Phytophylactica 12, 65–69 (1980)

CERATOCYSTIS IPS ASSOCIATED WITH *ORTHOTOMICUS EROSUS* (COLEOPTERA: SCOLYTIDAE) ON *PINUS* SPP. IN THE CAPE PROVINCE OF SOUTH AFRICA*

M. J. WINGFIELD[1] and W. F. O. MARASAS[2]

ABSTRACT

Keywords: *Pinus*; *Ceratocystis*; forest tree disease; bark beetles.

Ceratocystis ips is reported associated with the European bark beetle (*Orthotomicus erosus*) on *Pinus pinaster* and *P. radiata* in the Cape Province of South Africa. Some characteristics of a local isolate of the fungus are compared with those described for this species. The association of *C. ips* with *O. erosus* on trees infected with *Verticicladiella alacris* is also discussed.

Uittreksel

CERATOCYSTIS IPS *GEASSOSIEER MET* ORTHOTOMICUS EROSUS (*COLEOPTERA: SCOLYTIDAE*) *OP* PINUS *SPP. IN DIE KAAPPROVINSIE VAN SUID-AFRIKA*

Ceratocystis ips *is in assosiasie met die Europese baskewer* (Orthotomicus erosus) *op* Pinus pinaster *en* P. radiata *in die Kaapprovinsie van Suid-Afrika aangemeld. Enkele eienskappe van 'n plaaslike isolaat van die swam is vergelyk met die oorspronklike beskrywing van die spesies. Die assosiasie van* C. ips *met* O. erosus *op bome geïnfekteer met* Verticicladiella alacris *is ook beskryf.*

Résumé

CERATOCYSTIS IPS *ASSOCIÉ À* ORTHOTOMICUS EROSUS (*COLEOPTERA: SCOLYTIDAE*) *SUR* PINUS *SPP. DANS LA PROVINCE DU CAP D'AFRIQUE DU SUD*

Le Ceratocystis ips *est rapporté en association avec le scarabée européen de l'écorce* (Orthotomicus erosus) *sur le* Pinus pinaster *et* P. radiata *dans la province du Cap d'Afrique du Sud. Certaines caractéristiques d'un isolat local du fungus sont comparées avec celles décrites pour cette espèce. L'association de* C. ips *avec* O. erosus *sur des arbres infectés avec* Verticicladiella alacris *est également discutée.*

INTRODUCTION

Bark beetles (Scolytidae) usually colonise weakened trees (Rudinsky, 1962; Stark, Miller, Cobb, Wood & Parmeter, 1968; Felix, Uhrenholdt & Parmeter, 1971; Partridge & Miller, 1972; Miller & Partridge, 1974), and trees with root disease (Bega, Dotta, Miller & Smith, 1966; Partridge & Miller, 1972; Miller & Partridge, 1974; Hertert, Miller & Partridge, 1975; Lane & Goheen, 1979). They are also well known as vectors of fungi, notably *Ceratocystis* spp. which in many cases contribute to the death of trees (Rumbold, 1931, 1936, 1941; Mathiesen-Käärik, 1960; Franke-Grosmann, 1963; Mathre, 1964a, b; Molnar, 1965). In South Africa the European bark beetle, *Orthotomicus erosus* (Woll.), has recently been reported to colonise *Pinus* spp. infected with *Verticicladiella alacris* Wingfield & Marasas (Wingfield & Knox-Davies, 1980) but there has been no record of a bark beetle-*Ceratocystis* association in this country. The present paper records the occurrence of *C. ips* Rumbold associated with *O. erosus* on *Pinus* spp. infected with *V. alacris* and compares it with *C. ips* as described by Rumbold (1931).

PROCEDURE

Bark beetles (*O. erosus*) and diseased cambium associated with new bark beetle galleries were collected on *Pinus pinaster* Ait. and *P. radiata* D. Don. trees infected with *V. alacris* in nine centres in the following areas of the Western Cape Province: Cape Peninsula (Tokai State Forest); Franschhoek (La Motte State Forest); Grabouw (Grabouw and Lebanon State Forests). Freshly felled logs in plantations in the Western Cape and Southern Cape Forest regions were found to be colonised and were therefore also sampled.

Isolations were made, on malt extract agar (MEA) containing 2% vancomycin, from surface sterilised bark beetles and diseased cambium associated with their galleries (Wingfield & Knox-Davies, 1980). Cultures were maintained on MEA in petri dishes at 24 °C. Autoclaved pieces of *P. radiata* wood were placed on the agar and, after inoculation, dishes were incubated under near ultraviolet light at 15–20 °C to induce ascocarp formation.

To investigate the pathogenicity of a local isolate of *C. ips* (PREM 45512), ten year old *P. pinaster* trees were inoculated by removing cambial discs from their trunks about 2,5 m above ground level, and replacing them with discs of an agar culture (Wingfield & Knox-Davies, 1980).

RESULTS

Ceratocystis ips was isolated from bark beetles (Fig. 1) and their galleries (Fig. 2) collected from all trees infected with *V. alacris* (Fig. 3) and from freshly felled logs. Characteristics of the locally occurring *C. ips* compared with those described for *C. ips* by Rumbold (1931) are presented in Table 1. Dried cultures of an isolate of *C. ips* from *O. erosus* were deposited in the Herbarium of the Plant Protection Research Institute, Private Bag X134, Pretoria, South Africa (PREM).

Inoculations resulted in well developed lesions (Fig. 11) 150–200 mm long and 20 mm wide in the cambium and sapwood after one month. *C. ips* was re-isolated from all lesions.

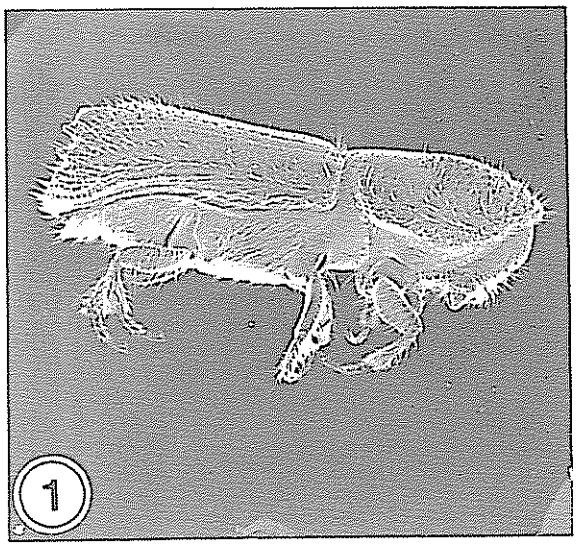
---

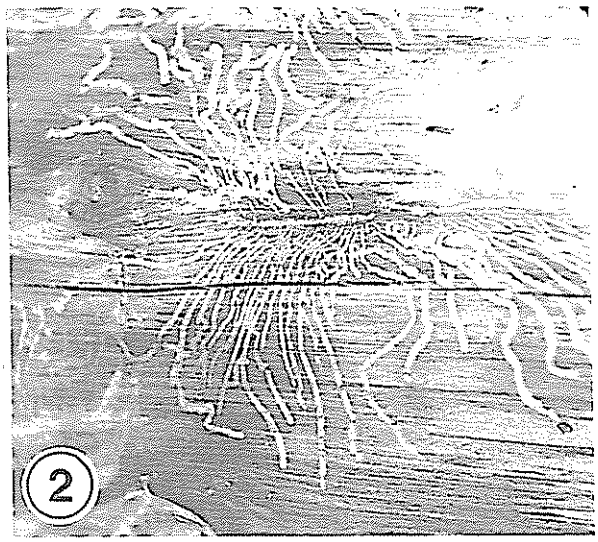
* Part of an M.Sc. thesis submitted by the senior author to the University of Stellenbosch, Stellenbosch 7600

[1] Plant Protection Research Institute, Private Bag X5017, Stellenbosch 7600

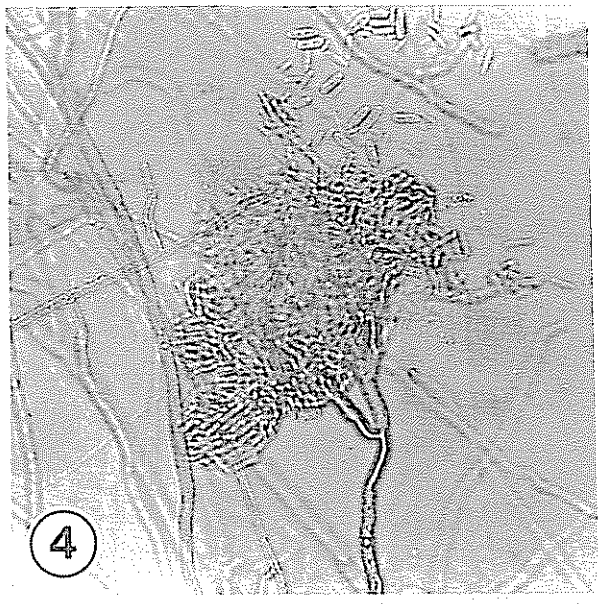
[2] National Research Institute for Nutritional Diseases, Medical Research Council, P.O. Box 70, Tygerberg 7505

Received 29 October 1979

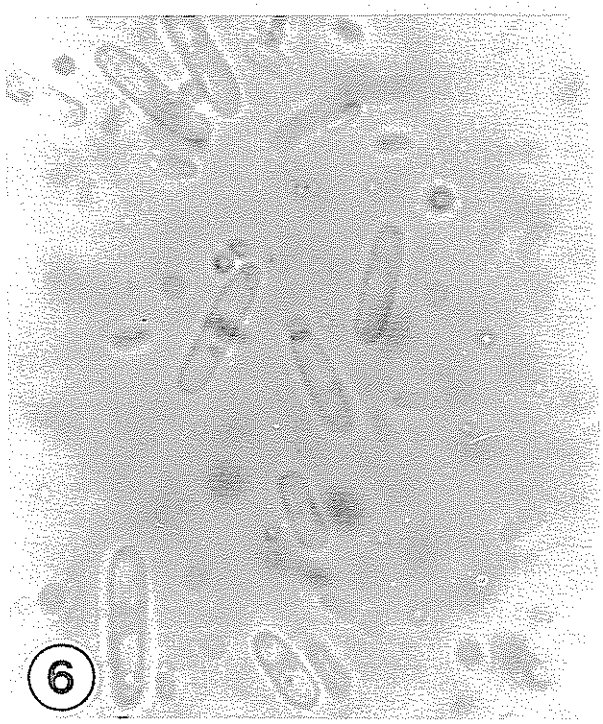

1


2


3


4


5


6

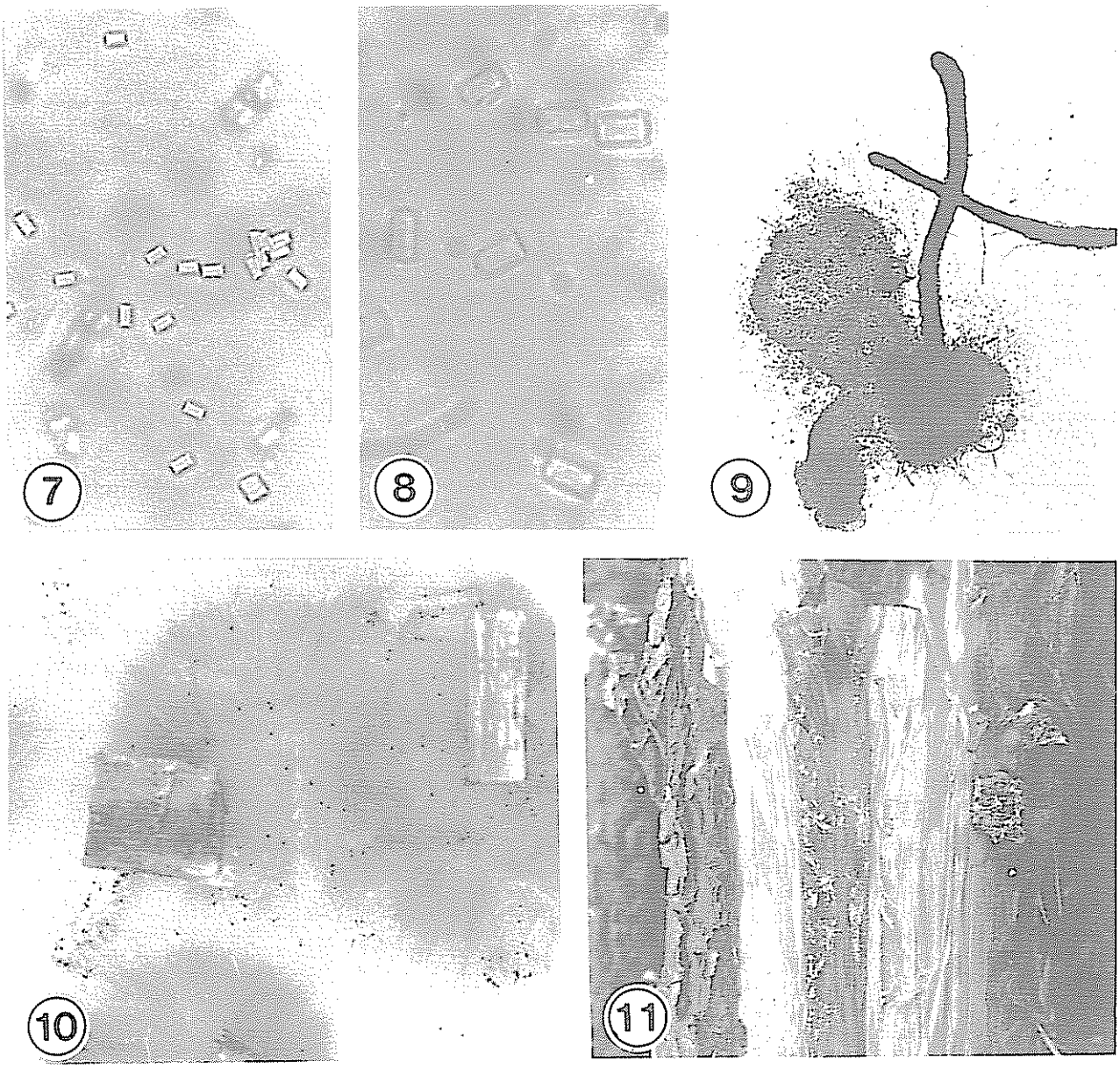


FIG. 7–11 *Ceratocystis ips* and/*en Pinus pinaster*. 7. *Ceratocystis ips* ascospores (×600)/Ceratocystis ips-*askospore* (×600). 8. *Ceratocystis ips* ascospores showing gelatinous sheath (×1 500)/ Ceratocystis ips-*askospore met gelatienagtige skede* (×1 500). 9. *Ceratocystis ips* perithecium (×10)/Ceratocystis ips-*peritekium* (×10). 10. *Ceratocystis ips* perithecia on malt extract agar with pieces of pine wood/Ceratocystis ips-*peritekia op moutekstrakagar met stukkies dennehout*. 11. *Ceratocystis ips* lesion in inoculated *Pinus pinaster* sapwood/Ceratocystis ips-*letsel op geïnokuleerde* Pinus pinaster *spinthout*

Discussion

Two *Ceratocystis* spp., *C. ips* and *C. montia* (Rumbold) Hunt, are similar and are separated from other *Ceratocystis* spp. by the fact that their ascospores are surrounded by a quadrangular gelatinous sheath, the perithecial necks have no ostiolar hyphae and the bases of the perithecia are dark coloured (Hunt, 1956; Griffin, 1968; Olchowecki & Reid, 1974). The two species are distinguished from each other by the diameter of the base of the perithecium which is less (*C. ips*) or greater (*C. montia*) than 200 μm (Hunt, 1956; Griffin, 1968; Olchowecki & Reid, 1974). The two species cannot be confused (Griffin, 1968) as the average diameter of the base of the perithecium in *C. montia* is usually twice that of *C. ips* The imperfect states of the two species are also different (Rumbold, 1931, 1941; Hunt, 1956). Based on these criteria, it was concluded that the *Ceratocystis* sp. isolated from *O. erosus* and associated galleries was *C. ips*.

FIG. 1–6 *Ceratocystis ips*, *Orthotomicus erosus* and/*en Pinus* spp. 1. *Orthotomicus erosus* (SEM ×22). 2. *Orthotomicus erosus* galleries under bark of *Pinus pinaster* (Photo by Dr H. Geertsema)/ Orthotomicus erosus-*tonnels onder bas van* Pinus pinaster (*Foto deur dr. H. Geertsema*). 3. *Pinus pinaster* trees infected with *Verticicladiella alacris*/Pinus pinaster-*bome geïnfekteer met* Verticicladiella alacris. 4. *Ceratocystis ips* branched conidiophore with conidia (×320)/Ceratocystis ips *vertakte konidiofoor met konidiums* (×320). 5. *Ceratocystis ips* branched conidiophore (×1 650)/Ceratocystis ips *vertakte konidiofoor* (×1 650). 6. *Ceratocystis ips* conidia (×1 600)/ Ceratocystis ips-*konidiums* (×1 600)

TABLE 1 Comparison of some characteristics of a local *Ceratocystis* isolate (PREM 45512) with those described for *Ceratocystis ips* by Rumbold (1931)

TABEL 1 *Vergelyking tussen enkele eienskappe van 'n plaaslike* Ceratocystis-*isolaat* (*PREM* 45512) *met die wat Rumbold* (1931) *vir* Ceratocystis ips *aangegee het*

Characteristics/*Eienskappe*	Local isolate/*Plaaslike isolaat*	*C. ips.* (Rumbold, 1931)
Hyphal—diameter	0,9–9,1 μm	2,0–3,0 μm
Conidiophores	At first hyphal conidiophores and later branched conidiophores. Conidia produced in a mucilaginous mass (Fig. 4, 5)	At first hyphal conidiophores, later becoming branched
Conidiogenesis	Apparently sympodial as well as phialidic	Not described
Conidium—shape	Cylindrical (Fig. 6)	Obovoid—ellipsoidal
Conidium—dimensions	3,7–14,7 × 1,4–4,6 μm	3,0–10,0 × 1,0–3,0 μm
Perithecium neck—length	324,0–1 239,0 μm	215,0–3 860,0 μm
Perithecium base—diameter	148,0–278,0 μm mean 198,0 μm	55,0–301,0 μm mean 198,0 μm
Ascospore—shape	Cylindrical, surrounded by a quadrangular gelatinous sheath (Fig. 7, 8)	Cylindrical
Ascospore—dimensions	3,2–6,4 × 1,8–3,2 μm	2,9–4,6 × 1,8–2,8 μm
Sporulation on MEA	Conidiophores sparse. Perithecia (Fig. 9) usually only on media containing pieces of pine wood (Fig. 10)	Perithecia produced in the medium

Ascospore dimensions of the *C. ips* isolate examined in the present study vary considerably from those previously given (Rumbold, 1931; Hunt, 1956). Griffin (1968) also found ascospore dimensions of certain *C. ips* isolates to differ from those previously recorded.

Ceratocystis ips is reported to form conidia directly on the mycelium and on branched, *Graphium*-like conidiophores (Rumbold, 1931; Hunt, 1956). The branched conidiophores of the local isolate may be similar to those described by previous authors (Rumbold, 1931; Hunt, 1956; Griffin, 1968) but cannot be termed *Graphium*-like, which implies that they are synnematous. The *Leptographium* complex with the mononematous genera, *Leptographium*, *Verticicladiella* and *Phialocephala* are grouped according to their anellidic, sympodial and phialidic conidiogenesis respectively (Kendrick, 1962). Because conidiogenesis in local isolates appeared to be sympodial as well as phialidic (Table 1) it would be difficult to assign a name to the conidial state. Previous authors (Hunt, 1956; Griffin, 1968; Olchowecki & Reid, 1974) encountered similar problems when dealing with large numbers of *Ceratocystis* spp. and chose not to assign names to conidial states.

C. ips is a pathogen of conifers and restricts the sapflow of infected wood (Nelson, 1934; Mathre, 1964b). The occurrence of bark beetles carrying *C. ips* on all trees infected with *V. alacris* suggests that this fungus-insect relationship is an important part of a disease complex, which results in significant losses in pine plantations in the Western Cape forest region.

This paper records new hosts and a new vector for *C. ips*.

Acknowledgements

Acknowledgement is made to Dr. Sharon von Broembsen, Miss Anthea Clarke, Prof. P. S. Knox-Davies and Dr. H. Geertsema for assistance during the investigation.

References

BEGA, R. V., DOTTA, D., MILLER, D. R. & SMITH, R. S. Jr., 1966. Root disease survey at Boggs Mountain State Forest, California. *Plant Dis. Reptr.* 50, 439–440.

FELIX, L. S., UHRENHOLDT, B. & PARMETER, J. R. Jr, 1971. Association of *Scolytus ventralis* (Coleoptera: Scolytidae) and *Phorodendron bolleanum* sub-species *pauciflorum* on *Abies concolor*. *Can. Ent.* 103, 1697–1703.

FRANCKE-GROSMANN, H., 1963. Some new aspects in forest entomology. *A. Rev. Ent.* 8, 415–438.

GRIFFIN, H. D., 1968. The genus *Ceratocystis* in Ontario. *Can. J. Bot.* 46, 689–718.

HERTERT, H. D., MILLER, D. L. & PARTRIDGE, A. D., 1975. Interaction of bark beetles (Coleoptera: Scolytidae) and root-rot pathogens in grand fir in Northern Idaho. *Can. Ent.* 107, 899–904.

HUNT, J., 1956. Taxonomy of the genus *Ceratocystis*. *Lloydia* 19, 1–58.

KENDRICK, W. B., 1962. The *Leptographium* complex: *Verticicladiella* Hughes. *Can. J. Bot.* 40, 771–797.

LANE, B. B. & GOHEEN, D. J., 1979. Incidence of root disease in bark beetle-infested Eastern, Oregon and Washington true firs. *Plant Dis. Reptr.* 63, 262–266.

MATHIESEN-KÄÄRIK, A., 1960. Studies on the ecology, taxonomy and physiology of Swedish insect-associated blue-stain fungi, especially the genus *Ceratocystis*. *Oikos* 11, 1–25.

MATHRE, D. E., 1964a. Survey of *Ceratocystis* spp. associated with bark beetles in California. *Contr. Boyce Thomson Inst. Pl. Res.* 22, 353–362.

MATHRE, D. E., 1964b. Pathogenicity of *Ceratocystis ips* and *Ceratocystis minor* to *Pinus ponderosa*. *Contr. Boyce Thomson Inst. Pl. Res.* 22, 363–388.

MILLAR, D. L. & PARTRIDGE, A. D., 1974. Root-rot indicators in grand fir. *Plant Dis. Reptr.* 58, 275–276.

MOLNAR, A. C., 1965. Pathogenic fungi associated with a bark beetle on alpine fir. *Can. J. Bot.* 43, 563–570.

NELSON, R. M., 1934. Effect of blue-stain fungi on Southern pines attacked by bark beetles. *Phytopath. Z.* 7, 327–353.

OLCHOWECKI, A. & REID, J., 1974. Taxonomy of the genus *Ceratocystis* in Manitoba. *Can. J. Bot.* 52, 1675–1711.

PARTRIDGE, A. D. & MILLER, D. L., 1972. Bark beetles, and root-rots related in Idaho conifers. *Plant Dis. Reptr.* 56 498–500.

RUDINSKY, J. A., 1962. Ecology of Scolytidae. *A. Rev. Ent.* 7, 327–348.

RUMBOLD, CAROLINE, T., 1931. Two blue-staining fungi associated with bark beetle infestation of pines. *J. agric. Res.* 43, 847–873.

RUMBOLD, CAROLINE T., 1936. Three blue-staining fungi, including two new species, associated with bark beetles. *J. agric. Res.* 52, 419–437.

RUMBOLD, CAROLINE T., 1941. A blue-stain fungus, *Ceratocystis montia* n. sp., and some yeasts associated with two species of *Dendroctonus*. *J. agric. Res.* 62, 589–601.

STARK, R. W., MILLER, P. R., COBB., F. W. Jr., WOOD, D. L. & PARMETER, J. R. Jr., 1968. Photochemical oxidant injury and bark beetle (Coleoptera: Scolytidae) infestation of ponderosa pine. I. Incidence of bark beetle infestation in injured trees. *Hilgardia* 39, 121–126.

WINGFIELD, M. J. & KNOX-DAVIES, P. S., 1980. A root disease of pines in South Africa, associated with *Verticicladiella alacris*. *Plant Disease* (in press).

Printed by the Government Printer, Bosman Street, Private Bag X85, Pretoria, 0001