .....	108
Taphrina nana .....	108
Taphrina populina .....	108
Taphrina populi-salicis .....	108
taxicola, Dothiora .....	40
tetraspora, Linospora .....	62
thujae, Kabatina .....	55
thujina, Didymascella .....	39
thujina, Keithia .....	39
thujina, Stigmina .....	103
Thyriopsis halepensis .....	107
Tiarosporella abietis .....	34, 109
Tiarosporella parca .....	34, 109
Tiarosporella pseudotsugae .....	109
Tremella translucens .....	11
tremulae, Drepanopeziza .....	72
tremulae, Venturia .....	114
Truncatella truncata .....	109
tsugae, Dimeriella .....	45
tsugae, Epipolaeum .....	45
tsugae, Fabrella .....	45
tsugae, Vanterpoolia .....	112

## U

uncinatum, Lophodermium .....	67
Uncinula adunca .....	112
Uncinula bicornis .....	109
Uncinula salicis .....	112
unicornis, Monochaetia .....	102
Uredinales .....	118
Uredinopsis .....	118



**V**

Vanterpoolia tsugae .....	112
veneta, Gnomonia .....	48
Venturia macularis .....	114
Venturia populina .....	115
Venturia saliciperda .....	115
Venturia tremulae .....	114
verrucosa, Stigmina .....	106
Virgella robusta .....	116

**W**

walteri, Capnodium .....	24
weirii, Rhabdocline .....	90
whetzeli, Ciborinia .....	29
wisconsinensis, Ciborinia .....	29
witches brooms .....	107



Canada