

Fungi occurring on *Proteaceae*: new anamorphs for *Teratosphaeria*, *Mycosphaerella* and *Lembosia*, and other fungi associated with leaf spots and cankers of proteaceous hosts

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Several fungi associated with leaf spots and stem cankers of *Proteaceae* are reported. The new species *Kabatiella proteae*, *Phloeosporella protearum*, *Septoria grandicipis*, *Stilbospora proteae* and *Trimmatostroma elginensis* are described. Several new teleomorph-anamorph connections are reported, including *Mycosphaerella stromatosa* and *Pseudocercospora stromatosa*, *Teratosphaeria microsporium* and *Trimmatostroma microsporium*, and *Lembosia proteae* and *Clasterosporium proteae*. Additional species described are *Lophiostoma fuckelii* and *Verrucisporota proteacearum* which are also newly recorded associated with leaf spots of *Proteaceae* in South Africa.

INTRODUCTION

There has been a recent interest in the pathogens associated with the *Proteaceae* (Swart *et al.* 1998, Taylor & Crous 1998, Crous & Palm 1999) following earlier work by Van Wyk, Marasas & Knox-Davies (1975 a), Knox-Davies, Van Wyk & Marasas (1986, 1987) and Von Broembsen (1989). This renewed concern is largely due to the increasing production of *Proteaceae* flowers (commonly known as proteas) for the export market (Crous & Palm 1999).

Currently there are approximately 1830 ha under commercial protea production world-wide in intensive flower orchards, 700 ha in S. Africa, 100–400 ha each in Australia, California, Zimbabwe and Israel, and small areas in Hawaii, El Salvador, Chile and New Zealand (Anon. 1998). South Africa remains the most important producer, in that it is the centre of diversity for the most important commercially cultivated members of the *Proteaceae*, such as *Protea*, *Leucospermum* and *Leucadendron*. Thus, potentially there is much scope for selecting and breeding new cultivars for commercial production, to enhance disease resistance and to add variety for the enlarging markets.

The study of protea diseases is in its early stages with only two fungicides registered for soil-borne diseases of *Proteaceae*, fosetyl-Al and furalaxyl (Krause, Nel & Van Zyl 1996). No fungicides are registered in South Africa for foliicolous pathogens, although a regular spraying programme with contact fungicides registered on ornamental plants can have prophylactic and curative effects. Part of this study involved collecting diseased material from the wild and from plants in cultivation, and surveying and culturing the pathogens

associated with the diseases. Trials are being initiated to screen the fungal pathogens against fungicides commonly used on other ornamentals, in an attempt to develop a comprehensive fungicide programme. The present paper is the third in a series reporting novel pathogens of *Proteaceae* (Swart *et al.* 1998, Crous & Palm 1999).

MATERIALS AND METHODS

Symptomatic leaf and stem samples of proteas were collected and the fungi associated were identified where possible. Any fertile samples were processed immediately, and the remainders were stored dry, in plastic bags, in a cold room at 4 °C, for approximately 1 mo. This method appears to encourage maturation of fruiting structures. Single conidium colonies were established on 2% malt extract agar (MEA; Biolab, Midrand, South Africa), supplemented with 0.1 g l⁻¹ streptomycin sulphate, then transferred to divided plates containing MEA and carnation leaf agar (CLA; Fisher *et al.* 1982) to encourage sporulation. Incubation was at 25° under continuous nuv light. Colony growth was measured, characteristics noted, and the colour rated (Rayner 1970). Single conidium colonies of some species were initiated using the spore shooting method described by Crous, Wingfield & Park (1991). For microscopic examination the fungi were mounted in water or lactophenol and measurements made at 1000 × magnification. The 95% confidence intervals were determined from 25 to 50 observations and the minimum and maximum ranges given in parentheses. Herbarium specimens are lodged at PREM and reference cultures are maintained in the culture

collection of the Department of Plant Pathology, University of Stellenbosch (STE-U).

TAXONOMY

Kabatiella proteae J. E. Taylor & Crous, **sp. nov.** (Figs 1–8)

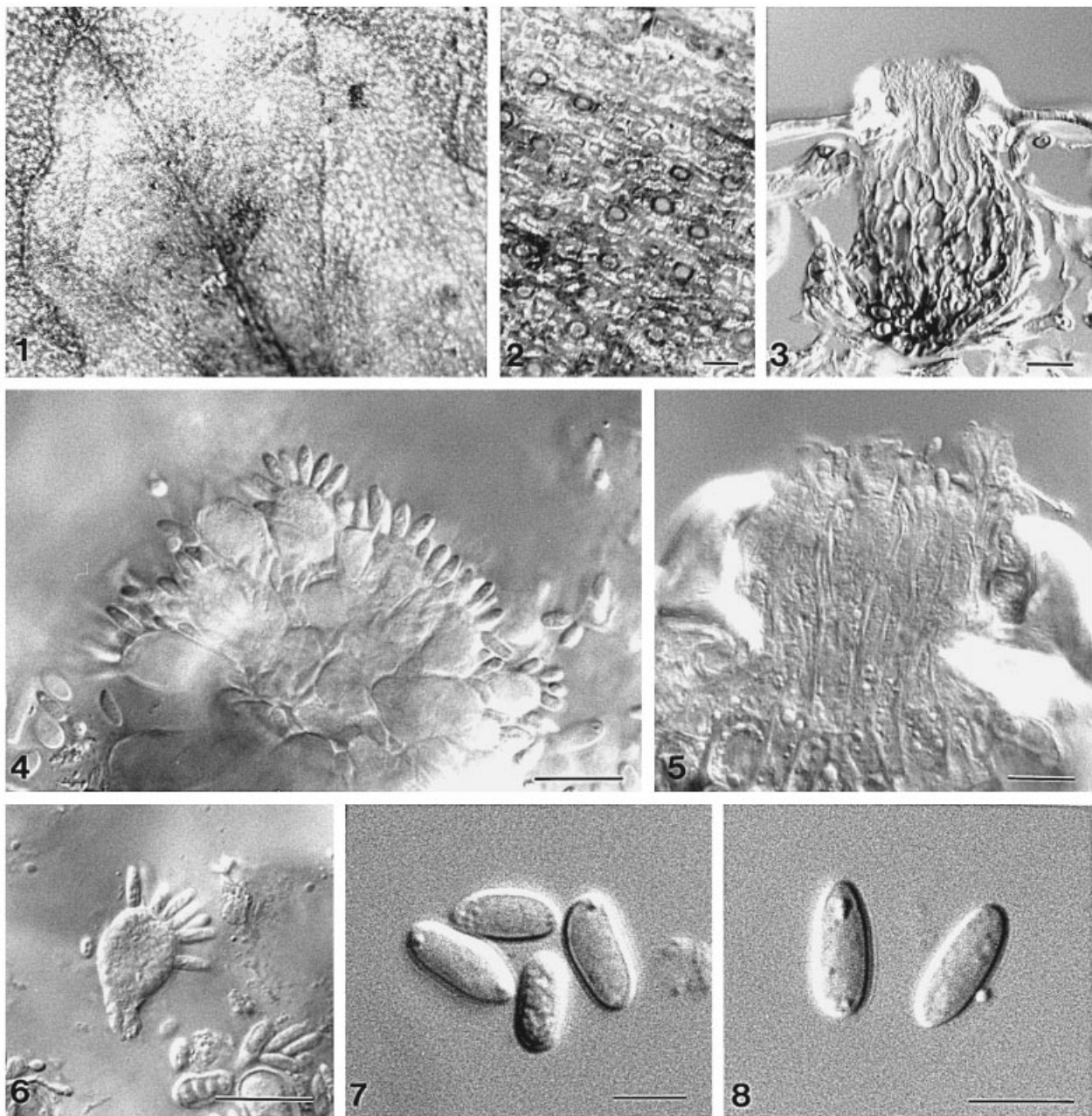
Etym.: In reference to the *Protea* host.

Maculae irregulares, morbescentes, pallide vel medio-brunneae. Acervuli amphigeni, sub stomatibus, subepidermales, pulvinati, siccii vel crystallini, 60–100 µm diam. Mycelium immersum. Stroma in cavitate sub stomate formatum, ex cellulis brunneis, elongatis, pseudoparenchymatis compositum, (80–)101–121(–125) × (50–)72–92(–100) µm. Cellulae conidiogenae cylindricae, clavatae vel globosae, holoblasticae, conidiis numerosis et simul formatis (13–)16–

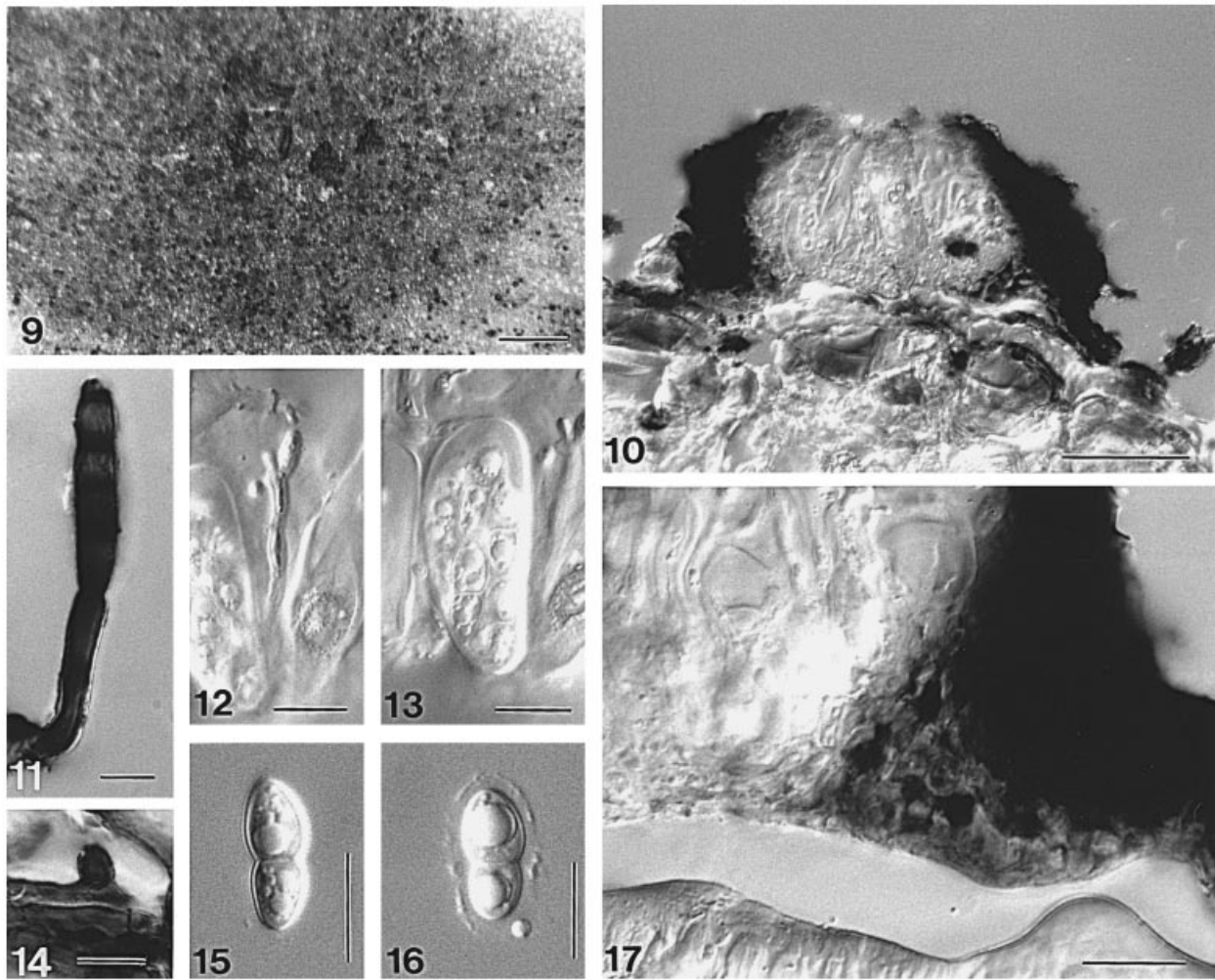
20(–27) × (4–)6–8(–11) µm. Conidia aseptata, ellipsoidea vel sphaerica, hyalina, levigata, (5–)6.5–7.5(–10) × (2–)2.5–3(–3.5) µm.

Holotype: **South Africa**, Somerset West, Hilly Lands Farm, on a living leaf of a *Protea cynaroides* seedling, 21 Jul. 1998, S. Denman & J. E. Taylor, JT338 (PREM 56192).

Leaf spots irregular, occurring on the petiole and base of lamina, extending up the leaf, necrotic, sunken, pale to mid-brown with a raised dark brown margin, areas where sporodochia occur often darkened (Fig. 1). *Acervuli* amphigenous, substomatal, subepidermal, pulvinate, dry or crystalline in appearance, pale brown, discrete, 60–100 µm diam. (Fig. 2). *Mycelium* immersed. *Stroma* visible in substomatal cavity, dark brown-walled, mainly comprising elongated pseudoparen-



Figs 1–8. *Kabatiella proteae* (holotype PREM 56192). **Fig. 1.** Lesion on *Protea cynaroides* leaf. **Fig. 2.** Acervuli on host substrate. **Fig. 3.** Sub-stomatal stroma. **Figs 4–6.** Conidiogenous cells. **Figs 7, 8.** Conidia. Bars: 2 = 100 µm, 3 = 20 µm, 4–6 = 10 µm, 7, 8 = 5 µm.



Figs 9–17. *Lembosia proteae* (holotype PREM 56304). **Fig. 9.** Ascomata on *Protea acaulos* leaf. **Fig. 10.** Cross section of ascoma. **Fig. 11.** Conidia and conidiogenous cell of *Clasterosporium proteae*. **Fig. 12.** Pseudoparaphyses. **Fig. 13.** Ascus. **Fig. 14.** Hyphopodia. **Figs 15, 16.** Ascospores. **Fig. 17.** Peridium. Bars: 9 = 1 mm, 10 = 50 μ m, 11–17 = 10 μ m.

chymatous cells with large lumina, becoming hyaline, thinner-walled at the apex (80–)101–121(–125) \times (50–)72–92(–100) μ m (Fig. 3). *Conidiogenous cells* cylindrical, clavate or globose, integrated, terminal, conidial ontogeny holoblastic, with numerous synchronously produced conidia, (13–)16–20(–27) \times (4–)6–8(–11) μ m (Figs 4–6). *Conidia* solitary, aseptate, ellipsoidal to spherical, occasionally with a slightly truncate base, hyaline, thin-walled, smooth, often with small guttules, (5–)6.5–7.5(–10) \times (2–)2.5–3(–3.5) μ m (Figs 7, 8).

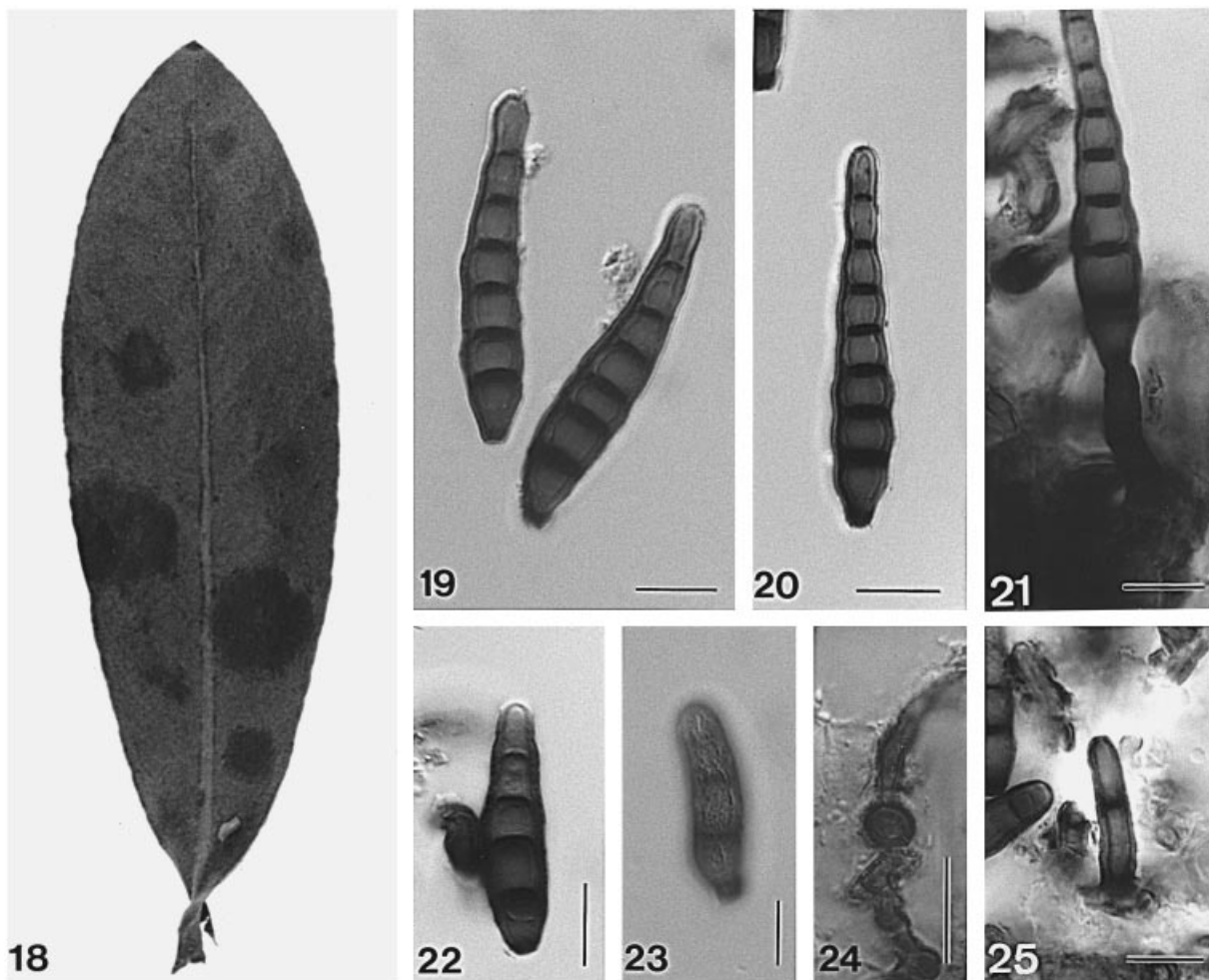
Teleomorph: Unknown.

Known distribution: South Africa.

Kabatiella is a mitosporic taxon, which comprises approximately 15 widespread, but mostly northern temperate species (Hawksworth *et al.* 1995). There is, however, some confusion regarding the identity of this genus. Hermanides-Nijhof (1977) listed *Kabatiella* as synonymous with *Aureobasidium*, but neither von Arx (1987) nor Hawksworth *et al.* (1995) recognised this synonymy. The explanation for the synonymy given by Hermanides-Nijhof (1977) is that the genera are morphologically similar, but are traditionally separated on their life strategies. *Kabatiella* species are mainly pathogenic, causing leaf spots, while *Aureobasidium* species are mainly

saprobies. As some *Kabatiella* strains are found on decaying leaves, Hermanides-Nijhof (1977) believed that the two genera cannot be sharply delimited and, therefore, combined them. Von Arx (1987) described *Kabatiella* as the parasitic, acervular relatives of *Aureobasidium*.

In general, *Kabatiella* spp. are common plant pathogens and have a restricted host range (von Arx 1987). *Kabatiella apocrypta* possesses a lightly pigmented stromata, but this consists of rounded cells, with clavate, rather than inflated conidiogenous cells and slightly larger conidia (7–12 \times 2.5–4.5) (Hermanides-Nijhof 1977). *Kabatiella microsticta*, *K. prunicola* and *K. ribis* have stromata with elongated cells, but which are unpigmented, and have generally larger conidia (Hermanides-Nijhof 1977). The stroma of *K. microsticta* is composed of tightly interwoven hyphae like *K. proteae*, but the hyphae comprising the stromata of *K. prunicola* and *K. ribis* are loosely interwoven. *Kabatiella prunicola* is similar in possessing inflated conidiogenous cells (Hermanides-Nijhof 1977). As no species corresponds to the collections on *Protea*, a new species is introduced. One point that is stressed by Hermanides-Nijhof (1977) is that many species of *Kabatiella* sporulate readily in culture, which does bring into question their degree of host specificity.



Figs 18–25. *Clasterosporium proteae* (PREM 56194). **Fig. 18.** Lesions on *Protea magnifica* leaf. **Figs 19, 20, 22, 23.** Conidia. **Figs 21, 25.** Conidiogenous cells. **Fig. 24.** Hyphopodia. Bars: 19–25 = 10 μ m.

Although *Kabatiella* species are uncommon pathogens of *Proteaceae*, they are potentially important as they have been recorded on material intercepted by APHIS in the U.S.A. (BPI 414041A, 414041B). Members of this genus are, therefore, of phytosanitary importance and of relevance to plant pathologists and protea producers alike.

Lembosia proteae J. E. Taylor & Crous, **sp. nov.**

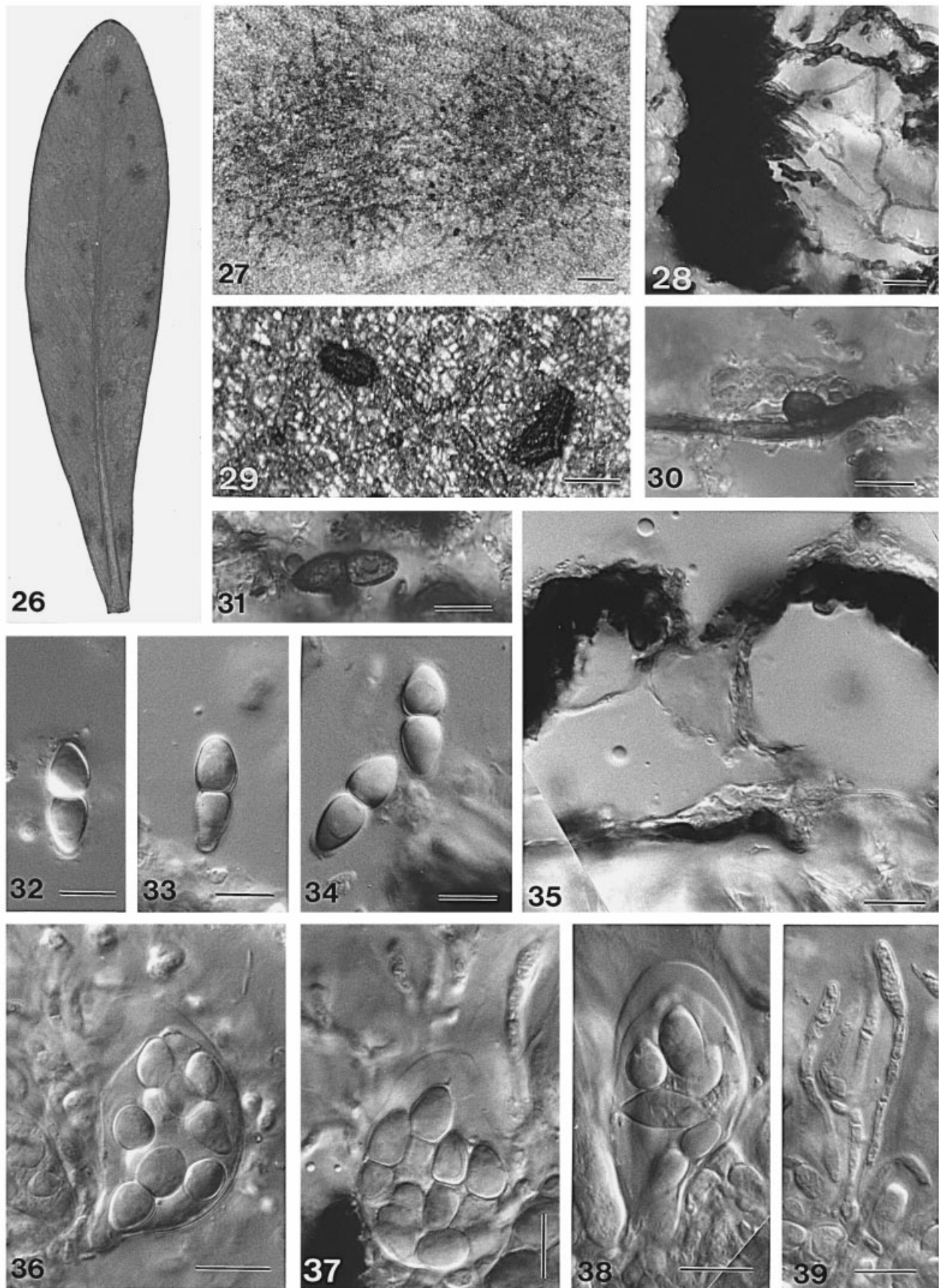
(Figs 9, 10, 12–17)
Anamorph: *Clasterosporium proteae* M. B. Ellis, *More Dematiaceous Hyphomycetes*: 100 (1976). (Figs 11, 18–25)

Maculae circulares, effusae, non morbescentes, atro-brunneae, (3–)5–10(–13) mm diam. Ascomata epiphylla, hysterothecia, atra, (250–)342–459(–510) μ m lata \times (120–)126–151(–180) μ m diam.; in sectione vadose conica, superficialia, haustoria formantia, asci parallelis in strato basali peridii, (120–)165–220(–250) μ m diam \times (50–)60–75(–85) alta μ m. Peridium parieti superioris ex uno strato cellularum atro-brunnearum vel atrarum compositum, (14–)15–23(–30) μ m, crassum stratum basale ad fissuram ostiole pariete exiliore, textura angulari pallida, cellulis (8–)9–16(–25) μ m diam. Hyphae superficiales vel intracuticulares superficiem peridii ascomatis obtegentes, hyphopodia lateralia formantem, (3.5–)4.5–6(–7) μ m diam. Pseudoparaphyses simplices vel ramosae apicibus tumidis, 2–3 μ m diam. Asci saccati ad clavati, bitunicati, sessiles, apice lato rotundato, 4–8 spori,

(30–)34–39(–48) \times (12–)13–15(–17) μ m. Ascospores fusiformes, septo maxime constricto divisae, hyalinae et levigatae, maturae pallide brunneae vel medio-brunneae et subtiliter verrucosae, pluriseriales, pusillo pulvino, (13–)13.5–14(–16) \times (4.5–)5–6(–6.5), coso ad apicem cellulae basilaris, et vagina mucosa circumdatae.

Holotype: **South Africa**, Western Cape Province, Jonkershoek Nature Reserve, on living leaves of *Protea acaulos*, 17 Jan. 1999, J. E. Taylor (PREM 56304-holotype of teleomorph).

Leaf spots circular with an uneven margin, effuse, discrete or occasionally confluent, non-necrotic, dark brown to black, (3–)5–10(–13) mm diam. (Figs 9, 18). *Ascomata* commonly epiphyllous, initially shield-shaped, becoming hysterothecoid, with a central longitudinal slit-like ostiole; isodiametric peridium cells radiate from the ostiolar slit; margin of ascomata uneven with rounded ends, black, singular and separate or sometimes coalescing, (250–)342–459(–510) μ m long \times (120–)126–151(–180) μ m diam. (Fig. 9); in section shallowly conical, base applanate, superficial with a central ostiolar cleft, forming haustoria comprising of thick-walled brown hyphae in epidermis cells, asci parallel on the basal layer of peridium, (120–)165–220(–250) μ m diam. \times (50–)60–75(–85) μ m high (Fig. 10). *Peridium* at upper side comprising one stratum of black melanised cells (14–)15–23(–30) μ m wide, at ostiolar cleft and at base becoming thin-walled, pale



Figs 26–39. *Lembosia proteae* (PREM 56193). **Figs 26, 27.** Lesions on *Protea* sp. leaf. **Fig. 28.** Uneven edge of hysterothelial ascoma. **Fig. 29.** Hysterothelial ascomata. **Fig. 30.** Hyphopodia. **Fig. 31.** Brown, verrucose mature ascospore. **Figs 32–34.** Ascospores. **Fig. 35.** Ascoma in cross section, showing peridium. **Figs 36–38.** Asci. **Fig. 39.** Pseudoparaphyses. Bars: 27 = 1 mm, 28 = 50 μ m, 29 = 200 μ m, 30–39 = 10 μ m.

brown *textura angularis*, and becoming hyaline inwardly, (8–)9–16(–25) μm diam. (Fig. 17). *Hyphae* superficial, branched, septate, mid-brown, roughened, growing over surface of the upper peridium of the ascomata (3.5–)4.5–6(–7) μm diam., forming lateral, simple, smooth, dark brown, rounded hyphopodia, with a small pore, (4–)4.5–6.5(–8) μm diam. (Figs 14, 24). *Pseudoparaphyses* embedded in a gelatinous matrix, simple or branched, hyaline, septate, thick-walled, hypha-like, longer than asci with swollen tips, 2–3 μm diam. (Fig. 12). *Asci* mainly saccate, some clavate to globose, bitunicate, sessile, with a broad rounded apex, ocular chamber lacking, 4–8-spored, (30–)34–39(–48) \times (12–)13–15(–17) μm (Fig. 13). *Ascospores* fusiform, two-celled highly constricted at the septum, upper cell broader, and widest at the base, hyaline and smooth, becoming pale to mid-brown and finely verrucose at maturity, overlapping pluriseriate, apices obtuse, (13–)13.5–14(–16) \times (4.5–)5–6(–6.5) μm , coated in a thin mucilaginous sheath (Figs 15, 16). *Conidiophores* developing laterally on hyphae, erect, cylindrical, mainly straight, dark brown, 1–2-septate, smooth or roughened, (7–)11–13.5(–16) \times (4–)4.5–5(–6) μm (Figs 11, 21, 25). *Conidiogenous cells* monoblastic, integrated terminal, cylindrical, dark brown, conidia detach by schizolytic secession, (3–)9–11(–18) μm (Figs 11, 21, 25). *Conidia* obclavate, base truncate, apex rounded, narrow, mid to dark brown, verrucose with vertical cracks or wrinkles, 1–9-distoseptate, darkened with distinct pore visible in each septum, solitary, dry, slightly constricted at septa, (16–)40–46(–58) \times (7–)8–9 μm diam. in the broadest part (Figs 19, 20, 22, 23).

Cultural characteristics: Colonies circular, convex with entire margins, fuscous black (7''k). Same in reverse. Dense, felty aerial mycelium. Colonies 5 mm diam. after 150 d. No anamorph was produced in culture.

Additional material examined (anamorph only): **South Africa**, Western Cape Province, Stellenbosch, J. S. Marais park, on a living leaf of *Protea magnifica*, 15 Jul. 1998, J. E. Taylor, JT304 (PREM 56194); Elgin, Molteno Brothers Farm, on a living leaf of *P. magnifica*, 20 Jul. 1998, J. E. Taylor & S. Denman, JT340 (PREM 56195); Somerset West, Hilly Lands Farm, 20 Jul. 1998, JT348 (PREM 56196); Stellenbosch, Jonkershoek Nature Reserve, on a living leaf of *P. acaulos*, 26 Jan. 1998, J. E. Taylor, JT687 (culture STE-U 2569-2572).

Host range: *Protea acaulos* (teleomorph), *P. eximia* and *P. magnifica* (anamorph only).

Known distribution: South Africa (Ellis 1976).

This teleomorph was identified as a member of *Asterinaceae* according to Barr (1987) and Müller & von Arx (1962), and differed from the similar *Englerulaceae* as the ascomata develop beneath the mycelium. *Lembosia* comprises approx. 40 species and occurs mainly in warmer climates (Müller & von Arx 1962, Hawksworth *et al.* 1995). *Lembosia* spp. are biotrophic pathogens and cause leaf spots on a variety of hosts (Hawksworth *et al.* 1995). The genus is very similar to *Cirsosia*, but differs in having lateral and not intercalary hyphopodia (Müller & von Arx 1962). The ascospores in this collection became brown, another characteristic of *Lembosia* (Ainsworth, Sparrow & Sussman 1973), but also of *Cirsosia* (Müller &

von Arx 1962, Hosagoudar & Pillai 1994). The anamorphs of the *Asterinaceae* include *Asterostomella*, *Clasterosporium*, *Pirozyskia*, *Septothyriella*, *Sporidesmium* and *Tripodosporium*.

Unfortunately, *Lembosia* is in taxonomic disarray with approximately 300 species listed in the Index of Fungi and the index of Saccardo, and there is no recent monograph or treatment available. As no *Lembosia* spp. appear to have been described on any proteaceous hosts, however, and due to the distinctive anamorph, this species is described here as new.

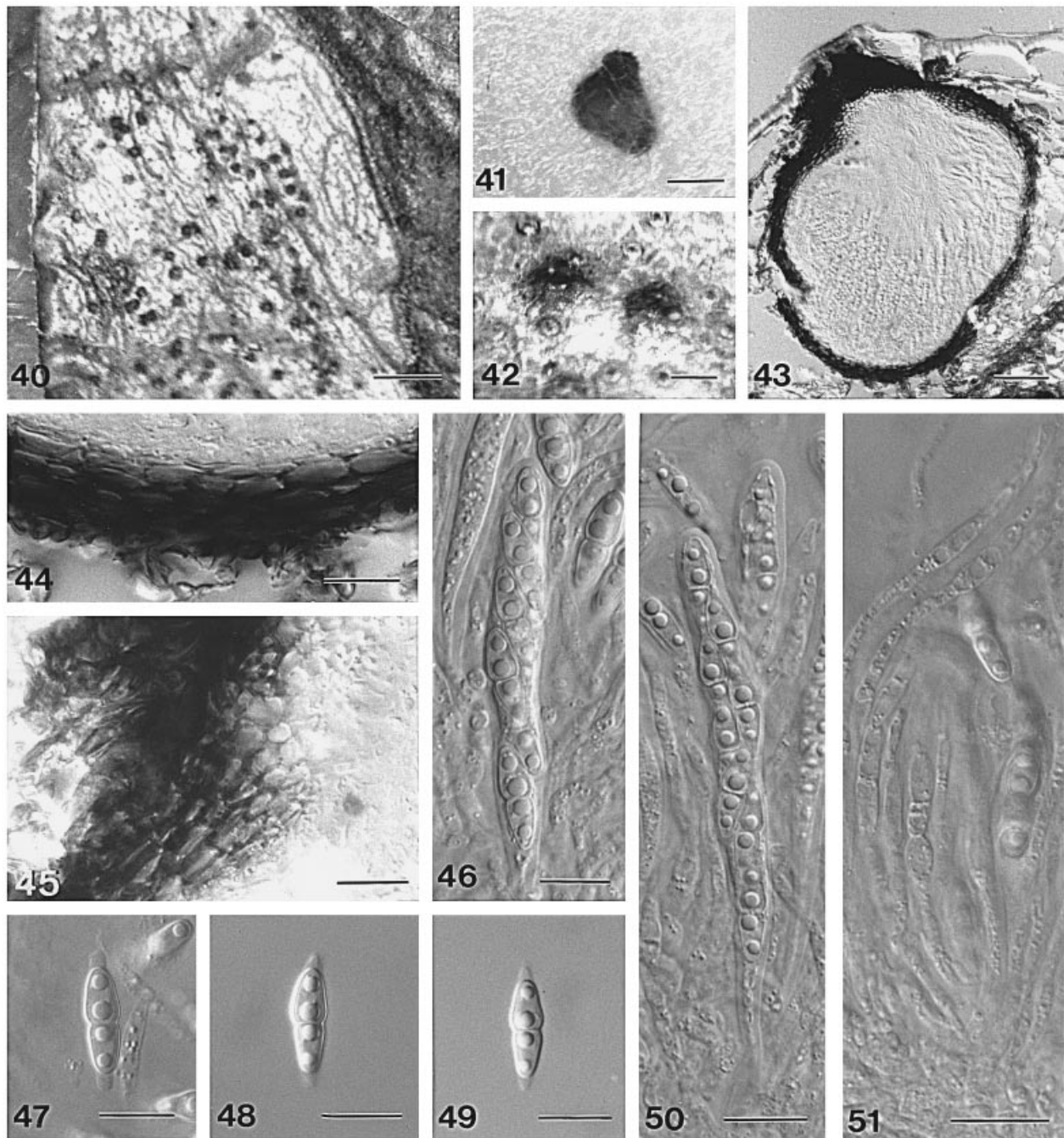
Another collection that appears to be conspecific has been made in South Africa (Mpumalanga, Sabie, D. R. de Wet Research Station, on living leaves of *Protea* sp., 15 Mar. 1988, M. J. Wingfield, PREM 56193) (Figs 26–39). The leaf spots are similar in size, 3–8.5 mm diam., and structure, but have a pale brown margin (Figs 26, 27). The hysterothecial ascomata (Fig. 29) had similar dimensions in section (170–210 μm diam. \times 55–80 μm high) (Fig. 35), but the peridium at the base was narrower (2–3 μm diam.), possibly due to the maturity of the specimens sectioned (Fig. 35). The asci overlapped in length (35–)40–44(–50) μm (Figs 36–38) with those of *L. proteae*, but the ascospores showed no overlap (16–)18–19(–22) \times (6–)6.5–8(–9) μm (Figs 31–34), and possessed mucilaginous caps at their apices, in addition to a thin mucilaginous sheath. It is difficult to ascertain whether this is different from *L. proteae* or within its range of variation. The *Clasterosporium* anamorph was not observed and no cultures are available.

Clasterosporium proteae is illustrated as culture characteristics are now available, and it is a reasonably common pathogen of *Protea*, being more frequently encountered than the *Lembosia* state.

Lophiostoma fuckelii Sacc., *Michelia* 1: 336 (1878).

(Figs 40–51)

Leaf spots circular to irregular, necrotic, sunken, grey-brown with a raised dark brown margin, often situated at the margin of the leaf, ascomata visible as blackened dots, scattered within the leaf spot, 3–13 mm diam. (Fig. 40). *Ascomata* epiphyllous, immersed, visible as a slightly raised, darkened area with a central, black slot-like ostiole, which becomes erumpent through the stomata, single and separate or loosely gregarious 150–220 μm diam. (Figs 41, 42); in section globose with a wide slot-like, periphysate, papillate ostiole, reduced clypeus consisting of brown hyphae within the host cells surrounding the ostiole, asci attached to the base and sides of the peridium, approximately 270 μm high \times 255 μm diam. (Fig. 43). *Peridium* comprising three strata, an outer stratum of thick-walled, brown compressed *textura angularis*, becoming thin-walled inwardly, with an inner layer of thin-walled, hyaline *textura angularis*, with thick-walled, large lumened *textura angularis* to *textura globulosa* at the ostiole, peridium marginally thinner at base, 14–27 μm diam. (Figs 44, 45). *Pseudoparaphyses* cellular, hyaline, tapering from base to a slightly narrower apex, longer than asci, embedded in a gelatinous matrix, 1.5–2 μm diam. (Fig. 51). *Asci* clavate to cylindro-clavate, bitunicate, pedicellate, rounded apex, with an inconspicuous ocular chamber, eight-spored, 60–83 \times 6.5–8.5 μm (Figs 46, 50). *Ascospores* fusiform, two-celled with two guttules in each cell, septum constricted, upper cell broader



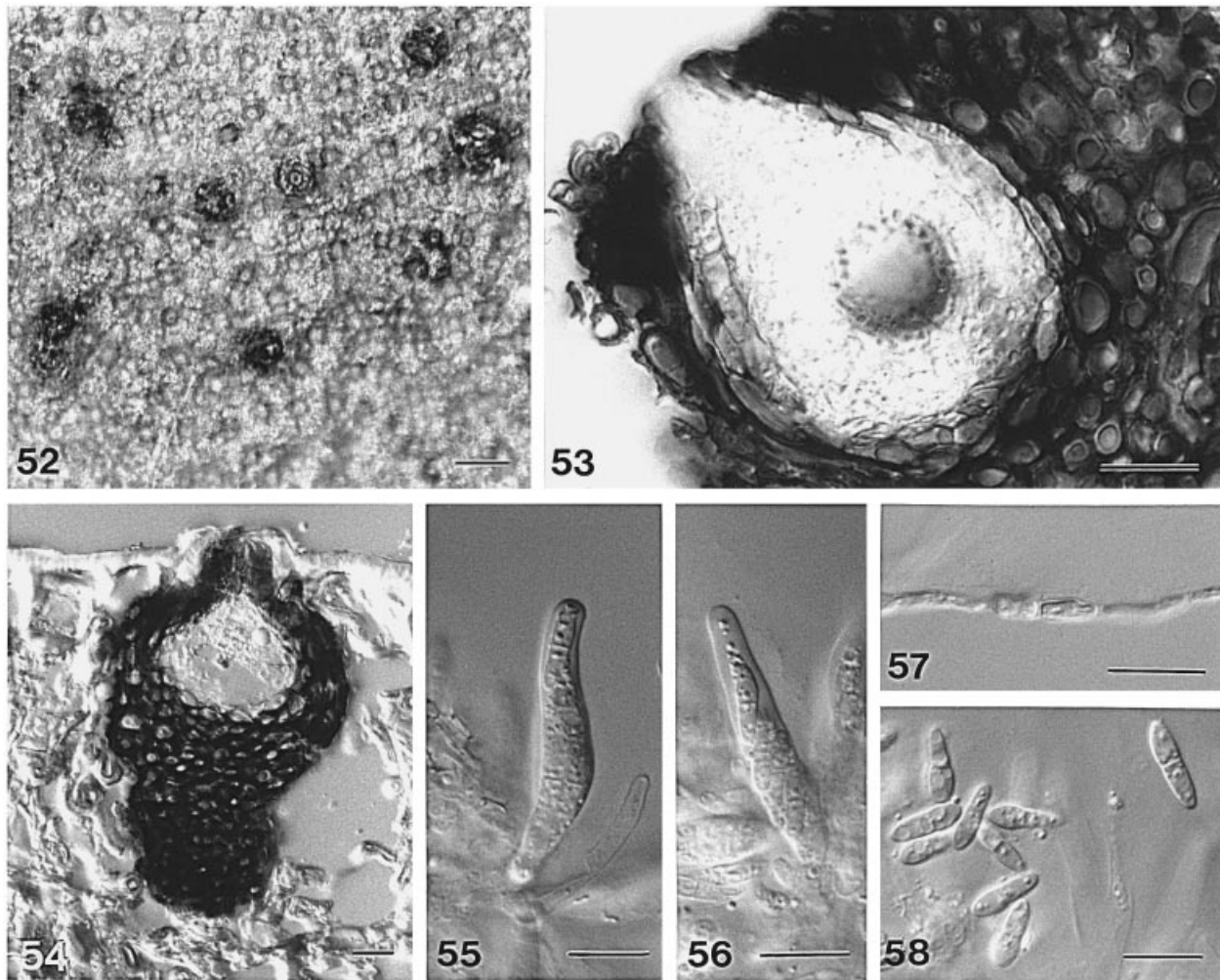
Figs 40–51. *Lophiostoma fuckelii*. (PREM 56200). **Fig. 40.** Lesion on *Protea cynaroides* leaf. **Fig. 41.** Ascoma in culture (STE-U 1725). **Fig. 42.** Ascomata on host substrate. **Fig. 43.** Ascoma in cross section. **Figs 44, 45.** Peridium. **Figs 46, 50.** Asci. **Figs 47–49.** Ascospores. **Fig. 51.** Pseudoparaphyses. Bars: 40 = 1 mm, 41–43 = 100 μ m, 44–51 = 10 μ m.

and widest at the base, hyaline, smooth, obtuse apices with a small mucilaginous appendage at the tip of each cell, 12–15.5 \times 4–5 μ m (Figs 47–49).

Cultural characteristics: Colonies circular with entire margins, pale mouse grey (17^{''}d) in the centre with a wide honey (9^{''}b) periphery, same in reverse. Moderately dense, felty aerial mycelium, broadly concentrically zoned. Colonies 25 mm diam. after 30 d, and fertile after 60 d on CLA (no anamorph produced).

Material examined: U.S.A., California, San Diego, Escondido, on a

living leaf of *Protea cynaroides*, 10 Apr. 1998, L. Swart, JT281 (PREM 56197). **South Africa**, Kwazulu-Natal, Drakensberg, Dragon's Peak, on a living leaf of *Protea* sp., 30 Jan. 1998, S. Denman, JT133 (PREM 56198); Western Cape Province, Stellenbosch, ARC-LNR Elsener Farm, on a living leaf of *Leucospermum cordifolium* cv. Pink Star, 5 Sep. 1998, S. Denman, JT379 (PREM 56199, STE-U 1965); Betty's Bay, Harold Porter Botanical Gardens, on a living leaf of *P. cynaroides*, 1 Apr. 1998, J. E. Taylor, JT300 (PREM 56200, STE-U 1725); Somerset West, Helderberg Nature Reserve, on a living leaf of *P. cynaroides*, Feb. 1998, J. E. Taylor, JT100 (PREM 56201); Stellenbosch, Moores End Farm, on a living leaf of *Protea* sp., Apr. 1998, J. E. Taylor, JT240 (PREM 56202); Gouriqua, Rein's Nature Reserve, on a living leaf of *P. susanna*, 8 Apr. 1998, L. Dreyer, JT226 (PREM 56203).



Figs 52–58. *Mycosphaerella stromatosa* (holotype PREM 56204). **Fig. 52.** Ascomata on *Protea* sp. leaf. **Figs 53, 54.** Ascomata in cross section. **Figs 55, 56.** Asci. **Fig. 57.** Germinating ascospore. **Fig. 58.** Ascospores. Bars: 52 = 100 μm , 53–58 = 10 μm .

Host range: *Leucospermum cordifolium* cv. Pink Star, *P. cynaroides*, *P. susannae*, *Protea* sp. Commonly associated with *Rubus fruticosus*, plurivorous on woody and herbaceous mainly dicotyledonous hosts (Chesters & Bell, 1970; Holm & Holm, 1988), and also on palms (Taylor 1997).

Known distribution: Asia (Taylor 1997), Europe, North America, (Chesters & Bell 1970, Holm & Holm 1988), South Africa.

This fungus is plurivorous, common and widespread and well documented (Chesters & Bell 1970, Holm & Holm 1988). The cellular pseudoparaphyses, clavate bitunicate asci, and ascomata with a slot-like ostioles are characteristic of *Lophiostoma*. The collection was identified as *L. fuckelii*, although the ascospores are slightly smaller than those cited by Holm & Holm (1988) (15–20 \times 4–5 μm), but correspond to those described by Chesters & Bell (1970) (11–18 \times 3–5 μm).

Mycosphaerella stromatosa J. E. Taylor & Crous, **sp. nov.**

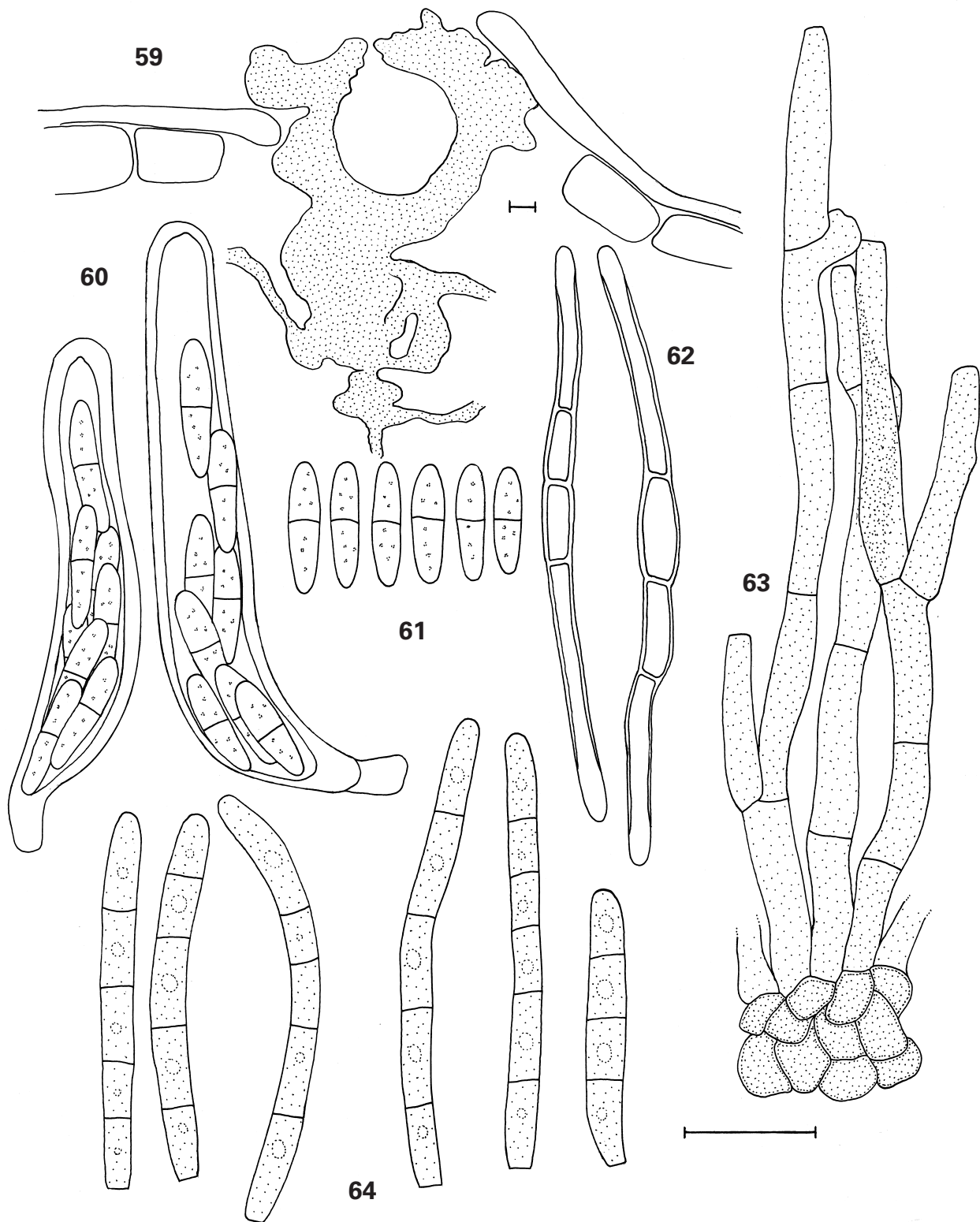
(Figs 52–62)

Anamorph: ***Pseudocercospora stromatosa*** J. E. Taylor & Crous, **sp. nov.**

(Figs 63, 64)

Etym.: From the latin suffix *osa*, indicating abundance or marked development, in reference to the well-developed stroma.

Maculae morbescentes, mortem apicis efficientes. Ascomata epiphylla, sub stomatibus, erumpentia; in sectione globosa, stromate irregulari circumdata, ostioli periphysibus carentibus, (95–)121–170(–180) μm lata \times (88–)100–119(–125) μm diam. Stromata ex cellulis atrobrunneis crassitunicatis, luminibus magnis, pseudostromate hyphis hospitis intersperso circumdata. Asci obclavati vel cylindro-clavati, bitunicati, sessiles, ad apicem rotundatum angustati, octospori (29–)33–36(–40) \times (6–)7–8(–10) μm . Ascosporeae late fusiformes, bicellulares, septo non constricto, cellula superiore latiore et latissima in medio, hyalinae, levigatae, guttulae, apicibus obtusis, (8.5–)10.5–11(–13) \times (2.5–)3–3.5(–4) μm . Mycelium olivaceum vel dilute brunneum, hyphae 1.5–3 μm latae. Caespituli fasciculati, amphigeni, medio-brunnei, 120 μm diam. \times 90 μm alti. Conidiophora fasciculata e stromate oriunda ascendunt, 120 μm diam. \times 60 μm lata; pallide brunnea, levigata, 0–6 septata, cylindrica, recta ad sinuosa, infra vel supra manifeste ramosa, 20–70 \times 2–3 μm . Cellulae conidiogenae terminales vel intercalares, non ramosae, olivaceae, levigatae, ad apicem obtusum gradatim angustate, simpodialiter proliferantes, 10–20 \times 2–3 μm . Conidia solitaria, olivacea, levigata, guttula, cylindrica, apice obtuso et base truncata vel longe obconice truncata, recta ad sinuosa, 3–6 septata, 25–40 \times 2.5–3 μm .



Figs 59–64. *Mycosphaerella stromatosa* (holotype PREM 56204) and its anamorph *Pseudocercospora stromatosa* (holotype PREM 56303, culture ex-type STE-U 1735). **Fig. 59.** Ascoma in cross section. **Fig. 60.** Asci. **Fig. 61.** Ascospores. **Fig. 62.** Germinating ascospores. **Fig. 63.** Conidiophore and conidiogenous cells. **Fig. 64.** Conidia. Bars = 10 μ m.

Holotypes: **South Africa**, Kwazulu-Natal, Drakensberg, Dragon's Peak, on a living leaf of *Protea* sp., Jan. 1998, S. Denman, JT127 (PREM 56204-holotype of teleomorph; culture ex-type STE-U 1731; PREM 56303-holotype of anamorph; culture ex-type STE-U 1735).

Leaf spots necrotic, sunken, pale brown with a raised dark brown margin, causing tip die-back, ascomata visible as densely scattered blackened dots within leaf spot. *Ascomata* mainly epiphyllous, immersed, becoming erumpent, sub-stomatal and initially sub-epidermal, visible as raised, darkened

area, papilla small or lacking, occurring singly but gregarious (Fig. 52); in section globose, surrounded by an extensive, and irregularly shaped stroma, with a well-developed, non-periphysate, central ostiolar pore, (95–)121–170(–180) μm high \times (88–)100–119(–125) μm diam. (Figs 53, 54, 59). *Peridium* not easy to differentiate from the stroma. *Stromata* composed of thick-walled, dark brown cells with large lumina, becoming paler, thin-walled and more compressed inwardly, melanized around the ostiole (15–)18–28(–40), embedded in pseudostroma comprising host cells loosely filled with thick-walled, smooth brown hyphae (Figs 53, 54). *Pseudoparaphyses* absent. *Asci* obclavate to cylindro-clavate, bitunicate, sessile, narrowing to a rounded apex, lacking an ocular chamber, 8-spored, (29–)33–36(–40) \times (6–)7–8(–10) μm (Figs 55, 56, 60). *Ascospores* broadly fusiform, two-celled, unconstricted at the septum, upper cell broader and widest at the middle, hyaline, smooth, eguttulate, with obtuse apices, (8.5–)10.5–11(–13) \times (2.5–)3–3.5(–4) μm (Figs 58, 61). *Mycelium* internal and external, branched, septate, smooth, olivaceous to pale brown, hyphae 1.5–3 μm wide. *Caespituli* amphigenous, medium brown, approximately 120 μm diam. \times 90 μm high. *Conidiophores* aggregated in dense fascicles arising from the upper cells of a brown stroma, approximately 120 μm diam. \times 60 μm high; conidiophores light-brown, smooth, 0–6-septate, cylindrical, straight to curved, prominently branched below or above, 20–70 \times 2–3 μm (Fig. 63). *Conidiogenous cells* terminal or intercalary, unbranched, olivaceous, smooth, tapering to flat tipped apical loci, proliferating sympodially, 10–20 \times 2–3 μm (Fig. 63). *Conidia* solitary, olivaceous, smooth, guttulate, cylindrical, apex obtuse and base truncate to long obconically truncate, straight to curved, 3–6 septate, 25–40 \times 2.5–3 μm (Fig. 64).

Cultural characteristics: Colonies circular, convex with crenated margins, uneven mixture of pale mouse grey (17''d) and vinaceous grey (5''f). In reverse, fuscous black (7''k). Dense, woolly aerial and immersed mycelium. Colonies 16 mm diam. after 30 d. No anamorph was produced in culture.

The anamorph and teleomorph were observed on the same leaf spot but did not develop in culture, so no conclusive link could be made. Single ascospore and conidial cultures were indistinguishable suggesting that they represent the same holomorph. Germinating ascospores produced germ tubes from one or, more often, both poles, which were initially parallel, but became irregular (Figs 57, 62).

Mycosphaerella stromatosa differs from other *Mycosphaerella* species on proteas as it possesses a well-developed stroma and has small ascospores, which lack a sheath, are eguttulate and are not constricted at the septum (Van Wyk, Marasas & Knox-Davies 1975b, Crous & Wingfield 1993, Swart *et al.* 1998, Taylor & Crous 1998). A key to the species of *Mycosphaerella* described from *Proteaceae* is presented below and it should be

noted that *M. proteae* has been synonymised under *Teratosphaeria maculiformis* (Taylor & Crous 1998).

Phloeospora protearum J. E. Taylor & Crous, **sp. nov.**

(Figs 65–73)

Etym.: Referring to the *Protea* host.

Laesiones deformatione cancriformi caulis consociatae. Conidiomata immersa, erumpentia, elongata, acervularia, pallide brunnea; in sectione, subglobose, subepidermalia, 163–205 μm lata \times 88–113 μm diam. Peridium strato texturae angularis vel intricatae compositum, hyalinae, cellulis compressis, tenuitunicatis. Cellulae conidiogenae hyalinae, irregulariter cylindricae ad doliiformes vel pyriformes, apicibus rotundatis vel applanatis non protuberantibus, non incrasatis, holoblastice formatae et sympodialiter proliferantes, (4–)5–6.5(–8) \times (2.5–)3–4.5(–6) μm . Conidia anguste cylindrica, recta, curvata vel irregularia, apice rotundato et basi truncata, tenuitunicata, levigata, hyalina, euseptata, 1–3-septata, (15–)20–22(–26) \times (2.5–)3–4.5(–6) μm .

Holotype: **Zimbabwe**, on a living stem of *Protea* sp., Apr. 1998, L. Swart, JT301 (PREM 56206; culture ex-type STE-U 1826).

Lesions associated with a stem canker characterised by shrunken, pale and parchment-like tissues (Fig. 65). *Conidiomata* occurring singly in loose groups, immersed, slightly raising the host surface or becoming erumpent, elongated parallel with venation of stem, acervular, pale brown (Fig. 67); in section subglobose, subepidermal, raising epidermis cells away from host mesophyll cells, conidiogenous cells peripheral, 163–205 μm high \times 88–113 μm diam. (Fig. 66). *Peridium* comprising a stratum of thin-walled hyaline, compressed *textura angularis* to *textura intricata*, slightly wider in the corners, with small-celled, dark brown, thin-walled, *textura angularis* occurring in places, (15–)21–41(–51) μm diam. (Fig. 73). *Conidiophores* reduced to conidiogenous cells. *Conidiogenous cells* hyaline, irregularly cylindrical to doliiform or pyriform, with rounded or flattened, non-protuberant, unthickened apices, conidial ontogeny holoblastic, with sympodial proliferation, (4–)5–6.5(–8) \times (2.5–)3–4.5(–6) μm , formed from the upper and lower walls of the conidiomata (Fig. 68). *Conidia* narrowly cylindrical, straight, curved or irregular, with a rounded apex and a truncate base, thin-walled, smooth, hyaline, euseptate, with 1–3 septa, (15–)20–22(–26) \times (2.5–)3–4.5(–6) μm (Figs 69–72).

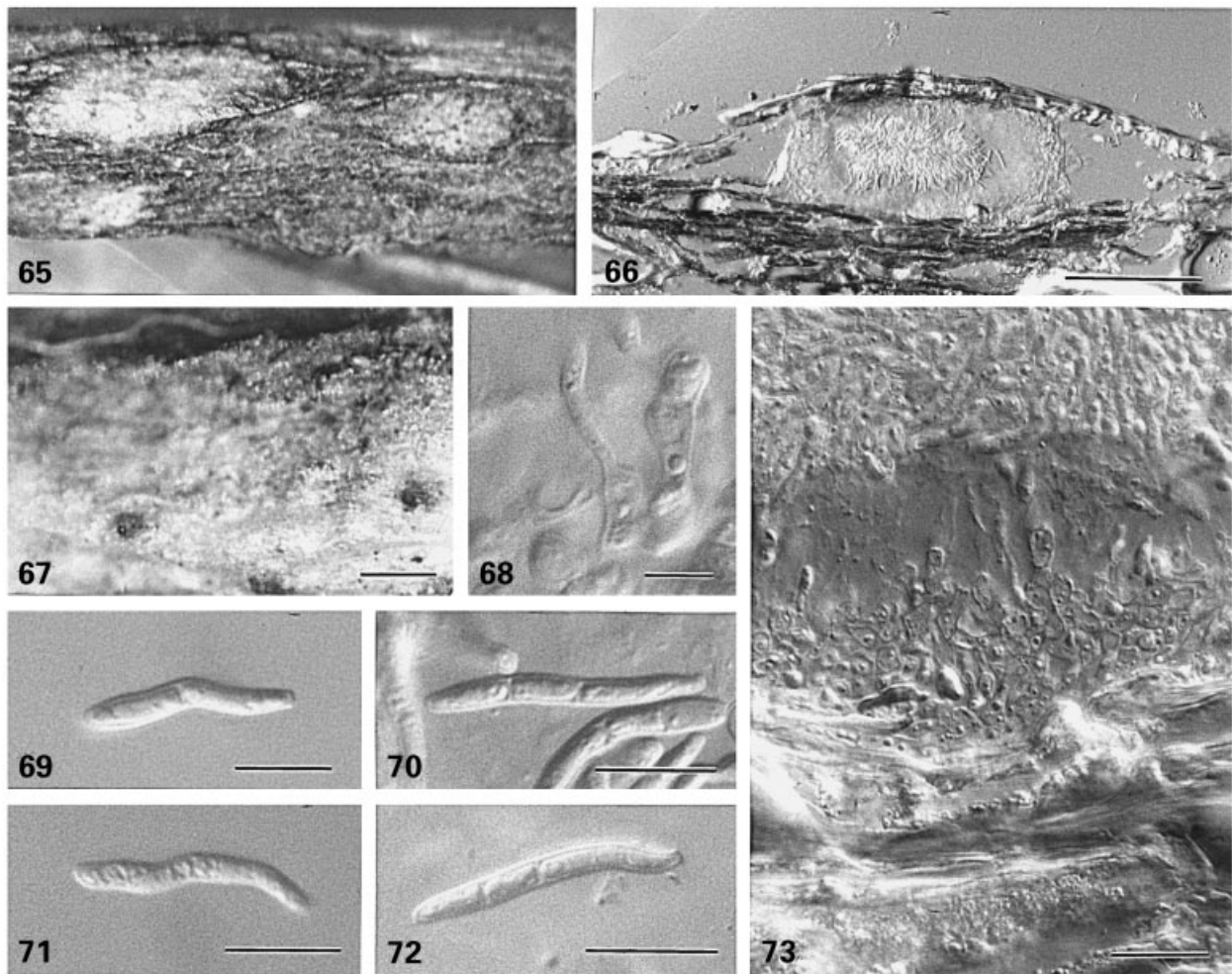
Cultural characteristics: Colonies circular, umbonate, with entire margins, buff (19''d) to honey (19''b), same in reverse. Moderately dense, slimy aerial mycelium, broadly concentrically zoned. Colonies 21 mm diam. after 60 d.

Teleomorph: Unknown.

Known distribution: Zimbabwe.

A key to *Mycosphaerella* species associated with *Protea*, *Leucospermum* and *Leucadendron*

- 1 Ascospores small, < 13 μm long 2
- Ascospores mainly > 13 μm long, eguttulate and unconstricted at the septum **jonkershoekensis**
- 2(1) Ascospores with guttules, a sheath and constricted at the septum **bellula**
- Ascospores eguttulate, unconstricted at the septum. Ascomata formed in a well-developed stroma **stromatosa**



Figs 65–73. *Phloeosporrella protearum* (holotype PREM 56206). **Fig. 65.** Lesions on *Protea* stem. **Fig. 66.** Cross section of conidiomata. **Fig. 67.** Conidiomata on host substrate. **Fig. 68.** Conidiogenous cells. **Figs 69–72.** Conidia. **Fig. 73.** Peridium. Bars: 66 = 50 μm , 67 = 200 μm , 68 = 5 μm , 69–72 = 10 μm , 73 = 20 μm .

Species of *Phloeosporrella* are anamorphs of *Blumeriella* (*Dermateaceae*), and comprise five widespread species (Hawksworth *et al.* 1995). This collection was identified as *Phloeosporrella* as it has acervular conidioma, sympodially proliferating conidiogenous cells and cylindrical, multiseptate, hyaline conidia (Sutton 1980, Dianese, Sutton & Tessman 1993 b). It does not resemble any described species of *Phloeosporrella* (Sutton 1980, Constantinescu 1984, Williamson & Bernard 1988, Bagyanarayana, Braun & Jagadeeswar 1992, Braun 1993, Dianese, Medeiros & Santos 1993 a; Dianese *et al.* 1993 b). During germination, germ tubes were produced more or less parallel to the long axis of the conidia or sometimes perpendicular. Germ tubes were irregular in shape and germination occurred from all cells.

***Septoria grandicipis* J. E. Taylor & Crous, sp. nov.**

(Figs 74–80)

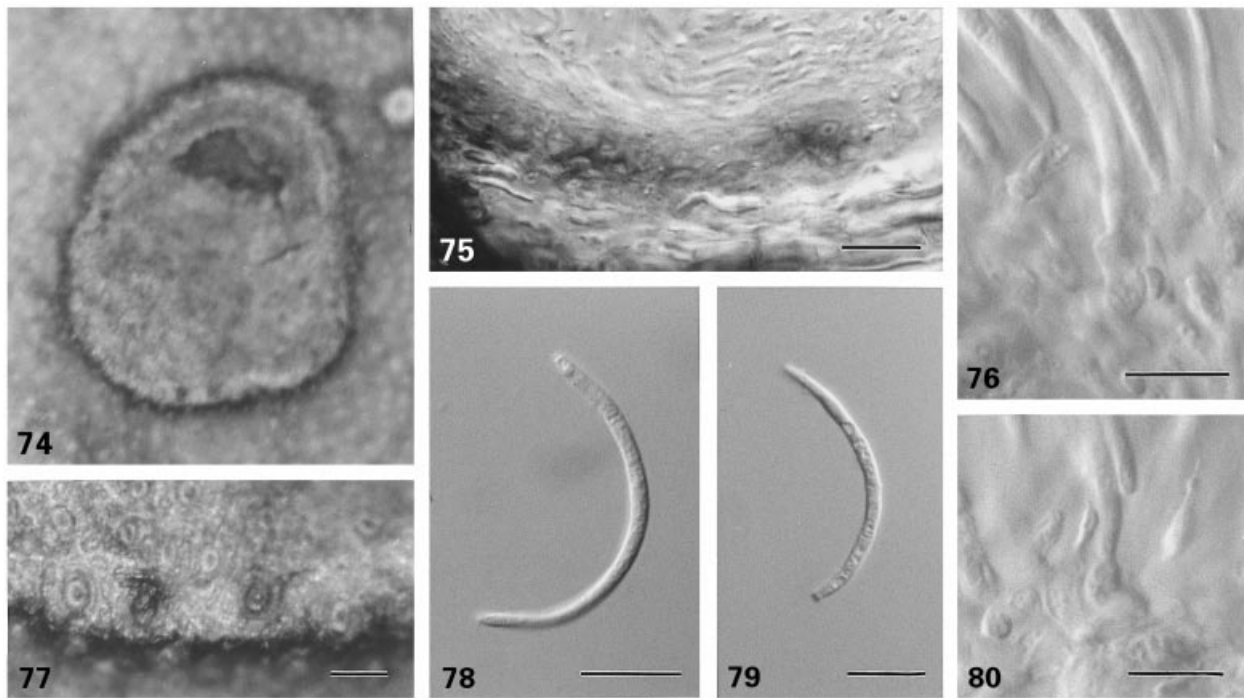
Etym.: Referring to the host *Protea grandiceps*.

Maculae circulares, morbescentes, 3 mm diam. Conidiomata amphigena, sub stomatibus, pycnidialia; in sectione, globosa, subepidermalia, ostiolata, 122 μm alta \times 100 μm diam. Peridium compositum ex strato texturae angularis vel texturae intricatae crassitunicatae, hyalinae, parvicellularis, (12–)13.5–18(–20) μm crassum. Conidiophora reducta ad cellulas conidiogenas. Cellulae conidigenae hyalinae,

irregulariter doliiformes, pyriformes vel ellipsoidales, apicibus rotundis vel complanatis, (2.5–)5–6(–8) \times (2–)3–4(–6) μm conidiogenesis holoblastica, sympodialiter proliferans. Conidia anguste cylindrica, recta vel curvata, apice rotundato, basi truncata, tenuitunicata, laevia, hyalina, euseptata, 6(–7)-septata, (33–)43–46(–57) \times 2–3 μm .

Holotype: **South Africa**, Western Cape Province, Elgin, Molteno Brothers Farm, on a living leaf of *Protea grandiceps*, 21 Jul. 1998, J. E. Taylor & S. Denman, JT313 (PREM 56205).

Leaf spots circular, necrotic, raised, grey-brown with a dark brown margin, 3 mm diam. (Fig. 74). *Conidiomata* amphigenous, substomatal, pycnidial with a central ostiole, occurring singly and visible only as pale brown areas surrounding the stoma (Fig. 77); in section globose, subepidermal, with a central, non-papillate ostiole, conidiogenous cells peripheral, 122 μm high \times 100 μm diam. *Peridium* comprising a stratum of thick-walled, hyaline, small-celled, compressed *textura angularis* to *textura intricata*, with mid brown, thick-walled, *textura angularis* surrounding the ostiolar pore, becoming hyaline and more compressed inwardly, (12–)13.5–18(–20) μm wide (Fig. 75). *Conidiophores* reduced to conidiogenous cells. *Conidiogenous cells* hyaline, irregularly doliiform, pyriform or ellipsoidal, with rounded or flattened apices, conidial ontogeny holoblastic, with sympodial proliferation, (2.5–)5–6(–8) \times



Figs 74–80. *Septoria grandicipis* (holotype PREM 56205). **Fig. 74.** Lesions on *Protea grandiceps* leaf. **Fig. 75.** Peridium. **Fig. 77.** Conidiomata on host substrate. **Figs 76, 80.** Conidiogenous cells. **Figs 78, 79.** Conidia. Bars: 77 = 100 μm , 75, 76, 78–80 = 10 μm .

(2–)3–4(–6) μm (Figs 76, 80). *Conidia* narrowly cylindrical, straight or curved, with a rounded apex and a truncate base, thin-walled, smooth, hyaline, euseptate, with up to seven septa, (33–)43–46(–57) \times 2–3 μm (Figs 78, 79).

Cultural characteristics: Colonies circular, umbonate, with entire margins, ochreous (13'b) to pale luteous (19d), becoming slightly darker (19'd) in the centre, same in reverse. Moderately dense, slimy aerial mycelium, becoming woolly in the centre. Colonies 10 mm diam. after 14 d.

Teleomorph: Unknown.

Known distribution: South Africa.

This collection was identified as *Septoria* as it possesses pycnidial conidiomata, sympodially proliferating conidiogenous cells and cylindrical, multiseptate, hyaline conidia (Sutton 1980). Over 1000 *Septoria* species have been described, which represent anamorphs of *Mycosphaerella* (*Dothideaceae*), and which are plant pathogens of numerous hosts (Hawksworth *et al.* 1995). Only *S. protearum* has been described from *Protea*, and it has smaller conidia (6–)15–22(–30) \times 1.5–2 μm (Swart *et al.* 1998) than *S. grandicipis*. *Septoria proteae* has been synonymised under *Phaeophleospora abyssinicae* (Crous & Palm 1999).

***Stilbospora proteae* J. E. Taylor & Crous, sp. nov.**

(Figs 81–91)

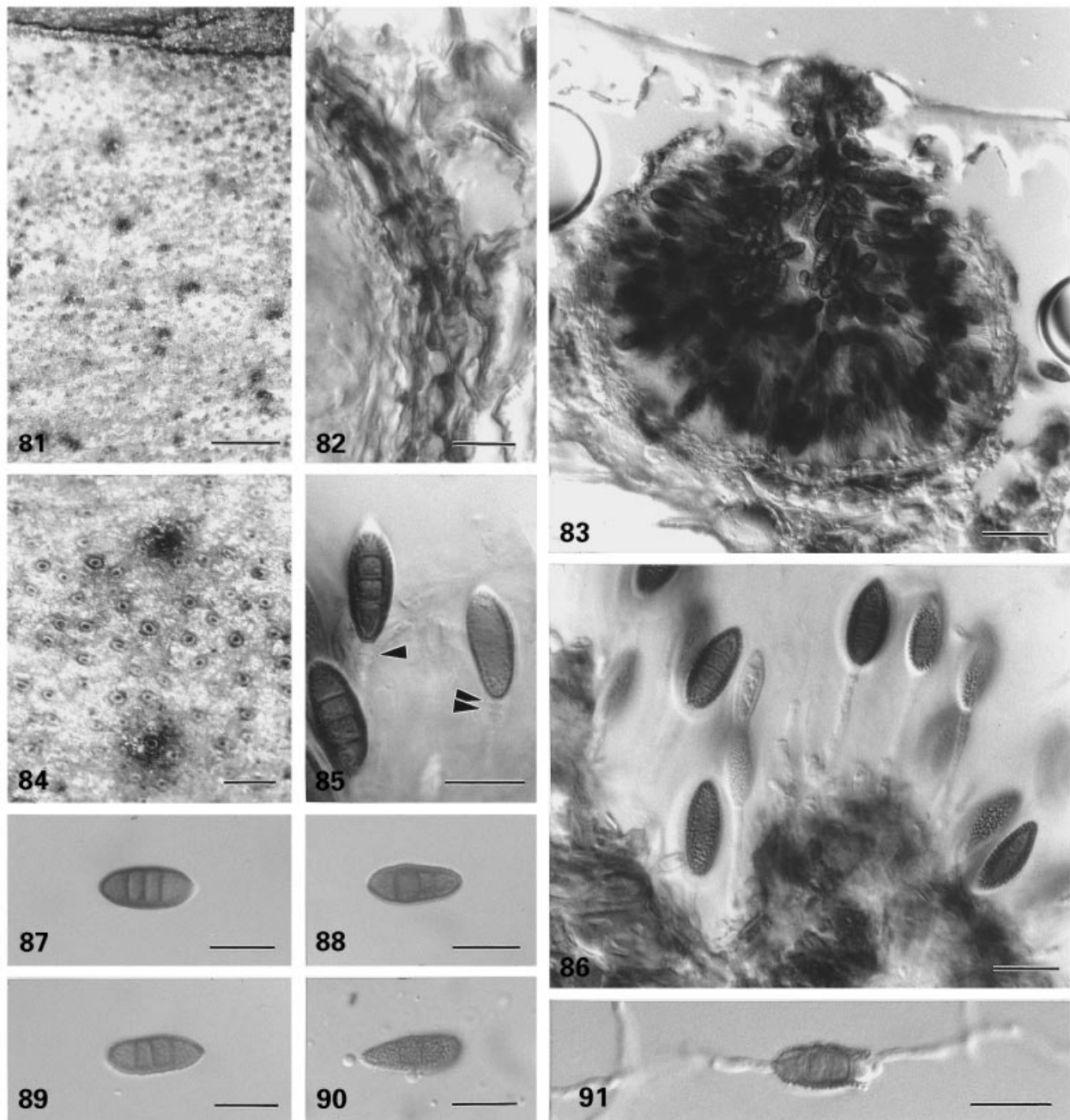
Etym.: referring to the *Protea* host.

Maculae circulares ad irregulares, morbescentes, 2–15 mm. Conidiomata epiphylla, pycnidialia, sub stomatibus, atro-brunnea, (90–)111–151(170) μm diam.; in sectione, globosa, ostiolata, pseudostroma

reductum circum ostiolum, 145–178 μm alta \times 135–182 μm diam. Peridium compositum ex strato externo texturae globosae, crassitunicatae, atro-brunneae, intus pallidius, (11–)14–17(–20) μm crassum. Paraphyses longiores quam cellulae conidiogenae, brunnescentes et maturitate deliquescentes. Conidiophora filiformia, hyalina, laevia, recta, supra simplicia vel ramosa, 1–3-septata, 10–17 \times 1.5–2 μm . Cellulae conidiogenae filiformes, hyalinae, holoblasticae, percurrenter proliferantes, ad ter annellatae, schizolyticae, (3–)9–15(–26) \times 1.5–2 μm . Conidia fusiformia vel ellipsoidea, crassitunicata, verrucosa, rubro-brunnea, 3-septata, euseptata, (11–)14–15(–18) \times (5–)6–6.5(–7.5) μm .

Holotype: South Africa, Western Cape Province, Gouriqua, Reins Nature Reserve, on a living leaf of *Protea susanna*, 8 Apr. 1998, L. Dreyer, JT229 (PREM 56191; culture ex-type STE-U 1811).

Leaf spots circular to irregular, necrotic, sunken, grey-brown with a raised dark brown margin, 2–15 mm (Fig. 81). **Conidiomata** epiphyllous, pycnidial, substomatal, nonerumpent but raising host surface slightly, dark brown, (90–)111–151(–170) μm diam. (Fig. 84); in section globose with a central, non-papillate ostiole; reduced stroma consisting of brown hyphae in hosts cells surrounding ostiole; conidiogenous cells peripheral, 145–178 μm high \times 135–182 μm diam. (Fig. 83). **Peridium** comprising an outer stratum of thick-walled, small-celled, dark brown *textura angularis* becoming paler inwardly; with the innermost cells thin-walled and hyaline, (11–)14–17(–20) μm diam. (Fig. 82). **Paraphyses** deliquesce early and remain as brown amorphous material between and above the conidiophores. **Conidiophores** filiform, hyaline, smooth, straight, simple or branched above, 1–3 septate, 10–17 \times 1.5–2 μm (Fig. 86). **Conidiogenous cells** terminal, filiform, hyaline, holoblastic, with percurrent proliferation, producing up to three annellations, secession schizolytic,



Figs 81–91. *Stilbospora proteae* (holotype PREM 56191). **Fig. 81.** Lesion on *Protea susanna* leaf. **Fig. 82.** Peridium. **Fig. 83.** Conidioma in cross section. **Fig. 84.** Conidiomata on host substrate. **Figs 85, 86.** Conidiogenous cells showing annellations (arrowed). **Figs 87–90.** Conidia. **Fig. 91.** Germinating conidium. Bars: 81 = 1 mm, 83 = 20 μ m, 84 = 100 μ m, 82, 85–91 = 10 μ m.

(3–)9–15(–26) \times 1.5–2 μ m (Figs 85, 86). Conidia fusiform to ellipsoidal, base truncate with or without a small hilum, narrowing slightly to a rounded or slightly acute apex, thick-walled, verrucose, reddish-brown, 1–3-euseptate, (11–)14–15(–18) \times (5–)6–6.5(–7.5) μ m (Figs 87–90).

Cultural characteristics: Colonies circular with undulate margins, fuscous black (7''k–7''k), often with white patches in the centre of younger colonies, same in reverse. Moderately dense, smooth aerial and immersed mycelium, becoming woolly in the centre, faintly concentrically zoned. Colonies 29 mm diam. after 40 d.

Teleomorph: Unknown.

Known distribution: South Africa.

Germination of *S. proteae* conidia was through development of bi-polar, parallel germ tubes, with occasionally one of the other cells also producing a germ tube (Fig. 91). This specimen proved difficult to identify. The fungus is pycnidial, and possesses percurrently proliferating conidiogenous cells with proliferations at progressively higher levels, and euseptate, multiseptate, thick-walled conidia. In the key provided by Sutton (1980) it is closest to *Camarosporium*, but the conidiogenous cells of this specimen differ in shape from those of *Camarosporium*, and the conidia are not muriform. It was also compared to species previously described as *Hendersonia* or *Stagonospora* (Sutton 1977). Species once included in *Hender-*

sonia have been removed to other genera (Sutton 1980, Swart & Walker 1988, Sutton & Dyko 1989, Walker, Sutton & Pascoe 1992, Ramaley 1995, Crous, Ferreira & Sutton 1997).

Ramaley (1995) discusses several genera with pycnidial conidiomata, but with conidial secession at approximately the same level on the conidiogenous cells. There are also many genera which have some similarities, but form acervular conidiomata, and possess combinations of either conidial secession at approximately the same level on the conidiogenous cells or distoseptate conidia (Sutton 1980, Swart & Walker 1988, Sutton & Dyko 1989, Walker *et al.* 1992, Ramaley 1995). Of the genera which develop pycnidia and percurrently proliferating conidiogenous cells, *Angiopomopsis* and *Sonderhenia* differ from this specimen as the conidia are distoseptate. *Phaeophloeospora* possesses all the characteristics of this specimen, but has thick-walled, brown conidiogenous cells and different shaped conidia.

This collection from *Protea*, therefore, appears to most closely resemble species of *Stilbospora* or *Sporocadus* (*sensu* Nag Raj 1993). Both are described as forming either acervuli only or acervuli and pycnidia (Shoemaker & Müller 1964, Sutton 1980, Hawksworth *et al.* 1995). In addition both genera are described as possessing smooth conidia, but in this collection the conidia are distinctly verrucose, and also lack the thickened septa possessed by most species of *Sporocadus* (Shoemaker & Müller 1964). Some species of *Stilbospora* have been reported to have roughened or finely pitted walls (Swart 1988), but all species are characterised by paraphyses which were not clearly identifiable in *S. proteae*.

This collection seems to be more affiliated to *Stilbospora*, but the generic limits of *Stilbospora* are uncertain, as it is suggested that conidiomata can be pycnidial or acervular (Hawksworth *et al.* 1995) and that distoseptate species can also be included (Swart 1988). Sutton (1980) acknowledges that the species limits of this genus have to be determined, as there are many taxa included in it which have not been re-examined. In light of this and despite the differences mentioned, this collection is placed in *Stilbospora*, as there is not enough evidence to justify the erection of a new genus. A previous record of a *Stilbospora* on a protea, *S. faurea* (PREM 1872, 5139, 5621) was examined, and the specimens were found to represent an undescribed *Phaeophloeospora*. Therefore, as no *Stilbospora* species has been described from *Proteaceae* or any other host in South Africa, a new species is being introduced to accommodate this collection.

***Teratosphaeria microsporum* J. E. Taylor & Crous, sp. nov.**
(Figs 92–94)

Anamorph: ***Trimmatostroma microsporum* J. E. Taylor & Crous, sp. nov.** (Fig. 95)

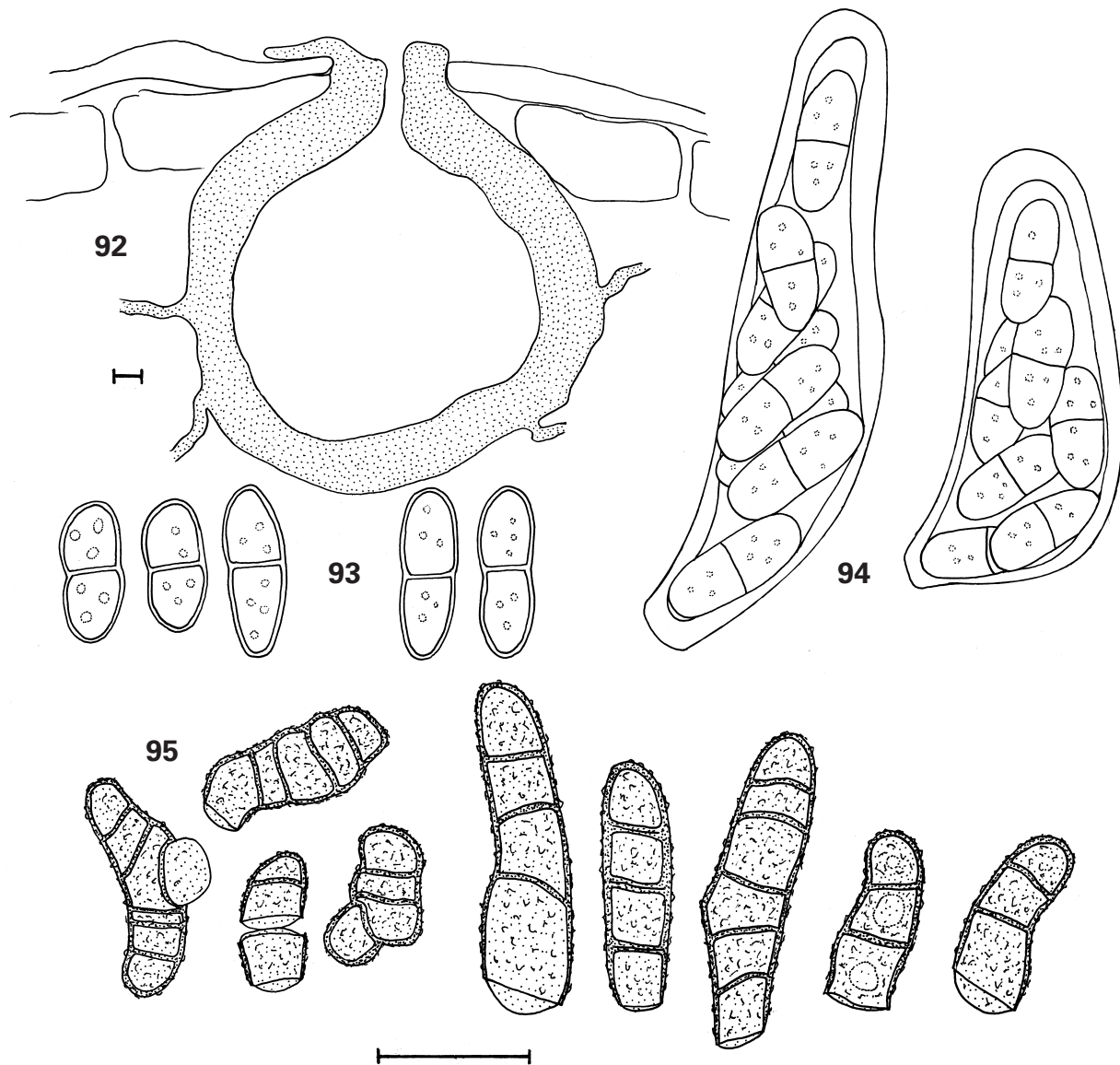
Ety.: Referring to the small size of the ascospores.

Species maculis *Teratosphaeriae maculiformis* consociata, maculae non morbescentes. Ascomata amphigena, immersa, sub stomate, sub-epidermalia; in sectione, globosa ad leniter subglobosa, ostiolo centrali periphysato, circa 150 µm alta × 140 µm diam. Peridium e duobus stratis texturae angularis brunneae compositum, intus pallidius, (15–)17–23(–27) µm crassum. Paraphyses ad periphysoides ostiolarum reductae, hyalinae, 1.5–2 µm latae. Asci obclavati ad globosi,

bitunicati, sessiles, apice rotundato, octospori, sparsi, (22–)30–36(–42) × (9–)11–13(–15) µm. Ascospores late fusiformes, bicellulares, septo centrali non constricto, cellula superiore paulo latiore, hyalinae vel pallide brunneae, levigatae, guttulate, apicibus obtusis, (7.5–)9–9.5(–12) × (3–)3.5–4(–4.5) µm, vagina mucosa circumdari videntur. Anamorphosis in eisdem maculis; conidiomata sporodochialia, pulvinata, sicca, atro-brunnea ad nigrae. Mycelium immersum, atrum, hyphis 3–5.5 µm latis. Stroma in cavitate sub stomatibus formatum, cellulis pseudoparenchymatis brunneitunicatis. Conidiophora sporodochialia per stomata emergentia. Cellulae conidiogenae cylindricae, terminales, holoblasticae. Proliferantes longitudine reductae, ca 6–8 × 3–4.5 µm. Conidia forma variabilia, cylindrica, y-formia, ellipsoidea, recta vel curvata, apicibus rotundatis vel truncatis, catenulata, schizolytice liberata, olivacea vel rubro-brunnea, multi-septata, septis transversalibus et frequenter longitudinalibus vel obliquis divisa, conidiis bicellularibus in hospite praedominantibus, crassitunicata, verrucosa, (8–)13–15(–21) × (3.5–)5.5–6(–8) µm. In cultura sporodochia absentia, conidiophora micronematosa 3–4.5 µm. Cellulae conidiogenae et conidia illis in materia hospitis similes, conidia olivaceo-brunnea, saepissime multicellaria, (5–)7.5–9(–16) × (3–)4.5–5.5(–7) µm.

Holotypes: **South Africa**, Western Cape Province, Somerset West, Hilly Lands Farm, on a living leaf of a *Protea cynaroides* seedling, 21 Jul. 1998, S. Denman & J. E. Taylor, JT352 (PREM 56207a-holotype of teleomorph, culture ex-type STE-U 1960; PREM 56207b-holotype of anamorph).

Leaf spots associated with those of *Teratosphaeria maculiformis*, non-necrotic. Ascomata amphigenous, immersed, raising the host surface, sub-stomatal, sub-epidermal, small papilla or lacking, occurring singly but gregarious; in section globose to slightly subglobose, with periphysate central ostiolo emerging through the stomata, asci attached at the periphery, stroma lacking, ca 150 µm high × 140 µm diam. (Fig. 92). *Peridium* comprising two strata, the outer composed of thick-walled, mid brown small-celled *textura angularis*, becoming thinner walled and hyaline inwardly, (15–)17–23(–27) µm diam. (Fig. 92). *Hamathecium* reduced to periphysoids lining the ostiolo, hyaline, 1.5–2 µm wide. *Asci* obclavate to globose, bitunicate, sessile, narrowing to a rounded apex lacking an ocular chamber, eight-spored, sparse, (22–)30–36(–42) × (9–)11–13(–15) µm (Fig. 94). *Ascospores* broadly fusiform, two-celled, unconstricted at the median septum, upper cell slightly broader, hyaline to pale brown, smooth, eguttulate, apices obtuse, (7.5–)9–9.5(–12) × (3–)3.5–4(–4.5) µm, appearing to be surrounded by a mucilaginous sheath (Fig. 93). *Sporodochial conidiomata* in the same spots, pulvinate, dry, dark brown to black, discrete. *Mycelium* immersed, pale brown, hyphae septate, smooth, 3–5.5 µm wide. *Stroma* forming in a substomatal cavity, and comprised of brown-walled pseudoparenchymatous cells. *Conidiophores* macronematous, mainly straight, caespitose, closely packed, emerging in masses through stomata, short, smooth, olivaceous-brown. *Conidiogenous cells* irregularly cylindrical, terminal, holoblastic, ca 6–8 × 3–4.5 µm, with retrogressive, schizolytic delimitation of subsequent conidia, giving an unconnected chain of conidia. *Conidia* variously cylindrical, Y-shaped, ellipsoidal, straight or curved, with rounded or truncated apices, catenate in branched basipetal chains, schizolytically liberated, olivaceous to reddish



Figs 92–95. *Teratosphaeria microsporum* (holotype PREM 56207a) and its anamorph *Trimmatostroma microsporum* (holotype PREM 56207b). **Fig. 92.** Ascoma in cross section. **Fig. 93.** Ascospores. **Fig. 94.** Asci. **Fig. 95.** Conidia. Bars = 10 μm .

brown, multiseptate, with transverse and often longitudinal or oblique septa, with bi-cellular conidia predominating on the host, thick-walled, verrucose, $(8\text{--}13\text{--}15\text{--}21) \times (3.5\text{--}5.5\text{--}6\text{--}8) \mu\text{m}$ (Fig. 95). *In culture* sporodochia not formed. *Conidiophores* micronematous, branched, flexuous, smooth, pale- to midbrown, 3–4.5 μm wide. *Conidiogenous cells* mainly cylindrical, integrated, conidiogenesis like that on the host, but forming an unconnected, branched chain of conidia, ca $4\text{--}12 \times 3.5\text{--}4 \mu\text{m}$. *Conidia* as above, with multicellular conidia predominating, $(5\text{--}7.5\text{--}9\text{--}16) \times (3\text{--}4.5\text{--}5.5\text{--}7) \mu\text{m}$.

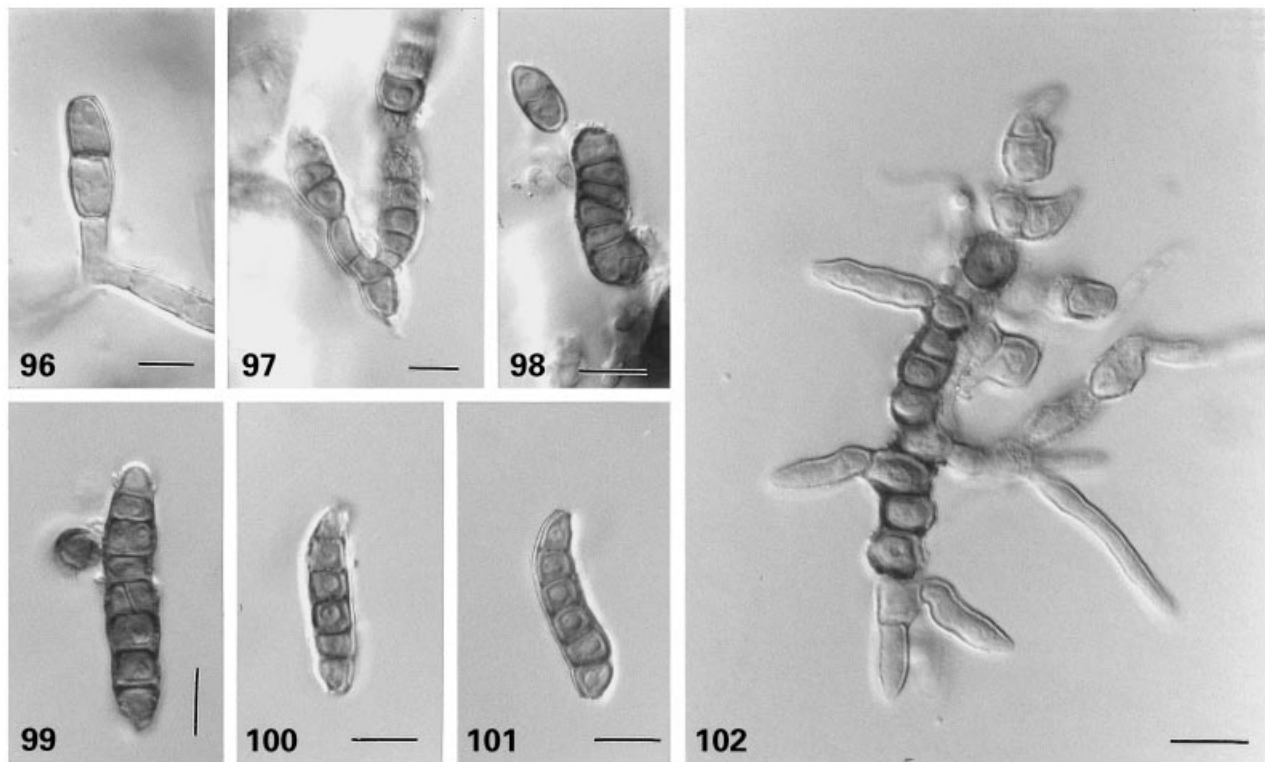
Cultural characteristics: Colonies circular, flat with entire margins, dark mouse-grey (13''k) to olivaceous-black (27''k), same in reverse. Moderately dense, felty aerial mycelium. Colonies 15 mm diam. after 14 d, and anamorph produced in culture after 2–3 d.

Host range: *Protea eynaroides*.

Known distribution: South Africa.

This collection was identified as *Teratosphaeria* according to von Arx & Müller (1975) as the ascomata are immersed, and the centrum comprises parallel bitunicate asci, with the hamathecium reduced to periphysoids at the ostiole. Ascospores are typically bicellular, hyaline to pale brown. Five other *Teratosphaeria* species are known, mainly occurring on members of the *Proteaceae* and all occurring in the Southern Hemisphere (Van Wyk *et al.* 1975 b, Müller & Oehrens 1982, Taylor & Crous 1998).

The taxonomic history of *Teratosphaeria* is discussed by Müller & Oehrens (1982) who suggest that it should be placed in the *Phaeosphaeriaceae*. In the system devised by Barr (1987) *Teratosphaeria*, which possesses periphysoids above the asci and lysigenously formed ostioles, appears to be more affiliated with the *Pleosporaceae* (= *Pseudosphaeriaceae*) or *Dothideaceae* (*Dothideales*). No holomorphic connections have ever been



Figs 96–102. *Trimmatostroma elginense* (holotype PREM 56208). **Figs 96, 97.** Conidiogenous cells. **Figs 98–101.** Conidia. **Fig. 102.** Germinating conidium. Bars = 10 μ m.

made for either *Teratosphaeria* or the anamorph isolated here, *Trimmatostroma*. The anamorph–teleomorph connection was noted on the host material and confirmed in culture.

Teratosphaeria microsporium differs from other members of this genus as it possesses smaller ascospores (Van Wyk *et al.* 1975b, Müller & Oehrens 1982, Taylor & Crous 1998) and produces a fertile anamorph in culture. It also differs in having a germination pattern different from other species associated with *Proteaceae*. The morphologically closest is *T. maculiformis*, with which the present collection was found associated, but it has much larger ascospores, different culture characteristics, and forms a single germ tube during germination (Swart *et al.* 1998). Germination of *T. microsporium* occurs from both cells and germ tubes grow parallel to the long axis of the spore. There is no constriction at the septum and the spore does not darken or become verruculose on germination as in *T. maculiformis*.

There are approximately 29 species of *Trimmatostroma* which are saprobes and plant pathogens of various plant hosts, occurring on leaves and woody parts (Saccardo 1915, Cooke & Shaw 1952, Hughes 1953, Ellis 1971, 1976, Sutton & Ganapathi 1978, Van Warmelo & Sutton 1981, Gadgil & Dick 1983, Crane & Schoknecht 1986, Sutton 1993, Goh & Yipp 1996, Crous & Palm 1999). *Trimmatostroma microsporium* is morphologically distinct from other *Trimmatostroma* species, including the three previously described on proteas. It is closest to *T. macowanii*, but the latter has generally longer, wider conidia (10–)15–17(–23) \times (6–)6.5–7(9) μ m, and very different culture characteristics (Ellis 1976, Taylor & Crous

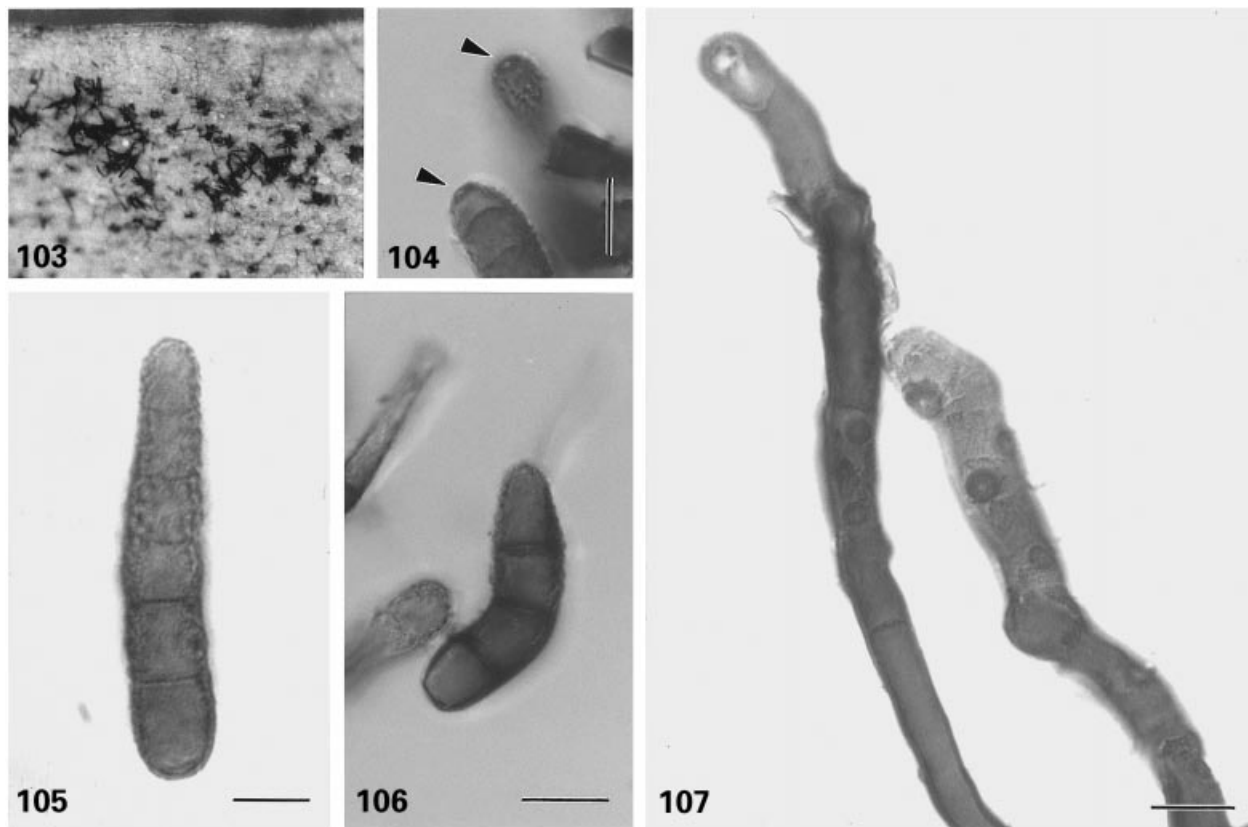
1998). In contrast, *T. protearum* (Crous & Palm, 1999) and *T. elginense* are distinguished by having much larger conidia.

Trimmatostroma elginense* J. E. Taylor & Crous, *sp. nov.
(Figs 96–102)

Etym.: Referring to the place, Elgin, where the collection was made.

In eisdem maculis atque *Septoria grandicipis*. Coloniae sporodochiales, pulvinatae, siccae, atrobrunneae ad nigrae, 90–100 \times 39–82 μ m. Mycelium immersum, pallide brunneum. Stroma in cavitate sub stomatibus formatum, cellulis pseudoparenchymatis brunneitunicatis. Cellulae conidiogenae irregulariter cylindricae, ad doliiformes, terminales, holoblasticae, schizolyticae, ca 10–18 \times 6–7 μ m. Conidia forma variabilia, cylindrica, fusiformia, ellipsoidea, recta vel curvata, apicibus rotundis vel truncatis, catenulata, schizogena, rubro-brunnea, multiseptata, septis transversalibus et multis longitudinalibus vel obliquis divisa, crassitunicata, verrucosa, (9–)16–20(–36) \times (10–)14–18(–27) μ m. In cultura sporodochia absentia, sed numerosae structure globosae, multicellulares, quasi chlamydosporae, pallide brunneae, laevigatae, 15–49 μ m diam. Conidiophora semimacronematosa, 5.5–7.5 μ m. Cellulae conidiogenae illis in materia hospitis similes, catenae conidiorum simplices vel ramosae, non connexa, ca 8–16 \times 6–8 μ m. Conidia illis in materia hospitis similia, olivaceo-brunnea, septis transversalibus et interdum longitudinalibus divisa, saepissime multicellularia, parietibus subtiliter verrucosis vel laevigatis, (10–)14–18(–27) \times (6–)7–8(–10) μ m.

Holotype: **South Africa**, Western Cape Province, Elgin, Molteno Brothers Farm, on a living leaf of *Protea grandiceps*, 21 Jul. 1998, J. E. Taylor & S. Denman, JT316 (PREM 56208; culture ex-type STE-U 1958).



Figs 103–107. *Verrucisporota proteacearum* (PREM 56209). **Fig. 103.** Conidiophores on host substrate. **Fig. 104.** Conidia showing thickened hila (arrowed). **Figs 105, 106.** Conidia. **Fig. 107.** Conidiophores and conidiogenous cells. Bars = 10 µm.

Leaf spots as for *Septoria grandicipis*, not found occurring separately. *Colonies* sporodochial, pulvinate, dry, dark brown to black, discrete, 90–100 × 39–82 µm. *Mycelium* immersed, pale brown, hyphae septate, smooth, 3–6 µm wide. *Stroma* forming in substomatal cavities, of brown-walled pseudoparenchymatous cells. *Conidiophores* macronematous, branched, fairly loosely packed, sporodochia emerging through stomata, smooth, mid red-brown. *Conidiogenous cells* irregularly cylindrical to doliiform, terminal, ca 10–18 × 6–7 µm, holoblastic, with retrogressive delimitation of subsequent conidia giving unconnected, branched or simple chains of conidia, secession schizolytic (Figs 96, 97). *Conidia* variously cylindrical, fusiform, ellipsoidal, straight or curved, with apices rounded or truncated, often with an indistinct frill, forming branched basipetal chains, reddish brown, with numerous transverse and often longitudinal or oblique septa, thick-walled, verrucose, (9–)16–20(–36) × (10–)14–18(–27) µm (Figs 98–101). *In culture* sporodochia not formed, but numerous globose, multicellular, chlamydospore-like structures, pale brown, smooth, 15–49 µm diam. *Conidiophores* semi-macronematous, branched, flexuous, smooth, pale to mid red-brown, 5.5–7.5 µm diam. *Conidiogenous cells* mainly cylindrical, integrated or terminal, ca 8–16 × 6–8 µm; conidiogenesis like that on the host, chains unconnected, simple or branched. *Conidia* as above, but less often longitudinal or oblique septa, with multicellular conidia predominating, thick-walled, finely verrucose to smooth, (10–)14–18(–27) × (6–)7–8(–10) µm.

Cultural characteristics: Colonies circular, umbonate with

entire margins, greenish black (3''''k), same in reverse. Aerial mycelium dense, felty. Colonies 15 mm diam. after 40 d, fertile after 7 d.

Teleomorph: Unknown.

Known distribution: South Africa.

This collection differs from the other three *Trimmatostroma* species recorded on proteas (Ellis 1976, Crous & Palm 1999), but does bear affinities to *T. salicis*. The conidia of *T. salicis* are slightly narrower (12–38 × 4–10 µm) and this species appears to be specific to *Salix* spp. On germination of *T. elginense* conidia, germ tubes are produced from individual cells, perpendicular to the long axis of the conidia, which are irregular and branched (Fig. 102).

Verrucisporota proteacearum (D. E. Shaw & Alcorn) D. E. Shaw & Alcorn, *Australian Systematic Botany* **6**: 273 (1993) (Figs 103–107)

Verrucisporota proteacearum D. E. Shaw & Alcorn, *Proceedings of the Linnean Society of New South Wales* **92**: 171 (1967).

Colonies round or irregular, hairy, dry, dark brown to black, discrete. *Mycelium* immersed, pale brown, septate, verrucose, 3–4 µm diam. (Fig. 103). *Stroma* forming in substomatal cavity, cells brown-walled, pseudoparenchymatous. *Conidiophores* macronematous, mononematous, caespitose, emerging through the stomata, simple, flexuous, often geniculate, approximately 4-septate, mainly smooth, dark reddish brown or slightly olivaceous, from a bulbous base tapering towards the apex, but often becoming more swollen, and also verrucose at the apex, (90–)121–136(–250) × (5–)6–7(–9) µm.

Conidiogenous cells cylindrical, becoming geniculate, integrated, terminal, becoming intercalary, polyblastic, proliferating sympodially, 15–35 × 7–9 µm, with conspicuous, cicatrized, protuberant, conidiogenous loci, 3–4 µm diam. (Fig. 107). *Conidia* cylindrical, narrowing slightly to an obtuse apex and a truncate base with a distinct thickened hilum, medium reddish brown, straight or curved, with 1–6(–7) mainly unconstricted eusepta, thick-walled, verrucose, (20–)31–36(–49) × (7–)8.5–9.5(–12) µm (Figs 104–106).

Material examined: **South Africa**, KwaZulu-Natal, Mpumalanga, D. R. de Wet Research Station, on living leaves of *Protea gaguedi*, 15 Mar. 1988, M. Wingfield (PREM 56209).

Host species: *Finschia chloroxantha*, *Grevillea* spp., *Hakea* spp., *Protea* spp. (Shaw & Alcorn 1967, Ellis 1971, Shaw & Alcorn 1993, Sutton 1993).

Known distribution: Australia, New Guinea, Malawi, Tanzania, Zambia (Shaw & Alcorn 1967, Ellis 1971, Shaw & Alcorn 1993, Sutton 1993), South Africa.

This is the first record of *V. proteacearum* from South Africa, and, although this is a well-documented fungus, a full description is given here for benefit of those who study the fungi associated with the *Proteaceae*.

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