

## SPECIES DESCRIPTIONS

1. *Leptographium abicolens* K. Jacobs & M.J. Wingf., *MycoScience* 1999. (Figs. 18-20).

**Teleomorph:** Not known.

**Etymology:** a-bi-có-lens: inhabiting the fir. From the Latin noun abies: fir and Latin verb incolere: to inhabit. This specific epithet refers to *Abies* which is the only known host of this species.

*Conidiophores* occurring singly or in groups of up to six, arising directly from the mycelium, erect, macronematous, mononematous, (120-) 160 - 196 (-360)  $\mu\text{m}$  in length, rhizoid-like structures present. *Stipes* dark olivaceous, smooth, cylindrical, simple, 2 - 11 septate, (72-) 92 - 239 (-264)  $\mu\text{m}$  long, 3.0 - 6.0  $\mu\text{m}$  wide below primary branches, apical cell not swollen, 4.5 - 7.5  $\mu\text{m}$  wide at base, basal cell not swollen. *Conidiogenous apparatus* (32-) 56.5 - 68 (-104)  $\mu\text{m}$  long, excluding the conidial mass, with 3 - 4 series of cylindrical branches, 2 - 3 primary branches, olivaceous to light olivaceous, smooth, cylindrical, aseptate, (8-) 12 - 14.5 (-31)  $\mu\text{m}$  long and 3.0 - 5.0  $\mu\text{m}$  wide, arrangement of the primary branches on the stipe - type B, secondary branches light olivaceous to hyaline, aseptate, (7.0-) 6.0 - 12 (-15)  $\mu\text{m}$  long, 2.0 - 4.0  $\mu\text{m}$  wide, tertiary branches hyaline, aseptate, (6.0-) 7.5 - 10 (-12)  $\mu\text{m}$  long, 2.0 - 4.0  $\mu\text{m}$  wide, quaternary branches aseptate, hyaline, (5.0-) 7.5 - 9.0 (-10)  $\mu\text{m}$  long, 2.0 - 4.0  $\mu\text{m}$  wide. *Conidiogenous cells* discrete, 2-3 per branch, cylindrical, tapering slightly at the apex, (8.0-) 11 - 15 (-23)  $\mu\text{m}$  long and 2.0 - 3.0  $\mu\text{m}$  wide. *Conidia*, aseptate, broadly ellipsoidal to obovoid, (4.0-) 5.0 (-7.0) x (2.0-) 2.0 (-3.0)  $\mu\text{m}$ . Conidia accumulating in slimy droplets at the apex of conidiogenous apparatus.

*Colonies* with optimal growth at 15°C on 2% MEA, reaching 18 mm in diameter in 14 days. No growth below 5°C or above 25°C Able to withstand high concentrations of cycloheximide with a 17% reduction in growth on 0.1 g/l cycloheximide after 6 days at 15°C in the dark. Colonies dark olivaceous (19" f). *Colony margin* smooth. *Hyphae* submerged or on top of agar with abundant aerial mycelium, light olivaceous to hyaline, smooth, not constricted at the septa, 1.0 - 6.0  $\mu\text{m}$  diameter.

**Specimens examined: Holotype:** U.S.A., Vermont, White Face Mountain, *Abies balsamea*, 30 August 1990, collected D.R. Bergdahl, PREM 56336. **Paratype:** U.S.A., Vermont, White Face Mountain, *Abies balsamea*, 30 August 1990, collected D.R. Bergdahl, PREM 56337. **Cultures:** CMW 2865; CMW 2866, CMW 2894, from *A. balsamea* roots wounded by *K. gracilus*, collected D.R. Bergdahl, White Face Mountain, New York, USA, August 1990.

**Known distribution:** North Western United States.

**Hosts/substrate:** *Abies balsamea* (Jacobs *et al.*, 1999).

**Associated insects:** *Korscheltellus gracilus* (Jacobs *et al.*, 1999).

**Notes:** *Leptographium abicolens* closely resembles *L. antibioticum* (Jacobs *et al.*, 1999). These species can, however, be distinguished based on the darker stipes and more complex conidiophores of *L. abicolens*. *Leptographium abicolens* has 2-3 primary branches, whereas up to five primary branches have been observed in *L. antibioticum*. Furthermore, *L. antibioticum* has an optimal growth temperature of 25-30 °C compared to the 15 °C of *L. abicolens*. *Leptographium abicolens* also can be distinguished from *L. antibioticum* by its larger, broadly ellipsoidal conidia (4 - 7 µm), in contrast to the smaller obovoid to oblong conidia (2.5 - 5 µm) in the latter species.

*Leptographium abicolens* occurs at high elevation sites together with *L. peucophilum*. The low optimal temperatures for growth of these fungi in culture are consistent with their habitat. This species is, furthermore, associated with the feeding activities of the larval stage of the conifer swift moth. The fungi appear to enter the roots of spruce and firs through the wounds created by the moths. This species does not appear to be pathogenic, although large areas of discoloration are associated with the wounds caused by the moths (Jacobs *et al.*, 1999).

It is not known whether *L. abicolens* is carried by the adult moths, and even if it were, these moths never enter the roots of the host plant. It is possible that this species is soil inhabiting and colonizes roots through the wounds made by the insects. Conidia

of this species may also be transmitted by phoretic mites associated with the conifer swift moth, although this is only a hypothesis (Jacobs *et al.*, 1999).

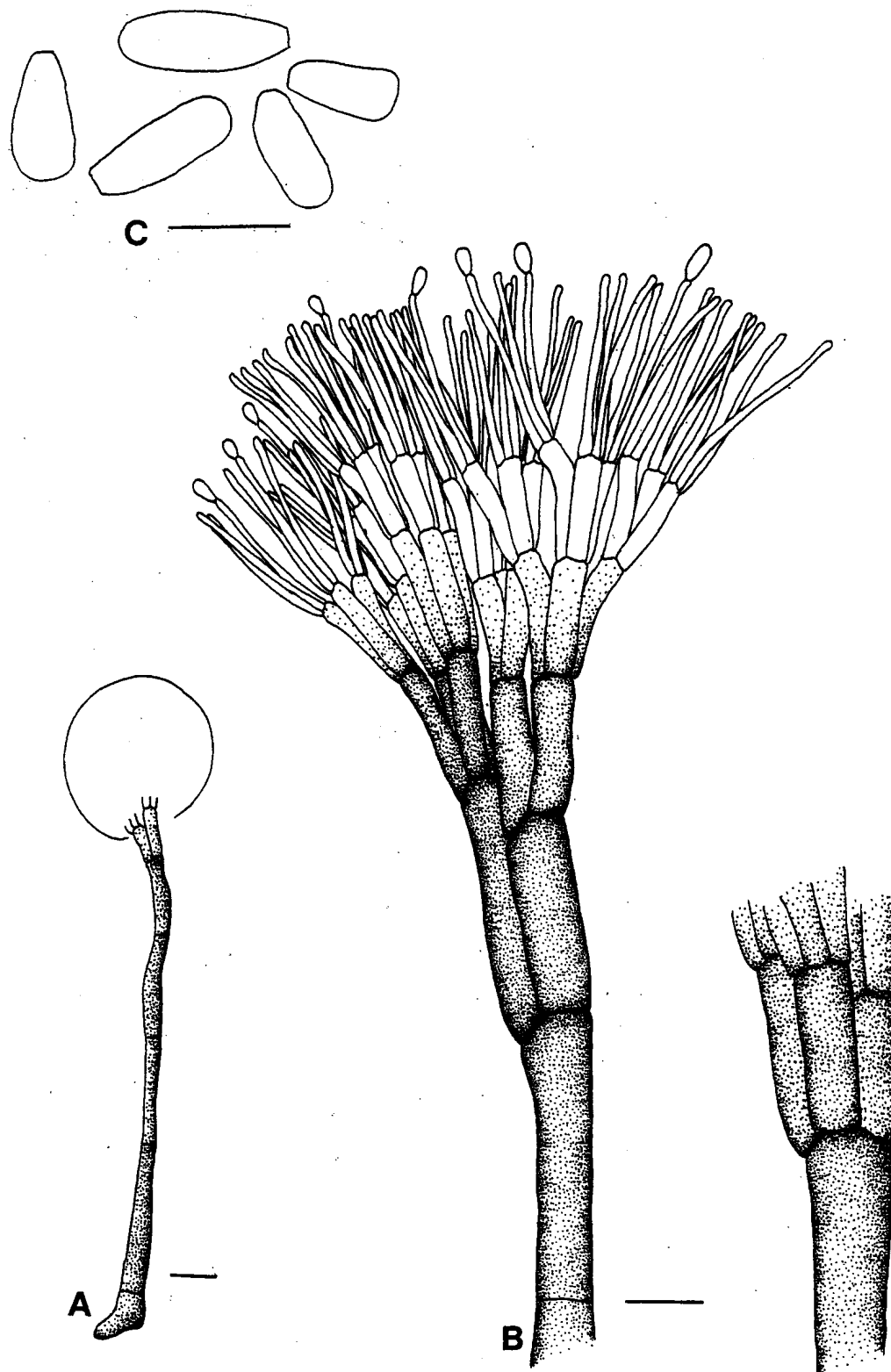
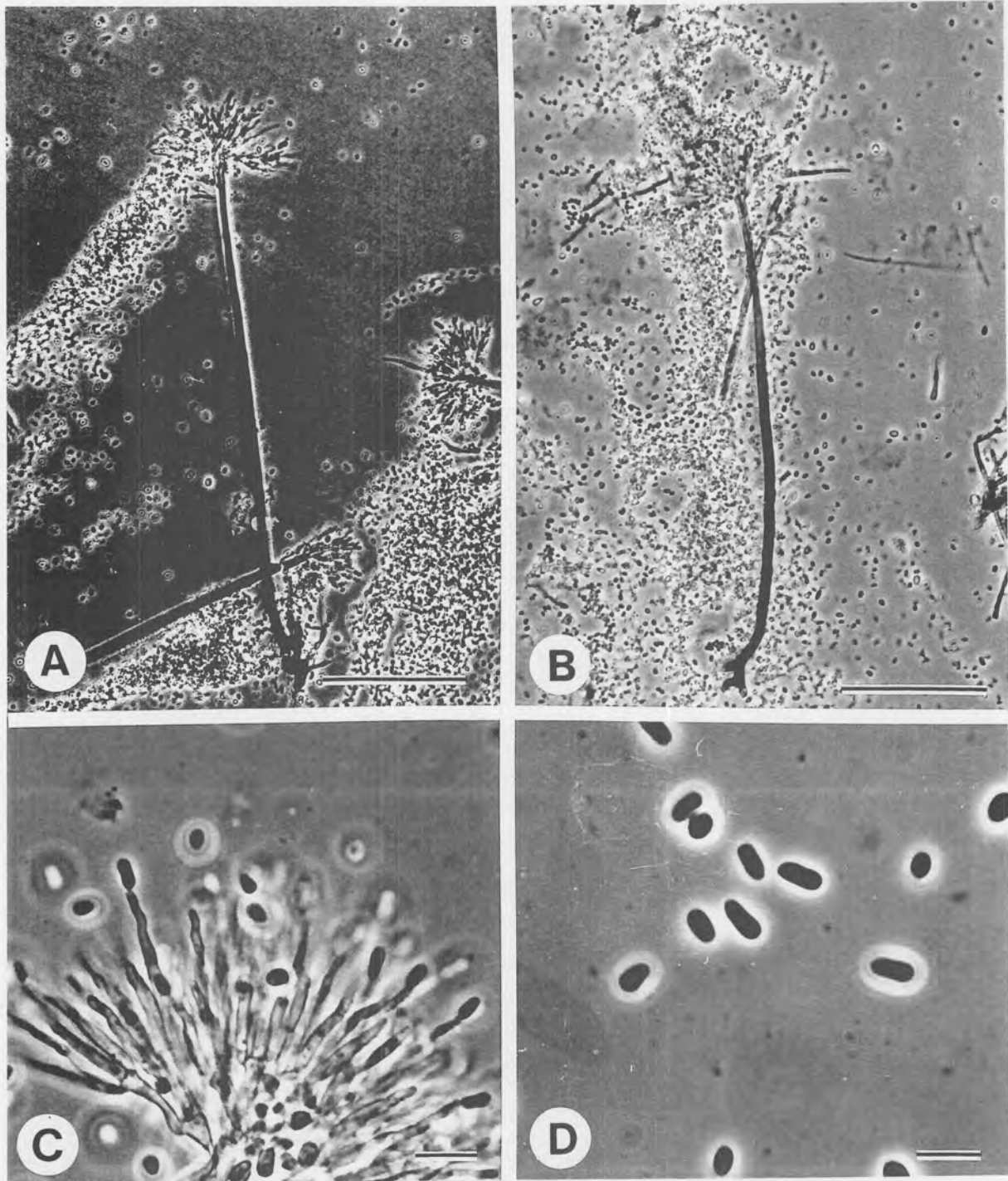
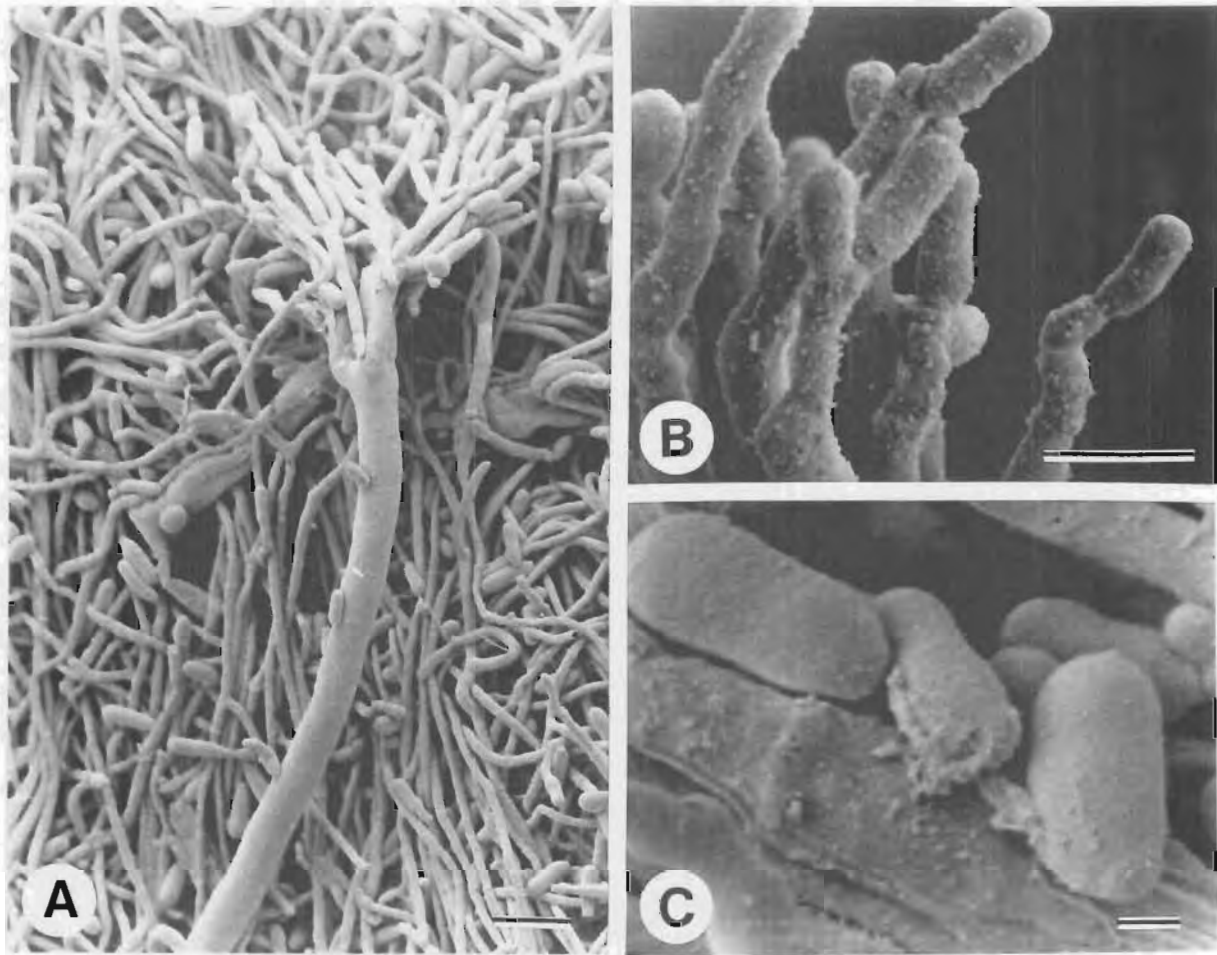


Fig. 18. Conidiophores and conidia of *L. abicolens* (PREM 56336). A. Habit sketch (Bar = 10  $\mu$ m). B. Conidiogenous apparatus (Bar = 5  $\mu$ m) C. Conidia (Bar = 5  $\mu$ m).



**Fig 19.** Light micrographs of the conidiophores and conidia of *L. abicolens* (PREM 56336). **A.** Conidiophore (Bar = 100  $\mu$ m). **B.** Conidiogenous apparatus (Bar = 100  $\mu$ m). **C.** Conidiogenous cells (Bar = 10  $\mu$ m). **D.** Conidia (Bar = 10  $\mu$ m).



**Fig. 20.** Scanning electron micrographs of the conidiophores and conidia of *L. abicolens* (PREM 56336).  
**A.** Conidiophore (Bar = 10  $\mu\text{m}$ ). **B.** Conidiogenous cells (Bar = 5  $\mu\text{m}$ ). **C.** Conidia (Bar = 1  $\mu\text{m}$ ).



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2. *Leptographium abietinum* (Peck) M.J. Wingf., *Transactions of the British Mycological Society* **85**, 92. 1985. (Figs. 21-23).

≡ *Verticicladiella abietina* (Peck) S. Hughes, *Canadian Journal of Botany* **31**, 653. 1953.

≡ *Sporocybe abietina* Peck, *New York State Museum Report* **31**, 45. 1879.

≡ *Periconia abietina* (Peck) Sacc., *Sylloge Fungorum*, **4**, 273. 1886.

= *Leptographium engelmannii* R.W. Davidson, *Mycologia* **47**, 59. 1955.

**Teleomorph:** Not known.

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**Etymology:** a-bi-e-ti-num: belonging to the fir. From the Latin noun *abies*: fir. This specific epithet was intended to refer to its occurrence on *Abies*. Kendrick (1962) noted, however, that the name for this species is misleading, as this fungus has never been reported on any species of *Abies*.

*Conidiophores* occurring singly or in groups of up to eight, arising directly from the mycelium, erect, macronematous, mononematous, 74 - 535 (-570)  $\mu\text{m}$  in length, rhizoid-like structures absent. *Stipes* olive-buff (21''b), smooth, cylindrical, simple, 2-7 septate, 37 - 442 (-471)  $\mu\text{m}$  long, 4.0 - 9.0  $\mu\text{m}$  wide below primary branches, apical cell not swollen, 3.0 - 9.0  $\mu\text{m}$  wide at base, basal cell swollen. *Conidiogenous apparatus* (25-) 45 - 50 (-99)  $\mu\text{m}$  long, excluding the conidial mass, with 2 - 4 series of cylindrical branches, 2-3 primary branches, olive-buff (21''b), smooth, cylindrical, aseptate, (8-) 13.5 - 15 (-22)  $\mu\text{m}$  long and 3.0 - 6.5  $\mu\text{m}$  wide, arrangement of the primary branches on the stipe - type B, secondary branches hyaline, aseptate, (7.5-) 10 - 12.5 (-15.5)  $\mu\text{m}$  long, 2.5 - 5.0  $\mu\text{m}$  wide, tertiary branches hyaline, aseptate, (6.0-) 7 - 11 (-13)  $\mu\text{m}$  long, 2.0 - 4.0  $\mu\text{m}$  wide, quaternary branches aseptate, (4.0-) 7.0 - 11 (-12.5)  $\mu\text{m}$  long, 2.0 - 4.0  $\mu\text{m}$  wide. *Conidiogenous cells* discrete, 2-4 per branch, tapering slightly from the base to the apex, (10.5-) 10 - 23 (-25)  $\mu\text{m}$  long and 1.0 - 2.0  $\mu\text{m}$  wide. *Conidia* hyaline, aseptate, distinctly curved at the base, (3.5-) 4.5 - 5.0 (-7.0) x 1.0 - 2.5  $\mu\text{m}$ , marginal frill absent. *Conidia* accumulating in white slimy droplets at the apex of conidiogenous apparatus, turning cream (19'f) when dry.

*Colonies* with optimal growth at 25°C on 2% MEA, reaching 39 mm in diam. in 8 days. Little growth at 5°C and no growth above 35°C. Able to withstand high concentrations of cycloheximide with a 17% reduction in growth on 0.5 g/l cycloheximide after 8 days at 20°C in the dark. Colonies cartridge buff (19''f). *Colony margin* laciniate. *Hyphae* submerged on agar with little aerial mycelium, hyaline, smooth, straight, not constricted at the septa, (2.0-) 2.0 - 3.5 (-5.0) µm diam.

**Specimens examined: Holotype:** Canada, Albany, on the bark and wood of spruce, *Picea mariana*, collected: Peck, DAOM 33942. **Paratypes:** Canada, Victoria, *Picea engelmannii*, 20 March 1953, collected: A. Molnar, DAOM 37980; British Columbia, McGillivray Lake, *Pseudotsuga menziesii*, 20 June 1958, collected: C. Cotrell, DAOM 64328 (DAVFP 11869). *L. engelmannii*: U.S.A., *Picea engelmannii*, collected: R. W. Davidson, US0 422466. **Cultures:** Utah, Dixie Nature Forest, *Picea engelmannii*, 1993, T.C. Harrington, C699 (same as CMW 2817; CTH 0054), Canada, *Picea* sp., Aug. 1994, collected M.J. Wingfield, CMW 3083 (PREM 56382); British Columbia, Victoria, *Picea engelmannii*, 1987; collected: A. Molnar, CMW 275, CMW 276.

**Known distribution:** Northern United States and Canada.

**Hosts/substrate:** *Picea mariana* (Kendrick, 1962), *P. engelmannii* (Davidson, 1955; Solheim, 1995b), *P. glauca* (Solheim, 1995b); *Pseudotsuga menziesii* (Mielke, 1979; Lewinsohn *et al.*, 1994; Solheim & Krokene, 1998), *Pinus contorta*, *P. sylvestris*, *P. ponderosa*, *P. aristata*, *P. mugo* (Mielke, 1979), *P. monticola* (Kulhavy *et al.*, 1978; Mielke, 1979).

**Associated insects:** *Dendroctonus pseudotsugae* (Harrington, 1988; Perry, 1991; Lewinsohn *et al.*, 1994; Solheim & Krokene, 1998), *D. rufipennis* (Davidson, 1955; Kendrick, 1962; Harrington, 1988; Perry, 1991; Reynolds, 1992; Solheim, 1995a,b), *Hylastes longicollis* (Harrington, 1982; 1988), *Hylurgops porosus* (Wagner, 1977), *Hylurgops planirostris* (Harrington, 1988).

**Notes:** Hughes (1953) named this species as the type of *Verticicladiella* based on its sympodial and apparently unique mode of conidium development. It was later



transferred to *Leptographium* by Wingfield (1985) after he found that the conidium development in the genera *Verticicladiella* and *Leptographium* could not be distinguished from each other. *Leptographium engelmannii* has similar conidia and hosts to *L. abietinum* and the two species were thought to be synonymous (Harrington, 1988). This hypothesis was supported by isozyme comparisons (Zambino & Harrington, 1992). A thorough morphological study later led to the two species being synonymised (Jacobs *et al.*, 1999).

*Leptographium abietinum* is morphologically similar to *L. hughesii*, but these fungi can be distinguished based on differences in colony morphology and host specificity. In addition, *L. abietinum* has conidia that are obviously curved, whereas *L. hughesii* has obovoid conidia. *Leptographium hughesii* is native to Asia, occurring on non-coniferous hosts, while *L. abietinum* is known only in North America where it occurs on spruce (Harrington, 1988).

*Leptographium abietinum* is not considered to be pathogenic, although a low level of pathogenicity to spruce has been demonstrated (Reynolds, 1992). The bark beetle *Dendroctonus rufipennis*, in association with this fungus can cause blue-stain of Lutz spruce (*Picea x lutzii*) in North America (Reynolds, 1992) as well as widespread mortality (Werner, 1995). *Leptographium abietinum* is also associated with various other bark beetles and has been shown to be weakly pathogenic to Ponderosa pine (*Pinus ponderosa*) and Douglas fir (*Pseudotsuga menziesii*) (Harrington & Cobb, 1983). Ross and Solheim (1995; 1996; 1997) indicated that this species might be able to kill healthy Douglas-fir trees and assist the Douglas-fir beetle (*Dendroctonus pseudotsugae*) in overcoming host defenses. It did, however, not prove to be the most pathogenic associate of *D. rufipennis* on spruce (Solheim, 1995a,b; Solheim & Safranyik, 1997).

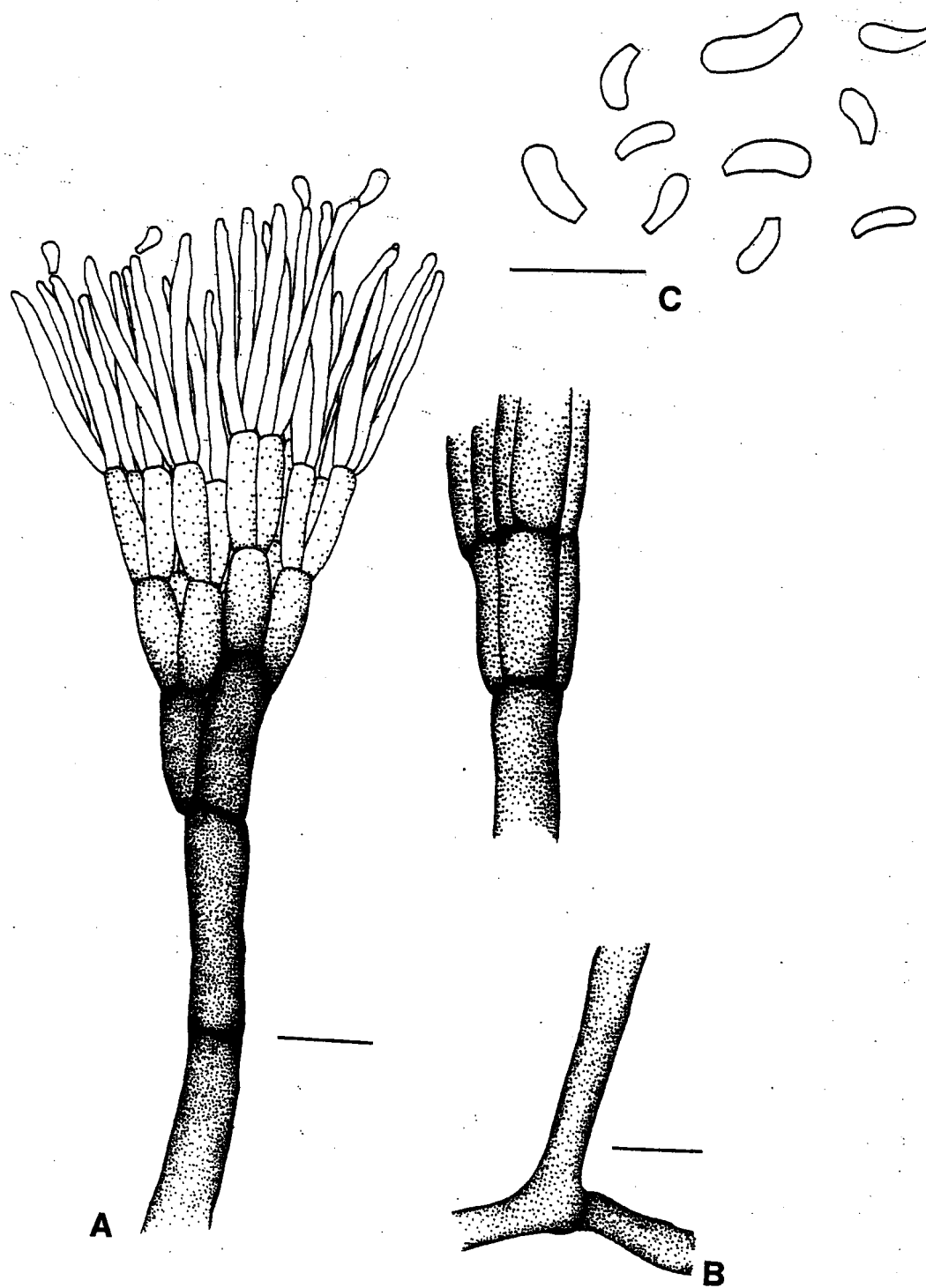


Fig. 21. Conidiophores and conidia of *L. abietinum* (CMW 2817). A. Habit sketch (Bar = 10  $\mu$ m). B. Conidiogenous apparatus (Bar = 10  $\mu$ m) C. Conidia (Bar = 10  $\mu$ m).

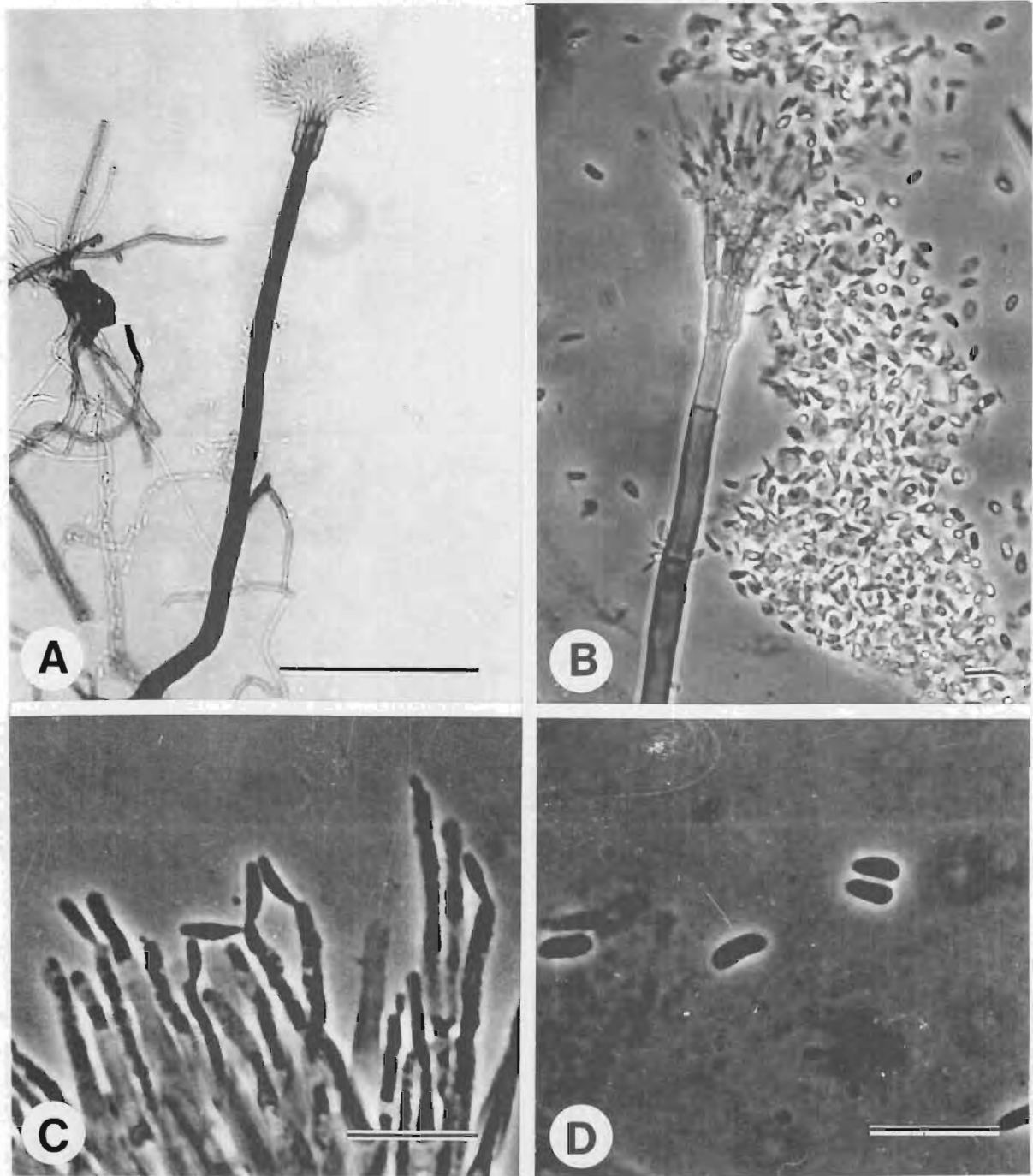
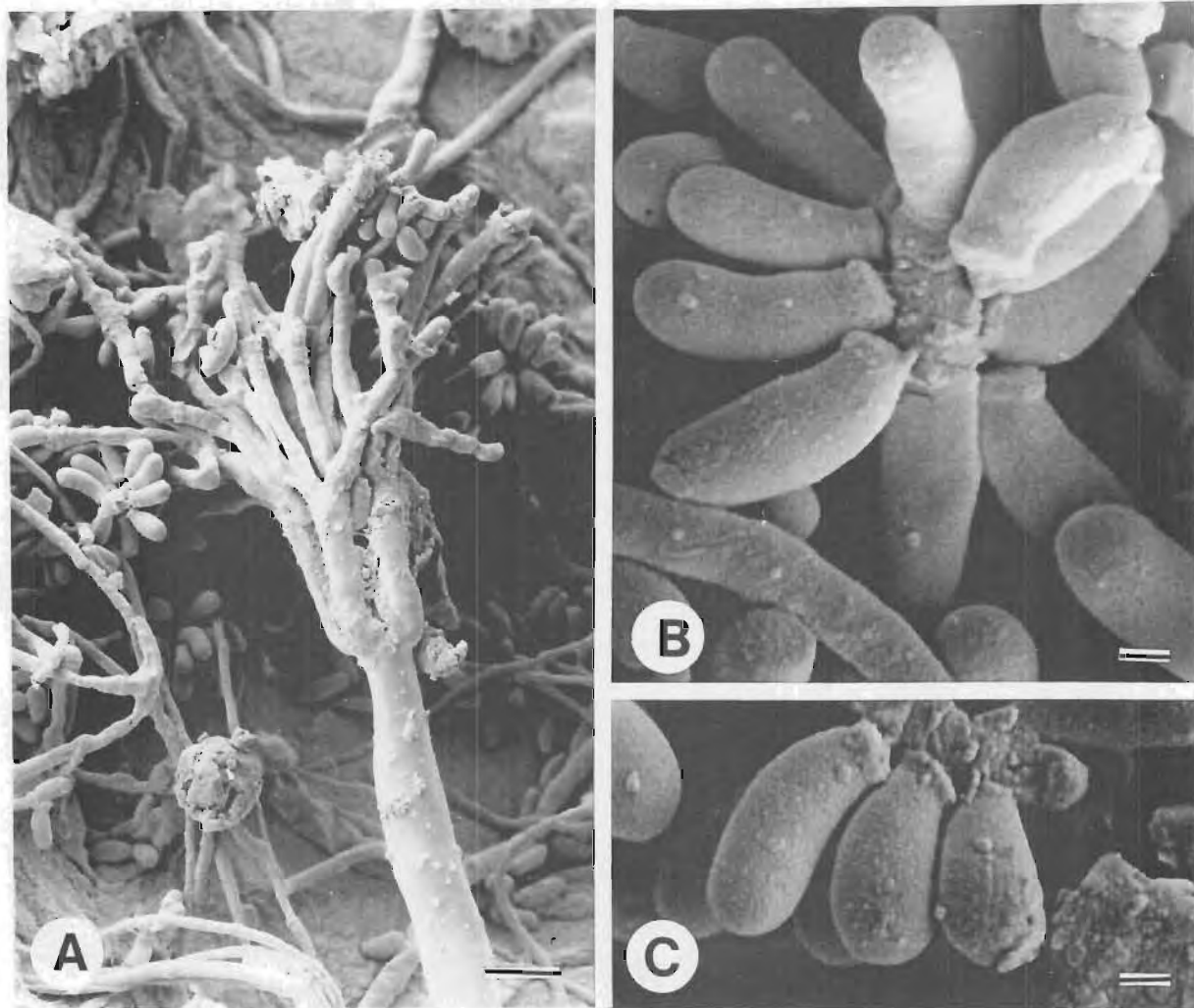


Fig. 22. Light micrographs of the conidiophores and conidia of *L. abietinum* (CMW 2817). **A.** Conidiophore (Bar = 100  $\mu$ m). **B.** Conidiogenous apparatus (Bar = 10  $\mu$ m). **C.** Conidiogenous cells (Bar = 10  $\mu$ m). **D.** Conidia (Bar = 10  $\mu$ m).



**Fig. 23.** Scanning electron micrographs of the conidiophores and conidia of *L. abietinum* (CMW 2817). **A.** Conidiophore (Bar = 10  $\mu\text{m}$ ). **B.** Conidiogenous cells (Bar = 1  $\mu\text{m}$ ). **C.** Conidia (Bar = 1  $\mu\text{m}$ ).

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**3. *Ophiostoma aenigmaticum* K. Jacobs *et al.*, *Mycological Research* 102, 291. 1998. (Figs. 24-26).**

**Anamorph:** *Leptographium aenigmaticum* K. Jacobs *et al.*, *Mycological Research* 102, 291. 1998.

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**Etymology:** ae-nig-má-ti-cum: enigmatic. From the Greek *αίνιγμα*: a riddle. This specific epithet refers to the enigma surrounding its occurrence. While it is found alongside *O. piceaperdum* that occurs mainly in Europe, *O. aenigmaticum* is restricted to Japan.

*Perithecial bases* black, globose and smooth walled, with abundant hyphal ornamentation, 143 - 254  $\mu\text{m}$  in diam. *Perithecial neck* dark brown to black, cylindrical with a slight apical taper, smooth, 117 - 310  $\mu\text{m}$  long, 37 - 99  $\mu\text{m}$  above globose base, 19 - 43  $\mu\text{m}$  wide at the apex, *ostiole hyphae* absent. *Asci* prototunicate, hyaline, evanescent. *Ascospores* cucullate in side view, aseptate, hyaline, invested in a sheath, 4 - 5 x 1.8 - 3.5  $\mu\text{m}$  (Jacobs *et al.*, 1998).

*Conidiophores* occurring singly or in groups of up to 4, arising directly from the mycelium, erect, macronematous, mononematous, 117 - 229  $\mu\text{m}$  in length, rhizoid-like structures absent. *Stipes* olivaceous (21"m), constricted at septa, cylindrical, simple, 1-6 septate, (40-) 91.5 - 113.5 (-170)  $\mu\text{m}$  long, 4.0 - 9.0  $\mu\text{m}$  wide below primary branches, apical cell not swollen, (8.0-) 10 - 12.5 (-15.5)  $\mu\text{m}$  wide at base, basal cell not swollen. *Conidiogenous apparatus* (34-) 54 - 76 (-95)  $\mu\text{m}$  long, excluding the conidial mass, with 2 to 4 series of cylindrical branches, 2 - 3 primary branches, olivaceous (21"m), smooth, cylindrical aseptate, (11-) 14.5 - 23.5 (-32.5)  $\mu\text{m}$  long and (2.0-) 4.0 - 5.0 (-6.0)  $\mu\text{m}$  wide, arrangement of the primary branches on the stipe - type B, secondary branches hyaline, 0-1 septate, 11 - 23  $\mu\text{m}$  long, 2.0 - 5.0  $\mu\text{m}$  wide, tertiary branches hyaline, aseptate, 9.0 - 22  $\mu\text{m}$  long, 2.0 - 4.0  $\mu\text{m}$  wide. *Conidiogenous cells* discrete, 2-3 per branch, cylindrical, tapering slightly at the apex, (10-) 15.5 - 18 (-23)  $\mu\text{m}$  long and 2.0 - 2.5  $\mu\text{m}$  wide. *Conidia* hyaline, aseptate, obovoid with truncate ends and rounded apices, 4.0 - 9.0 x 2.0 - 3.0  $\mu\text{m}$ . *Conidia* accumulating in slimy droplets at the apex of conidiogenous apparatus, hyaline at

first, becoming white with age. Conidial mass white when wet, remaining white when dry.

*Colonies* with optimal growth at 20°C on 2% MEA, reaching 40 mm in diam. in 9 days. No growth below 5°C or above 35°C. Able to withstand high concentrations of cycloheximide with a 11% reduction in growth on 0.5 g/l cycloheximide after 8 days at 20°C in the dark. Colonies cartridge buff (19" f) to light olivaceous (19" k). *Colony margin* effuse. *Hyphae* submerged on agar with little aerial mycelium, hyaline, smooth, straight, sometimes constricted at the septa, 2.0 - 8.0 µm diam.

**Specimens examined:** **Holotype:** Japan, Hokkaido, *Picea jezoensis*, June 1990, collected: Y. Yamaoka, PREM 54680. **Paratypes:** Japan, Hokkaido, *Picea jezoensis*, June 1990, collected: Y. Yamaoka, PREM 54681, PREM 54682, PREM 54683. **Cultures:** Japan, Hokkaido, *Picea jezoensis*, June 1990, collected: Y. Yamaoka, CMW 2199, CBS 501.96, CMW 2310, CBS 502.96, CMW 2311, CBS 503.96, CMW 2200, CBS 504.96.

**Known distribution:** Japan.

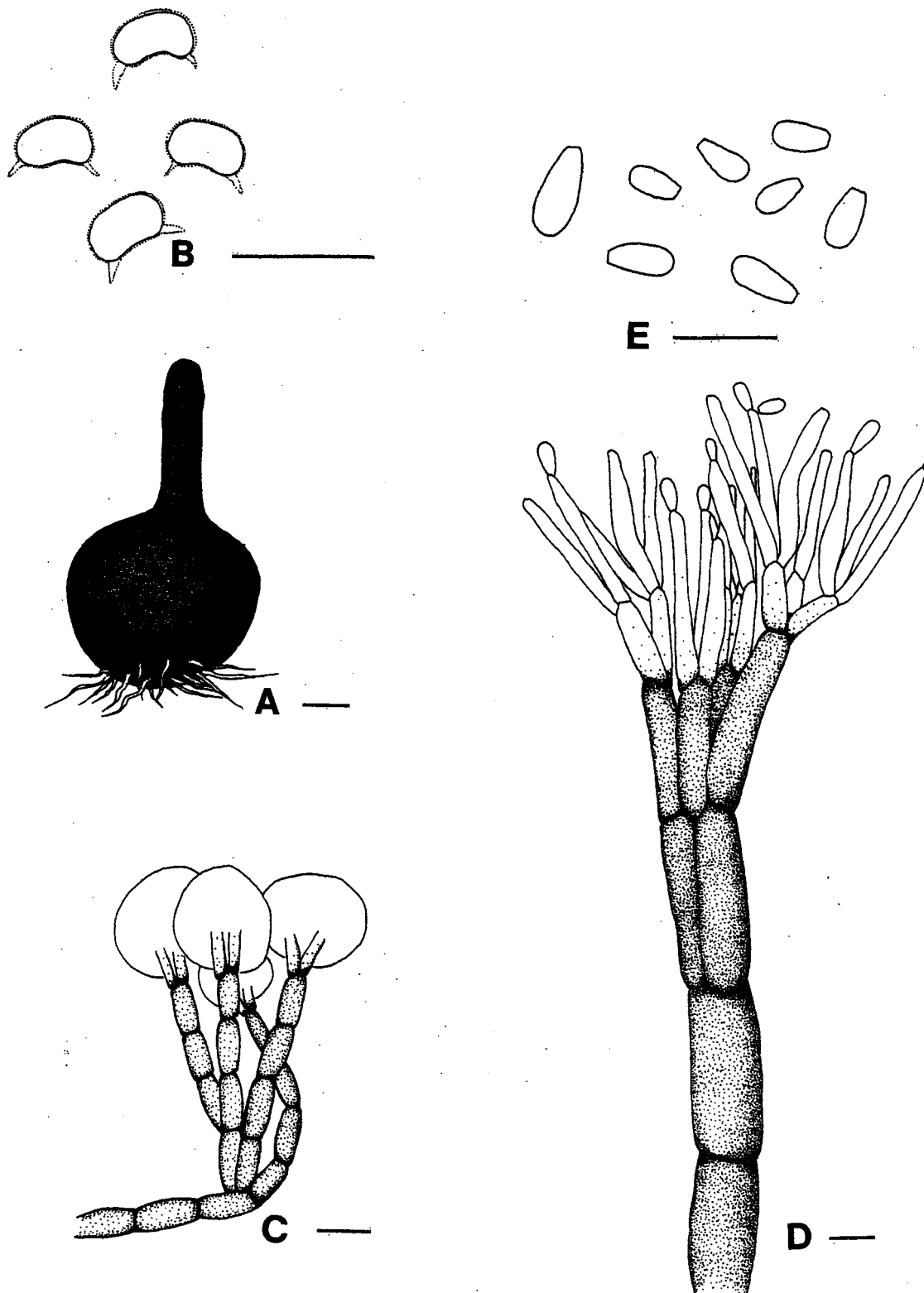
**Hosts/substrate:** *Picea jezoensis* Niiijima (Jacobs *et al.*, 1998).

**Associated insects:** *Ips typographus* f. *japonicus* (Jacobs *et al.*, 1998).

**Notes:** *Ophiostoma aenigmaticum* was initially thought to be similar to *O. penicillatum*, but can easily be distinguished based on conidial and ascospore morphology. *Ophiostoma aenigmaticum* is characterized by obovoid conidia and cucullate ascospores, in contrast to the allantoid conidia and curved ascospores of *O. penicillatum*. This fungus is morphologically similar to *O. piceaperdum* and *O. huntii*. It can, however be distinguished from these species based on the elongated brims of the sheath of the ascospores. The anamorph structures of *O. aenigmaticum* are also smaller than those of *O. piceaperdum* and *O. huntii* (Jacobs *et al.*, 1998).

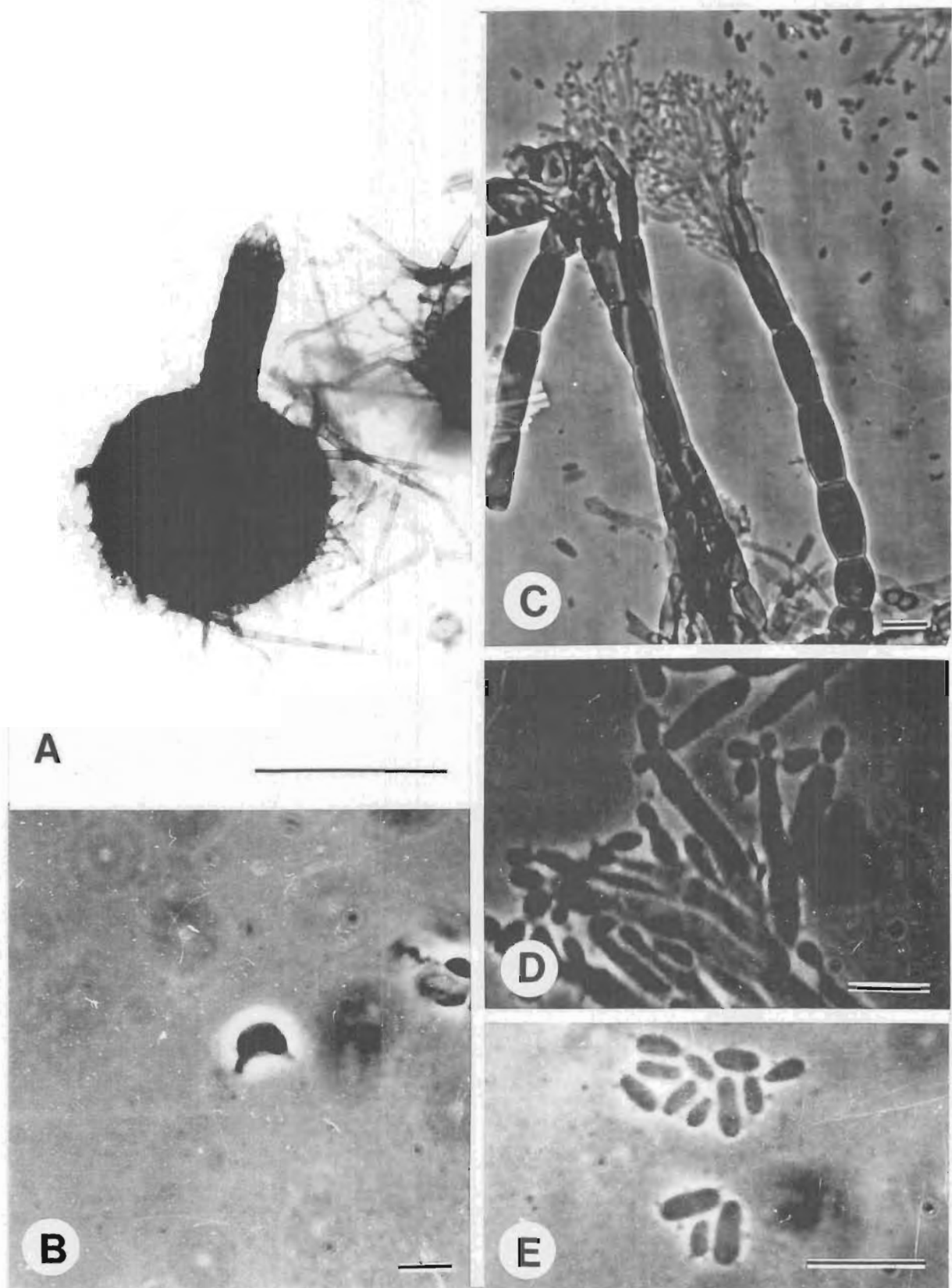
*Ophiostoma aenigmaticum* has been isolated from spruce as part of a project to

describe the associated fungi of *Ips typographus* f. *japonicus* in Japan. This insect is similar to its European counterpart, *Ips typographus* and the insects share some fungal symbionts such as *O. penicillatum* and *O. piceaperdum* (Yamaoka *et al.*, 1997; Jacobs *et al.*, 1998). *Ophiostoma aenigmaticum* is, however, unique to *I. typographus* f. *japonicus* and has not been reported outside Japan.



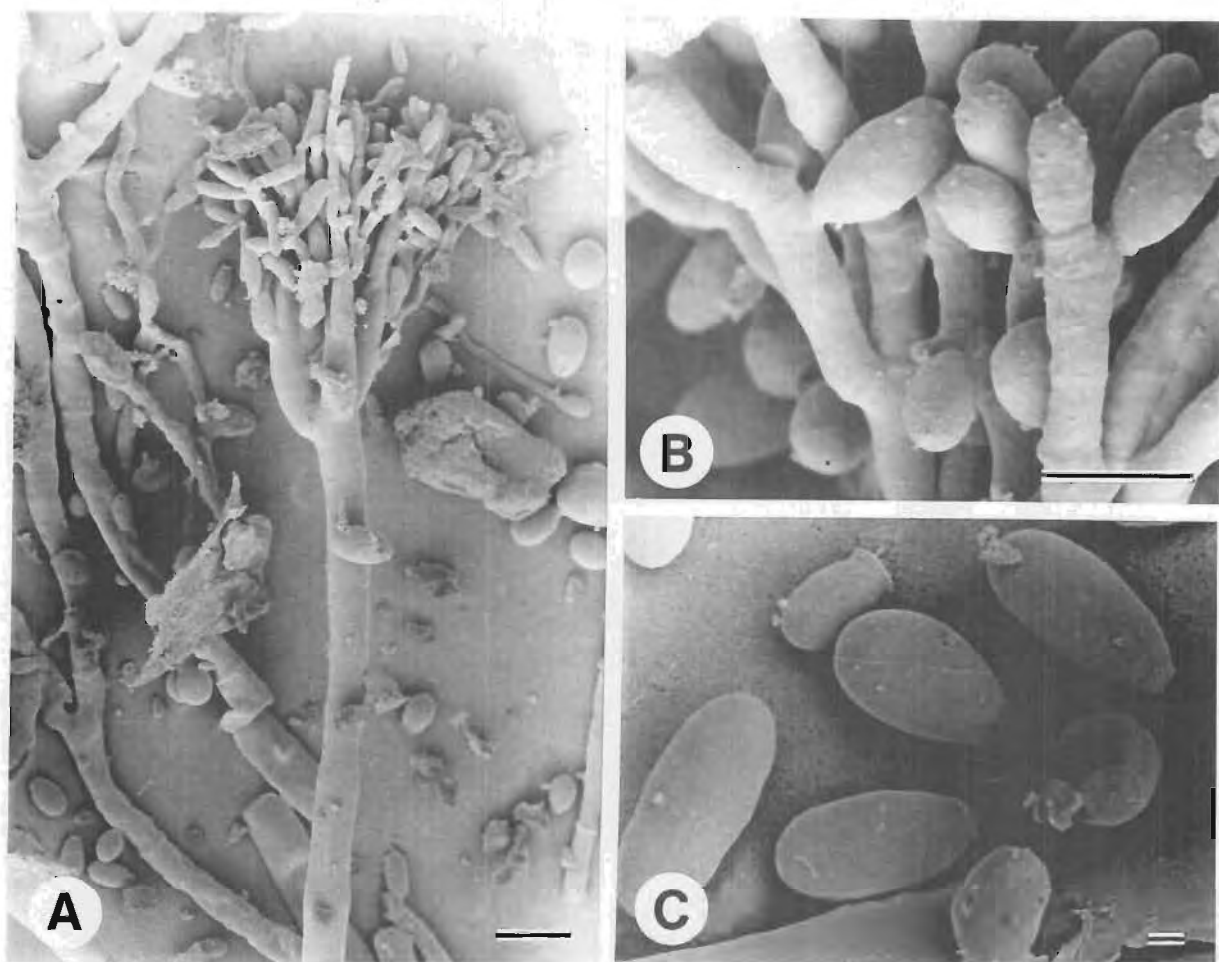
**Fig. 24.** Teleomorph and anamorph of *O. aenigmaticum* (PREM 54680). **A.** Perithecium (Bar = 100  $\mu\text{m}$ ). **B.** Ascospores (Bar = 10  $\mu\text{m}$ ). **C.** Conidiophore (Bar = 10  $\mu\text{m}$ ). **D.** Conidiogenous apparatus (Bar = 10  $\mu\text{m}$ ). **E.** Conidia (Bar = 10  $\mu\text{m}$ ).





**Fig. 25.** Light micrographs of the teleomorph and anamorph structures of *O. aenigmaticum* (PREM 54680). **A.** Perithecium (Bar = 100  $\mu$ m). **B.** Ascospore (Bar = 10  $\mu$ m). **C.** Conidiophore (Bar = 10  $\mu$ m). **D.** Conidiogenous cells (Bar = 10  $\mu$ m). **E.** Conidia (Bar = 10  $\mu$ m).





**Fig. 26.** Scanning electron micrographs of the conidiophores and conidia of *O. aenigmaticum* (PREM 54680). **A.** Conidiophore (Bar = 10  $\mu\text{m}$ ). **B.** Conidiogenous cells (Bar = 5  $\mu\text{m}$ ). **C.** Conidia (Bar = 1  $\mu\text{m}$ ).



**4. *Leptographium albopini*** M.J. Wingf., T.C. Harr. & Crous *Canadian Journal of Botany* 72, 234, 1994. (Figs. 27-29).

**Teleomorph:** Not known.

**Etymology:** al-bo-pí-ni: of the white pine. From the Latin adjective albus: white and Latin noun pinus: a pine tree. This specific epithet refer to *Pinus strobus* (white pine), which is the host of the fungus.

*Conidiophores* occurring singly, arising directly from the mycelium, erect, macronematous, mononematous, (168-) 431 - 567 (-936)  $\mu\text{m}$  in length, rhizoid-like structures absent. *Stipes* olivaceous (21''m), smooth, cylindrical, simple, 4 - 13 septate, (104-) 90.5 - 758 (-856)  $\mu\text{m}$  long, (4.5-) 7.5 - 10 (-12.5)  $\mu\text{m}$  wide below primary branches, apical cell not swollen, (4.5-) 7.5 - 10 (-15.5)  $\mu\text{m}$  wide at base, basal cell not swollen. *Conidiogenous apparatus* (32-) 70 - 81 (-152)  $\mu\text{m}$  long, excluding the conidial mass, with 3 - 4 series of cylindrical branches, 2-6 primary branches, olivaceous, smooth, cylindrical to barrel shape, aseptate (6.0-) 16 - 23 (-35)  $\mu\text{m}$  long and 4.0 - 13  $\mu\text{m}$  wide, arrangement of the primary branches on the stipe - type B, secondary branches hyaline, aseptate, (7.0-) 11.5 - 17 (-25)  $\mu\text{m}$  long, 2.5 - 8.0 (-12)  $\mu\text{m}$  wide, tertiary branches hyaline, aseptate, 10 - 20  $\mu\text{m}$  long, 2.0 - 5.0  $\mu\text{m}$  wide, quaternary branches, hyaline, aseptate, (8.0-) 11 - 14 (-20)  $\mu\text{m}$  long, 2.0 - 4.0  $\mu\text{m}$  wide. *Conidiogenous cells* discrete, cylindrical, 11 - 30  $\mu\text{m}$  long and 1.5 - 3.0  $\mu\text{m}$  wide. *Conidia* hyaline, aseptate, oblong to obovoid, 4.0 - 5.0 (-7.0) x 1.0 - 3.0  $\mu\text{m}$ . Conidia accumulating in slimy droplets at the apex of conidiogenous apparatus, hyaline at first, becoming cream colored (19'f) with age. Conidial mass cream colored when wet, turning honey-yellow (19'') when dry.

*Colonies* with optimal growth at 25°C on 2% MEA, reaching 40 mm in diam. in 9 days. No growth below 5°C or above 30°C. Able to withstand high concentrations of cycloheximide with a 17% reduction in growth on 0.5 g/l cycloheximide after 8 days at 20°C in the dark. Colonies dark mouse gray (15''''k). *Colony margin* smooth. *Hyphae* submerged on agar with no aerial mycelium, olivaceous (21''m), rough, thick walls, straight, frequently constricted at the septa, (4.5-) 6.5 - 8.5 (-12.5)  $\mu\text{m}$  diam.

**Specimens examined: Holotype:** U.S.A., Blue Ridge Parkway, Virginia, *Pinus strobus* roots infested by insects, 1980, collected: A. Lackner, PREM 51450.  
**Paratypes:** U.S.A., Mesa Verde, Colorado, *Pinus edulis* roots infested with insects, 1984, collected: R. Wagener, PREM 51452, PREM 51453. U.S.A Coweeta Hydrological Experiment Station near Otto, North Carolina, *Pinus edulis* roots infested by insects, 1985, collected: T.D. Leininger, PREM 51454, PREM 51455.  
**Cultures:** U.S.A., Blue Ridge Parkway, Virginia, *Pinus strobus*, 1980, collected: A Lackner, CMW 2868, CMW 2065 (PREM 56383), CMW 41.

**Known distribution:** U.S.A.

**Hosts/substrate:** *Pinus strobus*, *P. edulis* (Wingfield *et al.*, 1994).

**Associated insects:** *Hylastes* sp. (Wingfield *et al.*, 1994).

**Notes:** This fungus is associated with the roots of conifers and this is considered to be a distinguishing character (Wingfield *et al.* 1994). *Leptographium albopini* superficially resembles *L. procerum*, but can be distinguished by its conidiophores that are produced singly and not in groups. The colonies of *L. procerum* are also characterized by concentric rings when grown on 2% MEA. These rings are not observed in the colonies of *L. albopini*. *Leptographium albopini* also superficially represents *L. serpens*, but can be distinguished based on the absence of serpentine hyphae, that are characteristic of the latter species (Wingfield *et al.*, 1994).

*Leptographium albopini* is associated with root-feeding bark beetles, and is, therefore, also isolated from the roots of conifers, especially pine (Wingfield *et al.*, 1994). Nothing is known about the pathogenicity of *L. albopini* and there is no evidence to suggest that it is pathogenic.

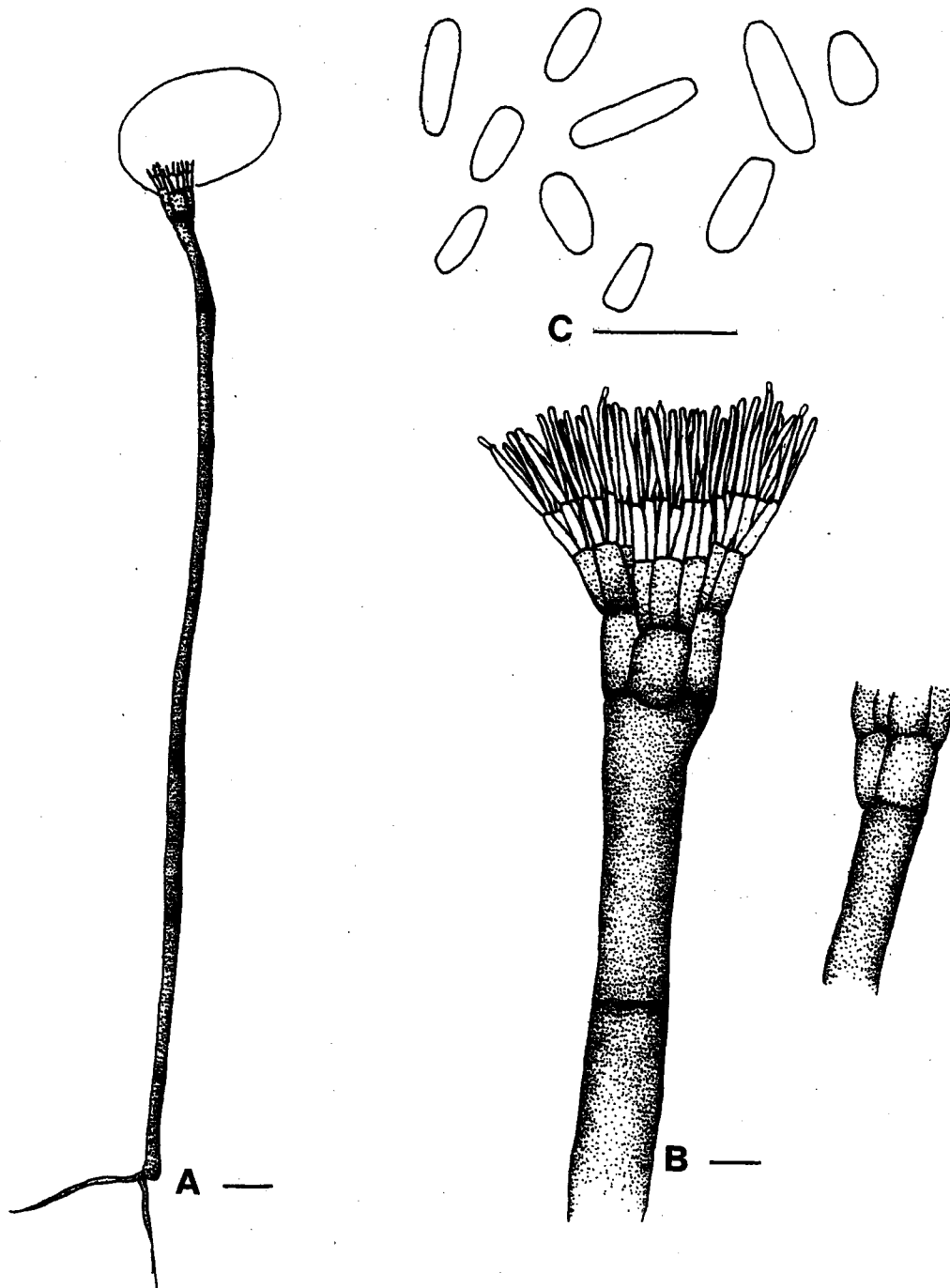
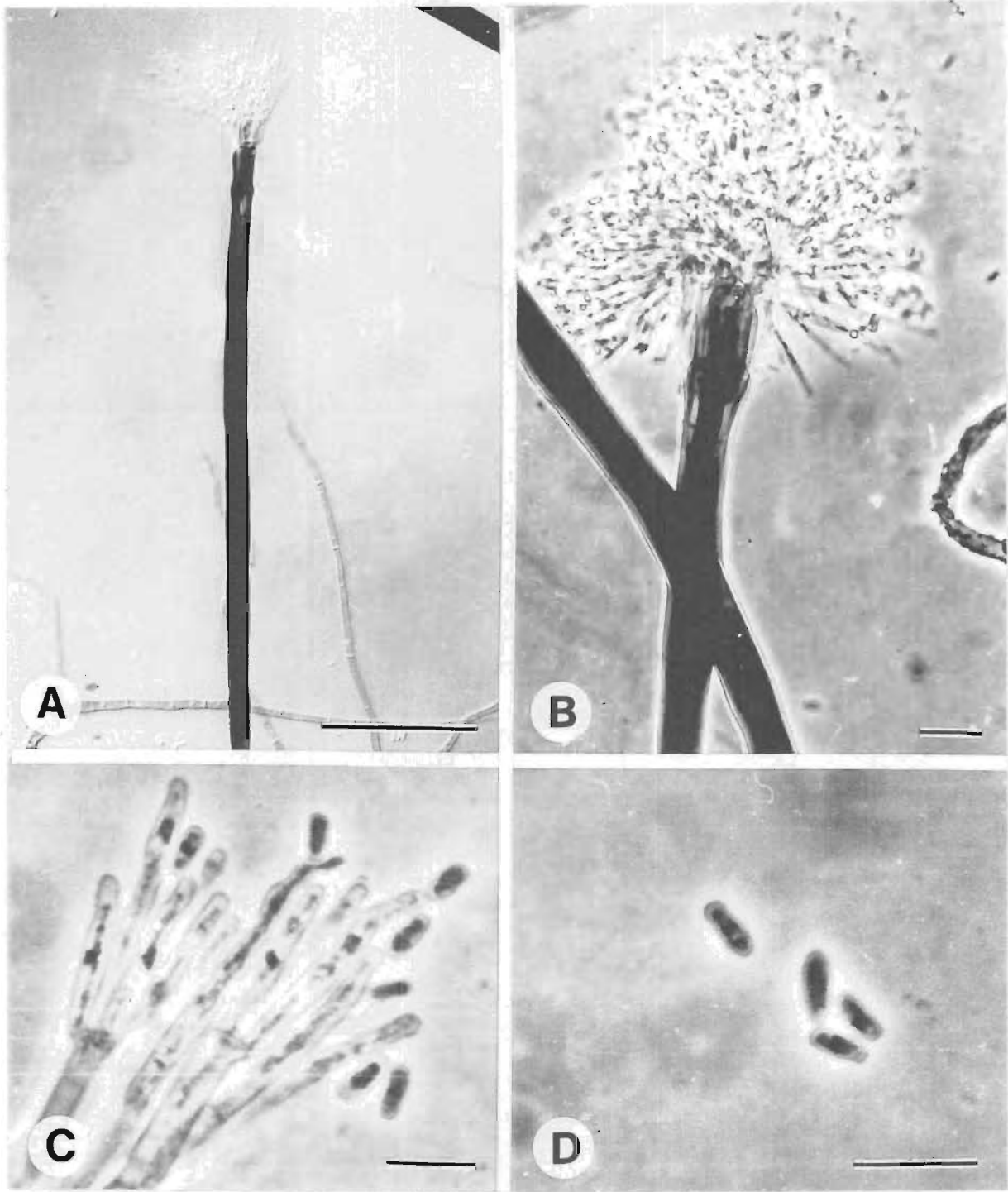
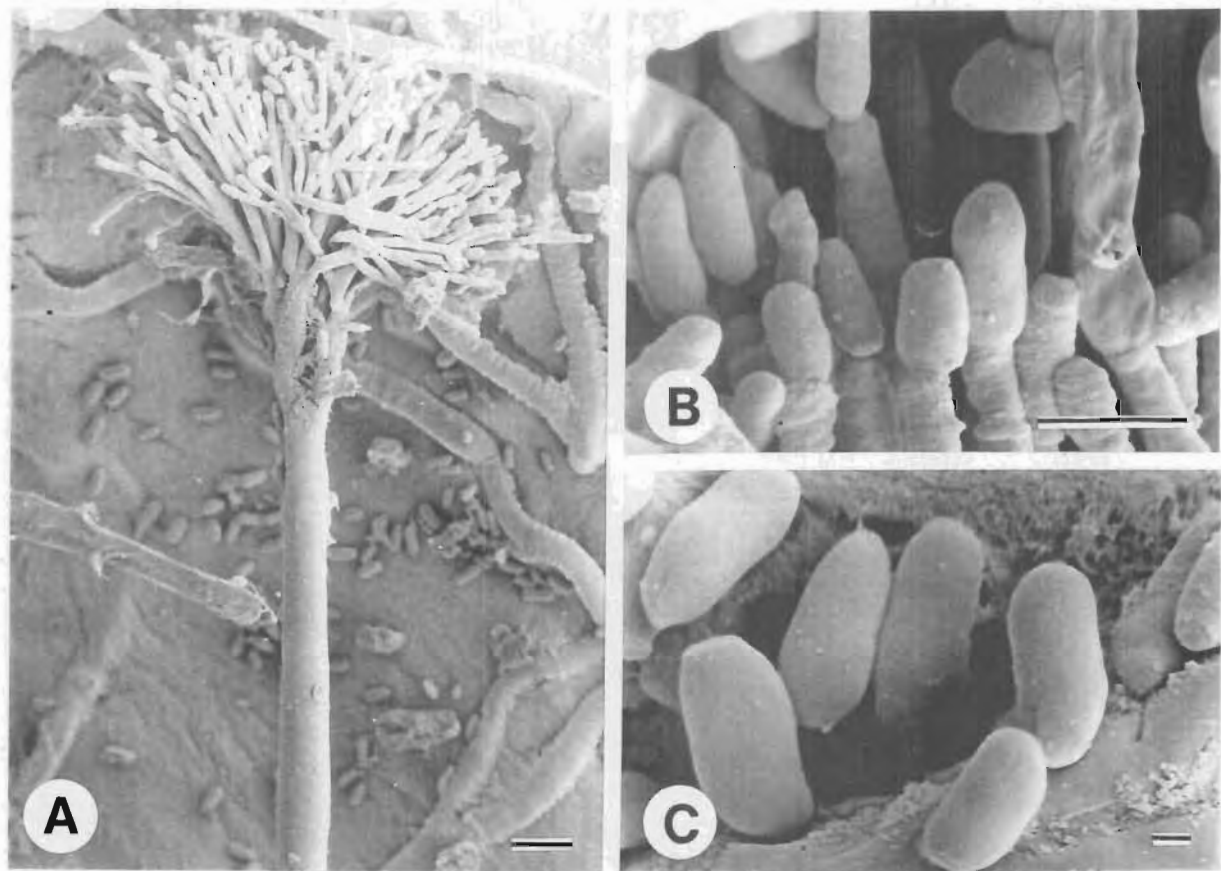


Fig. 27. Conidiophores and conidia of *L. albopini* (PREM 56383). A. Habit sketch (Bar = 10  $\mu$ m). B. Conidiogenous apparatus (Bar = 10  $\mu$ m). C. Conidia (Bar = 10  $\mu$ m).



**Fig. 28.** Light micrographs of the conidiophores and conidia of *L. albopini* (PREM 56383). **A.** Conidiophore (Bar = 10  $\mu$ m). **B.** Conidiogenous apparatus (Bar = 10  $\mu$ m). **C.** Conidiogenous cells (Bar = 10  $\mu$ m). **D.** Conidia (Bar = 10  $\mu$ m).



**Fig. 29.** Scanning electron micrographs of the conidiophores and conidia of *L. albopini* (PREM 56383).  
**A.** Conidiophore (Bar = 10  $\mu\text{m}$ ). **B.** Conidiogenous cells (Bar = 5  $\mu\text{m}$ ). **C.** Conidia (Bar = 1  $\mu\text{m}$ ).

**5. *Leptographium alethinum* K. Jacobs, M.J. Wingf. & A. Uzunovic, *Mycological Research* 1999. (Figs. 30-32).**

Teleomorph state: Not known.

**Etymology:** a-le-thí-num: genuine. From the Greek adjective *αληθινος*: real, genuine. This specific epithet refers to the well-developed conidiophores of this fungus which is characteristic of a true *Leptographium*.

*Conidiophores* occurring singly or in groups of up to six, arising directly from the mycelium, erect, macronematous, mononematous, (560-) 636.5 - 1270 µm in length, rhizoid-like structures absent. *Stipes* dark olivaceous, smooth, cylindrical, simple, 6 - 10 septate, (500-) 562 - 1150 µm long, 10 - 12.5 µm wide below primary branches, apical cell not swollen, 10 - 15 µm wide at base, basal cell not swollen. *Conidiogenous apparatus* (60-) 75 - 146 (-170) µm long, excluding the conidial mass, with 3 - 4 series of cylindrical branches, 2-4 primary branches, olivaceous, smooth, cylindrical, aseptate, (25-) 42.5 - 32 (-55) µm long and (5.0-) 6.0 - 10 (-13) µm wide, arrangement of the primary branches on the stipe - type B, secondary branches olivaceous to hyaline, aseptate, 12 - 30 (-33) µm long, 3.0 - 7.5 (-9.0) µm wide, tertiary branches hyaline, aseptate, 10 - 20 µm long, 2.0 - 5.0 µm wide, quaternary branches aseptate, hyaline, 8.0 - 17 µm long, 2.0 - 3.0 µm wide. *Conidiogenous cells* discrete, 2-3 per branch, cylindrical, tapering slightly at the apex, 12 -22 (-23) µm long and 1.0 - 3.0 µm wide. *Conidia*, aseptate, obovoid with truncate ends, (4.0-) 5.0 - 7.0 (-9.0) x 2.0 - 3.0 µm. Conidia accumulating in slimy droplets at the apex of conidiogenous apparatus.

*Colonies* with optimal growth at 20°C on 2% MEA, reaching 23 mm in diameter in 6 days. Little growth below 5°C and no growth above 30°C. Able to withstand high concentrations of cycloheximide with a 12% reduction in growth on 0.1 g/l cycloheximide after 6 days at 20°C in the dark. Colonies olivaceous (19" f). *Colony margin* smooth. *Hyphae* submerged with no aerial mycelium, olivaceous to light olivaceous, smooth, not constricted at the septa, (2.0-) 3.0 - 9.0 (-12) µm diameter.

**Specimens examined:** **Holotype:** England, *Hylobius abietis* galleries, collected A.



Uzunovic, PREM 56349. **Paratypes:** *Hylobius abietis* galleries, England, collected A. Uzunovic, PREM 56348, PREM 56350. **Cultures:** *Hylobius abietis* galleries, England, collected A. Uzunovic; CMW 3766, CMW 3767, CMW 3765, CMW 3764, *Hylobius abietis* galleries, England, collected A. Uzunovic, Corsican pine, England, collected: J.N. Gibbs. CMW 2159.

**Known distribution:** England.

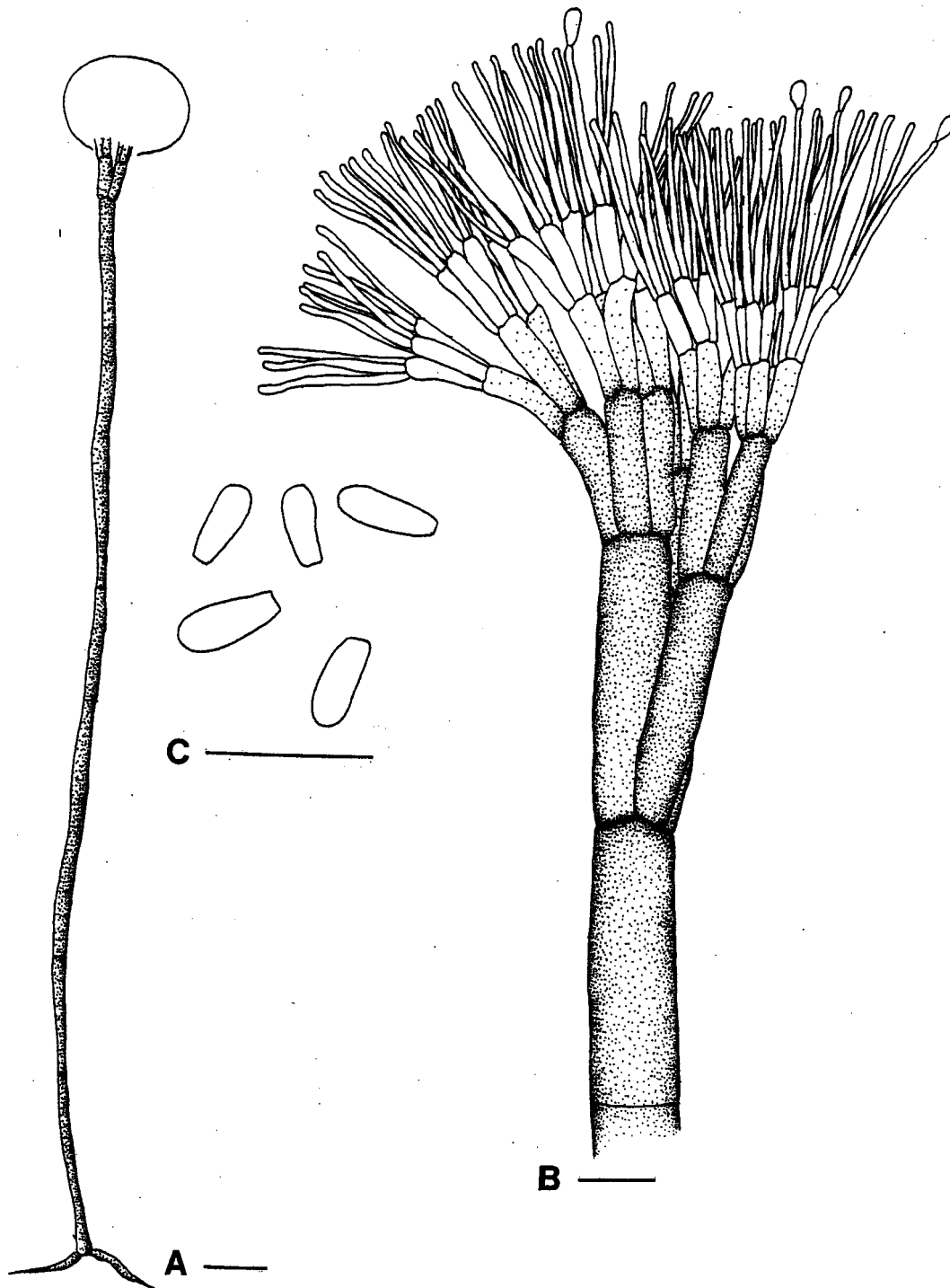
**Hosts/substrate:** *Abies* spp. (Jacobs *et al.*, 1999).

**Associated insects:** *Hylobius abietis* (Jacobs *et al.*, 1999).

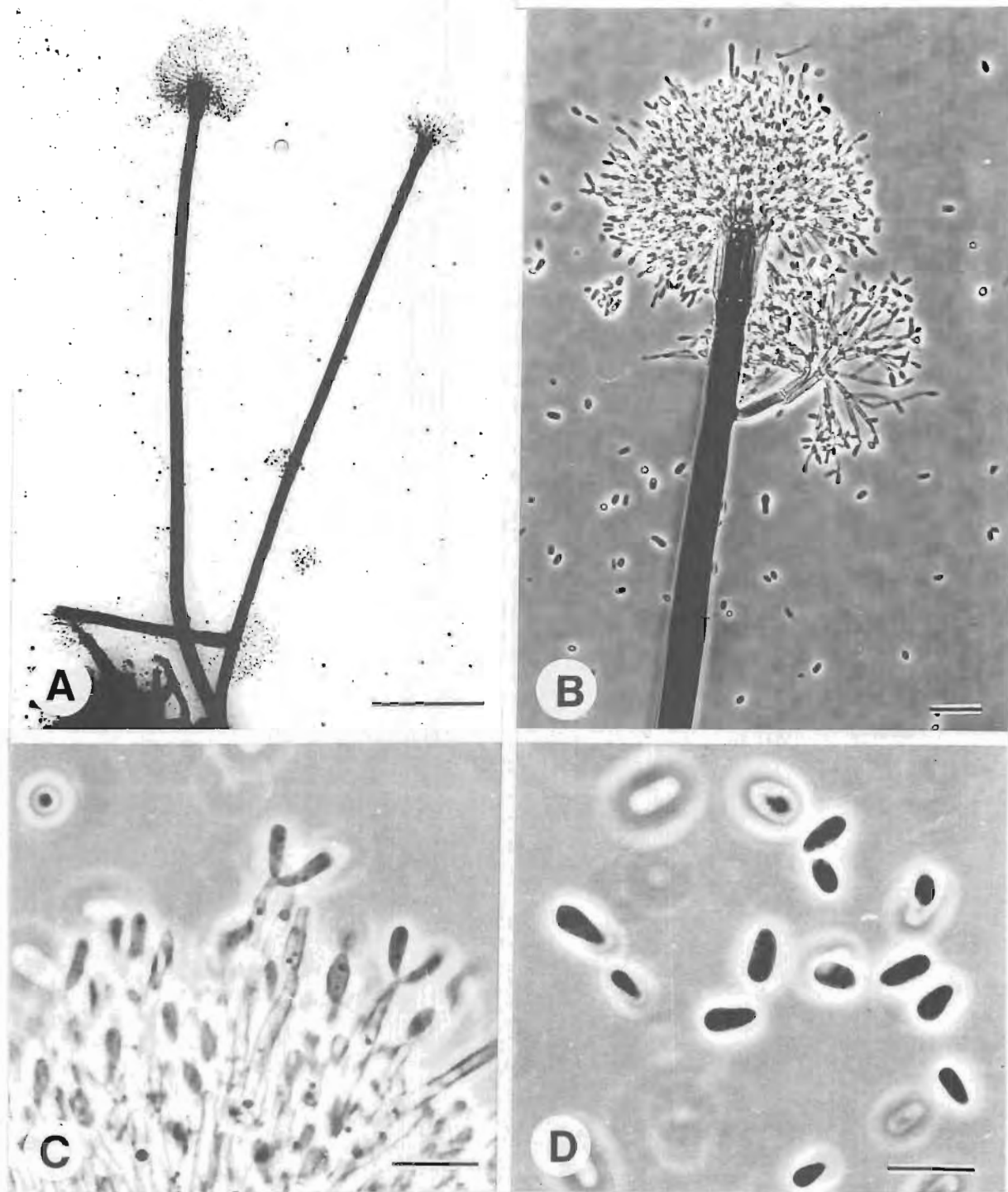
**Notes:** *Leptographium alethinum* is morphologically similar to *L. procerum*. The most obvious distinguishing character in these species is the absence of the characteristic concentric rings typically formed in agar colonies of *L. procerum*. *Leptographium alethinum* can further be distinguished from *L. procerum* based on the absence of rhizoids, whereas these structures are prominent in isolates of *L. procerum*. Furthermore, the conidia of *L. alethinum* are obovoid, but slightly longer (4 - 9  $\mu\text{m}$ ) than those of *L. procerum* (3 - 5  $\mu\text{m}$ ).

*Leptographium alethinum* is morphologically also similar to *L. douglasii* (Wingfield *et al.*, 1994). *Leptographium alethinum* can be distinguished from *L. douglasii* based on its considerably longer conidiophores (560 - 1270  $\mu\text{m}$ ) than those found in cultures of *L. douglasii* (57 - 512  $\mu\text{m}$ ). *Leptographium alethinum* is also characterized by primary branches that are almost twice as long as those of *L. douglasii* and the absence of rhizoids, which are present in *L. douglasii*.

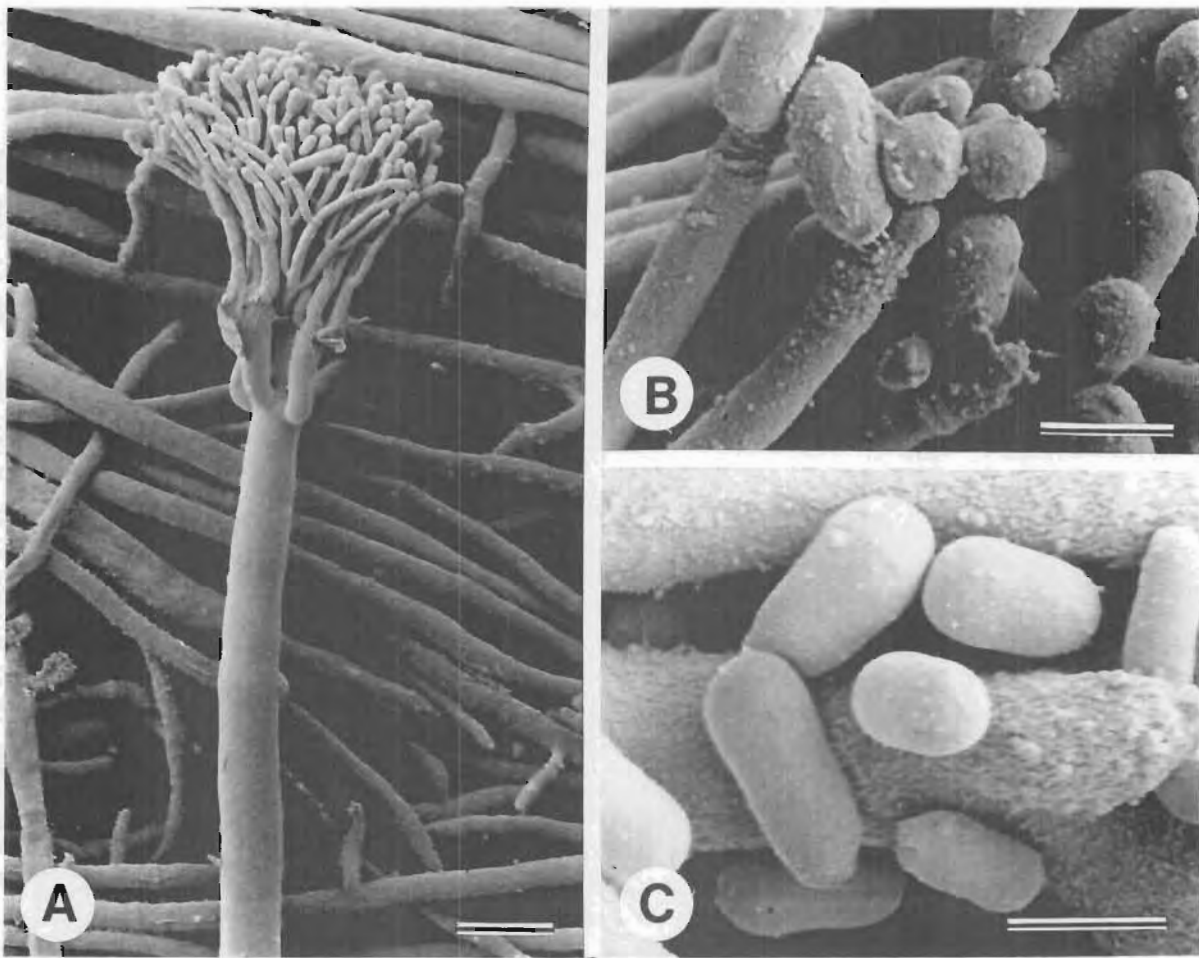
*Leptographium alethinum* occurs in the same habitat as *L. procerum*, and is therefore, associated with similar insects. However, nothing is known regarding the pathogenicity of *L. alethinum* although we expect that it might be mildly pathogenic or saprophytic.



**Fig. 30.** Conidiophores and conidia of *L. alethinum* (PREM 56349). **A.** Habit sketch (Bar = 100  $\mu$ m). **B.** Conidiogenous apparatus (Bar = 10  $\mu$ m). **C.** Conidia (Bar = 10  $\mu$ m).



**Fig 31.** Light micrographs of the conidiophores and conidia of *L. alethinum* (PREM 56349). **A.** Conidiophore (Bar = 100  $\mu$ m). **B.** Conidiogenous apparatus (Bar = 20  $\mu$ m). **C.** Conidiogenous cells (Bar = 10  $\mu$ m). **D.** Conidia (Bar = 10  $\mu$ m).



**Fig. 32.** Scanning electron micrographs of the conidiophores and conidia of *L. alethinum* (PREM 56349).  
**A.** Conidiophore (Bar = 20  $\mu\text{m}$ ). **B.** Conidiogenous cells (Bar = 5  $\mu\text{m}$ ). **C.** Conidia (Bar = 5  $\mu\text{m}$ ).

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6. *Ophiostoma americanum* K. Jacobs & M.J. Wingf. *Canadian Journal of Botany* 75, 1316. 1997. (Figs. 33-35).

Anamorph: *Leptographium americanum* K. Jacobs & M.J. Wingf. *Canadian Journal of Botany* 75, 1316. 1997.

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**Etymology:** a-me-ri-cá-num: connected with America. This specific epithet refers to the origin of this fungus in North America.

*Perithecial bases* black, globose and smooth walled, sparsely ornamented, (200-) 283 (-370)  $\mu\text{m}$  in diam. *Perithecial neck* dark brown to black, cylindrical with a slight apical taper, smooth, (690-) 1027.5 (-1300)  $\mu\text{m}$  long, (50-) 60.5 (-70)  $\mu\text{m}$  above globose base, (20-) 25.5 (-40)  $\mu\text{m}$  wide at the apex, *ostiole hyphae* absent. *Asci* prototunicate, hyaline, evanescent. *Ascospores* reniform, aseptate, hyaline, invested in a sheath, (3.0-) 4.5 (-5.5) x (1.0-) 1.5 (-2.5)  $\mu\text{m}$ . Sheaths not uniform, giving the ascospores a rectangular appearance (Jacobs *et al.*, 1997).

*Conidiophores* occurring singly or in groups of up to 9, arising directly from the mycelium, erect, macronematous, mononematous, (149-) 212 - 453 (-731.5)  $\mu\text{m}$  in length, rhizoid-like structures absent. *Stipes* light olivaceous (21" k), smooth, cylindrical, simple, 5 - 15 septate, (108.5-) 185 - 391 (-691)  $\mu\text{m}$  long, 3.0 - 6.0  $\mu\text{m}$  wide below primary branches, apical cell not swollen, 4.5 - 11  $\mu\text{m}$  wide at base, basal cell not swollen. *Conidiogenous apparatus* (25-) 45 - 53.5 (-77.5)  $\mu\text{m}$  long, excluding the conidial mass, with 3 to 5 series of cylindrical branches, 2 primary branches, light olivaceous (21" k), smooth, cylindrical to barrel shape, 0-1 septate (9.0-) 12.5 - 15 (-20)  $\mu\text{m}$  long and (3.0-) 4.0 - 6.0 (-8.0)  $\mu\text{m}$  wide, arrangement of the primary branches on the stipe - type A, secondary branches light olivaceous (21" k), aseptate, cylindrical to barrel shape 8.0 - 15 (-20)  $\mu\text{m}$  long, 3.0 - 6.0  $\mu\text{m}$  wide, tertiary branches light olivaceous (21" k), aseptate, (6.0-) 8.0 -10.5 (-15.5)  $\mu\text{m}$  long, 1.5 - 6.0  $\mu\text{m}$  wide, quaternary branches aseptate, (4.0-) 8.0 - 11.5 (-20)  $\mu\text{m}$  long, (1.0-) 2.5 -3.0 (-5.0)  $\mu\text{m}$  wide. *Conidiogenous cells* discrete, 2-3 per branch, cylindrical, tapering slightly at the apex, (8.0-) 8.5 - 21 (-30)  $\mu\text{m}$  long and 1.0 - 3.0  $\mu\text{m}$  wide. *Conidia* hyaline, aseptate, oblong to obovoid, 3.5 - 22 x 1.0 - 3.0  $\mu\text{m}$ . Conidia accumulating in slimy

droplets at the apex of conidiogenous apparatus, hyaline at first, becoming cream colored (19'f) with age. Conidial mass cream colored when wet, remaining cream colored when dry.

*Colonies* with optimal growth at 20°C on 2% MEA, reaching 45 mm in diam. in 9 days. No growth below 5°C and little growth above 35°C. Able to withstand high concentrations of cycloheximide with a 5% reduction in growth on 0.5 g/l cycloheximide after 8 days at 20°C in the dark. Colonies olivaceous (21''m). *Colony margin* effuse. *Hyphae* submerged on agar with abundant aerial mycelium, hyaline, smooth, straight, not constricted at the septa, 1.5 - 6.0 µm diam.

**Specimens examined:** **Holotype:** U.S.A., Vermont, *Larix laricina*, May, 1994, collected: D.R. Bergdahl and M.J. Wingfield, PREM 54866. **Paratypes:** U.S.A., Vermont, *Larix laricina*, May, 1994, collected: D.R. Bergdahl and M.J. Wingfield, PREM 54867, PREM 54868, PREM 54869. **Cultures:** U.S.A., Vermont, *Larix laricina*, May, 1994, collected: D.R. Bergdahl and M.J. Wingfield, CMW 495 (CBS 497.96), CBS 498.96, CBS 499.96; CBS 500.96.

**Known distribution:** Northern United States.

**Hosts/substrate:** *Larix decidua* (Jacobs *et al.*, 1997).

**Associated insects:** *Dendroctonus simplex* (Jacobs *et al.*, 1997).

**Notes:** This species is one of the few species of *Leptographium* that has conidia that are five times as long as they are wide. The others are *L. penicillatum* and *L. dryocoetidis*. *Leptographium americanum* can, however, be distinguished from these species based on the long needle-like appearance of its conidia. The conidial lengths of *L. americanum* are also distinctly variable ranging from 3.5 to 22 µm. This species has not been shown to be pathogenic and its role in its consistent association with the bark beetle *D. simplex* is not known.

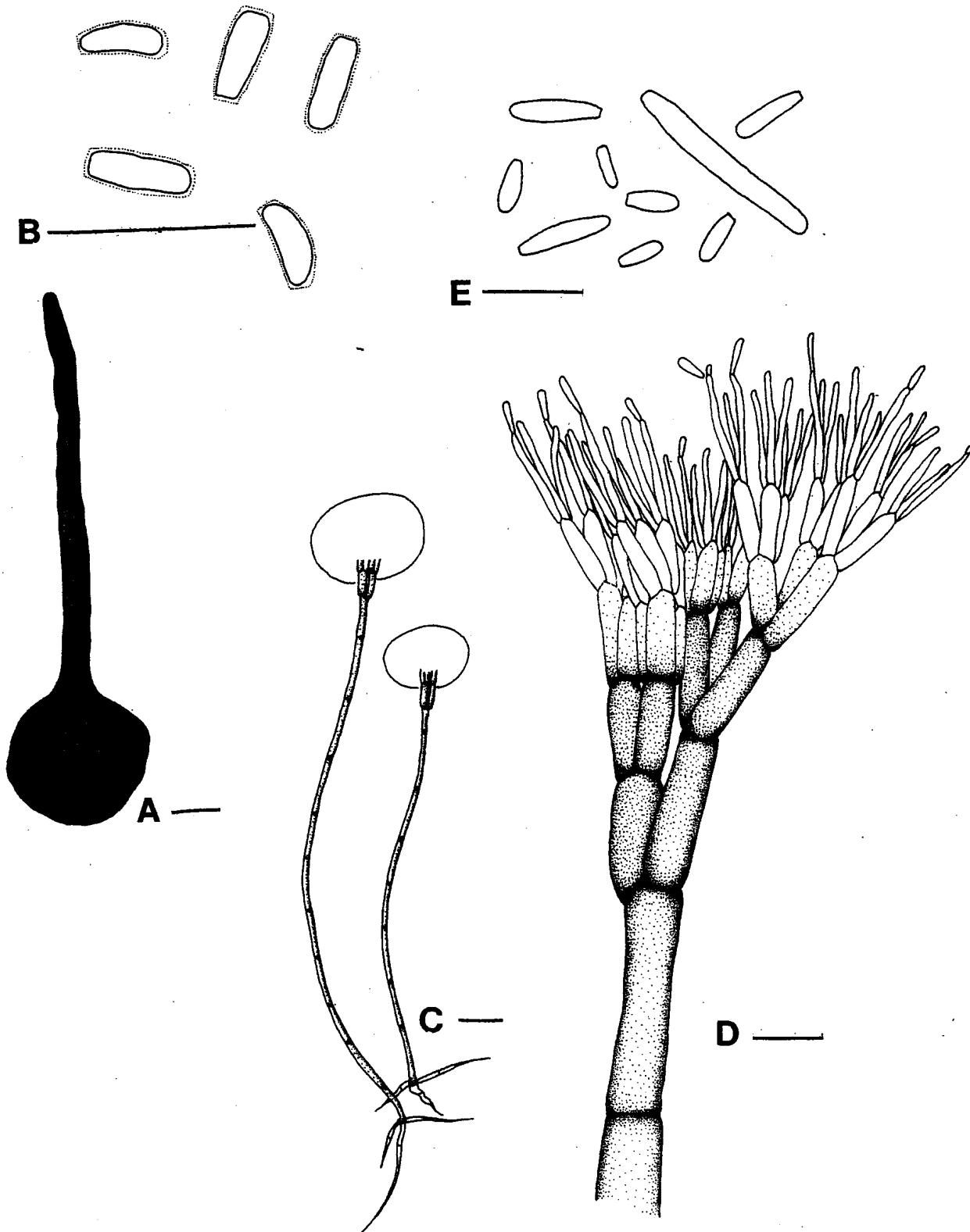
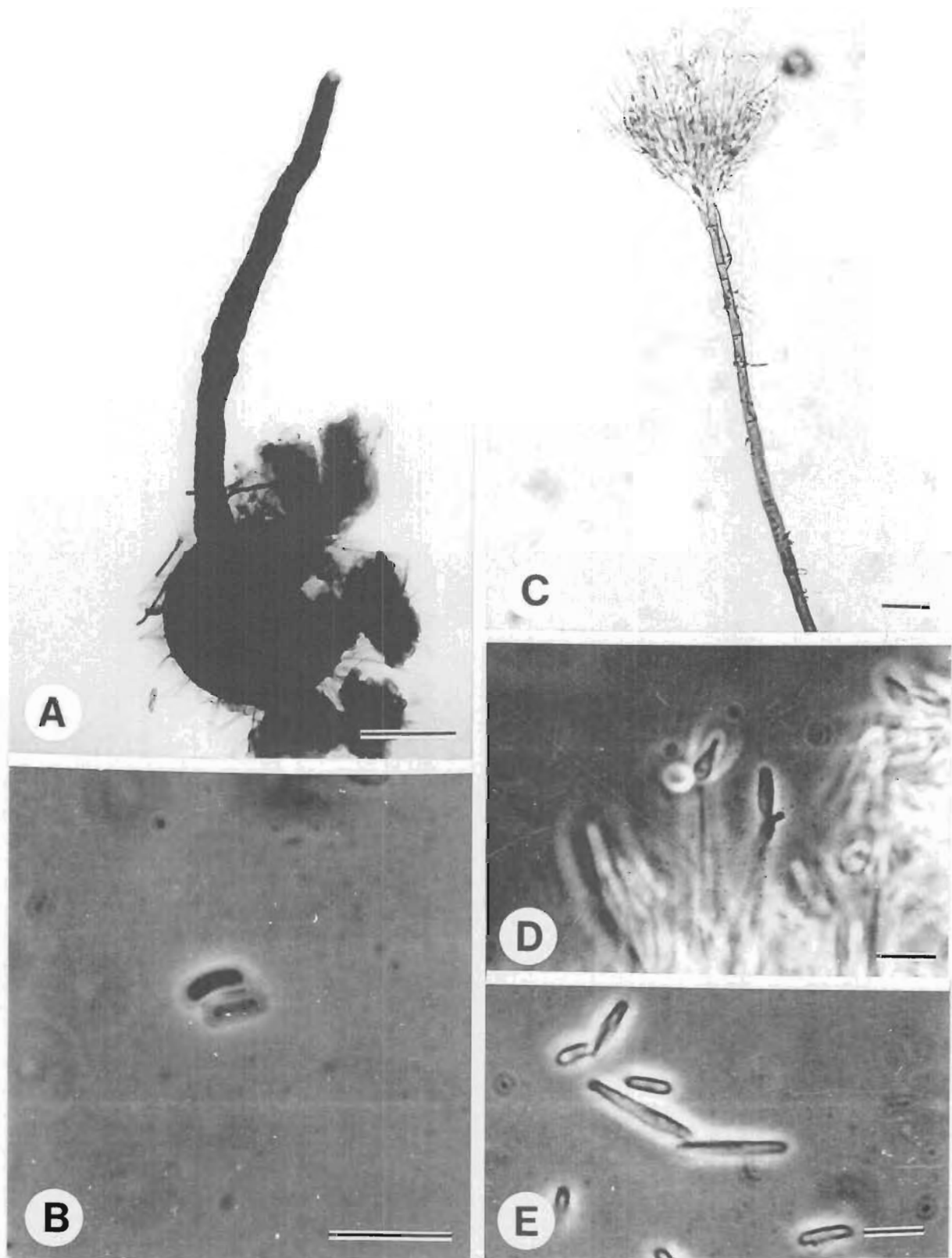
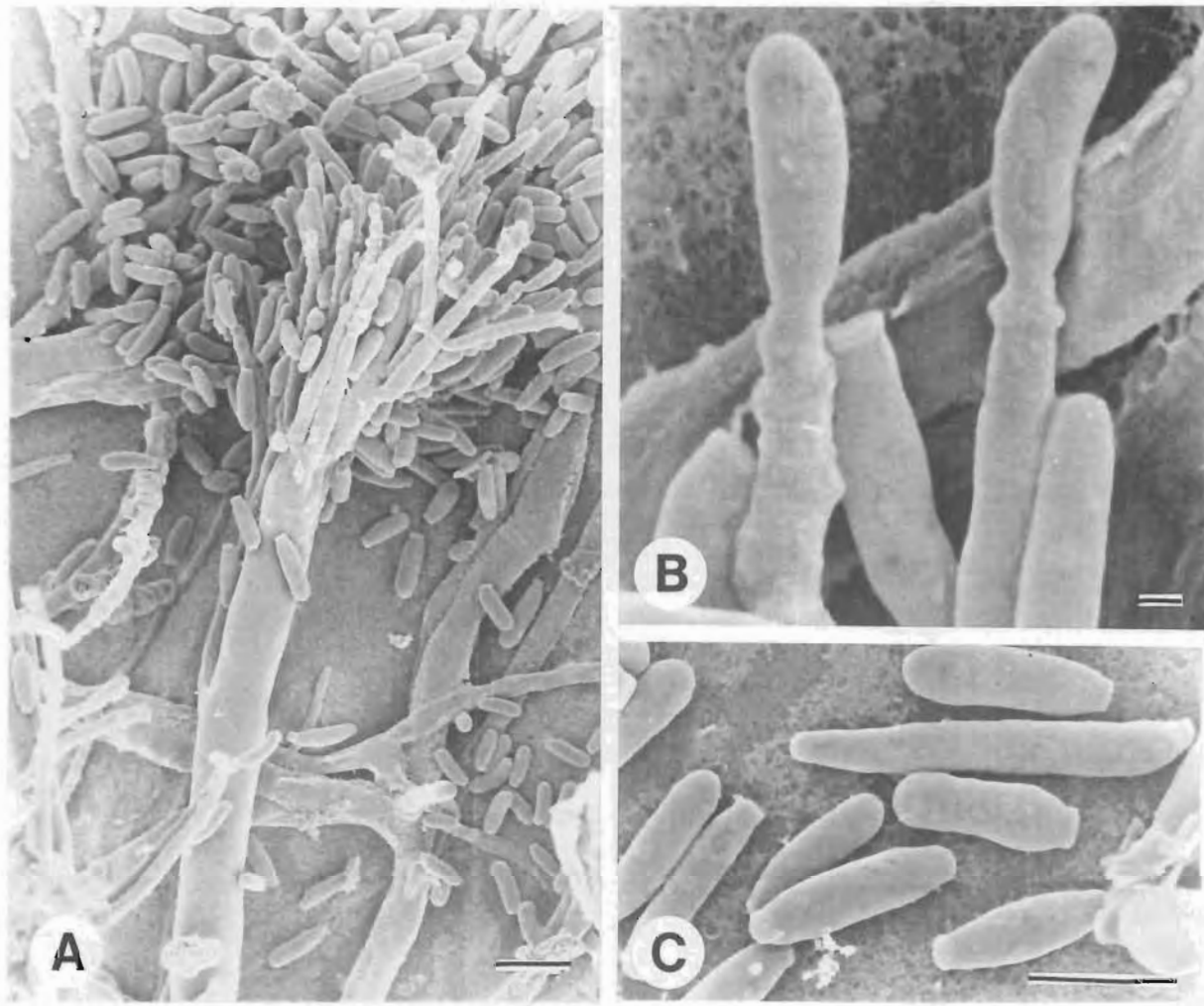


Fig. 33. Teleomorph and anamorph structures of *O. americanum* (PREM 54866). A. Perithecium (Bar = 100  $\mu$ m). B. Ascospores (Bar = 10  $\mu$ m). C. Conidiophore (Bar = 100  $\mu$ m). D. Conidiogenous apparatus (Bar = 10  $\mu$ m). E. Conidia (Bar = 10  $\mu$ m).



**Fig 34.** Light micrographs of the teleomorph and anamorph structures of *O. americanum* (PREM 54866). **A.** Perithecium (Bar = 100  $\mu\text{m}$ ). **B.** Ascospore (Bar = 10  $\mu\text{m}$ ). **C.** Conidiophore (Bar = 20  $\mu\text{m}$ ). **D.** Conidiogenous cells (Bar = 10  $\mu\text{m}$ ). **E.** Conidia (Bar = 10  $\mu\text{m}$ ).





**Fig. 35.** Scanning electron micrographs of the conidiophores and conidia of *O. americanum* (PREM 54866). **A.** Conidiophore (Bar = 10  $\mu\text{m}$ ). **B.** Conidiogenous cells (Bar = 1  $\mu\text{m}$ ). **C.** Conidia (Bar = 5  $\mu\text{m}$ ).

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**7. *Leptographium antibioticum*** (W.B. Kendr.) M.J. Wingf., *Transactions of the British Mycological Society* **85**, 92. 1985. (Figs. 36-38).

≡ *Verticicladiella antibiotica* W.B. Kendr. *Canadian Journal of Botany* **40**, 789. 1962.

**Teleomorph:** Not known.

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**Etymology:** an-ti-bi-ó-ti-cum: antibiotic. From the Greek αντι: against and βιοτος: life. This specific epithet refers to the fact that the fungus produces an antibiotic substance in culture.

*Conidiophores* occurring singly, arising directly from the mycelium, erect, macronematous, mononematous, (110-) 117 - 329 (-407)  $\mu\text{m}$  in length, rhizoid-like structures present. *Stipes* light olivaceous (21''k), smooth, cylindrical, simple, 3-10 septate, (65-) 76 -281 (-350)  $\mu\text{m}$  long, 3.0 - 4.5  $\mu\text{m}$  wide below primary branches, apical cell not swollen, 3.0 - 8.0  $\mu\text{m}$  wide at base, basal cell not swollen. *Conidiogenous apparatus* (22.5-) 35 -52 (-72.5)  $\mu\text{m}$  long, excluding the conidial mass, with 2 - 3 series of cylindrical branches, 2-5 primary branches, light olivaceous (21''k), smooth, cylindrical, aseptate (7.0-) 10 -12.5 (-14.0)  $\mu\text{m}$  long and 1.5 - 4.0  $\mu\text{m}$  wide, arrangement of the primary branches on the stipe - type B, secondary branches light olivaceous (21''k) to hyaline, aseptate, cylindrical, (5.0-) 7.0 - 11.5 (-13.0)  $\mu\text{m}$  long, 1.5 - 3.0  $\mu\text{m}$  wide, tertiary branches hyaline, (5.5-) 7.5 - 8.5 (-11.0)  $\mu\text{m}$  long, 2.0 - 3.0  $\mu\text{m}$  wide, aseptate, quaternary branches aseptate, hyaline. *Conidiogenous cells* discrete, 2-3 per branch, cylindrical, tapering slightly at the apex, 7 - 12.5  $\mu\text{m}$  long and 0.8 - 1.3  $\mu\text{m}$  wide (Kendrick, 1962). *Conidia* light gray olivaceous (19''m), aseptate, oblong to obovoid with truncate ends and rounded apices, 2.5 - 5.0 x 0.5 - 2.0  $\mu\text{m}$ . Conidia accumulating in slimy droplets at the apex of conidiogenous apparatus, hyaline at first, becoming cream colored (19'f) with age. Conidial mass cream colored when wet, becoming amber (21'b) when dry.

*Colonies* with optimal growth at 30°C on 2% MEA, reaching 7 mm in diam. in 8 days. No growth below 10°C or above 35°C. Able to withstand high concentrations of cycloheximide with a 5% reduction in growth on 0.5 g/l cycloheximide after 12 days

at 20°C in the dark. Colonies light yellow to light olivaceous. *Colony margin* smooth. *Hyphae* submerged on agar with no aerial mycelium, hyaline, smooth, straight, not constricted at the septa, 0.5 - 2.0 µm diam.

**Specimens examined: Holotype:** Canada, Big Rideau Lake near Portland, Ontario, *Pinus strobus*, 30 Aug. 1961, collected: S.J. Hughes, DAOM 84338. **Paratypes:** Canada, Banff, Alberta, *Picea* spp., 12 Aug. 1960, collected: S.J. Hughes DAOM 71293; U.S.A. **Cultures:** Jane County, G.A, *Pinus taeda*, 1989, collected: S. Alexander, CMW 2777 (same as C 393); U.S.A., Bleckley County, G.A, *Pinus taeda*, 1989, collected: Sam Alexander, CMW 2776; U.S.A. Mesa Verda, CO, *Pinus edulis*, 1984, CMW 2834 (same as C151).

**Known distribution:** Canada.

**Hosts/substrate:** worked conifer wood (Kendrick, 1962), *Pinus albicaulis* (Mielke, 1979), *Pinus contorta* (Mielke, 1979), *P. monticola* (Kulhavy et al., 1978; Mielke, 1979), *Abies lasiocarpa* (Mielke, 1979), *Abies balsamea* (Harrington, 1988).

**Associated insects:** Not known.

**Notes:** This is the only species in *Leptographium* known to produce an antibiotic substance in culture (Kendrick, 1962). Slow-growing isolates of this fungus are sensitive to cycloheximide, whereas faster growing isolates have a higher degree of tolerance (Harrington, 1988). This unusual characteristic might indicate that this species does not have a close affinity to *Ophiostoma* (Harrington, 1988), or that isolates represent a species complex.

*Leptographium antibioticum* can be distinguished from other *Leptographium* spp. based on its colony and conidiophore colour as well as rhizoids. Cultures of *L. antibioticum* can readily be recognized by its pale, almost white colour compared to the dark olivaceous colour of other *Leptographium* spp. In addition, the conidiophore stipes of this species is also not the characteristic olivaceous green observed in other *Leptographium* spp., but rather a light olive to yellow colour. At the bases of

the conidiophores, there are short, peg-like rhizoids.

Little is known about the pathogenicity or ecological role of *L. antibioticum*. Compared to other species of *Leptographium*, *L. antibioticum* was found to be a saprophyte and showed no pathogenicity in trails (Bertagnole *et al.*, 1983).

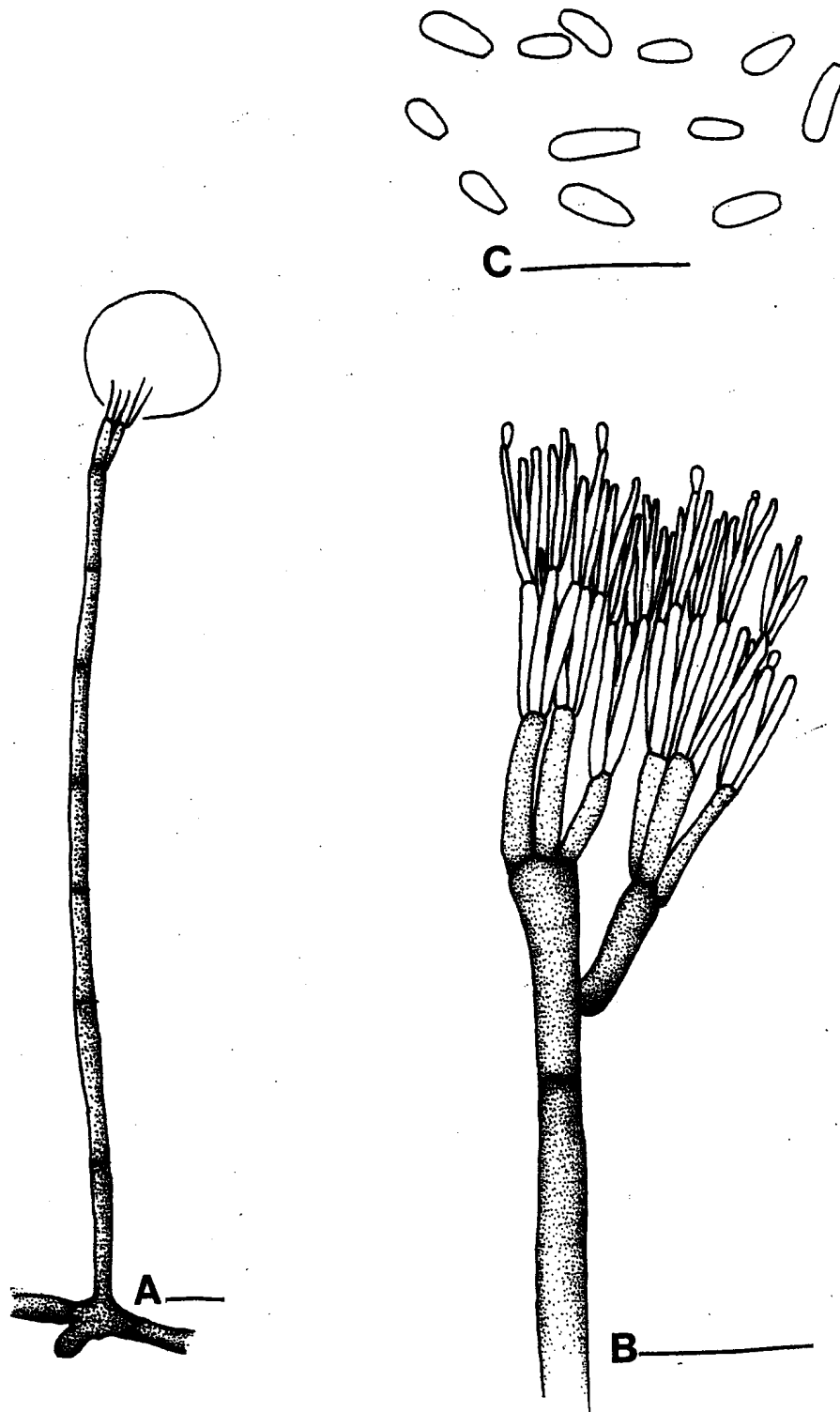
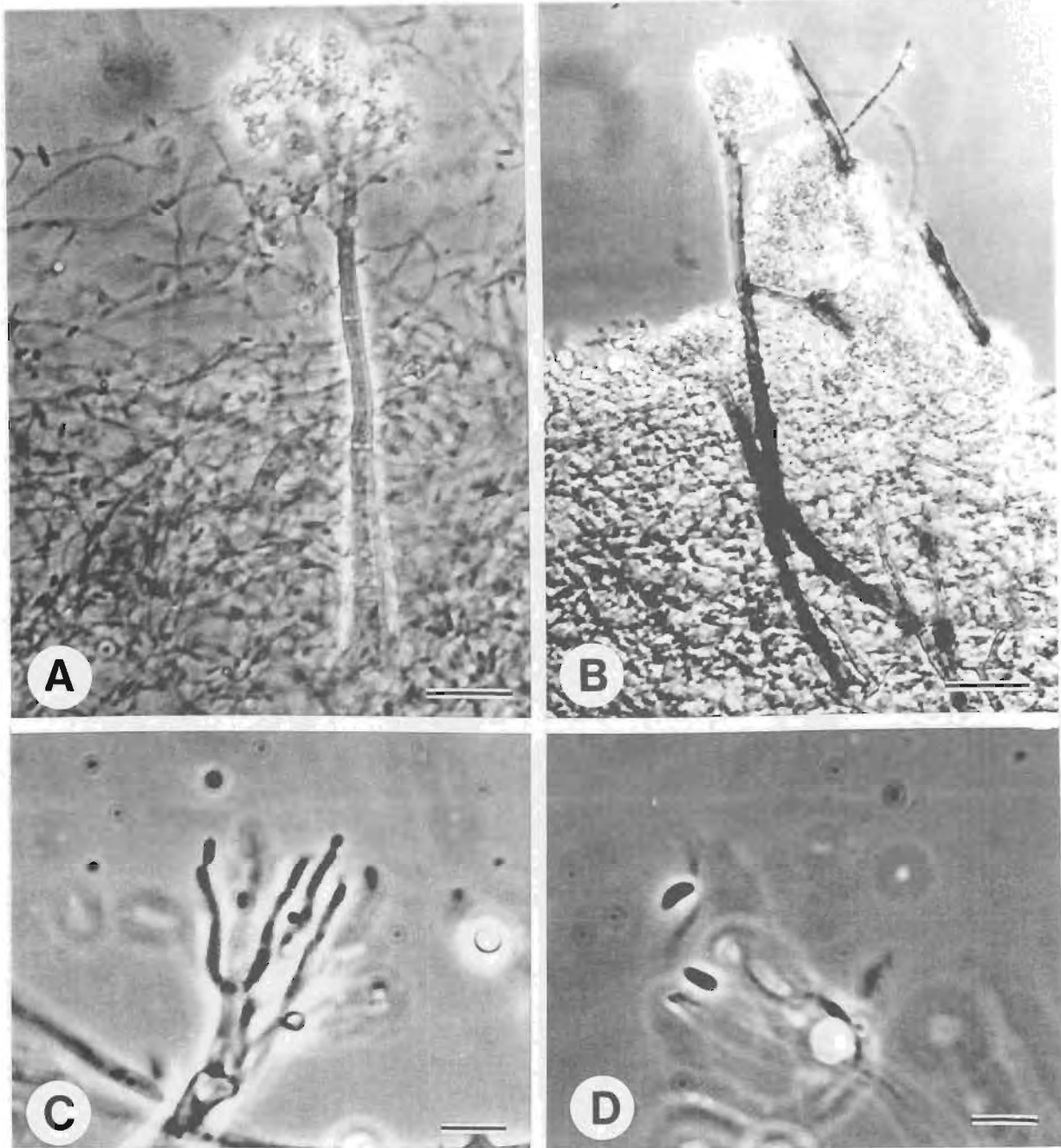
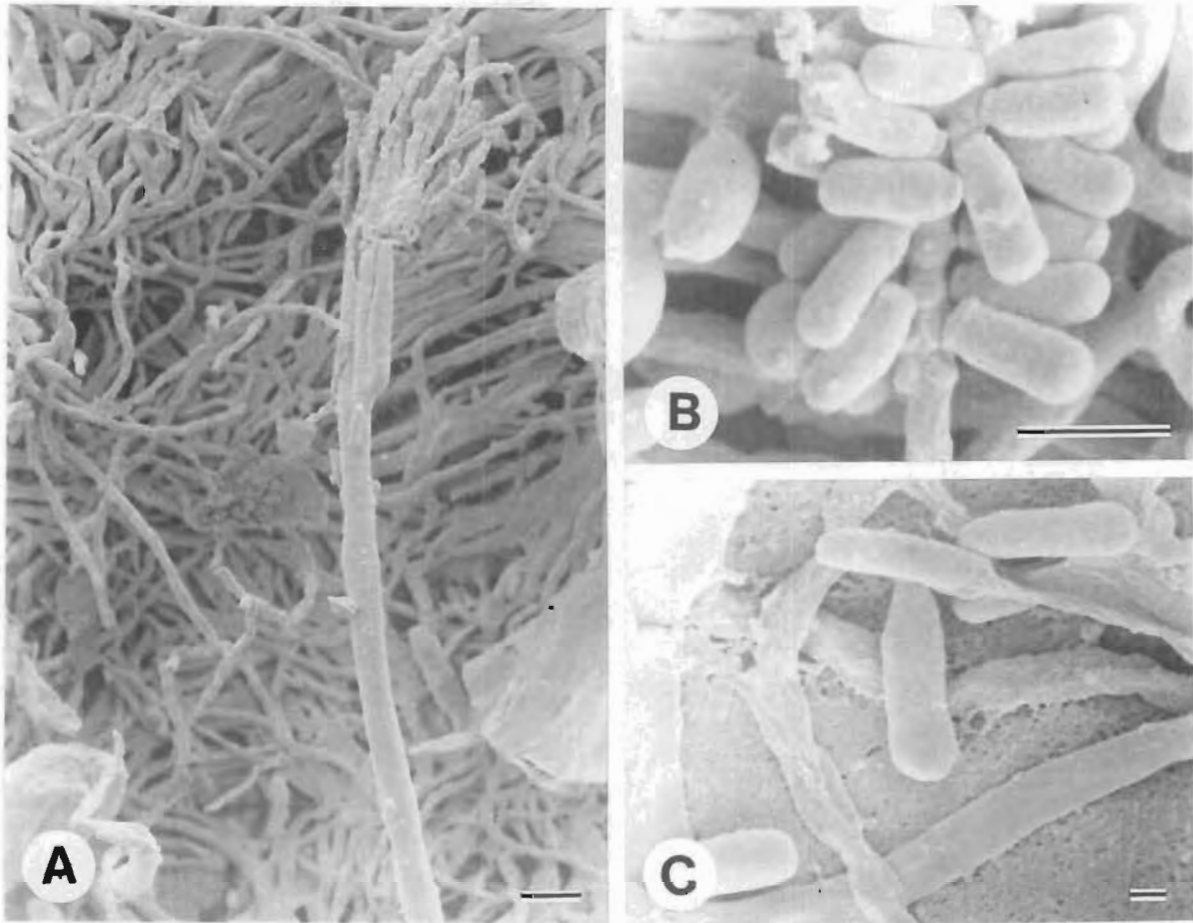


Fig. 36. Conidiophores and conidia of *L. antibioticum* (CMW 2777). A. Habit sketch (Bar = 10  $\mu$ m). B. Conidiogenous apparatus (Bar = 10  $\mu$ m) C. Conidia (Bar = 10  $\mu$ m).





**Fig 37.** Light micrographs of the conidiophores and conidia of *L. antibioticum* (CMW 2777). **A.** Conidiophore (Bar = 10  $\mu$ m). **B.** Conidiogenous apparatus (Bar = 10  $\mu$ m). **C.** Conidiogenous cells (Bar = 10  $\mu$ m). **D.** Conidia (Bar = 10  $\mu$ m).



**Fig. 38.** Scanning electron micrographs of the conidiophores and conidia of *L. antibioticum* (CMW 2777). **A.** Conidiophore (Bar = 10  $\mu\text{m}$ ). **B.** Conidiogenous cells (Bar = 5  $\mu\text{m}$ ). **C.** Conidia (Bar = 1  $\mu\text{m}$ ).

**8. *Ophiostoma aureum*** (Rob.-Jeffer. & R.W. Davidson) T.C. Harr. *Mycotaxon* **27**, 41. 1987. (Figs. 39-41).

≡ *Ceratocystis aurea* (Rob.-Jeffer. & R.W. Davidson) H.P. Upadhyay A Monograph of *Ceratocystis* and *Ceratocystiopsis*. 1981.

≡ *Europhium aureum* Rob.-Jeffer. & R.W. Davidson *Canadian Journal of Botany* **46**, 1525, 1968.

**Anamorph:** *Leptographium aureum* (Rob.-Jeffer. & R.W. Davidson) M.J. Wingf. *Transactions of the British Mycological Society* **85**, 92. 1985.

**Etymology:** aú-re-um: golden. From the Latin adjective aureus: golden. This specific epithet refers to the bright yellow masses of conidia produced by this fungus in culture (Robinson-Jeffrey & Davidson, 1968).

*Perithecial bases* black, globose and smooth walled, unornamented, 300 - 400 µm in diam. *Perithecial neck* dark brown to black, very short or no neck, *ostiole hyphae* absent. *Asci* prototunicate, hyaline, evanescent. *Ascospores* cucullate, aseptate, hyaline, invested in a sheath, 3.5 - 6.5 x 2.5 - 4 µm (Robinson-Jeffrey & Davidson, 1968).

*Conidiophores* occurring singly, arising directly from the mycelium, occasionally on aerial mycelium, erect, macronematous, mononematous, (100-) 369 - 772 (-1350) µm in length, rhizoid-like structures absent. *Stipes* olivaceous (21"m), smooth, cylindrical, simple, 3-19 septate, (35-) 150.5 - 490 (-785) µm long, 5.0 - 15 µm wide below primary branches, apical cell occasionally swollen, 5.0- 20 µm wide at base, basal cell not swollen. *Conidiogenous apparatus* (35-) 137.5 - 349.5 (-900) µm long, excluding the conidial mass, with complex series of cylindrical branches, 2-3 primary branches, olivaceous (21"m), smooth, cylindrical or barrel shaped 0-1 septate, (8.0-) 16.5 - 36 (-46.5) µm long and 4.5 - 11 µm wide, arrangement of the primary branches on the stipe - type B, secondary branches hyaline, conidiogenous apparatus to complex to measure. *Conidiogenous cells* discrete, 2-3 per branch, cylindrical, tapering slightly at the apex, (8.0-) 15.5 - 23 (-34) µm long and 1.0 - 3.0 µm wide. *Conidia* hyaline, aseptate, oblong with truncate ends and rounded apices, (5.5-) 7.5 - 9.5 (-12.5) x 2.0 - 4.0 µm. Conidia accumulating in slimy droplets at the



apex of conidiogenous apparatus, hyaline at first, becoming amber-yellow (21'b) with age. Conidial mass white to amber yellow when wet, turning golden brown when dry.

*Colonies* with optimal growth at 20°C. Colonies grew uniformly well at 25°C on 2% MEA, reaching 40 mm in diam. in 9 days. No growth below 5°C or above 35°C. Able to withstand high concentrations of cycloheximide with a 23% reduction in growth on 0.5 g/l cycloheximide after 8 days at 20°C in the dark. Colonies dark mouse gray (15''''k). *Colony margin* laciniate. *Hyphae* submerged on agar with very little aerial mycelium, olivaceous (21''m), thick rough walled, straight, occasionally clustered together, frequently constricted at the septa, 3.0 - 8.0 (-11) µm diam.

**Specimens examined:** **Holotype:** U.S.A., McCall, Idaho, *Pinus contorta* Dougl. var. *latifolia* Engelm., 28 October 1963, collected: R.C. Jeffrey and J.I. Ridgway, BPI 688941. **Paratype:** U.S.A., McCall, Idaho, *Pinus contorta* Dougl. var. *latifolia* Engelm., 28 October 1963, collected: R.C. Jeffrey and J.I. Ridgway, BPI 688943. (Note: The herbarium material for this species has deteriorated and it is not possible to observe any structures. For this description previous observations by Robinson-Jeffrey and Davidson (1968), and living cultures of the fungus were used.) **Cultures:** Canada, *Pinus contorta* var. *latifolia*, 1987, collected: R.W. Davidson, (CMW 714); Canada, *Pinus contorta* var. *latifolia*, 1987, collected: R.W. Davidson, CMW 709 (same as ATCC 16936).

**Known distribution:** Canada.

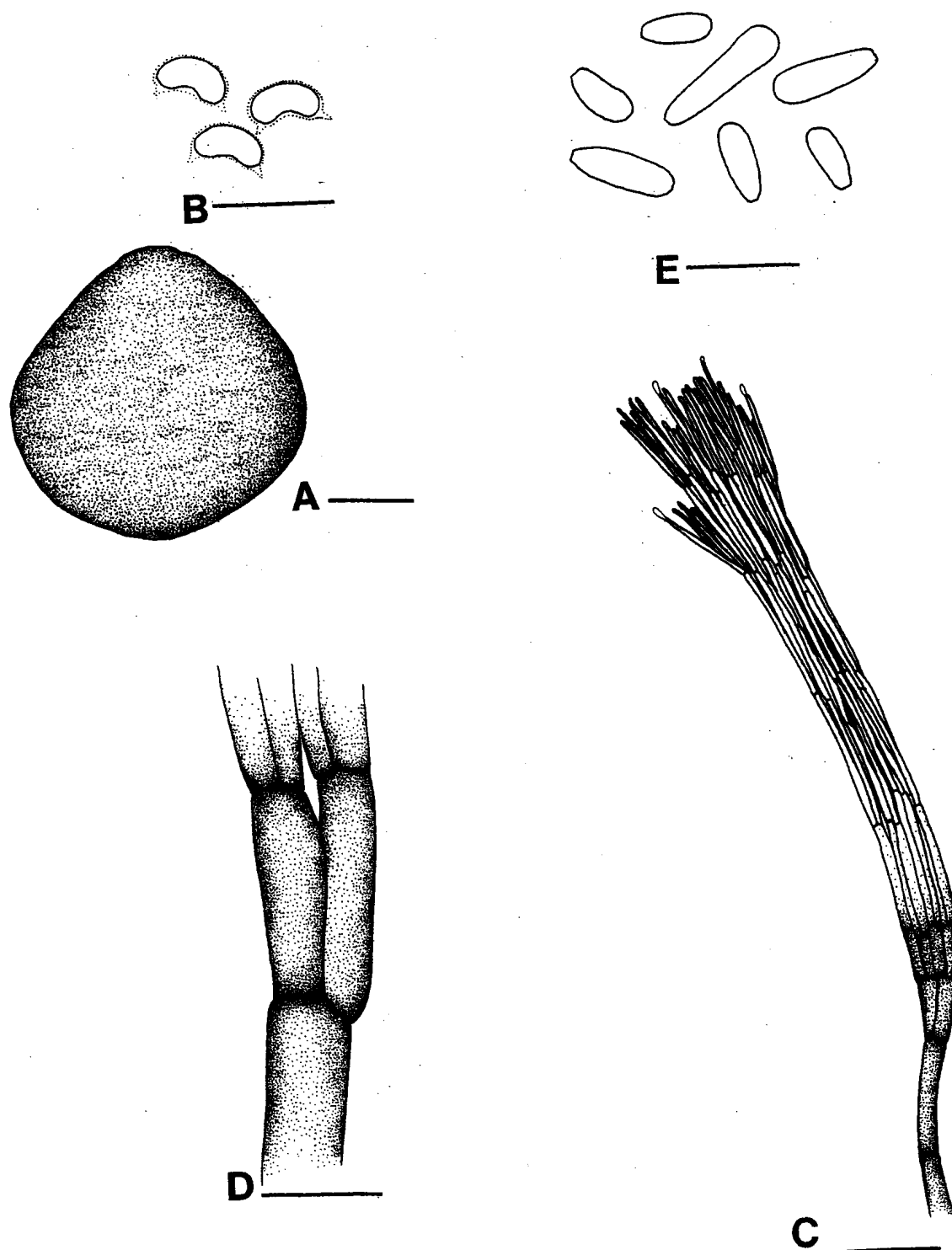
**Hosts/substrate:** *Pinus contorta* var. *latifolia* (Robinson-Jeffrey & Davidson, 1968), *Pinus ponderosa* (Harrington, 1988), *Pinus edulis* (Harrington, 1988).

**Associated insects:** *Dendroctonus* sp. (Robinson-Jeffrey & Davidson, 1968; Perry, 1991), *Hylurgops porosus* (Harrington, 1988).

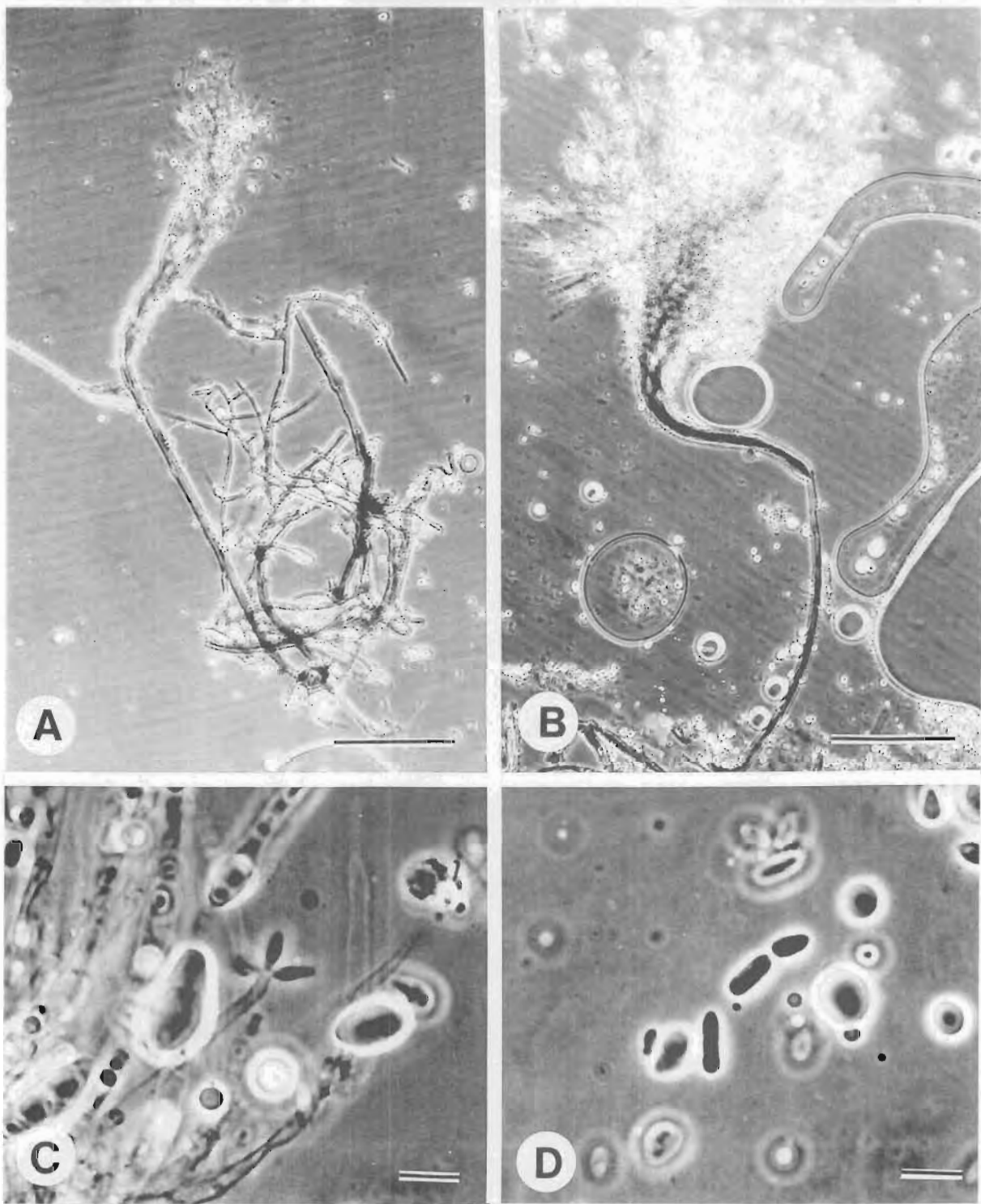
**Notes:** This is one of four species previously accommodated in *Europhium* (Robinson-Jeffrey & Davidson, 1968). These include *E. trinacriforme*, *E. aureum*, *E. clavigerum* Robinson & Davidson and *E. robustum* Robinson & Davidson, that were

all characterized by ascocarps with no, or very short necks. This genus was later reduced to synonymy with *Ceratocystis* (Upadhyay, 1981) and Harrington (1987) transferred these species to *Ophiostoma*.

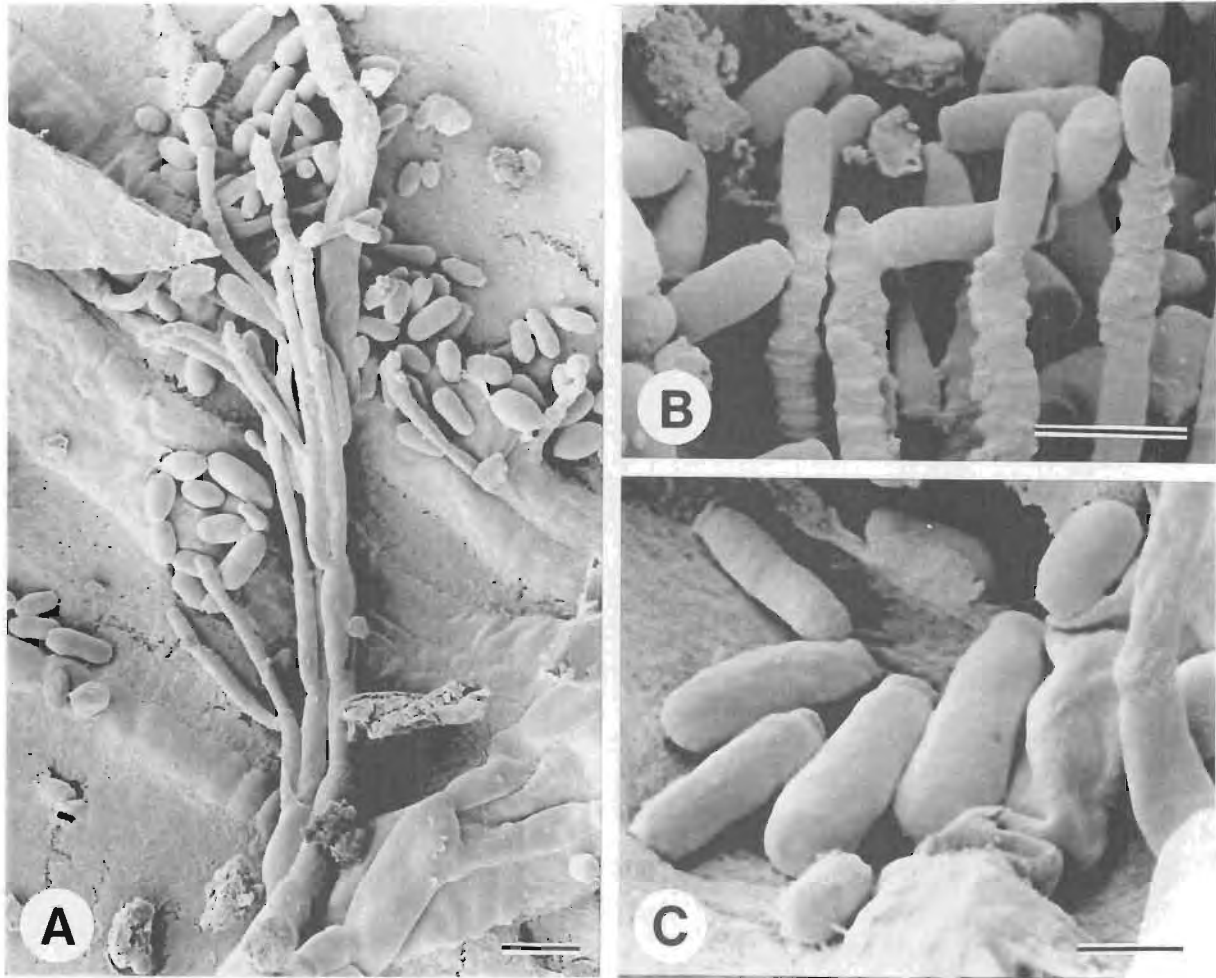
The conidiophores of *O. aureum* are characterized by a complex, brush-like conidiogenous apparatus, which is often more than half of the total conidiophore length. Two different conidial forms have been reported for this species. Robinson-Jeffrey and Davidson (1968) distinguish *O. aureum* and *O. robustum* from other species of *Europhium* based on their anamorph states, in particular, their conidia. In the case of *L. aureum*, the conidia have been described as slightly falcate, whereas, those of *L. robustum* are globose. *Ophiostoma aureum* has also been reported to have bright yellow conidial masses in culture which distinguishes it from other *Leptographium* spp.



**Fig. 39.** Teleomorph and anamorph of *O. aureum* (CMW 714). **A.** Perithecium (Bar = 100  $\mu\text{m}$ ). **B.** Ascospores (Bar = 10  $\mu\text{m}$ ). **C.** Conidiophore (Bar = 50  $\mu\text{m}$ ). **D.** Conidiogenous apparatus (Bar = 10  $\mu\text{m}$ ). **E.** Conidia (Bar = 10  $\mu\text{m}$ ).



**Fig 40.** Light micrographs of the teleomorph and anamorph structures of *O. aureum* (CMW 714). **A.** Conidiophore (Bar = 100  $\mu$ m). **B.** Conidiophore (Bar = 100  $\mu$ m). **C.** Conidiogenous cells (Bar = 10  $\mu$ m). **D.** Conidia (Bar = 10  $\mu$ m).



**Fig. 41.** Scanning electron micrographs of the conidiophores and conidia of *O. aureum* (CMW 714). **A.** Conidiophore (Bar = 10  $\mu$ m). **B.** Conidiogenous cells (Bar = 10  $\mu$ m). **C.** Conidia (Bar = 5  $\mu$ m).

**9. *Leptographium brachiatum*** (W.B. Kendr.) M.J. Wingf., *Transactions of the British Mycological Society* **85**, 1985. (Figs. 42-44).

≡ *Verticicladiella brachiata* W.B. Kendr., *Canadian Journal of Botany* **40**, 786, 1962.

**Teleomorph:** Not known.

**Etymology:** bra-chi-á-tum: having an arm. From the Latin noun brac(c)hium: an arm. This specific epithet refers to the characteristic side branches on the stipes of the fungus.

*Conidiophores* occurring singly, arising directly from the mycelium, erect, macronematous, mononematous, (73-) 112 -121 (-186)  $\mu\text{m}$  in length, rhizoid-like structures present. *Stipes* light olivaceous (21''k), smooth, cylindrical, simple, 2 - 5 septate, (37-) 78 - 89 (-150)  $\mu\text{m}$  long, 2.0 - 4.0  $\mu\text{m}$  wide below primary branches, apical cells not swollen, 4.0-) 4.5 - 6.0 (-7.0)  $\mu\text{m}$  wide at base, basal cell not swollen. *Conidiogenous apparatus* (19-) 21.5 - 45.5 (-51)  $\mu\text{m}$  long, excluding the conidial mass, with 2 to 3 series of cylindrical branches, 2 primary branches, hyaline, smooth, cylindrical, aseptate, (7.0-) 10 - 19 (-22)  $\mu\text{m}$  long and 2.0 - 3.0  $\mu\text{m}$  wide, arrangement of the primary branches on the stipe - type A, secondary branches hyaline, aseptate, (6.0-) 10 - 11 (-14.0)  $\mu\text{m}$  long, 1.0 - 2.5  $\mu\text{m}$  wide, tertiary branches hyaline, aseptate, 10 - 13.5  $\mu\text{m}$  long, 2.0 - 2.5  $\mu\text{m}$  wide. *Conidiogenous cells* discrete, 2-3 per branch, cylindrical, tapering slightly at the apex, 7.0 - 16  $\mu\text{m}$  long and 1.0 - 2.0  $\mu\text{m}$  wide. *Conidia* light gray olivaceous (19'''''), aseptate, oblong to obovoid, 3.0 - 5.5  $\mu\text{m}$  x 1.0 - 1.5  $\mu\text{m}$ . Conidia accumulating in slimy droplets at the apex of conidiogenous apparatus, hyaline at first, becoming greenish olivaceous (23''') with age. Conidial mass hyaline to greenish olivaceous when wet, turning cream colored when dry.

*Colonies* with optimal growth at 25°C on 2% MEA, slow growing reaching 4 mm in diam. in 9 days. No growth below 15°C or above 30°C. Able to withstand high concentrations of cycloheximide with a 16% reduction in growth on 0.5 g/l cycloheximide after 8 days at 25°C in the dark. Colonies greenish olivaceous (23'''), loose its color in culture after continuous transfer, colonies becoming white. *Colony*

*margin* smooth. *Hyphae* submerged in agar with no aerial mycelium, hyaline, smooth, straight, not constricted at the septa, 1.0 - 4.0 µm diam.

**Specimens examined: Holotype:** British Columbia, Copper Canyon, Vancouver Island, *Pseudotsuga menziesii*, 10 November 1949, collected: J. Short, DAOM 33961(b). **Paratypes:** 1953, collected: Rennerfelt, DAOM 34871; British Columbia, Copper Canyon, Vancouver Island, *Pseudotsuga menziesii*, 10 November 1949, collected: J. Short, DAOM 33974; Fredericton, N.B., *Picea mariana*, 24 October 1951, collected: Redmond, DAOM 34360. **Cultures:** U.S.A., Virginia, *Pinus* stump, 1987, collected: W. B. Kendrick and G.C. Bhatt, CMW 440 (same as CBS 660-70); U.S.A., New York, *Picea rubens*, 1989, collected S. Alexander, CMW 2855 (same as C388).

**Known distribution:** Canada.

**Hosts/substrate:** *Pseudotsuga menziesii*, *Picea mariana* (Kendrick, 1962).

**Associated insects:** Not known.

**Notes:** Lateral outgrowths of the stipe reported by Kendrick (1962) were observed in some of the cultures and in all the type specimens except DAOM 34871. As in the case of *L. antibioticum*, this fungus displays an unusually low level of tolerance to the antibiotic cycloheximide, suggesting that it might not be an anamorph of *Ophiostoma* (Harrington, 1988). *Leptographium brachiatum* does not appear to be pathogenic and is most probably a saprophyte (Harrington, 1988).

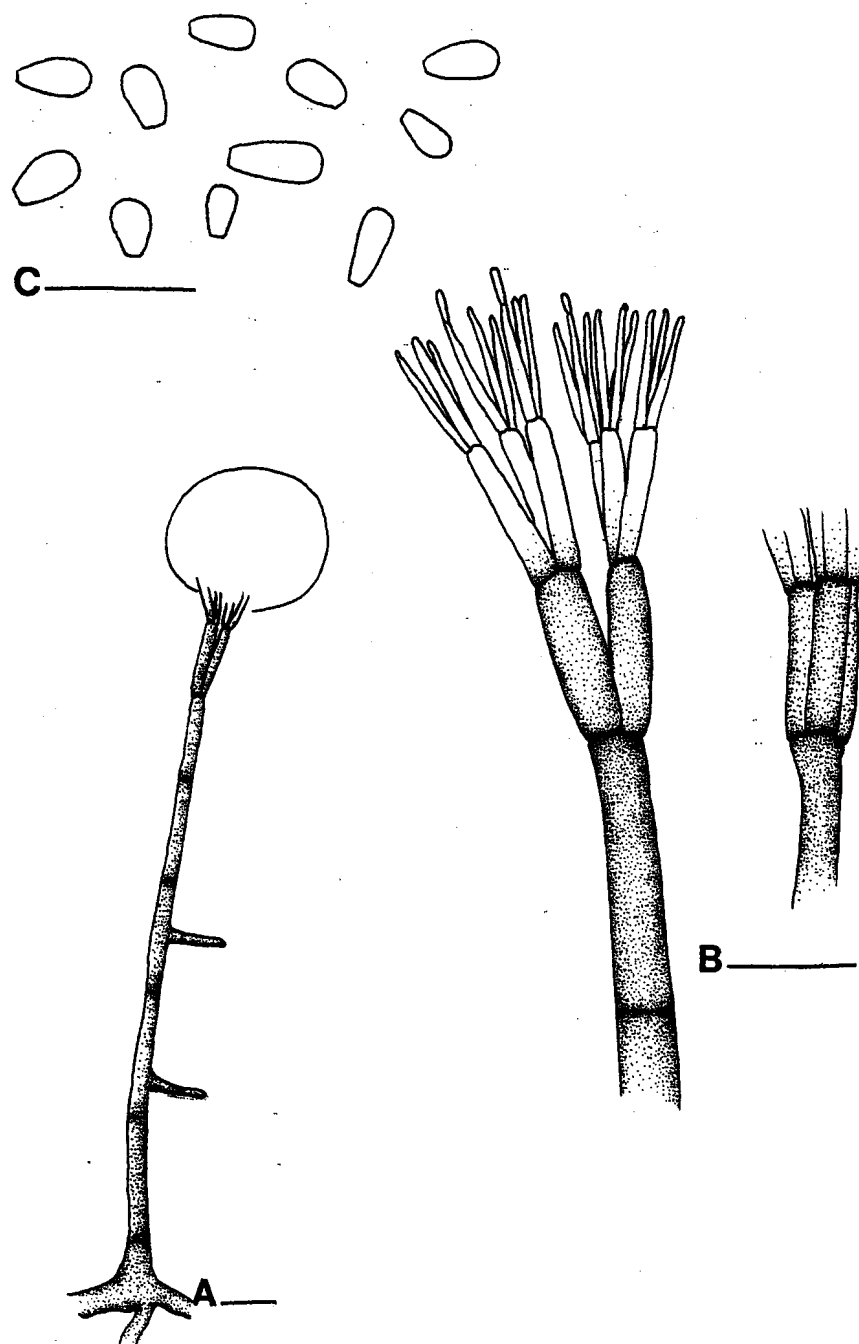
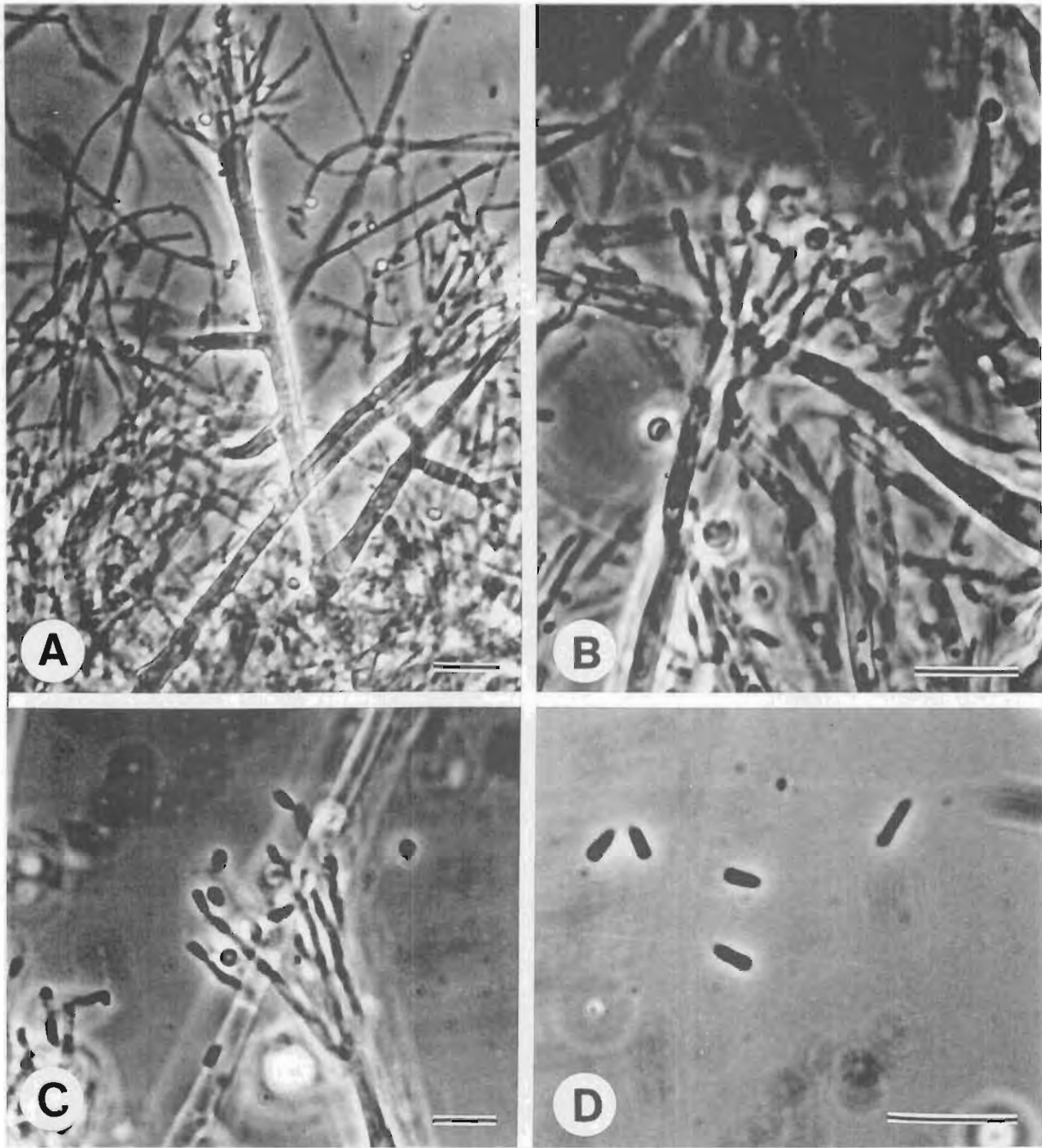


Fig. 42. Conidiophores and conidia of *L. brachiatum* (CMW 440). A. Habit sketch (Bar = 10  $\mu$ m). B. Conidiogenous apparatus (Bar = 10  $\mu$ m) C. Conidia (Bar = 10  $\mu$ m).





**Fig 43.** Light micrographs of the conidiophores and conidia of *L. brachiatum* (CMW 440). **A.** Conidiophore (Bar = 10  $\mu\text{m}$ ). **B.** Conidiogenous apparatus (Bar = 10  $\mu\text{m}$ ). **C.** Conidiogenous cells (Bar = 10  $\mu\text{m}$ ). **D.** Conidia (Bar = 10  $\mu\text{m}$ ).

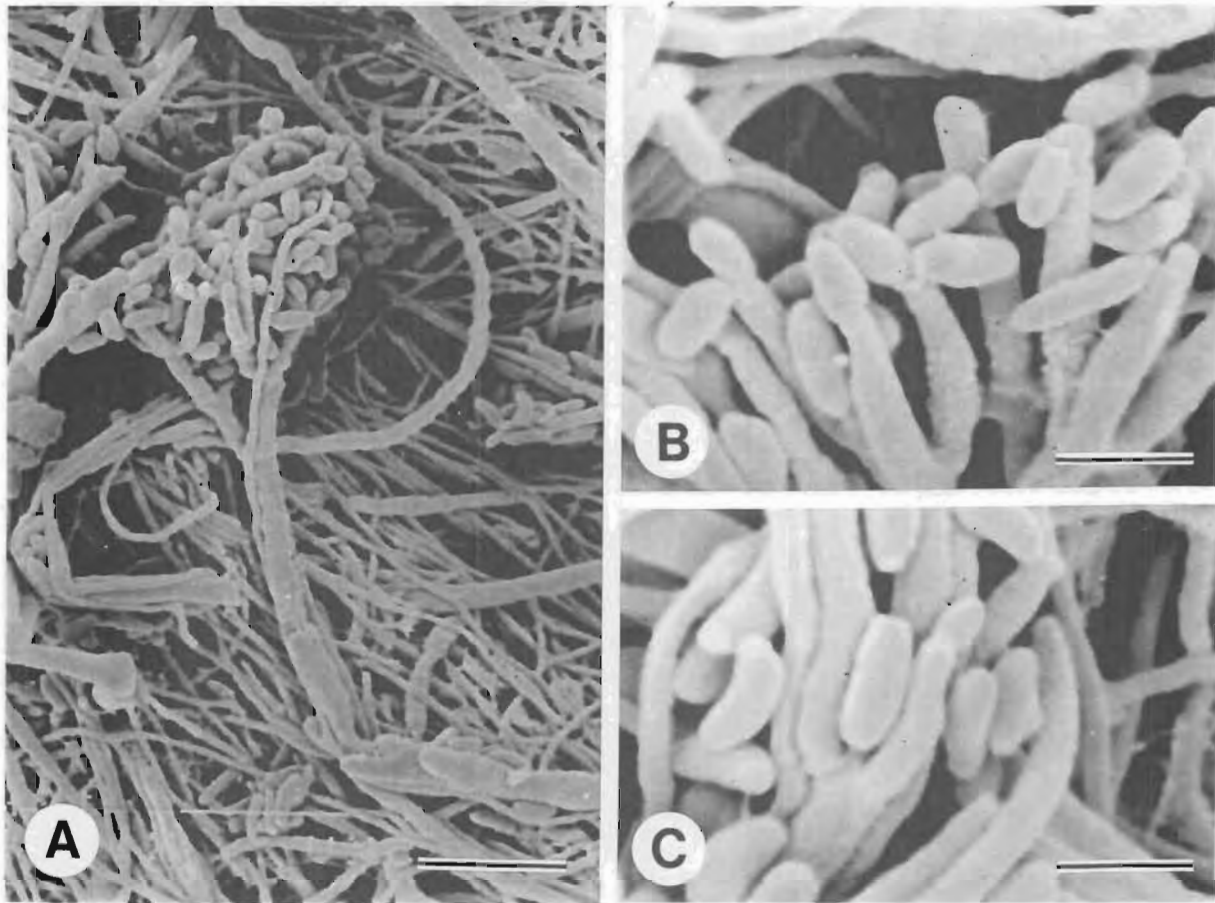


Fig. 44. Scanning electron micrographs of the conidiophores and conidia of *L. brachiatum* (CMW 440). A. Conidiophore (Bar = 10  $\mu\text{m}$ ). B. Conidiogenous cells (Bar = 5  $\mu\text{m}$ ). C. Conidia (Bar = 5  $\mu\text{m}$ ).

**10. *Ophiostoma brevicolle* (R.W. Davidson) De Hoog & R.J. Scheff., *Mycologia* 76, 297. 1984. (Figs. 45-47).**

≡ *Ceratocystis brevicollis* R.W. Davidson, *Mycologia* 50, 667. 1958.

**Anamorph:** *Leptographium brevicolle* Jacobs & Wingfield sp. nov.

**Etymology:** bre-vi-cól-lum: of the short neck. From the Latin adjective *brevis*: short and *collum*: a neck. This specific epithet refers to the short necks of the perithecia of the *Ophiostoma* state.

*Perithecial bases* olivaceous becoming black, globose and smooth walled, unornamented, 150 - 180 µm in diam. *Perithecial neck* dark brown to black, cylindrical with a slight apical taper, smooth, 200 - 300 µm long, 25 - 45 µm above globose base, 18 - 32 µm wide at the apex, *ostiole hyphae* absent. *Asci* prototunicate, hyaline, evanescent. *Ascospores* allantoid, aseptate, hyaline, invested in a uniform sheath, 4.0 - 5.5 x 1.3 - 2.0 µm (Davidson, 1958, Upadhyay, 1981).

*Conidiophores* occurring singly, arising directly from the mycelium, erect, macronematous, mononematous, (112.5-) 148.5 - 173.5 (-265) µm in length, rhizoid-like structures absent. *Stipes* olivaceous buff (21''b), becoming hyaline towards the apex, constricted at septa, cylindrical, simple, 4 - 13 septate, (77.5-) 112 - 150 (-232.5) µm long, 5.0 - 7.5 µm wide below primary branches, apical cell not swollen, (7.5-) 8.5 - 12.5 µm wide at base, basal cell not swollen. *Conidiogenous apparatus* (22.5-) 23 - 44 (-50) µm long, excluding the conidial mass, with 1 to 2 series of cylindrical branches, 2 primary branches, hyaline, smooth, cylindrical, aseptate (8.5-) 10.5 - 13.5 (-18.5) µm long and (2.5-) 4.0 - 4.5 (-7.5) µm wide, arrangement of the primary branches on the stipe - type A, secondary branches hyaline, aseptate, (5.5-) 9.5 - 11 (-14) µm long, (2.0-) 2.5 - 3.5 (-5.0) µm wide. *Conidiogenous cells* discrete, 2-3 per branch, cylindrical, tapering slightly at the apex, 9.0 - 15.5 µm long and 1.0 - 2.0 µm wide. *Conidia* olivaceous gray (21''c), aseptate, oblong with truncate ends and rounded apices, (3.0-) 4.0 - 4.5 (-6.0) x 1.0 - 2.5 µm. Conidia accumulating in slimy droplets at the apex of conidiogenous apparatus, hyaline at first, becoming white with age. Conidial mass white when wet, remaining white when dry.

*Colonies* with optimal growth at 30°C on 2% MEA, reaching 14 mm in diam. in 9 days. No growth below 10°C or above 35°C, little growth at 35°C. Able to withstand high concentrations of cycloheximide with a 10% reduction in growth on 0.5 g/l cycloheximide after 12 days at 20°C in the dark. Colonies olivaceous (21"m) with white aerial mycelium. *Colony margin* smooth. *Hyphae* submerged on agar with little aerial mycelium, hyaline, smooth, straight, not constricted at the septa, 1.0 - 3.0 µm diam.

**Specimens examined:** **Holotype:** U.S.A. Colorado Fort Collins, *Populus tremuloides*, Sept. 1954, collected: T.O. Thatcher, BPI 70810 (received from NFC). **Cultures:** collected: R.W. Davidson, CMW 447 (same as CBS 795-73 and ATCC 129771); U.S.A., Colorado, *Populus tremuloides*, 1970, collected: R.W. Davidson, CMW 474 (CBS 150.78).

**Known distribution:** U.S.A. (Colorado).

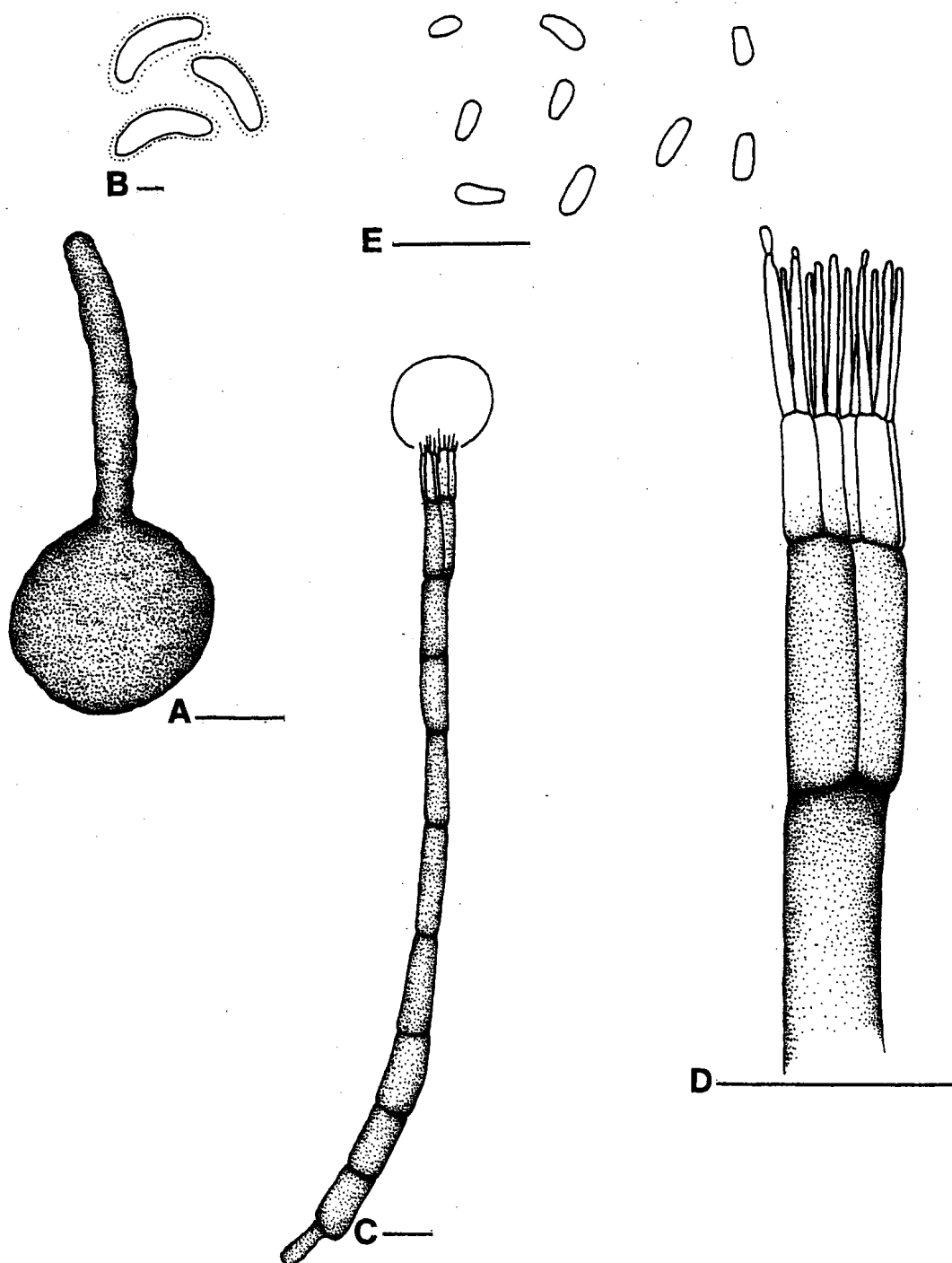
**Hosts/substrate:** *Populus tremuloides* (Davidson, 1958).

**Associated insects:** *Trypodendron retusus* (Davidson, 1958).

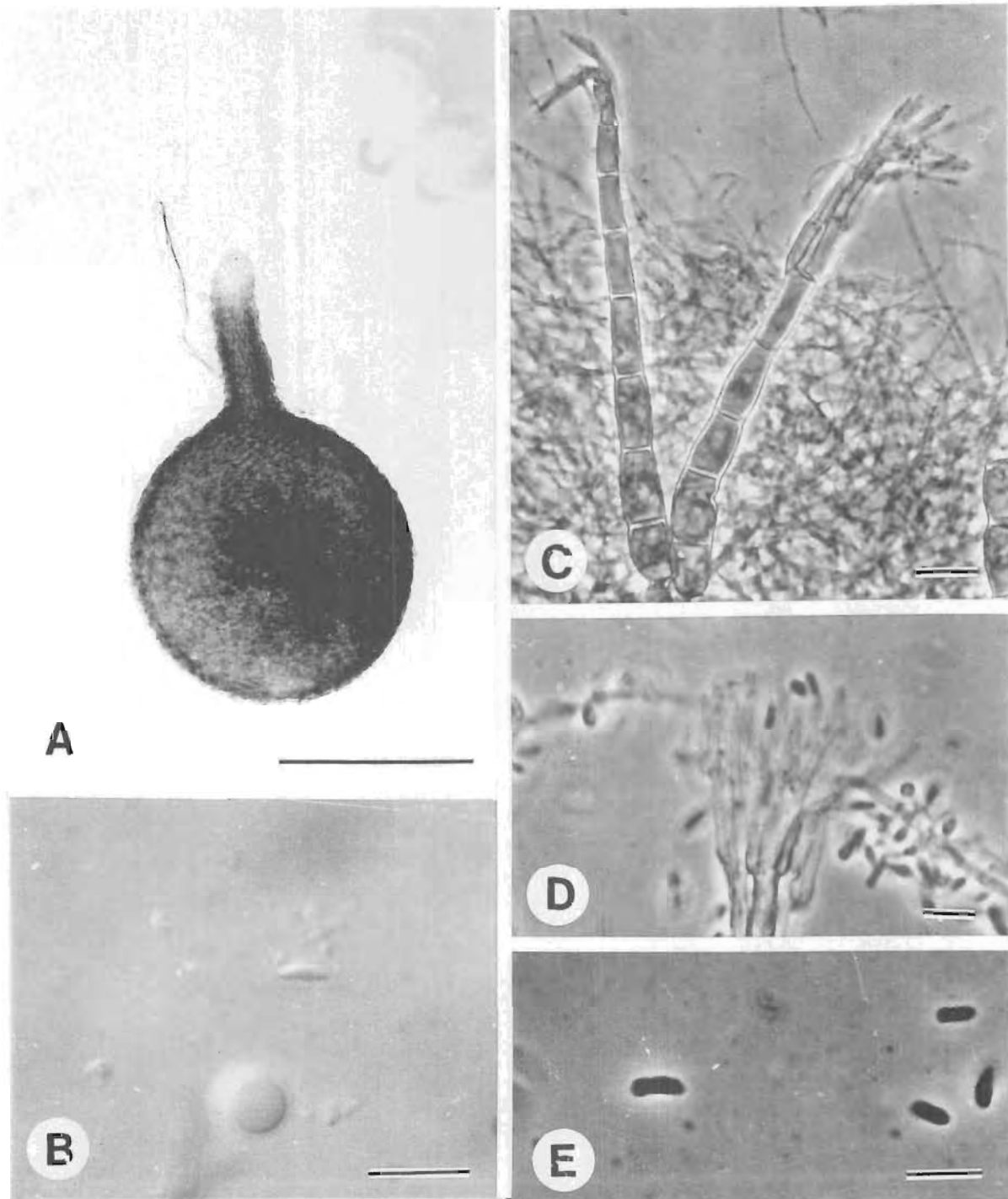
**Notes:** Davidson (1958) described only the teleomorph of this fungus and mentioned the presence of a *Leptographium* anamorph. A description of the anamorph was later provided by Upadhyay (1981). Based on ascospore morphology, this species was placed in the "fimbriata" - group by Olchowecki and Reid (1974). *Ophiostoma brevicolle* is similar to *O. francke-grosmanniae*. These species can, however, be distinguished based on the apparent phialidic appearance of the conidiogenous cells in *O. francke-grosmanniae*. In *O. brevicolle*, the conidiogenous cells are clearly annellidic. The conidia of *O. brevicolle* are also more oblong, compared to the short obovoid conidia of *O. francke-grosmanniae*.

*Ophiostoma brevicolle* was reported to be associated with *Trypodendron retusus*. However, no survey was conducted to determine whether the fungus is consistently associated with the bark beetle, or its distribution in the area (Davidson, 1958).

Hinds & Davidson (1972) also reported a loss of viability in the fungus (Hinds & Davidson, 1972).



**Fig. 45.** Teleomorph and anamorph structures of *O. brevicolle* (CMW 447). **A.** Perithecium (Bar = 100  $\mu\text{m}$ ). **B.** Ascospores (Bar = 1  $\mu\text{m}$ ). **C.** Conidiophore (Bar = 10  $\mu\text{m}$ ). **D.** Conidiogenous apparatus (Bar = 10  $\mu\text{m}$ ). **E.** Conidia (Bar = 10  $\mu\text{m}$ ).



**Fig 46.** Light micrographs of the teleomorph and anamorph structures of *O. brevicolla* (CMW 447). **A.** Perithecium (Bar = 100  $\mu\text{m}$ ). **B.** Ascospore (Bar = 10  $\mu\text{m}$ ). **C.** Conidiophore (Bar = 10  $\mu\text{m}$ ). **D.** Conidiogenous cells (Bar = 10  $\mu\text{m}$ ). **E.** Conidia (Bar = 10  $\mu\text{m}$ ).

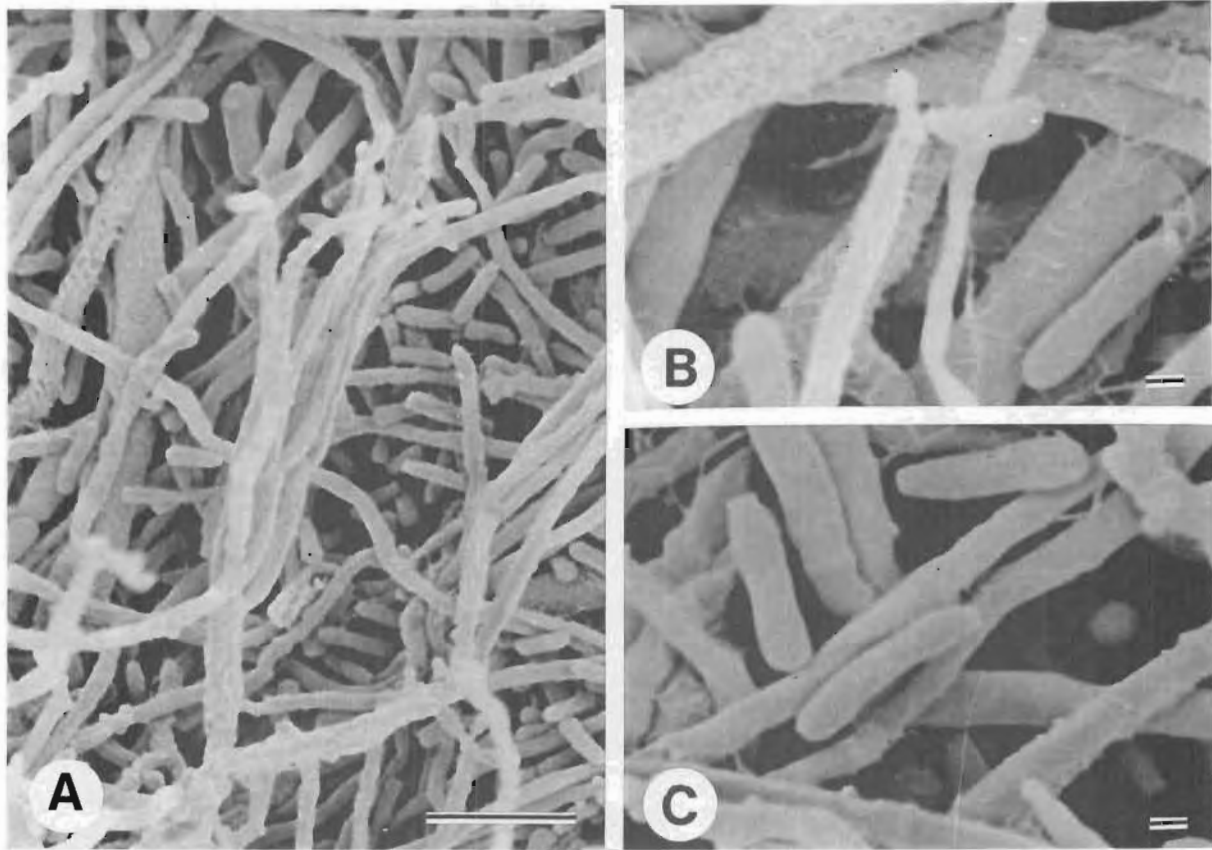


Fig. 47. Scanning electron micrographs of the conidiophores and conidia of *O. brevicolla* (CMW 447). A. Conidiophore (Bar = 10  $\mu\text{m}$ ). B. Conidiogenous cells (Bar = 1  $\mu\text{m}$ ). C. Conidia (Bar = 1  $\mu\text{m}$ ).



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**11. *Leptographium calophylli*** (Wiehe) J. Webber, K. Jacobs & M.J. Wingf.  
*Mycological Research*, **103**, 1580. 1999. (Figs. 48-50).

= *Haplographium calophylli* Wiehe *Mycological Papers* **29**, 5. 1949.

= *Verticillium calophylli* (Wiehe) W. Gams. 1971.

**Teleomorph:** Not known.

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**Etymology:** ca-lo-phylli: of dry leaves. From the Greek adjective καλον: dry and latinised Greek noun φυλλον: made of leaves. This specific epithet refers to *Calophyllum inophyllum* var. *tacamaha* which is the only known host of this fungus.

*Conidiophores* occurring singly, arising directly from the mycelium, erect, macronematous, mononematous, (41-) 46 - 89 (-100)  $\mu\text{m}$  in length, rhizoid-like structures absent. *Stipes* hyaline, smooth, cylindrical, simple, 0-1 septate, (5.0-) 12.5 - 18 (-30)  $\mu\text{m}$  long, 2.0 - 4.0  $\mu\text{m}$  wide below primary branches, apical cell not swollen, 2.0 - 4.0  $\mu\text{m}$  wide at base, basal cell swollen. *Conidiogenous apparatus* (30-) 43 - 58.5 (-80)  $\mu\text{m}$  long, excluding the conidial mass, with 2 - 3 series of cylindrical branches, arrangement of the primary branches on the stipe - type B, 2-3 primary branches, hyaline, smooth, cylindrical, 0-1 septate, (7.0-) 11 - 12.5 (-18)  $\mu\text{m}$  long and 1.5 - 4.0  $\mu\text{m}$  wide, secondary branches hyaline, aseptate, (7.0-) 9.5 - 11 (-15)  $\mu\text{m}$  long, 1.5 - 5.0  $\mu\text{m}$  wide, tertiary branches hyaline, aseptate, (6.0-) 8.0 - 11 (-16)  $\mu\text{m}$  long, 1.0 - 2.0  $\mu\text{m}$  wide. *Conidiogenous cells* discrete, 2-4 per branch, tapering slightly from the base to the apex, (8.0-) 13 - 20.5 (-25)  $\mu\text{m}$  long and 1.0 - 2.0  $\mu\text{m}$  wide. *Conidia* hyaline, aseptate, oblong to obovoid with truncate ends, (3.0-) 4.0 - 5.5 (-7.0)  $\times$  1.2 - 2.5  $\mu\text{m}$ . Conidia accumulating in slimy droplets at the apex of conidiogenous apparatus.

*Colonies* with optimal growth at 30°C on 2% MEA, reaching 20 mm in diam. in 8 days. Little growth at 15°C and no growth above 40°C. Able to withstand high concentrations of cycloheximide with a 80% reduction in growth on 5 g/l cycloheximide after 8 days at 30°C in the dark. Colonies olivaceous (21"m) (Rayner, 1970). *Colony margin* smooth. *Hyphae* submerged on agar with little aerial

mycelium, hyaline to light olivaceous (19" k), smooth, straight, not constricted at the septa, 1.0 - 3.0  $\mu\text{m}$  diam.

**Specimens examined: Holotype:** Mauritius, Plaine Sophie, isolated from tracheids and medullary rays of *Calophyllum inophyllum* var. *tacamaha* wood, March 1945, collected: P.O. Wiehe, IMI 28925. **Cultures:** Seychelles, Mahe, *Calophyllum* sp., 24 April 1997, collected: J. Webber, CMW 4257 (B2), CMW 4256 (B1), CMW 4260 (B5), CMW 4262 (B7), CMW 4263 (B9).

**Known distribution:** Seychelles, Mauritius.

**Hosts/substrate:** *Calophyllum* sp. (Webber *et al.*, 1999).

**Associated insects:** *Cryphalus trypanus* (Webber *et al.*, 1999).

**Notes:** *Leptographium calophylli* can easily be recognized by its short conidiophore stipes and large conidiogenous apparatus. Conidiophores of *L. calophylli* occur mainly on aerial mycelia, in contrast to other species where these structures occur directly on the substrate. Furthermore, this fungus is characterized by an optimal growth temperature of 30 °C, which is unusual for species in *Leptographium* (Webber *et al.*, 1999), but is consistent with its occurrence on tropical islands.

This species is unusual among *Leptographium* spp. in that it does not occur on conifers. *Leptographium calophylli* is thought to be the casual agent of a wilting disease of *Calophyllum* trees in the Seychelles (Ivory & Andre, 1995). The spread of the disease is probably the result of an insect vector (*C. trypanus*), although this has not been proven. It might also have an alternative host, which can explain the absence of the disease subsequent to its first report in 1949 by Wiehe (Ivory & Andre, 1995).

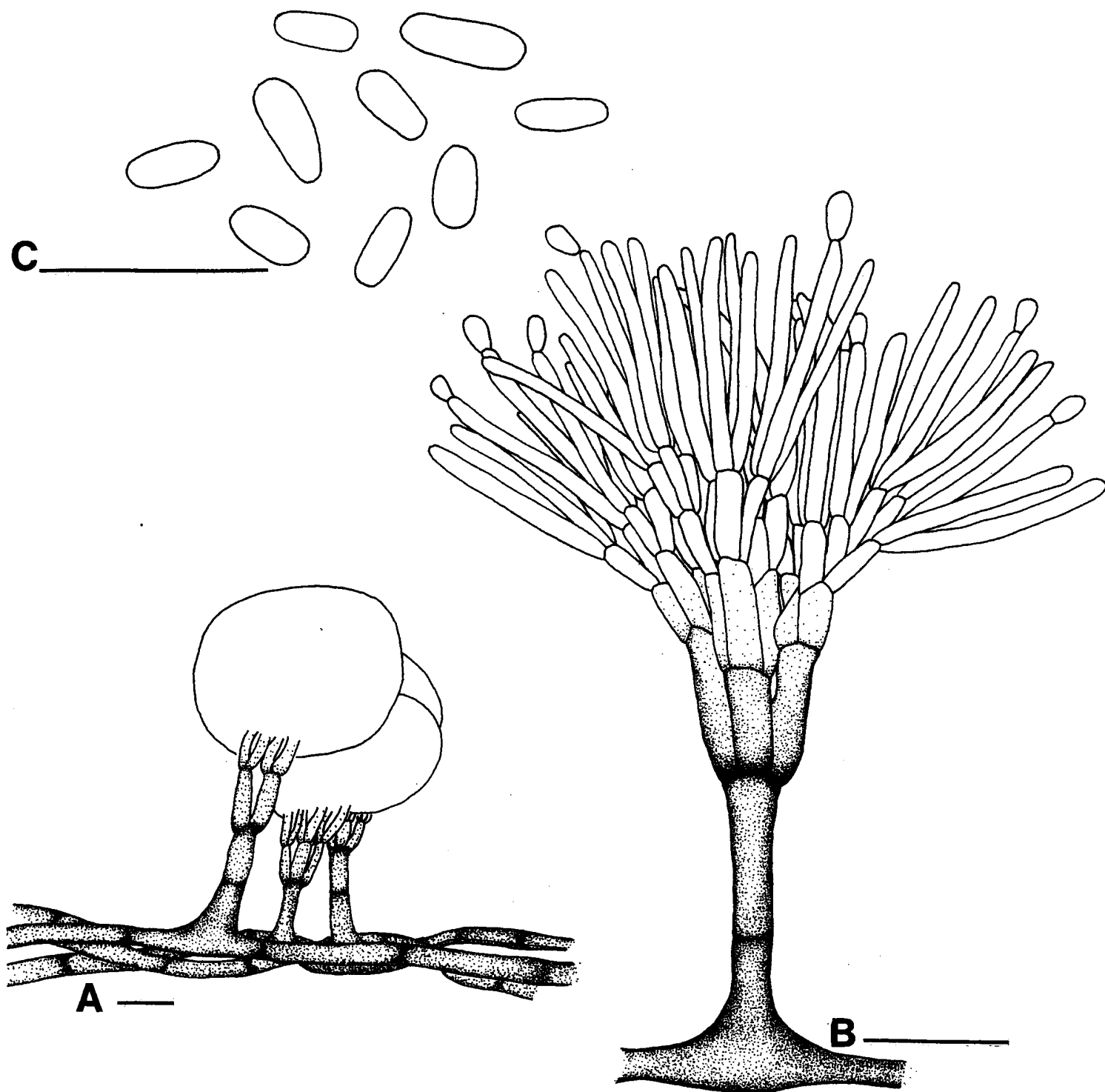
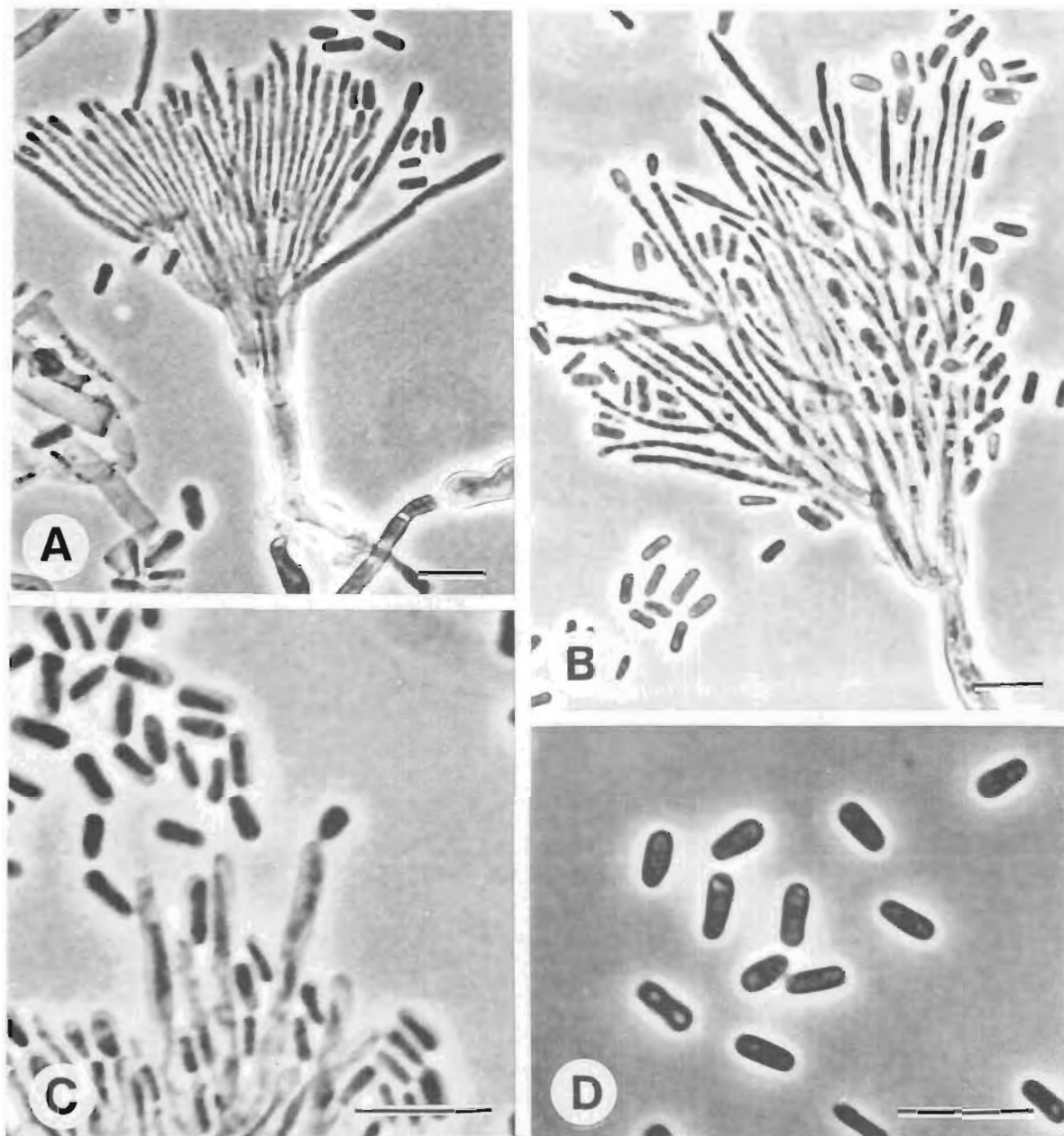
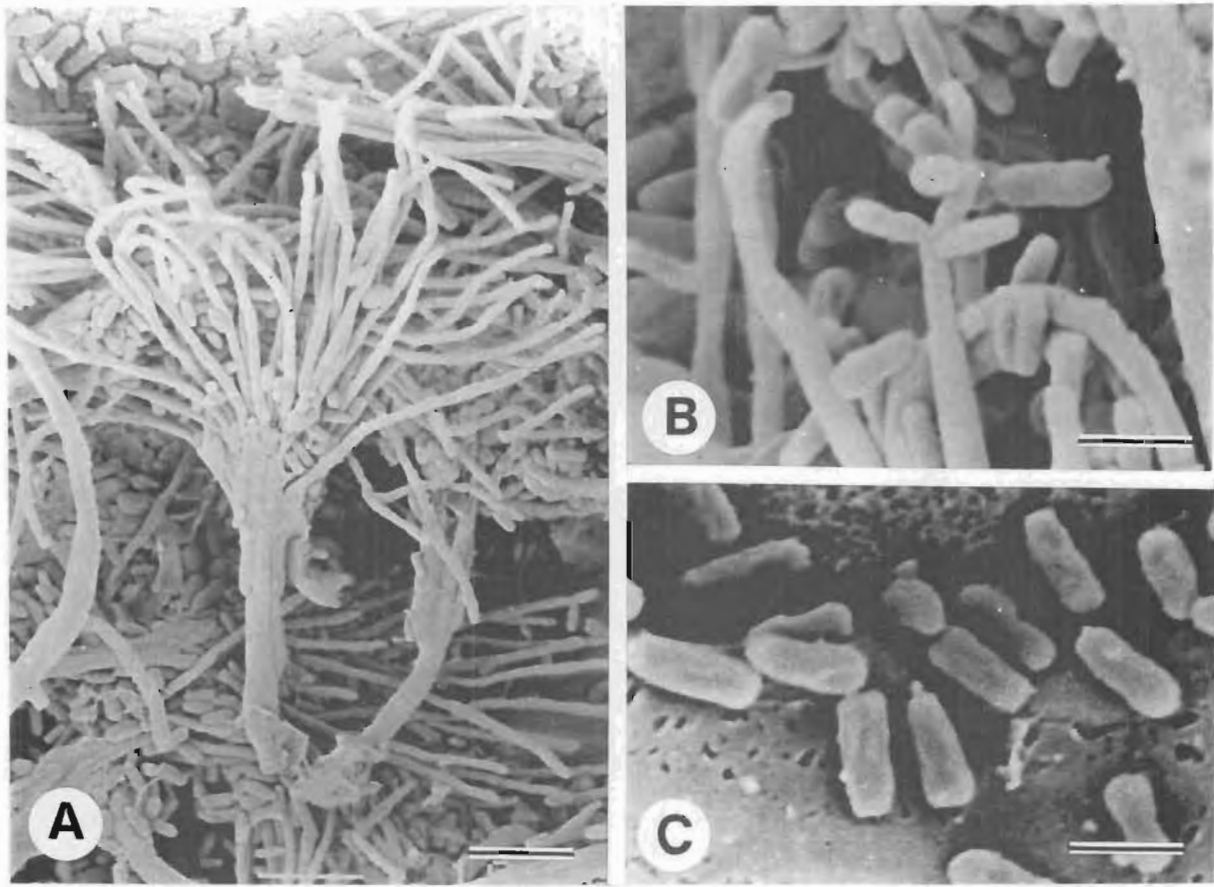


Fig. 48. Conidiophores and conidia of *L. calophylli* (CMW 4257). A. Habit sketch (Bar = 10  $\mu$ m). B. Conidiogenous apparatus (Bar = 10  $\mu$ m) C. Conidia (Bar = 10  $\mu$ m).



**Fig. 49.** Light micrographs of the conidiophores and conidia of *L. calophylli* (CMW 4257). **A.** Conidiophore (Bar = 10 µm). **B.** Conidiogenous apparatus (Bar = 10 µm). **C.** Conidiogenous cells (Bar = 10 µm). **D.** Conidia (Bar = 10 µm).



**Fig. 50.** Scanning electron micrographs of the conidiophores and conidia of *Leptographium calophylli* (CMW 4257). **A.** Conidiophore (Bar = 10 µm). **B.** Conidiogenous cells (Bar = 5 µm). **C.** Conidia (Bar = 5 µm).

**12. *Leptographium costaricense* G. Weber, Spaaij & M.J. Wingf. *Mycological Research* 100, 733. 1996. (Fig. 51-53).**

**Teleomorph:** Not known.

**Etymology:** cos-ta-ri-cense: growing in Costa Rica. This specific epithet refers to the origin of this fungus in Costa Rica.

*Conidiophores* occur mostly singly, arising directly from the mycelium, erect, macronematous, mononematous, (150-) 221 - 256 (-625)  $\mu\text{m}$  in length, rhizoid-like structures absent. *Stipes* light olivaceous (21''k), not constricted at septa, cylindrical, simple, 3-11 septate, (112-) 193.5 - 215 (-585)  $\mu\text{m}$  long, 2.0 - 4.0  $\mu\text{m}$  wide below primary branches, apical cell not swollen, 2.0 - 4.5  $\mu\text{m}$  wide at base, basal cell sometimes swollen. *Conidiogenous apparatus* (25-) 30 - 37 (-50)  $\mu\text{m}$  long, excluding the conidial mass, with 1 - 3 series of cylindrical branches, 2-4 primary branches, light olivaceous (21''k), smooth, cylindrical, aseptate 10 - 18 (-20)  $\mu\text{m}$  long and 2.0 - 4.0  $\mu\text{m}$  wide, arrangement of the primary branches on the stipe - type B, secondary branches hyaline to light olivaceous (21''m), aseptate, (5.0-) 8.0 - 9.0 (-12)  $\mu\text{m}$  long, 2.0 - 3.0  $\mu\text{m}$  wide, occasionally hyaline tertiary branches 6.0  $\mu\text{m}$  long and 2.0-3.0  $\mu\text{m}$  wide. *Conidiogenous cells* discrete, 2-3 per branch, cylindrical, tapering slightly at the apex, 8.0 - 15 (-16)  $\mu\text{m}$  long and 1.0 - 2.0  $\mu\text{m}$  wide. *Conidia* hyaline, aseptate, obovoid with truncate ends, 3.0 - 5.0 x 1.0 - 2.5  $\mu\text{m}$ . Conidia accumulating in slimy droplets at the apex of conidiogenous apparatus, hyaline at first, becoming amber (21'b) with age. Conidial mass amber when wet, remaining amber when dry.

*Colonies* with optimal growth at 25°C on 2% MEA, reaching 9 mm in diam. in 8 days. No growth below 10°C with little growth at 35°C. Not able to withstand high concentrations of cycloheximide with a 100% reduction in growth on 0.5 g/l cycloheximide after 8 days at 20°C in the dark. Colonies olivaceous (21''m) edges cartridge buff (19''f) becoming pale cinnamon pink (13''f) with age. *Colony margin* smooth. *Hyphae* submerged on agar with no aerial mycelium, hyaline, smooth, straight, not constricted at the septa, 2.0 - 4.0  $\mu\text{m}$  diam.

**Specimens examined: Holotype:** CMW 3041, isolated from roots of *Talauma*

*sambuensis*, Biological station of 'La Selva', Sarapiquí, Costa Rica, collected G. Weber, March 1992. **Cultures:** CMW 3066, isolated from roots of *Talauma sambuensis*, Biological station of 'La Selva', Sarapiquí, Costa Rica, collected G. Weber, March 1992.

**Known distribution:** Costa Rica.

**Hosts/substrate:** Rhizosphere of *Talauma sambuensis* (Weber *et al.*, 1996).

**Associated insects:** Not known.

**Notes:** This species is unusual in that it was isolated from soil, which is an unusual substrate for species of *Leptographium*. *Leptographium reconditum* is the only other *Leptographium* sp. that has been isolated from soil (Jooste, 1978). Weber *et al.* (1996) found that *L. costaricense* has a low tolerance to cycloheximide, which implies a lack of relatedness to *Ophiostoma*. This was confirmed in the present study. As a result of this, they suggested that the species deserved further study. Weber *et al.*, (1996) further suggested that although *L. costaricense* and *L. reconditum* are morphologically similar to other *Leptographium* species, their generic affinities might fall outside those of *Leptographium*.

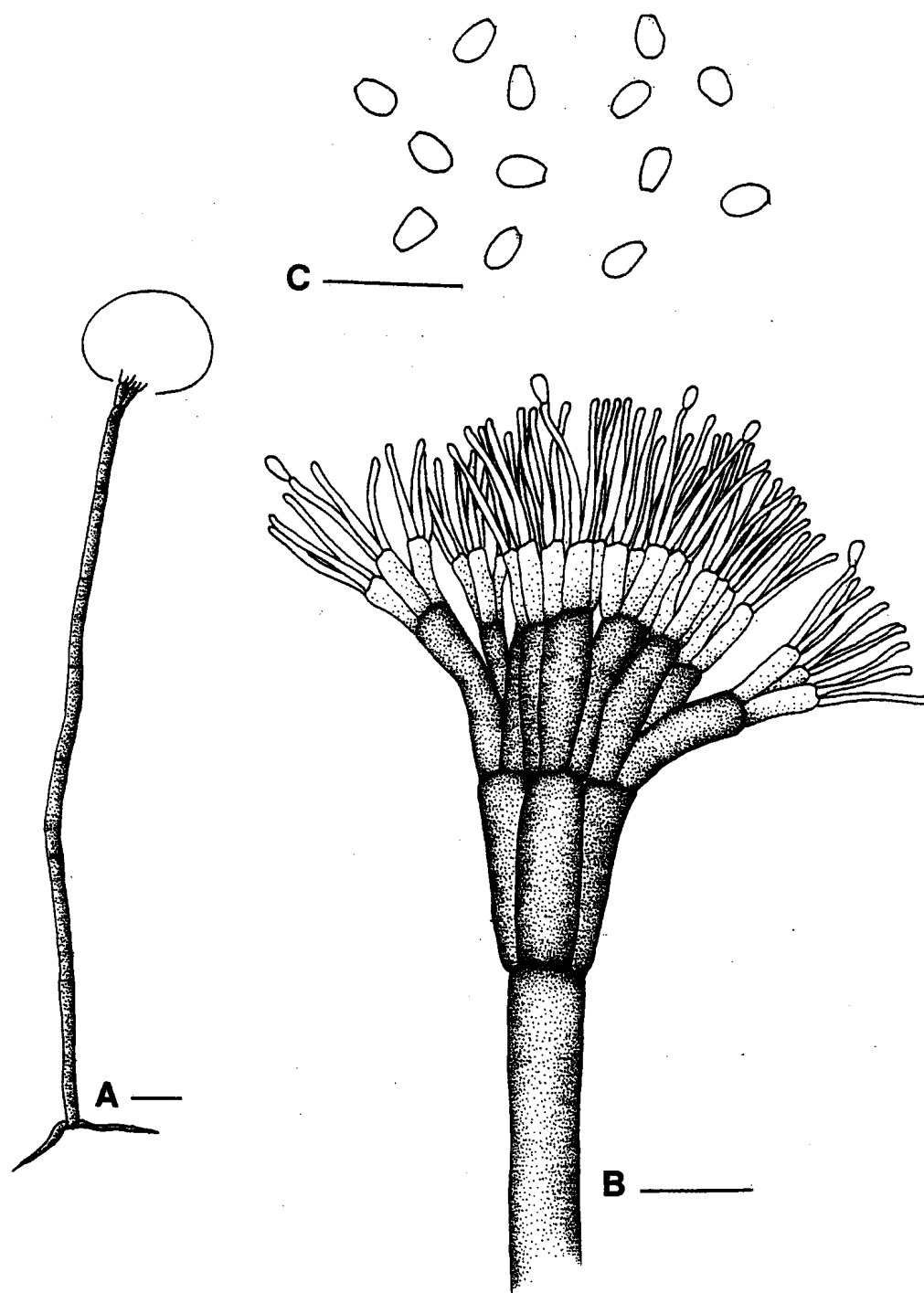
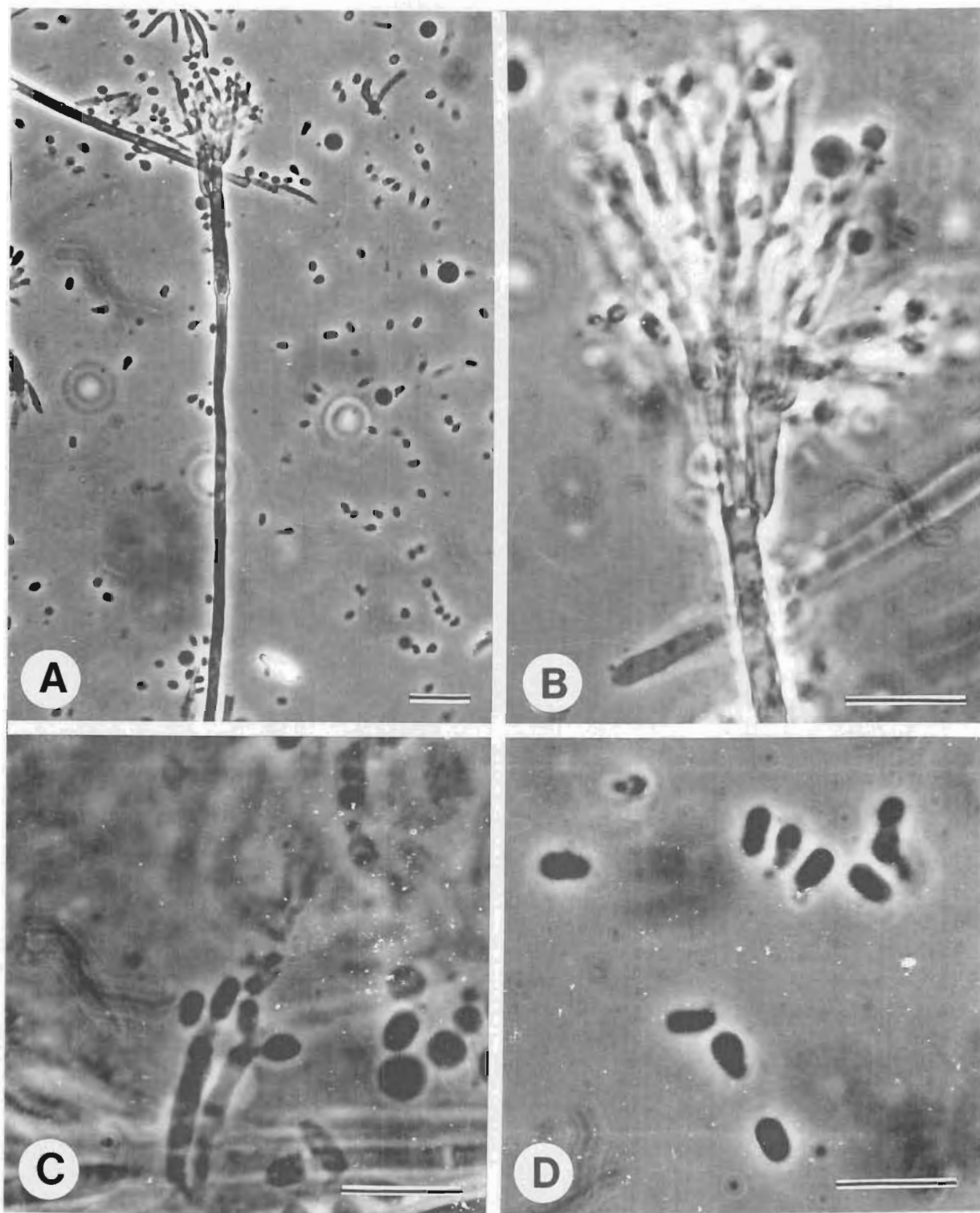
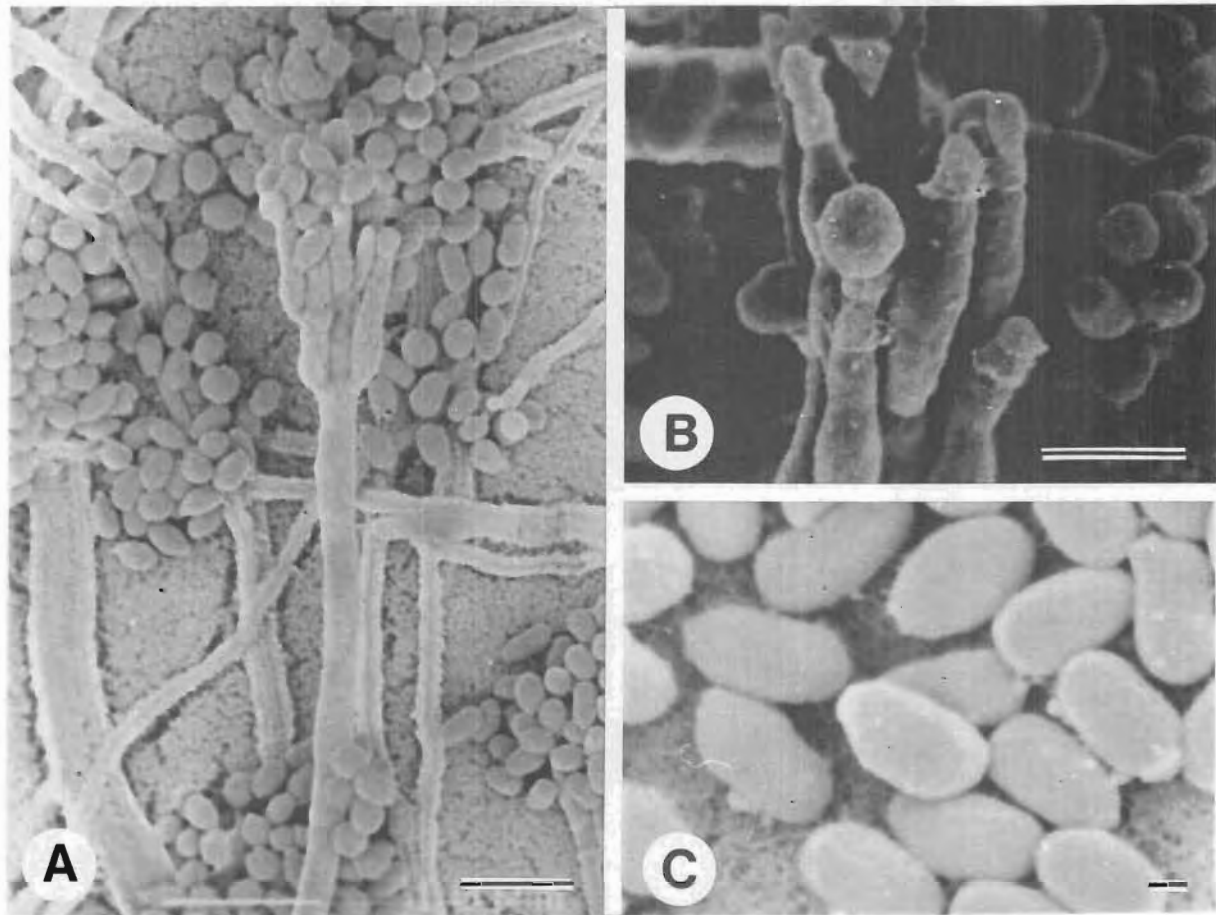


Fig. 51. Conidiophores and conidia of *L. costaricensis* (CMW 3041). A. Habit sketch (Bar = 50  $\mu\text{m}$ ). B. Conidiogenous apparatus (Bar = 10  $\mu\text{m}$ ). C. Conidia (Bar = 10  $\mu\text{m}$ ).





**Fig. 52.** Light micrographs of the conidiophores and conidia of *L. costaricensis* (CMW 3041). **A.** Conidiophore (Bar = 10  $\mu$ m). **B.** Conidiogenous apparatus (Bar = 10  $\mu$ m). **C.** Conidiogenous cells (Bar = 10  $\mu$ m). **D.** Conidia (Bar = 10  $\mu$ m).



**Fig. 53.** Scanning electron micrographs of the conidiophores and conidia of *L. costaricensis* (CMW 3041). **A.** Conidiophore (Bar = 10 µm). **B.** Conidiogenous cells (Bar = 5 µm). **C.** Conidia (Bar = 1 µm).

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**13. *Ophiostoma crassivaginatum*** (H.D. Griffin) T.C. Harr., *Mycotaxon* **27**, 41. 1987. (Figs. 54 - 56).

≡ *Ceratocystis crassivaginata* H.D. Griffin, *Canadian Journal of Botany* **46**, 701. 1968.

≡ *Ceratocystiopsis crassivaginata* (H.D. Griffin) H.P. Upadhyay, Monograph of *Ceratocystis* and *Ceratocystiopsis*, **123**. 1981.

**Anamorph:** *Leptographium crassivaginatum* (H.D. Griffin) M.J. Wingf. *Transactions of the British Mycological Society* **85**, 92. 1985.

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**Etymology:** cras-si-va-gi-ná-tum: possessing a thick sheath. From the Latin adjective crassus: thick and Latin noun vagina: a sheath. This specific epithet refers to the characteristic rough, granular sheath around the hyphae.

*Perithecial bases* black, globose and rough walled, unornamented, 40 - 90 µm in diam. *Perithecial neck* black at the base, turning dark brown towards the apex, 40 - 60 µm long, 15 - 30 µm above globose base, 12 - 15 µm wide at the apex, *ostiole hyphae* present. *Asci* prototunicate, hyaline, evanescent. *Ascospores* boat-shaped, aseptate, hyaline, invested in a sheath, 10.0 - 11.5 x 5.0 - 6.0 µm (Griffin, 1968).

*Conidiophores* occurring singly, arising directly from the mycelium, erect, macronematous, mononematous, 25 - 106 (-118) µm in length, rhizoid-like structures absent. *Stipes* light olivaceous (21"K), constricted at septa, cylindrical, simple, 0 - 5 septate, 8.0 - 60 (-85) µm long, (3.0-) 4.0 - 8.0 (-11) µm wide below primary branches, apical cell sometimes swollen, (3.0-) 4.0 - 8.0 (-11) µm wide at base, basal cell sometimes swollen. *Conidiogenous apparatus* 15.5 - 56.5 (-62) µm long, excluding the conidial mass, with 1 to 3 series of cylindrical branches, 2-3 primary branches, light olivaceous (21"K), smooth, cylindrical or barrel shape, 0-2 septate (8-) 12.5 - 14 (-23.5) µm long and 2.5 - 9.0 µm wide, arrangement of the primary branches on the stipe - type B, secondary branches light olivaceous, 0-1 septate, (7.5-) 11 - 15.5 (-22) µm long, (3.0-) 4.0 - 7.0 (-7.5) µm wide, occasionally hyaline

tertiary branches. *Conidiogenous cells* discrete, 2-3 per branch, cylindrical, tapering slightly at the apex, (7.0-) 8.5 - 10.5 (-12.5)  $\mu\text{m}$  long and 2.0 - 3.0  $\mu\text{m}$  wide. *Conidia* hyaline, aseptate, oblong to obovoid, (4.0-) 4.5 - 5.5 (-10)  $\times$  1.0 - 2.5  $\mu\text{m}$ . Conidia accumulating in slimy droplets at the apex of conidiogenous apparatus, hyaline at first, becoming amber (21'b) with age. Conidial mass amber when wet, remaining amber when dry.

*Colonies* with optimal growth at 30°C on 2% MEA, reaching 32 mm in diam. in 9 days. No growth below 5°C with little growth at 35°C. Able to withstand high concentrations of cycloheximide with a no reduction in growth on 0.5 g/l cycloheximide after 12 days at 20°C in the dark. Colonies olivaceous (21'm). *Colony margin* lacinate. *Hyphae* submerged on agar with little aerial mycelium, hyaline to light olivaceous (21'k), smooth, sometimes roughened with granular material, straight, occasionally constricted at the septa, (3.0-) 4.0 - 8.0 (-11)  $\mu\text{m}$  diam.

**Specimens examined: Holotype:** Canada, Ontario, Geraldton District near Stevens Highway 625, *Picea mariana*, June 1963, collected: H.D. Griffin, DAOM 110144. **Cultures:** collected: T. Hinds, 1986, CMW 90, CMW 134; Canada, *Populus* sp., 1986, collected: K.A. Seifert, CMW 884.

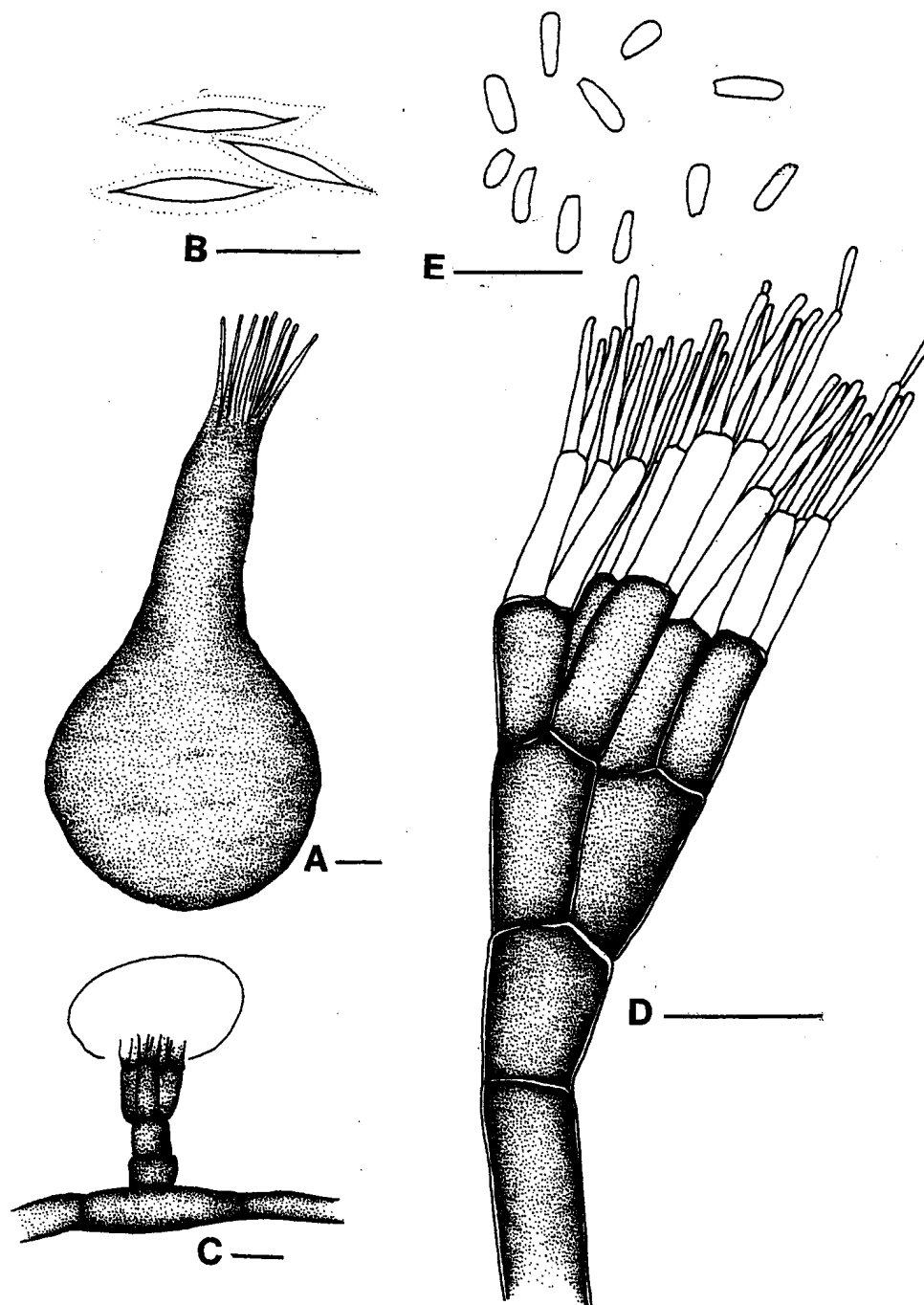
**Known distribution:** Canada.

**Hosts/substrate:** *Picea mariana* (Griffin, 1968; Olchowecki & Reid, 1974), *Picea glauca* (Olchowecki & Reid, 1974), *Pinus resinosa* (Olchowecki & Reid, 1974), *Pinus strobus* (Olchowecki & Reid, 1974), *Pinus sylvestris* (Olchowecki & Reid, 1974), *Populus grandidentata* (Griffin, 1968), *Populus tremuloides* (Griffin, 1968; Hinds, 1972), *Fraxinus nigra* (Olchowecki & Reid, 1974).

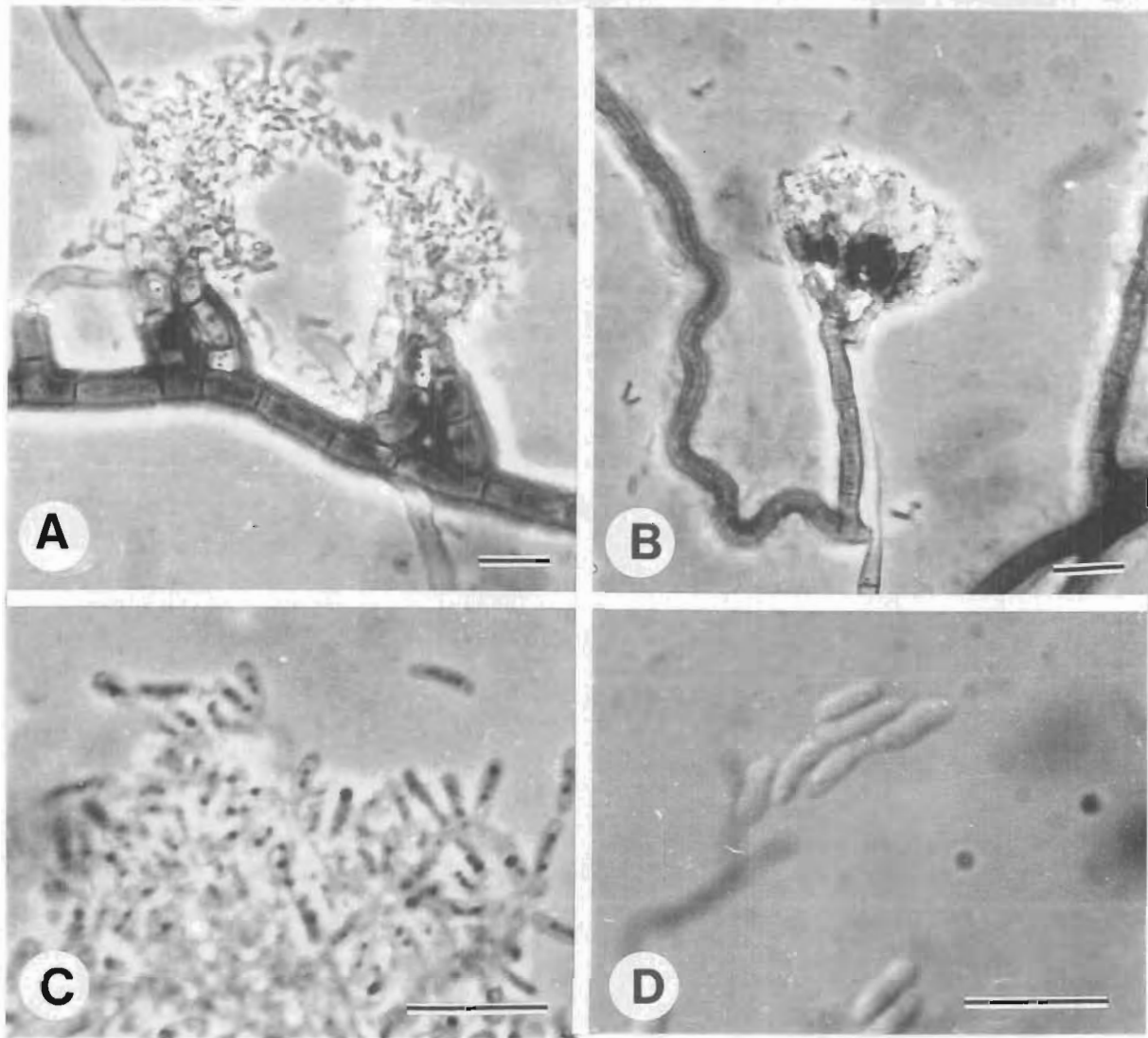
**Associated insects:** *Trypodendron retusus* (Harrington, 1988).

**Notes:** *Leptographium crassivaginatatum* can easily be distinguished from other *Leptographium* spp. based on the small, robust conidiophores and granulated sheath

material around the hyphae. *Leptographium pyrinum* and *L. yunnanensis* are also characterized by granular sheath material around the hyphae. However, the conidiophores and conidia of *L. pyrinum* are considerably larger than those of *L. crassivaginatium*. *Leptographium yunnanensis* can be distinguished from *L. crassivaginatium* based on the narrower conidia in the latter species. The hyaline pear-shaped cells in the mycelium reported by Griffin (1968) were observed in the isolates examined. This is also the only species of *Leptographium* with a teleomorph that has falcate ascospores (Harrington, 1988) and was placed in the minuta - group by Olchowecki and Reid (1974) based on this character. The teleomorph was transferred to *Ceratocystiopsis* by Upadhyay (1981). Later, Harrington (1987) transferred this species to *Ophiostoma*, where it currently resides. Nothing is known about pathogenicity of *Ophiostoma crassivaginatium*.

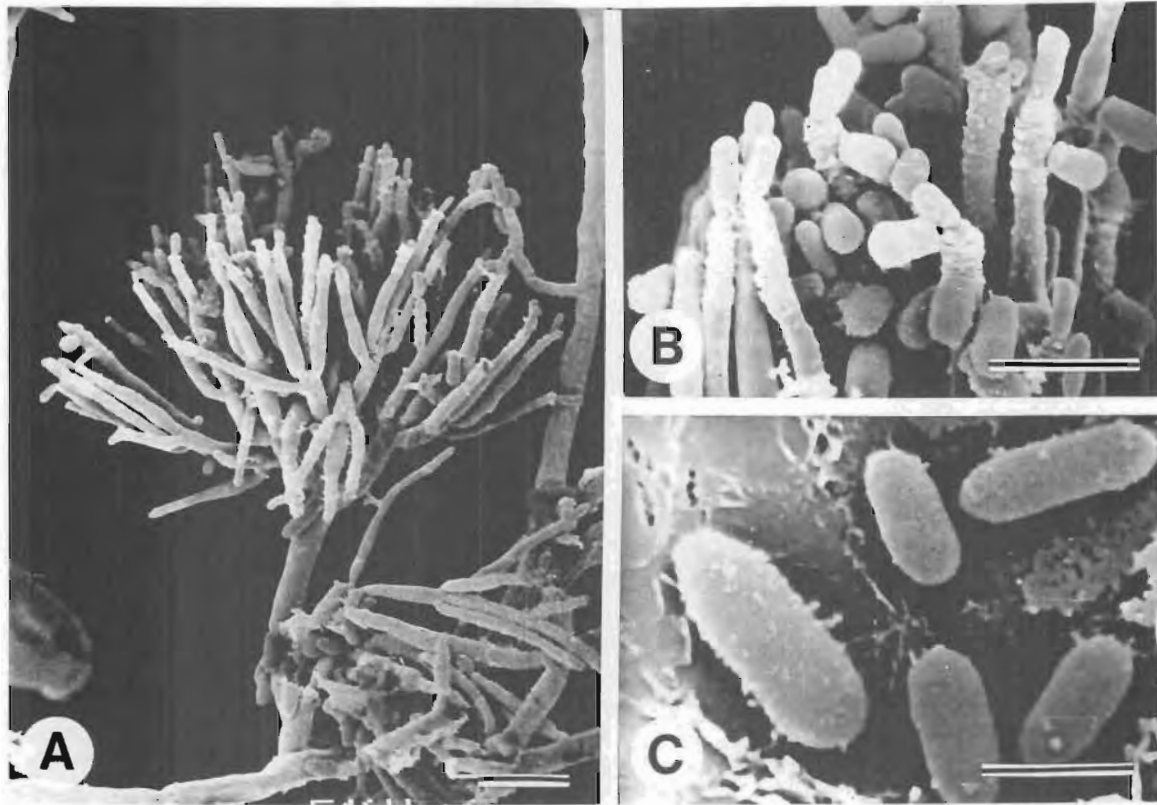


**Fig. 54.** Teleomorph and anamorph structures of *O. crassivaginatatum* (CMW 90). A. Perithecium (Bar = 10  $\mu$ m). B. Ascospores (Bar = 10  $\mu$ m). C. Conidiophore (Bar = 10  $\mu$ m). D. Conidiogenous apparatus (Bar = 10  $\mu$ m). E. Conidia (Bar = 10  $\mu$ m).



**Fig 55.** Light micrographs of anamorph structures of *O. crassivaginum* (CMW 90). **A.** Conidiophore (Bar = 10 µm). **B.** Conidiophore (Bar = 10 µm). **C.** Conidiogenous cells (Bar = 10 µm). **D.** Conidia (Bar = 10 µm).





**Fig. 56.** Scanning electron micrographs of the conidiophores and conidia of *O. crassivaginatium* (CMW 90). **A.** Conidiophore (Bar = 20 µm). **B.** Conidiogenous cells (Bar = 10 µm). **C.** Conidia (Bar = 5 µm).



**14. *Leptographium douglasii*** M.J. Wingf., T.C. Harr. & Crous, *Canadian Journal of Botany* 72,231. 1994. (Figs. 57 - 58).

**Teleomorph:** Not known.

**Etymology:** dóug-la-sii: of Douglas (-fir). This specific epithet refers to the occurrence of this fungus on Douglas-fir.

*Conidiophores* occurring singly, arising directly from the mycelium, erect, macronematous, mononematous, (57.5-) 107 - 320 (-512.5)  $\mu\text{m}$  in length, rhizoid-like structures present. *Stipes* olivaceous (21''m), smooth, cylindrical, simple, 3 - 11 septate, (42.5-) 52.5 - 282.5 (-475)  $\mu\text{m}$  long, (5.0-) 7.0 - 8.0 (-15)  $\mu\text{m}$  wide below primary branches, apical cell not swollen, (5.0-) 6.0 - 9.5 (-12.5)  $\mu\text{m}$  wide at base, basal cell not swollen. *Conidiogenous apparatus* (20-) 33.5 - 58.5 (-80)  $\mu\text{m}$  long, excluding the conidial mass, with 2 - 4 series of cylindrical branches, 2-3 primary branches, light olivaceous (21'k), smooth, cylindrical, aseptate, (6.0-) 12 - 14 (-22)  $\mu\text{m}$  long and (3.0-) 4.0 - 6.5 (-9.0)  $\mu\text{m}$  wide, arrangement of the primary branches on the stipe - type B, secondary branches light olivaceous (21''k), aseptate, (7.0-) 9.0 - 11 (-16)  $\mu\text{m}$  long, 2.0 - 5.0  $\mu\text{m}$  wide, tertiary branches hyaline, aseptate, (4.0-) 7.5 - 9.0 (-12)  $\mu\text{m}$  long, 1.0 - 2.5  $\mu\text{m}$  wide, quaternary branches aseptate, hyaline, 8.0 - 9.0  $\mu\text{m}$  long, 1.0 - 2.0  $\mu\text{m}$  wide. *Conidiogenous cells* discrete, 2-3 per branch, cylindrical, tapering slightly at the apex, (6.0-) 9.5 - 20 (-21)  $\mu\text{m}$  long and 1.0 - 2.0  $\mu\text{m}$  wide. *Conidia* light gray olivaceous (19'''), aseptate, obovoid, 4.0 - 6.0 (-7.0) x 1.0 - 2.5  $\mu\text{m}$ . Conidia accumulating in slimy droplets at the apex of conidiogenous apparatus, hyaline at first, becoming cream colored (19'f) with age. Conidial mass cream colored when wet, remaining cream colored when dry.

*Colonies* with optimal growth at 20°C on 2% MEA, reaching 16 mm in diam. in 9 days. No growth below 10°C or above 25°C. Able to withstand high concentrations of cycloheximide with a 22% reduction in growth on 0.5 g/l cycloheximide after 12 days at 20°C in the dark. Colonies olivaceous black (21''m). *Colony margin* sinuate. *Hyphae* submerged on agar with little aerial mycelium, hyaline to light olivaceous (21''k), smooth, slightly serpentine, occasionally constricted at the septa,

(2.5-) 5.0 - 8.0 (-15)  $\mu\text{m}$  diam.

**Specimens examined: Holotype:** U.S.A., Oregon Prospect, *Pseudotsuga menziesii* roots, 1980, collected: D. Goheen, PREM 51446. **Paratypes:** U.S.A., Clouderof Indian Reserve near Mescalero, *Pseudotsuga menziesii* roots, 1980, collected: M. Mielke, PREM 51447; U.S.A. California, *Pseudotsuga menziesii* roots, 1980, collected: T.C. Harrington, PREM 51448; U.S.A., Colorado San Juan National Forest, *Pseudotsuga menziesii* roots, 1980, collected: R. James, PREM 51449. **Cultures:** U.S.A., Prospect Oregon, *Pseudotsuga menziesii*, 1980, collected: D. Goheen, CMW 2078, CMW 2782 (PREM 56386), CMW 725 (PREM 56370).

**Known distribution:** U.S.A.

**Hosts/substrate:** *Pseudotsuga menziesii* (Wingfield *et al.*, 1994).

**Associated insects:** *Hylastes nigrinus* (Wingfield *et al.*, 1994).

**Notes:** *Leptographium douglasii* is restricted to douglas-fir (*Pseudotsuga menziesii*) and is consistently associated with a root-feeding insect (*Hylastes nigrinus*) (Wingfield *et al.*, 1994). This is the same insect that occasionally carries *L. wagneri* var. *pseudotsugae*. *Leptographium douglasii* can, however, be distinguished from *L. wagneri* var. *pseudotsugae* based on a more robust conidiogenous apparatus and longer narrower conidia in the former species as well as differences in their optimal growth temperatures. This fungus was also shown to have a low level of virulence towards *P. menziesii* (Harrington & Cobb, 1983).

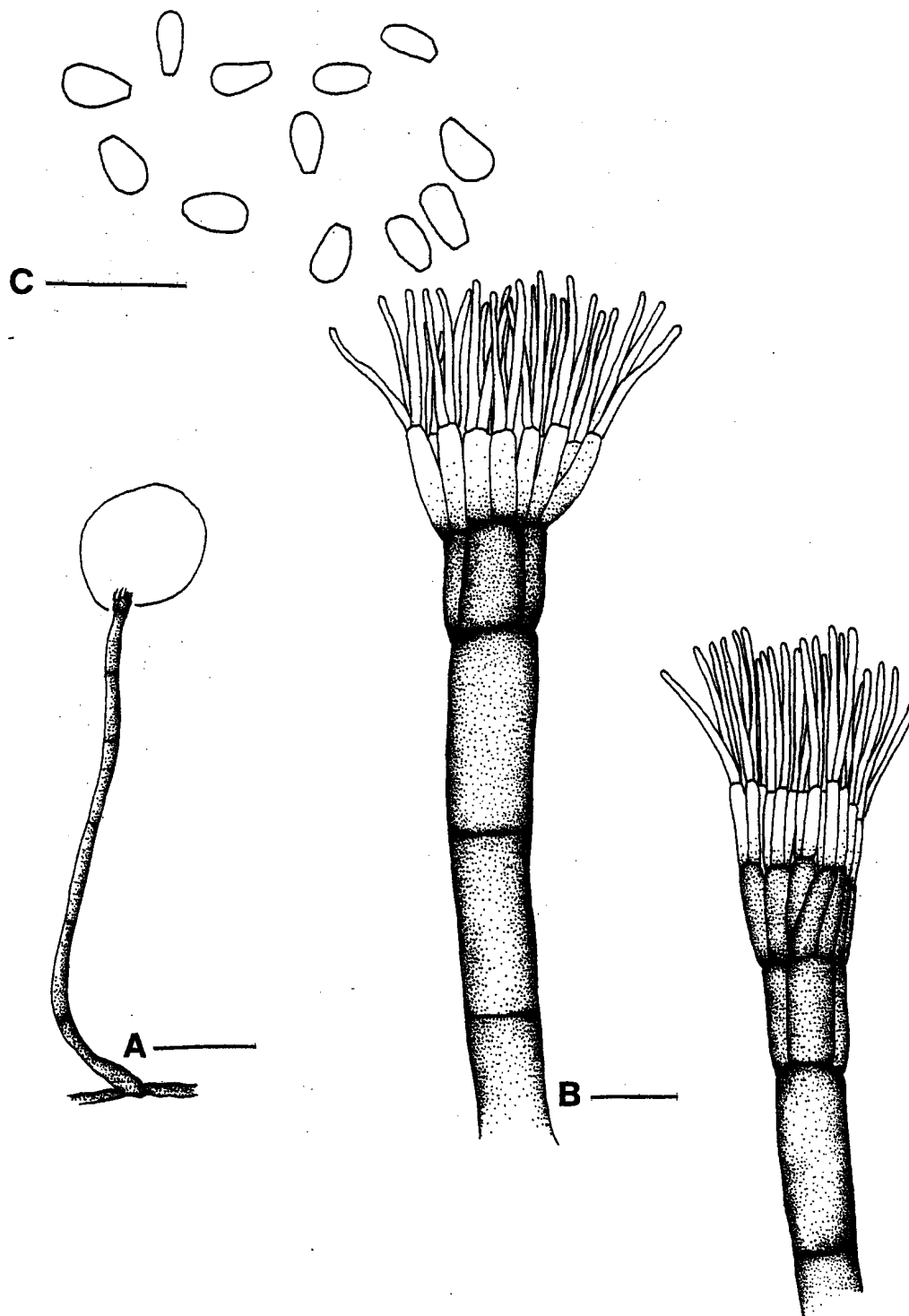
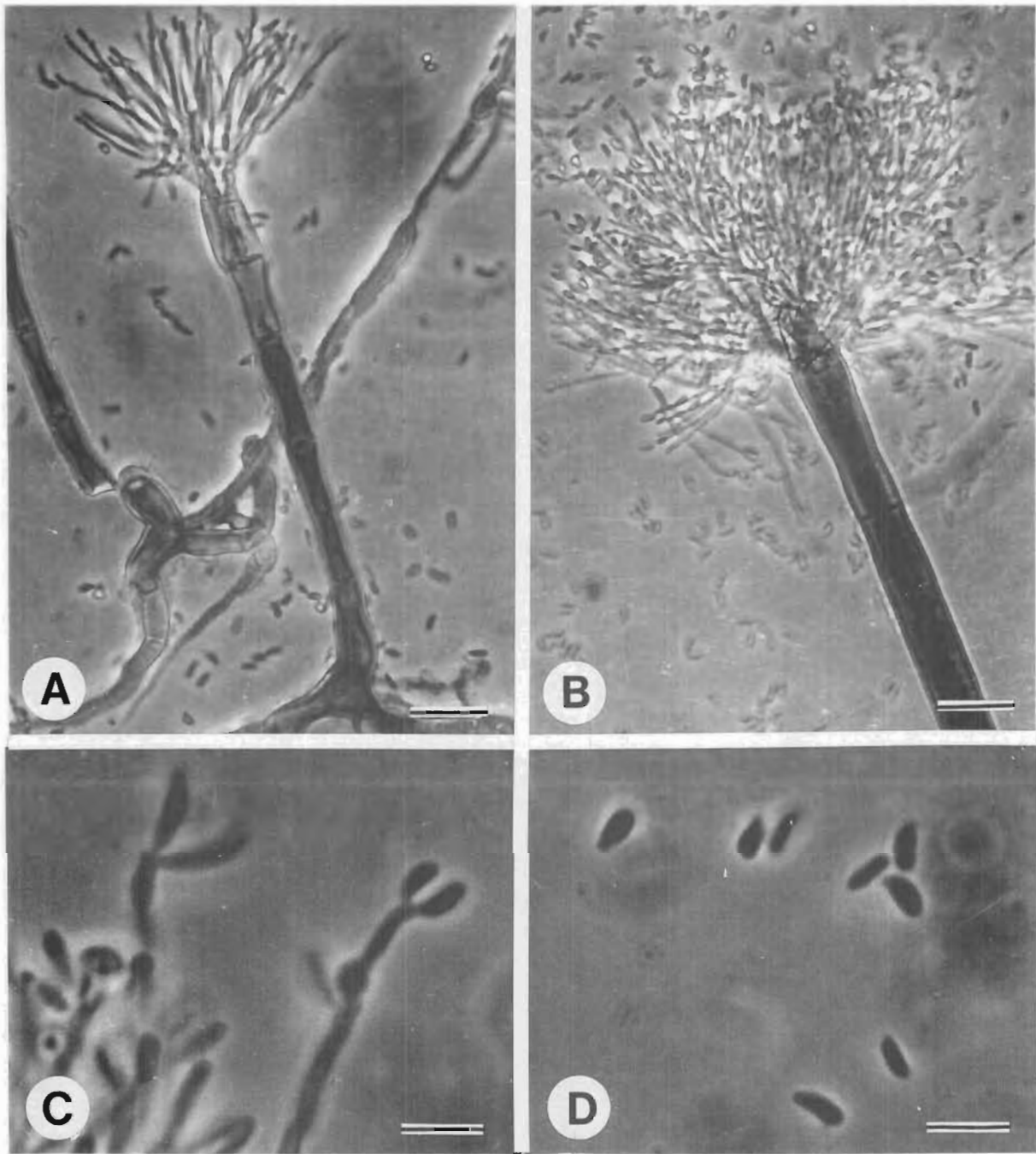
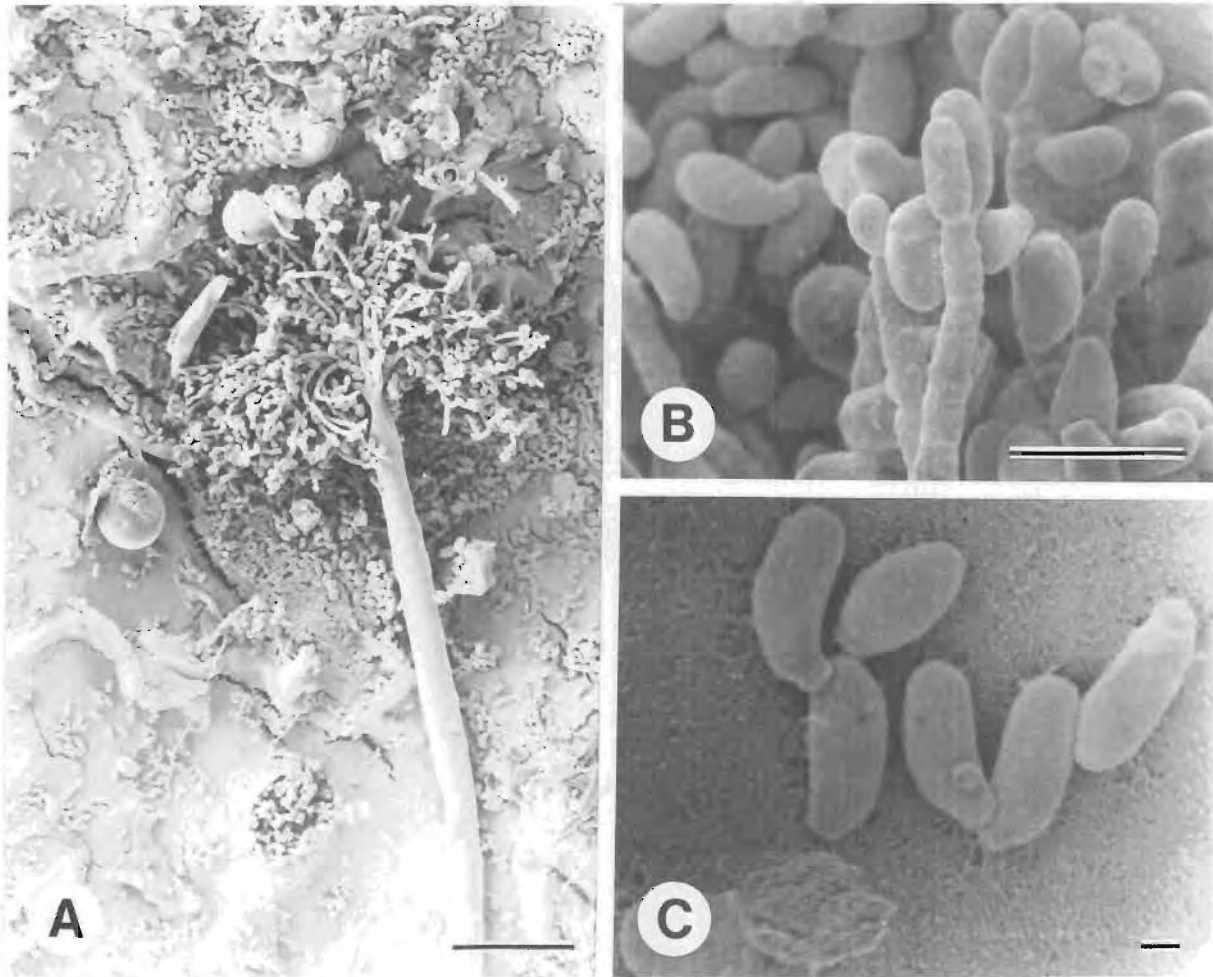


Fig. 57. Conidiophores and conidia of *L. douglasii* (CMW 2078). A. Habit sketch (Bar = 10  $\mu$ m). B. Conidiogenous apparatus (Bar = 10  $\mu$ m) C. Conidia (Bar = 10  $\mu$ m).



**Fig. 58.** Light micrographs of the conidiophores and conidia of *L. douglasii* (CMW 2078). **A.** Conidiophore (Bar = 20  $\mu\text{m}$ ). **B.** Conidiogenous apparatus (Bar = 20  $\mu\text{m}$ ). **C.** Conidiogenous cells (Bar = 10  $\mu\text{m}$ ). **D.** Conidia (Bar = 10  $\mu\text{m}$ ).



**Fig. 59.** Scanning electron micrographs of the conidiophores and conidia of *L. douglasii* (CMW 2078). **A.** Conidiophore (Bar = 50  $\mu\text{m}$ ). **B.** Conidiogenous cells (Bar = 10  $\mu\text{m}$ ). **C.** Conidia (Bar = 1  $\mu\text{m}$ ).

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**15. *Ophiostoma dryocoetidis*** (W.B. Kendr. & Molnar) De Hoog & R.J. Scheff., *Mycologia* **76**, 297. 1984. (Figs. 60 - 61).

≡ *Ceratocystis dryocoetidis* W.B. Kendr. & Molnar, *Canadian Journal of Botany* **43**, 39. 1965.

**Anamorph:** *Leptographium dryocoetidis* (W.B. Kendr. & Molnar) M.J. Wingf., *Transactions of the British Mycological Society* **85**, 92. 1985.

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**Etymology:** dry-o-coé-ti-dis: connected with *Dryocoetus*. This specific epithet refers to the association of this fungus with the bark beetle *Dryocoetus confusus*.

*Perithecial bases* black, globose and smooth walled, unornamented, 170 - 260 in diam. *Perithecial neck* dark brown to black, cylindrical with a slight apical taper, paler near the apex, smooth, 150 - 560 µm long, 40 - 60 µm above globose base, 35 - 45 µm wide at the apex, *ostiole hyphae* absent. *Asci* prototunicate, hyaline, evanescent. *Ascospores* allantoid, aseptate, hyaline, invested in a sheath, 5.2 - 7 x 2.2 - 3.2 µm (Kendrick & Molnar, 1965).

*Conidiophores* occurring singly, arising directly from the mycelium, erect, macronematous, mononematous, (37.5-) 123.5 - 134.5 (-250) µm in length, rhizoid-like structures absent. *Stipes* light olivaceous (21"K), smooth, cylindrical, simple, 0-8 septate, (27.5-) 88 - 74 (-205) µm long, 2.5 - 8.0 µm wide below primary branches, apical cell not swollen, (2.5-) 4.0 - 7.5 µm wide at base, basal cell not swollen. *Conidiogenous apparatus* (34-) 44 - 75 (-99) µm long, excluding the conidial mass, with 2 to 4 series of cylindrical branches, 2-3 primary branches, light olivaceous (21"K), smooth, cylindrical or barrel shape, 0-1 septate (6.0-) 10.5 - 15 (-20) µm long and 3.0 - 6.0 µm wide, arrangement of the primary branches on the stipe - type B, secondary branches light olivaceous (21"K), aseptate, (4.0-) 10 - 11.5 (-13.5) µm long, 2.5 - 4.0 µm wide, tertiary branches light olivaceous (21"K), aseptate, (5.5-) 9.0 - 11 (-15) µm long, 2.5 - 4.0 µm wide, quaternary branches aseptate, 7.0 - 13 (-14) µm long, 2.0 - 4.0 µm wide. *Conidiogenous cells* discrete, 2-3 per branch, cylindrical, tapering slightly at the apex, (10-) 15.5 - 19 (-25) µm long and 1.0 - 2.5 µm wide. *Conidia* hyaline, aseptate, oblong with truncate ends and rounded apices, 9.0 - 18 x

2.0 - 3.0  $\mu\text{m}$ . Conidia accumulating in slimy droplets at the apex of conidiogenous apparatus, hyaline at first, becoming cream colored (19'f) with age. Conidial mass cream colored when wet, turning amber (21'b) when dry.

*Colonies* with optimal growth at 25°C on 2% MEA, reaching 27 mm in diam. in 9 days. No growth below 5°C or above 30°C. Able to withstand high concentrations of cycloheximide with no reduction in growth on 0.5 g/l cycloheximide after 8 days at 20°C in the dark. Colonies brownish olive (21''m). *Colony margin* smooth. *Hyphae* submerged on agar with little aerial mycelium, hyaline to light olivaceous (21''k), smooth, straight, frequently constricted at the septa, 2.5 - 7.5  $\mu\text{m}$  diam.

**Specimens examined: Holotype:** British Columbia, Bolean Lake, *Abies lasiocarpa*, Oct. 1963, collected: A.C. Molnar and W.B. Kendrick, DAOM 97704. **Cultures:** British Columbia, Bolean Lake, *Abies lasiocarpa*, Oct. 1963, collected: A.C. Molnar and W.B. Kendrick, CMW 442 (same as CBS 376.66 and DAOM 97704).

**Known distribution:** Canada.

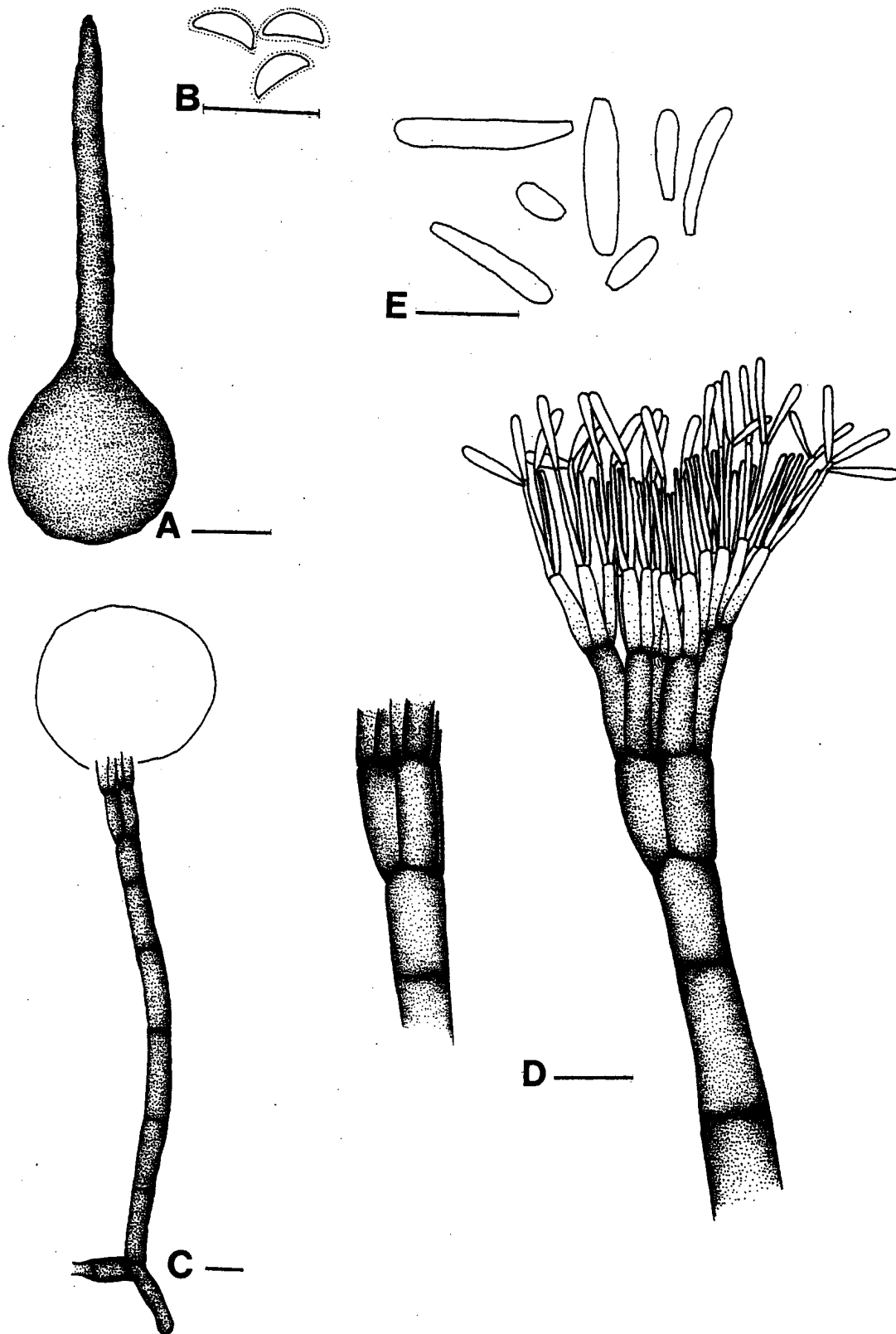
**Hosts/substrate:** *Abies lasiocarpa* (Kendrick and Molnar, 1965; Molnar, 1965).

**Associated insects:** *Dryocoetus confusus* (Kendrick and Molnar, 1965; Molnar, 1965).

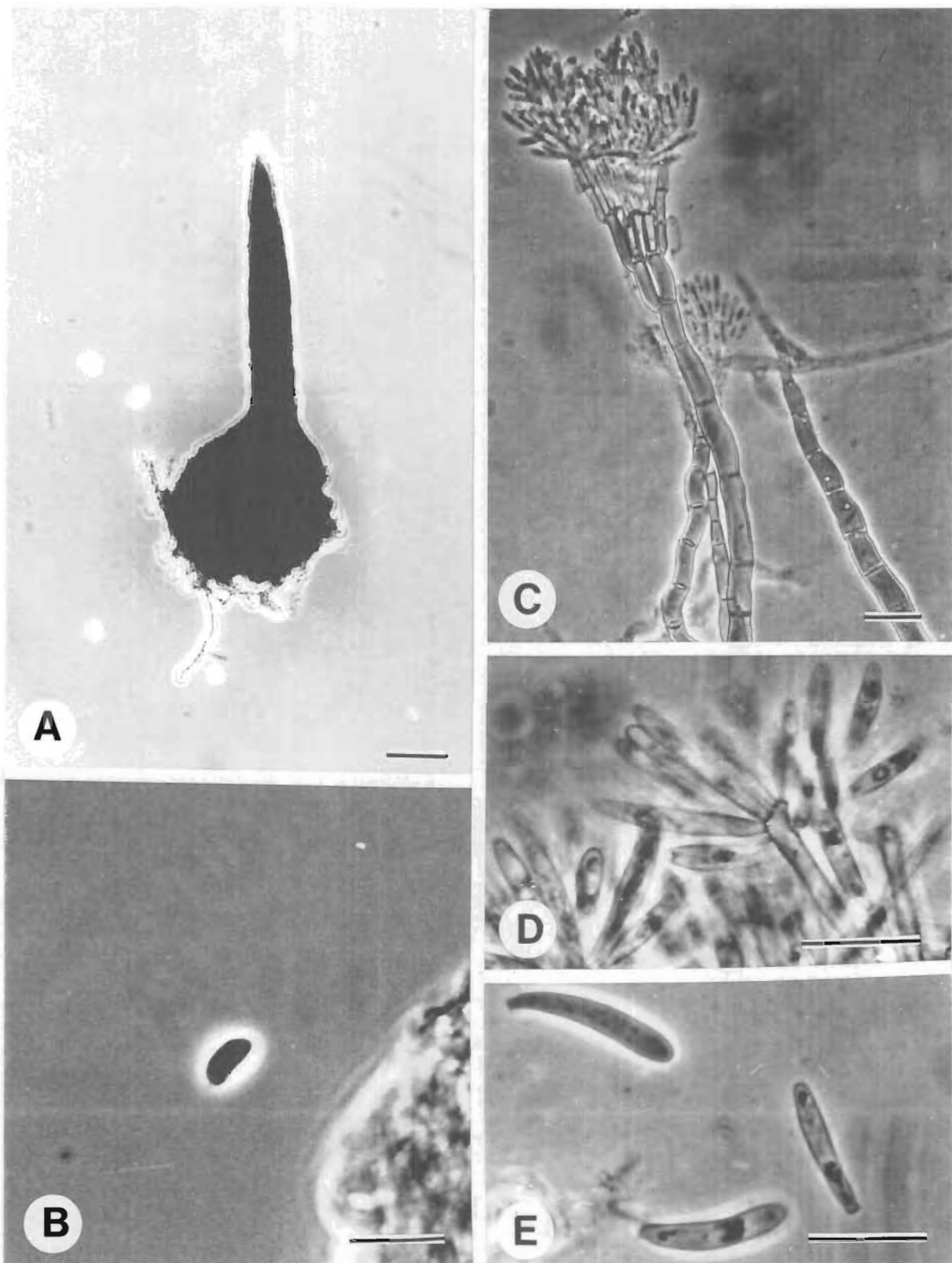
**Notes:** This is one of four *Leptographium* spp. with conidia that are three times as long as they are wide. The others are *O. penicillatum*, *O. americanum* and *L. eucalyptophilum*. Although this fungus closely resembles *O. penicillatum*, by having similar conidia, Kendrick and Molnar (1965) distinguished these two species based on their perithecial characters. *Ophiostoma dryocoetidis* can be distinguished from *O. americanum* based on the more curved conidia of the former, in contrast to the needle shaped conidia of the latter species (Jacobs *et al.*, 1998). *Leptographium eucalyptophilum* is distinguished from *O. dryocoetidis* based on the more needle shaped conidia and longer conidiophores of the former, compared to the curved conidia and shorter conidiophores of the latter species (Jacobs *et al.*, 1999). This

fungus was the most common species isolated from stained wood of alpine fir, and it was also shown to have the ability to kill this host in inoculation trials (Molnar, 1965).

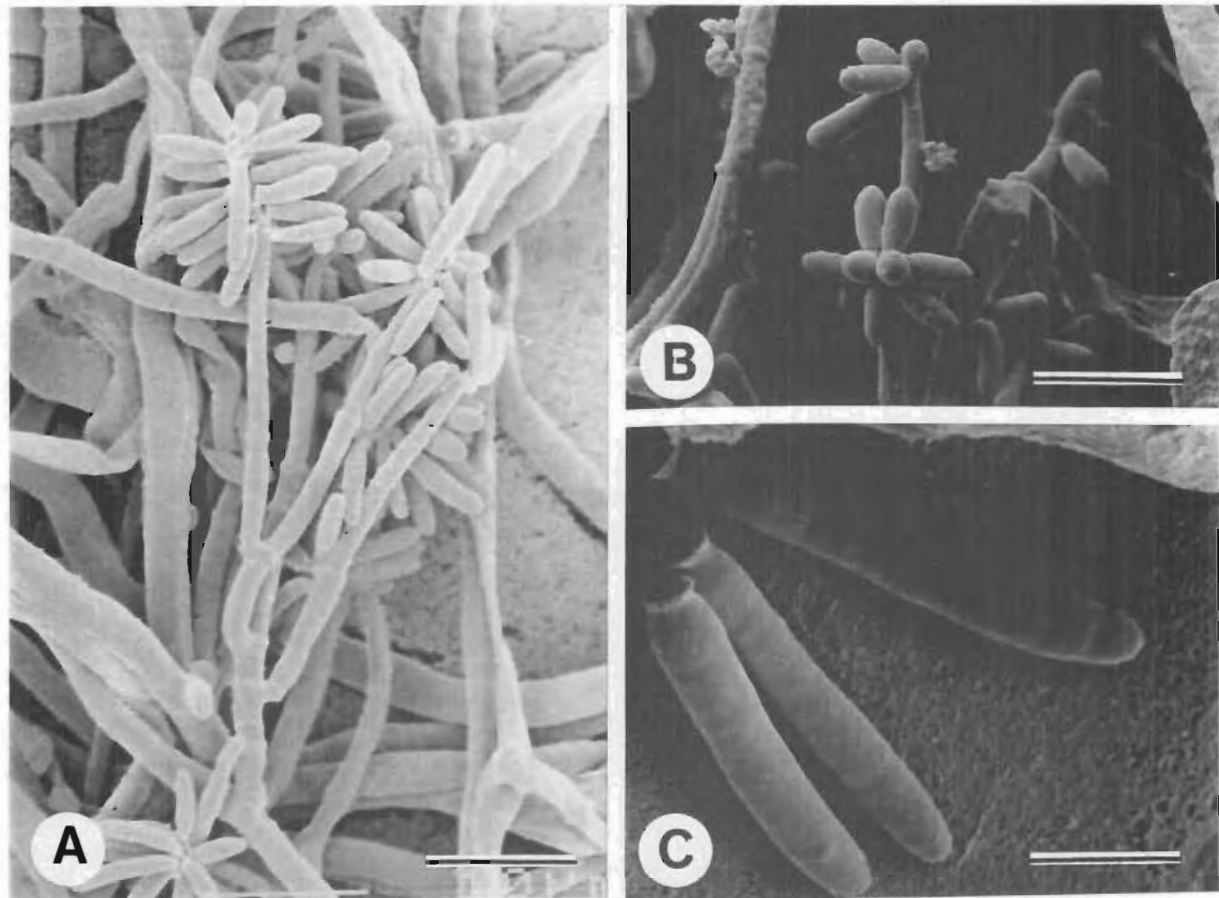




**Fig. 60.** Teleomorph and anamorph structures of *O. dryocoetidis* (CMW 442). **A.** Perithecium (Bar = 100  $\mu\text{m}$ ). **B.** Ascospores (Bar = 10  $\mu\text{m}$ ). **C.** Conidiophore (Bar = 10  $\mu\text{m}$ ). **D.** Conidiogenous apparatus (Bar = 10  $\mu\text{m}$ ). **E.** Conidia (Bar = 10  $\mu\text{m}$ ).



**Fig. 61.** Light micrographs of the teleomorph and anamorph structures of *O. dryocoetidis* (CMW 442). **A.** Perithecium (Bar = 100  $\mu\text{m}$ ). **B.** Ascospore (Bar = 10  $\mu\text{m}$ ). **C.** Conidiophore (Bar = 10  $\mu\text{m}$ ). **D.** Conidiogenous cells (Bar = 10  $\mu\text{m}$ ). **E.** Conidia (Bar = 10  $\mu\text{m}$ ).



**Fig. 62.** Scanning electron micrographs of the conidiophores and conidia of *O. dryocoetidis* (CMW 442).  
**A.** Conidiophore (Bar = 10  $\mu\text{m}$ ). **B.** Conidiogenous cells (Bar = 10  $\mu\text{m}$ ). **C.** Conidia (Bar = 5  $\mu\text{m}$ ).



**16. *Leptographium elegans* M.J. Wingf., Crous & Tzean *Mycological Research* 98, 783. 1994. (Figs. 63-65).**

**Teleomorph:** Not known.

**Etymology:** é-le-gans: elegant. From the Latin adjective elegans: choice, fine, neat. The specific epithet refers to the small, fine, conidiophores of this fungus.

*Conidiophores* occurring mostly singly, arising directly from the mycelium, erect, macronematous, mononematous, (102.5-) 237 - 241 (-432.5)  $\mu\text{m}$  in length, rhizoid-like structures absent. *Stipes* light olivaceous (21''k), smooth, cylindrical, simple, 2-8 septate, (62 5-) 195 - 188 (-377.5)  $\mu\text{m}$  long, 2.5 - 5.0  $\mu\text{m}$  wide below primary branches, apical cell not swollen, 4.0 - 6.0  $\mu\text{m}$  wide at base, basal cell not swollen. *Conidiogenous apparatus* (30-) 41 - 48.5 (-82.5)  $\mu\text{m}$  long, excluding the conidial mass, with 2 to occasionally 3 series of cylindrical branches, 2-3 primary branches, light olivaceous (21''k), smooth, cylindrical, aseptate, (10-) 11.5 - 22 (-25)  $\mu\text{m}$  long and 2.0 - 4.0  $\mu\text{m}$  wide, arrangement of the primary branches on the stipe - type B, secondary branches light olivaceous, aseptate, 7.0 - 13.5 (-15)  $\mu\text{m}$  long, 2.0 - 5.5  $\mu\text{m}$  wide, tertiary branches hyaline, aseptate, (6.0-) 9.0 -11.5 (-13)  $\mu\text{m}$  long, 2.0 - 4.0  $\mu\text{m}$  wide. *Conidiogenous cells* discrete, 2-3 per branch, cylindrical, tapering slightly at the apex, (13.5-) 18 - 20 (-26)  $\mu\text{m}$  long and 1.0 - 4.0  $\mu\text{m}$  wide. *Conidia* hyaline, aseptate, oblong, 3.0 - 5.0 x 1.0 - 2.0  $\mu\text{m}$ . Conidia accumulating in slimy droplets at the apex of conidiogenous apparatus, hyaline at first, becoming cream colored (19'f) with age. Conidial mass cream colored when wet, remaining cream colored when dry.

*Colonies* with optimal growth at 25°C on 2% MEA, reaching 9 mm in diam. in 8 days. No growth below 10°C with very little growth at 35°C. Able to withstand high concentrations of cycloheximide with a 18% reduction in growth on 0.5 g/l cycloheximide after 12 days at 20°C in the dark. Colonies olivaceous (21''m). *Colony margin* smooth. *Hyphae* submerged on agar with little aerial mycelium, hyaline to light olivaceous (21''k), smooth, slightly serpentine, strands of hyphae aggregated, not constricted at the septa, (2.5-) 3.5 - 5.0 (-7.5)  $\mu\text{m}$  diam.

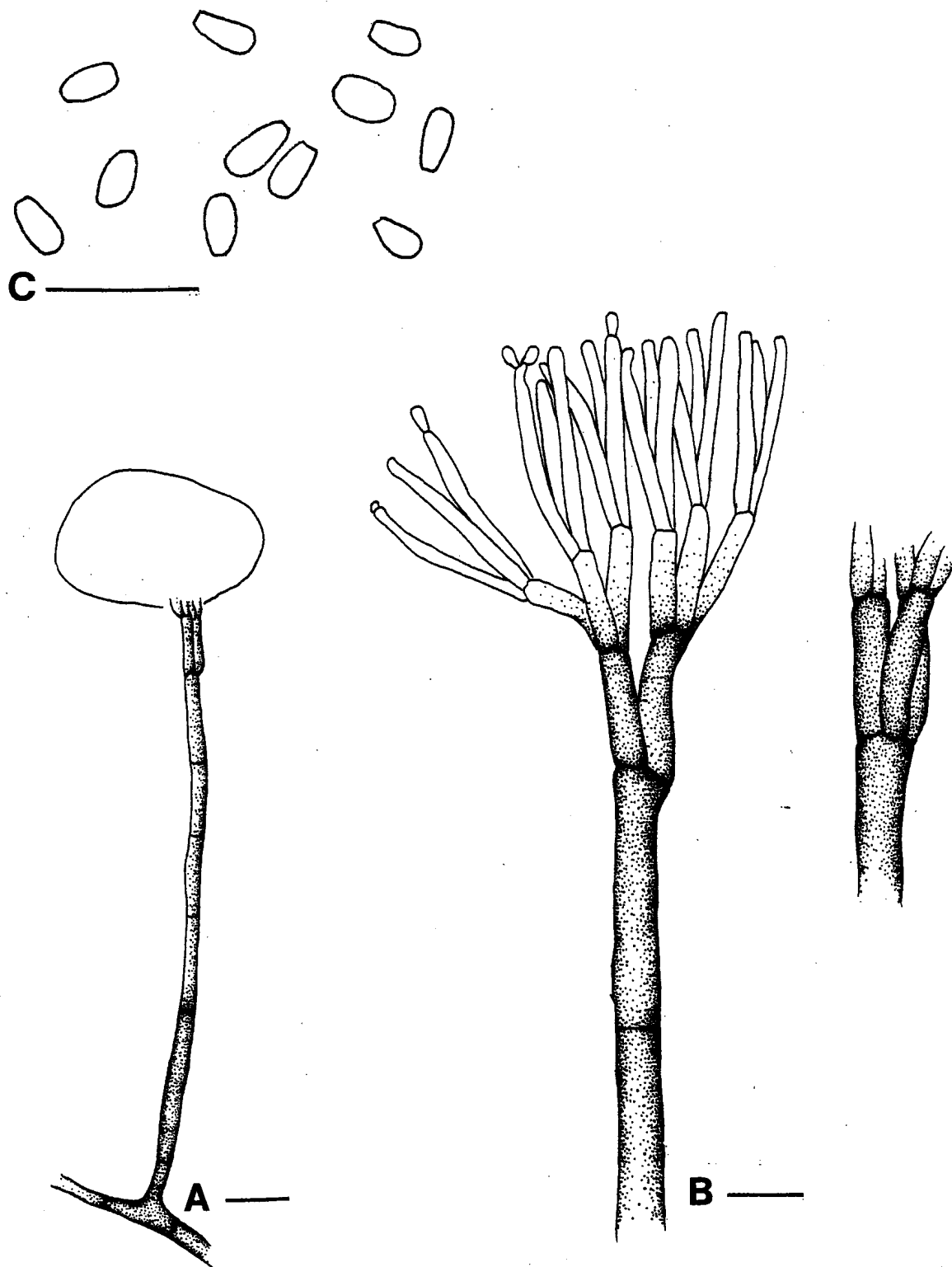
**Specimens examined:** **Holotype:** N.E. of Taiwan, Lotung, Ilan country, *Chamaecypris* sp., 1992, collected: M.J. Wingfield, PREM 51442. **Cultures:** N.E. of Taiwan, Lotung, Ilan country, *Chamaecypris* sp., 1992, collected: M.J. Wingfield, CMW 2245, CMW 2248 (PREM 56345), CMW 2249 (PREM 56344).

**Known distribution:** Taiwan.

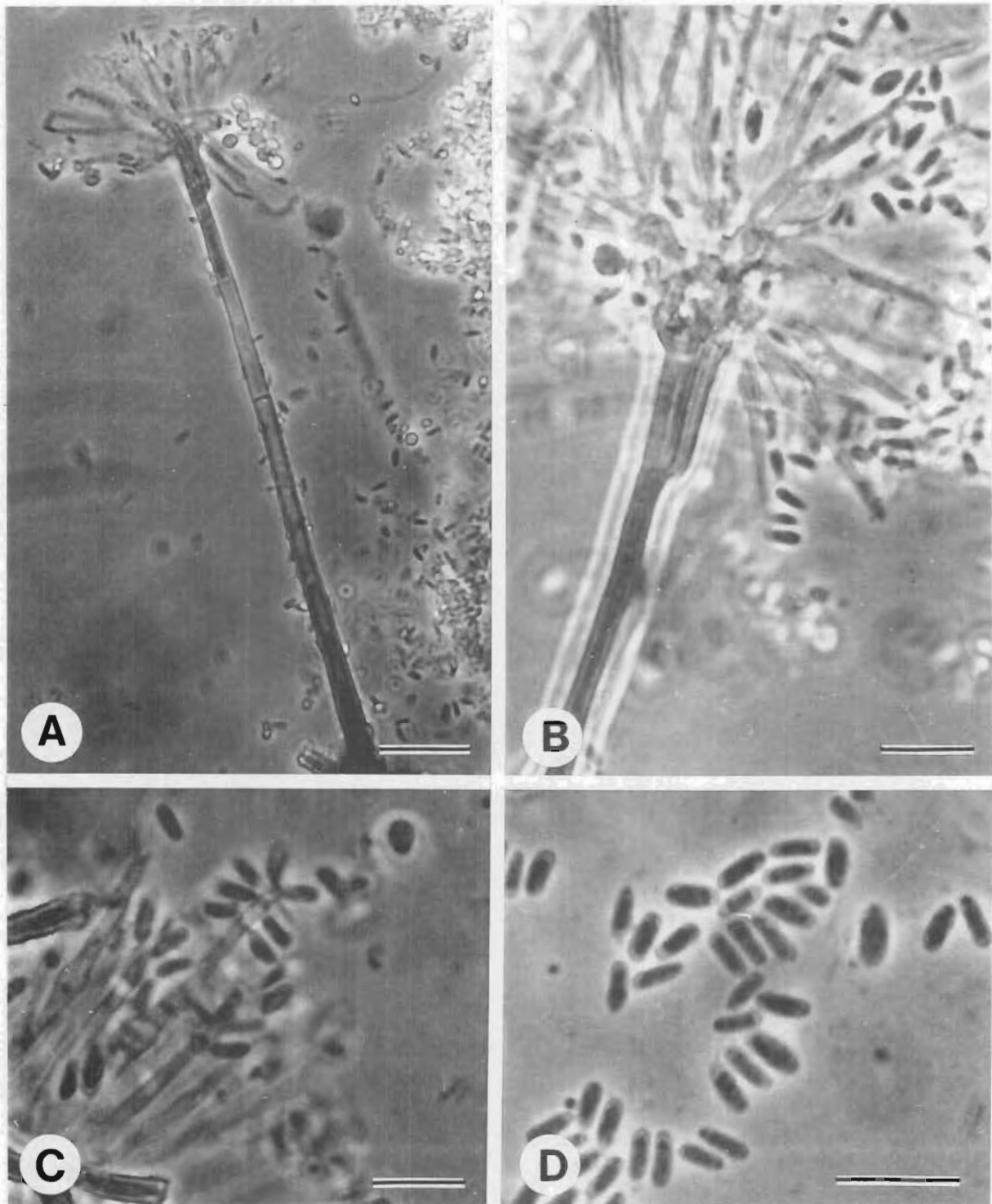
**Hosts/substrate:** *Chamaecypris formosensis* (Wingfield *et al.*, 1994).

**Associated insects:** Not known.

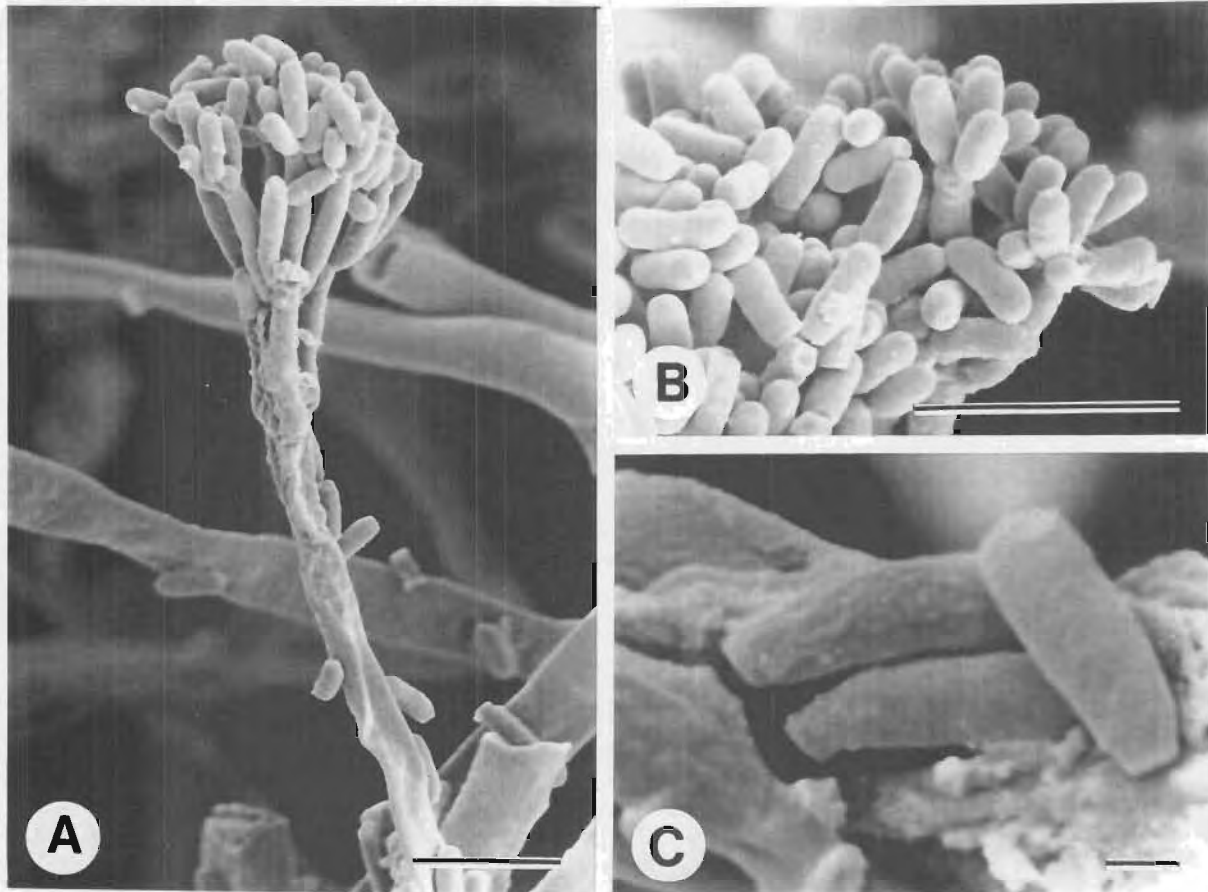
**Notes:** *Leptographium elegans* is distinguished from other species in this genus based on the presence of a prominent *Sporothrix* synanamorph in culture. *Sporothrix* synanamorphs have also been observed in other species of *Ophiostoma*, especially those with *Pesotum* anamorphs, but not those with *Leptographium* anamorphs. *Leptographium elegans* is morphologically similar to *L. sibiricum*. These species can, however, be distinguished based on the absence of a *Sporothrix* anamorph in the latter species. Nothing is known about the pathogenicity of this fungus.



**Fig. 63.** Conidiophores and conidia of *L. elegans* (CMW 2245). **A.** Habit sketch (Bar = 10  $\mu$ m). **B.** Conidiogenous apparatus (Bar = 10  $\mu$ m). **C.** Conidia (Bar = 10  $\mu$ m).



**Fig. 64.** Light micrographs of the conidiophores and conidia of *L. elegans* (CMW 2245). **A.** Conidiophore (Bar = 20  $\mu\text{m}$ ). **B.** Conidiogenous apparatus (Bar = 10  $\mu\text{m}$ ). **C.** Conidiogenous cells (Bar = 10  $\mu\text{m}$ ). **D.** Conidia (Bar = 10  $\mu\text{m}$ ).



**Fig. 65.** Scanning electron micrographs of the conidiophores and conidia of *L. elegans* (CMW 2245). **A.** Conidiophore (Bar = 10  $\mu$ m). **B.** Conidiogenous cells (Bar = 10  $\mu$ m). **C.** Conidia (Bar = 1  $\mu$ m).





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**17. *Leptographium eucalyptophilum*** K. Jacobs, M.J. Wingf. & J. Roux, *South African Journal of Botany*, 1999. (Figs. 66-68).

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**Teleomorph state:** Not known.

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**Etymology:** eu-ca-lyp-to-phi-lum: loving the Eucalypt. From *Eucalyptus* and the Greek adjective φιλος: loving. This specific epithet refers to *Eucalyptus* which is the only host of this fungus.

*Conidiophores* occurring singly or in groups of up to three, arising directly from the mycelium, erect, macronematous, mononematous, (180-) 203 - 443.5 (-500)  $\mu\text{m}$  in length, rhizoid-like structures absent. *Stipes* light olivaceous, smooth, cylindrical, simple, 4 - 9 septate, (140-) 152 - 392 (-440)  $\mu\text{m}$  long, 4.0 - 5.0  $\mu\text{m}$  wide below primary branches, apical cell not swollen, 5.0 - 8.5 (-10)  $\mu\text{m}$  wide at base, basal cell not swollen. *Conidiogenous apparatus* 30 - 80  $\mu\text{m}$  long, excluding the conidial mass, with 2 - 3 series of cylindrical branches, 2-3 primary branches, light olivaceous to hyaline, smooth, cylindrical, aseptate, 12 - 22.5 (-26)  $\mu\text{m}$  long and 3.0 - 5.0 (-6.0)  $\mu\text{m}$  wide, arrangement of the primary branches on the stipe - type B, secondary branches hyaline, aseptate, (7.0-) 9.0 - 10.5 (-13)  $\mu\text{m}$  long, 1.0 - 4.0  $\mu\text{m}$  wide, tertiary branches hyaline, aseptate, 5.0 - 10  $\mu\text{m}$  long, 2.0 - 3.0  $\mu\text{m}$  wide. *Conidiogenous cells* discrete, 2-3 per branch, cylindrical, tapering slightly at the apex, 7.0 - 13  $\mu\text{m}$  long and 1.0 - 2.0  $\mu\text{m}$  wide. *Conidia*, hyaline, aseptate, oblong to obovoid, 6.0 - 9.0 x 3.0 - 5.0  $\mu\text{m}$ . *Conidia* accumulating in slimy droplets at the apex of conidiogenous apparatus.

*Colonies* with optimal growth at 30 °C on 2 % MEA, reaching 27 mm in diameter in 6 days. No growth below 10 °C or above 35 °C. Able to withstand high concentrations of cycloheximide with a 15 % reduction in growth on 0.1 g/l cycloheximide after 6 days at 30 °C in the dark. Colonies dark green olivaceous (23"). *Colony margin* smooth. *Hyphae* submerged or on top of agar with abundant aerial mycelium, light olivaceous to hyaline, smooth, not constricted at the septa, 2.0 - 5.0  $\mu\text{m}$  diameter.

**Holotype:** PREM 56312, isolated from the xylem of diseased *Eucalyptus urophylla* X

*E. pellita* hybrid, collected: J. Roux, Kissoko plantation, Point Noire area, Republic of Congo, June 1998. **Paratypes:** PREM 56313, PREM 56314, PREM 56315, PREM 56316, PREM 56317, PREM 56318, PREM 56319 PREM 56320, isolated from the xylem of diseased *Eucalyptus urophylla* X *E. pellita* hybrid, collected: J. Roux, Kissoko plantation, Point Noire area, Republic of Congo, June 1998. **Cultures:** C1(ex holotype), C2, C3, C4, C5, C6, C7, isolated from the xylem of diseased *Eucalyptus urophylla* X *E. pellita* hybrid, collected: J. Roux, Kissoko plantation, Point Noire area, Republic of Congo, June 1998.

**Known distribution:** Central Africa, Republic of Congo.

**Host/substrate:** *Eucalyptus urophylla* X *E. pellita* hybrid (Jacobs *et al.*, 1999).

**Associated insects:** Not known.

**Notes:** *Leptographium eucalyptophilum* closely resembles the other *Leptographium* spp. with long conidia namely *L. americanum*, *L. penicillatum* and *L. dryocoetidis* (Grosman, 1932; Kendrick & Molnar, 1965; Jacobs *et al.*, 1997). It can, however, easily be distinguished from *O. penicillatum* and *O. dryocoetidis* based on the long allantoid and oblong conidia of these species, respectively. These are twice as broad as those in *L. eucalyptophilum* (Grosman, 1932; Kendrick & Molnar, 1965). Rhamoconidia are occasionally observed in *L. eucalyptophilum*, and these have never been reported from the other species. In addition, *O. penicillatum* and *O. dryocoetidis* are characterized by teleomorph structures. No teleomorph has been found in association with *L. eucalyptophilum*. *Leptographium eucalyptophilum* can be distinguished from *O. americanum* based on the considerably longer conidia of the latter species.

*Leptographium eucalyptophilum* is found on *Eucalyptus* and has thus far not been associated with any insect activity. Pathogenicity trials showed that *L. eucalyptophilum* most likely does not play a primary role in disease development on *Eucalyptus* trees (Jacobs *et al.*, 1999).

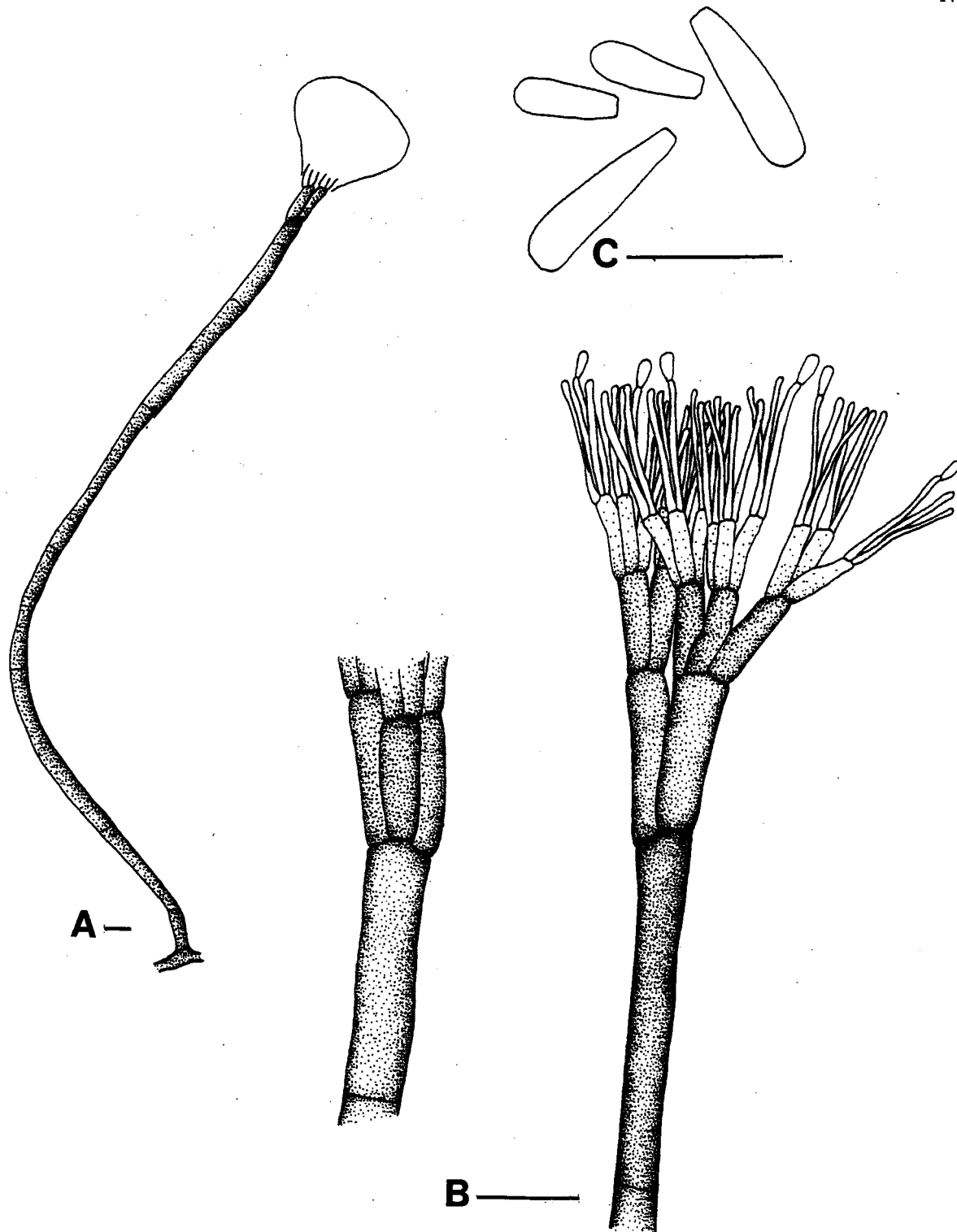
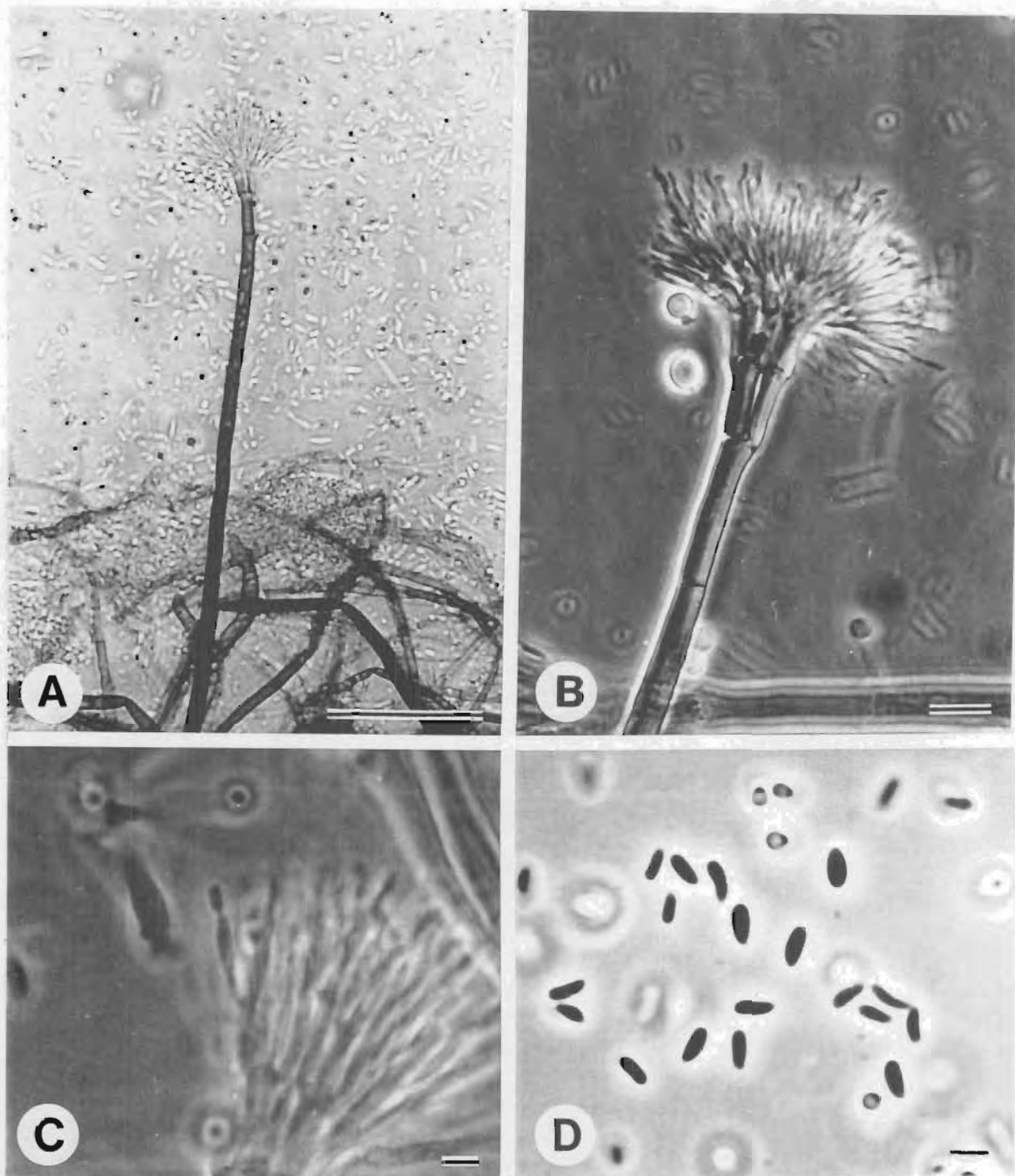
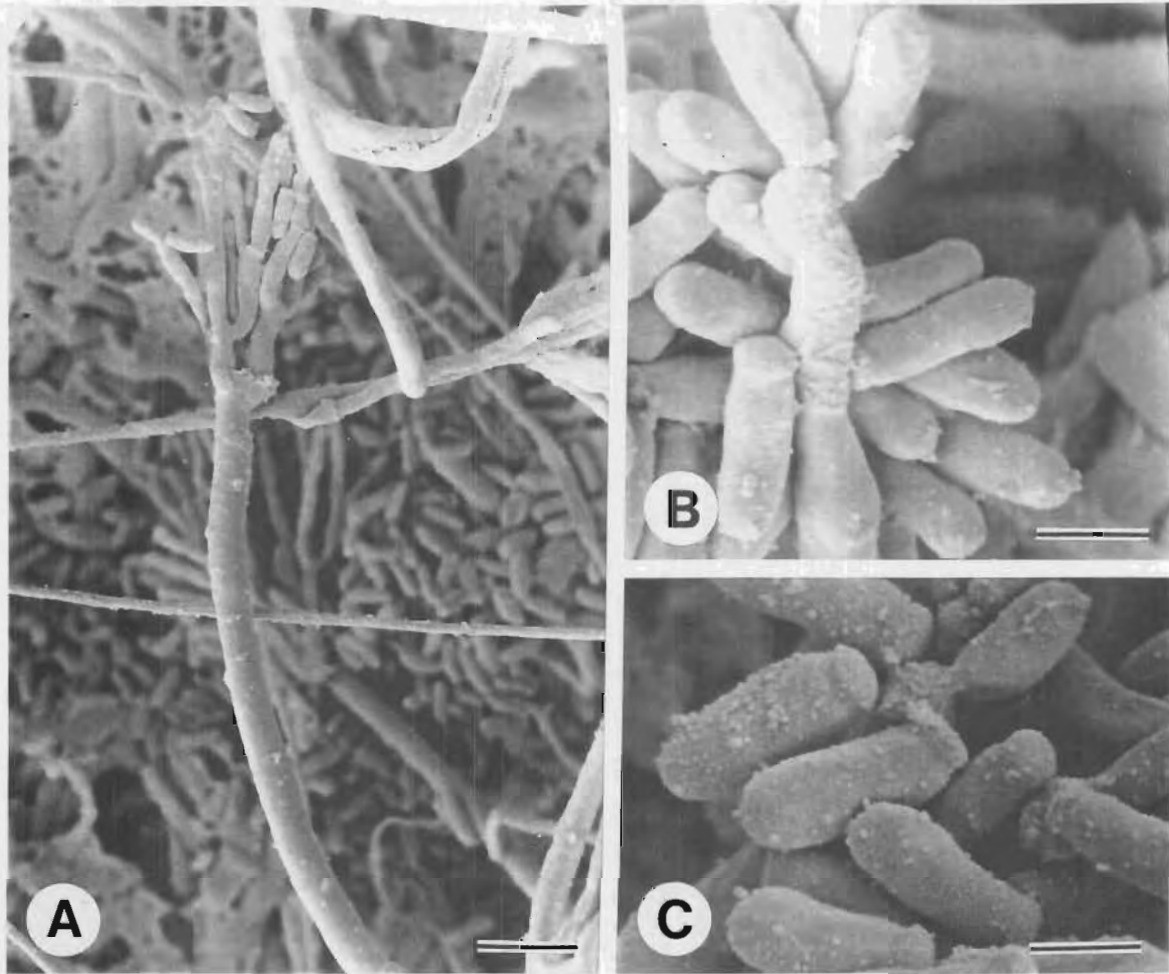


Fig. 66. Conidiophores and conidia of *L. eucalyptophilum* (PREM 56312). A. Habit sketch (Bar = 10  $\mu$ m). B. Conidiogenous apparatus (Bar = 10  $\mu$ m) C. Conidia (Bar = 10  $\mu$ m).



**Fig. 67.** Light micrographs of the conidiophores and conidia of *L. eucalyptophilum* (PREM 56312). **A.** Conidiophore (Bar = 50  $\mu$ m). **B.** Conidiogenous apparatus (Bar = 10  $\mu$ m). **C.** Conidiogenous cells (Bar = 10  $\mu$ m). **D.** Conidia (Bar = 10  $\mu$ m).





**Fig. 68.** Scanning electron micrographs of the conidiophores and conidia of *L. eucalyptophilum* (PREM 56312). **A.** Conidiophore (Bar = 20  $\mu\text{m}$ ). **B.** Conidiogenous cells (Bar = 5  $\mu\text{m}$ ). **C.** Conidia (Bar = 5  $\mu\text{m}$ ).



**18. *Leptographium euphyes*** K. Jacobs & M.J. Wingf., *Mycological Research*, 1999.  
(Figs. 69 - 71).

**Teleomorph state:** Not known

**Etymology:** eu-phý-es: shapely. From the Greek adjective *εὐφύης*: well-grown, shapely. This specific epithet refers to the small, but shapely conidiophores of this fungus.

*Conidiophores* occurring singly, arising directly from the mycelium, erect, macronematous, mononematous, (204-) 265 - 335 (-415)  $\mu\text{m}$  in length, rhizoid-like structures present. *Stipes* olivaceous, smooth, cylindrical, simple, 3 - 9 septate, (142.5-) 194 - 255 (-353.5)  $\mu\text{m}$  long, 6.0 - 9.0  $\mu\text{m}$  wide below primary branches, apical cell not swollen, 6.0 - 12.5  $\mu\text{m}$  wide at base, basal cell not swollen. *Conidiogenous apparatus* (31-) 68 - 77 (-93)  $\mu\text{m}$  long, excluding the conidial mass, with 3 - 4 series of cylindrical branches, 2 - 3 primary branches, light olivaceous, smooth, cylindrical, aseptate, (11-) 16 - 20.5 (-47)  $\mu\text{m}$  long and 5.0 - 7.0 (-8.0)  $\mu\text{m}$  wide, arrangement of the primary branches on the stipe - type B, secondary branches light olivaceous to hyaline, aseptate, 8.0 - 16.5 (-18)  $\mu\text{m}$  long, (3.0-) 4.0 - 5.0 (-6.0)  $\mu\text{m}$  wide, tertiary branches hyaline, aseptate, 8.0 - 13  $\mu\text{m}$  long, 2.0 - 3.0  $\mu\text{m}$  wide, quaternary branches aseptate, hyaline, 7.0 - 12  $\mu\text{m}$  long, 2.0 - 3.0  $\mu\text{m}$  wide. *Conidiogenous cells* discrete, 2-3 per branch, cylindrical, tapering slightly at the apex, (10-) 12.5 - 17 (-20)  $\mu\text{m}$  long and 1.0 - 2.0  $\mu\text{m}$  wide. *Conidia* aseptate, obovoid with truncate ends, occasionally oblong, 4.0 - 5.0 (-6.0) x 2.0 - 3.0  $\mu\text{m}$ . Conidia accumulating in slimy droplets at the apex of conidiogenous apparatus.

*Colonies* with optimal growth at 25°C on 2% MEA, reaching 19 mm in diameter in 6 days. No growth below 5°C or above 30°C. Able to withstand high concentrations of cycloheximide no reduction in growth on 0.1 g/l cycloheximide after days at 25°C in the dark. Colonies olivaceous (19" f). *Colony margin* smooth. *Hyphae* submerged or on top of agar with no aerial mycelium, light olivaceous to hyaline, smooth, occasionally constricted at the septa, (2.0-) 2.5 - 4.0 (-5.0)  $\mu\text{m}$  diameter.

**Specimens examined:** Holotype: New Zealand, *Pinus strobus*, collected: M. Dick,

PREM 45703. **Paratypes:** New Zealand, *P. radiata*, collected: M. Dick, PREM 45701; *Pinus strobus*, New Zealand, collected: M. Dick; PREM 56363. **Cultures:** New Zealand, *Pinus strobus*, collected: M. Dick, CMW 259; *Pinus strobus*, New Zealand, collected: M. Dick; CMW 301.

**Known distribution:** New Zealand.

**Host/substrate:** *Pinus strobus* (Jacobs *et al.*, 1999).

**Associated insects:** not known.

**Notes:** Isolates of *Leptographium euphyes* have been mistakenly identified as *L. procerum* (Wingfield & Marasas, 1983). However, this species is unlike isolates of *L. procerum* and can be distinguished based on its short robust conidiophores (Jacobs *et al.*, 1999). *Leptographium euphyes* is morphologically similar to *L. grandifoliae*. These species could, however, be distinguished based on the presence of a teleomorph in the latter species (Davidson, 1976) and its absence in the former species. In the absence of a teleomorph, *L. euphyes* can be distinguished from *O. grandifoliae* based on more complex conidiogenous apparatuses as well as larger conidia (4 - 6  $\mu\text{m}$ ) compared to *O. grandifoliae* (2.5 - 4  $\mu\text{m}$ ).

*Leptographium euphyes* is commonly isolated together with *L. procerum* in New Zealand. The fungus originates from a collection of isolates that were linked to a report of a root disease of *Pinus strobus* in New Zealand (Shaw & Dick, 1980). Later, Wingfield and Marasas (1983) studied this collection of isolates and noted that it represented isolates having two distinct morphological forms. These included one group that was typical of *L. procerum* and another which were considered to be different. This latter group represents *Leptographium euphyes*. Nothing is known about the pathogenicity of *L. euphyes* although we expect that they are mildly pathogenic or saprophytic associates of the insects with which they are associated.

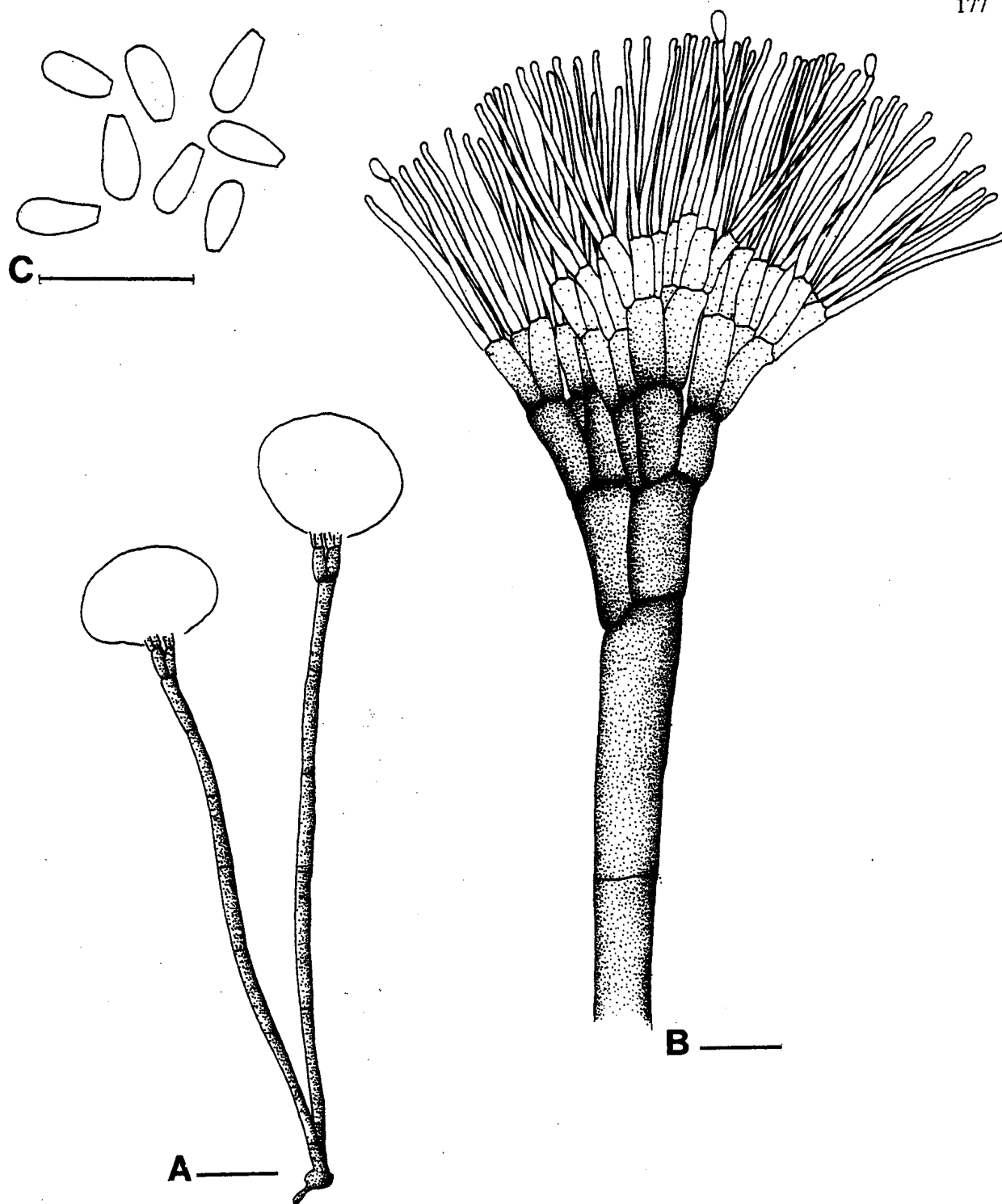
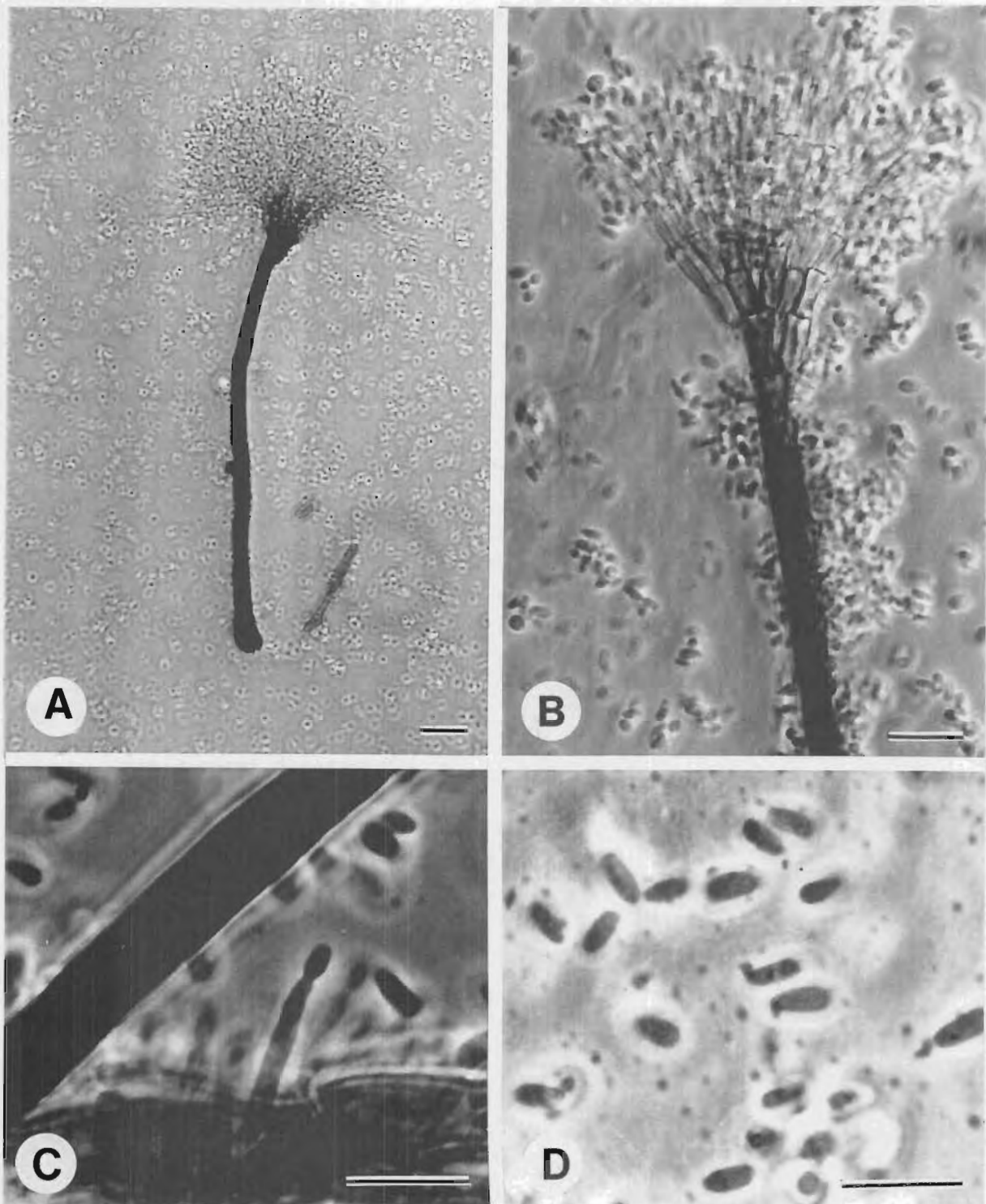
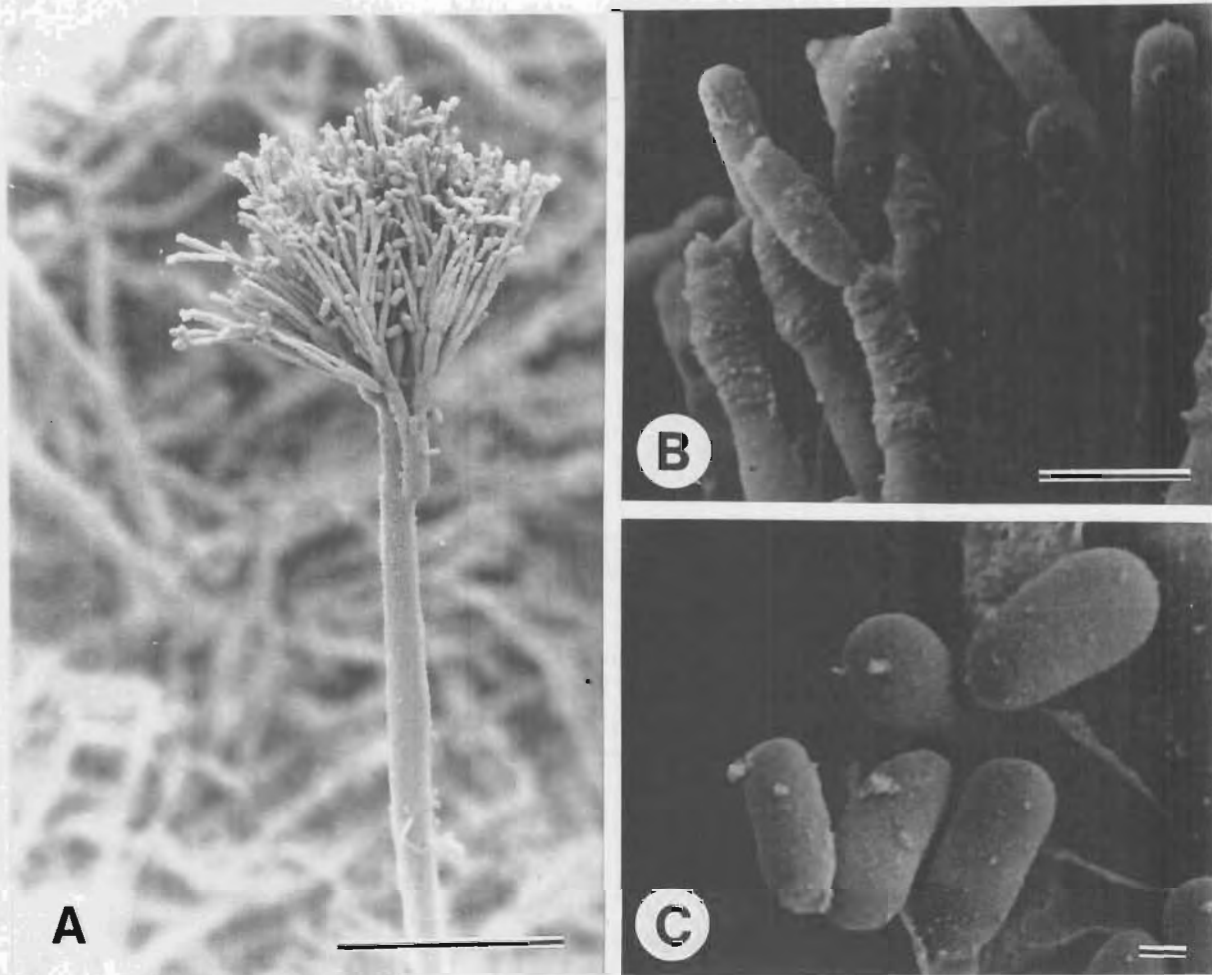


Fig. 69. Conidiophores and conidia of *L. euphyes* (PREM 45703). A. Habit sketch (Bar = 100  $\mu\text{m}$ ). B. Conidiogenous apparatus (Bar = 10  $\mu\text{m}$ ). C. Conidia (Bar = 10  $\mu\text{m}$ ).





**Fig. 70.** Light micrographs of the conidiophores and conidia of *L. euphyes* (PREM 45703). **A.** Conidiophore (Bar = 20  $\mu\text{m}$ ). **B.** Conidiogenous apparatus (Bar = 20  $\mu\text{m}$ ). **C.** Conidiogenous cells (Bar = 10  $\mu\text{m}$ ). **D.** Conidia (Bar = 10  $\mu\text{m}$ ).



**Fig. 71.** Scanning electron micrographs of the conidiophores and conidia of *L. euphyes* (PREM 45703).  
**A.** Conidiophore (Bar = 50  $\mu\text{m}$ ). **B.** Conidiogenous cells (Bar = 5  $\mu\text{m}$ ). **C.** Conidia (Bar = 1  $\mu\text{m}$ ).

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19. *Ophiostoma francke-grosmanniae* (R.W. Davidson) De Hoog & R.J. Scheff., *Mycologia* 76, 297. 1984. (Figs. 72-74).

≡ *Ceratocystis francke-grosmanniae* R.W. Davidson, *Mycologia* 63, 6. 1971.

**Anamorph:** *Leptographium francke-grosmanniae* Jacobs & Wingfield sp. nov.

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**Etymology:** fran-cke-gros-mán-ni-ae: genitive of Francke-Grosmann. This specific epithet honors Helene Francke-Grosmann, who made major contributions in the study of blue-stain fungi and in particular species in the genera *Ophiostoma* and *Leptographium*.

*Perithecial bases* black to dark brussels brown (15m), globose and smooth walled, unornamented, 115 - 160 µm in diam. *Perithecial neck* dark brussels brown to black, cylindrical with a slight apical taper, smooth, 200 - 300 µm long, 30 - 35 µm above globose base, 20 - 25 µm wide at the apex, *ostiole hyphae* convergent. *Asci* prototunicate, hyaline, evanescent. *Ascospores* reniform, almost cucullate, aseptate, hyaline, invested in a sheath, 3.0 - 4.0 x 1.0 - 2.5 µm, without sheath (Davidson, 1971).

*Conidiophores* occurring singly or in groups up to 4, arising directly from the mycelium, erect, macronematous, mononematous, (59-) 105.5 - 134 (-170.5) µm in length, rhizoid-like structures present. *Stipes* light olivaceous (21" k), smooth, cylindrical, simple, 4-7 septate, (43.5-) 91.5 - 93.5 (-150) µm long, 3.0 - 6.0 µm wide below primary branches, apical cell not swollen, (6.0-) 8.5 - 10.5 (-11) µm wide at base, basal cell occasionally swollen. *Conidiogenous apparatus* (15.5-) 26.5 - 29 (-39) µm long, excluding the conidial mass, with 1 to 2 series of cylindrical branches, 2-3 primary branches, hyaline to light olivaceous (21" k), smooth, cylindrical, aseptate (8.0-) 9.5 - 11.5 (-14) µm long and 3.0 - 6.0 µm wide, arrangement of the primary branches on the stipe - type B, secondary branches hyaline, aseptate, (6.0-) 9.0 - 10.5 (-12.5) µm long, 2.0 - 4.0 µm wide. *Conidiogenous cells* discrete, 2-3 per branch, cylindrical, tapering slightly at the apex, (6.0-) 7.5 - 10 (-11) µm long and 2.0 - 3.0 µm wide. Tightly packed annulations gives a phialidic appearance to the conidiogenous cells under the light microscope (Mouton, Wingfield and Van Wyk,

1992). *Conidia* hyaline, aseptate, broadly ellipsoid with truncate ends and rounded apices, (2.5-) 3.0 - 4.5 (-5.0) x 1.0 - 2.5  $\mu\text{m}$ . Conidia accumulating in slimy droplets at the apex of conidiogenous apparatus, hyaline. Conidial mass hyaline when wet, turning cream colored (19'f) when dry.

*Colonies* with optimal growth at 25°C on 2% MEA, reaching 9 mm in diam. in 8 days. No growth below 10°C with little growth at 35°C. Able to withstand high concentrations of cycloheximide with no reduction in growth on 0.5 g/l cycloheximide after 12 days at 20°C in the dark. Colonies cartridge buff (19''f) at first becoming olivaceous (21''m) with age. *Colony margin* smooth. *Hyphae* submerged on agar with no aerial mycelium, hyaline, smooth, straight, not constricted at the septa, (1.5-) 3.0 - 4.5 (-6.0)  $\mu\text{m}$  diam.

**Specimens examined: Holotype:** West Germany, *Quercus* sp., May 1967, collected: R.W. Davidson, BPI 595654 (received from NFC). **Cultures:** Germany, Reinbeck, *Quercus* infested with *Hylecoetus dermestoides*, May 1967, collected: Helene Francke-Grosmann, CMW 445, CMW 2857.

**Known distribution:** Germany.

**Hosts/substrate:** *Quercus* sp. (Davidson, 1971).

**Associated insects:** *Hylecoetus dermestoides* (Davidson, 1971).

**Notes:** *Ophiostoma francke-grosmanniae* was considered to be similar to *O. leptographioides* but could be distinguished based on perithecial dimensions (Davidson, 1971). The conidiogenous cells of this species superficially resemble phialides and it was at one time thought to reside in *Phialocephala* (Upadhyay, 1981). Mouton *et al.*, (1992) determined that the conidiogenous cells are annelidic and that this species can tolerate high concentrations of cycloheximide, in contrast to species of *Phialocephala* (Harrington, 1988; Marais, 1996). Nothing is known about the pathogenicity of this species.

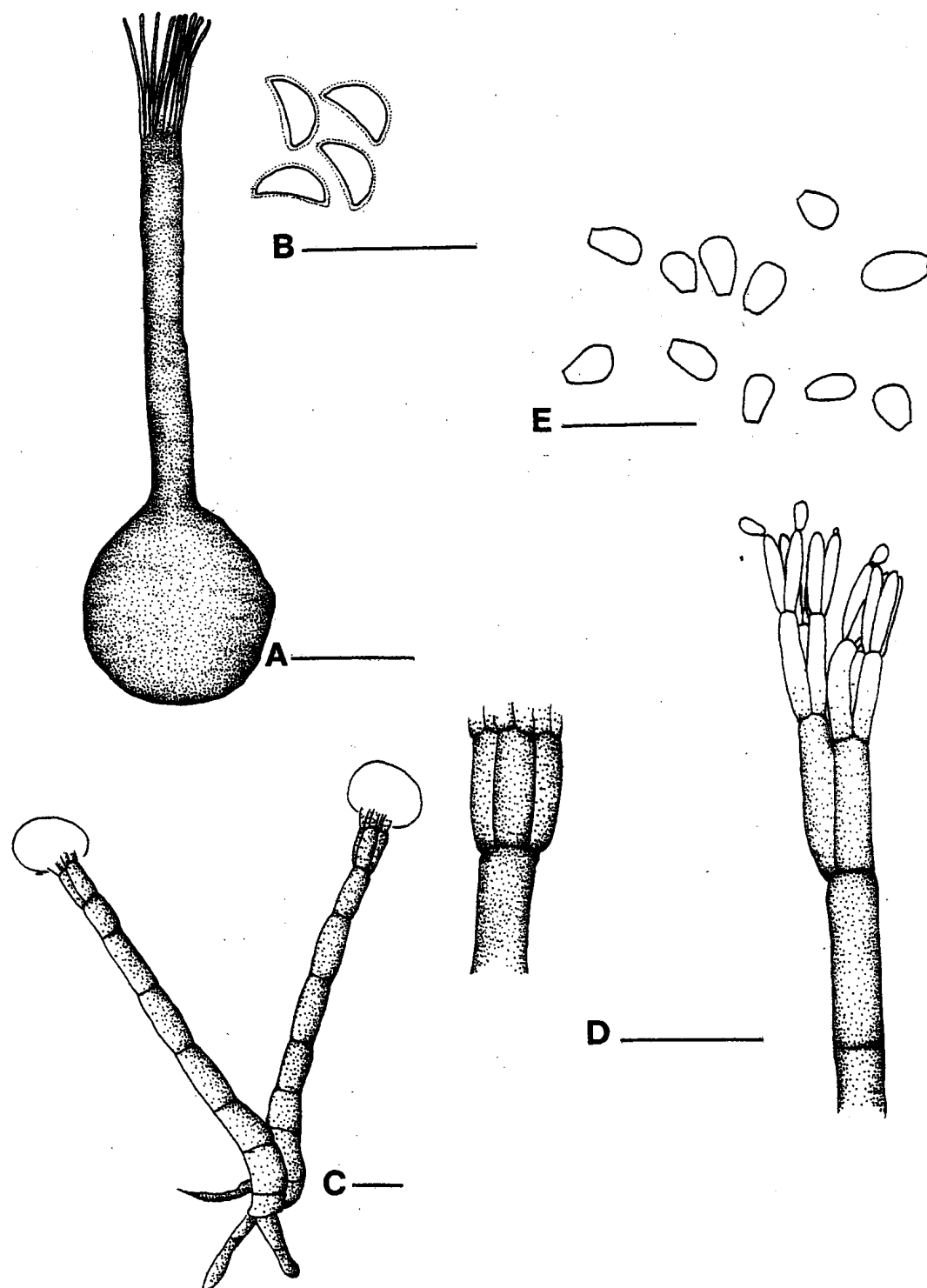
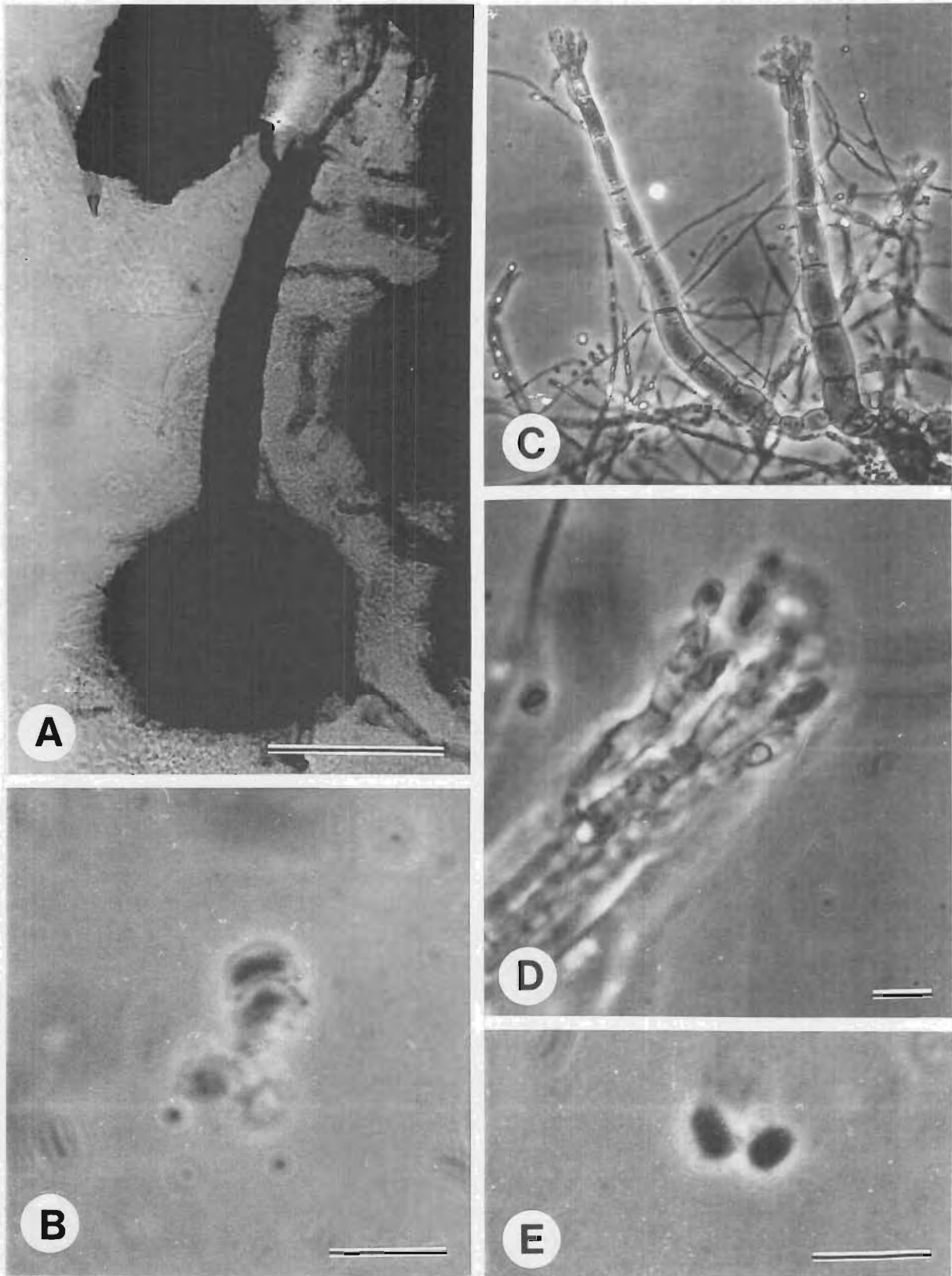
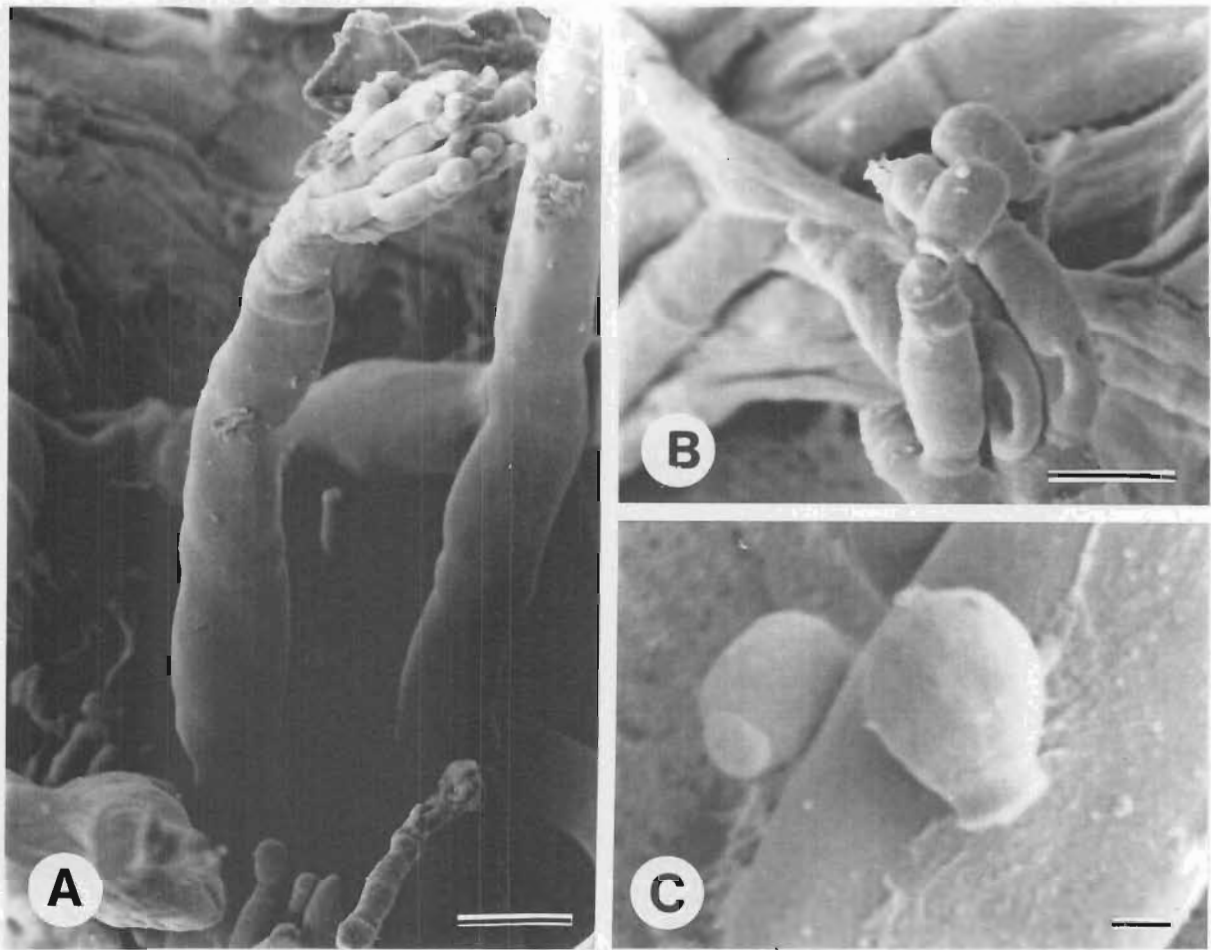


Fig. 72. Teleomorph and anamorph structures of *O. francke-grosmanniae* (CMW 445). A. Perithecium (Bar = 100  $\mu\text{m}$ ). B. Ascospores (Bar = 10  $\mu\text{m}$ ). C. Conidiophore (Bar = 10  $\mu\text{m}$ ). D. Conidiogenous apparatus (Bar = 10  $\mu\text{m}$ ). E. Conidia (Bar = 10  $\mu\text{m}$ ).



**Fig. 73.** Light micrographs of the teleomorph and anamorph structures of *O. franke-grosmanniae* (CMW 445). **A.** Perithecium (Bar = 100  $\mu$ m). **B.** Ascospore (Bar = 10  $\mu$ m). **C.** Conidiophore (Bar = 10  $\mu$ m). **D.** Conidiogenous cells (Bar = 10  $\mu$ m). **E.** Conidia (Bar = 10  $\mu$ m).





**Fig. 74.** Scanning electron micrographs of the conidiophores and conidia of *O. francke-grosmanniae* (CMW 445). **A.** Conidiophore (Bar = 10  $\mu\text{m}$ ). **B.** Conidiogenous cells (Bar = 5  $\mu\text{m}$ ). **C.** Conidia (Bar = 1  $\mu\text{m}$ ).



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**20. *Ophiostoma grandifoliae*** (R.W. Davidson) T.C. Harr., *Mycotaxon* **28**, 41. 1987. (Figs. 75-77).

≡ *Ceratocystis grandifoliae* R.W. Davidson, *Memoirs of the New York Botanical Garden* **28**, 45. 1976.

**Anamorph:** *Leptographium grandifoliae* (R.W. Davidson) M.J. Wingf., *Transactions of the British Mycological Society* **85**, 92. 1985.

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**Etymology:** gran-di-fo-li-ae: of the large leaves. From the Latin adjective grandis: large and Latin noun folium: a leaf. This specific epithet refers to *Fagus grandifoliae* which is the host of this fungus.

*Perithecial bases* black, globose and smooth walled, unornamented, 170 - 200 µm in diam. *Perithecial neck* black, cylindrical with a slight apical taper, smooth, 500 - 1700 µm long, 40 - 55 µm above globose base, 20 - 30 µm wide at the apex, *ostiole hyphae* convergent. *Asci* prototunicate, hyaline, evanescent. *Ascospores* allantoid, aseptate, hyaline, invested in a sheath, 3.2 - 4.5 x 1.6 - 2.5 µm (Davidson, 1976).

*Conidiophores* occurring in groups of up to 8, mostly on aerial mycelium, erect, macronematous, mononematous, 80 - 374 (-397.5) µm in length, rhizoid-like structures present. *Stipes* light olivaceous (21" k), smooth, cylindrical, simple, 2-14 septate, 62.5 - 327 (-347.5) µm long, (2.5-) 3.0 - 4.5 (-5.0) µm wide below primary branches, apical cell not swollen, 4.0 - 7.5 µm wide at base, basal cell not swollen. *Conidiogenous apparatus* (20-) 21.5 - 46 (-62.5) µm long, excluding the conidial mass, with 1 to occasionally 3 series of cylindrical branches, 2 - 3 primary branches, light olivaceous (21" k), smooth, cylindrical, aseptate, (6.0-) 8.5 - 10 (-13) µm long and 2.0 - 3.5 (-5.0) µm wide, arrangement of the primary branches on the stipe - type B, secondary branches light olivaceous (21" k) to hyaline, aseptate, (5.5-) 7.0 - 8.5 (-12) µm long, 2.0 - 3.0 µm wide, tertiary branches hyaline, aseptate, 5.5 - 9.0 µm long, 1.0 - 2.5 µm wide. *Conidiogenous cells* discrete, 2-3 per branch, cylindrical, tapering slightly at the apex, (10-) 12 - 15.5 (-18.5) µm long and 1.0 - 2.0 µm wide. *Conidia* hyaline, aseptate, obovoid with truncate ends and rounded apices, 2.5 - 4.0 x 1.0 - 2.0 µm. Conidia accumulating in slimy droplets at the apex of conidiogenous



apparatus, hyaline at first, becoming cream colored (19'f) with age. Conidial mass cream colored when wet, turning amber (21'b) when dry.

*Colonies* with optimal growth at 25°C on 2% MEA, reaching 9 mm in diam. in 8 days. No growth below 10°C with some growth at 35°C. Able to withstand high concentrations of cycloheximide with a 22% reduction in growth on 0.5 g/l cycloheximide after 12 days at 20°C in the dark. Colonies gray olivaceous (21'''). *Colony margin* smooth. *Hyphae* above on agar with abundant aerial mycelium, hyaline, smooth, straight, not constricted at the septa, 1.5 - 3.0 µm diam.

**Specimens examined: Holotype:** U.S.A., eastern Iowa, *Fagus grandifoliae*, 1976, collected: R.W. Davidson, BPI 596248 (received from NFC). **Cultures:** U.S.A., eastern Iowa, *Fagus grandifoliae*, 1976, collected: R.W. Davidson, CMW 703 (same as ATCC 28746).

**Known distribution:** U.S.A.

**Hosts/substrate:** *Fagus grandifoliae* (Davidson, 1976).

**Associated insects:** Not known.

**Notes:** *Ophiostoma grandifoliae* is similar to *L. sibiricum* and *O. leptographioides*. *Ophiostoma grandifoliae* can be distinguished from *L. sibiricum* based on the presence of rhizoids at the base of conidiophores, and the absence of these structures in *L. sibiricum*. In addition, *O. grandifoliae* is associated with a teleomorph, whereas no teleomorph has been reported for *L. sibiricum*.

*Ophiostoma grandifoliae* is one of a small number of *Leptographium* spp. not isolated from a coniferous host. This is also true for *O. leptographioides*. *Ophiostoma leptographioides* is associated with an *Ophiostoma* teleomorph, which makes it similar to *O. grandifoliae*. *Ophiostoma grandifoliae* and *O. leptographioides* can be distinguished from each other based on the longer conidia of the latter species. Furthermore, *Ophiostoma grandifoliae* is characterized by perithecia with long necks and small allantoid ascospores. This is in contrast to the short-necked

perithecia and pillow-shaped ascospores of *O. leptographioides*. *Ophiostoma grandifoliae* has been isolated from blue-stain in sapwood of *Fagus grandifolia* (Davidson, 1976). This is the only report of this fungus to date (Harrington, 1988).

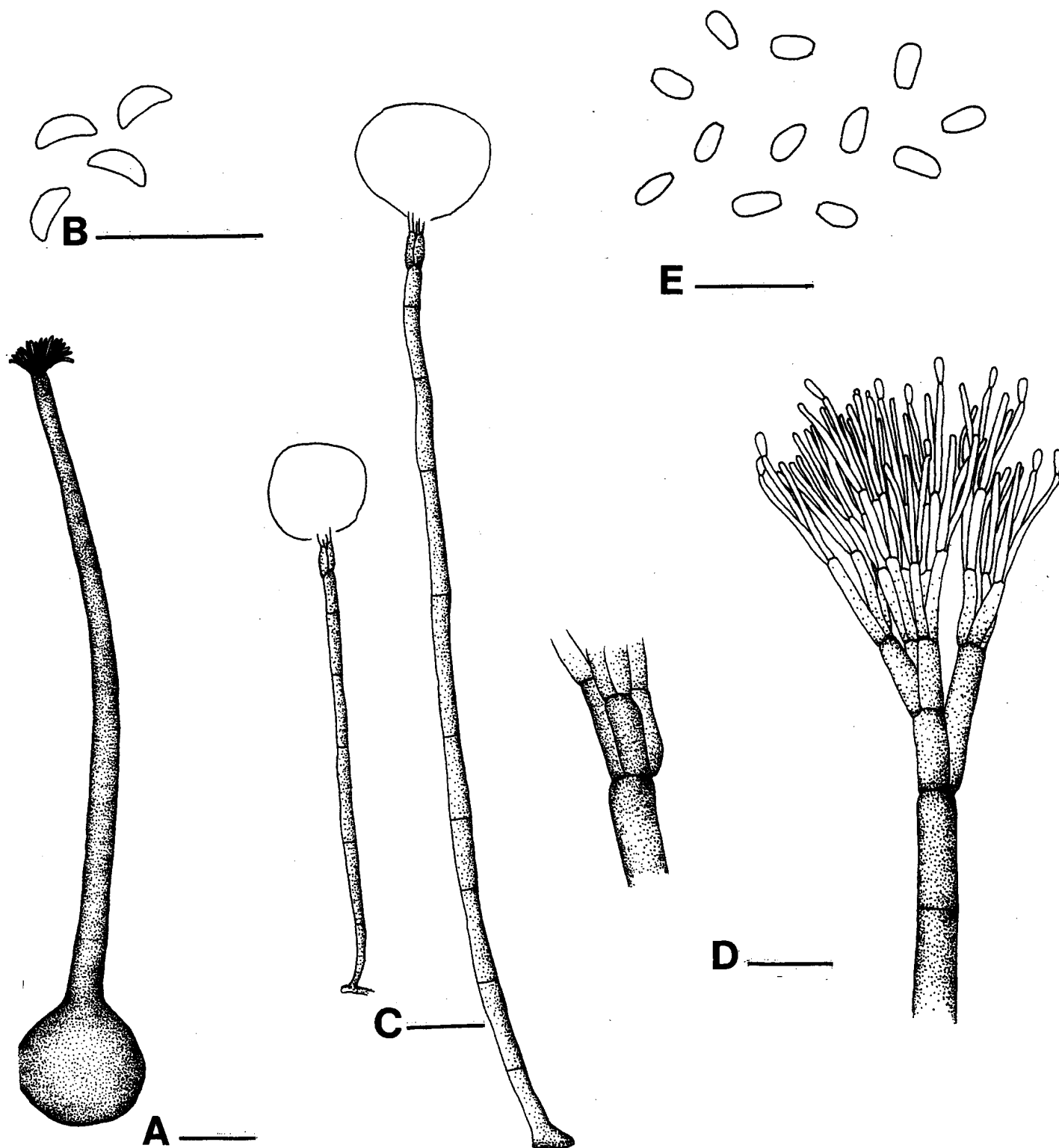
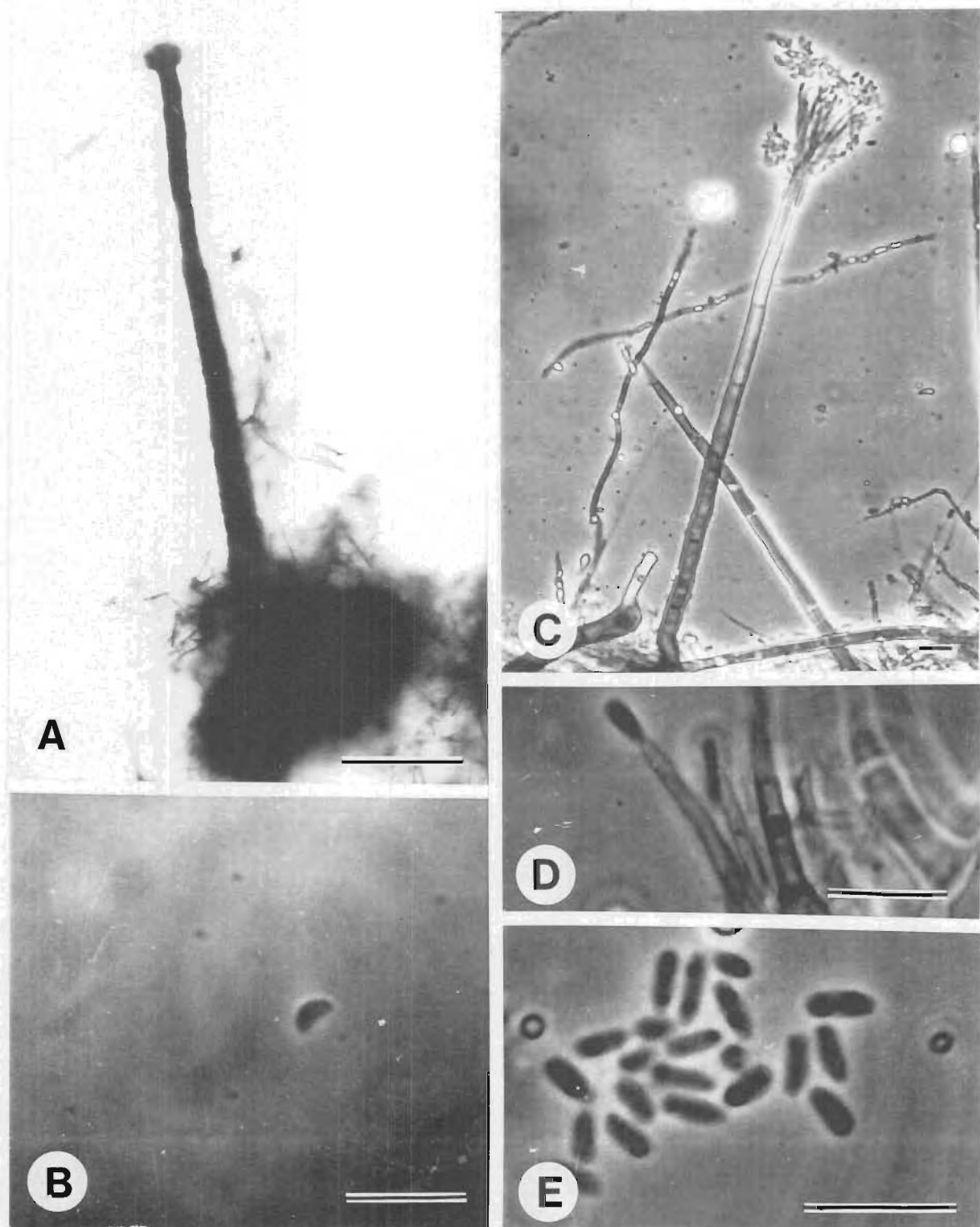
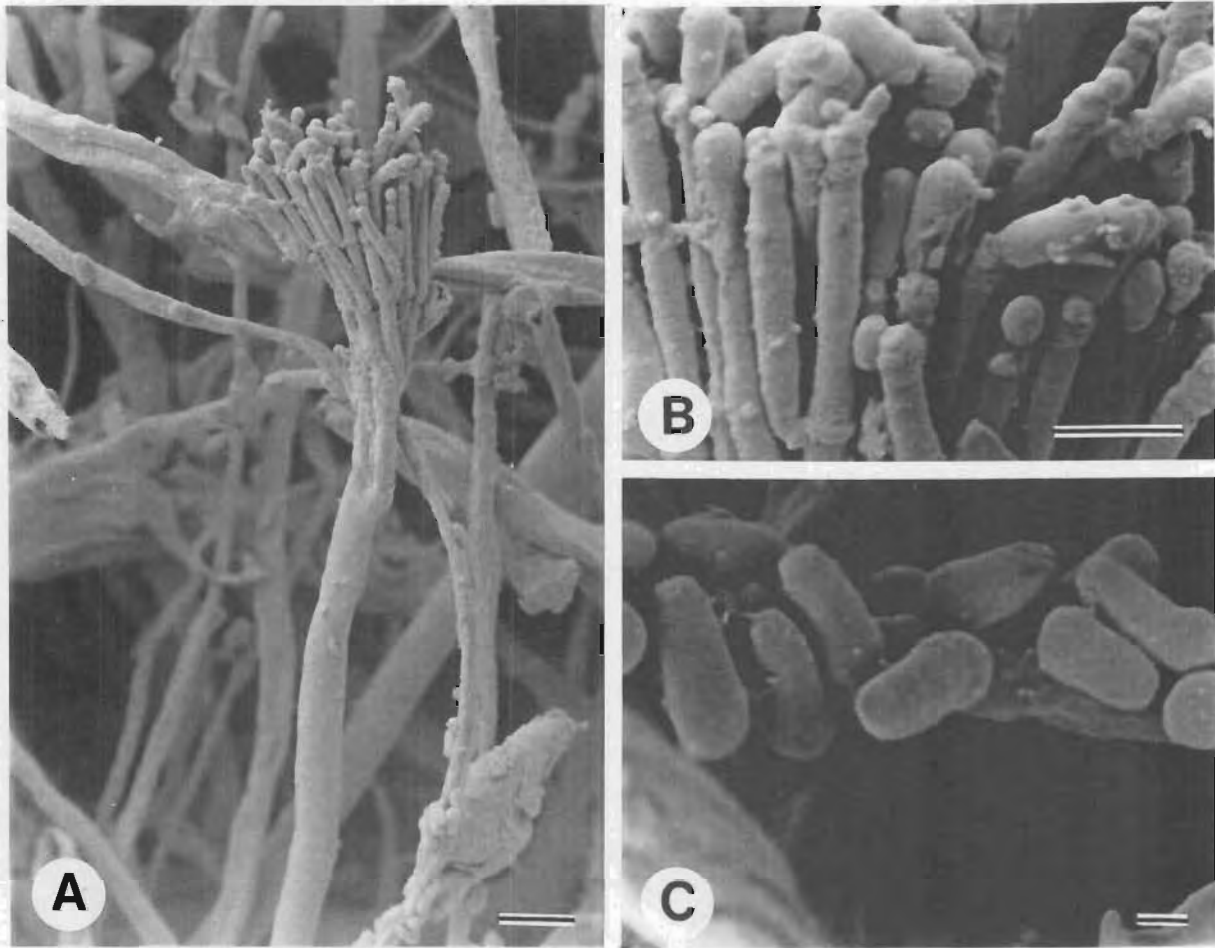


Fig. 75. Teleomorph and anamorph structures of *O. grandifoliae* (CMW 703). A. Perithecium (Bar = 100  $\mu\text{m}$ ). B. Ascospores (Bar = 10  $\mu\text{m}$ ). C. Conidiophore (Bar = 10  $\mu\text{m}$ ). D. Conidiogenous apparatus (Bar = 10  $\mu\text{m}$ ). E. Conidia (Bar = 10  $\mu\text{m}$ ).



**Fig. 76.** Light micrographs of the teleomorph and anamorph structures of *O. grandifoliae* (CMW 703). **A.** Perithecium (Bar = 100  $\mu$ m). **B.** Ascospore (Bar = 10  $\mu$ m). **C.** Conidiophore (Bar = 10  $\mu$ m). **D.** Conidiogenous cells (Bar = 10  $\mu$ m). **E.** Conidia (Bar = 10  $\mu$ m).





**Fig. 77.** Scanning electron micrographs of the conidiophores and conidia of *O. grandifoliae* (CMW 703).  
**A.** Conidiophore (Bar = 10  $\mu\text{m}$ ). **B.** Conidiogenous cells (Bar = 5  $\mu\text{m}$ ). **C.** Conidia (Bar = 1  $\mu\text{m}$ ).



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**21. *Leptographium guttulatum*** M.J. Wingf. & K. Jacobs, *Mycological Research*. 1999. (Figs. 78-80).

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**Teleomorph:** Not known.

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**Etymology:** gut-tu-lá-tum: provided with droplets. From the Latin noun guttula: a little drop. This specific epithet refers to the guttules or droplets that are characteristic of the conidia of this species.

*Conidiophores* occurring singly, arising directly from the mycelium or aerial mycelium, erect, macronematous, mononematous, (200-) 365 - 465 (-810)  $\mu\text{m}$  in length, rhizoid-like structures absent. *Stipes* olivaceous (21''k), smooth, cylindrical, simple, 2 - 7 septate, (120-) 258 - 343 (-670)  $\mu\text{m}$  long, (5.0-) 6.5 - 10 (-12)  $\mu\text{m}$  wide below primary branches, apical cell not swollen, 5.0 - 12  $\mu\text{m}$  wide at base, basal cell not swollen. *Conidiogenous apparatus* (60-) 107 - 121 (-200)  $\mu\text{m}$  long, excluding the conidial mass, with 2 to 4 series of cylindrical branches, 2-4 primary branches, arrangement of the primary branches - type B, light olivaceous (21''k) to olivaceous (21''m), smooth, cylindrical, aseptate, (18-) 25.5 - 33 (-40)  $\mu\text{m}$  long and 5.0 - 10  $\mu\text{m}$  wide, secondary branches light olivaceous (21''k), aseptate, (15-) 19 - 30 (-35)  $\mu\text{m}$  long, (3.0-) 4.0 - 7.5 (-8.0)  $\mu\text{m}$  wide, tertiary branches hyaline, aseptate, (10-) 16 - 26.5 (-33)  $\mu\text{m}$  long, 3.0 - 5.0  $\mu\text{m}$  wide, quaternary branches hyaline, aseptate, (9.0-) 10 - 19.5 (-25)  $\mu\text{m}$  long, 2.0 - 4.0  $\mu\text{m}$  wide. *Conidiogenous cells* discrete, 2-3 per branch, cylindrical, tapering slightly at the apex, (10-) 11.5 - 21.5 (-27)  $\mu\text{m}$  long and 2.0 - 3.0  $\mu\text{m}$  wide. *Conidia* hyaline, aseptate, oblong to slightly obovoid, prominent guttulate, (4.0-) 5.0 - 9.0 (-10) x 2.0 - 3.0  $\mu\text{m}$ . Conidia accumulating in slimy droplets at the apices of conidiogenous apparatus, hyaline at first, becoming cream coloured (19'f) with age. Conidial masses cream coloured when wet, remaining the same colour when dry.

*Colonies* with optimal growth at 25°C on 2 % MEA, reaching 36 mm in diameter in 9 days. Little growth at 5°C and no growth above 30°C. Able to withstand high concentrations of cycloheximide with a 5% increase in growth on 0.5 g/l cycloheximide after 9 days at 25°C in the dark. Colonies dark olive (21''m). *Colony*

*margin* smooth. *Hyphae* submerged on agar with little aerial mycelium, olivaceous (21" k), smooth, straight, not constricted at the septa, 5.0 - 13 µm diameter.

**Specimens examined:** **Holotype:** France, Orleans, isolated from *Tomicus* sp. from *Pinus sylvestris*, 1984, M. Morelet, PREM 56307. **Paratypes:** England, Fresley Cannon Wood, Hampshire, isolated from *Tomicus piniperda* from *Pinus*, 1988, J.N. Gibbs, PREM 56310; Austria, Niederösterreich, Flatz, isolated from *Hylurgops palliatus* from Norway spruce, 28 May 1997, T. Kirisits, PREM 56311; Austria, Glein, Styria, isolated from *Hylurgops glabratus* from Norway spruce, 3 August 1993, T. Kirisits, PREM 56309; Austria, Niederösterreich, Flatz, isolated from *Hylurgops palliatus* from Norway spruce, 28 May 1998, T. Kirisits, PREM 56308. **Cultures:** France, Orleans, isolated from *Tomicus* sp. from *Pinus sylvestris*, 1984, M. Morelet, CMW 742; England, Fresley Cannon Wood, Hampshire, isolated from *Tomicus piniperda* from *Pinus*, 1988, J.N. Gibbs, CMW 1310; Austria, Niederösterreich, Flatz, isolated from *Hylurgops palliatus* from Norway spruce, 28 May 1997, T. Kirisits, CMW 4921; Austria, Glein, Styria, isolated from *Hylurgops glabratus* from Norway spruce, August 1993, T. Kirisits, CMW 4922; Austria, Niederösterreich, Flatz, isolated from *Hylurgops palliatus* from Norway spruce, 28 May 1998, T. Kirisits, CMW 4923.

**Known distribution:** Europe (England, France, Austria, Sweden).

**Hosts/substrate:** *Picea abies*, *Pinus sylvestris* (Wingfield & Gibbs, 1991; Jacobs *et al.*, 1999)

**Associated insects:** *Hylurgops glabratus* (Jacobs *et al.*, 1999), *Hylurgops palliatus* (Mathiesen, 1950; Harrington, 1988; Wingfield & Gibbs, 1991; Jacobs *et al.*, 1999), *Hylastes ater* (Wingfield & Gibbs, 1991), *Hylastes opacus* (Wingfield & Gibbs, 1991), *Ips typographus* (Mathiesen, 1950), *Tetropium* sp. (Mathiesen, 1950), *Tomicus piniperda* (Jacobs *et al.*, 1999).

**Notes:** Mathiesen (1950) described this species as a variety of *Ophiostoma penicillatum*. Harrington (1988) noted that this variety as well as the "pini" variety

could easily and consistently be distinguished morphologically from *O. penicillatum*. He also indicated that these fungi might represent distinct taxa. Comparison of *L. guttulatum* with *L. penicillatum*, revealed that these species could easily be distinguished from each other. Whereas *L. penicillatum* is characterized by large allantoid conidia, the conidia of *L. guttulatum* are also large, but more globose than those of *L. penicillatum*. The conidiogenous apparatuses of *L. guttulatum* have a similar brush-shaped appearance to those found in *L. piceaperdum*. These species can, however, be distinguished based on the larger, guttulate conidia of *L. guttulatum*. These two species were clearly separated when comparing ribosomal DNA sequences (Coetsee, 1999).



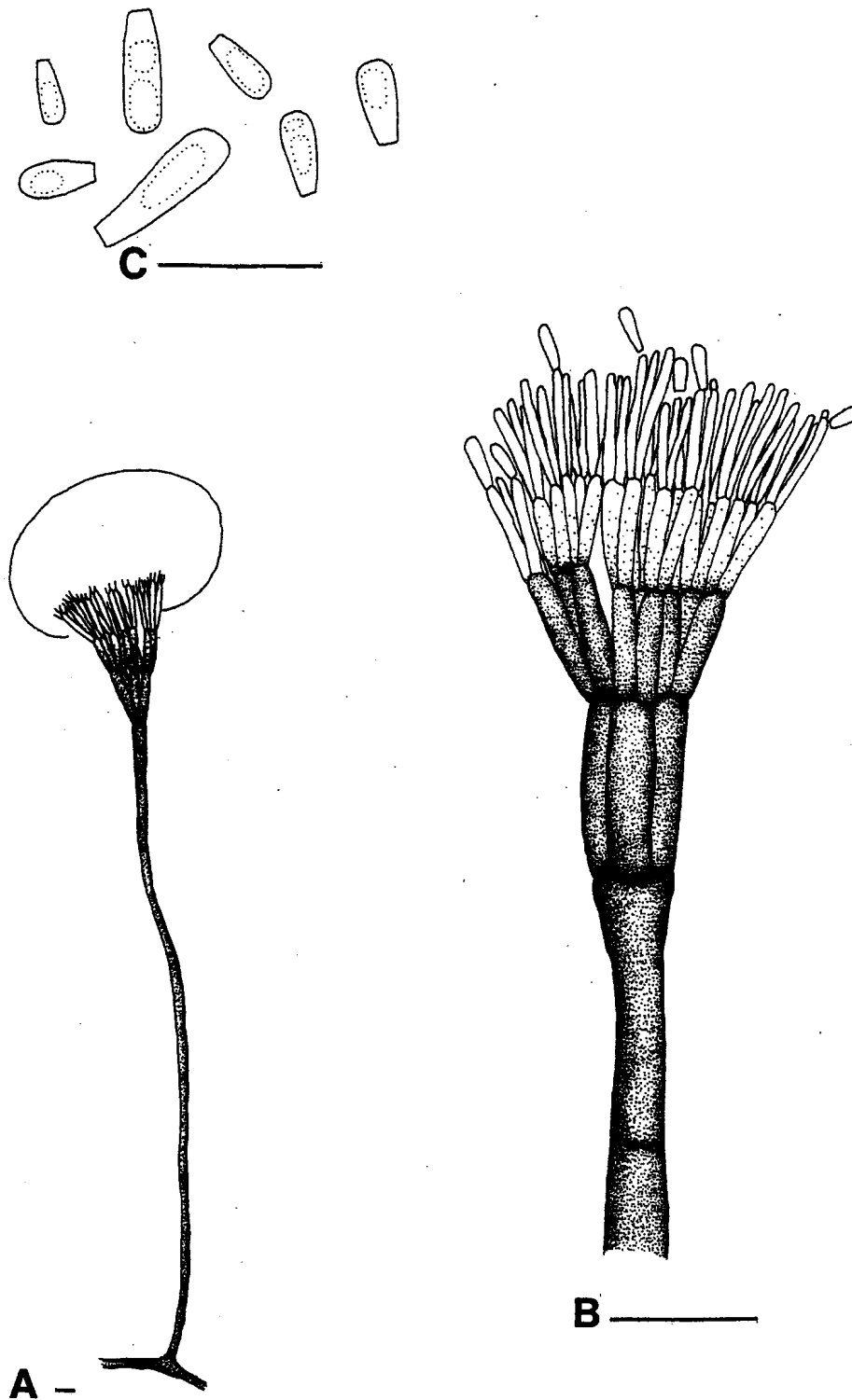
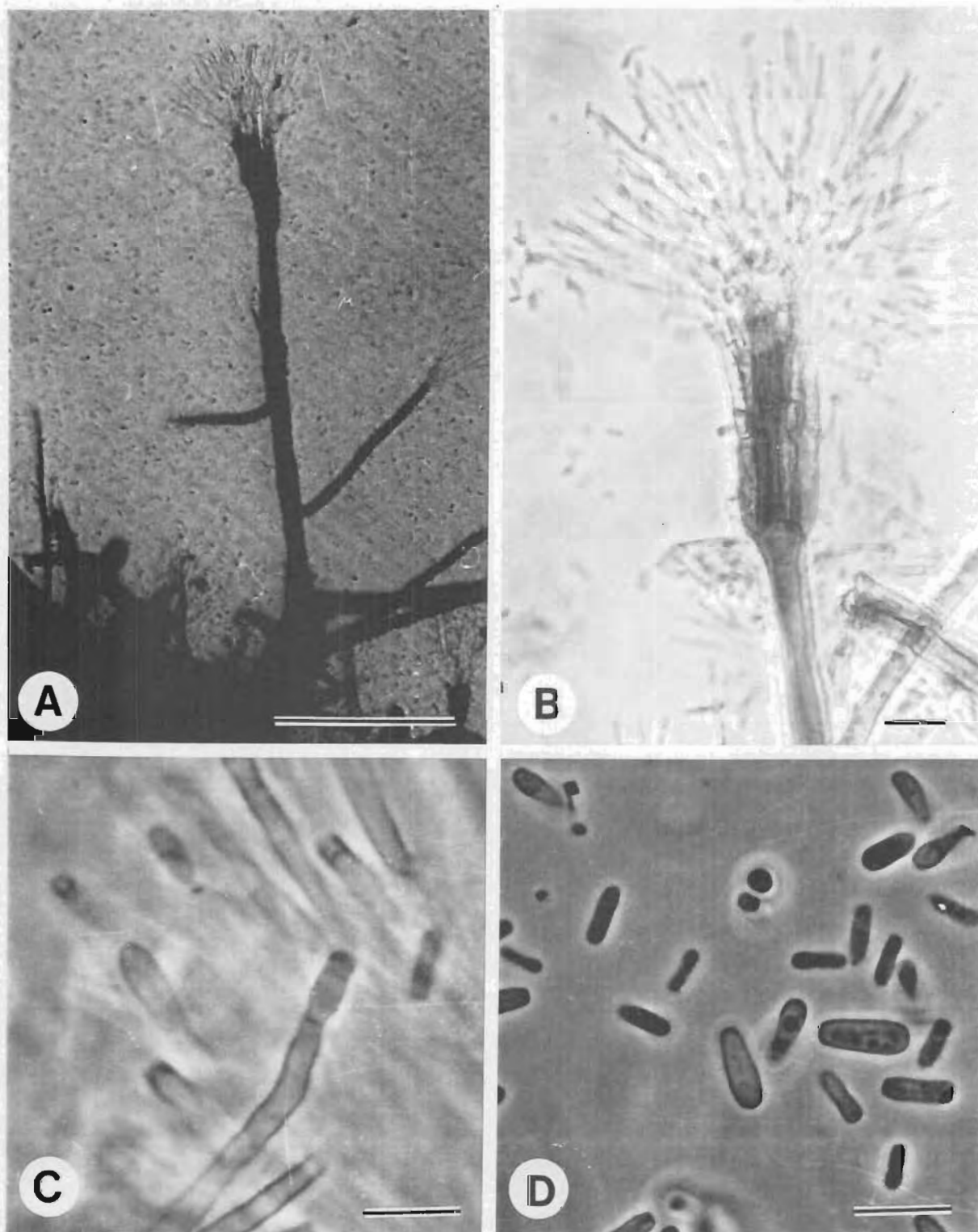
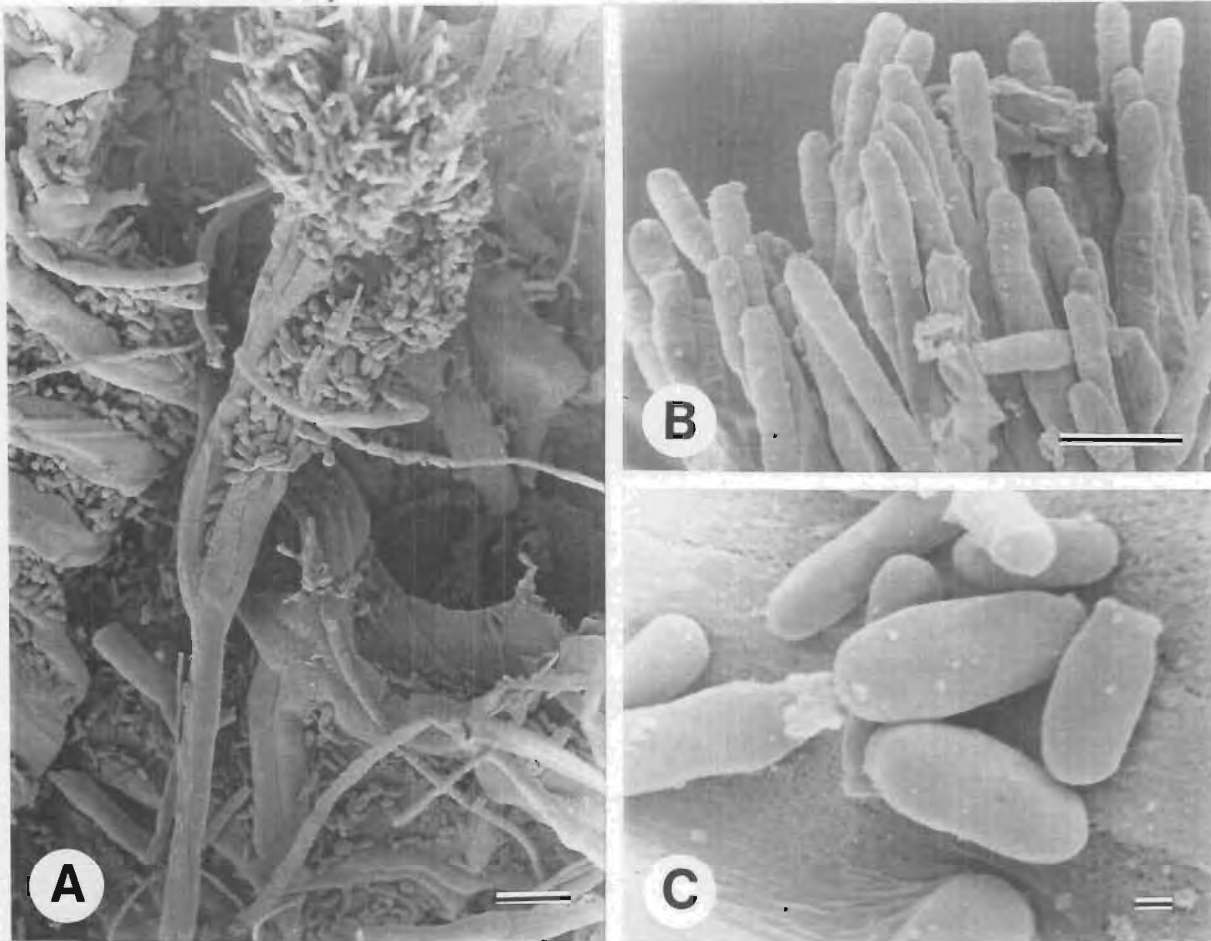


Fig. 78. Conidiophores and conidia of *L. guttulatum* (PREM 56307). A. Habit sketch (Bar = 10  $\mu$ m). B. Conidiogenous apparatus (Bar = 10  $\mu$ m). C. Conidia (Bar = 10  $\mu$ m).



**Fig. 79.** Light micrographs of the conidiophores and conidia of *L. guttulatum* (PREM 56307). **A.** Conidiophore (Bar = 100  $\mu\text{m}$ ). **B.** Conidiogenous apparatus (Bar = 10  $\mu\text{m}$ ). **C.** Conidiogenous cells (Bar = 10  $\mu\text{m}$ ). **D.** Conidia (Bar = 10  $\mu\text{m}$ ).





**Fig. 80.** Scanning electron micrographs of the conidiophores and conidia of *L. guttulatum* (PREM 56307).  
**A.** Conidiophore (Bar = 10  $\mu\text{m}$ ). **B.** Conidiogenous cells (Bar = 10  $\mu\text{m}$ ). **C.** Conidia (Bar = 1  $\mu\text{m}$ ).

**22. *Leptographium hughesii*** K. Jacobs, M.J. Wingf. & T.C. Harr., *Canadian Journal of Botany* **76**, 1662. 1999. (Figs. 81-83).

**Teleomorph:** Not known.

**Etymology:** h́ughe-si-i: genitive of Hughes. This specific epithet honors S.J. Hughes who established the genus *Verticicladiella* in 1953.

*Conidiophores* occurring singly or in groups of up to eight, arising directly from the agar or aerial mycelium, erect, macronematous, mononematous, (240-) 559.5 - 913 (-1200)  $\mu\text{m}$  in length, rhizoid-like structures present at the base. *Stipes* olive-buff (21''b), smooth, cylindrical, simple, 4 - 18 septate, (210-) 484.5 - 711 (-1130)  $\mu\text{m}$  long (3.5-) 4.0 - 7.5  $\mu\text{m}$  wide below primary branches, apical cell not swollen, 5.0 - 12.0  $\mu\text{m}$  wide at base, basal cell slightly swollen. *Conidiogenous apparatus* (30.0-) 67.5 - 89 (-175)  $\mu\text{m}$  long, excluding the conidial mass, with 2 to 3 (occasionally 4) series of cylindrical branches, 2 to 3 primary branches, olive-buff (21''b), arrangement of primary branches - type B, smooth, cylindrical, aseptate, (7.5-) 16 - 25 (-35.5)  $\mu\text{m}$  long and (2.0-) 3.5 - 5.5 (-6.0)  $\mu\text{m}$  wide, secondary branches hyaline to olive-buff (21''b), aseptate, (6.0-) 10 - 14 (-16)  $\mu\text{m}$  long, 2.0 - 4.0)  $\mu\text{m}$  wide, tertiary branches hyaline, aseptate, 4.0 - 13.5  $\mu\text{m}$  long, 1.0 - 3.0  $\mu\text{m}$  wide, quaternary branches aseptate, 6.0 - 8.5  $\mu\text{m}$  long, 1.0 - 2.0  $\mu\text{m}$  wide. *Conidiogenous cells* discrete, 2 to 4 per branch, tapering slightly from the base to the apex, (8.0-) 9.0 - 15.5 (-18.5)  $\mu\text{m}$  long and 1.0 - 2.0  $\mu\text{m}$  wide. *Conidia* hyaline, aseptate, ellipsoid to obovoid, occasionally slightly curved, 1.0 - 2.5 x 3.0 - 5.0  $\mu\text{m}$  . Conidia accumulating in white, slimy droplets at the apex of conidiogenous apparatus.

*Colonies* with optimal growth at 25°C on 2% MEA, reaching 8 mm in diam. after 8 days, with little growth at 5°C and no growth at 35°C. Colonies olivaceous (21''m), with lacinate margins. Able to withstand high concentrations of cycloheximide with a 60% increase in linear growth on 0.1 mg/ml cycloheximide, with a 63% reduction in growth on 0.5 g/l cycloheximide after 8 days at 20°C in the dark. Colony covered in a dense mat of aerial mycelium, hyphae mostly submerged, hyaline, smooth, straight, not constricted at the septa, 1.0 - 6.0  $\mu\text{m}$  diam.

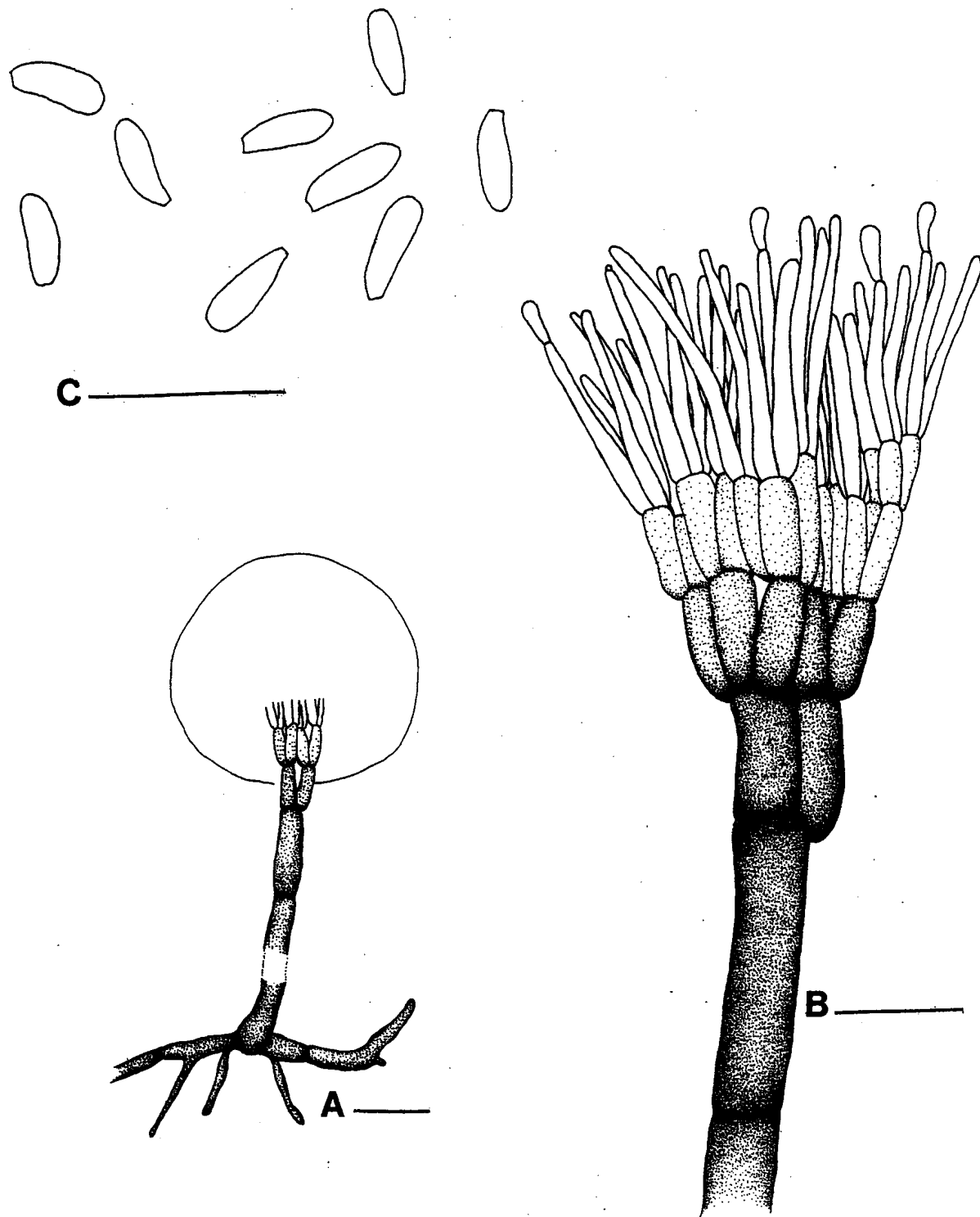
**Specimens examined: Holotype:** England, on a ship from Borneo, Princess Risborough, *Parashorea plicata*, December 1957, Savary, DAOM 62102. **Cultures:** Southern part of Vietnam, Phu Quoc island, isolated from the wounds of live *Aquilana* sp., June, 1996, B. Blanchette, CMW 4052.

**Known distribution:** Borneo, Vietnam.

**Hosts/substrate:** *Parashorea plicata* (Kendrick, 1962; Jacobs *et al.*, 1999).

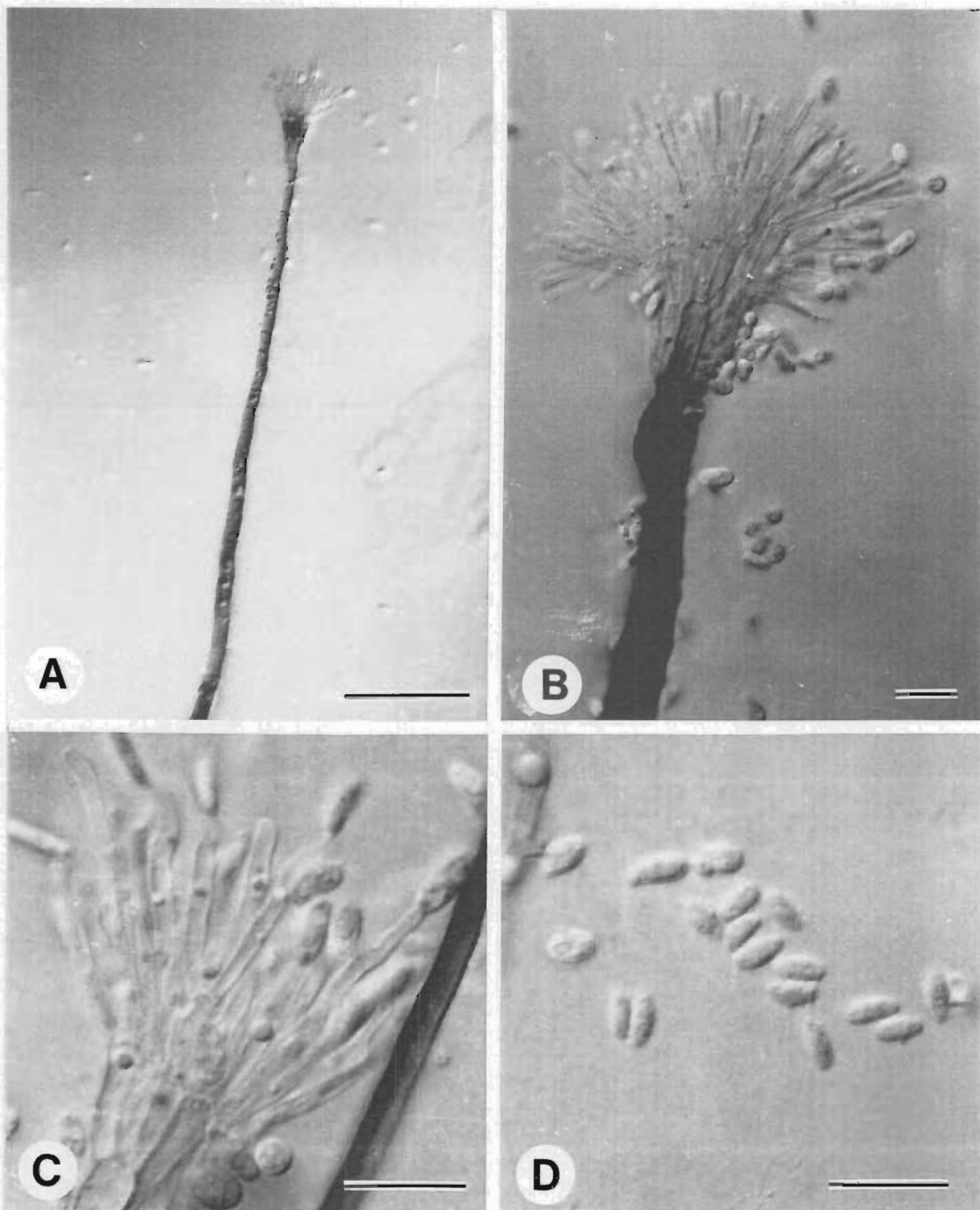
**Associated insects:** Not known (Kendrick, 1962; Jacobs *et al.*, 1999).

**Notes:** This fungus was initially identified as a specimen of *L. abietinum* (Kendrick, 1962) due to the fact that its conidia are slightly curved, similar those of *L. abietinum*. Closer examination of the herbarium type as well as new isolates revealed that this specimen could readily be distinguished from other isolates identified as *L. abietinum*. The colonies of *L. hughesii* are characterized by a thick mat of aerial mycelium that covers the whole colony. This character has not been observed in isolates of *L. abietinum*. *Leptographium hughesii* originates from a non-coniferous host in Asia, which is in contrast to *L. abietinum* that occurs exclusively in North America, and is almost always associated with conifers, especially spruce (Kendrick, 1962; Jacobs *et al.*, 1999). *Leptographium abietinum* is also associated with insect infesting spruce, whereas no insect associations has been reported for *L. hughesii*.



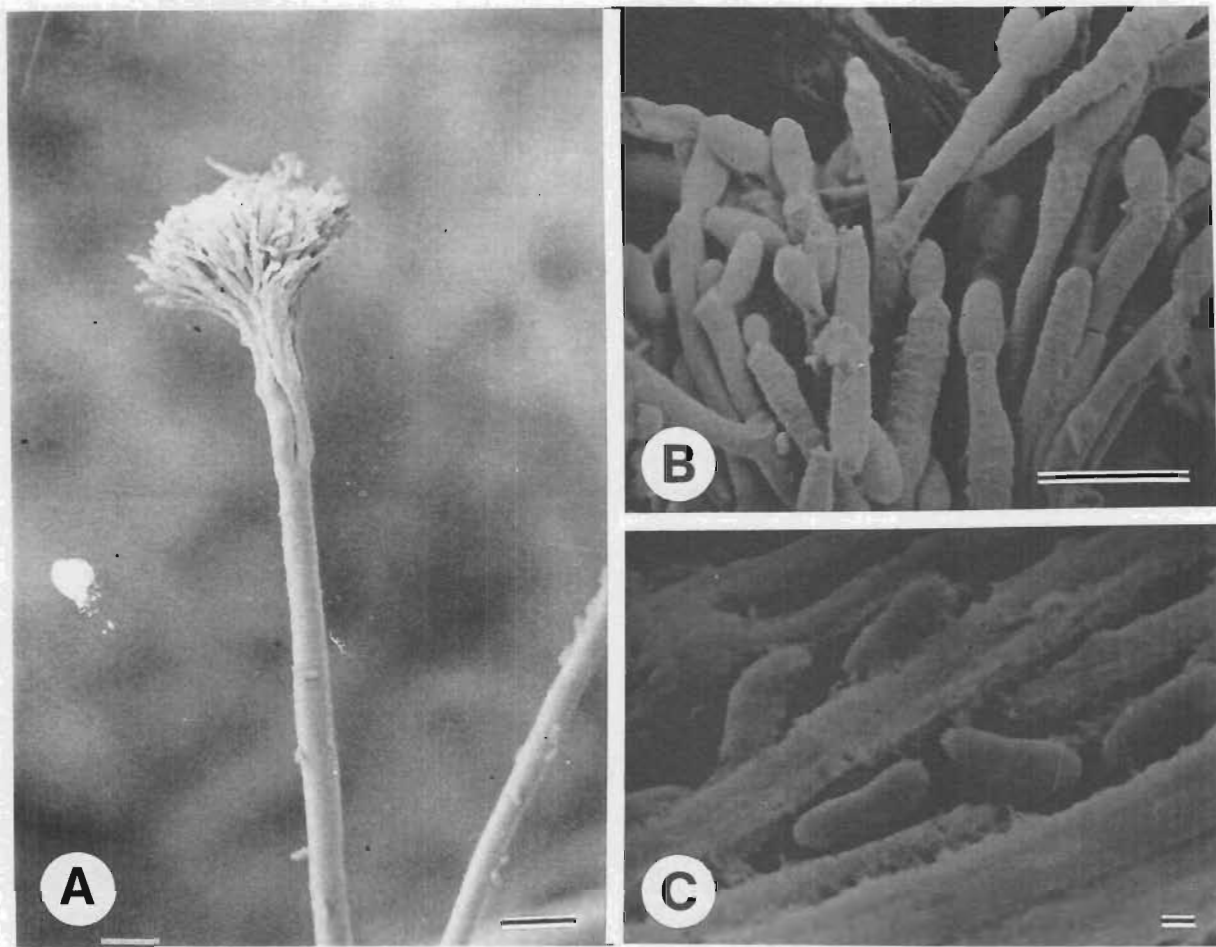
**Fig. 81.** Conidiophores and conidia of *L. hughesii* (CMW 4052). **A.** Habit sketch (Bar = 10  $\mu$ m). **B.** Conidiogenous apparatus (Bar = 10  $\mu$ m) **C.** Conidia (Bar = 10  $\mu$ m).





**Fig. 82.** Light micrographs of the conidiophores and conidia of *L. hughesii* (CMW 4052). **A.** Conidiophore (Bar = 50  $\mu\text{m}$ ). **B.** Conidiogenous apparatus (Bar = 10  $\mu\text{m}$ ). **C.** Conidiogenous cells (Bar = 10  $\mu\text{m}$ ). **D.** Conidia (Bar = 10  $\mu\text{m}$ ).





**Fig. 83.** Scanning electron micrographs of the conidiophores and conidia of *L. hughesii* (CMW 4052). **A.** Conidiophore (Bar = 10  $\mu$ m). **B.** Conidiogenous cells (Bar = 10  $\mu$ m). **C.** Conidia (Bar = 1  $\mu$ m).



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**23. *Ophiostoma huntii*** (Robinson) De Hoog & R.J. Scheff., *Mycologia* **76**, 197. 1984. (Figs. 84-86).

≡ *Ceratocystis huntii* Robinson, *Canadian Journal of Botany* **42**, 528. 1964.

**Anamorph:** *Leptographium huntii* (Robinson) M.J. Wingf., *Transactions of the British Mycological Society* **85**, 92. 1985.

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**Etymology:** hún-ti-i: genitive of Hunt. This specific epithet honors J. Hunt who made a considerable contribution towards the taxonomy of the ophiostomatoid fungi.

*Perithecial bases* black, globose and smooth walled, ornamented with fragile hyphal hairs, 280 - 448 µm in diam. *Perithecial neck* dark brown to black, cylindrical with a slight apical taper, smooth, 140 - 720 µm long, 40 - 70 µm above globose base, 21 - 42 µm wide at the apex, *ostiole hyphae* absent. *Asci* prototunicate, hyaline, evanescent. *Ascospores* cucullate, aseptate, hyaline, invested in a sheath, 3.0 - 4.0 x 1.5 - 2.0 µm (Robinson-Jeffrey & Grinchenko, 1964).

*Conidiophores* occurring singly or in groups, arising directly from the mycelium but mostly on aerial mycelium, erect, macronematous, mononematous, (135-) 216.5 - 541.5 (-775) µm in length, rhizoid-like structures absent. *Stipes* light olivaceous (21"K), smooth or occasionally constricted at septa, cylindrical, simple, 5-18 septate, (100-) 145.5 - 484.5 (-720) µm long, (5.0-) 6.0 - 10 µm wide below primary branches, apical cell not swollen, 7.5 - 15 µm wide at base, basal cell not swollen. *Conidiogenous apparatus* (30-) 47.5 - 61 (-95) µm long, excluding the conidial mass, with 1 to 3 series of cylindrical branches, 2-3 primary branches, light olivaceous (21"K), smooth, cylindrical to barrel shaped, 0-1 septate (8.0-) 8.5 - 21 (-28) µm long and (3.0-) 4.5 - 5.5 (8.0) µm wide, arrangement of the primary branches on the stipe - type B, secondary branches light olivaceous (21"K), aseptate, (8.0-) 11 - 15 (-20) µm long, (3.0-) 3.5 - 5.0 (-7.0) µm wide, tertiary branches hyaline, aseptate, (7.0-) 10.5 - 12 (-17) µm long, 2.0 - 6.0 µm wide, quaternary branches aseptate, (6.0-) 9.0 - 11.5 (-13) µm long, (2.0-) 2.5 - 4.0 (-5.0) µm wide. *Conidiogenous cells* discrete, 2-4 per branch, cylindrical, tapering slightly at the apex, (10-) 17.5 - 20.5 (-33) µm long and 2.0 - 4.0 µm wide. *Conidia* hyaline, aseptate, obovoid with truncate ends and

rounded apices, (3.0-) 4.0 - 6.0 (-8.5) x 1.0 - 3.0  $\mu\text{m}$ . Conidia accumulating in slimy droplets at the apex of conidiogenous apparatus, hyaline at first, becoming cream colored (19'f) with age. Conidial mass cream colored when wet, remaining cream colored when dry.

*Colonies* with optimal growth at 25°C on 2% MEA, reaching 43 mm in diam. in 8 days. No growth below 5°C or above 35°C. Able to withstand high concentrations of cycloheximide with a 22% reduction in growth on 0.5 g/l cycloheximide after 12 days at 20°C in the dark. Colonies greenish olivaceous (23''m) to olivaceous (21''m), losing color with continuous subculturing. *Colony margin* effuse. *Hyphae* submerged on agar with abundant aerial mycelium, hyaline to olivaceous (21''m), smooth, serpentine, occasionally constricted at the septa, (2.5-) 3.5 - 10.5 (-15)  $\mu\text{m}$  diam.

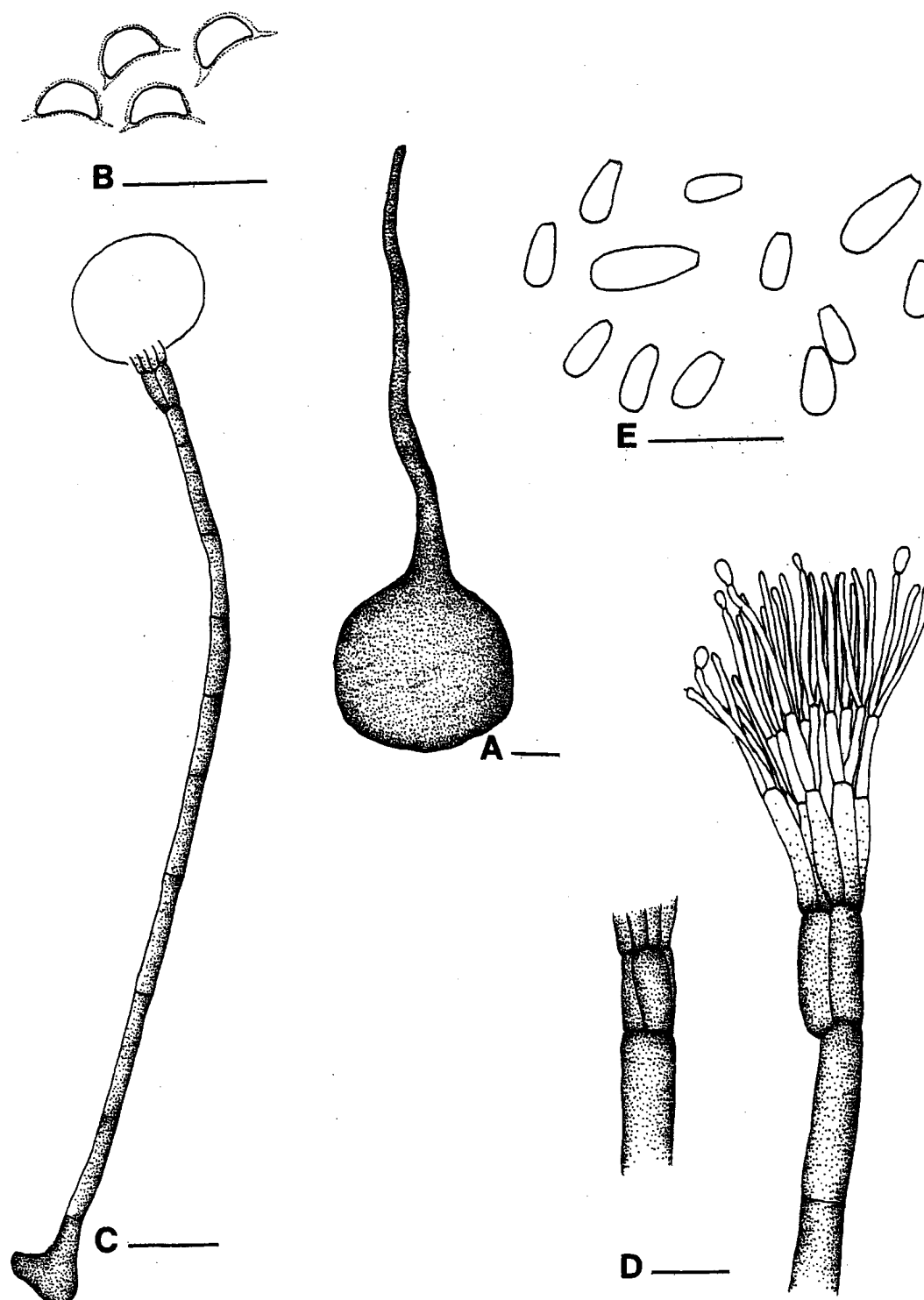
**Specimens examined: Holotype:** British Columbia, Toby Creek, near Invermere, *Pinus contorta* var. *latifolia* in bark beetle galleries, 6 Aug. 1962, collected: R. C. Jeffrey, DAOM 90235. **Cultures:** New Zealand, Mulberry Road, pine infested with *Hyalstes ater*, collected: M. Mackenzie, CMW 185 (same as IMI 5551, CMW 2820), CMW 1003; Scots pine infested with *Tomicus piniperda*, collected: J. Gibbs, CMW 1790 (same as CMW 2851); U.S.A., collected T.C. Harrington, C113 (same as CMW 2824); U.S.A., *Pinus resinosa*, collected: C.J. Randall, C583, (same as CMW 2768).

**Known distribution:** Canada, Australia, New Zealand.

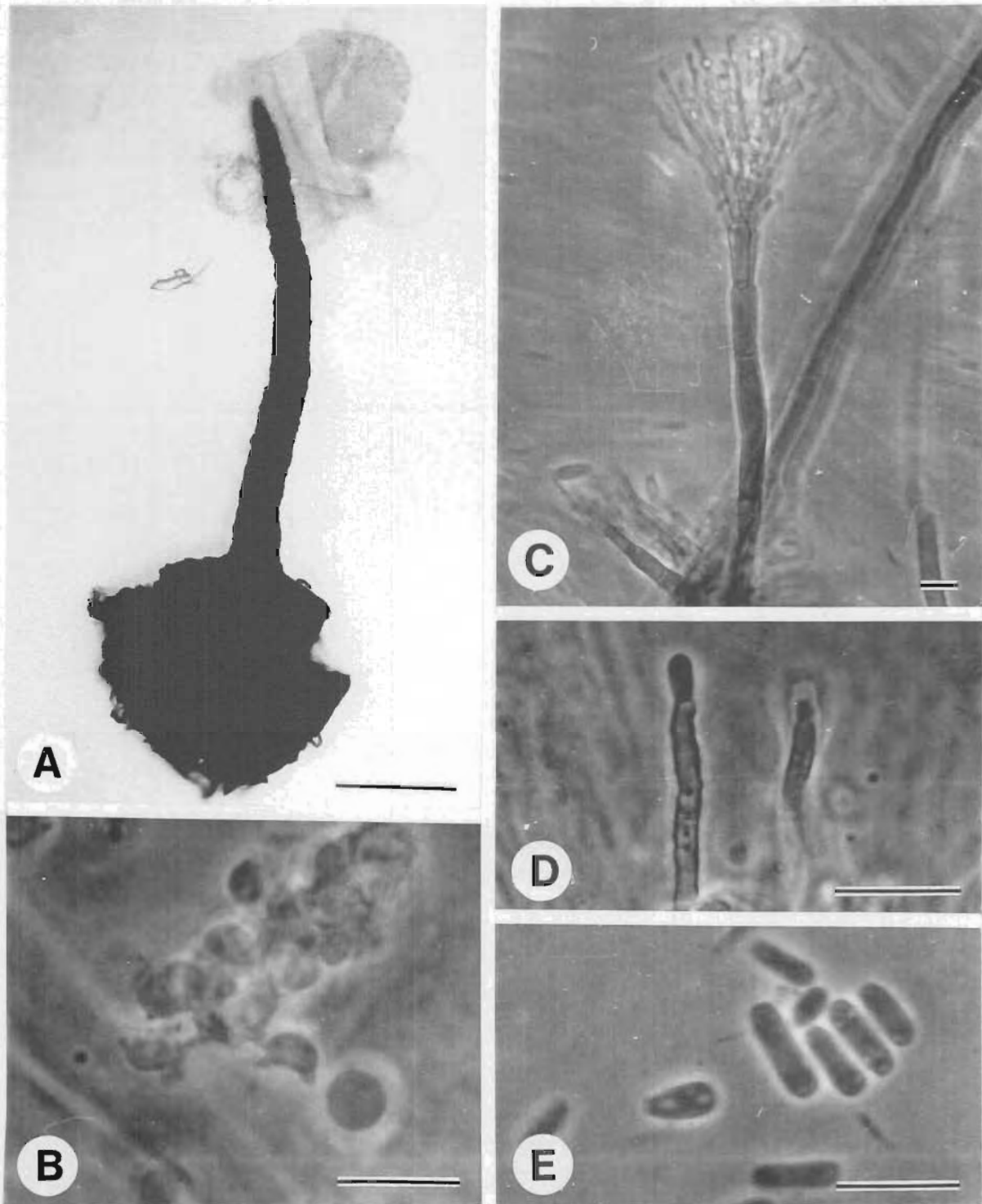
**Hosts/substrate:** *Pinus contorta* var. *latifoliae* (Robinson-Jeffrey & Grinchenko, 1964; Solheim, 1995c), *Pinus ponderosa* (Davidson & Robinson-Jeffrey, 1965), *Pinus monticola* (Davidson & Robinson-Jeffrey, 1965), *Pinus banksiana* (Olchowecki & Reid, 1974), *Pinus strobus* (Davidson & Robinson-Jeffrey, 1965), *Picea mariana* (Olchowecki & Reid, 1974).

**Associated insects:** *Dendroctonus ponderosae* (Robinson-Jeffrey & Grinchenko, 1964; Harrington, 1988; Perry, 1991; Solheim, 1995c), *Hylastes ater* (Jacobs *et al.*, 1998), *Hylastes macer* (Harrington, 1988), *Ips pini* (Davidson & Robinson-Jeffrey, 1965; Harrington, 1988), *Tomicus piniperda* (Gibbs & Inman, 1991).

**Notes:** Griffin (1968) proposed that *O. huntii* might be a possible synonym of *O. penicillatum*. However, as in the case of *O. piceaperdum*, the ascospores of *O. huntii* are hat-shaped in contrast to the curved ascospores of *O. penicillatum*. Robinson-Jeffrey and Grinchenko (1964) distinguished *O. piceaperdum* and *O. huntii* based on small differences in the teleomorph states, although the anamorph states are morphologically similar. Olchowecki and Reid (1974) also noted the similarity of this fungus to *O. piceaperdum*, but could distinguish them based on the smaller ascospores in *O. huntii*. *Ophiostoma huntii* can be distinguished from *O. piceaperdum* based on the presence of serpentine hyphae in the latter species and the absence of these in *O. huntii*. *Ophiostoma piceaperdum* also has conidiogenous apparatuses that are more brush-like than those of *O. huntii*. *Ophiostoma huntii* does not readily produce conidiophores in culture and when these are present, they are mostly on the aerial mycelium. Nothing is known about the pathogenicity of this species.

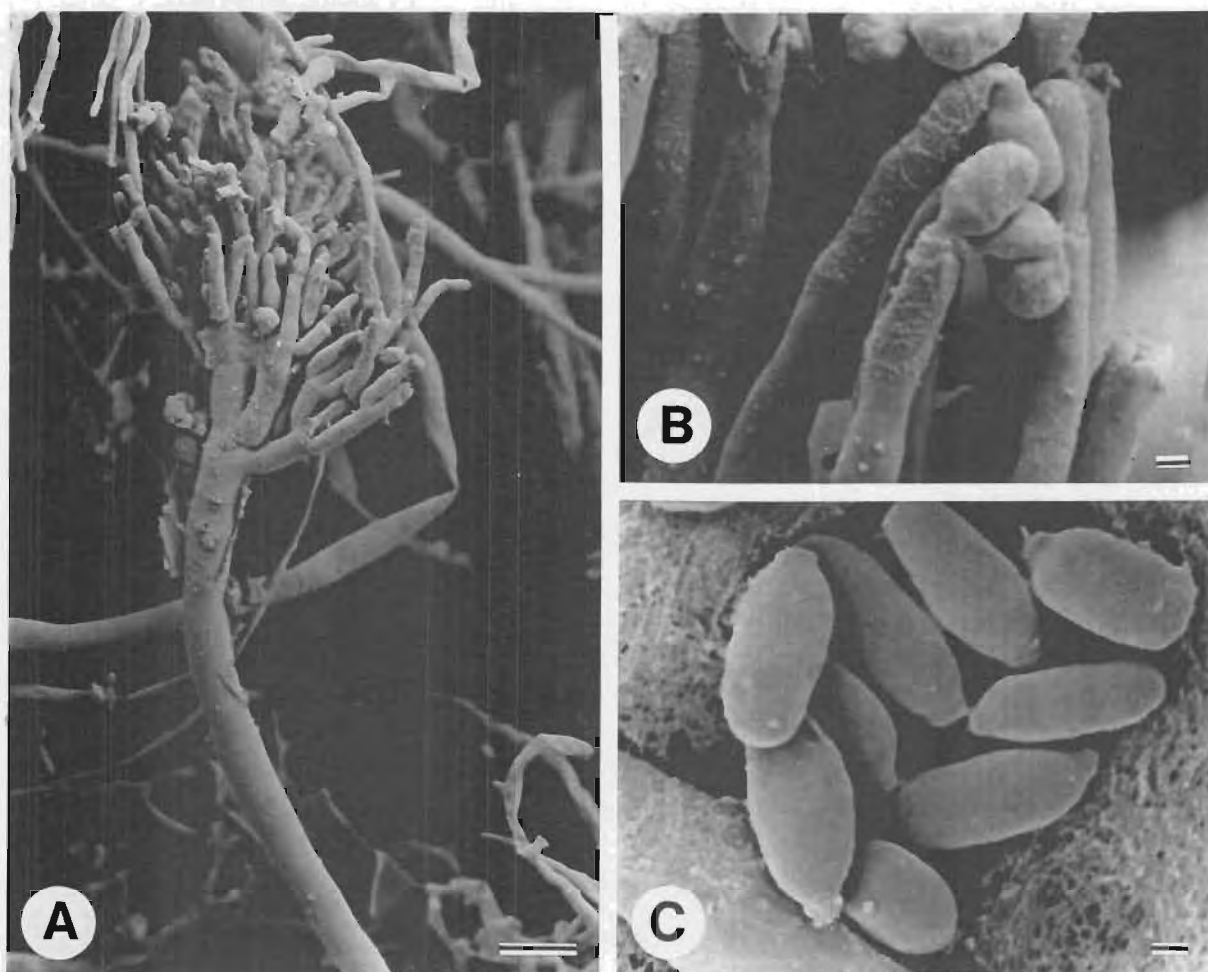


**Fig. 84.** Teleomorph and anamorph structures of *O. huntii* (CMW 2824). **A.** Perithecium (Bar = 100  $\mu\text{m}$ ). **B.** Ascospores (Bar = 10  $\mu\text{m}$ ). **C.** Conidiophore (Bar = 100  $\mu\text{m}$ ). **D.** Conidiogenous apparatus (Bar = 10  $\mu\text{m}$ ). **E.** Conidia (Bar = 10  $\mu\text{m}$ ).



**Fig. 85.** Light micrographs of the teleomorph and anamorph structures of *O. huntii* (CMW 2824). **A.** Perithecium (Bar = 100  $\mu$ m). **B.** Ascospore (Bar = 10  $\mu$ m). **C.** Conidiophore (Bar = 10  $\mu$ m). **D.** Conidiogenous cells (Bar = 10  $\mu$ m). **E.** Conidia (Bar = 10  $\mu$ m).





**Fig. 86.** Scanning electron micrographs of the conidiophores and conidia of *O. huntii* (CMW 2824). **A.** Conidiophore (Bar = 10  $\mu\text{m}$ ). **B.** Conidiogenous cells (Bar = 1  $\mu\text{m}$ ). **C.** Conidia (Bar = 1  $\mu\text{m}$ ).