

**11. *Bionectria zelandiaenovae*** Schroers, *sp. nov.* — Figs 27 a–h, 28 a–b.

Anamorph: *Clonostachys zelandiaenovae* Schroers, *stat. nov.* — Figs 27 i, j, 28 c–f.

*Bionectria ochroleuca* similis sed peritheciis verrucosis. *Bionectria byssicolae* similis sed cellulis strati exterioris peritheciolorum et verrucis peritheciolorum uniformiter tenuitunicatis. Ascospores (11.6–)14.6–15.8–16.8(–21.4) × (3.8–)5–5.4–5.8(–7.4) μm. Anamorphosis *Clonostachydi roseae* et anamorphosi *C. byssicolae* similis, sed coloniis lente crescentibus (diametro coloniae 30 mm post 7 dies temperatura 24°C). Coloniae non vel minime crescentes temperatura 30°C. Stipes conidiophorum primariorum saepe brevior quam pars ramosa. Conidia (4–)5.2–6–6.4(–13.2) × (2.4–)2.8–3–3.2(–4.2) μm.

Holotypus teleomorphosis: Specimen PDD 49456. Holotypus anamorphosis: PDD; cultura sicca, isolata ex specimine PDD 49456; isotypus herb. CBS; cultura viva CBS 100979.

Etymology: *Zelandiaenovae* (Latin) referring to its geographical distribution (New Zealand).

**Description from natural substratum:** **Stroma** well-developed, erumpent through bark, bearing sporodochia or perithecia, often seated on or incorporating other pyrenomycetes; cells angular to subglobose. **Perithecia** crowded frequently in groups of up to 12 or more (to 30), rarely solitary, globose to subglobose, 290–550 μm diam (n = 25), not markedly pinched when dry, orange to brownish orange, not or minutely papillate, particularly when dry, ostiolar region sometimes reddish brown, warted to scaly. **Perithecial warts** less pigmented, off-white, 30–80 μm high, 50–80 μm diam; cells angular to globose, of the same type as the cells of the outer perithecial wall region, to 19 × 17 μm, with uniformly thickened walls up to 2 μm thick, rarely with unevenly thickened walls. **Perithecial wall** 65–77–90 μm thick, composed of three regions. Outer region 30–42–50 μm or to 5 cells thick; cells angular to subglobose, 5–20 × 4–17 μm, with uniformly thickened walls up to 2 μm thick; vacuoles not observed. Middle region 10–15.5–24 μm thick, of up to 5 layers of intertwined hyphae. Inner region 12–19.5–25 μm thick. **Asci** narrowly clavate, (60–)71–78.5–86(–104) × (7–)9.5–10.5–11.5(–15.5) μm (n = 92), 8-spored; apex rounded or flat with rounded edges, ring clearly visible. **Ascospores** ellipsoidal, spinulose, rarely smooth, (11.6–)14.6–15.8–16.8(–21.4) × (3.8–)5–5.4–5.8(–7.4) μm (n = 263). **Sterile mycelium** not developed or inconspicuous. **Mononematous conidiophores** not observed. **Sporodochia** ca 500 μm high, to 700 μm diam, covered by a white, cream-coloured, or yellowish conidial mass; branches of conidiophores and phialides arranged in a *textura porrecta*.

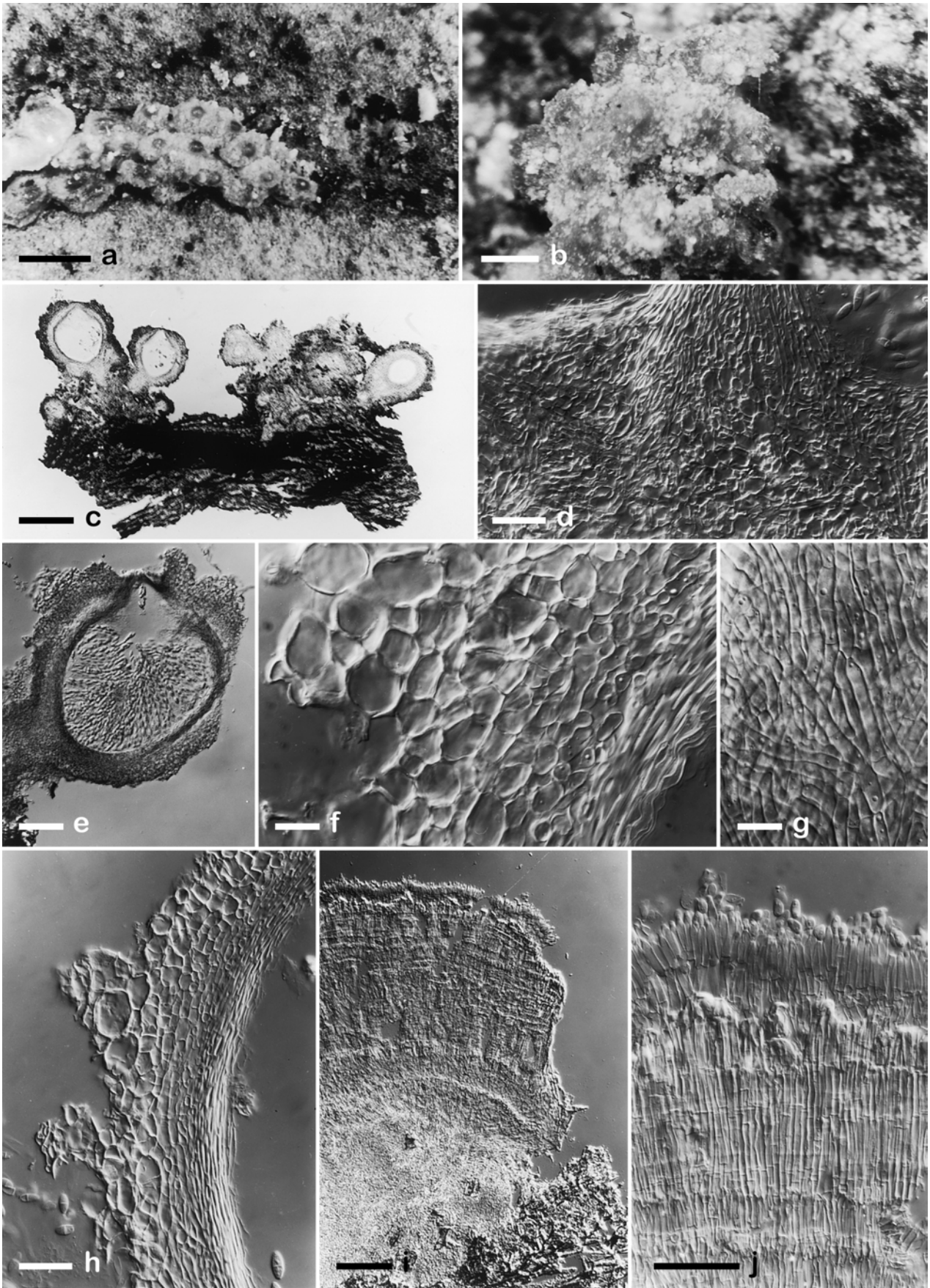
**Description from culture:** **Colonies** reaching 25–30 mm diam in 7 d at 24°C; optimum for growth 18–27°C, maximum 30/33°C. Colony reverse yellowish

white, after incubation under UV in orange hues. Colony surface finely to coarsely granular because of the sporodochia and confluent conidial masses or exudates, somewhat cottony, white or pale orange, granulose because of the confluent conidial masses; aerial mycelium almost absent or organized in strands; stroma formation not observed. **Conidiophores** dimorphic. Primary conidiophores verticillium-like, formed throughout the colony, but dominating near the margin, arising from the agar surface or from aerial mycelium, infrequently also simple, acromonium-like; branches and phialides divergent; stipe ca 50 μm long, to 4 μm wide at base; branching part ca 100 μm high, with diverging branches; phialides generally in whorls of 2–3, rarely solitary, straight, cylindrical, slightly and continuously tapering towards the tip, with a minute collarette, (21.2–)27–32.6–34(–46.6) μm long, (2.2–)2.6–2.8–3.2(–3.2) μm wide at base, (1.6–)1.8–2–2.2(–2.6) μm wide near aperture (n = 33), each producing a small, hyaline drop of conidia. Secondary conidiophores penicillate, ter- to quinquiesverticillate, generally in small pustules or sporodochia, formed on the agar surface or from strands of the aerial mycelium; branches rather divergent, phialides divergent or adpressed; phialides in loose whorls of 2–5, straight to slightly curved, narrowly flask-shaped, generally with widest point in the lower third, or almost cylindrical, but generally slightly tapering in the upper part, without a visible collarette, (4.8–)11.4–13.6–16(–20.6) μm long, (1.6–)2.2–2.4–2.6(–3.4) μm wide at base, (1.8–)2.4–2.8–3(–3.8) μm at widest point, (1–)1.2–1.4–1.6(–2.2) μm wide near aperture (n = 89); intercalary phialides not observed. **Conidial masses** white to pale orange, in short imbricate chains or in slimy masses on pustules or sporodochia. **Conidia** hyaline, slightly curved, distally broadly rounded, with laterally displaced hilum, (4–)5.2–6–6.4(–13.2) × (2.4–)2.8–3–3.2(–4.2) μm (n = 237). **Perithecia** only observed in the dried culture of G.J.S. 81-351 (PDD 49526). **Sporodochia** composed of loosely aggregated conidiophores, divergent branches of conidiophores arranged in a *textura intricata*.

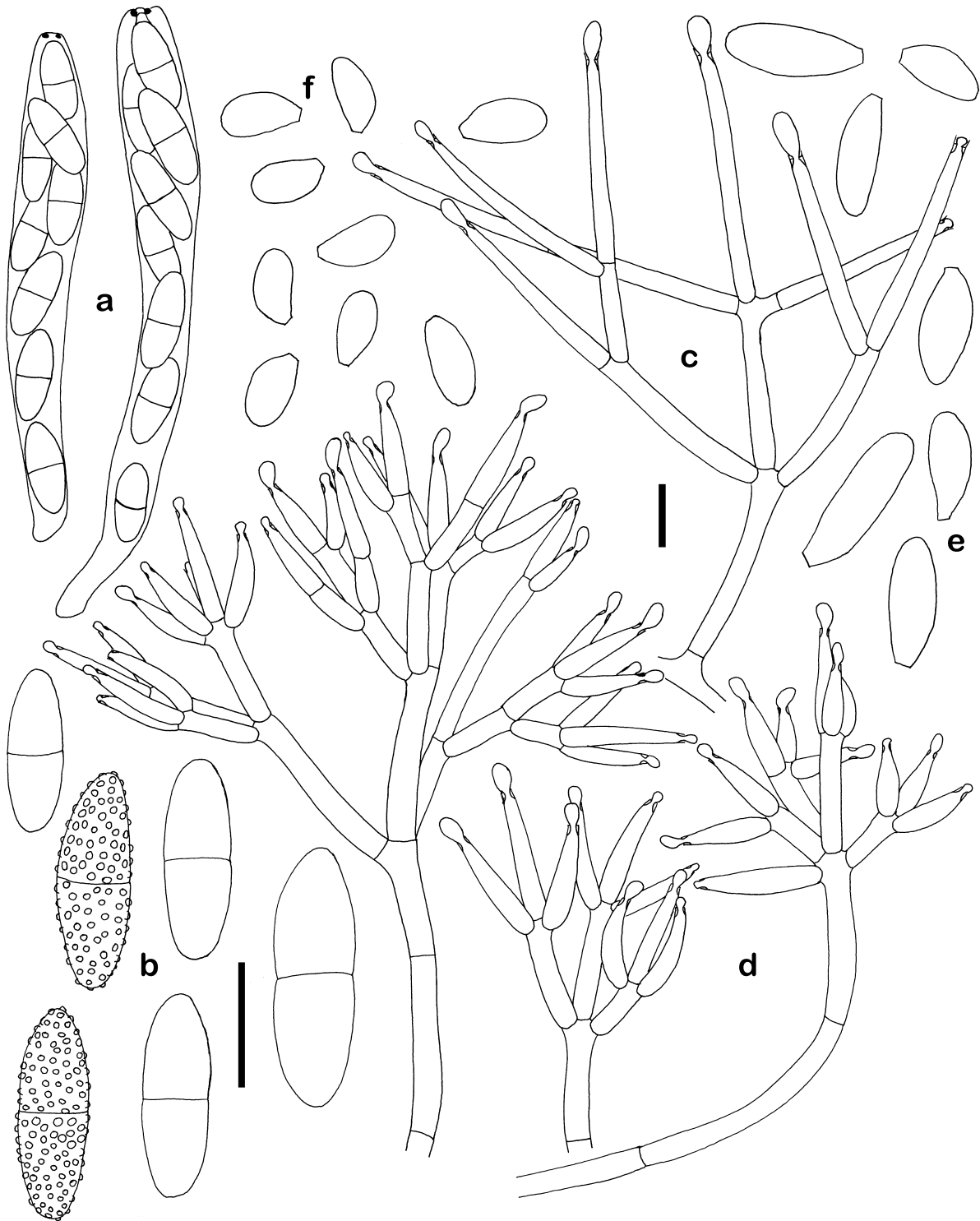
**Type for *Bionectria zelandiaenovae*:** NEW ZEALAND. Northland: Waipoua Forest, Kauri Rikker Trail, on ?*Agathis australis*, 22 May 1981, G.J.S., A.P. Hawthorne, E. Horak, R.H. Petersen (PDD 49456; G.J.S. isolate 81-274, CBS 100979, derived from ascospores). **Type for *Clonostachys zelandiaenovae*:** dried culture ex CBS 100979, filed together with type of *B. zelandiaenovae* (PDD 49456); isotype: herb. CBS.

**Known distribution:** New Zealand.

**Habitat:** On bark of woody plants, of which some are endemic to New Zealand, frequently on or close to other, frequently subcortical pyrenomycetes, indicating mycoparasitism.



**Fig. 27.** *Bionectria zelandiaenovae* / *Clonostachys zelandiaenovae*. **a, b.** Habit of crowded, warted perithecia with darker ostiolar region (**a**). **c–f, h.** Sections through perithecia and stroma; stroma below perithecia (**d**); detail of subapical perithecial wall showing three wall regions, cell-walls of perithecial warts uniformly thick. **g.** Subsurface view of middle perithecial wall region showing hyphae. **h.** Lateral perithecial wall. **i, j.** Sections through sporodochia, with branches of conidiophores arranged in *textura porrecta*. – **a, d, f, h:** PDD 50052; **b, e, g:** PDD 49456; **c:** PDD 32496; **i, j:** PDD 50046. All from natural substratum. **a, b:** DM; **c:** LM; **d–j:** DIC. Scale bars: **a** = 500  $\mu\text{m}$ ; **b, c** = 250  $\mu\text{m}$ ; **d, h, j** = 30  $\mu\text{m}$ ; **e, i** = 100  $\mu\text{m}$ ; **f, g** = 10  $\mu\text{m}$ .



**Fig. 28.** *Bionectria zelandiaenovae* / *Clonostachys zelandiaenovae*. **a.** Almost mature asci. **b.** Discharged ascospores. **c.** Verticillium-like primary conidiophore with relatively long phialides and short stipe. **d.** Secondary conidiophores with divergent branches and mostly divergent phialides. **e, f.** Conidia from primary (e) and secondary conidiophores (f). – a: PDD 50052, PDD 49456; b: PDD 50052, PDD 49456, PDD 50065; c, d (right): PDD 50048; d (left), e: PDD 50052; d (middle): PDD 50046; f: PDD 49526. a, b: natural substratum; c–f: 7–10-d-old OA culture. Scale bars = 10 µm; the shorter bar applies to a, c, d, the longer to b, e, f.

**Additional specimens/strains examined:** NEW ZEALAND. NORTH ISLAND. NORTHLAND: Hobson Co., Waipoua Kauri Reserve, track to Toetoe stand, road between Katui & Forest lookout; on bark of *Geniostoma ligustrifolium*; 23 Nov 1973; G.J.S., J.M. Dingley, W.B. Kendrick (PDD 32496; G.J.S. isolate 73-280, ex ascospores). – Waipoua Kauri Forest, vic. Forestry Headquarters; on bark of *Coprosma australis*; 22 Nov 1973; J.M. Dingley, G.J.S., W.B. Kendrick (PDD 32501; G.J.S. isolate 73-283, ex ascospores, CBS 232.80). – Waipoua Forest,

vic. Te Matua Ngahere Kauri; on *Freycinetia banksii*; 23 Jun 1981; G.J.S., A.P. Hawthorne, E. Horak, R.H. Petersen (PDD 49512; G.J.S. isolate 81-217, ex ascospores, CBS 217.93). – Waitakere Ra., Kauri Grove Trail; on *Rhipogonum scandens*; 12 Aug 1981; G.J.S., P.R. Johnston, R.P. Korf, J.W. Paden, R.E. Beever (PDD 49526; G.J.S. isolate 81-351, ex ascospores, CBS 100978). – Taranaki, Mt. Egmont Nat. Park, Puniho Trail; on bark of indet. tree; 25 Apr 1983; G.J.S., P.R. Johnston, R.H. Petersen (PDD 46409). – AUCKLAND: Waitemata Co., Wai-

takere Range, vic. Kitekite Stream, along Marguerite Track; on bark of *Coprosma australis*; 30 May 1973; J.M. Dingley, G.J.S., S. Haydon (PDD 31792; G.J.S. isolate 73-88, ex ascospores, CBS 233.80). – SOUTH ISLAND. WESTLAND: Mt. Aspiring Nat. Park, Haast Pass, Gap Creek; on bark, 28 Apr 1985; G.J.S., L.M. Kohn (PDD 50046; G.J.S. isolate 85-34, ex ascospores, CBS 100977). – Ibid., Roaring Billy Forest Walk; on *Podocarpus* sp.; 28 Apr 1985; G.J.S., L.M. Kohn (PDD 50048; G.J.S. isolate 85-36, ex ascospores). – Ibid.; on *Metrosideros* sp.; 28 Apr 1985; G.J.S., L.M. Kohn (PDD 50050; G.J.S. isolate 85-38, ex ascospores). – Ibid.; on *Coprosma* sp.; 28 Apr 1985; G.J.S., L.M. Kohn (PDD 50052; G.J.S. isolate 85-42, ex ascospores, CBS 197.93). – Westport, Buller Gorge, junction of Buller & Ohikini Rivers; on *Rhipogonum scandens*; 6 May 1985; G.J.S., P.R. Johnston, L.M. Kohn (PDD 50065; G.J.S. isolate 85-55, ex ascospores). – Taranaki Prov., Taranaki County, New Plymouth, Barrett Domain; on bark of unidentified tree; 22 Apr 1973; G.J.S., C. Samuels, B. van Fleet, S. van Fleet (PDD 30791; G.J.S. isolate 73-41, ex ascospores, dead).

**Notes:** *Bionectria zelandiaenovae* was initially recognized based on characters of the *Clonostachys* anamorph. Both types of conidiophores have rather divergent branches and phialides (Fig. 28 c, d); however, the conidiophores of sporodochia found on the natural substratum are densely adpressed, forming a *textura porrecta* in the subhymenium (Fig. 27 i, j). The branched part of the primary conidiophores is mostly wide because of divergent side branches and exceeds the length of the stipe in its height (Fig. 28 c), while the verticillium-like primary conidiophores in other species mostly have a relatively narrow branching part because of a lack of shorter side branches. While the divergent branches of the primary conidiophore are reminiscent of species with a *C. rosea*-like anamorph, the secondary conidiophores are more similar to those found in *C. solani*-like species with divergent branches. *Bionectria zelandiaenovae* generally forms sporodochia both on the natural substratum and in culture. However, in a few cultures, the secondary conidiophores are only sparsely developed, which might be a symptom of degeneration. *Bionectria zelandiaenovae* is similar to *B. byssicola* with respect to the warted perithecial surface (Fig. 27 a, b, e) and size range of the ascospores. In contrast to *B. byssicola* and *B. capitata*, hardly any unevenly thickened walls in the cells of the perithecial warts were found (Fig. 27 f, h). The teleomorph differs from *B. ochroleuca* in having longer ascospores and perithecial warts. The colonies are relatively slow-growing in comparison to *B. byssicola* and *B. ochroleuca*, and the fungus typically does

not grow at 30°C. *Bionectria zelandiaenovae* is only known from New Zealand, where it seems to be rather common. *Bionectria verrucispora*, also known only from New Zealand, differs from *B. zelandiaenovae* by rather thick-warted ascospores, smooth and superficial perithecia and by more adpressed secondary conidiophores. Specimens of *Bionectria zelandiaenovae* were previously identified as *Nectria aureofulva*, *Nectria* cf. *aureofulva*, *B. ochroleuca*, and *Nectria* sp.

*Bionectria zelandiaenovae* appears closely related to *B. pseudostrata* (Figs 2–4). Both belong to a supported clade of species with dimorphic conidiophores that is basal to other such clades (Fig. 4: Q). While the primary conidiophores of *B. zelandiaenovae* are morphologically similar to those of *B. ochroleuca* and related species in its divergent branches, the conidiophores of *B. pseudostrata* are similar to those of *B. solani* and related species.

## 12. *Bionectria verrucispora* Schroers & Samuels, *sp. nov.* — Figs 29 a–g, i, j, l, m, 30 a, b.

Anamorph: *Clonostachys verrucispora* Schroers, *stat. nov.* — Figs 29 h, k, 30 c–e.

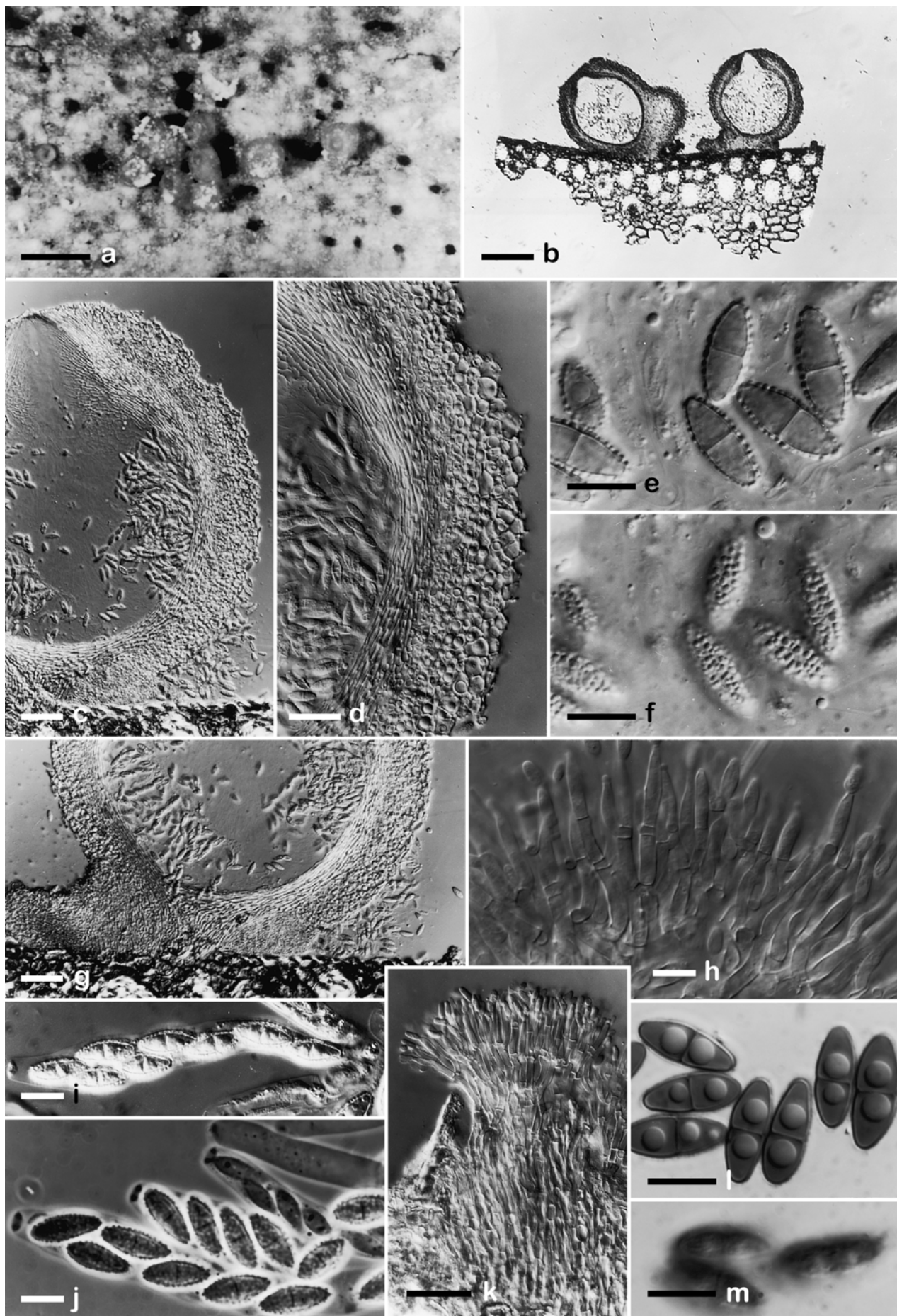
Stroma superficiale, minimum; perithecia gregaria, non dense aggregata, levigata; cellulae strati exterioris peritheciarum constanter tenuitunicatae. Ascospores grosse verrucosae, (12.2–)14–15.6–17(–19.2) × (4.4–)5.4–5.8–6.2(–7) µm. Anamorphosis *Clonostachys verrucispora*, *C. zelandiaenovae* similis sed ramis terminalibus conidiophorum secundariorum plus minusve adpressis. Phialides intercalares sub phialidibus terminalibus praesentes. Conidia fere magna, (5.6–)7.4–8.4–9.2(–15.6) × (2.2–)3–3.2–3.6(–4.4) µm.

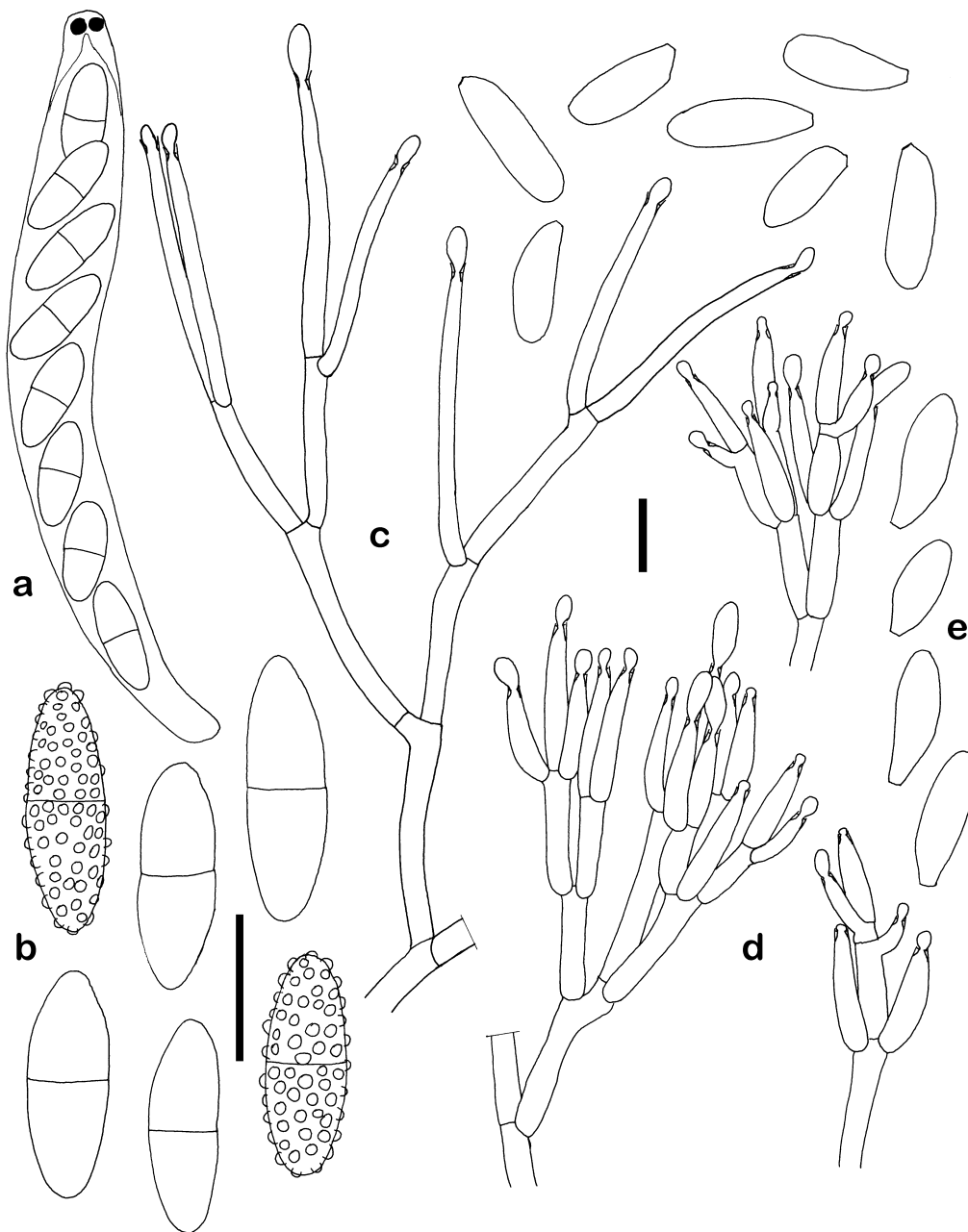
Holotypus teleomorphosis: Specimen PDD 46425. Holotypus anamorphosis: PDD; cultura sicca, isolata ex specimine PDD 46425.

Etymology: Latin *verruca* = wart, referring to the conspicuously warted ascospores.

**Description from natural substratum:** **Stroma** flat, superficial, inconspicuously erumpent through the outer cortex of the substratum, prosenchymatous, surrounding the perithecial base; cells ca 6 × 4 µm, angular to subglobose, smaller than and not merging with the cells of the outermost perithecial wall region. **Perithecia** easily removable, solitary to gregarious, sometimes crowded in groups of < 5, subglobose to globose, somewhat higher than wide, 300–500 µm

**Fig. 29.** *Bionectria verrucispora* / *Clonostachys verrucispora*. **a.** Habit of solitary to aggregated perithecia. **b–d, g.** Sections of perithecia and perithecial base; perithecia with three contrasting wall regions (b); lateral perithecial wall (c, d); base of perithecium; cells of stroma not continuous with cells of outer perithecial wall region (g.). **e, f, l, m.** Discharged ascospores mounted in water (e, f), in optical section (e) and surface view (f), showing relatively thick warts; warts invisible after KOH treatment (l, m), in optical section (l), in surface view (m). **h, k.** Sections through sporodochia; intercalary phialides, sometimes in chains of two, frequently short, square-like (h); somewhat synnema-like sporodochium erumpent through outer cortex of host (k). **i, j.** Almost mature asci; ring visible. — a, e, f, i, j: PDD 46418; b–d, g: PDD 46425; h, k, l, m: PDD 46315. All from natural substratum. a: DM; b: LM; j: PC; others: DIC. Scale bars: a = 500 µm; b = 250 µm; c, g = 50 µm; d, k = 30 µm; e, f, h–j, l, m = 10 µm.





**Fig. 30.** *Bionectria verrucispora* / *Clonostachys verrucispora*. **a.** Almost mature ascus. **b.** Discharged ascospores. **c.** Verticillium-like primary conidiophore. **d.** Parts of penicillate secondary conidiophores, sometimes with intercalary phialides. **e.** Conidia. – a, c: PDD 46315; b: PDD 46418, PDD 49452; d: PDD 46425; PDD 49513. e, above d: PDD 46315, right of d: PDD 46425. a, b: natural substratum; c–e: dried cultures. Scale bars = 10  $\mu\text{m}$ ; the shorter bar applies to a, c, d, the longer to b, e.

diam, laterally pinched when dry, light orange, not- or minutely papillate, often with a slightly darker-coloured ostiolar region, smooth. **Perithecial wall** 40–90  $\mu\text{m}$  thick, composed of three regions. Outer region 30–45  $\mu\text{m}$  or 4–6 cells thick; cells angular to subglobose, (6.5–)10.5–12.5–14(–18.5)  $\times$  (3.5–)7.5–9–10.5(–14)  $\mu\text{m}$ , with uniformly thickened walls up to 2  $\mu\text{m}$  thick, frequently containing one round vacuole. Middle region 5–20  $\mu\text{m}$  thick, of up to 4 layers of intertwined hyphae, not easily visible in longitudinal sections. Inner region to 30  $\mu\text{m}$  thick. **Asci** narrowly clavate, (72–)83.5–89–94.5(–121)  $\times$  (7–)10–11–12(–14.5)  $\mu\text{m}$  (n = 79), 8-spored; apex rounded, ring clearly visible. **Ascospores** ellipsoidal, coarsely warted, smooth in KOH,

(12.2–)14–15.6–17(–19.2)  $\times$  (4.4–)5.4–5.8–6.2(–7)  $\mu\text{m}$  (n = 202). **Sporodochia** flat to almost synnematosus, erumpent through the outer cortex of the substratum, consisting of penicillate, short-stiped conidiophores. **Sterile mycelium** generally not observed on the substratum.

**Description from culture** (only dried, dead colonies available). Colony surface finely to coarsely granular because of slimy sporodochial conidial masses; aerial mycelium felty to tufted to cottony, frequently arranged in strands. Surface not pigmented, white, or with pale orange granules because of the conidial masses. **Conidiophores** dimorphic. Primary conidio-

phores verticillium-like, formed throughout the colony, solitary to gregarious, arising from the agar surface or from aerial mycelium, simple (acromonium-like) to repeatedly branched; branches and phialides divergent or more or less divergent; stipe shorter than the branching part, to 50  $\mu\text{m}$  long, *ca* 3  $\mu\text{m}$  wide at base; branching part to 100  $\mu\text{m}$  high and wide; phialides in groups of up to 3, also solitary, straight, cylindrical, slightly tapering towards the tip, with a minute collarette, (15.6–)19–26.2–33(–41.6)  $\mu\text{m}$  long, (1.8–)2–2.2–2.4(–2.8)  $\mu\text{m}$  wide at base, (1–)1.2–1.4–1.6(–2.2)  $\mu\text{m}$  wide near aperture ( $n = 48$ ), each producing a small, hyaline drop of conidia. Secondary conidiophores penicillate, ter- to quinquiesverticillate, generally forming aggregates or sporodochia, formed on the agar surface or from strands of aerial mycelium, divergently branched to adpressed; phialides in whorls of up to 4, straight to slightly curved, narrowly flask-shaped, generally with widest point in the lower third, or almost cylindrical, but generally slightly tapering in the upper part, without a visible collarette, (4–)10.4–13.6–16.6(–22.6)  $\mu\text{m}$  long, (1.4–)2.0–2.4–2.8(–3.2)  $\mu\text{m}$  wide at base, (1.6–)2.4–2.8–3(–3.8)  $\mu\text{m}$  at widest point, (0.8–)1.2–1.4–1.6(–1.8)  $\mu\text{m}$  wide near aperture ( $n = 71$ ). Intercalary phialides infrequent, solitary or in chains of two, up to 7  $\mu\text{m}$  long, mostly below a single terminal phialide, sometimes arising from  $\pm$  square cells, the neck sometimes as long as terminal phialides. **Conidial masses** white, in short, imbricate chains, or pale to light orange on sporodochial aggregates. **Conidia** hyaline, slightly curved, with  $\pm$  broadly rounded distal end, with laterally displaced hilum, (5.6–)7.4–8.4–9.2(–15.6)  $\times$  (2.2–)3–3.2–3.6(–4.4)  $\mu\text{m}$  ( $n = 104$ ); in PDD 49452 smaller, 3.4–5.6  $\times$  1.6–2.8  $\mu\text{m}$ . **Perithecia** observed in dried OA colonies of PDD 46418, PDD 49452, PDD 46425, formed on the agar surface or among the aerial mycelium, smooth to rough, lacking a stroma. **Sporodochia** composed of loosely aggregated conidiophores, generally with a subhymenium of *textura intricata* because of divergent conidiophores.

**Type for *Bionectria verrucispora*:** NEW ZEALAND. NORTHLAND: Waipoua State Forest, Kauri Rikker Trail; on *Rhopalostylis sapida*; 13 Jun 1983; G.J.S. (PDD 46425; G.J.S. isolate 83-224, derived from ascospores, dead). **Type for *Clonostachys verrucispora*:** dried culture of G.J.S. 83-224, filed together with type of *B. verrucispora* (PDD 46425).

**Known distribution:** New Zealand.

**Habitat:** Known from dead leaf midribs of the palm *Rhopalostylis sapida*.

**Additional specimens/strains examined** (all on *Rhopalostylis sapida*; all cultures dead): NEW ZEALAND. Auckland: Waitemata City, Waitakere Ranges, Piha Rd., Kauri Grove-Marguerite Tracks; 12 May 1986; G.J.S., Y. Doi (NY). – Waitakere Ranges, Piha Rd., Cowan Trail; 4 Jun 1983; G.J.S., A.Y.R. (PDD 46315; G.J.S. isolate 83-133, ex ascospores). – Waitakere Ranges; 7 May 1981; G.J.S. *et al.* [PDD 45722; G.J.S. isolate 81-73, ?ex ascospores (the living strain 81-73 obviously is a hypocrealean fungus not related to *Clonostachys*)]. – Waitemata Co., Waitakere Ranges, vic. Kitekite Stream, along Marguerite Track; 30 May 1973; J.M. Dingley, G.J.S., S. Haydon (PDD 31791; G.J.S. isolate 73-97, ex ascospores). – Northland: Waipoua Forest, vic. Te Matua Ngahere Kauri; 23 Jun 1981; G.J.S., E. Horak, A.P. Hawthorne, R.H. Petersen [PDD 49513; G.J.S. isolate 81-218, ex ascospores (culture contaminated; contamination is overgrown by *Clonostachys* sp., possibly the anamorph of *B. verrucispora*)]. – Mangamuka Scenic Reserve, Mangamuka River; 9 May 1983, G.J.S. (PDD 46418; G.J.S. isolate 83-217, ex ascospores). – Waipoua Forest, Kauri Rikker Trail; 22 May 1981; G.J.S., A.Y.R. (PDD 49452; G.J.S. isolate 81-269, ex ascospores).

**Notes:** *Bionectria verrucispora* is characterized by superficial, solitary to gregarious, smooth perithecia (Fig. 29 a–c, g), relatively large and conspicuously warted ascospores (Fig. 29 e, f), and by its restricted occurrence to the palm *Rhopalostylis sapida* in New Zealand. The perithecial wall consisting of three regions (Fig. 29 b, d), the warted ascospores, and the *Clonostachys* anamorph (dimorphic conidiophores, conidia with a laterally displaced hilum) (Fig. 30 c–e) place the species in the core group of *Bionectria*. The superficial perithecial stroma, however, differs from the erumpent stroma found in other species of subgenus *Bionectria* and clearly suggests patterns found in subgenus *Epiphloea*. The superficial stroma possibly is a result of the very hard and smooth palm tissue. If so, *B. verrucispora* can be seen as a striking example of how the substratum or other ecological circumstances can affect the morphology of the stroma and ascocarp (as discussed by Schroers, 2000). Placement of this species in subgenus *Bionectria*, however, needs confirmation by sequence data. Because of the superficial stroma and the infrequent formation of intercalary phialides (Fig. 30 d), *B. verrucispora* also could be classified in *Bionectria* subgenus *Epiphloea*. The intermediate morphological character pattern in *B. verrucispora* is a main reason for the broad generic circumscription of *Bionectria*. Short-stiped primary conidiophores and relatively long phialides possibly indicate close relatedness of *B. verrucispora* and *B. zelandiaenovae*. Both species are also characterized by relatively long conidia (Figs 28 e, f, 30 e).

**13. *Bionectria compactiuscula*** Schroers, *sp. nov.* — Figs 31 a–k, 33 a, b.

*Bionectriae ochroleucae* similis sed peritheciis levigatis, nec scruposis. Ascosporis (6.2–)9–9.8–10.4(–13.4) × (2.2–)2.8–3.2–3.4(–4.4) µm. Anamorphosis *Clonostachys compactiuscula*, *Clonostachydi rogersoniana* similis sed conidiis cylindricis nec ovoideis. *Clonostachydi roseae* similis sed conidiis cylindricis nec curvatis, ramulis secundariis conidiophorum divergentibus nec compressis, conidiophoris compressis in vitro raro formatis. Conidiis (3.9–)5.4–6.6–7.5(–12.4) × (1.5–)1.9–2.2–2.5(–3.2) µm.

Holotypus teleomorphosis: Specimen G.J.S. 89-134 (NY); cultura viva CBS 913.97.

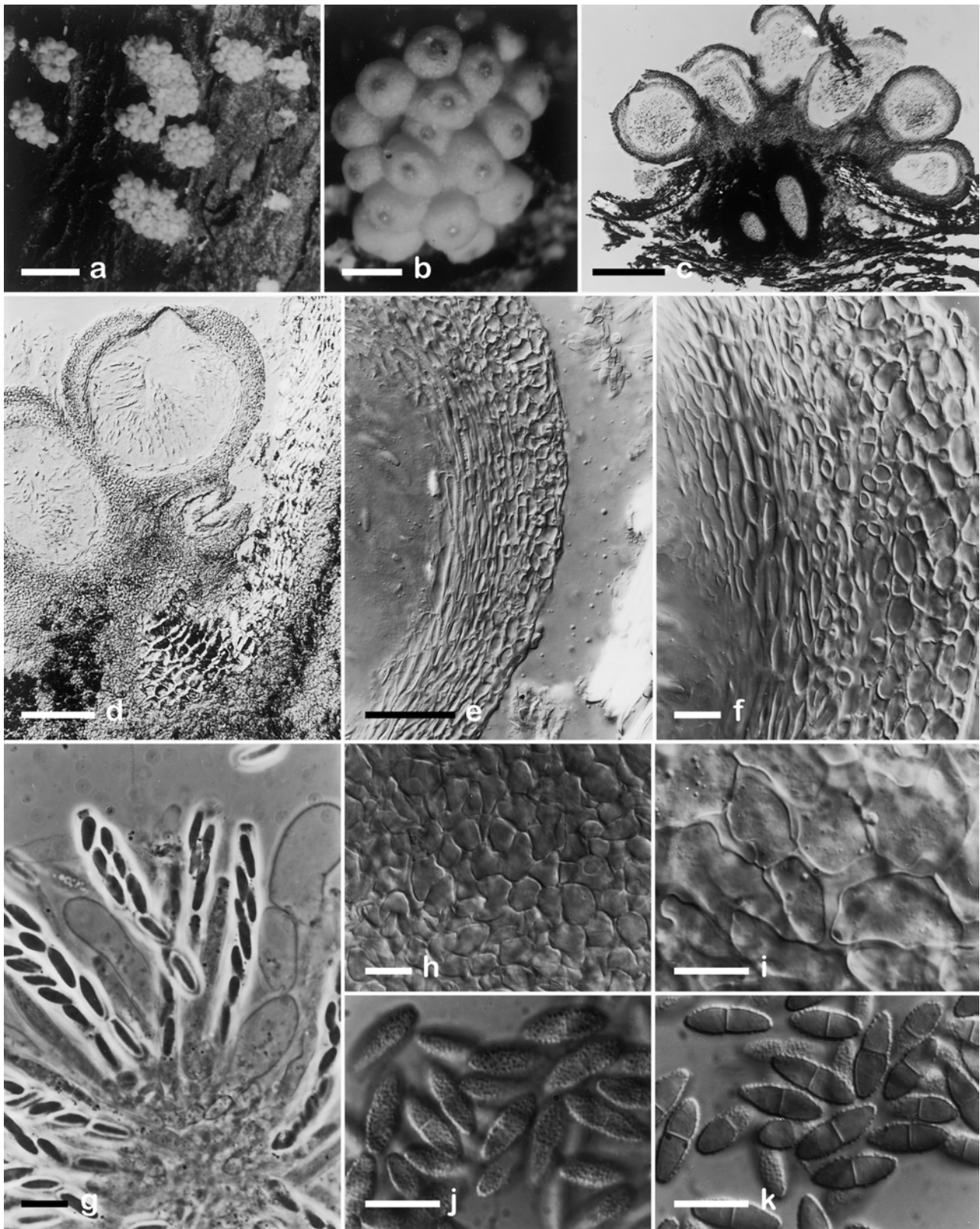
Anamorph: *Clonostachys compactiuscula* (Saccardo) D. Hawksworth & W. Gams in Hawksworth & Punithalingam, Trans. Brit. Mycol. Soc. 64: 90. 1975. — Figs 32 a–c, 33 c–e.

- ≡ *Verticillium compactiusculum* Sacc., Michelia 2: 553. 1882.
- = *Verticillium candidulum* Sacc., Michelia 2: 553. 1882.
- = *Clonostachys cylindrospora* G. Arnaud, Bull. Trimestriel Soc. Mycol. Fr. 68: 196. 1952 [Nom. inval., Art. 36].
- ≡ *Gliocladium cylindrosporum* (G. Arnaud) Matsush., Icon. Microf. Mats. lect.: 73. 1975.
- = *Verticillium compactiusculum* Sacc. var. *phyllogenum* Sacc., Bull. Soc. Bot. Belg. 35: 128. 1896 [(slide W.G. 182 (CBS) ex 'Binot 1895': secondary conidiophores with up to 6 µm wide stipes; conidia cylindrical, held in columns (typical of *C. compactiuscula*)].

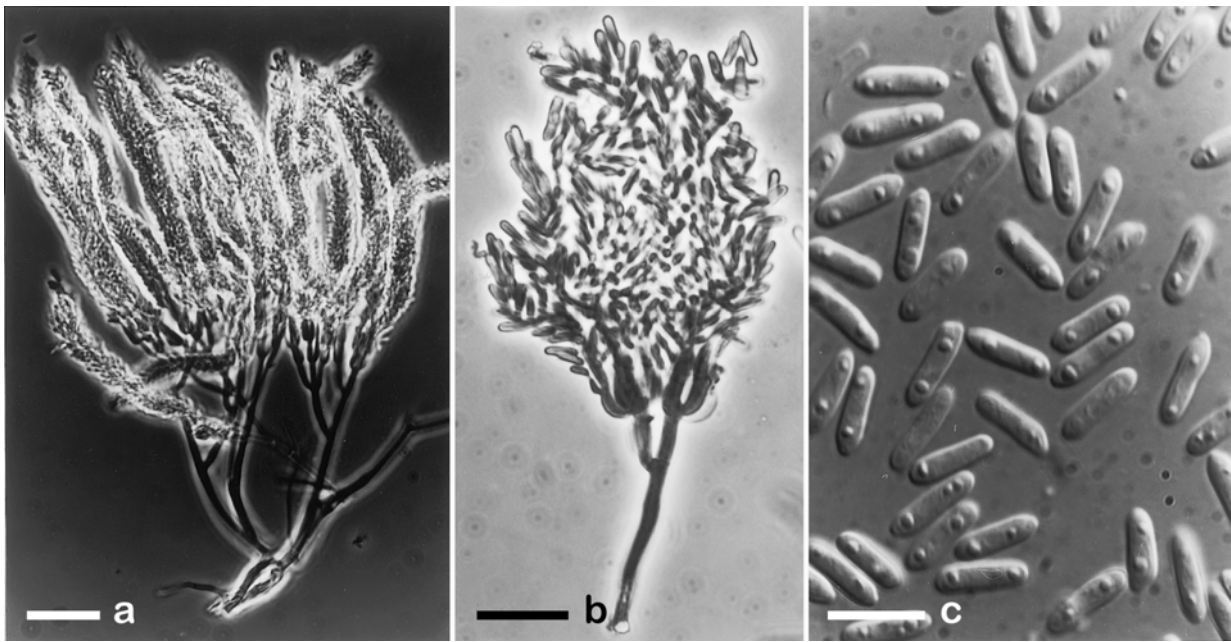
**Description from natural substratum:** **Stroma** well-developed, erumpent through bark, frequently seated on or close to other (subcortical) pyrenomycetes; cells angular, 4–13.5 × 3–11.5 µm. **Perithecia** in groups of up to 100 on a common stroma, rarely solitary, globose, subglobose to pyriform, 240–390 µm high, 180–320 µm diam, laterally pinched when dry, particularly in the lower part, light orange to yellowish orange, rarely brownish orange, when dry with a pale brown, slightly sunken ostiolar region, not or minutely papillate, with a smooth surface. **Perithecial wall** about 50 µm thick, consisting of three regions. Outer region to 25 µm or 3–5 cells thick; cells angular to globose, (4–)7–8.5–10(–13.5) × (3–)5.5–6.5–7.5(–11.5) µm, inwards sometimes larger, reaching 18 × 10 µm, with uniformly thickened walls around 1.5 µm thick; vacuoles not observed. Middle region to 10 µm thick, consisting of 1–3 hyphal layers. Inner region to 15 µm thick. **Asci** narrowly clavate, (40.5–)48–55–60(–73.5) × (5–)6–7–7.5(–10) µm (n = 89), 8-spored; apex flat with somewhat rounded edges, with a visible ring. **Ascospores** ellipsoidal to oblong-ellipsoidal, spinulose, rarely smooth, (6.2–)9–9.8–10.4(–13.4) × (2.2–)2.8–3.2–3.4(–4.4) µm (n = 362). **Sterile mycelium** generally invisible on the substratum. **Conidiophores** of both kinds frequently scattered on or close to the perithecia, similar to those formed in culture. **Sporodochia** not observed.

**Description from culture:** **Colonies** reaching 25–35 mm diam in 7 d at 24°C; optimum for growth 24–27°C, maximum 30°C. Colony reverse pale to pastel-yellow, with orange hues after incubation under UV; yellow pigment increasing towards the colony margin, fading towards the centre; older colonies with brown spots or concentric rings. Colony surface with structures best developed on OA, finely granular and white to yellowish because of the conidial masses; aerial mycelium sparsely formed or arranged in strands; colonies frequently with light-brown spots or concentric brownish rings formed by submerged or through the agar surface erumpent stromata that consist of prosenchymatous to pseudoparenchymatous cells; hyphal strands with time becoming brownish, particularly near the agar; structures on CMD/CMA similar, but mycelium more sparsely developed; aerial mycelium on PDA strongly developed, in thick, often erect strands. **Conidiophores** dimorphic. Primary conidiophores verticillium-like, rare, sometimes not observed, mononematous, arising from the agar surface or from aerial mycelium, monoverticillate or more-level branched, with divergent branches and phialides; stipe 40–250 µm long, 2.5–4.5 µm wide at base; branching part 40–130 µm high; phialides in whorls of 2–4, in lower levels also solitary, straight, cylindrical, but slightly and continuously tapering towards the tip, with or without a minute collarete, (17–)22.2–28–31.2(–56) µm long, (1.8–)2–2.4–2.6(–3) µm wide at base, (1.2–)1.4–1.6–1.6(–2) µm wide near aperture (n = 28), each producing a small, hyaline drop of conidia. Secondary conidiophores scattered on the agar surface or arising from strands of aerial hyphae; penicillus frequently branched; side-branches ± divergent forming independent, bi- to quaterverticillate, adpressed penicillate units; stipes to 100 µm long, to 7 µm wide at base; branching part *ca* 150 µm high, to 100 µm wide; penicilli of independent units around 60 µm high, less than 40 µm wide; phialides in adpressed whorls of up to 6, narrowly flask-shaped, slightly tapering in the upper part, (5.2–)8.4–8.8–11(–17.2) µm long, (1.2–)1.8–2–2.2(–3) µm wide at base, (1.2–)2.2–2.4–2.6(–3.4) µm at widest point, (0.8–)1–1.2–1.2(–1.6) µm wide near aperture (n = 130), frequently collapsing already on relatively young conidiophores. Intercalary phialides rather frequent, solitary, with one lateral neck, 2.5–5.0 µm long (n = 42), below a whorl of terminal phialides; intercalary phialides remaining visible after the collapse of the terminal phialides. **Conidial masses** white, pale yellow or pale orange, held in long imbricate columns; several such columns frequently arising from one conidiophore (each from an independent penicillate unit). **Conidia** hyaline, ellipsoidal to cylindrical, almost straight, but with a laterally displaced hilum, broadly rounded at the end, (3.9–)5.4–6.6–7.5(–12.4) × (1.5–)1.9–2.2–2.5(–3.2) µm (n = 393). **Sporodochia** not observed. **Perithecia** not formed.





**Fig. 31. *Bionectria compactiuscula*.** **a, b.** Habit of crowded perithecia; perithecia smooth, with somewhat darker ostiolar region. **c–f.** Sections through perithecia or stroma; perithecia crowded on an erumpent stroma seated on dark subcortical fungal host (c); mature perithecium (d); lateral perithecial wall showing three regions, middle region recognizable as round cells of dissected hyphae (e, f). **g.** Immature asci with apical rings and disintegrating non-functional asci. **h, i.** Surface and subsurface view of perithecial wall, outermost region (h), innermost region showing lobed cells with ‘pseudopores’ (i). **j, k.** Discharged ascospores in surface view (j) and optical section (k). – a–c, f: PDD 46503; d, e, h, i: G.J.S. 94-36; g: G.J.S. 89-134; j, k: Vittal 20153. All from natural substratum. a, b: DM; c: LM; d–f, h–k: DIC; g: PC. Scale bars: a = 1250  $\mu$ m; b, c = 250  $\mu$ m; d = 100  $\mu$ m; e = 30  $\mu$ m; f–k = 10  $\mu$ m.



**Fig. 32.** *Bionectria compactiuscula* / *Clonostachys compactiuscula*. **a, b.** Secondary conidiophores with multiple conidial columns. **c.** Straight, oblong-ellipsoidal conidia, some with laterally displaced hilum. – **a, b:** G.J.S. 89-134; **c:** Vital 20153. All from natural substratum. **a, b = PC;** **c = DIC.** Scale bars: **a, b = 30 µm;** **c = 10 µm.**

**Type for *Bionectria compactiuscula*:** U.S.A. NORTH CAROLINA: Jackson Co., Nantahala Natl. Forest, Bull Pen Rd. to Chattooga River, Ellicott Rock Trail from Fowler Creek; on bark of recently dead *Fagus* sp.; 28 Sept 1989; G.J.S., C.T.R., W.R. Buck, R.C. Harris (NY; Samuels specimen and culture 89-134, derived from ascospores, ex-type strain CBS 913.97).

**Type for *Verticillium compactiusculum*:** ITALY. Selva, Treviso; on bark of *Prunus domestica*; autumn 1878 (PAD).

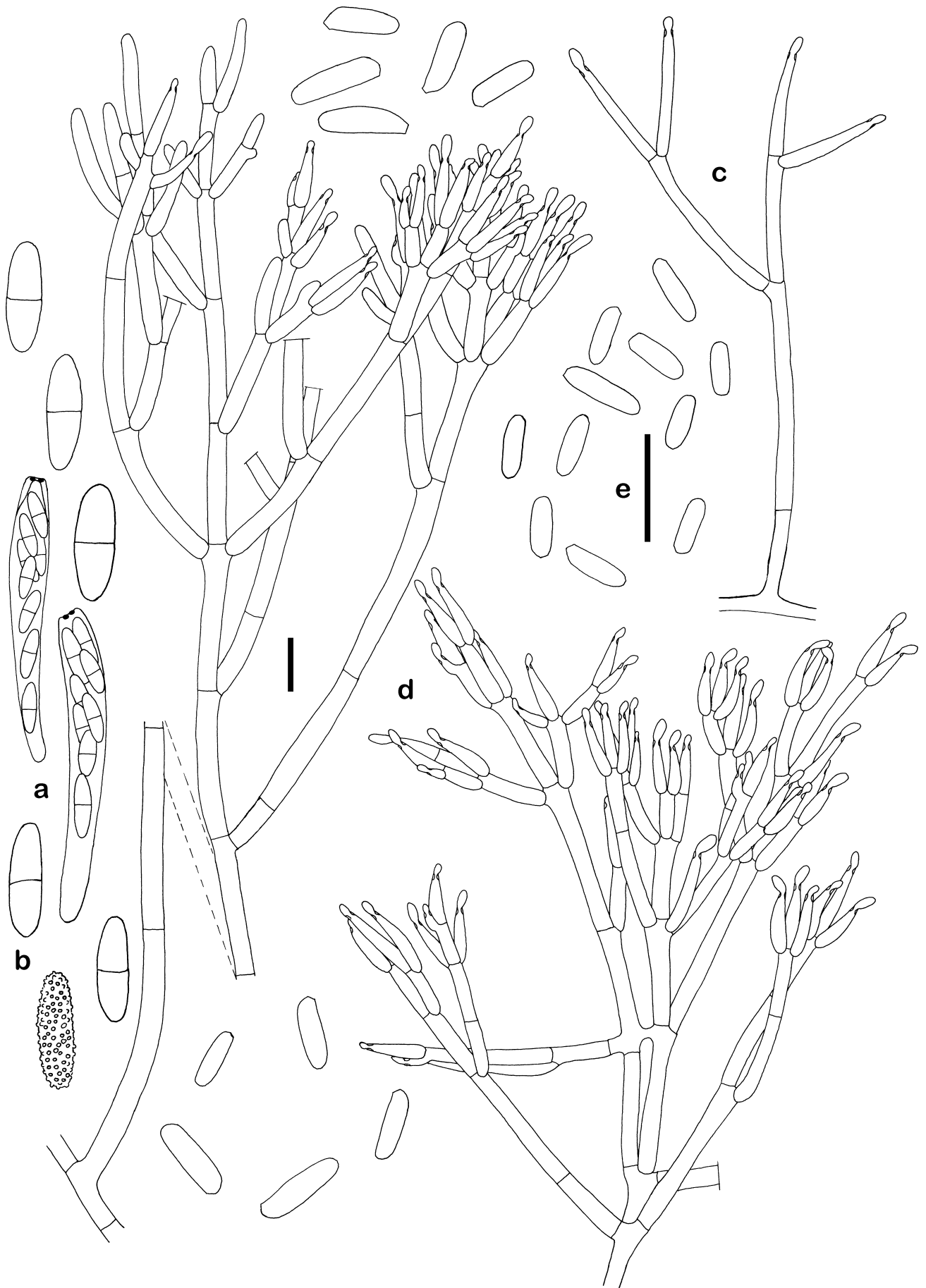
**Known distribution:** Holomorph known from temperate and tropical regions, U.S.A. (North Carolina, Virginia, South Carolina, New York), Japan, French Guiana, Ecuador, Bermuda, France (Pyrénées Atlantiques). Anamorph also known from Europe (Netherlands, Germany), Guadeloupe, France, India, and U.S.A. (New York).

**Habitat:** Perithecia on bark of recently dead trees, frequently seated on or close to fruiting structures of various pyrenomycetes; both kinds of conidiophores frequently scattered on the bark close to the perithecia; anamorph also isolated from soil or, for example, from an apothecium of *Rhizina undulata*. Habitat of perithecia and anamorph indicates potential for mycoparasitism.

**Published descriptions and illustrations of the anamorph:** Tubaki (1963), Arnaud (1952), Hawksworth & Punithalingam (1975), Hosoya *et al.* (1995).

**Additional specimens/strains examined:** AUSTRALIA. NEW SOUTH WALES: Sydney, Royal Botanical Garden; on seeds of *Archontophoenix cunninghamiana* King; Aug 2000; K.A. Seifert (KAS 1182) (*teste* K.A. Seifert). – BERMUDA (U.K.): on Sabal Paget Marsh; 6 Dec 1940; F.J. Seaver, J.M. Waterston (NY). – BRAZIL. BAHIA: Mun. Ilhéus, Centro de Pesquisas do Cacao, km 22 on BR 415 between Ilhéus and Itabuna, mata higrófila sul baiana, in Parque Zoobotânico, overgrown cacao plantation, 14°50' S, 39°13' W, *ca* 50 m alt.; on dead cacao pods; 15 Jul 1991; W.R. Buck (NY; M. Vital, R. Buck 20153). – CANADA. ONTARIO: Ottawa; on seeds of *Quercus* sp. 23. Feb 1988 (*teste* K.A. Seifert). – QUEBEC: on submerged wood (DAOM 226738) (*teste* K.A. Seifert). – ECUADOR. Prov. Cotopaxi: *ca* 87 km from Latacunga, on the Latacunga–Quevedo Rd., *ca* 3300 m alt.; on leaf; 23 Jul 1975; K.P.D., S.E. Carpenter, P. Buriticá (NY; Dumont-EC 1079). – FRANCE. Forêt de Bugangue, Oloron 64; on *Fagus* sp.; 22 Aug 1993; F. Candoussau (BPI 802501; F. Candoussau 266; G.J.S. isolate 93-27, CBS 592.93). – FRENCH GUIANA. Paul Isnard Area. *ca* 150 km S of St. Laurent du Moroni, Citron, Mt. Lucifer, 04°70' N, 53°90' W; on decaying dicotyledonous fruit; Mar 1986; G.J.S., P. Searwar (CAY, NY; G.J.S. 4291; G.J.S. isolate 86-304). – On decaying dicotyledonous fruit; Mar 1986; G.J.S., P. Searwar (CAY, NY; G.J.S. 4297; G.J.S. isolate 86-306). – Saül. along trail from village to water source, 03°60' N, 53°20' W, *ca* 200 m alt.; on recently dead tree; 6 Jan 1986;

**Fig. 33.** *Bionectria compactiuscula* / *Clonostachys compactiuscula*. **a.** Almost mature asci. **b.** Discharged ascospores. **c.** Verticillium-like primary conidiophore (rarely formed in culture, frequently associated with perithecia on natural substratum). **d.** Repeatedly branched secondary conidiophores; primary branches ± divergent, terminal branches ± adpressed. **e.** Conidia. – **a:** PDD 46503 (right), G.J.S. 94-32 (left); **b, e (top):** 913.97; **c:** CBS 729.87; **d:** CBS 653.70 (left), CBS 919.97 (right); **e:** CBS 729.87 (middle), CBS 653.70 (bottom). **a, b:** natural substratum; **c–e:** 7–10-d-old OA culture. Scale bars = 10 µm; the shorter bar applies to **a, c, d,** the longer to **b, e.**



G.J.S., J.R. Boise (NY G.J.S. 2667; G.J.S. isolate 86-34). – Monts La Fumée, dry primary forest, 03°60' N, 53°20' W, ca 400 m alt.; on decaying petiole of *Cecropia* sp.; Feb 1986; G.J.S. (NY; G.J.S. 3528). – GERMANY. Freiburg i.B., forest soil, S. Schönhar (Schönhar No. D6, CBS 729.87; anamorph only). – INDIA. M.N. Kamat (CBS 668.70; anamorph only). – ITALY. Selva, Treviso; on decaying fruits of *Rosa* sp.; Aug 1877; Saccardo (ex-type slide S 172, made by W.G., CBS). – JAPAN. Honshu: Asetata Chuzenji, Okka-nikko; on bark; 25 Aug 1983; G.J.S. (PDD 46503; G.J.S. isolate 83-325). – Hinotaki waterfall, Minenohara heights, Suzaka City, Nagano-Prefecture, 1333 m alt.; on dead twig on ground; 16. Aug 1997; H.-J. Schroers, W.G., M. Klamer, T. Gräfenhan, Y. Kurihara (H.J.S. 218, anamorph only; CBS 101923). – Tsukuba; on deciduous twigs; 30 Jul 1983; G. Okada (G. Okada 219) (*teste* K.A. Seifert). – On nuts of deciduous tree; K.A. Seifert (KAS 254) (*teste* K.A. Seifert). – NETHERLANDS. Schovenhorst near Putten; on decaying wood; W.G. (CBS 653.70; anamorph only). – U.S.A. VIRGINIA: Giles Co.: Cascades Recreation Site, 4 miles N of Pembroke, Little Stony Creek, 37°02' N, 80°35' W, 840 m alt.; on twigs of *Acer* sp.; 18 Sept 1991, G.J.S., C.T.R., S.M. Huhndorf, S. Rehner, M. Williams (BPI 1112889; G.J.S. isolate 91-120, CBS 919.97). – NORTH CAROLINA: Jackson Co., Nantahala Natl. Forest: Bull Pen Rd. to Chattooga River, Ellicott Rock Trail from Fowler Creek; on base and roots of *Acer rubrum*; 28 Sept 1989; G.J.S., C.T.R., W.R. Buck, R.C. Harris; (NY; G.J.S. isolate 89-133). – Ammons Camp, off Bull Pen Rd.; on bark; 30 Aug 1994; G.J.S., H.-J. Schroers (BPI; G.J.S. isolate 94-36). – Ammons Camp, off Bullpen Rd; on bark; 29 Aug 1994; G.J.S., H.-J. Schroers (BPI; G.J.S. isolate 94-35). – Ammons Camp, off Bull Pen Rd; on bark; 29 Aug 1994; G.J.S., H.-J. Schroers (BPI; G.J.S. isolate 94-34). – Ammons Camp, vic. Highlands, off Bullpen Rd; on bark; 29 Aug 1994; G.J.S., H.-J. Schroers (BPI; G.J.S. isolate 94-29). – Macon Co.: Blue Valley Rd along E Fork of Overflow Creek; on bark of *Magnolia* sp.; 1 Sept 1994; G.J.S., H.-J. Schroers (BPI; G.J.S. isolate 94-32). – Ammons Branch Campground, off Bull Pen Rd., 35°01' N, 83°08' W, 1000 m alt.; on bark of *Pinus* sp.; 1990; Y. Doi, A.Y.R., G.J.S. (BPI 1109345). – Ellicott Rock Trail, off Bull Pen Rd., 35°01' N, 83°08' W, 1000 m alt.; on bark of *Pinus* sp.; 14 Oct 1990; Y. Doi, A.Y.R., G.J.S. (BPI 1109345). – SOUTH CAROLINA: Pickens Co.: ca 4 km SW of Rocky Bottom, W side of Twisting Pine Mt., along Eastatoe Creek; on recently dead *Betula* sp.; 27 Sept 1989; G.J.S., C.T.R., W.R. Buck, R.C. Harris; G.J.S. (NY; Samuels specimen and culture 89-128). – NEW YORK: Westchester Co.: Ward Pound Ridge Reservation; on apothecium of *Rhizina undulata*, on spruce duff; 1 Oct 1975; C.T.R. (C.T.R. isolate 75-150; CBS 123.79; anamorph only).

**Notes:** *Bionectria compactiuscula* is particularly distinct in its secondary conidiophores, which form several independent side branches, each terminating in adpressed whorls of phialides that form separate columns of conidia (Figs 32 a, 33 d) and by the shape of the conidia. Although the conidiophores may be formed in aggregates, sporodochia have never been observed on the natural substratum close to the perithecia or in culture.

Phialides of secondary conidiophores tend to collapse in relatively young colonies. The walls of the phialides may remain recognizable. Terminal phialides frequently are associated with an intercalary phialide. After collapse of the terminal phialides the necks of the intercalary phialides remain visible.

Conidia in *C. compactiuscula* are ellipsoidal to almost cylindrical, almost straight and not curved as in other species of the genus (Figs 32 c, 33 e). Nevertheless, the hila are laterally displaced and the conidia extrude asymmetrically from the phialides. The cylindrical shape of the conidia was already used by Hawksworth & Punithalingam (1975) to delineate the species from *C. rosea*. A considerable variation in conidial size was evident among different isolates examined, and conidia may even be longer than the measurements given here.

The primary conidiophores are verticillium-like and similar to those of, for example, *C. rosea* (Fig. 33 c). However, while the primary conidiophores are formed early and throughout the colony in strains of *B. ochroleuca* and other species, they are very rare in cultures of *B. compactiuscula*. In fact, earlier descriptions of the fungus provided by Tubaki (1963) and Hawksworth and Punithalingam (1975) did not mention verticillium-like conidiophores. Hosoya *et al.* (1995) described the verticillium-like conidiophores of *B. compactiuscula* for the first time. In contrast, on the natural substratum the verticillium-like conidiophores were found on many of the specimens. Colonies derived from conidia from verticillium-like conidiophores, penicillate conidiophores, and ascospores all yielded identical anamorphs.

Another characteristic feature of *B. compactiuscula* is the frequent formation of light brown stromata in culture.

The ascomata in *B. compactiuscula* are similar to those of *B. ochroleuca*. Most teleomorph specimens were initially identified as *B. ochroleuca* (or *B. aureo-fulva*). The perithecia of *B. compactiuscula*, however, are entirely smooth (Fig. 31 a–d), pale orange to pale yellow, and the ascospores (Figs 31 j, k, 33 b) are more finely warted and smaller than in *B. ochroleuca*. However, the species is easily recognizable when ascospores are grown and, if no strains are available, the anamorph from the natural substratum can also be used in most cases as a reliable criterion. The combination of (i) the occurrence of dimorphic conidiophores, (ii) frequently branched secondary conidiophores, (iii) almost cylindrical conidia with a laterally displaced hilum, (iv) the absence of sporodochia, both on the natural substratum and in culture, (v) pallid perithecia, and (vi) relatively finely warted ascospores is typical of *B. compactiuscula*.

*Bionectria compactiuscula* falls outside of a highly supported clade of species characterized by dimorphic conidiophores (Fig. 4). The sparse formation of the primary conidiophores, the lack of curvature of the conidia and the frequent occurrence of intercalary phialides may explain this inference. Moreover, the morphological characters intergrade with the patterns found in subgenus *Zebrinella* (almost symmetrical conidia) and subgenera *Epiphloea* / *Uniparietina* (lack of primary conidiophores, frequent occurrence of interca-

lary phialides). The teleomorph, however, places *B. compactiuscula* in subgenus *Bionectria* because of the pseudoparenchymatous erumpent stroma, crowded perithecia, presence of a hyphal layer in the perithecial wall, and warted ascospores.

*Verticillium compactiusculum* was described from the bark of branches of *Prunus domestica*. The original description focuses on the habitat of the conidiophores on the natural substratum [*'caespitulis effusis, albis, compactiusculis'* (Saccardo 1882: 553)] and on the form of the conidia [*'cylindraceo-oblongis'* (Saccardo 1882: 554)]. *Verticillium candidulum* Saccardo was similarly described, but from fruits of *Rosa* sp. Hawksworth & Punithalingam (1975) chose *C. compactiuscula* among the simultaneously competing synonyms. Arnaud (1952) first discussed the relatedness of this fungus to *Clonostachys araucaria* and regarded *C. cylindrospora* as a new species based on the conidial form and measurements. Classification of *Verticillium compactiusculum* and other original material of Saccardo and Arnaud is also based on observations made by Gams (in Hawksworth & Punithalingam, 1975). I examined the ex-type slides of Saccardo's material provided by Gams and agree with his conclusions.

The complexly branched secondary conidiophores and the formation of a brown prosenchymatous stroma in culture are similar to structures found in *C. rogersoniana*.

*Bionectria compactiuscula* occurs in temperate as well as tropical regions. Many collections of perithecia are available from the eastern U.S.A., particularly from the Nantahala National Forest in North Carolina. Otherwise the teleomorph has been collected relatively rarely, but from a broad geographical range (France, New Zealand, the neotropics). Similarly, conidial isolates are reported from distant regions (Japan, Europe, the tropics).

#### 14. *Clonostachys rogersoniana* Schroers, *sp. nov.* — Fig. 34 a–c.

*Clonostachydi compactiusculae* similis sed conidiophoris primariis in vitro copiosis. Conidiis ovoideis quasi rectis, hilo invisibili vel quasi medio, (4.8–)5.8–6.6–7.2(–9.6) × (2.2–)3–3.2–3.8(–4.2) µm. Coloniae saepe stroma brunnescens in agaro submersum vel superficiale formantes.

Holotypus anamorphosis: cultura sicca ex CBS 920.97 (in Herb. CBS); cultura viva CBS 920.97.

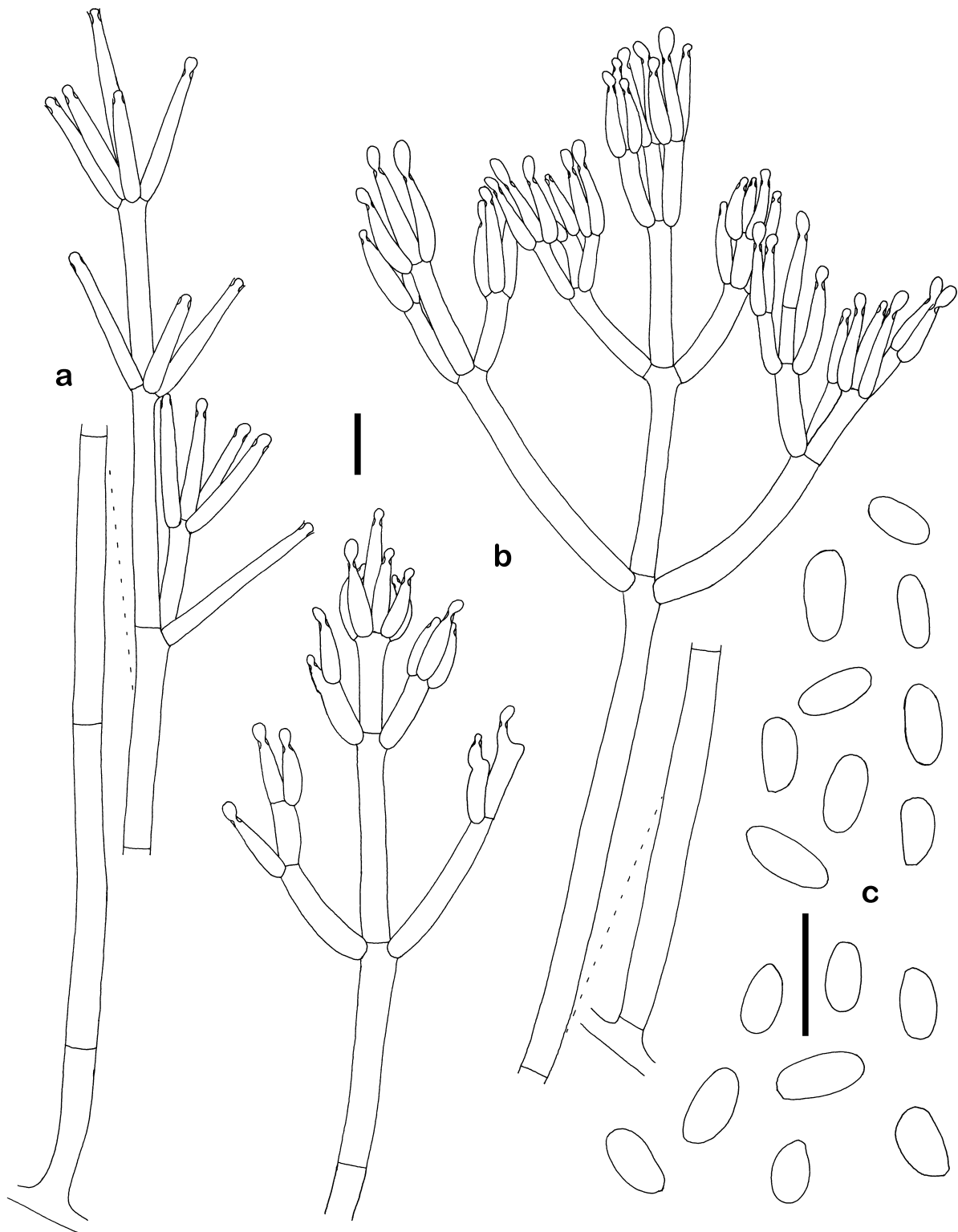
Etymology: *Rogersoniana*, in honour of Dr Clark T. Rogerson.

Teleomorph: Unknown.

**Description from culture:** Colonies reaching 30–40 mm diam in 7 d at 24°C; optimum for growth 24–30°C, maximum 30/33°C. Colony reverse almost unpigmented (darkness), pale to light yellow (2A3–5)

under daylight, or orange-white (5A2) under UV; older colonies frequently with distinct brown (6D7–6F7) spots or hues caused by submerged to superficial stromatic tissue composed of prosenchymatous to pseudoparenchymatous cells. Colony surface with structures best developed on OA, sparsely on CMA, finely granular, white to yellowish, later brownish in spots because of the pigment of the agar or the stroma respectively; aerial mycelium inconspicuous, developed as single hyphae or thin strands, creeping, hardly affecting the colony habit; aerial structures, pigmentation of the agar, and sporulation more strongly developed in concentric rings in daylight/darkness conditions; on PDA velvety to lanose, because of the stronger production of aerial mycelium with hyphae arranged in strands. **Conidiophores** dimorphic, arising from aerial hyphae or scattered on the agar surface or stroma. Primary conidiophores verticillium-like, formed throughout the colony, predominant towards the margin, with monoverticillate or more-level-verticillate divergent phialides, sometimes with side-branches; stipe 60–200 µm long, 3–5 µm wide at base; penicillus 40–150 µm high; phialides generally in whorls of 2–4, in lower levels frequently in whorls from short side branches or solitary from the main axis, straight, cylindrical, slightly tapering towards the tip, with or without a short collarete, (14.9–)20.8–23.6–26.8(–38) µm long, (2.2–)2.4–2.6–2.6(–3.2) µm wide at base, (1–)1.6–1.6–1.6(–2.2) µm wide near aperture (n = 36), each producing a small, hyaline drop of conidia. Secondary conidiophores penicillate, solitary to gregarious, not sporodochial, bi- to quaterverticillate; branches of the penicillus divergent, each branch terminating in less divergent metulae and adpressed phialides; stipes 70–160 µm long, 5–7.5 µm wide at base; penicilli 50–100 µm and higher, to 100 µm diam at widest point; phialides in adpressed whorls of up to 6, narrowly flask-shaped, with widest point in the lower third, slightly tapering toward the apex, (10.2–)11.8–12.4–13.4(–16.6) µm long, (1.6–)2.4–2.6–2.8(–3.2) µm wide at base, (2.2–)2.6–3–3.4(–4.2) µm at widest point, (1–)1–1.2–1.4(–1.8) µm wide near aperture (n = 30), frequently collapsing in relative young conidiophores. Intercalary phialides solitary, with a lateral neck 3–5 µm long, normally below a whorl of terminal phialides; intercalary phialides remaining visible after the collapse of the terminal phialides. **Conidial masses** pale yellow to yellowish white to white, held in long imbricate columns. **Conidia** hyaline, broadly ellipsoidal to oval, rarely minutely curved, ends broadly rounded, (4.8–)5.8–6.6–7.2(–9.6) × (2.2–)3–3.2–3.8(–4.2) µm (n = 110); hilum laterally displaced, almost median or invisible.

**Type for *Clonostachys rogersoniana*:** BRAZIL. São Paulo: soil under *Araucaria* sp.; Feb 1995; coll. L. Pfenning, isol. W.G. (herb. CBS; dried culture of CBS 920.97).



**Fig. 34.** *Clonostachys rogersoniana*. **a.** Verticillium-like primary conidiophore. **b.** Secondary conidiophores; primary branches  $\pm$  divergent, terminal branches addressed; intercalary cells left with phialidic necks after collapse of terminal phialides (left). **c.** Conidia. – a, b (left), c (above): CBS 920.97; b (right), c (below): CBS 582.89. – All from 7–10-d-old OA cultures. Scale bars = 10  $\mu$ m; the shorter bar applies to a, b, the longer to c.

**Known distribution:** Probably cosmopolitan (Brazil, Japan, Spain, Italy, Netherlands), mostly recorded from warmer or tropical countries/regions.

**Habitat:** Frequently isolated from soil or roots in soil, or on bark of dead twigs, or from leaf litter; killing larvae of *Diptera* (R. Milner, CSIRO Entomology, Canberra, pers. comm.).

**Additional strains examined:** INDIA. M.N. Kamat (CBS 668.70). – SPAIN. Gran Canaria; soil under *Apollonias* sp.; 1976; J.A. von Arx (CBS 363.76). – JAPAN. K. Tubaki (herbarium: CBS, IFO 10263; strain: CBS 377.65; IFO 7066). – ITALY. Sicily, Bot. Garden Palermo; litter of *Ficus rubiginosa*; 1984; W.G. (CBS 394.85). – BRAZIL. PARÁ: 200 km SE from Belém, Capitão Poço; rain forest soil; L. Pfenning, No. R 372 (CBS 582.89). – AUSTRALIA. QUEENSLAND: from *Inopus rubriceps* larvae (Diptera); 1998; R. Milner.

**Notes:** *Clonostachys rogersoniana* is similar to *B. compactiuscula* (*C. compactiuscula*) in branching patterns of the conidiophores, a less pronounced curvature of the conidia, and brownish prosenchymatous stroma that sometimes is produced in culture (OA). Both species at least infrequently form intercalary phialides and in both species a relatively early collapse of the terminal phialides has been observed (Fig. 34 b, left).

*Clonostachys rogersoniana* and *B. compactiuscula* differ mainly in the frequency of primary conidiophores in culture (in *C. rogersoniana* abundant; in *B. compactiuscula* rare) and in shape and size of the conidia [in *C. rogersoniana* broadly ellipsoidal, L/W = (1.5–)1.8–2–2.2(–3.1); in *C. compactiuscula* oblong-ellipsoidal, L/W = (1.8–)2.9–2.9–3.3(–4.5); compare Fig. 32 c with Fig. 34 c].

Secondary conidiophores in *Clonostachys rogersoniana* have rather divergent primary branches that terminate in adpressed units of metulae and phialides (Fig. 34 b). In common with *B. compactiuscula*, several conidial columns are formed from one conidiophore. The conidial columns in both species are stable and remain visible even in older colonies.

*Clonostachys rogersoniana* clusters outside of most other species with dimorphic conidiophores. It appears close to *B. samuelsii* and *C. divergens* (Figs 2–4). No teleomorph is known for *C. rogersoniana* and no perithecial primordia have been found in the stromatic tissue that is frequently formed in or on the agar.

### 15. *Bionectria solani* (Reinke & Berthold) Schroers, *comb. nov.* — Figs 35 a–c, e–j, 37 a, b.

≡ *Nectria solani* Reinke & Berthold, Die Zersetzung der Kartoffel durch Pilze. Von Wiegand. Berlin. p. 39. 1879.  
= *Nectria pallidula* Cooke, Grevillea 17: 3. 1888.

Anamorph: *Clonostachys solani* f. *solani*

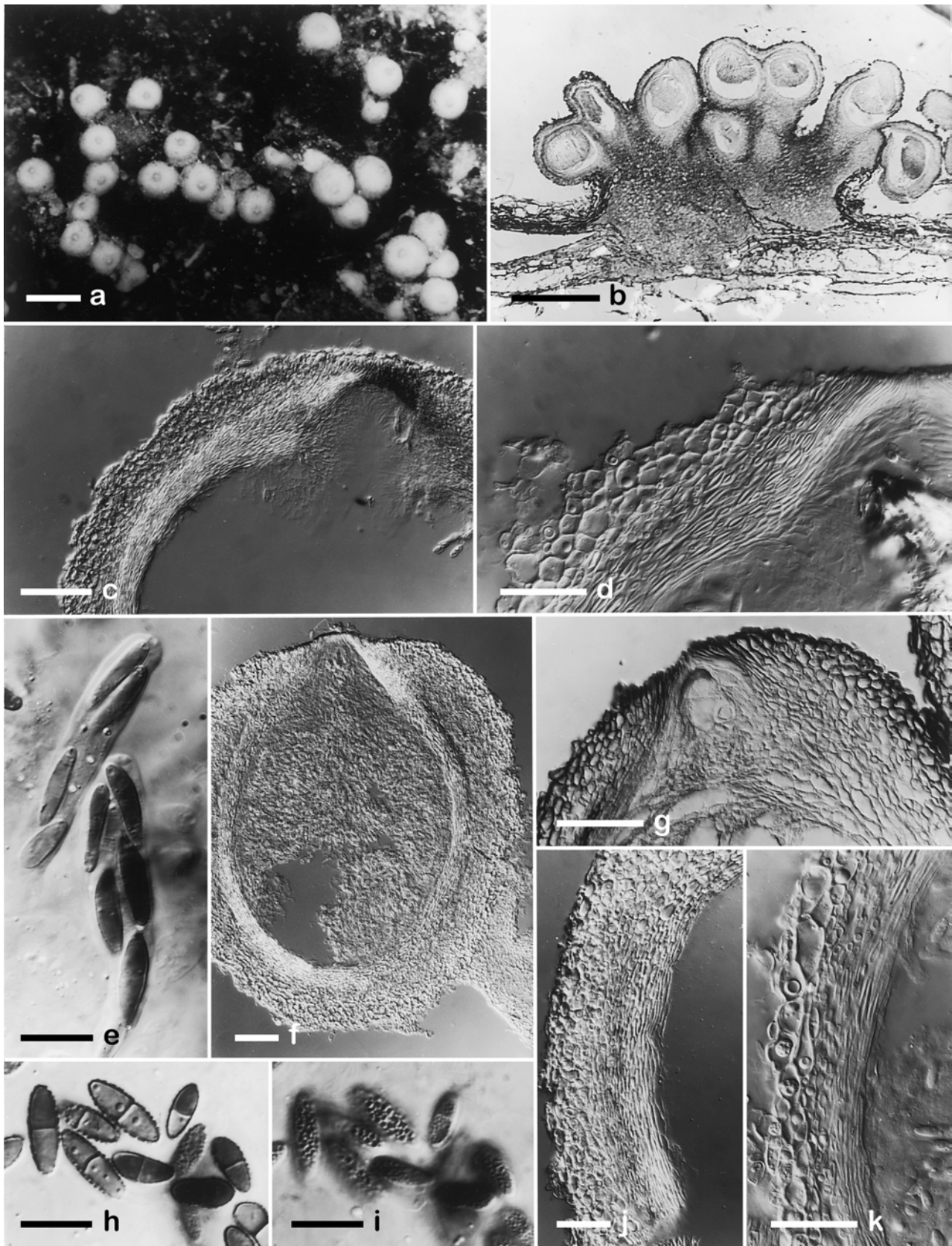
### *Clonostachys solani* (Harting) Schroers & W. Gams, *comb. nov.* f. *solani*. — Figs 36 a–e, 37 c–f.

≡ *Spicaria solani* Harting, Nieuwe Verh. Kon. Inst. Wet. Amsterdam 12: 226. 1846 [non *Spicaria solani* Rivolta, Parass. veget.: 563. 1873].  
= *Dendrodochium aurantiacum* Bonorden, Handb. allg. Mykol. p. 135. 1851; pl. 228, a, b in Abhandlungen aus dem Gebiete der Mykologie. Zweiter Theil. 1870.

= *Acrostalagmus roseus* Bainier, Bull. Trimestriell. Soc. Mycol. France 21: 225. 1905.

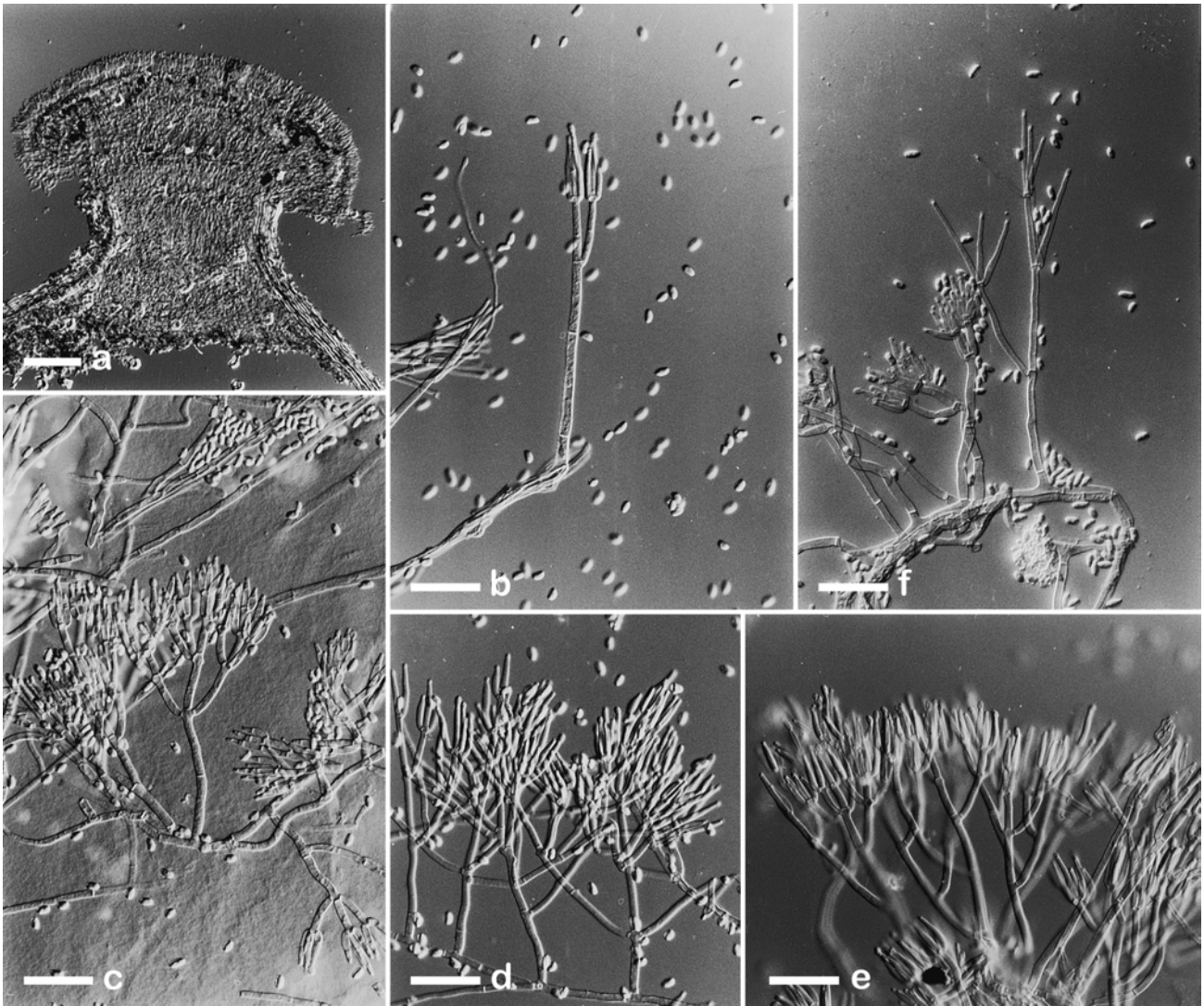
**Description from natural substratum:** **Stroma** well-developed, erumpent through bark; cells angular, to 10 µm diam, forming a *textura angularis*. **Perithecia** crowded on the stroma, in groups of to more than 50, generally higher than wide, subglobose to obovoid, 250–650 µm high, 190–450 µm diam, laterally pinched when dry, pale to light orange, minutely papillate when dry, with a darker contrasting ostiolar region, smooth to slightly rough. **Perithecial wall** 30–80 µm thick, composed of three regions. Outer region 20–40 µm or 4–7 cells thick; cells angular to subglobose, (4–) 7.7–10(–12.5) × (3–)5–6(–10.5) µm, frequently containing a vacuole, generally with uniformly thickened walls *ca* 1 µm thick. Middle region 10–25 µm thick. Inner region 10–20 µm thick. **Asci** narrowly clavate, (52–)61–66–89(–84) × (5–)7–8–9(–10.5) µm (n = 37), 8-spored; ascus apex rounded or flat with rounded edges, ring visible. **Ascospores** ellipsoidal to oblong-ellipsoidal, spinulose to warted, (8.8–)11–11.8–12.8(–16) × (2.8–)3.4–3.8–4(–5) µm (n = 148). Mononematous conidiophores sometimes scattered on or close to the perithecial stroma.

**Description from culture:** **Colonies** reaching 21–30 mm diam in 7 d at 24°C; optimum for growth 24 (–27)°C (35 mm diam), maximum 27–30°C. Colony reverse on OA and PDA pale to light yellow (4A3–4) to brownish orange (5C3); under UV pale to light orange (6A2–5); on CMD in similar hues but pigmentation less pronounced. Colony surface on OA floccose, felty to tomentose to granulose, particularly towards the colony centre because of strands of aerial mycelium and dome-shaped conidial masses, unpigmented, white because of the aerial mycelium (particularly on PDA), pale yellow to pale orange or pale brownish orange (OA, CMD) because of the conidial masses or a diffusing pigment in the agar; aerial mycelium of interwoven hyphae or arranged in hyphal strands, white or pigmented because of the conidial slime; on CMD similar to OA, but surface structures less intense; surface structures often forming concentric rings if incubated in a daylight/darkness cycle; aerial mycelium on PDA strongly developed in thick, often erect hyphal strands. **Conidiophores** dimorphic, rarely almost monomorphic: primary conidiophores narrowly penicillate, formed first, arising from the agar surface or from strands of aerial mycelium, predominating in young parts of the growing colony, rarely dominating in all parts of the colony, narrowly penicillate, mono- to quaterverticillate; branches including the phialides adpressed; stipe 60–240 µm long, generally longer than the penicillus, 3–6.5 µm wide at the base; penicillus 20–100 µm high; phialides in apical whorls of 2–5, also solitary arising from lower levels, straight, almost



**Fig. 35 a–c, e–j. *Bionectria solani***, compared with *B. ochroleuca* (d, k). **a.** Habit of crowded or solitary perithecia. **b, c, d, f, g, j, k.** Sections through perithecia. **b.** Crowded perithecia on erumpent stroma. **c, d, g.** Upper parts of perithecia; cells of outer perithecial wall region larger in *B. ochroleuca* (d) than in *B. solani* (c, g). **e.** Immature asci with rounded apex. **f.** Perithecial walls; thicker in *B. solani* and with relatively small cells in outer region (j), in *B. ochroleuca* thinner and with relatively large cells in outer region (k). **h, i.** Discharged ascospores in optical section (h) and surface view (i). **j, k.** Lateral perithecial walls; thicker in *B. solani* and with relatively small cells in outer region (j), in *B. ochroleuca* thinner and with relatively large cells in outer region (k). **a:** Carlyle 1888; **b, e, g:** Carlyle 1885 (type of *N. pallidula*). **c:** CUP-MJ 804; **d, k:** Ellis 2859 (type of *N. aureofulva*); **f, h, i:** IMI 71731; **j:** W.G. 1440 (neotype of *N. solani*). All from natural substratum. The section in b and g was prepared by G.J. Samuels. **a:** DM; **b:** LM; others: DIC. Scale bars: **a** = 300  $\mu$ m; **b** = 250  $\mu$ m; **c, f** = 50  $\mu$ m; **d, g, j, k** = 30  $\mu$ m; **e, h, i** = 10  $\mu$ m.

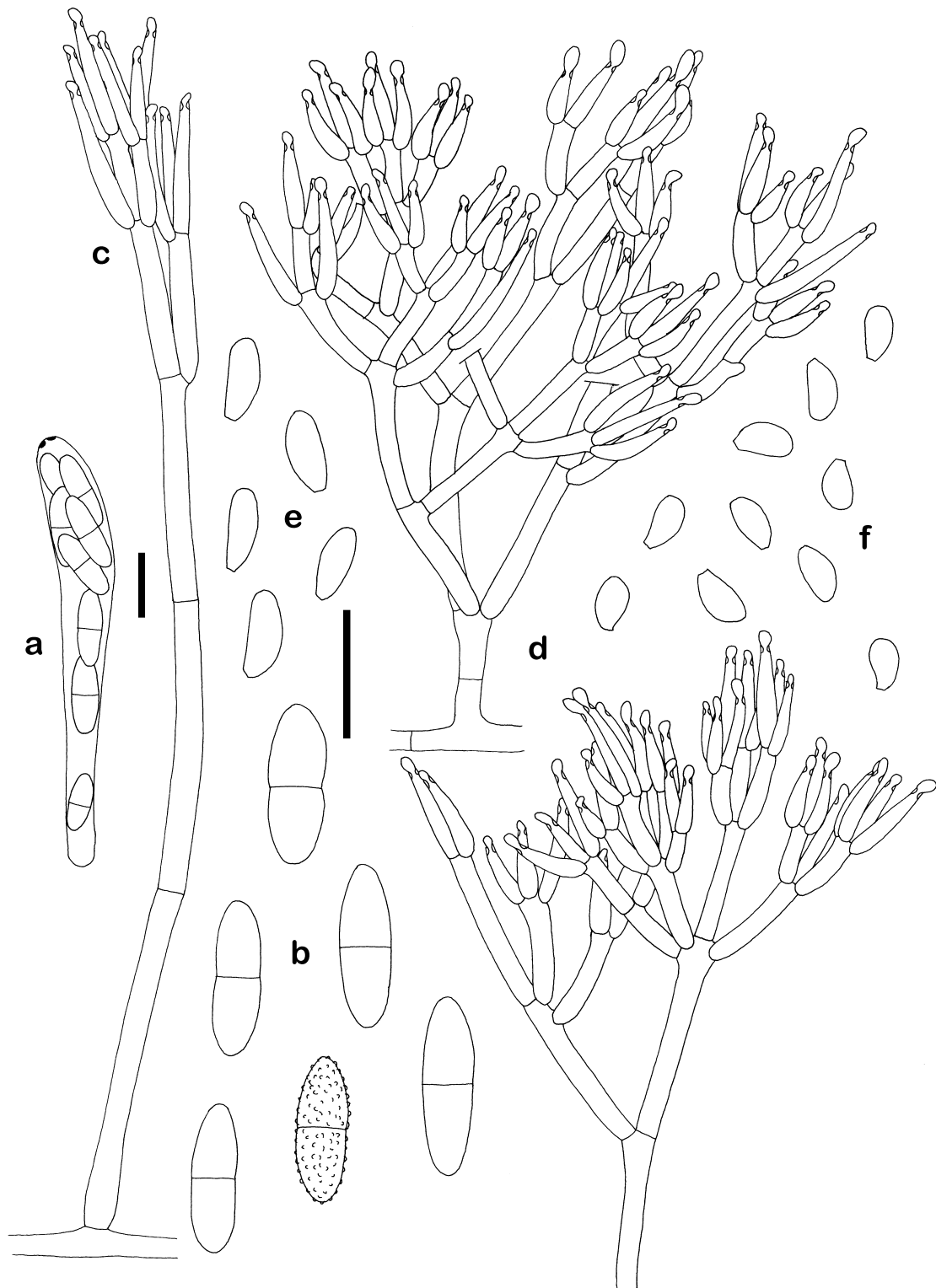




**Fig. 36 a–e.** *Bionectria solani* / *Clonostachys solani*, compared with *B. ochroleuca* / *C. rosea* (f). **a.** Section through sporodochium. **b.** Addressed primary conidiophore. **c–e.** Secondary, divergently branched conidiophores. **f.** Primary, divergently branched (right) and secondary, addressed conidiophores (left). – a: Herb. CBS 04367 (neotype of *Spicaria solani*); b, d, e: CBS 702.97; c: CBS 697.88 (ex Herb. CBS 04367); f: CBS 102.94. a: natural substratum; b–f: 7–10-d-old OA cultures. All: DIC. Scale bars: a = 100  $\mu\text{m}$ ; b–f = 30  $\mu\text{m}$ .

cylindrical, slightly tapering towards the tip, without or with a somewhat visible collarette, variable in length, solitary phialides frequently longer than those of apical whorls, (11.2–)15.6–19–20.6(–38.6)  $\mu\text{m}$  long, (1.6–)2–2.2–2.4(–3)  $\mu\text{m}$  wide at base, (1–) 1.2–1.4–1.4(–1.8)  $\mu\text{m}$  wide near aperture (n = 73). Secondary conidiophores broadly penicillate, mostly formed from strands of aerial mycelium, on CMD also from the agar surface, often in concentric rings, frequently forming sporodochia; penicilli quater- or higher-verticillate, divergently branched, particularly the basal branches, mostly 50–100  $\mu\text{m}$  high, 70–150  $\mu\text{m}$  wide, normally wider than high; phialides in whorls of 2–5, divergent at acute angles or adpressed, straight to slightly curved, flask-shaped, generally with widest point in the lower third, or almost cylindrical, but generally slightly tapering in the upper part, without a visible

collarette, (9–)11.6–14–15.2(–25)  $\mu\text{m}$  long, (1.8–)2.2–2.4–2.6(–3.4)  $\mu\text{m}$  wide at base, (1.4–)2.4–2.6–3(–3.8)  $\mu\text{m}$ , (0.8–)1.2–1.2–1.4(–1.8)  $\mu\text{m}$  wide near aperture (n = 66). **Conidial masses** on primary conidiophores in round heads of ca 50  $\mu\text{m}$  diam, in watery drops, transparent to white to off-white; on secondary conidiophores in short or long, broad or slender columns, with imbricate conidia, or sliming down to dome-shaped, white, pale yellow, pale orange or olive-brown masses (4E–F5). **Conidia** hyaline, ellipsoidal, asymmetric with one more flattened side, distally broadly rounded, with laterally displaced hilum; conidia from primary conidiophores (5–)6.4–7–7.4(–10)  $\mu\text{m}$  long (n = 55) from secondary conidiophores (3.8–)4.4–4.8–5(–6.8)  $\times$  (2–)2.4–2.6–2.8(–3.8)  $\mu\text{m}$  (n = 185). Perithecia not formed.



**Fig. 37. *Bionectria solani* / *Clonostachys solani*.** a. Almost mature ascus. b. Discharged ascospores. c. Addressed primary conidiophore. d. Divergently branched secondary conidiophores. e, f. Conidia, from secondary (e), and primary conidiophores (f). – a: Carlyle 1885 (from type of *N. pallidula*); b: CBS 752.68 (W.G. 1440, ex neotype strain of *B. solani*), Carlyle 1888, CUP-MJ 804; c: CBS 752.68; d: CBS 101924 (top), CBS 702.97 (bottom); e: CBS 228.74; CBS 752.68; f: CBS 752.68. a, b: natural substratum; c–f: 7–10-d-old OA cultures. Scale bars = 10  $\mu$ m; the shorter bar applies to a, c, d, the longer to b, e, f.

**Iconotype for *Nectria solani*:** GERMANY. Göttingen, on rotten potato tubers; specimen not preserved (Reinke & Berthold, 1879: Taf. III, Figs 1–16). **Neotype for *Nectria solani*** designated herewith: GERMANY. Orbishöhe near Zwingenberg/Bergstraße; on

bark of deciduous tree; 5 Oct 1968; W.G. (herb. CBS, specimen W.G. 1440; ex-neotype strain: CBS 752.68, derived from ascospores). **Neotype for *Spicaria solani*** designated herewith: GERMANY. Aachen; bark of tree trunk; fall 1988; W.G. (herb. CBS, W.G. 4367;

dried culture ex CBS 697.88, derived from conidia). **Neotype for *Dendrodochium aurantiacum*** Bonorden designated herewith: NETHERLANDS. Prov. Utrecht: Nijenroode; on bark; Sept 1998; W.G. (herb. CBS; dried culture ex CBS 102418, derived from conidia).

**Known distribution:** From tropical as well as temperate regions. Teleomorph known from Venezuela, Jamaica, Germany, Netherlands, United Kingdom (England), rather rare. Anamorph mainly collected in temperate regions.

**Habitat:** Teleomorph and anamorph mostly on bark of recently dead trees; anamorph on various other plant material including different parts of potato plants or from soil.

**Published description and illustration:** Booth (1959) [Fig. 12 b, c probably referable to *C. rosea*].

**Additional teleomorphic specimens/isolates examined:** JAMAICA. St. Andrew Parish, vic. Dick's Pond, west of Hardwar Gap, near Holywell Recreation Area and Wag Water River, 850–910 m alt.; on *Hypoxylon* sp. on bark; 11 Jan 1971; R.P. Korf *et al.* (NY; CUP-MJ 804, A.Y.R. 395; C.T.R. isolate 71-32, CBS 101924). – Hanover Parish, Dolphin Head Mt., vic. Askenish, ca 300 m alt.; on wood; R.P. Korf *et al.*; 22 Jan 1971 (NY; CUP-MJ 946; C.T.R. isolate 71-116, CBS 101920). – NETHERLANDS. Rolde; on stolon of *Solanum tuberosum*; Sept 1962; J.H. van Emden, No. 452 (CBS 728.69). – Nederhemert; on bark of *Fraxinus sylvatica*; 31 Oct 1999; L. Rommelaars (CBS; CBS 102425). – UK. Carlisle; on *Fagus* sp.; Sept 1885; Dr Carlyle (K, type for *Nectria pallidula*). 1888 (same data as type, syntype for *N. pallidula*). – Birmingham; on roots of *Aesculus hippocastanum*; 11 Sept 1886 (K). – Coombe Bristol; on *Acer* sp.; Sept 1955; J. Webster (IMI 71731). – North Wootton; on *Sarothamnus scoparius*; Oct 1934 (K) and Oct 1935 (K). – Carlisle, on bark of *Fagus* sp.; Sept 1888; Carlyle (K). – Moulin Huet, Guernsey; on *Robinia* sp.; Sept 1948; M.B. & J.P. Ellis (IMI 33709). – Wheatfen Broad; on *Solanum* sp.; 18 Aug 1946; E.A. Ellis (IMI; slides ex IMI 6358, differing in a narrower perithecial wall of ca 30 µm). – VENEZUELA. Edo. Aragua: Parque Nac. Henri Pittier, vic. Rancho Grande Biological Station, trail between El Portachuelo and Pico Periquito, ca 10°21' N, 67°41' W, 1200–1400 m alt.; on decaying palm inflorescence; 2 Dec 1990; G.J.S., B. Hein, S.M. Huhndorf, A. Ortega (B, BPI, NY, USB, VEN; G.J.S. 7781; CBS 101926, G.J.S. isolate 90-187). – Edo. Yaracuy: in mountains N of Nirgua; on unidentified palm spathe; 7 Jul 1971; KP Dumont, J.H. Haines, G.J.S., G.S. Bunting (NY; Dumont-VE 1541; C.T.R. isolate 71-224). – Edo. Miranda: Vic. Quebrada, Los Palos Grandes, south facing slope of La Silla, Parque Nac. El Avila; on unidentified bark; 2 Jul 1972; K.P.D., G.J.S., B. Manara (NY; Dumont-VE 3627; C.T.R. isolate 71-85, or ?72-84).

**Additional conidial isolates of *B. solani* / *C. solani* examined:** Location and substratum unknown; T. Benedek (CBS 187.29, MUCL 7583). – CANADA. Winnipeg; from wood; J. Reid (CBS 707.86, 708.86). – FRANCE. Coudrée (Haute Savoie), Forêt des buis (*Buxus* forest); on rotten fruit of *Aesculus hippocastanum*; 25 Sept 1996; H.-J. Schroers (CBS 702.97). – GERMANY. From forest soil under *Picea abies* and *Vaccinium myrtillus*; 1984; F. Spaay (CBS 376.85). – Kiel-Kitzeberg, from

wheat-field soil; W.G. (CBS 224.72e). – NETHERLANDS. Prov. Groningen: Haren (GR); sclerotium of *Rhizoctonia solani*; G. Jager, No. M 77 (CBS 227.80). – Prov. Utrecht: Baarn; on tuber of *Solanum tuberosum*; W. Gams (CBS 228.74). – On decaying angiosperm wood; W. Gams (CBS 906.72D). – PORTUGAL. Coruche-Alentejoex; gallery of *Platypus cylindrus* Fabr. (ambrosia beetle) on *Quercus suber* (cork-oak); 1994 (E.M.R. Sousa F10; E.M.R. Sousa F29). – U.S.A. CALIFORNIA: G. Mes (CBS 191.31, MUCL 7580).

***Clonostachys solani* f. *nigrovirens*** (van Beyma) Schroers, *stat. nov.* — Fig. 38 a–c.

= *Gliocladium nigrovirens* van Beyma, Verh. Kon. Ned. Akad. Wet., Afd. Natuurk., Sect. 2, 29: 30. 1931.

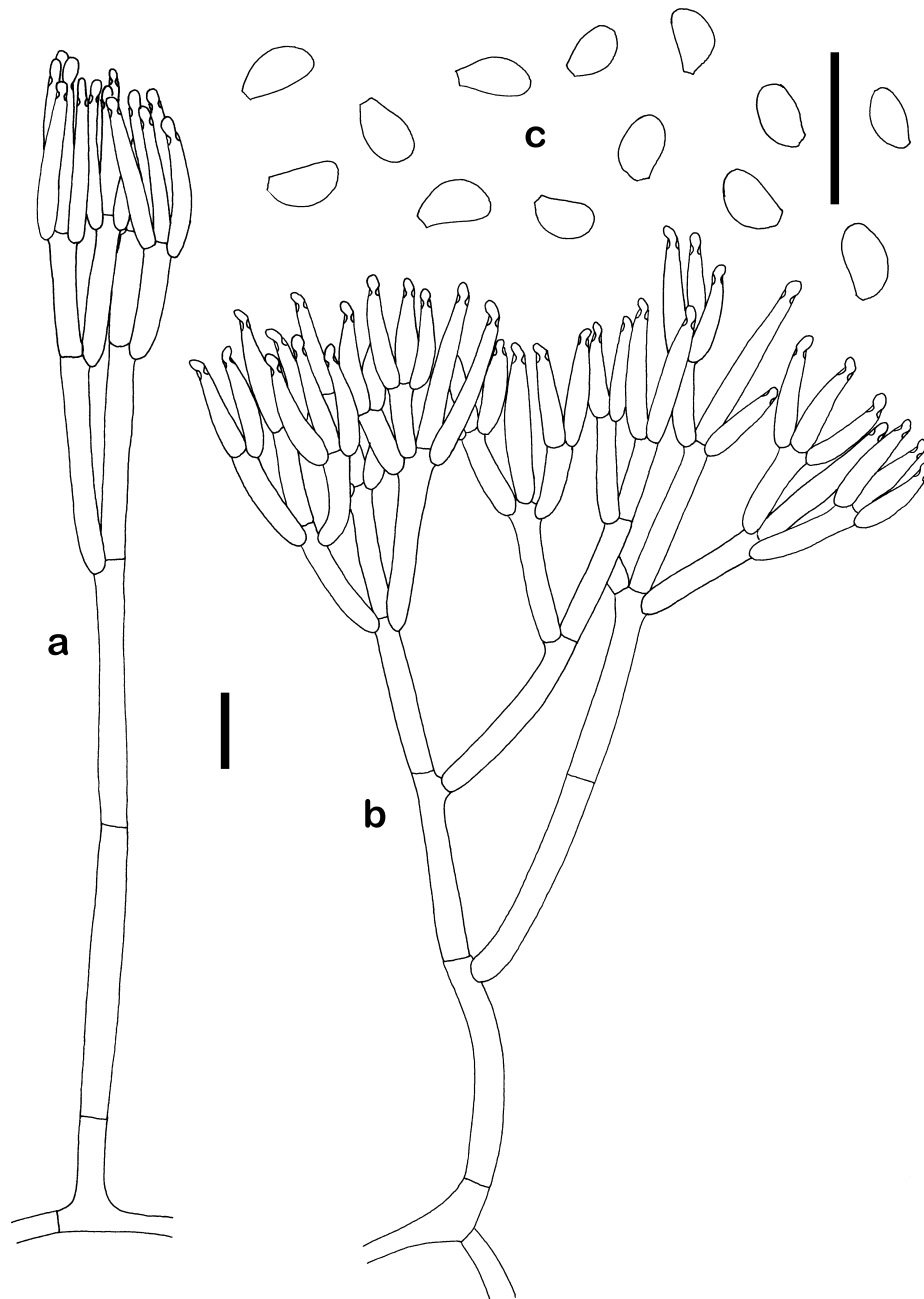
**Description from culture:** Similar to *C. solani* f. *solani* in growth rate and surface structures. **Colony** reverse on OA and PDA pale to light yellow (4A3–4), greyish yellow, olive-yellow, brownish orange (5C3), or greenish to dark green. Colony surface typically grey-green, dull green to almost black-green or pale yellow to pale orange or brownish to brownish orange because of the pigmentation of conidial masses on secondary conidiophores or aggregates of conidiophores. **Conidiophores** as in *C. solani*. Phialides of the primary conidiophores (11–)14–16.6–18.6(–22.8) µm long, (1.6–)2–2.2–2.4(–3) µm wide at base, (1–)1–1.2–1.4(–1.8) wide near aperture (n = 31); phialides of the secondary conidiophores (8–)11.2–13.4–14.4(–23.4) µm long, to (2.4–)2.6–2.8–3(–3.2) µm wide, (1–)1–1.2–1.4(–1.6) µm wide near aperture (n = 38). **Conidial masses** on primary conidiophores as clear or greenish hyaline watery drops; on secondary conidiophores as short or long columns, with imbricate conidia or sliming down to dome-like masses over several conidiophores or sporodochial aggregates, grey-green or dull green to almost black-green, less typically brownish to pale orange or white. **Conidia** as in *C. solani*, greenish hyaline or hyaline, 4.2–9 × 2.1–3.4 µm when formed from primary conidiophores, (3.4–)4.2–4.6–4.8(–6.4) × (2.2–)2.6–2.8–3(–3.8) µm when formed on secondary conidiophores or sporodochial aggregates (n = 105).

**Type:** NETHERLANDS. Prov. Utrecht: Baarn; from garden soil; F.H. van Beyma; ex-type strain: CBS 183.30.

**Known distribution:** Known from northern temperate regions.

**Habitat:** Isolated from soil, recently dead trees, and various other plant material including different parts of potato plants, jute bag; rarely also known in water or as a pathogen of the slug *Arion ater*.

**Published description and illustration:** Van Beyma (1931).



**Fig. 38.** *Clonostachys solani* f. *nigrovirens*. **a.** Adpressed primary conidiophore. **b.** Divergently branched secondary conidiophore. **c.** Conidia. – a, b: CBS 142.91; c: CBS 728.69, CBS 223.72b. a–c: 7–10-d-old OA cultures. Scale bars = 10  $\mu$ m; the shorter bar applies to a, b, the longer to c.

**Additional conidial isolates examined:** BELGIUM. ex potato; L. Verbruggen (Janssen Pharmaceutica, Beerse) (Verbruggen 95051). – GERMANY. Kiel-Kitzeberg; wheat-field soil; W.G. (CBS 223.72a, 223.72b). – Monheim; egg of *Arion ater*, toxic to slugs; Sept 1990; B. Rehbein, No 516C (CBS 142.91). – Bonn, from *Sorbus intermedia*, inside stem at 1.5 m from ground; 1995; K. Weise (CBS 101919). – NETHERLANDS. Jute bag; H.J. Hueck, TNO (CBS 147.65). – Baarn; tuber of *Solanum tuberosum*; 1972; W.G. (CBS 229.74). – Lienden; on potato slice in acid clay soil; Jan 1976; J.C. Mooi (CBS 350.76). – UKRAINE. Crimea, Sebastopol; water; 1966; A.A. Milko (CBS 223.72C, VKM F-1096).

**Notes:** No original material of *Spicaria solani* is available. Harting illustrated adpressed primary conidiophores (1846: Fig. III, 2, 3) and a sporodochium (Fig.

III, 1) erumpent through the outer cortex of a potato tuber. The original figures of Harting were reproduced by Brown & Smith (1957). Reinke & Berthold (1879) described the *Nectria solani* teleomorph of *C. solani*, consisting of perithecia on a specimen of potato in Germany, of which no original material is available. They illustrated a primary conidiophore (1879: Taf. III, Figs 7, 9) that is not distinguishable from that illustrated by Harting and mention ‘coremia’ that possibly were similar to the sporodochium illustrated by Harting. Reinke & Berthold (1879) identified the anamorph as *Spicaria solani* but incorrectly ascribed it to de Bary (1861), who had clearly referred to Harting. Petch (1944) transferred the anamorph to *Gliocladium* as *G.*

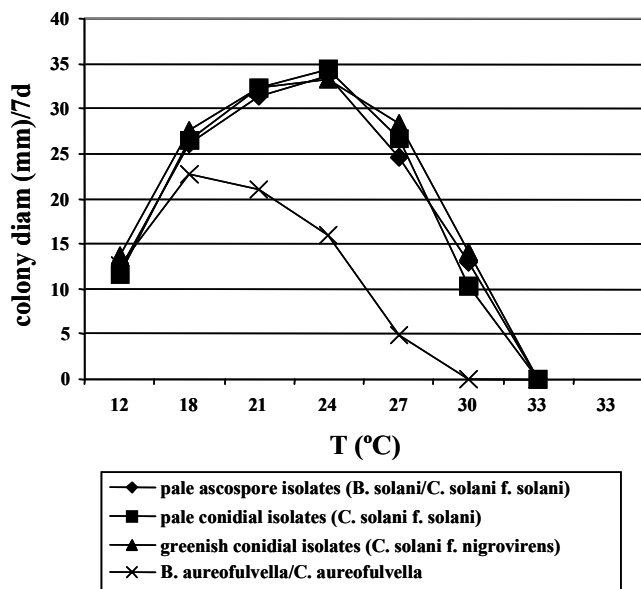


Fig. 39. Colony diameters of each taxon are averages based on studies of several strains.

*solani* (Harting) Petch. Domsch *et al.* (1980) keyed out *G. solani* next to *G. nigrovirens*, distinguishing the two only by the pigmentation of the conidial masses. Several strains from potato have been obtained in which the primary conidiophores match the illustration provided by Harting and Reinke & Berthold (Figs 36 b, 37 c, 38 a). In culture, the addressed conidiophores are associated with frequently sporodochial,  $\pm$  divergently branched secondary conidiophores (Figs 36 c–e, 37 d, 38 b) forming imbricate conidial masses. Other strains, with identical conidiophores in culture, have been isolated from sporodochia from bark of recently dead trees (e.g. W.G. 4367, CBS 102418) and these sporodochia are similar to the pustules illustrated by Harting (compare Harting, 1846: Fig. III, 1 and Fig. 36 a). To reflect the characters described by Harting, *Spicaria solani* is neotypified by a specimen forming sporodochia on bark (CBS 697.88) that result in a *C. solani* in culture. Because of the dimorphic conidiophores, the imbricate conidial columns, and sporodochia that are formed at least sometimes in nature, *Spicaria solani* is transferred to *Clonostachys*. The species differs from *Clonostachys rosea* in the branching patterns of both kinds of conidiophores (compare Fig. 36 b–e with Figs 16 a, b, 36 f).

Orange perithecia on a potato collected by W.G. Bramley were identified as *Nectria solani* Reinke & Berthold by Petch (1944) and Booth (1959). Petch obviously did not grow ascospores of the fresh material he received from Mr Bramley and he described the anamorph growing in association with the perithecia on the specimen (as also stated by Booth, 1959). Booth again received fresh material from Bramley in 1957 (possibly IMI 70653b, which is cited by Booth) and isolated the ascospores. The illustrated anamorph, however, represents a *C. rosea* (Booth, 1959: Fig. 12 b, c) because the primary conidiophores are verticil-

lium-like and the secondary conidiophores are adpressed. The specimen IMI 70653b is identified here as *B. levigata* (subgenus *Zebrinella*) based on characters of the perithecial stroma and perithecial wall anatomy. Only Matsushima (1971: Figs 137, 138) followed the concept provided by Booth, connecting a *C. rosea* to the name *Nectria solani*.

Recent teleomorphic material with a proven *Clonostachys solani* anamorph differ considerably from the several British specimens collected by W.G. Bramley (and identified by Booth as *N. solani*): specimens with a proven *C. solani* anamorph have a fleshy, to 80  $\mu$ m thick perithecial wall consisting of three regions and a stroma consisting of angular cells (Fig. 35 b, c, f, j); in contrast, some British collections from potato have perithecial walls less than 50  $\mu$ m thick, consisting of 2 regions, and have a stroma consisting of hyphal cells (Fig. 73 a–c). These specimens are identified here as *B. levigata*. Ascospore isolates from perithecia that are here designated as the neotype for *Nectria solani* (W.G. 1440) form adpressed primary conidiophores in culture similar to those illustrated by Reinke & Berthold. Apart from its similar geography (Germany for both the original material and the neotype), the choice of the neotype therefore relies also on anamorphic characters. Because the neotype matches in all characters species in *Bionectria*, *N. solani* is placed in that genus. Other specimens from UK (IMI 71731, Fig. 35 f), the Netherlands (L. Rommelaars, CBS 102425), and some from tropical regions (MJ 804, CBS 101924; G.J.S. 7781, CBS 101926) all have relatively thick perithecial walls, relatively small cells in the outer perithecial wall region (Fig. 35 c, g, j, compare with those of *B. ochroleuca*: Fig. 35 d, k), divergently branched secondary conidiophores (Fig. 36 c–e, in IMI 71731 also found on the herbarium specimen) and adpressed primary conidiophores (Fig. 36 b, not seen in IMI 71731). These specimens therefore support the holomorphic species concept of *B. solani* / *C. solani* presented here.

*Dendrodochium aurantiacum* was described as forming sporodochia on bark (Bonorden, 1851; 1870: Fig. 228 a) and a rather divergently branched conidiophore (Bonorden, 1870: Fig. 228 b) was illustrated. The description fits the patterns found in the neotype specimen of *C. solani* that forms robust erumpent sporodochia (Fig. 36 a) and produces *C. solani* in culture. Because of the sporodochia and the rather divergently branched conidiophores, *D. aurantiacum* is considered a synonym of *C. solani*. To support this interpretation, *D. aurantiacum* is neotypified by another European specimen forming sporodochia on bark of recently dead trees, which forms a *C. solani* in culture. Because *D. aurantiacum* is the type species of *Dendrodochium*, this genus is listed as a synonym under *Clonostachys*.

*Acrostalagmus roseus* was described and illustrated with adpressed primary conidiophores and divergently

branched secondary conidiophores (Bainier, 1905) that are typical of *C. solani*. *Acrostalagmus roseus* is therefore considered a synonym of *C. solani*.

*Nectria pallidula* is regarded as a synonym under *B. solani*; it matches the neotype specimen in having rather small cells in the outer perithecial wall (Fig. 35 g) although its type specimen has a perithecial wall less than 35 µm wide. *Nectria pallidula* was accepted as a species by Booth (1959) and Samuels (1976a), but regarded as a synonym of *B. aureofulva* by Schroers & Samuels (1997). *Bionectria aureofulva* is here interpreted as a synonym of *B. ochroleuca* based on the width of the perithecial walls and slightly larger cells in the outer perithecial wall region (compare Fig. 35 k [type specimen of *B. aureofulva*] and Schroers *et al.*, 1999b: Fig. 9).

*Bionectria solani* is one of the species in subgenus *Bionectria* with entirely smooth perithecia and without unevenly thickened walls in the outermost cell layers. Size ranges of the warted ascospores (Fig. 35 i) in *Bionectria solani* overlap with those of other species of the subgenus, although they may be slightly longer than for example in *B. ochroleuca*, *B. pseudochroleuca*, and *B. compactiuscula*.

Branching patterns of conidiophores (Figs 36 b–e, 37 c–d, 38 a, b; van Beyma, 1931: Fig. 1: 1, 2), morphology of the imbricate conidial masses, a tendency to sporodochium formation in culture, conidial shape and size, and growth–temperature relationships (Fig. 39) are identical in *B. solani* and conidial isolates that either form white to pale orange or greenish conidial masses. However, isolates with green or light brown conidial masses were formerly also identified as *G. nigrovirens*. Conidial masses in the ex-type strain of *G. nigrovirens*, CBS 183.30, are now white under all tested culture conditions, but were described as black-green in the original description (van Beyma, 1931) and greenish shades in this strain were observed some years ago (W. Gams, pers. comm.). Other recent isolates sometimes form sectors in which the conidial masses remain white, even after subculturing (which consequently would be identified as *C. solani*). Based on the morphological similarities, the variable pigmentation of conidial masses in greenish isolates, and supported by *tub2* sequence analyses (Fig. 4 a–c), *G. nigrovirens* is considered a forma of *C. solani*.

*Bionectria solani* (tropical and temperate ascospore isolates), *C. solani* f. *nigrovirens*, and *B. aureofulvella* (another species with a *C. solani*-like anamorph), form a monophyletic group among other species with dimorphic conidiophores in sequence analyses of the ITS

regions and *tub2* (Figs 2–4 a–c). Within this group, sequences of the ex-neotype strains of *Nectria solani* and *Spicaria solani*, both originating from bark, have identical *tub2* introns. Other isolates with green, white or formerly green conidial masses (*C. solani* f. *nigrovirens*), isolated from various substrata including potato, also have identical *tub2* introns but differ slightly from those determined for the two ex-neotype strains. Other strains with non-green conidial masses and two ascospore isolates from tropical regions are intermediate between these groups. The tropical ascospore isolate from bark (G.J.S. 7781, CBS 101926) that is closest to the apparently clonal segregate of *C. solani* f. *nigrovirens* has almost brown conidial masses. The relationship of pale-coloured to greenish conidial masses in *C. solani* matches the situation of *C. rosea*. The close relationship of the tropical strain (only 3 differing nucleotides) with brownish conidial masses, however, integrates *C. solani* f. *nigrovirens* into a pool of strains that all show identical conidiophores.

The specimens that yielded the ex-neotype strains of *Nectria solani* and *Spicaria solani* originated from bark, a choice deviating from the originally described substratum (*Solanum tuberosum*). However, sporodochia that are similar to the sporodochium illustrated by Harting, are generally associated with many holomorphic species of *Bionectria*, which typically occur on the bark of recently dead trees. The illustrated sporodochium of the type specimen of *S. solani* and its similarity to sporodochia found on bark therefore are considered a key-character, taking precedence over the substratum. No teleomorphic specimens of *B. solani* from potato have been collected in recent years, there are no recent reports of tuber rot problems caused by *Clonostachys* or *C. solani* in particular, and there are no data suggesting a specific interaction between *Clonostachys solani* and potato. However, as saprotrophs with strong abilities to attack living organisms of a broad taxonomic range, there is no reason to assume why *Clonostachys* species should be unable to grow on potato tubers and not to cause a rot of stored plant material under certain conditions [as described by van Beyma (1928) for *Verticillium foexii* (= *C. rosea*) on potato or by Rader (1948) for *Gliocladium aureum* (= *C. rosea*) on carrots]. It is not clear why there are no reports of potato rot problems of *Clonostachys* species in recent years, however, it is possible that modern treatments and storage conditions of potatoes or potato genotypes grown nowadays do not favour the development of *Clonostachys* species.

**16. *Bionectria aureofulvella*** Schroers & Samuels, *sp. nov.* — Figs 40 a–k, 41 a, b.

Anamorph: *Clonostachys aureofulvella* Schroers, *stat. nov.* — Fig. 41 c–e.

*Bionectriae solani* et *B. pseudochroleucae* similis, sed ascosporis maioribus latoribusque, (9.6–)12.6–13.2–13.8(–16) × (3.4–)4.6–5–5.6(–7.2) µm. *Bionectriae ochroleucae*, *B. byssicolae*, *B. zelandiaenovae* similis sed peritheciis levigatis nec verruculosus. Anamorphosis *Clonostachydi solani* similis, sed conidiophora secundaria rarissima vel absentia. Coloniae lente crescentes (post 7 dies diametro < 10 mm, 24°C). Conidia (3.6–)4.8–5.8–7(–9) × (1.8–)2.4–2.8–3.2(–3.8) µm.

Holotypus teleomorphosis: Specimen PDD 50044. Holotypus anamorphosis: PDD; cultura sicca, isolata ex specimine PDD 50044; isotypus herb. CBS; cultura viva CBS 100980.

Etymology: Latin *aureus* (golden-yellow) and *fulvus* (tawny), diminutive of ‘*aureofulva*’, a name that Ellis used for a species, which is now regarded as a synonym of *Bionectria ochroleuca*.

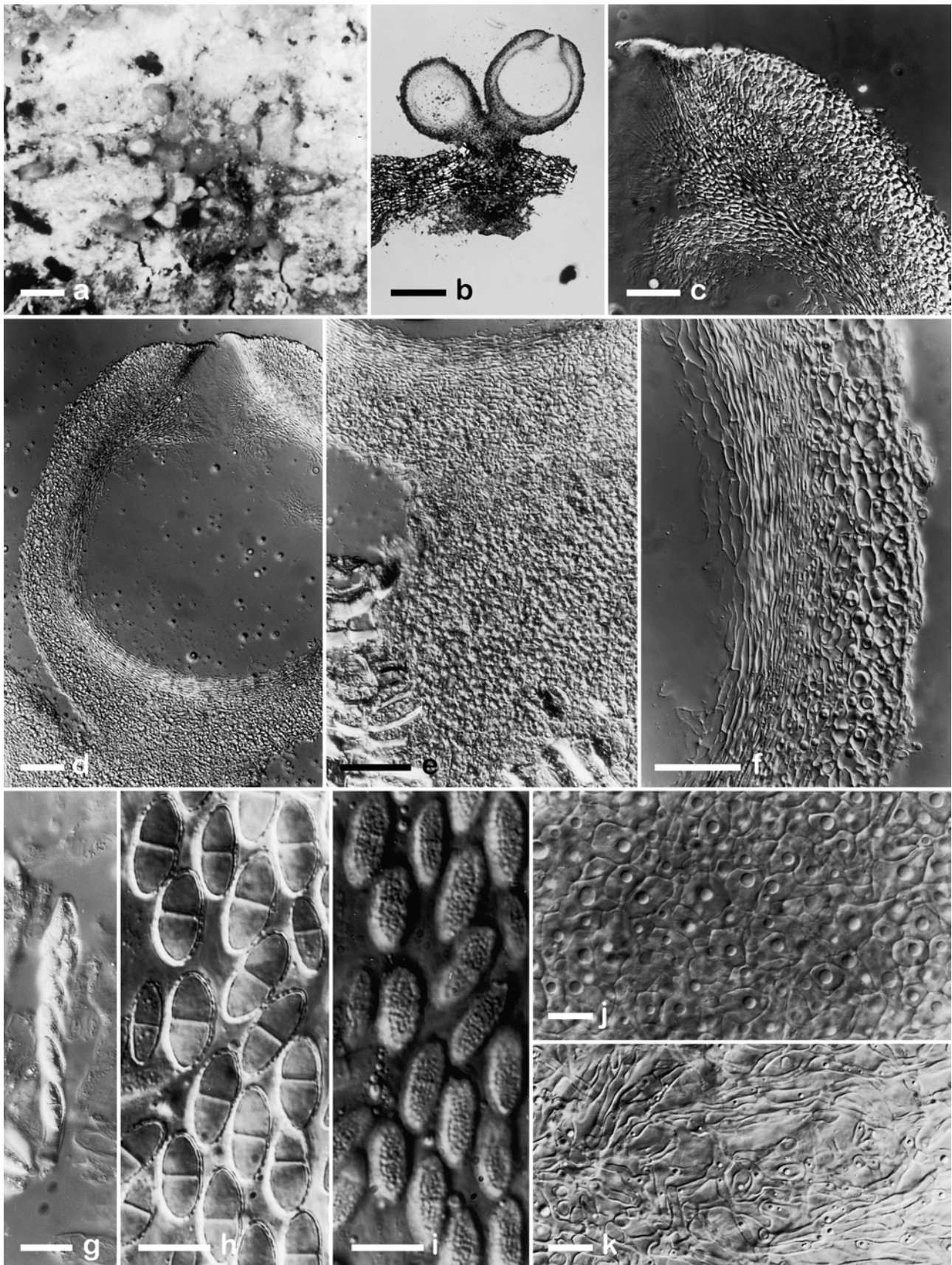
**Description from natural substratum:** **Stroma** well-developed, erumpent through bark, bearing perithecia or sporodochia; cells angular, to 12 µm diam, forming a *textura angularis*. **Perithecia** crowded or loosely formed on the stroma, in groups of 30 to more than 100, subglobose to obovoid, generally higher than wide, to 450 µm high, 250–400 µm diam, laterally pinched when dry, light orange, minutely papillate when dried, with or without a brownish contrasting ostiolar region, smooth. **Perithecial wall** 55–70 µm thick, composed of three regions. Outer region 30–45 µm or 5–7 cells thick; cells angular to subglobose, 4–13 × 2.5–11.5 µm, with uniformly thickened walls around 1 µm thick, frequently containing a vacuole. Middle region 7–14 µm thick. Inner region 14–20 µm thick. **Asci** narrowly clavate, (58–)73.5–79–83(–113) × (6.5–)8–9.5–11(–13.5) µm (n = 59), 8-spored; ascus apex rounded or flat with rounded edges, ring visible. **Ascospores** ellipsoidal to broadly ellipsoidal, warted, (9.6–)12.6–13.2–13.8(–16) × (3.4–)4.6–5–5.6(–7.2) µm (n = 263). **Sterile mycelium** not developed or inconspicuous. **Conidiophores** visible on some specimens, dimorphic, with primary conidiophores scattered on the perithecia or on the bark surrounding the perithecia; secondary conidiophores sporodochial.

**Description from culture:** **Colonies** 4–6 mm diam in 7 d at 24°C; optimum for growth 18–21(24)°C (12–20 mm); all strains growing slowly at 27°C, not growing at 30°C. Colony reverse on OA and PDA yellowish white to pale yellow (4A2–3), in older colonies to light yellow (4A4) or pale orange (5A2–3), on CMD not pigmented, translucent or in very pale orange hues on OA, in CBS 195.93 and CBS 200.93 with time greyish. Colony surface on OA and CMA finely granular because of the conidial heads of the primary conidio-

phores; aerial mycelium sparsely produced or absent, on PDA more abundant, almost sterile. Surface generally not pigmented. **Conidiophores** dimorphic. Primary conidiophores predominant throughout the culture, densely scattered, arising from the agar surface, or from the sparsely formed aerial mycelium, narrowly penicillate, adpressed, mono- to terverticillate, or with side-branches and phialides arising from several levels; stipe 30–190 µm long, 3–5 µm wide at the base; penicillus 30–100 µm high, frequently higher than the length of the stipe; phialides in apical whorls of 2–5, also solitary, straight, cylindrical, slightly tapering towards the tip, without a visible collarette, (10.6–)16.4–20–22.4(–33.4) µm long, (1.2–)1.8–2–2.2(–3.2) µm wide at base, (1–)1.2–1.4–1.6(–1.8) µm wide near aperture (n = 62), variable in length, solitary, lateral phialides frequently longer than the whorled apical phialides. Secondary conidiophores of freshly isolated strains abundant, solitary to aggregated and sporodochial; those of subcultured strains inconspicuous, almost lacking, formed among the primary conidiophores, ter- to quaterverticillate, with somewhat divergent branches; phialides in loose whorls of 2–5, straight to slightly curved, flask-shaped to cylindrical, generally with widest point in the lower third, or almost cylindrical, but generally slightly tapering towards the apex, without a visible collarette, (8.4–)11.4–13.4–15.2(–21.2) µm long, (1.6–)2–2.4–2.6(–3) µm wide at base, (1.6–)2.4–2.6–3(–3.2) µm at widest point, (1–)1.2–1.4–1.6(–1.8) µm wide near aperture. Intercalary phialides not observed. **Conidial masses** on primary conidiophores in round heads of ca 50 µm diam, watery, transparent to whitish to slightly creamy, on several heads from solitary conidiophores collapsing to form one large mass of up to 300 µm diam; conidial masses on secondary conidiophores not conspicuous; conidial masses of sporodochia in freshly isolated strains slimy, dome-shaped, pale orange. **Conidia** hyaline, straight to slightly curved, distally broadly rounded, with or without recognizable hilum, frequently laterally displaced, (3.6–)4.8–5.8–7(–9) × (1.8–)2.4–2.8–3.2(–3.8) µm (n = 129). Perithecia not observed in culture.

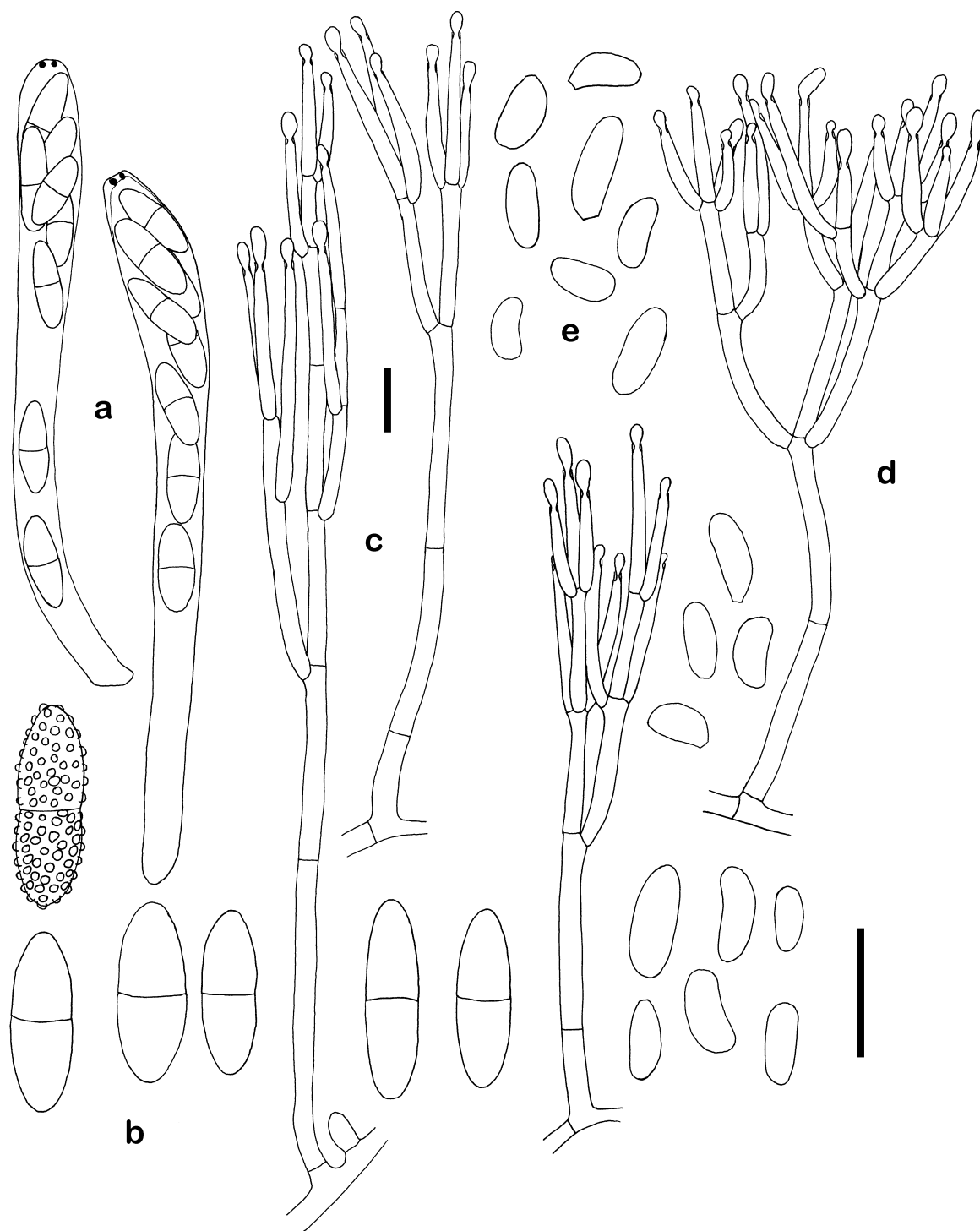
**Type for *Bionectria aureofulvella*:** NEW ZEALAND. Southland: Catlins State Forest Park, L. Wilkie, on bark, 18 Apr 1985, G.J.S., P.K. Buchanan, L.M. Kohn (PDD 50044; G.J.S. isolate 85-31, CBS 100980, derived from ascospores). **Type for *Clonostachys aureofulvella*:** dried culture ex CBS 100980, filed together with type of *B. aureofulvella* (PDD 50044); isotype: herb. CBS.

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



**Fig. 40.** *Bionectria aureofulvella*. **a.** Habit of crowded perithecia. **b–f.** Sections through perithecia and stroma. **c.** Ostiolar region. **d, f.** Lateral perithecial wall. **e.** Stroma below perithecia. **g.** Almost mature ascus, ring visible. **h, i.** Discharged ascospores in optical section (**h**) and surface view (**i**). **j, k.** Subsurface view of outermost perithecial wall region (**j**) and middle, hyphal region (**k**). – All: PDD 50044, natural substratum. **a:** DM; **b:** LM; **c–k:** DIC. Scale bars: **a** = 750  $\mu\text{m}$ ; **b** = 250  $\mu\text{m}$ ; **c, f, g** = 30  $\mu\text{m}$ ; **d, e** = 50  $\mu\text{m}$ ; **h–k** = 10  $\mu\text{m}$ .





**Fig. 41. *Bionectria aureofulvella* / *Clonostachys aureofulvella*.** a. Almost mature asci. b. Discharged ascospores. c. Adressed primary conidiophores. d. Secondary conidiophore with basal branches somewhat divergent. e. Conidia. – a, b: natural substratum; c–e: 6–10-d-old OA cultures. a: PDD 46431 (left), PDD 32427 (right). b: PDD 32427, PDD 50044, PDD 46431. c: CBS 100980, CBS 195.93, and CBS 200.93. d: CBS 195.93. e: CBS 100980 (upper group), CBS 195.93 (middle), CBS 200.93 (bottom). Scale bars = 10  $\mu$ m; the shorter bar applies to a, c, d, the longer to b, e.

**Habitat:** On bark of woody plants, often closely associated or seated on the stroma of other ascomycetous fungi.

**Additional specimens/strains examined:** AUSTRALIA. VICTORIA: Otway Ranges, vic. Lorne, Angahook-Lorne State Forest, along track from Blanket Leap Picnic Ground to Cora Lynn Cascades, along Cora Lynn Creek, primarily *Eucalyptus* sp.; 350–200 m alt.; on bark of recently dead tree; 28 Aug

1999; G.J.S. (BPI; G.J.S. 8649; CBS 102839. – BPI; G.J.S. 8643; CBS 102837. – BPI; G.J.S. 8640a). – Wilson's Prom. N.P., vic. the river, Lilly Pilly Gully, 0 m alt., *Syzygium* sp., *Nothofagus* sp., and tree-ferns; 22 Aug 1999; G.J.S., J. Dyke (BPI; G.J.S. 8583; CBS 102838). – VENEZUELA. Edo. Mérida: Parque Nacional Sierra Nevada, above Apartaderos, Laguna Negra, 00°47' N, 70°49' W, 3050 m alt.; on bark of *Polylepis sericea*; 11 Nov 1990; G.J.S., B. Hein, S.M. Huhndorf, T. Iturriaga, M. Herrera (BPI, VEN, G.J.S. 6968;

CBS 200.93; G.J.S. isolate 90-151). – NEW ZEALAND. Taranaki Prov., Taranaki Co., Mt. Egmont N.P., N Egmont Chalet, along track to Waiwhakaiho River; on unidentified decorticated wood; 1 Nov 1973; G.J.S. (PDD 32427; G.J.S. isolate 73-224, ex ascospore; CBS 235.80). – Buller, Nelson Lakes Nat. Park, Lake Rotoroa; on root of unidentified tree; 25 May 1983; G.J.S., T. Matsushima, A.Y.R. (PDD 46431; G.J.S. isolate 83-230; CBS 195.93; dried OA culture in PDD containing sporodochia).

**Notes:** *Bionectria aureofulvella* is characterized by relatively long asci and large and strongly warted ascospores (Fig. 40 h, i). The adpressed penicillate primary conidiophores (Fig. 41 c) are similar to those formed in *B. solani*. The close relationship of these species is supported by DNA sequence data (Figs 2–4), entirely smooth perithecia, and rather fleshy and thick perithecial walls (Fig. 40 f). The species was originally delimited from others based on the growth temperature relationships and the lack or the sparse formation of the secondary conidiophores (Fig. 41 d). It is characterized by relatively slow growth (generally less than 10 mm diam in 7 d at 24°C) and typically failing to grow at 27°C (Fig. 39). Two strains (CBS 195.93 and 235.80) are identified as *B. aureofulvella* based on ascospore morphology and conidial characters, although they grow somewhat faster (18–28 mm diam in 7 d at 24°C; 25–30 mm at optimum), thus similar to *C. solani*, however, not growing at 30°C. The lack or the sparse production of secondary conidiophores was initially considered as a diagnostic feature for *B. aureofulvella*. Secondary conidiophores were, however, more abundantly produced in fresh isolates (dried agar plates of the ascospore isolates prepared by G.J. Samuels; recently isolated Australian strains CBS 102837, 102838, 102839) and sporodochia were seen associated with perithecial stromata of some specimens. The lack of secondary conidiophores is probably an artefact of cultivation.

### 17. *Bionectria pseudochroleuca* Schroers & Samuels, *sp. nov.* — Figs 42 a–k, 43 a, b.

Anamorph: *Clonostachys pseudochroleuca* Schroers, *stat. nov.* — Fig. 43 c–e.

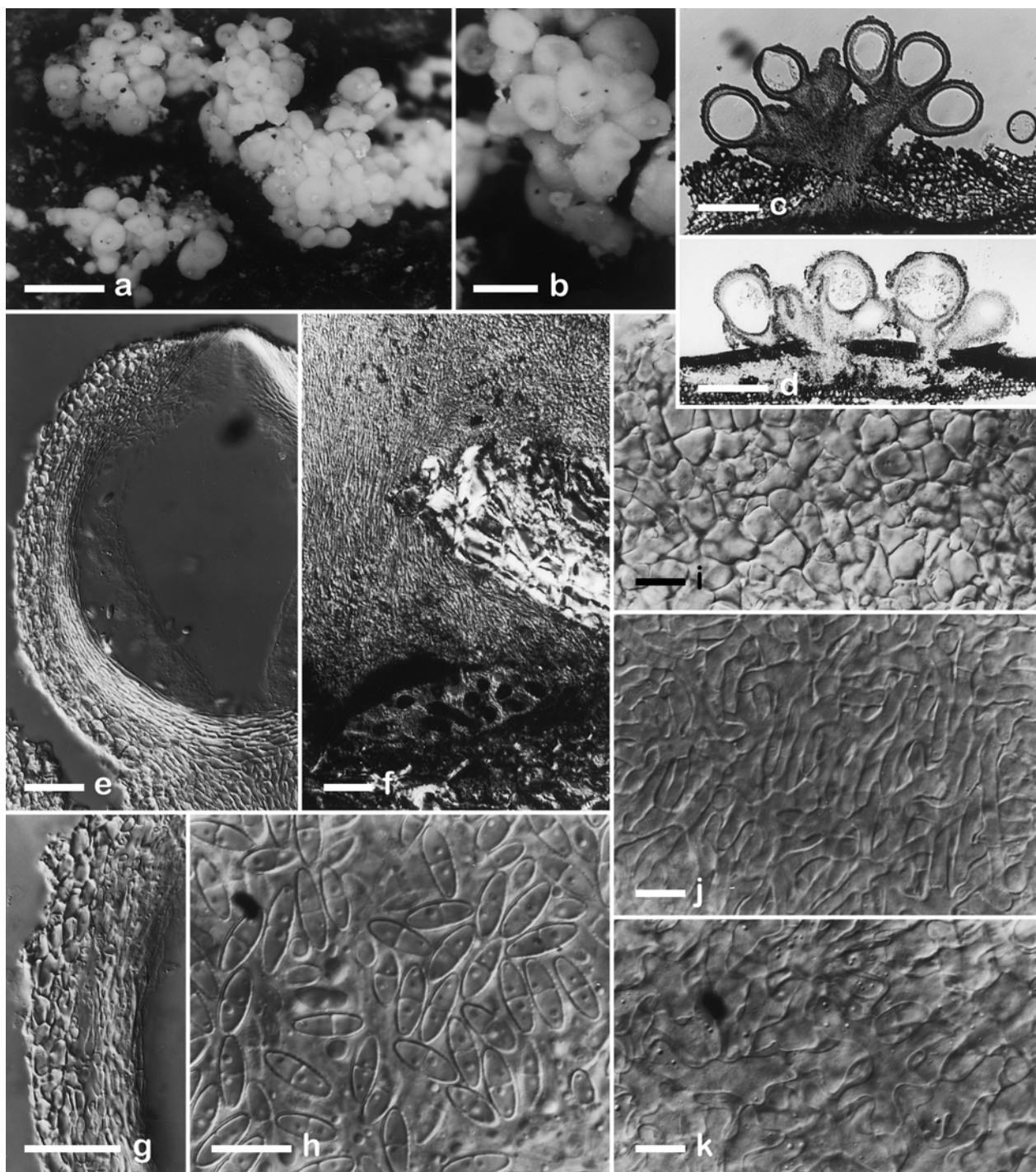
*Bionectriae solani* similis sed ascosporis minoribus, (6–)8.4–8.8–9.4(–11) × (2.2–)2.8–3.2–3.4(–4.4) µm. Anamorphosis *Clonostachydi solani* similis sed penicillis conidiophorum secundariorum adpressis (sicut in *C. rosea*); *Clonostachydi roseae* similis sed phialides conidiophorum primariorum adpressae (sicut in *C. solani*). Conidia (3.2–)4–4.4–4.6(–6.4) × (1.2–)2.2–2.2–2.4(–3) µm.

Holotypus teleomorphosis: Specimen G.J.S. 4231 (NY). Holotypus anamorphosis: NY; cultura sicca, isolata ex specimine G.J.S. 4231 (NY); isotypus herb. CBS; cultura viva CBS 187.94.

Etymology: *pseudochroleuca*, referring to its similarities to *B. ochroleuca*.

**Description from natural substratum:** **Stroma** well-developed, erumpent through bark; cells angular, forming a *textura angularis*. **Perithecia** crowded on the stroma, in groups of up to 50, globose to subglobose, 250–350 µm high, 190–280 µm diam, laterally pinched when dry, pale yellow to yellowish orange, minutely papillate, mostly with a somewhat darker contrasting ostiolar region, smooth. **Perithecial wall** 30–45 µm thick, composed of three regions. Outer region 15–20 µm or *ca* 3 cells thick; cells angular to subglobose, 4.5–12.5 × 3–9.5 µm, with uniformly thickened walls around 1 µm thick; vacuoles rarely observed. Middle region 4–10 µm thick. Inner region 9.5–13 µm thick. **Asci** narrowly clavate, (40–)46–49.5–53(–60) × (5–)6.5–7–7.5(–9) µm (n = 51), 8-spored; ascus apex flat with rounded edges, ring visible. **Ascospores** ellipsoidal, finely warted, (6–)8.4–8.8–9.4(–11) × (2.2–)2.8–3.2–3.4(–4.4) µm (n = 263). **Sterile mycelium** sometimes developed on specimens from palms. **Conidiophores** not observed.

**Description from culture:** **Colonies** reaching 35–45 mm diam in 7 d at 24°C; optimum for growth 24–30°C (48 mm diam), maximum 33 or more than 36°C. Colony reverse on OA and PDA pale yellow (4A3) to light yellow (2A56), on CMD not pigmented, translucent or with pale yellow pigment, generally visible beyond the colony, generally light orange (5A5) when incubated under UV. Colony surface on OA cottony to finely granular because of the aerial mycelium and conidial masses; aerial mycelium in strands; on CMD almost smooth, aerial mycelium sparse, to granular because of the conidial masses; on PDA aerial mycelium more abundant. **Conidiophores** dimorphic; both primary and secondary conidiophores penicillate, formed from the aerial mycelium or from the agar surface. Primary conidiophores narrowly penicillate, adpressed or with adpressed phialides and slightly divergent metulae, mono- to terverticillate, normally without independent side-branches; stipes 50–180 µm long, 2–5.5 µm wide at the base; penicilli 40–90 µm high; phialides in apical whorls of 2–5, straight, cylindrical, slightly tapering towards the tip, without a visible collarette, (13.6–)17.4–20.8–22.8(–34) µm long, (1.3–)1.6–1.8–2(–2.4) µm wide at base, (1–)1.2–1.2–1.4(–1.8) µm wide near aperture (n = 56). Secondary conidiophores ter- to quaterverticillate, branches and phialides adpressed; phialides in whorls of 3–5, narrowly flask-shaped, generally with widest point in the lower third, slightly narrowing towards the apex, without a visible collarette, (6.2–)10.2–11.4–12.6(–17.6) µm long, (1.3–)1.8–1.9–2(–2.2) µm wide at base, (1.4–)2–2.2–2.4(–3) µm at widest point, (1–)1.2–1.2–1.4(–1.6) µm wide near aperture (n = 46). Intercalary **phialides** rarely observed, formed below whorls of terminal phialides. **Conidial masses** on primary conidiophores in round heads of *ca* 50 µm diam, watery, transparent to whitish; conidial masses on secondary conidiophores



**Fig. 42. *Bionectria pseudochroleuca*.** **a, b.** Habit of crowded perithecia. **c–g.** Sections through perithecia and stroma; perithecial stroma on deciduous tree (c) and palm (d); perithecium (e); erumpent stroma seated on fungal host (f); lateral perithecial wall (g). **h.** Discharged ascospores in optical section. **i.** Surface view of outer perithecial wall region. **j, k.** Subsurface views of middle, hyphal region (j) and inner region (k) showing lobed cells and 'pseudopores'. – d: G.J.S. 4231; j: G.J.S. 5426; others: H.J.S. 80. All from natural substratum. a, b = DM; c, d: LM; others: DIC. Scale bars: a = 500  $\mu\text{m}$ ; b = 200  $\mu\text{m}$ ; c, d = 250  $\mu\text{m}$ ; e, g = 30  $\mu\text{m}$ ; f = 50  $\mu\text{m}$ ; h–k = 10  $\mu\text{m}$ .

in long white imbricate columns. **Conidia** hyaline, slightly curved, distally broadly rounded, with laterally displaced hilum,  $(3.2\text{--})4\text{--}4.4\text{--}4.6\text{--}(6.4) \times (1.2\text{--})2.2\text{--}2.2\text{--}2.4\text{--}(3) \mu\text{m}$  ( $n = 257$ ). Perithecia not observed.

**Type for *Bionectria pseudochroleuca*:** FRENCH GUIANA. Paul Isnard Area, ca 150 km S of St.

Laurent du Moroni, Citron, Mt. Decou Decou,  $04^{\circ}70' \text{N}$ ,  $53^{\circ}90' \text{W}$ ; on base of decaying palm frond; 11, 12 Mar 1986; G.J.S., P. Searwar (NY; G.J.S. 4231; G.J.S. isolate 86-293; CBS 187.94, derived from ascospores). **Type for *Clonostachys pseudochroleuca*:** dried culture ex CBS 187.94, filed together with type of *B. pseudochroleuca* (NY); isotype: herb. CBS.

**Known distribution:** The neotropics, Australia, Papua-New Guinea.

**Habitat:** Mostly on hard fronds or midribs of decaying palms; also on bark of recently dead trees; anamorph from soil, one strain possibly antagonistic to nematodes (Ja-On Park, pers. comm.).

**Additional specimens/strains examined:** AUSTRALIA. WEST-AUSTRALIA: Perth (Ja-On Park No. 4680, conidial isolate). – FRENCH GUIANA. Location unknown; on palm sheathing base; Jan–Mar 1986; G.J.S. (NY; G.J.S. 3098, specimen not seen; G.J.S. isolate 86-98, CBS 220.93). – Saül, Mt. Boeuf Mort. tall forest on well-drained ridges, fallen wood dry and hard; 03°60' N, 53°20' W, 300–350 m alt.; on decaying palm; 8 Feb 1986; G.J.S. (CAY, NY; G.J.S. 3582; G.J.S. isolate 86-170, CBS 191.94). – Saül, Circuit Grand Fosse, primary forest on well drained slope, decaying wood, dry and hard, 03°60' N, 53°20' W, 300–350 m alt.; on palm midrib; 10 Feb 1986; G.J.S. (CAY, NY; G.J.S. 3650; G.J.S. isolate 86-186). – Paul Isnard Area, ca 150 km S of St. Laurent du Moroni, Citron, Mt. Lucifer, 04°70' N, 53°90' on *Hypoxylon* sp.; 7–14 Mar 1986; G.J.S., P. Searwar (NY; G.J.S. 4176; G.J.S. isolate 86-283; CBS 186.94). – Paul Isnard Area, ca 150 km S of St. Laurent du Moroni, Citron, Mt. Decou Decou, 04°70' N, 53°90' W; on base of decaying palm frond; 11, 12 Mar 1986; G.J.S., P. Searwar (CAY, NY; G.J.S. 4240; G.J.S. isolate 86-294). – Vic. of Cayenne; on bark; 23 Mar 1986; G.J.S., C. Feuillet (CAY, NY; G.J.S. 4431; G.J.S. isolate 86-326, CBS 192.94). – GUYANA. East Berbice-Corentyne Region VI, subregion VI-5, Canje River, south half of Cow Savanna, 1 km N of Digitima Creek, 05°36' N, 57°35' W, 0–25 m alt.; on decaying trunk of *Mauritia* sp.; 12–15 Apr 1987; G.J.S., J. Pipoly, G. Gharbarran, G. Bacchus (NY; G.J.S. 5426; G.J.S. isolate 87-101, CBS 194.93). – PAPUA-NEW GUINEA: Madang Prov., Finisterre Range; from soil in tropical rain forest; Nov 1995; A. Aptroot, isol. A. van Iperen (CBS 309.96). – U.S.A. PUERTO RICO: Caribbean National Forest, Luquillo Mts., Bisley Experimental Watershed; on bark of recently dead *Guarea* sp.; 21 Feb 1996; G.J.S., H.-J. Schroers, D.J. Lodge (BPI; H.J.S. 77). – Caribbean National Forest, Luquillo Mts., Bisley Experimental Watershed; on bark of recently dead tree; 21 Feb 1996; G.J.S., H.-J. Schroers, D.J. Lodge (BPI; H.J.S. 80). – Caribbean National Forest, Luquillo Mts., El Verde Research Area, La Prieta Creek; on bark of rotten tree, in between lichen; 20 Feb 1996; G.J.S., H.-J. Schroers, D.J. Lodge (BPI; H.J.S. 67). – On *Nectriopsis* sp., on bark; Feb 1996; G.J.S., H.-J. Schroers (G.J.S. isolate 96-49, CBS 447.96). – VENEZUELA. Amazonas: Cerro de la Neblina, 6.2 km NNE of Pico Phelps, 51°45' N, 58°52' W, 1390–1515 m alt.; on sheath of palm leaf; 23 Feb 1985; A.Y.R. (BPI; A.Y.R. 2296).

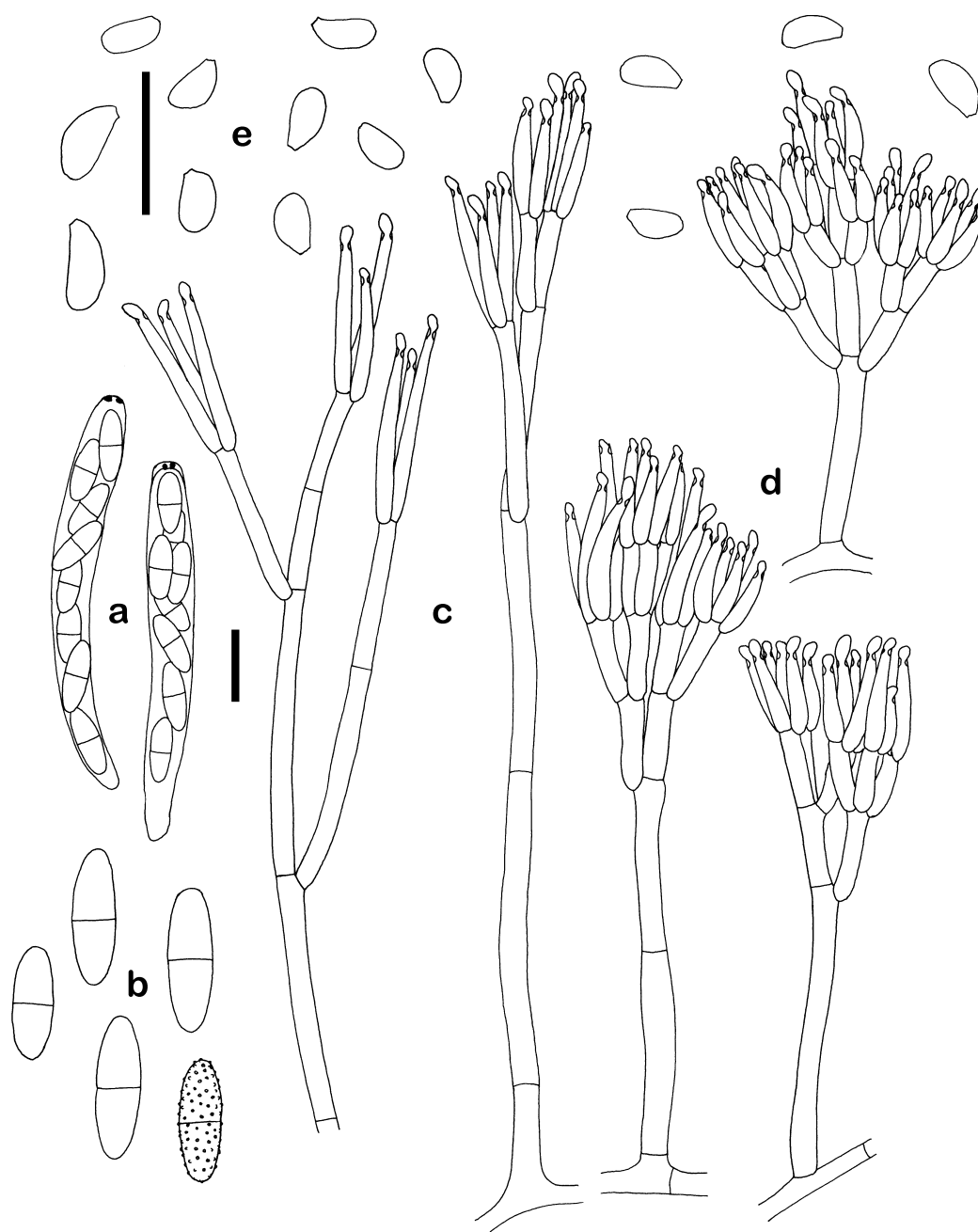
**Notes:** The anamorph of *B. pseudochroleuca* is morphologically an intermediate between *B. solani* and *B. ochroleuca*. The phialides of the primary conidiophores are adpressed like those of *B. solani* (compare Fig. 43 c with Fig. 36 b), while the secondary conidiophores are adpressed as in *B. ochroleuca* (compare Fig. 43 d with Fig. 16 b) and not divergently branched as in *B. solani* (Fig. 36 c–e). However, because the primary branches of the primary conidiophores can diverge slightly (Fig. 43 c, left), the primary conidiophores may have a verticillium-like aspect as well.

Yellow colony pigments are common in most species of *Bionectria*, however, in most of the strains of *B. pseudochroleuca* the yellow pigment is formed early in 4 day-old colonies, which contrasts slightly with the condition in other species.

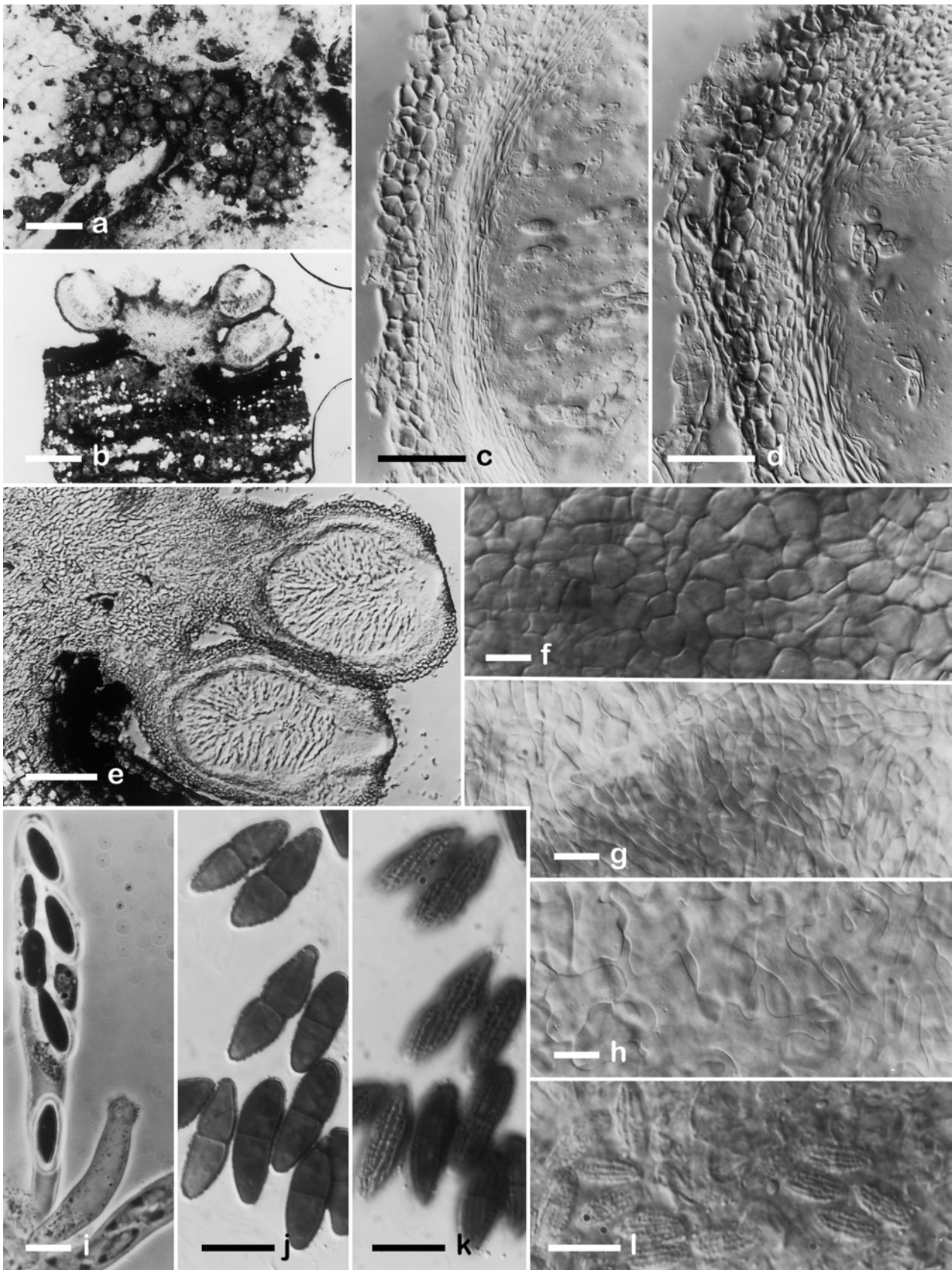
The size range of ascospores in *B. pseudochroleuca* (most ascospores shorter than 10 µm) is more or less the shortest found in subgenus *Bionectria*, but the lengths of ascospores still overlap with those of other species. *Bionectria pseudochroleuca* has almost entirely smooth perithecia, as do *B. solani*, *B. aureofulvella*, *B. compactiuscula*, *B. sesquicillii*, and *B. verrucispora*, but can be distinguished by ascospore size (*B. solani*, *B. aureofulvella*, *B. verrucispora*) and characters of the anamorphs (*B. sesquicillii*, *B. compactiuscula*), respectively. Perithecia of *B. pseudochroleuca* are difficult to distinguish from those of *B. ochroleuca*, because of the lack of cells with unevenly thickened walls (Fig. 42 e, g).

Strains identified here as *B. pseudochroleuca* form a statistically unsupported clade (Fig. 4 a, b: L) among subgenus *Bionectria*. The clade consists of 2 subgroups. Both cluster between species closely related to *B. ochroleuca* / *B. apocyni* and *B. solani* respectively (Figs 2–4). Because of more or less adpressed primary conidiophores, *B. pseudochroleuca* is similar to *B. solani*, while it is more similar to *B. ochroleuca* because of the adpressed secondary conidiophores.

Teleomorph specimens have been found on fronds or midribs of decaying palms or bark of recently dead trees. The different habitat, however, does not correlate with the subgroups that are suggested by the data. A conidial isolate from Australia showed antagonistic activities against nematodes.



**Fig. 43.** *Bionectria pseudochroleuca* / *Clonostachys pseudochroleuca*. **a.** Almost mature asci. **b.** Discharged ascospores. **c.** Primary conidiophores; phialides adpressed, primary branches divergent or adpressed. **d.** Secondary conidiophores with adpressed penicilli. **e.** Conidia. – a: H.J.S. 80 (left), G.J.S. 3582 (right); b: G.J.S. 4231, G.J.S. 4431; c: CBS 191.94 (left), CBS 447.96 (right); d: CBS 192.94 (left), CBS 447.96 (top), CBS 187.94 (bottom). e: CBS 191.94, 192.94. a, b: natural substratum; c–e: 6–10-d old OA cultures. Scale bars = 10  $\mu$ m; the shorter bar applies to a, c, d, the longer to b, e.



**Fig. 44. *Bionectria pseudostrata*.** **a.** Habit of crowded perithecia. **b–e.** Sections through perithecia and stroma; erumpent stroma with perithecia (**b**); lateral perithecial wall showing three regions (**c**, **d**); erumpent stroma (**e**). **f.** Surface view of outer, pseudoparenchymatous, perithecial wall region. **g**, **h.** Subsurface views of middle, hyphal region (**g**) and inner region (**h**) showing lobed cells and ‘pseudopores’. **i.** Immature ascus, ring visible. **j–l.** Mature ascospores in optical section (**j**) and surface view (**k**, **l**) showing warts arranged in striae (**j**, **k** stained with cotton blue). **a**, **d**, **f**, **g–k**: Doi 64; **b**, **c**, **e**, **l**: G.J.S. 2217a. All from natural substratum. **a**: DM; **b**: LM; **c–h**, **j–l**: DIC; **i**: PC. Scale bars: **a** = 750  $\mu$ m; **b** = 250  $\mu$ m; **c**, **d** = 30  $\mu$ m; **e** = 100  $\mu$ m; **f–l** = 10  $\mu$ m.

**18. *Bionectria pseudostrata*** Schroers, *sp. nov.*

— Figs 44 a–l, 45 a, b.

Anamorph: *Clonostachys pseudostrata* Schroers, *stat. nov.* — Fig. 6 in Samuels (1988b); Fig. 45 c–f.

*Bionectriae ochroleucae* similis, sed peritheciis brunneolis. Ascospores striatae, sed striae e verrucis compositae, (9–)10.6–12.4–14.4(–17.2) × (3–)3.6–4.2–4.6(–5.8) µm. Anamorphosis *Clonostachdi solani* similis, sed 33°C crescere potest. Conidia (3.6–)5–5.6–6.2(–8) × (2–)2.6–3–3.2(–3.8) µm.

Holotypus teleomorphosis: Specimen 2217A (NY). Holotypus anamorphosis: NY; cultura sicca, isolata ex specimine G.J.S. 2217A (NY); isotypus herb. CBS; cultura viva CBS 120.87.

Etymology: *Pseudostrata*, referring to the striate appearance of the ascospores, caused by rows of warts.

**Description from natural substratum:** **Stroma** well-developed, erumpent through bark, to 3.5 × 2.5 mm wide and to 700 µm high; cells to 16 µm diam, smaller towards the perithecia. **Perithecia** densely crowded on the stroma, in groups of up to 50 or more, subglobose to ellipsoidal to broadly obovoidal, generally higher than wide, around 300 µm diam (measured from the natural substratum), in sections 250–350 µm high, and *ca* 200 µm diam, lateral pinching not observed when dry, sometimes with a slightly sunken ostiolar region, orange-brown to brown, sometimes with a darker contrasting ostiolar region, smooth or with inconspicuous scales. **Perithecial wall** 30–50 µm thick, consisting of three regions. Outermost region 14–24 µm or 3–4 cells thick; cells angular, with *ca* 1 µm thick walls, 5–12.5 × 3–11.5 µm, on average less than 10 µm diam; vacuoles not observed. Middle region 7–14 µm thick, visible even in longitudinal sections. Inner region 7–15 µm thick. **Asci** clavate, (50–)54–60–69(–77) × (7–)8.5–9.5–9(–16) µm (n = 14); ascus apex rounded to flat, ring visible. **Ascospores** ellipsoidal to broadly ellipsoidal, warted, with warts arranged in striae (appearing striate), (9–)10.6–12.4–14.4(–17.2) × (3–)3.6–4.2–4.6(–5.8) µm (n = 39). **Sterile mycelium** forming a white mat close to the perithecia or invisible. **Conidiophores** with a slender penicillus, adpressed branches, and long stipes arising from the mycelium, similar to the primary conidiophores in culture.

**Description from culture:** **Colonies** reaching 35–45 mm diam in 7 d at 24°C; optimum for growth (21–)24–30°C, maximum 33°C. Colony reverse on OA and PDA pale to light yellow (4A3–3A5) after incubation in darkness or daylight, light orange (5–6A5) after incubation in UV, on CMD pale yellow/pale orange or not pigmented. Colony surface cottony because of the aerial mycelium or granulose because of sporodochial conidial masses; aerial mycelium most developed on OA, less on CMD/CMA, arranged in strands particularly in older parts of the colony. **Conidiophores** dimorphic. Primary conidiophores narrowly penicillate,

arising from the agar surface or the aerial mycelium, formed throughout the colony, narrowly penicillate, adpressed or with branches at somewhat acute angles, mono- to terverticillate; stipe 50–300 µm long, 3.5–6 µm wide at base; penicillus 25–80 µm high; phialides in apical whorls of *ca* 4, straight, cylindrical, slightly tapering towards the tip, in general without a visible collarette, (11.6–)16.2–22.8–26.8(–44.2) µm long, (1.6–)1.8–2.2–2.4(–3.2) µm wide at base, (1–)1.4–1.6–1.6(–2.2) µm wide near aperture (n = 59). Secondary conidiophores broadly penicillate, solitary in young colonies, generally forming sporodochia, frequently on a pseudoparenchymatous base, quater- or higher-verticillate, branches divergent, in developed sporodochia rather adpressed, phialides almost adpressed; metulae 9–15 × 2.5–3.5 µm; phialides in loose whorls of 2–4, straight, flask-shaped, widest in the lower third or almost cylindrical, slightly tapering in the upper part towards the tip, without a visible collarette, (7–)12.2–15.8–18.8(–30.4) µm long, (1.8–)2.6–2.8–3(–3.2) µm wide at base, (1–)1.4–1.6–1.6(–1.8) µm wide near aperture (n = 50). **Conidial masses** on primary conidiophores in round heads, watery, transparent; on secondary conidiophores initially in small columns, on aggregates or sporodochia in dome-like slimy masses, white, later orange, grey-orange (5A5–5B2–4) to almost orange-brown. **Conidia** hyaline, slightly curved, with a laterally displaced hilum, those from the secondary conidiophores (3.6–)5–5.6–6.2(–8) × (2–)2.6–3–3.2(–3.8) µm (n = 91), those from primary conidiophores to 13 × 4 µm. **Perithecia** immature, brown, formed on older OA colonies of CBS 120.87.

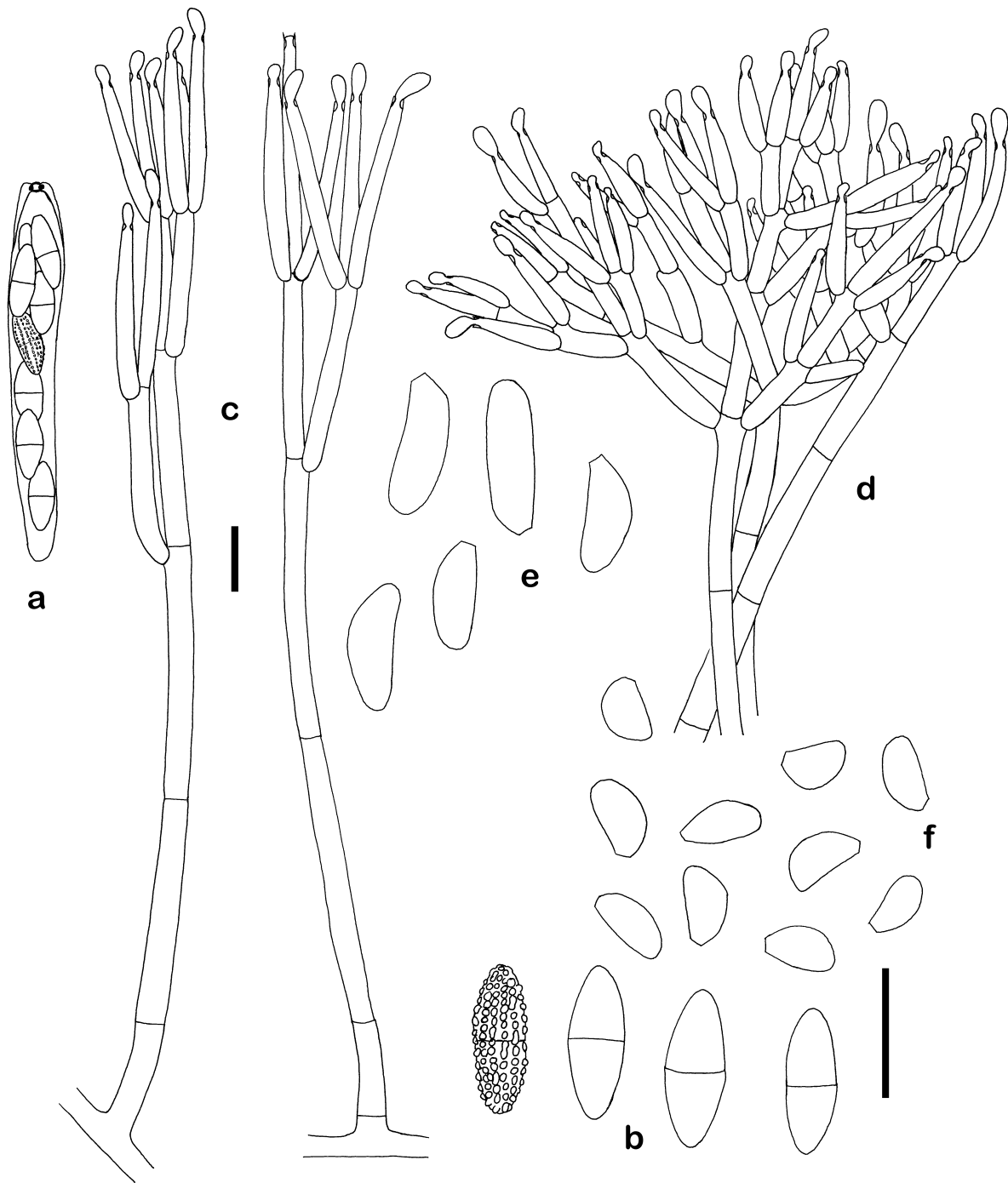
**Type for *Bionectria pseudostrata*:** INDONESIA. North Sulawesi, Eastern Dumoga-Bone National Park, at confluence of Toraut & Tumpah Rivers, Project Wallace Base Camp, 00°43' N, 123°57' E, 211 m alt.; on bark; Sept–Nov 1985; G.J.S. (NY, G.J.S. 2217A; G.J.S. isolate 85-173; CBS 120.87, derived from ascospores. **Type for *Clonostachys pseudostrata*:** dried culture ex CBS 120.87, filed together with type of *B. pseudostrata* (NY); isotypus: herb. CBS.

**Known distribution:** Indonesia, Japan.

**Habitat:** On bark of woody plants.

**Additional specimens/strains examined:** INDONESIA. North Sulawesi, G.J.S. (G.J.S. 2156, G.J.S. isolate 85-155, NY, package includes only the dried culture; CBS 119.87). – JAPAN. Kiyosumi Forestry experiment Station of Tokyo Univ., Chiba Pref.; on bark; 9 Nov 1965; Y. Doi (D-64; NY; National Science Museum, Tokyo, Herbarium of Cryptogams).

**Notes:** *Bionectria pseudostrata* is characterized by brown perithecia (Fig. 44 a) and ascospores that are striate but with striae consisting of warts (Figs 44 k, l; 45 b). The few available specimens of *B. pseudostrata* were initially identified as *Nectria grammicospora*



**Fig. 45.** *Bionectria pseudostriata* / *Clonostachys pseudostriata*. **a.** Almost mature ascus. **b.** Discharged ascospores. **c.** Primary adpressed conidiophores. **d.** Secondary conidiophores from young sporodochium; branches of penicillus  $\pm$  divergent, phialides adpressed. **e, f.** Conidia from primary conidiophores (**e**), from secondary conidiophores (**f**). – **a, b, c** (left), **d:** CBS 120.87 (G.J.S. 2217a); **c** (right), **e, f:** CBS 119.87. **a, b:** natural substratum; **c–f:** young parts of 7 d-old OA-colonies. Scale bars: 10  $\mu$ m; the shorter bar applies to **a, c, d**, the longer to **b, e, f**.

Ferd. & Winge (Samuels, 1988b) but differ from that species in the surface of perithecia [smooth (Fig. 44 b, c–e) vs. warty (Fig. 62 a, b, d)], anatomy of the stroma [pseudoparenchymatous (Fig. 44 e) vs. prosenchymatous (Fig. 62 c)], the perithecial wall anatomy [three regions (Fig. 44 f–h) vs. two regions (Fig. 62 d–f)], ascospore ornamentation [pseudostriate (Fig. 44 k, l) vs. striate (Fig. 62 h)], and shape of conidia [hilum laterally displaced (Fig. 45 e, f) vs. almost median

(Fig. 63 f)]. *Bionectria pseudostriata* is in subgenus *Bionectria* the only species with warts arranged in striae. In all other species of this subgenus the warts are irregularly scattered on the ascospore surface, but all other characters (habit and morphology of perithecial stroma, perithecial wall anatomy, ascus morphology, dimorphy of the conidiophores) place *B. pseudostriata* in subgenus *Bionectria*. The branching pattern of the conidiophores is indistinguishable from *C. solani*.



Slight differences are found in a deeper pigmentation of the conidial masses (almost brown), a slightly stronger tendency to form sporodochia in culture on an almost pseudoparenchymatous base and faster growth rates. *Bionectria pseudostrata* deviates clearly from other species with a *B. solani*-like anamorph in sequence analyses (Figs 2–4).

**19. *Bionectria samuelsii*** Schroers, *sp. nov.* — Fig. 20 D–F in Samuels *et al.* (1990); Figs 46 a–k, 47 a–d, g, h, 48 a, b.

Anamorph: *Clonostachys samuelsii* Schroers, *stat. nov.* — Fig. 20 G in Samuels *et al.* (1990); Figs 47 e, f, 48 c, d.

*Bionectriae solani* similis sed cellulis ostiolum circumdantibus cylindricis, nec angularibus. Ascospores (7.8–)10.4–11.4–12.2(–15.4) × (2.8–)3.6–3.8–4(–5.6) μm, verrucosae. Anamorphosis omnino sporodochialis. Cellulae penicilli saepe sursum inflatae. Phialides fere cylindricae, sursum paulo dilatatae et in ipso summo angustatae. Conidia (4.4–)5.8–6.6–7(–11.6) × (2.2–)2.6–2.8–3(–3.8) μm.

Holotypus teleomorphosis: Specimen Dumont-VE 3882 (NY). Holotypus anamorphosis: NY; cultura sicca, isolata ex specimen Dumont-VE 3882 (NY); isotypus herb. CBS; cultura viva CBS 699.97.

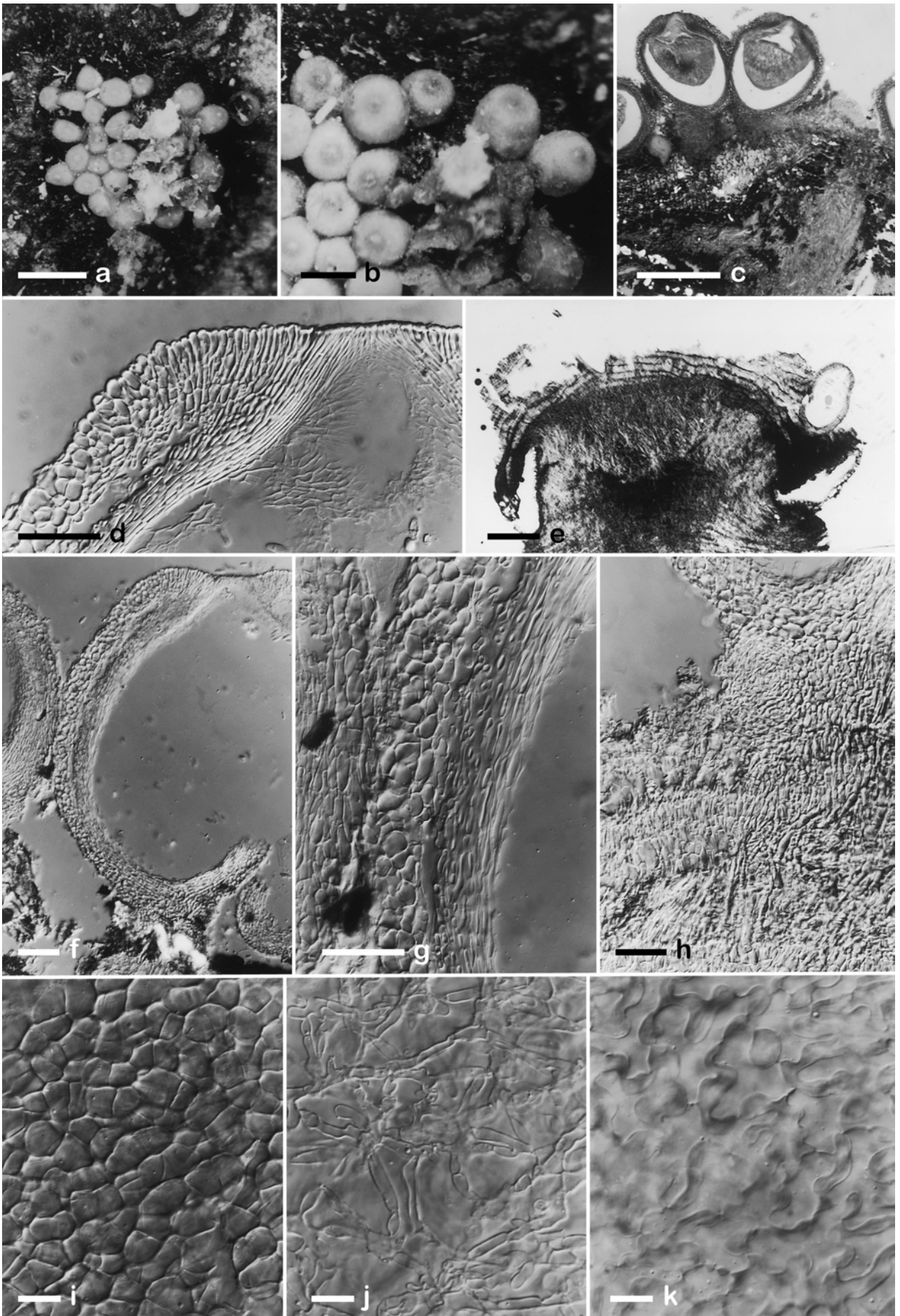
Etymology: *Samuelsii*, in honour of Dr G.J. Samuels.

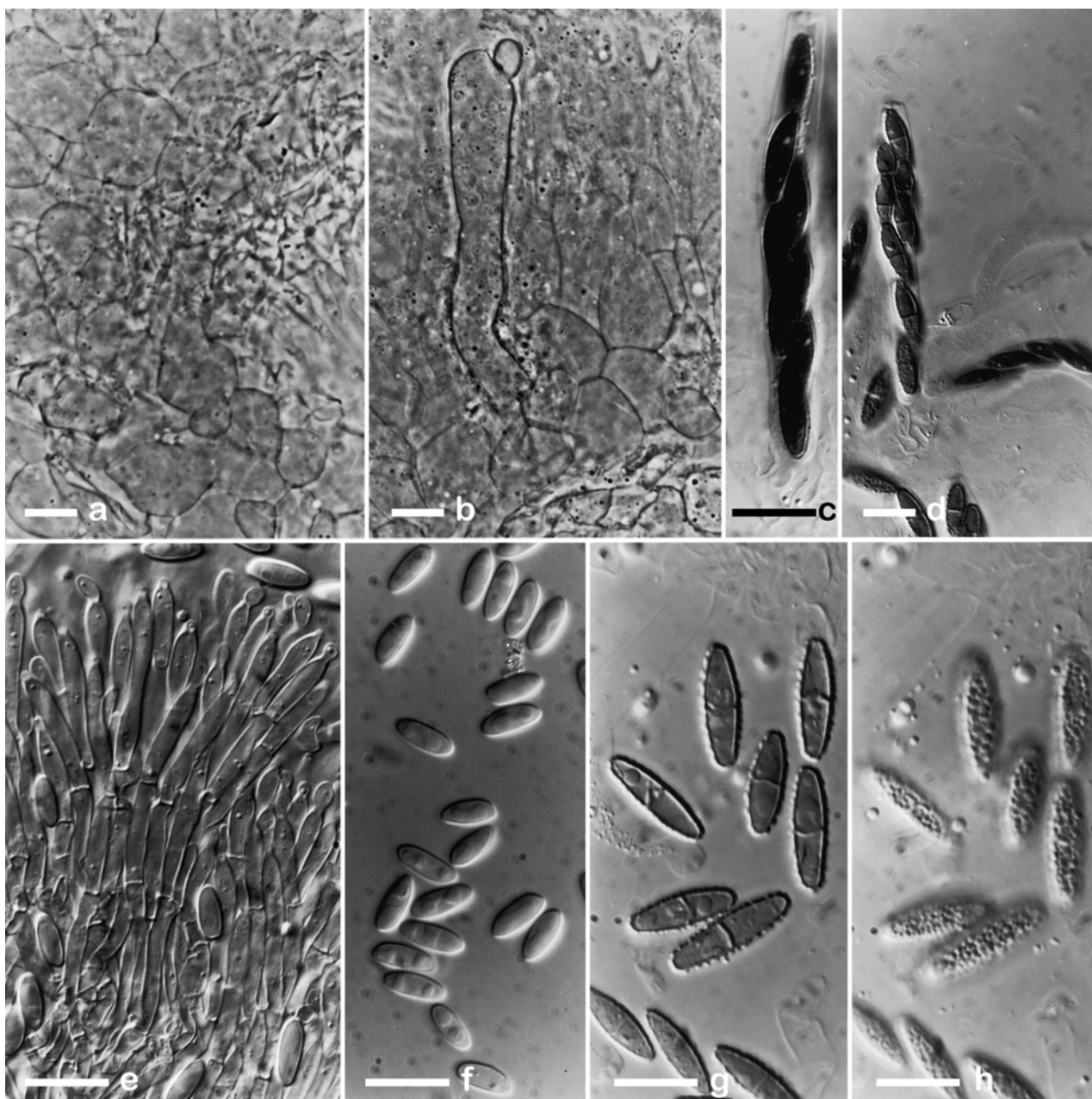
**Description from natural substratum:** **Stroma** mostly erumpent through bark, or rarely on leaves, bearing sporodochia or perithecia; perithecial stroma frequently bearing remnants of sporodochia or perithecia sometimes appearing on old, oversized sporodochia; cells below the perithecia pseudoparenchymatous, below the bark hyphal, prosenchymatous. **Perithecia** loosely to densely crowded in groups of <10–30, subglobose to oval, 250–300–350 μm diam, laterally pinched or not pinched when dry, light orange to brownish orange to orange-brown, smooth, not or minutely papillate, particularly when dry, with a slightly darker contrasting ostiolar region, smooth. **Perithecial wall** 30–45 μm thick, composed of three regions. Outermost region *ca* 20 μm or 3–5 cells thick; cells angular to subglobose, 5–15 × 3.5–11.5 μm; subapical cells elongated, slender, arranged vertically in a palisade around the ostiole. Middle region inconspicuous, 3.5–5.5–9.5 μm thick, *ca* 1–3 cells thick. Inner region 9.5–12–15 μm thick. **Asci** narrowly clavate, (43–)51–56–61(–71) × (5–)7–7.5–8.5(–11.5) μm (n = 138); ascus apex flat, edges somewhat rounded, ring clearly visible. **Ascospores** ellipsoidal to broadly ellipsoidal, distinctly warted, (7.8–)10.4–11.4–12.2(–15.4) × (2.8–)3.6–3.8–4(–5.6) μm (n = 495).

**Sterile mycelium** normally invisible. **Sporodochia** with subhymenial hyphae forming a *textura porrecta* or *textura intricata*.

**Description from culture:** **Colonies** reaching 25–30 mm diam in 7 d at 24°C; optimum for growth 21–27°C (33 mm diam), maximum 27°C. Colony reverse pale yellow to light yellow (4A3–5), or pale orange to light orange under UV; sometimes eventually producing brownish spots in the agar. Colony surface on OA and CMA white cottony because of the aerial mycelium from which flat sporodochia develop, later with large yellowish to orange to brownish orange granules because of the conidial masses; sporodochia or sporodochial tufts frequently arranged in concentric rings, in older colonies confluent; aerial mycelium creeping, finely interwoven, less typically arranged in strands. **Conidiophores** monomorphic, sporodochial, penicillate or irregularly penicillate, ter- to quaterverticillate or more frequently branched; cells of the penicillus frequently with swollen upper ends (node-like) from which further branches arise; phialides in apical whorls of 2–5, rarely arising from lower levels, divergent in the conidiophores of young sporodochial pustules or adpressed in developed sporodochia, almost cylindrical, very slightly widening towards the apex and narrowing just below the apex, or narrowly flask-shaped and somewhat widening in the lower third, without a visible collarette, (3.8–)9.4–11.2–13(–20.6) μm long, (1.2–)2–2.2–2.4(–3.2) μm wide at base, (1.8–)2.4–3–3.4(–5) μm at widest point, (1.0–)1.2–1.4–1.6(–2.2) μm wide near aperture (n = 188). **Conidial masses** yellowish orange to light orange or somewhat brownish orange, slimy, those of neighbouring sporodochia frequently flowing together; conidial columns not observed or inconspicuous. **Conidia** hyaline, ellipsoidal, almost straight, symmetrical, without a visible hilum, or with a hardly visible laterally displaced hilum, (4.4–)5.8–6.6–7(–11.6) × (2.2–)2.6–2.8–3(–3.8) μm (n = 583). Perithecia not observed in culture. **Sporodochia** flat, to 1.3 mm high, arranged in tufts throughout the colony, frequently in concentric rings, in somewhat older colonies in to 10 mm large spots; base soft, composed of irregularly, loosely interwoven hyphae, merging with the aerial mycelium; hyphae of the subhymenium normally forming a *textura intricata*, because of a somewhat divergent branching pattern of the conidiophores.

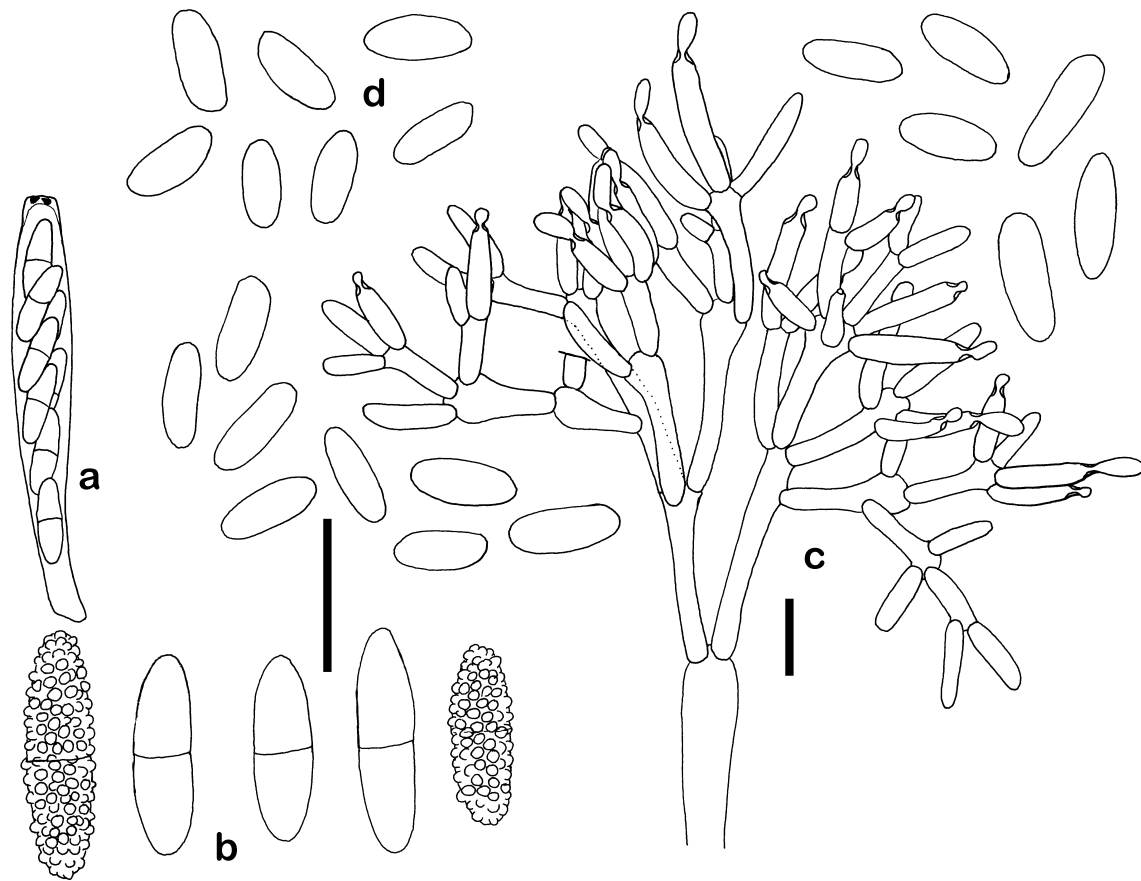
**Type for *Bionectria samuelsii*:** VENEZUELA. Edo. Miranda: Vic. refugio ‘No Te Apures’, south facing slope of La Silla, Parque Nac. El Avila; on unidentified bark; 30 Jun 1972; K.P.D., G.J.S., B. Manara (NY; Dumont-VE 3882; C.T.R. isolate 72-76, CBS 699.97, derived from ascospores). **Type for *Clonostachys samuelsii*:** dried culture ex CBS 699.97, filed together with type of *B. samuelsii* (NY); isotype: herb. CBS.





**Fig. 47. *Bionectria samuelsii* / *Clonostachys samuelsii*.** **a, b.** Subsurface view of innermost cell layer consisting of thin-walled cells (a) from which a clavate structure arises (b). **c, d.** Almost mature asci in optical section; ascus apex flattened, ring visible. **e.** Longitudinal section through sporodochium; phialides tapering below the apex. **f.** Conidia from sporodochium, almost straight, only with slightly laterally displaced hila. **g, h.** Discharged ascospores in optical section (g) and surface view (h). – a, b: G.J.S. 7234; c, d: G.J.S. 7496; e, f: G.J.S. 2781; g, h: Dumont-VE 4781. All from natural substratum. a, b: PC; c–h: DIC. Scale bars = 10  $\mu$ m.

**Fig. 46. *Bionectria samuelsii*.** **a, b.** Habit of crowded perithecia, with slightly protruding apical part (b). **c–h.** Sections through perithecia and stroma; perithecial apex; cells close to ostiole cylindrical, palisade-like (d); large stroma with remnants of sporodochium indicated by horizontal lines (e). **f, g.** Lateral perithecial wall, showing three regions; space between inner and outer perithecial wall regions indicating location of middle, hyphal region. **h.** Perithecial base, consisting of angular cells that originate from older sporodochium. **i.** Surface view of pseudoparenchymatous, outer perithecial wall. **j, k.** Subsurface views of middle, hyphal perithecial wall region (j) and of inner region (k) showing lobed cells and ‘pseudopores’. – a, b, d, f, g: H.J.S. 46; c: Dumont-VE 2513; e, h: Dumont-VE 7185; i: G.J.S. 7450; j, k: Dumont-VE 4781. All from natural substratum. The section in c was prepared by G.J. Samuels. a, b: DM; c, e: LM; d, f–k: DIC. Scale bars: a = 500  $\mu$ m; b = 200  $\mu$ m; c, e = 250  $\mu$ m; d, g, h = 30  $\mu$ m; f = 50  $\mu$ m; i–k = 10  $\mu$ m.



**Fig. 48.** *Bionectria samuelsii* / *Clonostachys samuelsii*. **a.** Almost mature ascus. **b.** Ascospores. **c.** Penicillate conidiophore from young sporodochial pustule with apically widening branches; phialides tapering below the apex, some phialides immature. **d.** Almost symmetrical conidia; hilum not or hardly laterally displaced. – a: G.J.S. 4929. b: G.J.S. 7234, G.J.S. 7496. c: CBS 100976. d: CBS 188.94, CBS 201.93, CBS 198.93. a, b: natural substratum; c: 5-d-old OA culture; d: 7–10-d-old OA culture. Scale bars = 10  $\mu$ m; the shorter bar applies to a, c, the longer to b, d.

**Known distribution:** Mainly neotropical (Venezuela, Guyana, French Guiana, Puerto Rico, Colombia); one specimen from Indonesia; possibly pantropical.

**Habitat:** On bark of recently dead woody plants, rarely from leaves (e.g. of *Zingiberaceae*).

**Published descriptions and illustrations** (as *Nectria aureofulva*): Samuels (1976a), Samuels *et al.* (1990).

**Additional specimens/strains examined:** COSTA RICA: Osa Peninsula, near Treesite along Survey Cut; on dead branches; 18 Nov 1992; G. Bills (BPI 1113205, G. Bills 0554). – FRENCH GUIANA. Saül *ca* 10 km SW of Saül toward Mt. Galbao, 03°50' N, 53°03' W, *ca* 200 m alt.; on twigs of recently dead tree; Jan, Feb 1986; G.J.S., J.R. Boise (NY; G.J.S. 2781; G.J.S. isolate 86-43). – *Ca* 15 km SW of Saül (03°60' N, 53°20' W), toward Mt. Galbao (03°50' N, 53°20' W), 600–650 m alt.; on bark of recently dead tree; Jan 1986; G.J.S., J.R. Boise (CAY, NY; G.J.S. 2822; G.J.S. isolate 86-48, dead). – GUYANA. Cuyuni-Mazaruni Region VII, Mazaruni Subregion VII-2: Foothills immediately S of Mt. Ayanganna, *ca* 1 km W of Pong River, 05°28' N, 60°04' W, 550–650 m alt.; on twigs of recently dead tree; 26 Feb 1987; G.J.S., J. Pipoly, G. Gharbarran, J. Chin, R. Edwards (BRG, BPI, NY; G.J.S. 4850; CBS 199.93; G.J.S. isolate 87-34). – *Ibid*; on twigs of recently dead tree; 26 Feb 1987; G.J.S., J. Pipoly, G. Gharbarran, J. Chin, R.

Edwards (NY; G.J.S. 4826; G.J.S. isolate 87-25 (?dead). – Along Koatse River, *ca* 2 km E of Pong River, *ca* 5 h walk W of Chinoweing Village, 05°28' N, 60°04' W, 600–650 m alt.; on wood of recently dead tree; Feb–Mar 1987; G.J.S., J. Pipoly, G. Gharbarran, J. Chin, R. Edwards (BRG, BPI, NY; G.J.S. 4929; CBS 198.93, G.J.S. isolate 87-42). – INDONESIA. Eastern Dumoga-Bone Natl. Park, vic. Project Wallace Base Camp at confluence of Toraut and Tumpah Rivers, 00°34' N, 123°57' W, 211 m alt.; on living root of tree; Sept–Nov 1985; G.J.S. [BO, NY; G.J.S. 2009, G.J.S. isolate 85-130 (dead)]. – JAMAICA. St. Andrew Parish: Along Wagwater River near source, Holywell Recreation Area, 930–1000 m alt.; 11 Jan 1971; on wood; R.P. Korf *et al.* (NY; CUP-MJ 806; C.T.R. isolate 71-26). – Vic. Dick's Pond, W of Hardwar Gap, near Holywell Recreation Area and Wag Water River, 930–1000 m alt.; 11 Jan 1971; R.P. Korf *et al.* (NY, CUP-MJ 793; C.T.R. isolate 71-35). – St. Thomas Parish: between Wheelerfield and Johnson Mt., 100 m alt.; on bark; 15 Jan 1971; R.P. Korf *et al.* (NY; CUP-MJ 879, A.Y.R. 459; C.T.R. isolate 71-72). – Between Wheelerfield and Johnson Mt., 100 m alt.; on wood; 15 Jan 1971; R.P. Korf *et al.* (NY; CUP-MJ 877, A.Y.R. 460). – PANAMA. Prov. Veraguas: lower slopes of Cerro Tuté, *ca* 8 km NE of Santa Fé, on property of agricultural school Alto de Piedra, *ca* 660 m alt.; on branch; 19 Jun 1975; K.P.D., S.E. Carpenter, S.M. Carpenter, S.A. Mori (NY; PA 720). – U.S.A. PUERTO RICO: Caribbean National Forest: Luquillo Mts., El Verde Research Area; on bark of *Casearia arborea* killed by hurricane in 1989; 19 Feb 1996; G.J.S., H.-J. Schroers, D.J. Lodge (BPI 749137, CBS; H.J.S. 46; CBS 701.97). – Luquillo

Mts., Bisley Experimental Watershed; bark of recently dead tree; 21 Feb 1996; G.J.S., H.-J. Schroers, D.J. Lodge (CBS; H.J.S. 72; CBS 700.97). – Luquillo Mts., Veredia El Toro; on bark of recently dead tree; 24 Feb 1996; G.J.S., H.-J. Schroers, D.J. Lodge (BPI 749177; CBS; H.J.S. 117; CBS 100976). – Ibid.; on bark of recently dead tree; 24 Feb 1996; G.J.S., H.-J. Schroers, D.J. Lodge (BPI; H.J.S. 119). – VENEZUELA. Edo. Aragua: Path between hotel and hotel's water source, Rancho Grande, Parque Nac. Henry Pittier; on unidentified wood; 3 Jul 1971; K.P.D., H. Haines, G.J.S. (NY; Dumont-VE 1148; C.T.R. isolate 71-328). – Edo. Bolivar: km 110–111 S of El Dorado, on road between El Dorado and Sta. Elena; on unidentified wood; 6 Aug 1972; K.P.D., R.F. Cain, G.J.S., C. Blanco (VEN, NY; Dumont-VE 7120; C.T.R. isolate 72-191). – Ibid.; on road between El Dorado and Sta. Elena; on leaf of *Zingiberaceae*; 6 Aug 1972; K.P.D., R.F. Cain, G.J.S., C. Blanco (NY; Dumont-VE 7185; C.T.R. isolate 72-190). – Edo. Mérida: ca 63 km W of Mérida, Univ. Los Andes Forest Reserve, La Carbonera; on unidentified wood; 20 Jul 1971; K.P.D., J.H. Haines, G.J.S., S. Silverborg, L. Borjas (NY; Dumont-VE 2513; C.T.R. isolate 71-351). – Parque Nacional Sierra Nevada, above Tabay, Qda. Coromoto, La Mucuy, 08°36' N, 71°02' W, 2300 m alt.; on bark of recently dead tree; 9–17 Nov 1990; G.J.S., B. Hein, S.M. Huhndorf, T. Iturriaga, G. Rodríguez, M. Hererra (B, BPI, NY, USB, VEN; G.J.S. 7234; CBS 201.93, G.J.S. isolate 90-173). – Edo. Sucre: Trail between Los Pocitos and the peak of Cerro Humo, NW of Irapa; on unidentified wood; 12 Jul 1972; K.P.D., R.F. Cain, G.J.S., G. Morillo, F. Farfan (Ven, NY; Dumont-VE 4781; C.T.R. isolate 72-134. Dumont-VE 4808; C.T.R. isolate 72-118). – Trail between Manacal and Los Pocitos, NW of Trapa; on unidentified bark; 10 Jul 1972; K.P.D., R.F. Cain, G.J.S., G. Morillo, J. Farfan (NY; Dumont-VE 4620; C.T.R. isolate 72-101). – Edo. Trujillo: Parque Nacional Guaramacal, ca 10 km SW of Bata-tal, La Defensa, along Río Saguás, Campamiento Granja Boco-no, in forest along trail to water source, 09°18' N, 70°10' W, 660 m alt.; on dead palm trunk; 20, 23 Nov 1980; G.J.S., B. Hein, S.M. Huhndorf (BPI, VEN, NY; G.J.S. 7450). – Ibid.; 730 m alt.; on bark; 23 Nov 1980; G.J.S., B. Hein, S.M. Huhndorf (BPI, VEN, NY; G.J.S. 7496; CBS 188.94, G.J.S. isolate 90-227). – Edo. Yaracuy: 2–4 km above Jobito, near San Felipe, Parque Yurubi; on unidentified wood; 10 Jul 1971; K.P.D., J.H. Haines, G.J.S., G. Morillo, J. Leal (Ven, NY; Dumont-VE 1873; C.T.R. isolate 71-253). – Amazonas: Neblina Base Camp on Río Bario (= Río Mawarinuma), left bank, 00°49'50" N, 66°09'40" W, 140 m alt.; 23 Feb 1985; A.Y.R. (BPI 550155, A.Y.R. 2209). – Neblina Base Camp on Río Bario, 00°49'50" N, 66°09'40" W, 140 m alt.; 19 Feb 1985; A.Y.R. (BPI 550146, A. A.Y.R. 2160B). – Cerro de la Neblina, 2 km NNE of Pico Phelps, 00°51'45" N, 65°58'52" W, 1390–1515 m alt.; 22 Feb 1985; A.Y.R. (BPI 550156, A.Y.R. 2261).

**Notes:** *Bionectria samuelsii* is a common tropical species. It is characterized by (i) vertical, almost cylindrical cells in the uppermost part of the outer perithecial wall region (Fig. 46 d; Samuels *et al.*, 1990: Fig. 20 D), (ii) monomorphic conidiophores exclusively forming sporodochia, (iii) somewhat apically widening cells in the penicilli (Fig. 48 c; Samuels *et al.*, 1990: Fig. 20 G), (iv) ± cylindrical phialides that taper slightly just below the tip (Figs 47 e, 48 c), and (v) ellipsoidal, almost symmetrical conidia with invisible or inconspicuously laterally displaced hila (Figs 47 f, 48 d). *Bionectria samuelsii* is similar to other species in subgenus *Bionectria* in habit of the perithecia (Fig.

46 a, b), anatomy of the perithecial wall, which consists of three regions (Fig. 46 g, i–k), and ascospore morphology (Fig. 47 g, h). The species appears closely related to *C. divergens* and *C. rogersoniana* based on sequences of the *tub2* and the ITS regions (Figs 2–4). While it clusters outside the clade comprising most species of subgenus *Bionectria* (Fig. 4), data of the LSU rDNA place it close to *B. ochroleuca* (Rossman *et al.*, 2001, there cited as *B. aureofulva*).

Specimens of *B. samuelsii* were previously identified as *N. aureofulva* (Samuels, 1976a; Samuels *et al.*, 1990; Rossman *et al.*, 2001), which is a synonym of *B. ochroleuca*. Ascocarps of *B. samuelsii* differ from the type of *B. aureofulva* in the shape of cells close to the ostiole (compare Fig. 46 d and Fig. 35 d). *Bionectria samuelsii* is only known from tropical regions, while *B. ochroleuca* (and *B. aureofulva*) originally was described from temperate regions (eastern U.S.A.) but occurs in tropical regions as well.

## 20. *Clonostachys divergens* Schroers, *sp. nov.* – Fig. 49 a–d.

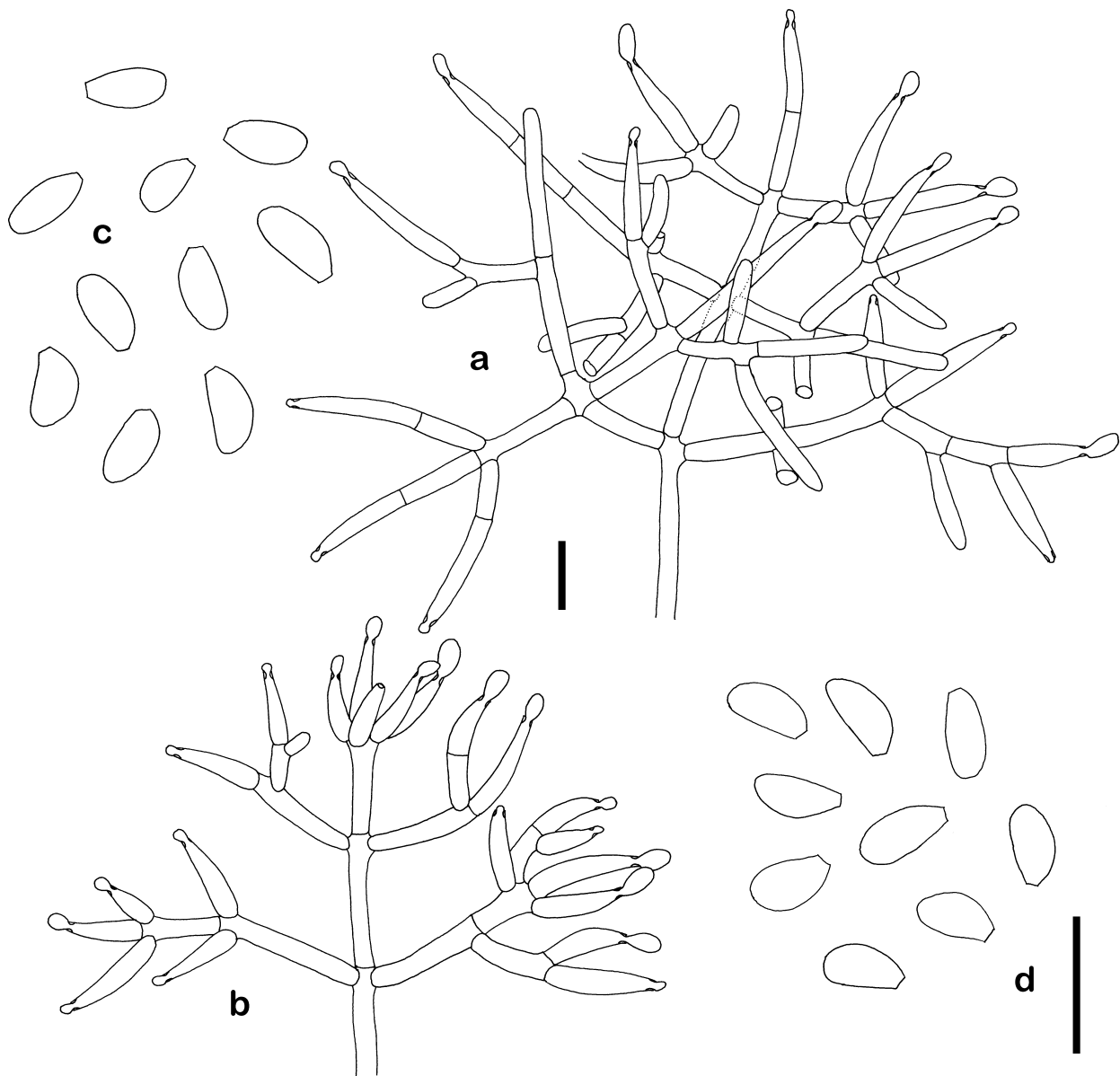
Coloniae initio albae, postea atrovirentes; conidiophora divergenter fere rectangulariter ramosa in sporodochiis aggregata, postea convergentia; sporodochiis plusminusve confluentibus, non-distinctis. Phialides divergentes, postea convergentes. Conidia catenata vel irregulariter imbricata ex phialidibus singulis oriunda; catenae postea in massa atroviridi, myrothecii simili collabentes. Conidia ellipsoidea, leviter curvata; hilo minime lateraliter disposito, (4.8–)5.8–6.2–6.4(–7.4) × (2.6–)3.2–3.2–3.2(–3.8) µm.

Holotypus anamorphosis: herb. CBS; cultura sicca, isolata ex CBS 967.73b; cultura viva CBS 967.73b.

Etymology: *Divergens* referring to the divergent branches of the conidiophores.

Teleomorph: Unknown.

**Description from culture:** Colonies reaching ca 20 mm diam in 7 d at 24°C; optimum for growth 21–24°C, maximum 27°C. Colony reverse on OA pale to light yellow (2A3–5) or dull yellow (3B3), on PDA dull to mustard yellow (3B3–6), with time olive-grey (3E2); yellow pigmentation diffusing into the agar; OA- and PDA colonies after incubation under UV pale to light orange (5A3–5). Colony surface on CMD smooth, aerial mycelium almost lacking, finely granu-lose because of small, green sporodochium-like tufts. Sporulation on OA and PDA stronger; colonies dull to dark green (28E–F4), densely finely powdery to granu-lose or finely felty because of the conidial masses of confluent sporodochial tufts; aerial mycelium not protruding beyond the level of confluent sporulation, in older colonies forming white mats from which conidiophores arise. **Conidiophores** monomorphic, arising from single hyphae or hyphal strands, aggregated, in all elements divergently branched, forming loosely



**Fig. 49.** *Clonostachys divergens*. **a, b.** Conidiophores from young sporodochial pustules with strongly divergent branches and phialides (conidiophores in older sporodochia almost adpressed). **c, d.** Conidia. – **a, c:** CBS 532.69; **b, d:** CBS 967.73B. – All from 6–8-d-old OA cultures. Scale bars = 10  $\mu\text{m}$ ; the shorter bar applies to **a, b** the longer to **c, d**.

aggregated sporodochial tufts with a subhymenium composed of intertwined conidiophore branches, short-stiped (stipe length about 10  $\mu\text{m}$ ), or on long supporting hyphae that continue into the mycelium below the sporodochial tufts. **Phialides** narrowly flask-shaped, widest near the lower third, continuously tapering upwards, in whorls of 3–7 or arising directly from the cells of the penicillus, without a visible collarette, (9–) 11.6–13.8–16.6(–19.2)  $\mu\text{m}$  long, (1.8–)2.6–2.8–3(–3.8)  $\mu\text{m}$  wide at base, (2.2–)2.6–3–3.2(–4.2)  $\mu\text{m}$  at widest point, (1–)1–1.2–1.4(–1.6)  $\mu\text{m}$  wide near aperture ( $n = 43$ ). **Conidial chains** almost linear, with only slightly overlapping ends, initially rather dry, dull green (27–29E4), in older colonies sliming down to dark green (27–28F4) or olivaceous (2F5) conidial masses; several chains from phialides of neighbouring conidiophores intricately intertwined, or sticking together.

**Conidia** greenish, smooth, ellipsoidal, heteropolar, slightly curved, with a laterally displaced hilum and broadly rounded distal end, (4.8–)5.8–6.2–6.4(–7.4)  $\times$  (2.6–)3.2–3.2–3.2(–3.8)  $\mu\text{m}$  ( $n = 76$ ). Conidial masses green in vivo, water, and lactic acid, turning brownish in KOH.

**Type for *Clonostachys divergens*:** GERMANY. Kiel-Kitzeberg; ex soil from wheat-field; W. Gams culture C 1349 (herb. CBS; dried culture of CBS 967.73b).

**Known distribution:** Europe, North America (Canada, Ontario).

**Habitat:** Known from soil, isolated once from sclerotia of *Rhizoctonia solani*.

**Additional specimen/strains examined:** CANADA. ONTARIO: Puslinch; ex forest soil under *Thuja occidentalis*; G.C. Bhatt, G.C.B. 1720 (IMI 144464ii; CBS 532.69). – NETHERLANDS. Prov. Groningen, Haren; ex soil, from sclerotia of *Rhizoctonia solani* used as bait, showing antagonistic activity against *Rhizoctonia solani*; G. Jager No. M 61 (CBS 381.77). – Ex soil, from sclerotia of *Rhizoctonia solani* used as bait; G. Jager (CBS 229.80). – Nederhemert; sporodochium on bark of *Fraxinus* sp.; 31 Oct 1999; L. Rommelaars (CBS; CBS 102426).

**Notes:** Entirely sporodochial conidiophores and green conidial masses characterize *Clonostachys divergens*. The branches of the conidiophores in young cultures are strongly divergent, almost rectangular (Fig. 49 a, b). Because the phialides are strongly divergent, chains rather than columns of conidia are formed, each arising from a solitary phialide. With time, however, the sporodochia become confluent and the branches of the sporodochia as well as the phialides become more and more adpressed; as a result of strong sporulation and exudation, the conidial chains may collapse into conidial masses. The divergent branching of conidiophores in young sporodochial pustules intergrades with the adpressed branching in developed sporodochia. This difference therefore is seen as a result of advanced sporulation and not as an evidence of conidiophore dimorphism.

The conidia of *C. divergens* are ellipsoidal to slightly curved and have a slightly laterally displaced hilum (Fig. 49 c, d), as is typical of species of subgenus *Bionectria*.

*Clonostachys divergens* is similar to the anamorphs of species of subgenus *Astromata* in the colour of the conidial masses and arrangement of conidia in simple chains (Fig. 57 d), but it differs in conidial shape [somewhat curved, without protruding hilum in *C. divergens* (Fig. 49 c, d)]; almost clavate, hilum slightly laterally protruding as in *B. epichloë* (Fig. 57 e, f). A similar conidial shape is seen in *Myrothecium verrucaria* (Alb. & Schw. : Fr.) Ditm. but this species differs in the formation of warted hyphae at the sporodochial margin, conidiophore morphology, and fan-shaped conidial appendages (Tulloch, 1972). *Clonostachys divergens* differs from the anamorph of *Bionectria pityrodes* in all aspects of conidial shape, conidiophore branching patterns, and phialide shape.

Strains of *C. divergens* have been isolated mainly from soil and particularly from sclerotia of *Rhizoctonia solani*, similarly to the habits of *C. rosea*. One isolate of *C. divergens* (CBS 102426) originated from sporodochia on bark, a similar habitat to sporodochia and ascocarps of other species of *Bionectria*, especially subgenus *Bionectria*.

The anamorph on the herbaceous Dumont-EC 1451 was identified as *C. divergens* because of its conidiophore morphology and size range of the conidia. Associated with the anamorph was a teleomorph most similar to *B. ochroleuca* (asci 55–70–88 × 7–7.6–9 µm; as-

cospores 11–12.3–14 × 3–3.9–4.5 µm) but forming somewhat larger perithecia (400 × 300 µm). The identity of the anamorph and its connection to the *Bionectria* teleomorph, however, is uncertain.

## 21. *Bionectria ralfsii* (Berk. & Broome) Schroers & Samuels, *comb. nov.* — Figs 50 a–j, 52 a, b.

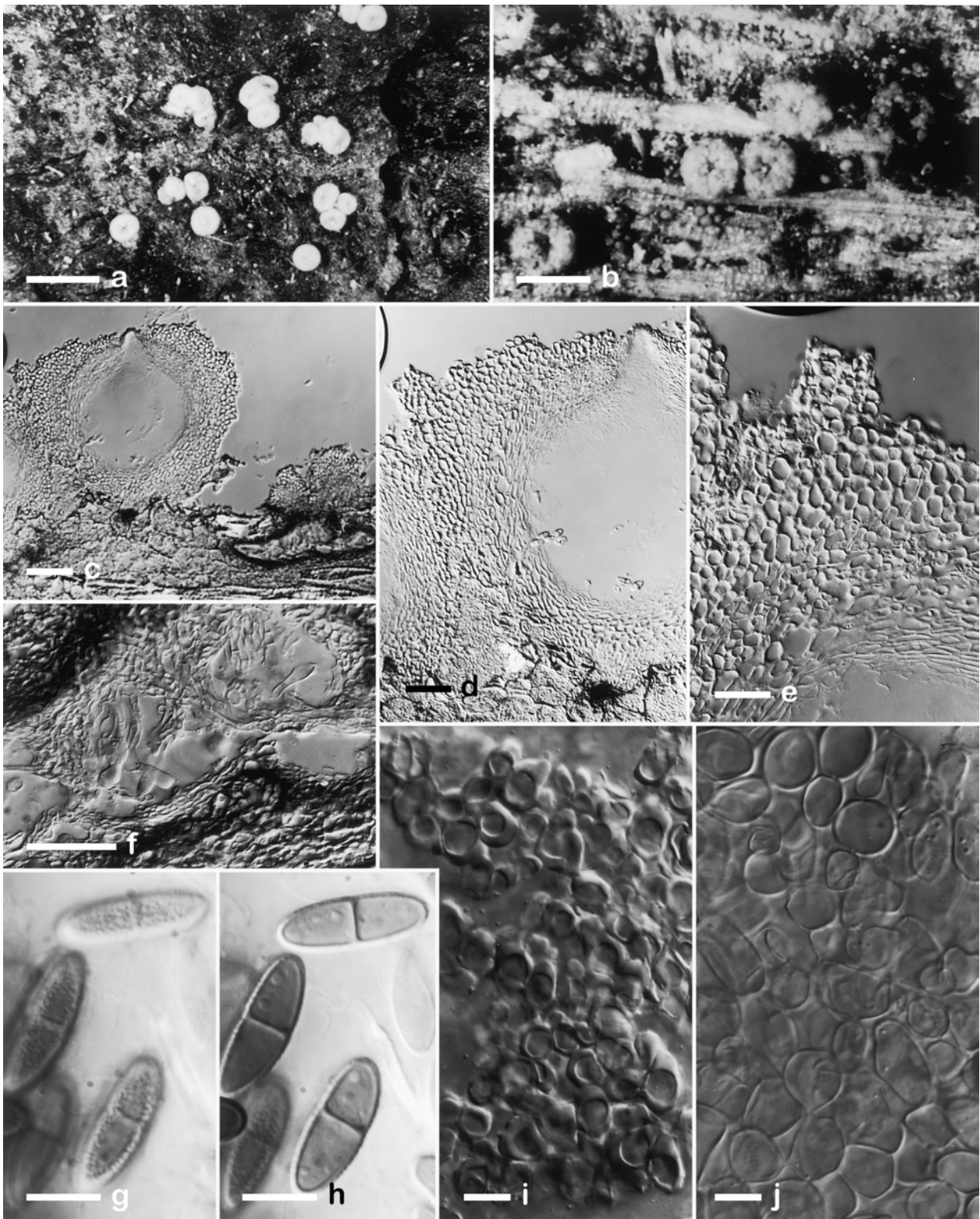
≡ *Nectria ralfsii* Berk. & Broome, Ann. Mag. Nat. Hist., Ser. 2, 13: 467. 1854.

Anamorph: *Clonostachys ralfsii* Schroers, *stat. nov.* — Figs 51 a–f, 52 c, d.

Conidiophora monomorphica, penicillata, in sporodochia vel synnemata aggregata; massa conidiorum olivaceo-nigra. Conidia fere limoniformia, viridia, hilo basilari applanato laterali et apice angustato, paulo curvato protrudente, (7.4–)11.6–12.6–13.6(–17.8) × (4.8–)6.4–7–7.6(–11) µm.

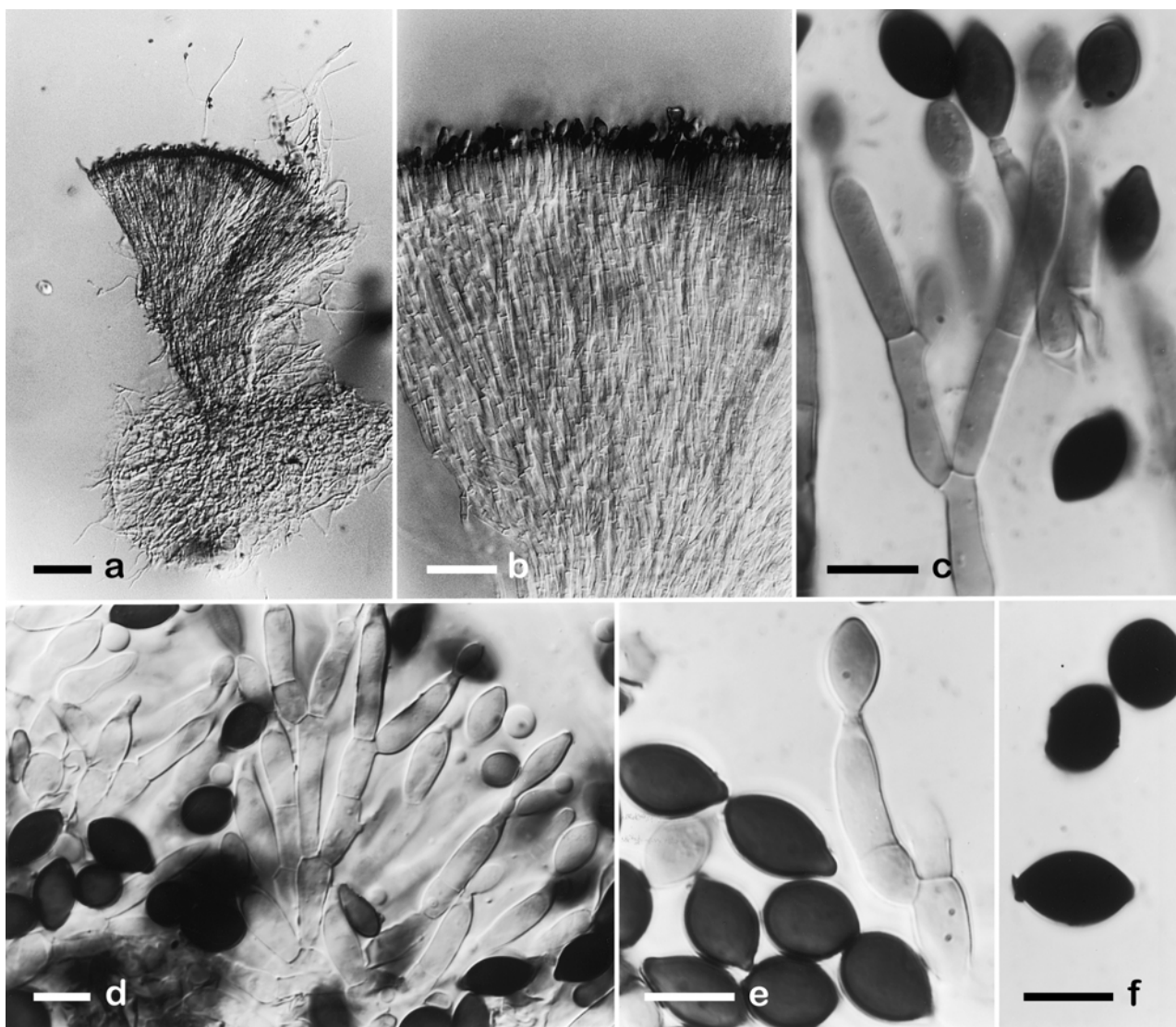
Holotypus anamorphosis: PDD; cultura sicca, isolata ex specimine PDD 30637 (PDD); isotypus herb. CBS; cultura viva CBS 703.97.

**Description from natural substratum: Stroma** erumpent through bark, bearing crowded perithecia, reduced in size, inconspicuous when bearing solitary perithecia, frequently on or close to stromata or fruiting structures of pyrenomycetes; cells pseudoparenchymatous to somewhat prosenchymatous, < 10 µm diam. **Perithecia** solitary or crowded in groups of less than 10, broadly obovoid or subglobose, with a flat apex, mostly broader than wide, 300–400 µm high, 400–500 µm wide, in dried condition frequently apically pinched, somewhat cupulate, light orange, rough to scaly or finely warted; scales generally slightly less intensely coloured. **Perithecial warts** with outermost cells having unevenly thickened walls up to 6.5 µm thick; inner cells of warts 6–15 × 5–13 µm, with uniformly thickened walls. **Perithecial wall** 70–120 µm thick, composed of two regions (hyphal layer not observed). Outer region 35–52–60 µm or 7 layers thick; cells globose to subglobose to angular, variable in size, 6.5–17.5 × 5.5–14.5 µm, without vacuoles, intergrading with the cells of the warts; cell-walls uniformly thickened ca 1.5 µm thick; adjacent cells not firmly connected with each other, possibly connected by pores. Inner region 25–35–50 µm thick. **Asci** clavate, broadly rounded; apical ring invisible, 8-spored, 70–80–95 × 11–14–17 µm (n = 17). **Ascospores** ellipsoidal to broadly ellipsoidal, equally two-celled, not constricted at the septum, smooth to finely roughened, (14.6–)17.6–18.6–19.4(–22.8) × (5.4–)6–6.6–7.2(–8) µm (n = 49). **Sporodochia** close to the perithecial cluster or absent, on obscurely developed erumpent stroma, higher than wide, somewhat funnel-shaped or with phialides arising directly from angular cells. **Sterile mycelium** invisible on the bark surface.



**Fig. 50. *Bionectria ralfsii*.** **a, b.** Small groups of crowded or solitary perithecia, perithecia broadly rounded with sunken apex. **c–f.** Sections through perithecia or subcortical hyphae. **c.** Perithecium on a somewhat erumpent stroma; perithecial primordia at right seated on subcortical fungal stroma; **d, e.** Lateral perithecial wall and perithecial wart. **f.** Subcortical hyphae growing downwards from perithecial primordium into fungal host. **g, h.** Discharged, rough ascospores in surface view (**g**) and optical section (**h**). **i.** Surface view of cells from perithecial wart with unevenly thickened walls. **j.** Cells of outer perithecial wall region in subsurface view with uniformly thickened walls and gaps between neighbouring cells. **– a, i:** PDD 30638; others: PDD 49950. All from natural substratum. **a–b:** DM; **c–j:** DIC. Scale bars: **a** = 750  $\mu\text{m}$ ; **b** = 500  $\mu\text{m}$ ; **c** = 100  $\mu\text{m}$ ; **d** = 50  $\mu\text{m}$ ; **e** = 30  $\mu\text{m}$ ; **f** = 30  $\mu\text{m}$ ; **g, h** = 10  $\mu\text{m}$ ; **i, j** = 10  $\mu\text{m}$ .

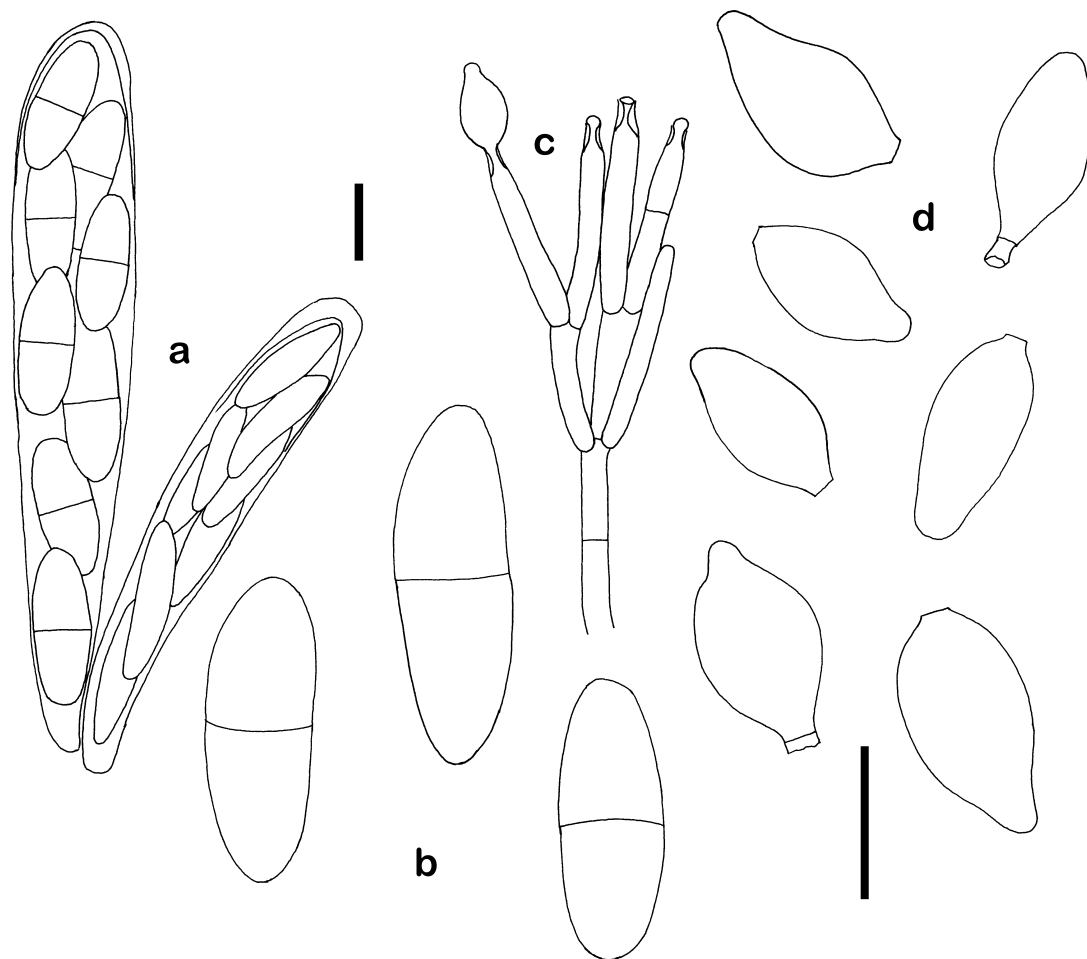




**Fig. 51. *Bionectria ralfsii* / *Clonostachys ralfsii*.** a. Somewhat synnematus sporodochia. c–e. Details of conidiophores, phialides. f. Conidia. – a, b: CBS 703.97; c, f: PDD 49950; d, e: PDD 32655. a, b: ca 21-d-old OA culture; c–f: dried cultures. All: DIC. Scale bars: a = 100  $\mu$ m; b = 30  $\mu$ m; c–f = 10  $\mu$ m.

**Description from culture:** **Colonies** reaching 8–12 mm diam in 7 d at 24°C; optimum for growth 21°C (12–16 mm diam), maximum 24°C. Colony reverse on OA and CMA unpigmented in darkness, pale yellow 4A2 in daylight, pale orange under UV; on PDA pale to light yellow (4A2–5) in daylight in orange hues under UV. Colony surface on CMD translucent, fine white floccose because of sterile aerial mycelium; on OA and PDA white floccose, in older colonies dark olive-green from conidiophores or sporodochia because of the colour of the conidia; green spots of sporodochia to 4 mm diam, dark green to dark olive-green. **Conidiophores** monomorphic, penicillate, to quaterverticillate, adpressed, in sporodochial aggregates, or in synnema-like conidiomata; phialides almost cylindrical, or slightly widening upwards, tapering in the upper third towards the apex, with a short collarette and conspicuous periclinal thickening, in whorls of 2–3, (12–)16.8–20.4–24(–32.2)  $\mu$ m long, (2.2–)3.2–3.6–4(–5.4)  $\mu$ m wide at base, (2.2–)3.4–4–

4.6(–5.4)  $\mu$ m at widest point, (1–)1.8–2–2.2(–2.8)  $\mu$ m wide near aperture (n = 49). **Conidial masses** dry to slimy, dark olive-green or nickel green (2–7F3), with a surface appearing finely granular because of rather large conidia when observed under DM. **Conidia** olive-green, smooth, asymmetric, broadly ellipsoidal to lemon-shaped, with a flat, slightly laterally displaced hilum, often with collarette-like remains of the phialidic tip; apical end tapering, slightly curved, protruding, initially arranged in imbricate chains, collapsing to slimy masses, (7.4–)11.6–12.6–13.6(–17.8)  $\times$  (4.8–)6.4–7–7.6(–11)  $\mu$ m (n = 94). Colour of conidial masses pH-dependent, green in vivo, water, more brightly green in lactic acid, brownish in KOH; colour reaction of the conidia similar. **Sporodochia** arising from the aerial mycelium or from agar surface within 21d old (OA), narrowly funnel-like, widening continuously towards the top (e.g., 100–130  $\mu$ m wide at base, 350–600  $\mu$ m wide at top), initially composed of loosely and later densely packed hyphae with cell-



**Fig. 52.** *Bionectria ralfsii* / *Clonostachys ralfsii*. **a.** Asci without apical ring. **b.** Mature ascospores. **c.** Part of conidiophore. **d.** Conidia. – a, d (bottom): PDD 32655; b: PDD 49950; c, d (top): CBS 703.97. a, b: natural substratum; c–d: 14-d-old OA culture. Scale bars = 10  $\mu$ m; the shorter bar applies to a, c the longer to b, d.

widths up to 7  $\mu$ m; in older colonies several sporodochia can aggregate to form more complex conidiomata, up to 5 mm diam; sporodochial base prosenchymatous or obscurely pseudoparenchymatous, generally with hyphae radiating into the agar.

**Type for *Nectria ralfsii*:** U.K.: On dead branches of *Fagus* sp. (Berkeley & Broome No. 780; not seen).

**Type for *Clonostachys ralfsii*:** NEW ZEALAND. AUCKLAND: Waitemata County, Piha; on bark; 21 Mar 1973; J.M. Dingley, G.J.S. [dried culture of CBS 703.97 (= G.J.S. isolate 73-15), derived from ascospores of PDD 30637 and filed with it (PDD); isotype: herb. CBS].

**Known distribution:** Temperate to subtropical (Mediterranean), New Zealand, UK, Portugal (Booth, 1959).

**Habitat:** On bark of various woody plants (Booth, 1959: 34), frequently on or associated with stromata of pyrenomycetes.

**Published descriptions:** Weese (1918), Booth (1959).

**Additional specimens/strains examined:** Location unknown: E.W. Mason (CBS 267.36, anamorph only). – AUSTRALIA. VICTORIA: Rte. 1, Drummer Rain Forest Walk, forest dominated by *Eucalyptus* sp., ca. 300 m alt.; on bark of twigs; 20 Aug 1999; G.J.S. (BPI; G.J.S. 8547; CBS 102849). – Ibid.; on bark of recently dead tree; 20 Aug 1999; G.J.S. (BPI; G.J.S. 8544; CBS 102851). – Ibid.; on bark of twigs; 20 Aug 1999; G.J.S. (BPI; G.J.S. 8533; CBS 102845). – Otway Ranges, vic. Lorne, Angahook-Lorne State Forest, along track from Blanket Leap Picnic Ground to Cora Lynn Cascades, along Cora Lynn Creek, dominated by *Eucalyptus* sp., 200–350 m alt.; on bark of twigs; 28 Aug 1999; G.J.S. (BPI; G.J.S. 8646; CBS 102850). – Ibid.; on bark; 28 Aug 1999; G.J.S. (BPI; G.J.S. 8641; CBS 102852). – NEW ZEALAND. Waitemata County, Waiatarua, Nature Track; on *Pittosporum* sp.; 21 Mar 1973; J.M. Dingley, G.J.S. (PDD 30638; G.J.S. isolate 73-14). – Waitemata County, Wenderholm Scenic Reserve; on bark of *Sophora microphylla*; 26 Sept 1973; J.M. Dingley, G.J.S., S. Haydon, J.D. Fletcher (PDD 32655; G.J.S. isolate 73-197). – Northland, vic. Mangamuka Bridge, Omahuta State Forest, Omahuta Kauri Sanctuary; on *Olearia* sp.; 10 May 1981; G.J.S. (PDD 49950; G.J.S. isolate 81-107). – Taupo, 9 May 1986; Y. Doi (G.J.S. isolate 86-548, CBS 129.87, only strain observed).

**Notes:** *Bionectria ralfsii* is well characterized by the teleomorph and anamorph and occupies an isolated position within the genus. The perithecial wall is rela-

tively thick (to 120 µm, Fig. 50 d), the perithecia are solitary or crowded in rather small groups (Fig. 50 a, b), generally broader than high (Fig. 50 c), apically pinched when dry (Fig. 50 a, b), sporodochia in culture are sometimes funnel-shaped to synnematosus (Fig. 51 a), and the conidia have a slightly protruding apex, are dark green, and have a pigmented wall (Fig. 51 c–f).

The loosely connected cells in the outermost layers of the perithecial wall (Fig. 50 j) are similar to those of *B. epichloë* (Fig. 54 d), subgenus *Astromata*, and *B. pityrodes* (Fig. 59 f), subgenus *Myronectria*. On the natural substratum of PDD 49950, phialides were formed directly on angular cells (not shown), similar to those found in *B. parva* (Fig. 56 j), subgenus *Astro-*

*mata*. Based on sequences of the rDNA, however, no strong relatedness of *B. ralfsii* to subgenus *Astromata* is indicated and not statistically supported; *B. pityrodes* is unrelated to both (Schroers, 2000: Figs 1, 2). *Bionectria ralfsii* is classified here in subgenus *Bionectria* because of the overall characters of the ascocarp, including rough ascospores (Fig. 50 g), erumpent stromata formed below crowded perithecia (not shown), and truncate, laterally displaced hila of the conidia. The sporodochial anamorph is well-developed in recent isolates (e.g. CBS 703.97). In strain CBS 129.87 sporulation was observed only from small tufts of conidiophore aggregates, and in the oldest strain available (CBS 267.36) no sporulation was observed.

### BIONECTRIA SUBGEN. ASTROMATA Schroers, *subgen. nov.* — Species 22–24.

Stroma absens vel vix formatum. Perithecia in substratis lignosis vel herbaceis, saepe fungorum stromati vel carposomati superficiali vel subcorticali insidentia, solitaria vel laxe vel dense aggregata, superficie minute verrucosa, parietibus cellularum inegaliter inspissatis. Tunica perithecorum e duobus stratis composita; stratum exterius e cellulis angularibus vel subglobosis; stratum interius e cellulis lobatissimis; stratum medium deficiens. Ascosporae ellipsoideae, uniseptatae, verruculosae. Anamorphosis *Clonostachys*; conidiophoris omnino sporodochialibus; conidia catenata vel imbricata; catenae postea in massa atroviridi, myrothecii simili, collabentes. Conidia nonseptata, clavata, hilo minute lateraliter protrudente.

Type species: *Bionectria epichloë* (Speg.) Schroers

Etymology: Greek *alpha privativum* and *stroma*, referring to the lacking stroma.

Anamorphs: *Clonostachys* (myrothecium-like).

**Stroma** absent or barely developed. **Perithecia** on woody or herbaceous substrata, frequently on superficial or subcortical fungal stroma or fruiting structures, superficial, solitary, gregarious, or loosely to densely aggregated, with slightly warted surface; cells of warts with unevenly thickened walls. **Perithecial wall** consisting of two regions. Cells of outer region angular to subglobose, frequently not firmly connected to each other, with gaps in between. **Ascospores** 1-septate, ellipsoidal, somewhat heteropolar with a rounded and a more tapering end, warted or smooth. **Anamorph** *Clonostachys*. Conidiophores monomorphic, entirely sporodochial, penicillate, sparsely branched, generally with 2 branches or phialides arising from subtending branches, or irregularly penicillate, or phialides directly arising from aggregated angular cells. **Conidia** 1-celled, clavate to ellipsoidal, mostly with a somewhat laterally protruding hilum and a rounded distal end, greenish hyaline, initially held in almost linear chains with somewhat overlapping ends. **Conidial masses** greenish grey to dark green.

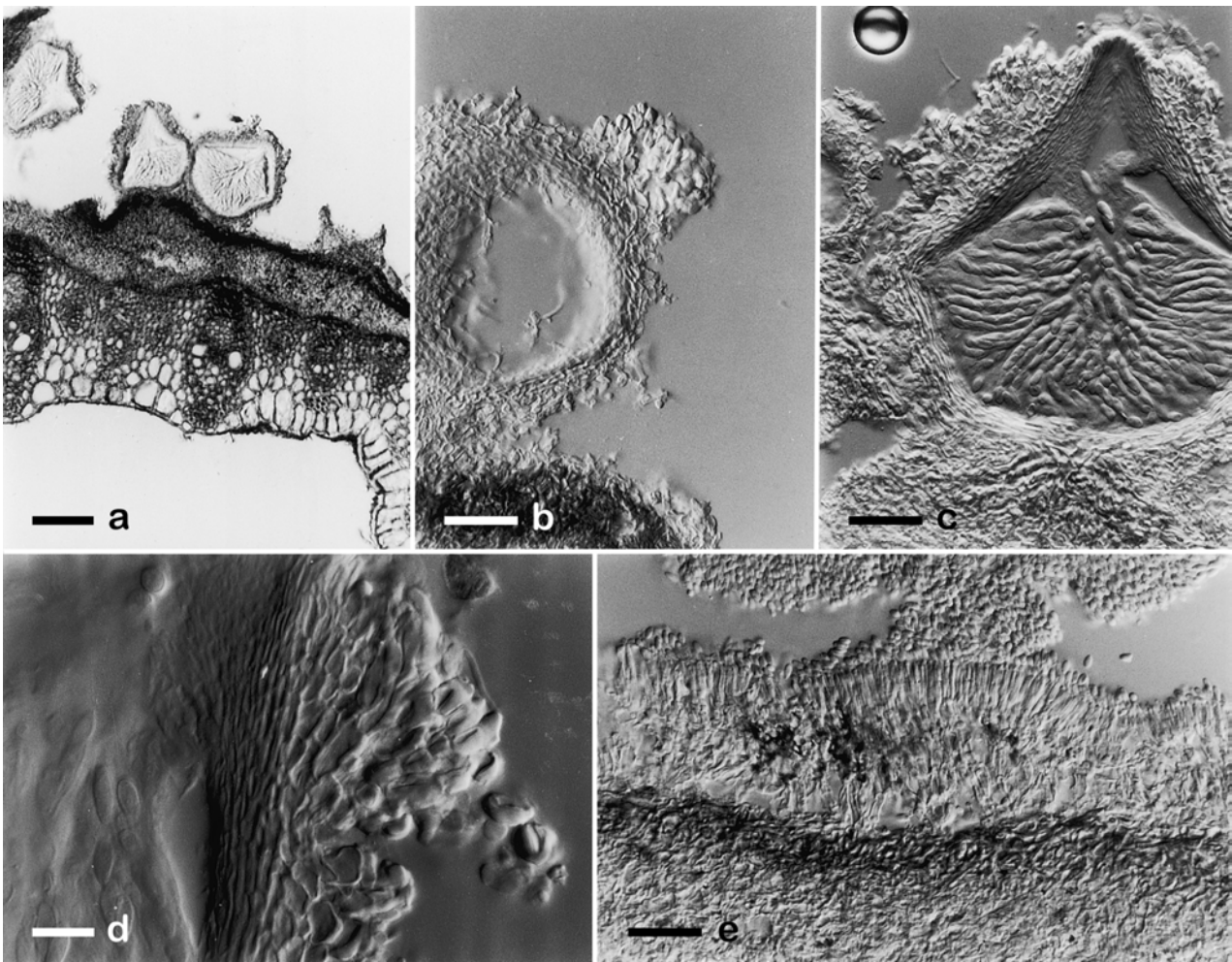
**Known distribution:** Tropical to temperate.

**Habitat:** Teleomorph on grasses, ferns, or bark, frequently on superficial or subcortical fungi, with hyphae arising from the perithecial base infiltrating the fungal host. Anamorphs known from ascospore isolations and conidial isolates from soil.

**Notes:** *Bionectria* subgenus *Astromata* is based on *Nectria epichloë* described by Spegazzini, who obviously mistook the dark stroma in the type specimen as belonging to the same fungus that produced the orange perithecia. The correct identity of the stroma was recognized later (Möller, 1901: 120–121; Samuels, 1988a). A possible preference of parasitism on clavicipitalean fungi (*Balansia*, *Epichloë*) has been discussed for *N. epichloë* (Samuels, 1988a), which could mean that its frequent occurrence on ferns or grasses is of secondary significance.

*Nectria epichloë* was transferred to *Nectriopsis* (Samuels 1988a) because of the small perithecia, their loose connection to the substratum, rather thin perithecial walls, heteropolar ascospores, and particularly because of its mycophilic habit. However, the species of subgenus *Astromata* differ considerably from *Nectriopsis violacea*, the type species of *Nectriopsis*, in perithecial wall anatomy, presence of sporodochia, morphology of the conidiophores, and conidial shape.

*Bionectria* subgenus *Astromata* is characterized by astromatic or weakly stromatic perithecia, perithecial walls of 2 regions, and a sporodochial anamorph forming green conidial masses (myrothecium-like). Additional characters are (i) gaps between adjacent cells of the outer perithecial wall region, (ii) somewhat heteropolar ascospores that have one more rounded and one more tapering end (Figs 54 g, 56 h), (iii) sporodochia sometimes consisting only of phialides, arising ± directly from aggregated angular cells (Fig. 56 j) in



**Fig. 53.** *Bionectria epichloë* (type) / *Clonostachys epichloë*. **a–d.** Sections through perithecia. **a.** Perithecia seated on dark layer that obviously belongs to host-fungus, *Balansia* sp., covering the leaf surface of a grass. **b.** Perithecial wart. **c.** Somewhat ampulliform perithecium. **d.** Perithecial wart covered by cells with unevenly thickened walls. **e.** Conidiophores densely scattered on substratum, not organized in discrete sporodochia. — All from Balansa 3432, natural substratum, DIC. Scale bars: a = 100  $\mu$ m; b, c, e = 30  $\mu$ m; d = 10  $\mu$ m.

addition to penicillate conidiophores and sporodochia (Figs 55 c, 57 g; Samuels, 1988a: Fig. 28 A, B), and (iv) clavate conidia with slightly laterally protruding hila (Figs 55 d, 57 f, 58 f).

Penicillate conidiophores, asymmetrical conidia, mostly warted ascospores, cells with unevenly thickened walls in the perithecial warts, an outer perithecial wall region consisting of angular to subglobose cells, the fungicolous habit, and the overall morphology of the asci link the subgenus *Astromata* to *Bionectria*. The close relatedness of subgenus *Astromata* to other subgenera of *Bionectria* also is suggested by rDNA sequence analyses (Schroers, 2000).

**22. *Bionectria epichloë*** (Speg.) Schroers, *comb. nov.* — Figs 53 a–d, 54 a–j, 55 a, b.

≡ *Nectria epichloë* Speg., *Anales Soc. Ci. Argent.* 19: 39. 1885.

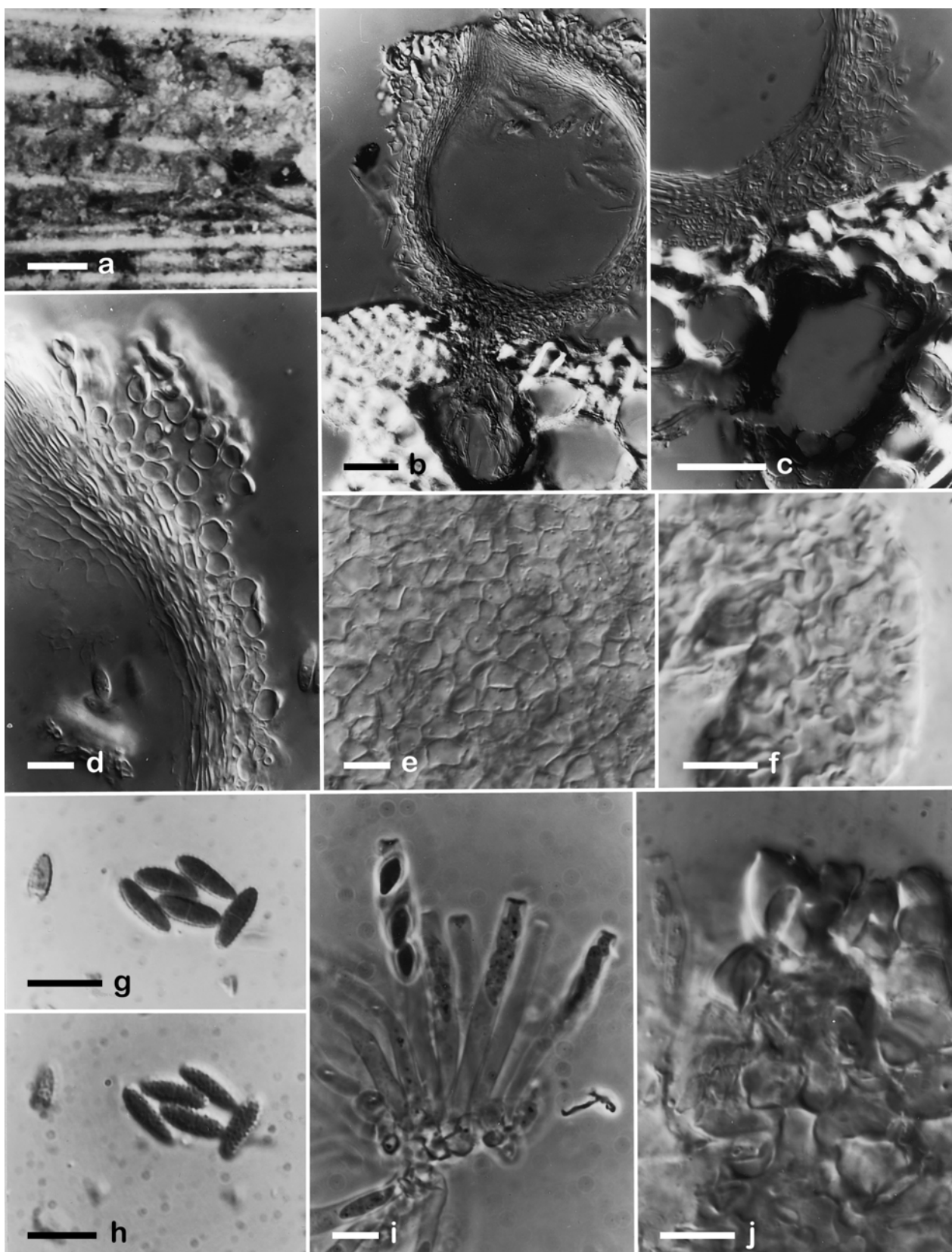
≡ *Nectriopsis epichloë* (Speg.) Samuels, *Mem. New York Bot. Gard.* 48: 69. 1988.

Anamorph: *Clonostachys epichloë* Schroers, *stat. nov.* — Figs 53 e, 55 c, d, 57 e–l.

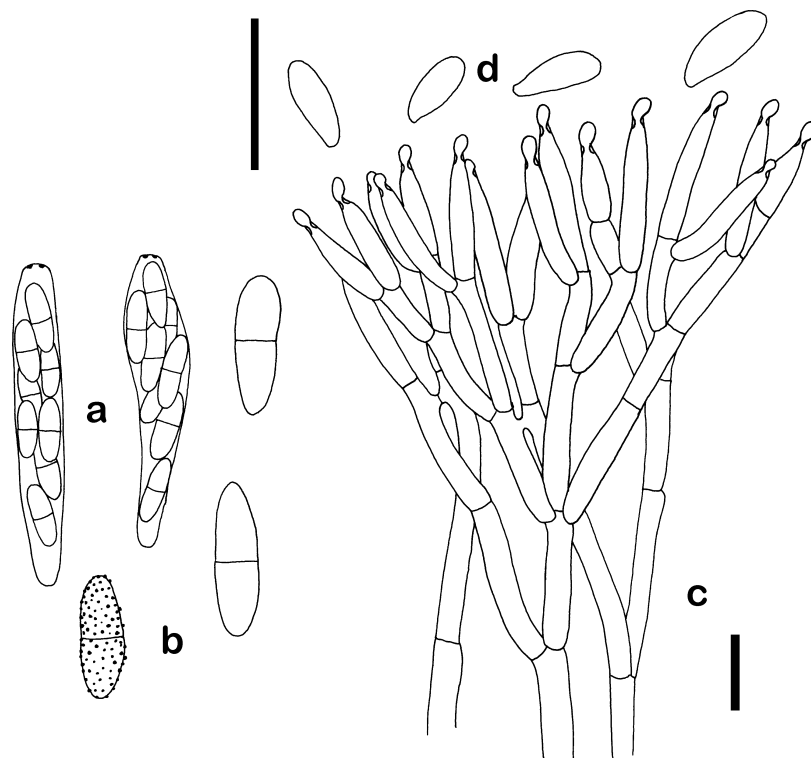
Conidiophora monomorphica, penicillata, dense aggregata vel sporodochialia. Phialides plerumque binae in quaque metula. Conidiorum massa fusce viridis. Conidia fere regulariter catenata, dilute viridia, anguste clavata, hilo paulo laterali, apice rotundato, (4.8–)6–6.6–7(–9.6)  $\times$  (1.6–)2.2–2.6–2.8(–3.6)  $\mu$ m.

Holotypus anamorphosis: PDD; cultura sicca, isolata ex specimine PDD 46484 (PDD); isotypus herb. CBS; cultura viva CBS 101037.

**Description from natural substratum:** **Stroma** absent. **Perithecia** associated with fungi on grasses or ferns, solitary to gregarious, seated loose on the superficial or subcortical fungal host, 140–240  $\mu$ m high, 140–200  $\mu$ m diam, tapering in the upper part, particularly when dry, minutely papillate, apically or laterally pinched when dry, pale yellow to orange to brownish, finely warted, particularly in the upper part. **Perithecial warts** ca 30  $\mu$ m high; cells with unevenly thickened walls up to 6  $\mu$ m thick, inwards with uniformly



**Fig. 54.** *Bionectria epichloë* (Japanese specimen). **a.** Habit of solitary to gregarious perithecia. **b–d.** Sections through perithecia and substratum; perithecium; hyphae connecting perithecium to another subcortical fungus (b, c); lateral perithecial wall consisting of two regions; cells of outermost region and of warts subglobose; walls of adjacent cells loosely connected (d). **e, f.** Surface and subsurface view of lateral perithecial wall; outer region of angular cells (e); inner region of lobed cells; walls with ‘pseudopores’. **g, h.** Discharged ascospores in optical section (g) and surface view showing ornamentation (h). **i.** Immature asci. **j.** Perithecial wart in squash mount; cells with unevenly thickened walls. – a–d, g, h: PDD 46482; e, i: PDD46484; f: G.J.S. 6266; j: Dumont-VE 5256. All from natural substratum. a: DM; b–j: DIC; g, h stained with cotton blue. Scale bars: a = 250  $\mu$ m; b, c = 30  $\mu$ m, d–j = 10  $\mu$ m.



**Fig. 55.** *Bionectria epichloë* / *Clonostachys epichloë*. **a.** Almost mature asci. **b.** Discharged, somewhat unevenly 2-celled ascospores. **c.** Conidiophores from sporodochial aggregate with anastomoses between cells from different conidiophores; phialides and branches mostly in groups of two. **d.** Conidia. – All from PDD 46482 (G.J.S. 83-298). **a, b:** natural substratum; **c, d:** dried colonies. Scale bars = 10  $\mu\text{m}$ ; the shorter bar applies to **a, c**, the longer to **b, d**.

thickened walls, similar to the cells of the outer perithecial wall region. **Perithecial wall** *ca* 25  $\mu\text{m}$  thick, consisting of 2 regions. Outer region *ca* 15  $\mu\text{m}$  or 2–3 cells thick; cells angular to subglobose, thin-walled, merging with the cells of the warts, 4.5–10.5  $\times$  3.5–8  $\mu\text{m}$ ; walls of adjacent cells in the outer layers not firmly connected with each other. Inner region *ca* 10  $\mu\text{m}$  thick. **Asci** clavate to narrowly clavate, (32–) 37–43–47(–65)  $\times$  (5–)7–8–9(–10)  $\mu\text{m}$  ( $n = 63$ ), 8-spored; apex rounded to truncate; ring visible. **Ascospores** ellipsoidal, 1-septate, somewhat heteropolar, finely spinulose or smooth, colourless, (7.2–)9–9.8–10.8(–13)  $\times$  (2.4–)3–3.4–4(–4.4)  $\mu\text{m}$  ( $n = 125$ ). **Conidiophores** penicillate, frequently with 2 branches or phialides arising from the supporting cell, densely scattered, aggregated, forming a palisade, covering the area between the perithecia, or sporodochial; sporodochia formed on a minute erumpent prosenchymatous stroma or from the white mycelium on the substratum, to 700  $\mu\text{m}$  diam, flat (e.g. 250  $\mu\text{m}$  high).

**Description from culture:** **Colonies** reaching *ca* 25 mm diam in 7 d at 24°C; optimum 18–24°C (20–25 mm diam); maximum at 27–30°C. Colony reverse without pigmentation, or pale yellow (4A2) (OA) or greenish because of the translucent coloration of the conidial masses. Colony surface almost smooth or finely cottony, white because of scanty production of aerial mycelium, with time dark green (29F7) because of the conidial masses. **Sporodochia** appearing at first

as distinct white pustules, with time coalescing. **Conidiophores** in young sporodochia somewhat divergently branched, in developed sporodochia adpressed, *ca* 200  $\mu\text{m}$  high. **Phialides** typically paired per supporting cell, cylindrical or somewhat narrowly flask-shaped, narrowing in the uppermost part, without a visible collarette, (7–)12–14.8–17(–29)  $\mu\text{m}$  long, (2.2–) 2.4–2.6–3(–3.2)  $\mu\text{m}$  at base, (0.8–)1–1.2–1.2(–1.6)  $\mu\text{m}$  wide near aperture ( $n = 63$ ). **Conidia** in linear chains with somewhat overlapping ends, greenish hyaline, ellipsoidal to narrowly clavate, slightly curved near the hilum, with a slightly protruding hilum and a rounded distal end, (4.8–)6–6.6–7(–9.6)  $\times$  (1.6–)2.2–2.6–2.8(–3.6)  $\mu\text{m}$  ( $n = 153$ ). **Conidial masses** dark green (28–29F7) watery to slimy, becoming dry on older sporodochia; several conidial chains forming dense, parallel aggregates. Colour of conidial masses depending on pH, green *in vivo*, water, and lactic acid, brownish in KOH.

**Type for *Nectria epichloë*:** BRAZIL. Guarapí; on *Andropogon* sp., Balansa 3432, Dec 1882 (LPS). **Type for *Clonostachys epichloë*:** JAPAN. Gunma Prefecture, Marunuma-ko; on *Sasa* sp.; 20 Aug 1983; R.P. Korf [dried culture of CBS 101037 (= G.J.S. isolate 83-301) derived from ascospores of PDD 46484 and filed with it (PDD), isotype: herb. CBS.

**Known distribution:** The Neotropics, U.S.A. (Georgia), Japan.

**Habitat:** On stromata of *Epichloë* sp. and *Balansia* sp. on grasses; dead rhachies of ferns (*Pteridium aquilinum*), *Sasa* sp., and other grasses.

**Published descriptions and illustrations:** Samuels (1988a).

**Additional specimens/strains examined:** JAPAN. Mori Institute; on unidentified *Graminae*; 24 Aug 1983; G.J.S. (PDD 46482; G.J.S. isolate and specimen 83-298). – Gunma Prefecture, Marunuma-ko; on *Sasa* sp.; 20 Aug 1983; R.P. Korf (PDD 46484; G.J.S. isolate 83-301, CBS 101037). – GUYANA. Vic. Kopinang Village, disturbed forest, 04°58' N, 59°50' W, 670 m alt.; on dead rachis of *Pteridium aquilinum*; 24 Jun 1989; G.J.S., B.M. Boom, G. Bacchus (NY, BRG, G.J.S. 6266; G.J.S. isolate 89-54). – VENEZUELA. Edo. Monagas: La Carmelita, Hacienda Las Acacias, SE of Caripe; on unidentified fern; 17 Jul 1972; K.P.D., R.F. Cain, G.J.S., G. Morillo, F. Malave (NY, Dumont-VE 5256; C.T.R. isolate 72-158). – U.S.A. Georgia: Newton Co.; on stroma of *Balansia henningsiana*; Oct 1978; Bacon (PDD 40125; C.T.R. isolate 79-207; specimen not seen, characters evaluated using unpublished notes provided by Samuels). – BRAZIL. Santa Catarina, Blumenau; on *Andropogon*; Möller 28a (S, herb. Bresadola; type for *Nectria epichloë* var. *rosea*, not seen, cited after Samuels, 1988a).

**Notes:** Perithecia in the type specimen of *B. epichloë* are densely aggregated (Fig. 53 a) and cover large parts of the substratum (of up to 4 cm along and ± surrounding the grass culm). On the grass, perithecia of *B. epichloë* are more or less restricted to the area covered by fruiting structures of the host fungus. A similar situation is seen in specimens from Japan, however, possibly because the host fungus only consists of isolated, solitarily occurring fruiting bodies, perithecia of *B. epichloë* occur singly or in discrete groups of only a few (Fig. 54 a, b). Similarly, conidiophores are rather densely gregarious on the fungal host in the type specimen (Fig. 53 e) while the sporodochia occur more distinctly on the specimens from Japan (Fig. 57 g). Despite the differences in the habit of the perithecia (solitary vs. densely aggregated covering large spots), the Japanese specimens are identified as *B. epichloë* because of their perithecial wall anatomy, size of ascospores, and characters of the anamorph such as conidiophore branching pattern, conidial size and shape. Until now, the anamorph of *B. epichloë* has only been found in connection with the teleomorph. Conidia of *B. epichloë* are similarly asymmetrical to those of species in subgenus *Bionectria*, but are distinguished by a somewhat protruding hilum (Figs 55 d, 57 e, f).

### 23. *Bionectria parva* Schroers, *sp. nov.* — 56 a–i.

Anamorph: *Clonostachys ?miodochialis* — Fig. 56 j.

Perithecia solitaria, laxe connexa, minute verrucolosa. *Bionectriae epichloë* similes sed ascosporis (10–)12.2–13–13.4(–15.8) × (2.8–)3.4–3.8–4(–4.6) μm. Anamorphosis *Clonostachydi miodochiali* similis. Conidia (4.6–)5.4–5.6–6(–6.6) × (1.8–)2.2–2.4–2.6(–3) μm.

Holotypus teleomorphosis: Specimen Dumont-VE 1147 (NY).

Etymology: Latin *parvus*, referring to the small perithecia.

**Description of the teleomorph from natural substratum: Teleomorph** similar to *Bionectria epichloë*. **Perithecial warts** containing cells with unevenly thickened walls up to 5 μm thick; cells 4–9.5 × 3–8 μm. **Perithecial wall** 20–25 μm thick, composed of two regions. Outer region *ca* 15 μm or 2–3 cells thick; cells subglobose to angular, 4.5–10.5 × 3.5–8 μm, intergrading with the cells of the warts. **Asci** not observed. **Ascospores** ellipsoidal, 1-septate, somewhat heteropolar with a rounded and a more tapering end, finely spinulose, colourless, (10–)12.2–13–13.4(–15.8) × (2.8–)3.4–3.8–4(–4.6) μm (n = 34). **Sporodochia** and mycelium not observed on the natural substratum.

**Description of the anamorph from culture (ex ascospores, dead): Phialides** on prosenchymatous, partly swollen cells, arranged to dense aggregates of *ca* 100 μm diam, sporodochial, (6–)7.4–8.8–9.6(–12.2) μm long, (1.4–)2–2.2–2.4(–2.8) μm at base, (1.6–)2.4–2.6–2.8(–3.2) μm at widest point, (0.8–)1–1.2–1.2(–1.4) μm wide near aperture (n = 73). **Conidia** ellipsoidal to narrowly clavate, with a slightly protruding hilum and a rounded distal end, (4.6–)5.4–5.6–6(–6.6) × (1.8–)2.2–2.4–2.6(–3) μm (n = 47).

**Type for *Bionectria parva*:** VENEZUELA. Edo. Aragua: Path between hotel and hotel's water source, Rancho Grande, Parque Nac. Henry Pittier; on unidentified wood; 3 Jul 1971; K.P.D., J.H. Haines, G.J.S. (NY; Dumont-VE 1147; C.T.R. isolate 71-303, ex ascospores, no longer viable).

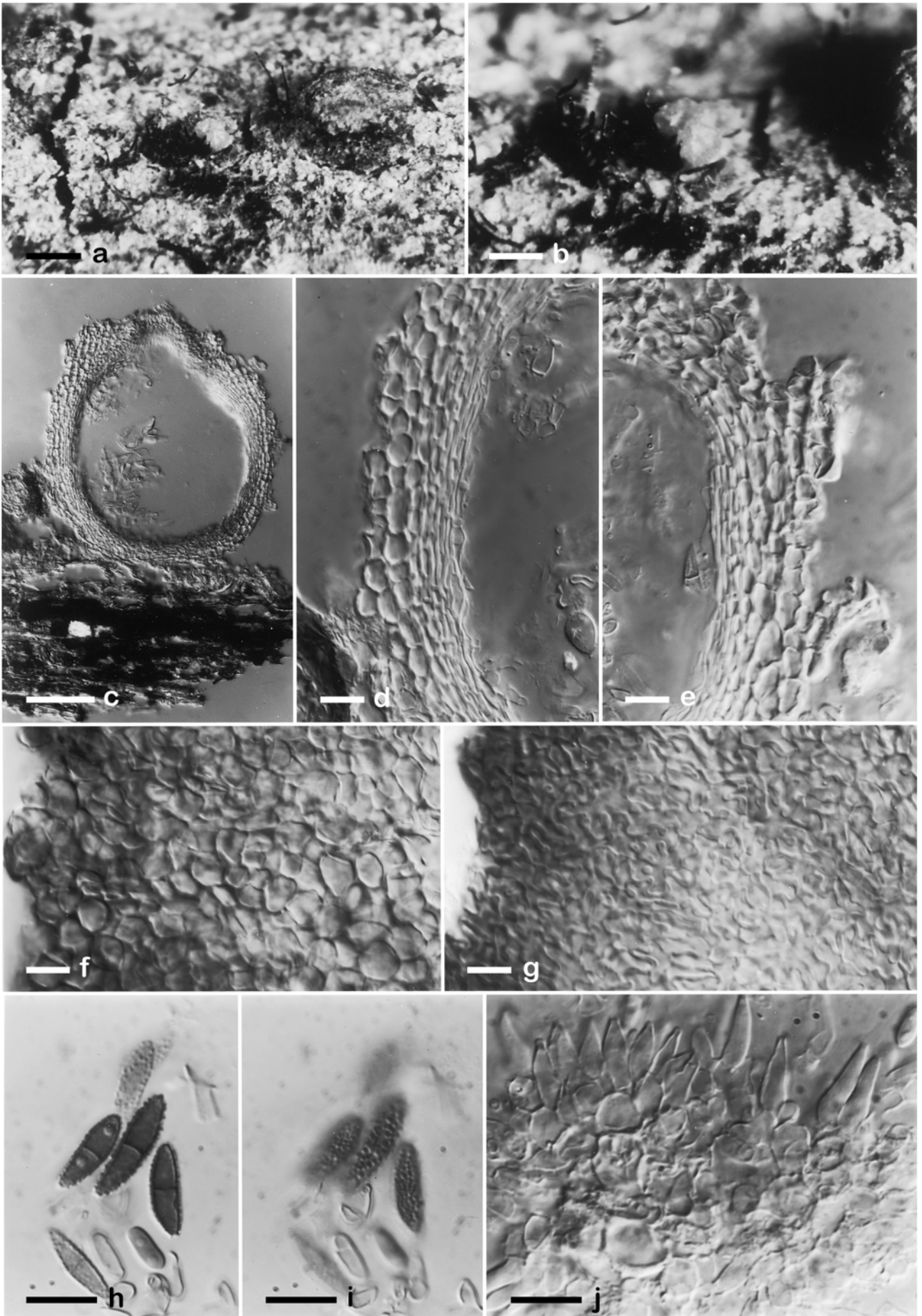
**Known distribution:** Venezuela.

**Habitat:** Known from bark of branch.

### 24. *Clonostachys miodochialis* Schroers, *sp. nov.* — Figs 57 a–d, 58 a–f.

Conidiophora sporodochialia vel raro penicillata; phialides sporodochiales e cellulis subglobosis vel ex hyphis inflatis oriundae. Conidia *Clonostachydi epichloëi* similia, leviter clavata, catenata vel modice imbricata, (5.2–)5.8–6.6–7.2(–8) × (1.8–)2.6–2.8–3(–3.4) μm; catenae in massa atroviridi, myrothecii simili collabentes.

Holotypus anamorphosis: cultura sicca, isolata ex cultura viva CBS 997.69.





Etymology: Greek *meion* (smaller) referring to the small sporodochial conidiomata.

Teleomorph: ?*Bionectria parva*.

**Description of European isolates from culture** (compare with *B. parva*, Fig. 56 j): **Colonies** reaching ca 20 mm in 7 d at 24°C; optimum for growth 18–24°C (18 mm diam), maximum 27°C. Colony reverse without pigmentation on CMD, pale yellow (4A2) on OA and PDA, with time spotted or entirely olive grey (3E2) because of the conidial sporulation on agar surface, light orange (4–5A4–5) under permanent UV. Colony surface on CMD sparsely white cottony to smooth, with minute green granular sporodochia; on OA and PDA white to yellowish white cottony because of a mat of sterile aerial mycelium, with small sporodochia, on OA and PDA later densely granular, dull green to dark green (28E–F4), with sporodochia covering most of the colony. **Conidiophores** variable, somewhat penicillate or with irregularly scattered phialides on short supporting cells or arising directly from hyphae or angular cells. **Penicillate conidiophores** mainly seen at the margin of the colony, loosely aggregated from stipe-like hyphae; stipes to 50 µm long; penicillus with irregular, mostly adpressed and anastomosed with each other; branching in the penicillus without a regular pattern, frequently with 2 terminal phialides. **Other conidiophores** with phialides on short supporting cells scattered along hyphae, or on irregularly branched conidiophores, or from aggregates of angular to globose cells within a sporodochium. **Phialides** slender flask-shaped to cylindrical, widest near the middle, in the upper part slightly and continuously tapering, without a visible collarette, (6.4–)10.4–14–15(–25.6) µm long, (2.2–)2.6–2.8–3(–3.2) µm at base, (2.4–)2.6–3–3.2(–3.4) µm at widest point, (0.8–)1–1.2–1.4(–1.6) µm wide near aperture (n = 73). **Conidia** in almost linear chains with somewhat overlapping ends, greenish hyaline, ellipsoidal to narrowly clavate, with a slightly laterally protruding hilum and a rounded distal end, somewhat imbricate, with overlapping ends, greenish hyaline, narrowly clavate to slightly curved to ellipsoidal, with a somewhat laterally protruding base, sometimes also broadly clavate, (5.2–)5.8–6.6–7.2(–8) × (1.8–)2.6–2.8–3(–3.4) µm (n = 86). **Conidial masses** of sporodochia consisting of numerous parallel, vertical chains, forming long and broad columns that remain stable in older colonies.

**Perithecial primordia** light orange, formed as stromatic structures of up to 400 µm diam on the agar surface in older OA cultures, remaining immature.

**Type for *Clonostachys miodochialis*:** NETHERLANDS. Oostelijk Flevoland; from agricultural soil; 1 Jul 1969; J.W. Veenbaas-Rijks 1269 (herb. CBS; dried culture ex CBS 997.69).

**Known distribution:** Europe.

**Habitat:** Soil.

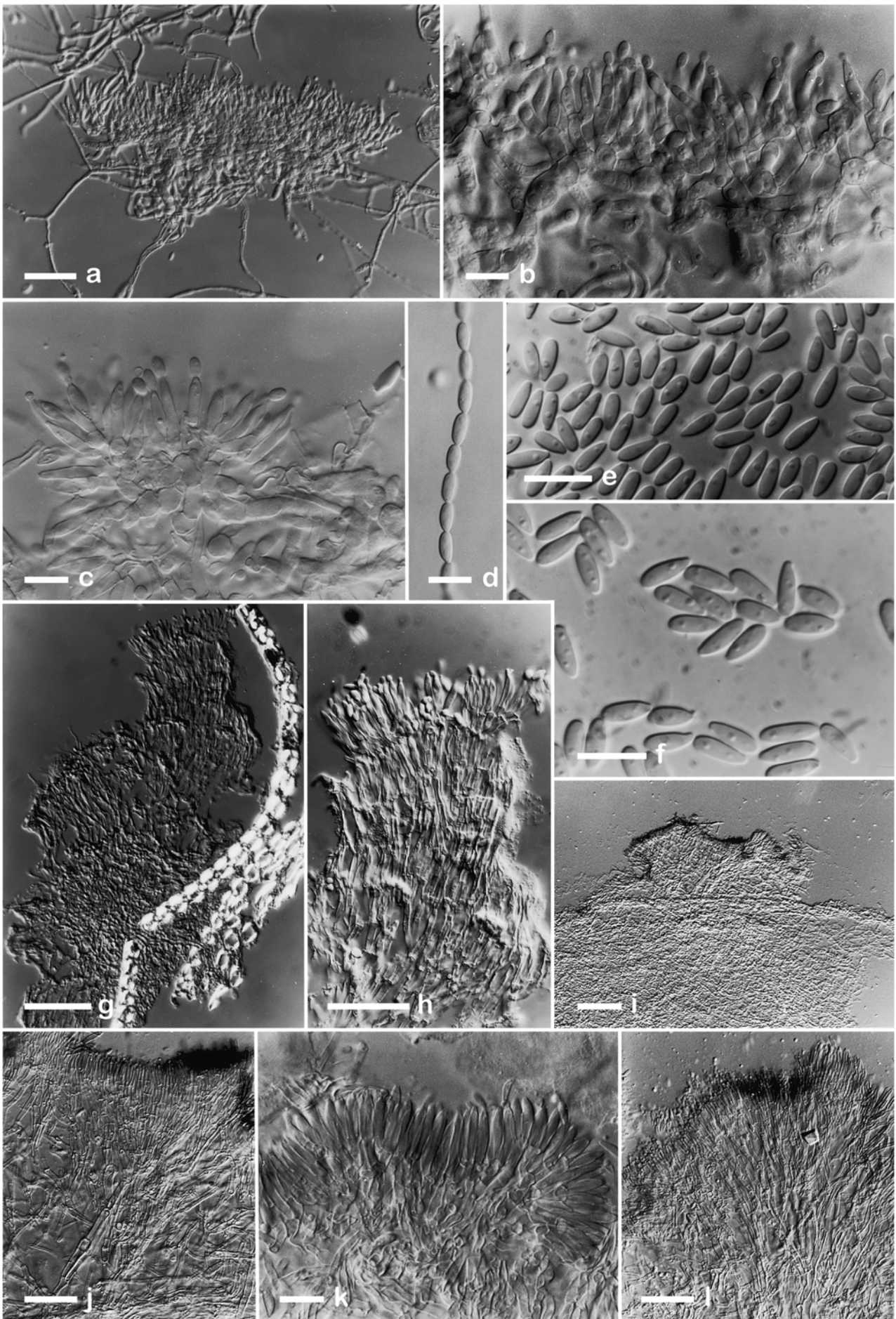
**Additional strain examined:** GERMANY. Berlin (CBS 647.91).

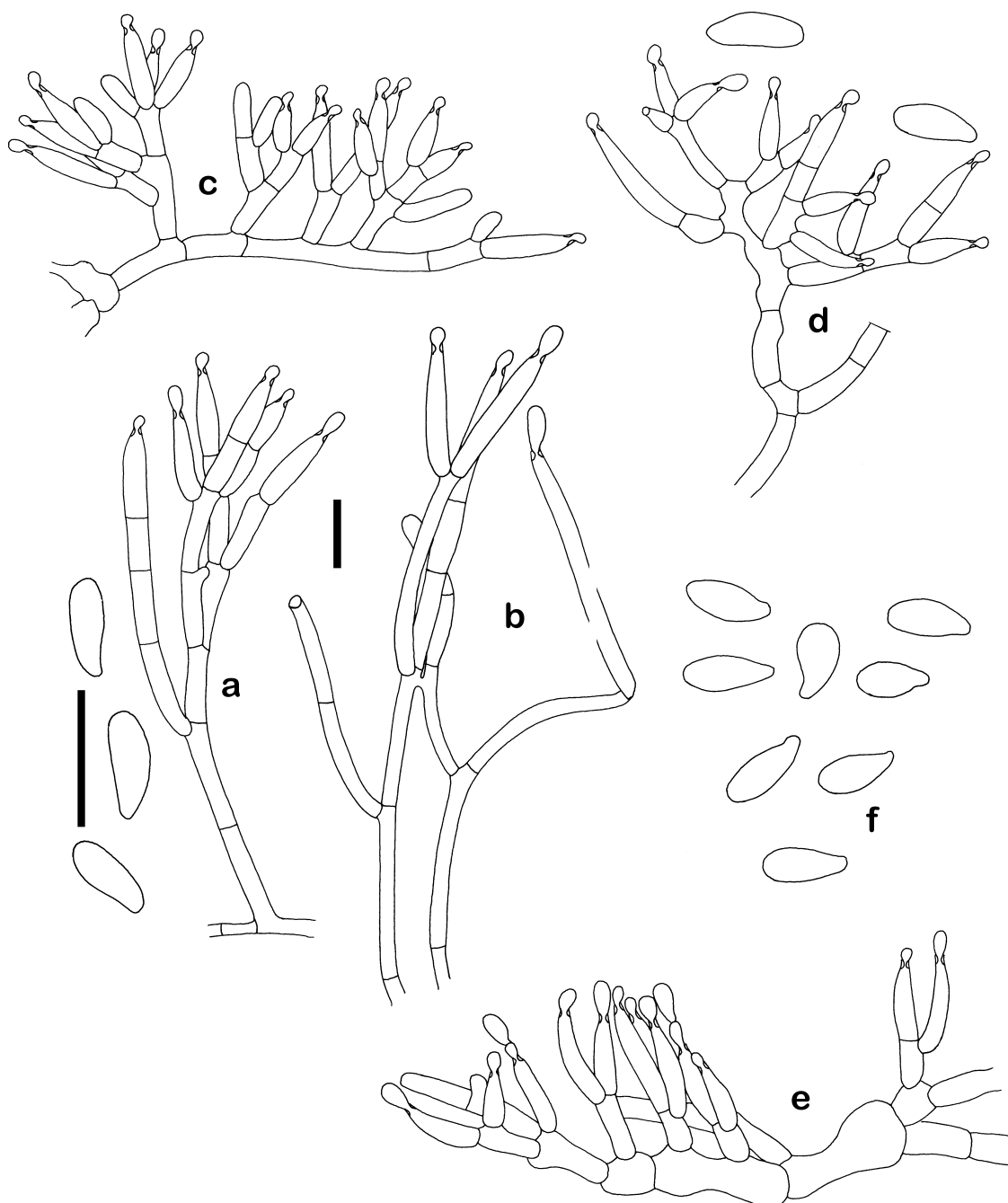
**Notes:** *Bionectria parva* differs from *B. epichloë* in longer ascospores (compare Fig. 54 g and Fig. 56 h), shorter conidia, and characters of the sporodochia. While the sporodochia of *B. parva* consist of phialides seated on aggregates of angular cells (Fig. 56 j), those of *B. epichloë* consist of penicillate conidiophores (Fig. 57 g–l). In common with *B. epichloë*, *B. parva* has a perithecial wall consisting of 2 regions (Fig. 56 d–g), perithecia loosely connected to the substratum (Fig. 56 c), no perithecial stroma, and green conidial masses.

The close relationship between the tropical *B. parva* (Dumont-VE 1147; C.T.R. 71-303) and the two European soil isolates of *C. miodochialis* (CBS 997.69 and CBS 647.91) is indicated by morphologically similar sporodochia (compare Fig. 56 j and Fig. 57 a–c). They may belong to the same species. Because the link between the tropical teleomorph and the European conidial isolates could not be proven by means of comparison of living cultures or DNA-data, the holomorph of *B. parva* and the anamorph of *C. miodochialis* are described separately.

Sporodochia of *B. parva* and *C. miodochialis* differ considerably from those found in *B. epichloë* and other species of *Bionectria*. Although somewhat penicillate conidiophores were also seen (Fig. 58 a, b), the phialides are typically formed on short cells that are scattered on frequently swollen hyphal cells or directly on angular to globose cells (Figs 56 j, 57 b, c, 58 c–e). While a close relationship of *B. epichloë* and *C. miodochialis* is supported by the sequence analysis of rDNA and *tub2*, the species are separated by several nucleotide differences (Fig. 2; Schroers, 2000: Figs 1, 2).

**Fig. 56. *Bionectria parva* / *Clonostachys miodochialis*.** a, b. Habit of solitary or aggregated perithecia. c–e. Sections through perithecia and substratum; whole perithecium superficial on bark (c); lateral perithecial wall consisting of two regions (d) and with warts (e). f, g. Surface and subsurface views of lateral perithecial wall; outer region consisting of angular cells (f); inner region consisting of lobed cells with ‘pseudopores’ (g). h, i. Discharged, somewhat unevenly 2-celled ascospores in optical section (h) and surface view (i) showing ornamentation. j. Section through sporodochium consisting of phialides aggregated on swollen cells. – All from Dumont-VE 1147 (C.T.R. 71-303); a–i: natural substratum; j: dried CMD colony. a, b: DM; c–j: DIC; h, i stained with cotton blue. Scale bars: a = 300 µm; b = 150 µm; c = 50 µm; d–j = 10 µm.





**Fig. 58.** *Clonostachys miodochialis*. **a–e.** Conidiophores or systems of conidiophores; penicillate conidiophores (**a**, **b**); irregularly branched conidiophores (**c–e**), typically with short conidiophores scattered on main branch (**c**) or aggregated on swollen cells (**e**). **f.** Conidia. – **a**, **c**, **f** (left): CBS 647.91; **b**, **d**, **e**, **f** (right): CBS 997.69. All from 7–10-d-old OA cultures. Scale bars = 10  $\mu\text{m}$ ; the shorter bar applies to **a–e**, the longer to **f**.

**Fig. 57 a–d.** *Clonostachys miodochialis*. **a–c.** Sections through sporodochia. **a.** Overview. **b**, **c.** Phialides mostly in groups of 2 on short cylindrical cells (**b**) or on swollen, almost globose cells (**c**; compare **b** and **c** with Fig. 56 **j**). **d.** Conidia arranged in almost linear chain. **e–l.** *Clonostachys epichloë*. **e**, **f.** Clavate conidia with slightly laterally protruding hila. **g–l.** Sections through sporodochia. – **a**, **b**: CBS 997.69; **c**, **d**: CBS 647.91; **e**, **g**, **h**: PDD 46484 (CBS 101037); **f**: G.J.S. 6266; **i–l**: CBS 101037. **a–d**, **i–l** from 10-d-old OA colonies; **e**, **g**, **h** from natural substratum; **f** from dried CMD colony. All: DIC. Scale bars: **a**, **h**, **j**, **l** = 30  $\mu\text{m}$ ; **b–f**, **k** = 10  $\mu\text{m}$ ; **g** = 50  $\mu\text{m}$ . **i** = 100  $\mu\text{m}$ .

**BIONECTRIA SUBGEN. MYRONECTRIA** Schroers, *subgen. nov.* — Species 25.

Perithecia e stromate in substratis lignosis erumpente exorientia, dense coarctata, globosa vel subglobosa, verrucosa, pallide lutea ad pallide aurantiaca, verrucis pallidioribus. Cellulae stromatis hyphis similes, prosenchymaticae vel pseudoparenchymaticae. Tunica perithecii e tribus stratis composita; stratum exterius e cellulis angularibus vel subglobosis; stratum medium e hyphis, cellulis stromatis similibus; stratum interius e cellulis lobatissimis. Ascosporeae ellipsoideae, uniseptatae, levigatae, saepe fabiformes. Anamorphoses myrothecii similes, omnino sporodochiales vel conidiophora penicillata solitaria. Conidia unicellularia, saepe ovoidea vel ellipsoidea, hilo mediano.

Type species: *Bionectria pityrodes* (Mont.) Schroers.

Etymology: Referring to the myrothecium-like anamorph.

Anamorphs: *Clonostachys* (myrothecium-like).

**25. Bionectria pityrodes** (Mont.) Schroers, *comb. nov.* — Figs 59 a–i, 60 a, b, 61 a, b.

= *Sphaeria pityrodes* Mont. in Sagra, Hist. Fis., Pol. Nat. Cuba 2 (Hist. Nat. 9) (IX Criptogamia o plantas cellulaires par Camilo Montagne): 205. 1845.

= *Nectria pityrodes* (Mont.) Mont., Syll. Pl. Crypt.: 224. 1856.

= *Nectria pityrodes* var. *saccharina* Berk. & Broome, J. Linn. Soc., Bot. 14: 117. 1873.

= *Nectria blumenaviae* Rehm, Hedwigia 37: 192. 1898.

= *Nectria juruensis* Hennings, Hedwigia 43: 244. 1904.

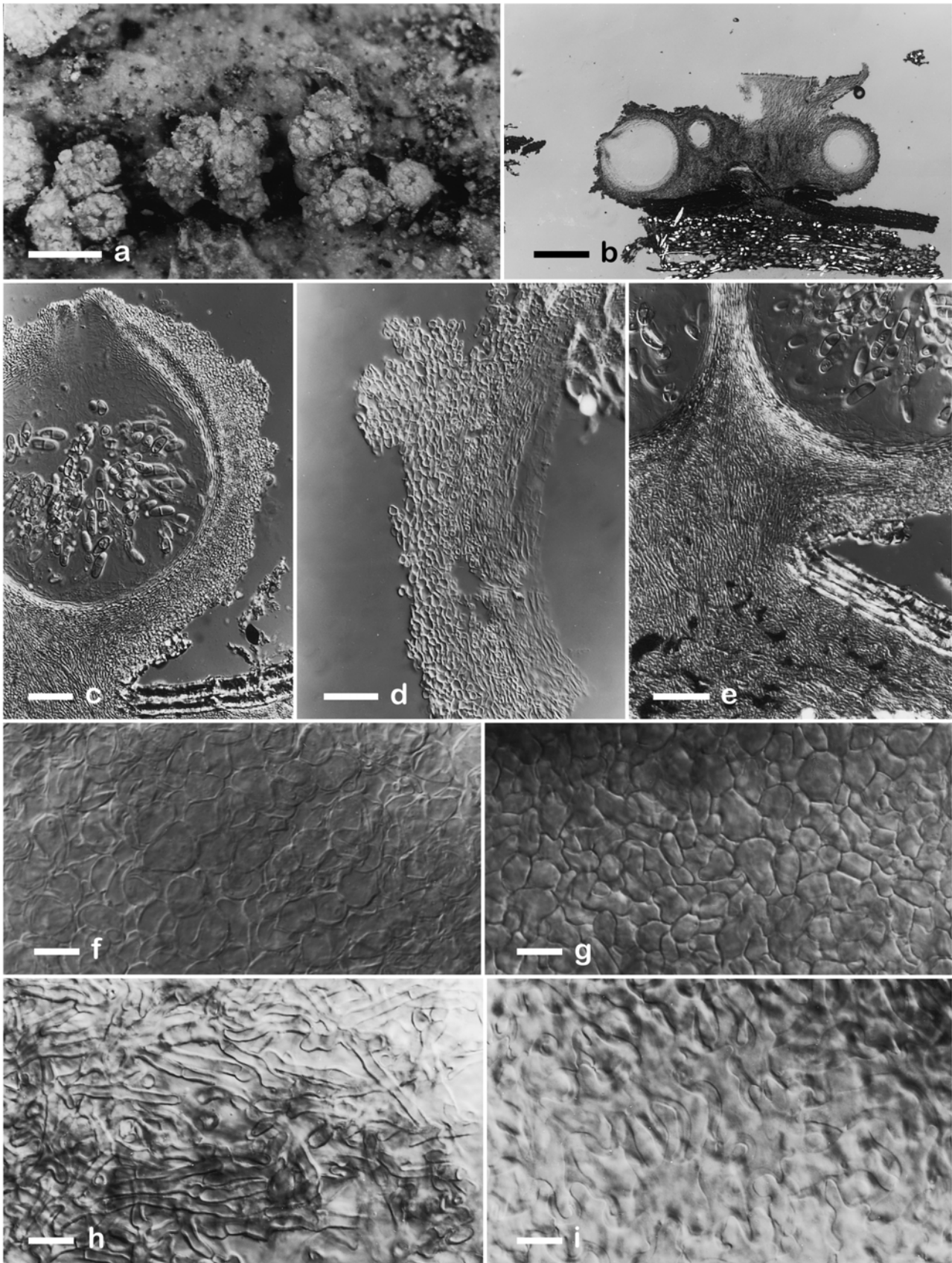
Anamorph: *Clonostachys pityrodes* Schroers, *stat. nov.* — Figs 59 b, 60 c–f, 61 c–g; Fig. 22 F in Samuels *et al.* (1990).

Conidiophora monomorphica, sporodochialia; sporodochia saepe cupulata vallo hypharum marginalium paulo supra hymenium protrudente. Conidia primum catenata, deinde ad massam viridem agglutinantia, ellipsoidea vel ovalia, utrinque rotundata, hilo invisibili vel medio, (4.8–)5.8–6.6–7.2(–9.0) × (2.4–)2.8–3–3.4(–4) µm.

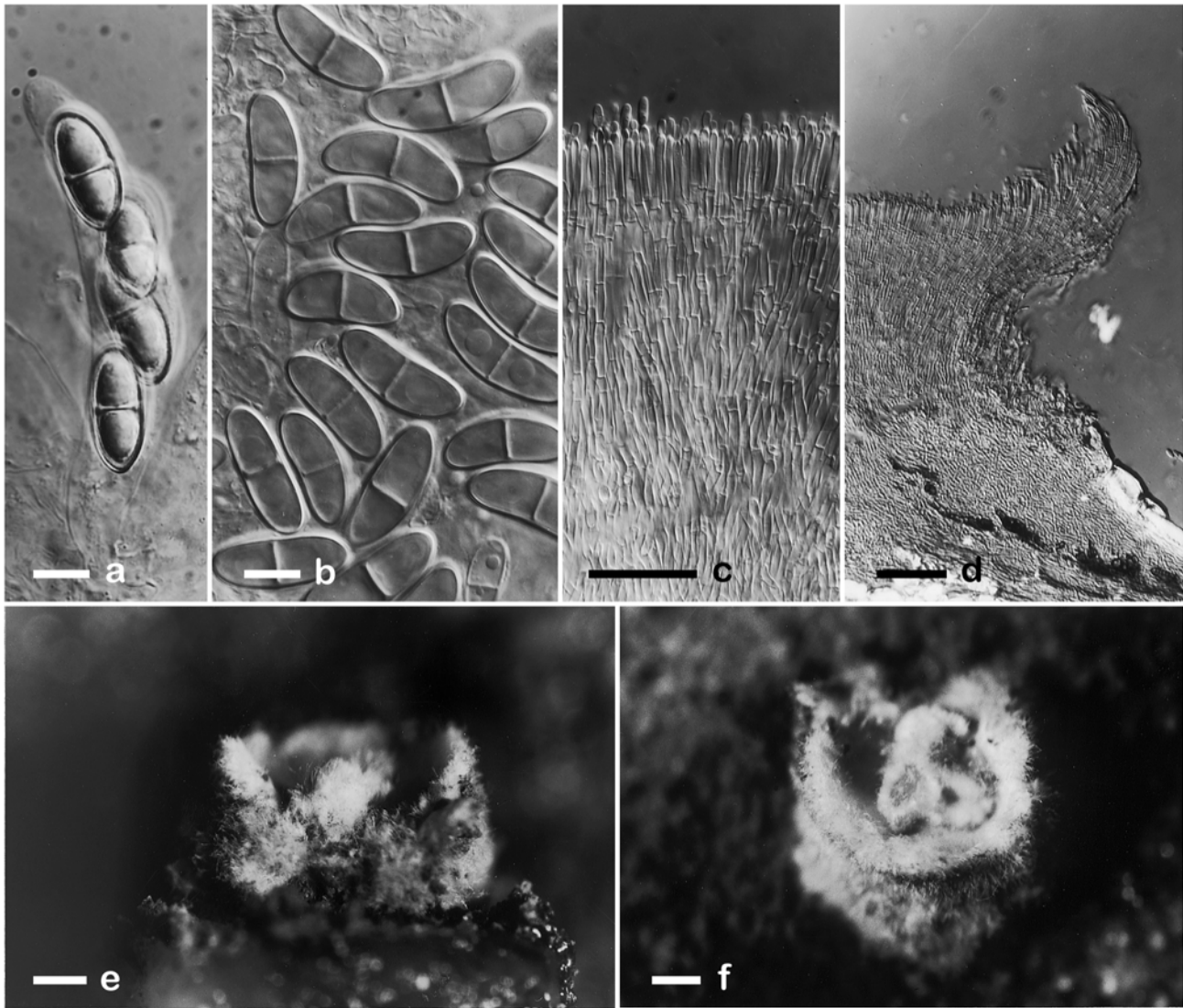
Holotypus anamorphosis: BPI; cultura sicca, isolata ex specimen BPI 737867 (BPI); isotypus herb. CBS; cultura viva CBS 102033.

**Description from natural substratum: Stroma** prosenchymatous, hyphal cells forming a *textura porrecta*. **Perithecia** formed on the stroma, or at the base of sporodochia, frequently also on the stroma of black pyrenomycetes, densely crowded in groups of 2 to up to 50, 300–600 µm diam, subglobose, subbasally and apically pinched when dry, yellowish orange to orange, with a warted surface. Perithecial warts small, orange; cells 4–13 × 3–10 µm, with uniformly thickened walls around 2 µm thick; adjacent cells with free space in between; vacuoles not observed. **Perithecial wall** 60–80 µm thick, consisting of three regions. Outer region 20–35 µm or 5–8 cells thick; cells angular to globose, continuous with the cells of the perithe-

cial warts, not merging with the prosenchymatous stroma. Middle region 17–21 µm thick, consisting of several (up to 8) layers of intertwined hyphae, forming a *textura intricata*, conspicuous even in longitudinal sections. Inner region to 15–30 µm thick. **Asci** clavate to broadly clavate, (64–)80.5–89–97(–133) × (7.5–)11.5–15–18.5(–23) µm (n = 41), frequently with a reduced number of ascospores; apex rounded, without a conspicuous ring. **Ascospores** slightly curved, bean-shaped, broadly rounded, ellipsoidal, equally two-celled, not constricted at the septum, smooth, rough, or very finely warted, particularly while in the ascus, somewhat brownish, (15.4–)24.2–26.8–29(–39.6) × (6.4–)8.2–9.2–10.2(–13.2) µm (n = 292), completely filling the ascus. **Sporodochia** flat or cupulate, olive-green because of the conidial masses, independently formed beside the perithecia or on or within the perithecial stroma, up to 650 µm wide and 450 µm high; margin of sporodochia white because of subhymenium mycelium or sterile marginal hyphae; base of the sporodochia prosenchymatous, erumpent through the bark, similar to the perithecial stroma; phialides and conidiophores densely aggregated in a *textura porrecta*. **Sterile mycelium** sometimes visible on the bark surface, white, surrounding the base of the perithecia or sporodochia. **Description from culture: Colonies** reaching 30–40 mm diam in 7 d at 24°C; optimum for growth 21–27°C (40 mm diam), maximum 33°C. Colony reverse not pigmented or somewhat orange under UV-light, with time becoming olive-grey (2E2) to olive (3E3). Colony surface on CMD with little aerial mycelium, almost smooth; on OA within 21 d finely to coarsely granular because of sporodochia or fluffy cottony if conidiophores or sporodochia arise within aerial mycelium; on PDA similar, but with more aerial mycelium. **Sporodochia** formed on a stroma or from aerial mycelium, up to 100 µm diam, in older colonies and particularly if formed on a stroma more than 2 mm diam, frequently cupulate with a palisade of marginal hyphae/conidiophores extending beyond the sporodochial hymenium. Stroma, if formed, orange, KOH–, oval to flat, up to 1.5 mm diam, originating from under the agar surface of older OA cultures. **Conidiophores** monomorphic, sporodochial, in young aggregates divergently branched, in sporodochia adpressed throughout, often anastomosing, irregularly penicillate, quinquies-verticillate or more. **Phialides** in irregular whorls of 2–5, often arising from 2 levels, slightly, widening towards the apex or straight, narrowing below the tip, without visible collarette (5.8–)13–14.4–16.4(–19.6) µm long, (1.4–)1.8–2–2.2(–3.2) µm wide at base, (1.6–)2.2–2.4–2.4(–3) µm wide subapically, the aperture generally less than 1.5 µm wide (n = 68).



**Fig. 59. *Bionectria pityrodes*.** **a.** Habit of crowded perithecia. **b–e.** Sections through stroma, perithecia, and sporodochium (**b**). **b.** Perithecia with cupulate sporodochium. **c, d.** Lateral perithecial wall consisting of three regions. **e.** Stroma erumpent through bark, prosenchymatous cells showing hyphal characteristics, continuous with inner perithecial wall region. **f–i.** Surface and subsurface views of perithecial wall regions; walls of adjacent, subglobose cells in outermost perithecial wall layers loosely connected (**f**); angular to subglobose cells of outermost perithecial wall region (**g**). **h.** Intertwined hyphae of middle region. **i.** Lobed Cells of inner region, with ‘pseudopores’. – **a–e:** Dumont-VE 3222; **f, h:** G.J.S. 898; **g, i:** Dumont-VE 3935. All from natural substratum. **a:** DM; **b:** LM; **c–i:** DIC. Scale bars: **a** = 500  $\mu$ m; **b** = 250  $\mu$ m; **c, e** = 50  $\mu$ m; **d** = 30  $\mu$ m; **f–g** = 10  $\mu$ m; **h, i** = 10  $\mu$ m.



**Fig. 60.** *Bionectria pityroides* / *Clonostachys pityroides*. **a.** Almost mature ascus containing 4 ascospores. **b.** Mature, bean-shaped ascospores in optical section. **c, d.** Longitudinal sections through mature sporodochia, phialides and conidiophores forming *textura porrecta*; sporodochium cupulate; margin consisting of sterile or fertile hyphae; base erumpent through bark, consisting of prosenchymatous cells. **e, f.** Cupulate sporodochium seen laterally (**e**, front removed) and from above (**f**). **a:** A.Y.R. 2409a; **b:** Korf 3959; **c, d:** Dumont-VE 3222; **e, f:** CBS 102033. **a–d:** natural substratum, DIC; **e, f:** 21-d-old OA culture. Scale bars: **a, b** = 10  $\mu\text{m}$ ; **c** = 30  $\mu\text{m}$ ; **d** = 50  $\mu\text{m}$ ; **e, f** = ca 65  $\mu\text{m}$ .

**Conidia** greenish hyaline to pale green, smooth, symmetrical (homopolar-polysymmetrical), oval, (4.8–) 5.8–6.6–7.2(–9.0)  $\times$  (2.4–) 2.8–3–3.4(–4)  $\mu\text{m}$  ( $n = 129$ ); hilum not or hardly recognizable, median; conidial chains linear, not imbricate, initially dry, with time sliming down into olive masses; in young sporodochia chains from neighbouring phialides frequently aggregated, columnar; columns from different conidiophores slightly separated from each other; colour of conidial masses, dark green (29F4) in vivo, in water and also in lactic acid, brownish in KOH.

**Type for *Sphaeria pityroides*:** CUBA. S. Marco; on bark of twigs (Montagne, 1856) (specimen not seen).

**Type for *Clonostachys pityroides*:** – MAURITIUS. Bois du Lait; on bark [dried culture ex CBS 102033

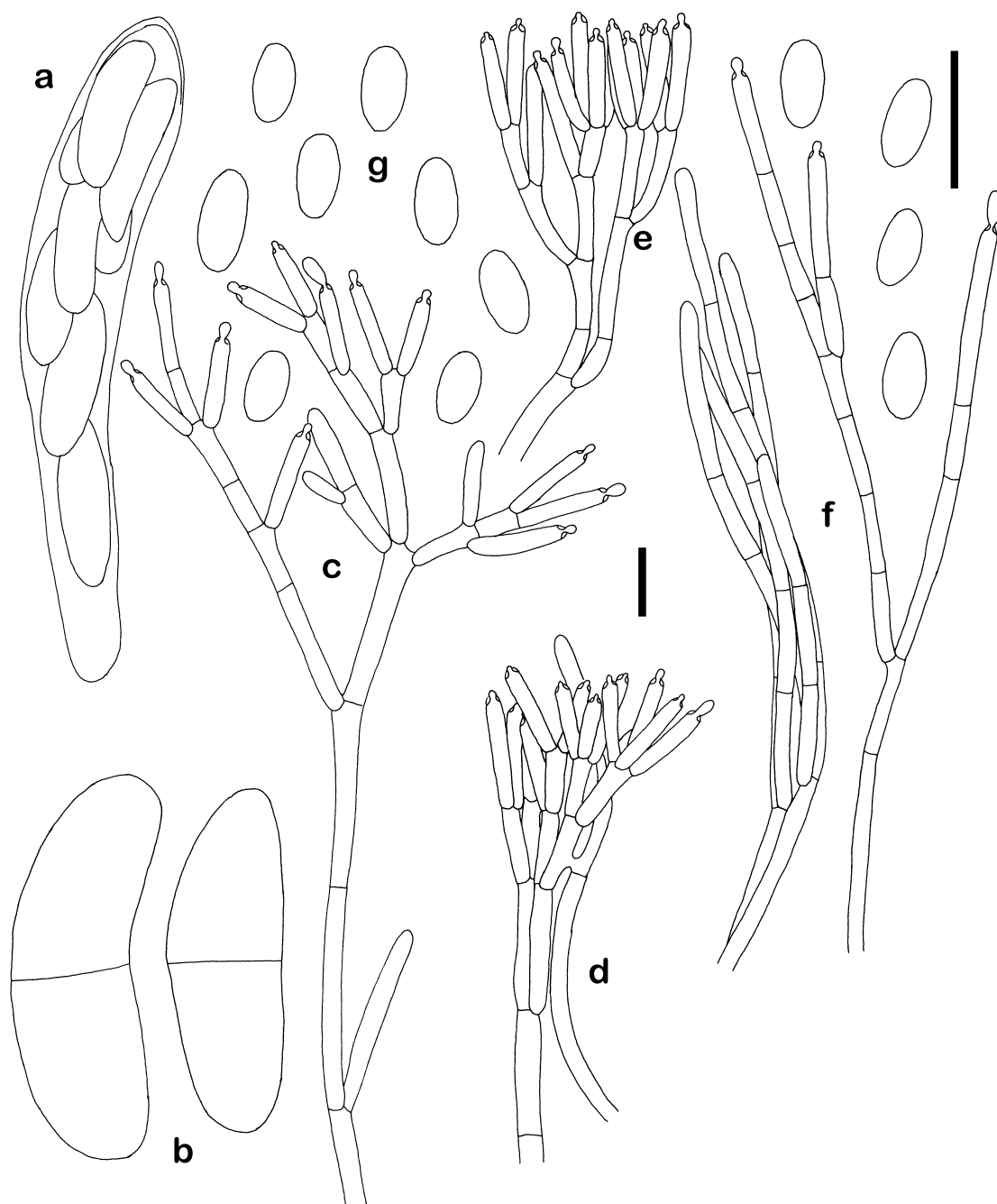
(= IMI 3663387, G.J.S. isolate 95-26), derived from ascospores of BPI 737867 and filed with it (BPI)].

**Known distribution:** Teleomorph frequent, pantropical. Anamorphic isolates unknown, although sporodochia sometimes occur without associated perithecia.

**Habitat:** On bark of recently dead woody plants, frequent on other pyrenomycetes.

**Published descriptions:** Samuels *et al.* (1990).

**Additional specimens/isolates:** BRAZIL. Manaus, Bairro Adrianopolis; on undetermined wood; 25 Jan 1984; G.J.S. (NY, G.J.S. Br 2; G.J.S. isolate 84-195). – Base of west-facing talus slope of Serra Araca, near central portion of Serra, about 45 min walk from lower airstrip, tall moist Igapó forest with



**Fig. 61.** *Bionectria pityrodes* / *Clonostachys pityrodes*. **a.** Immature ascus containing 8 still aseptate ascospores; apical ring invisible. **b.** Somewhat curved, bean-shaped, smooth-walled ascospores. **c–e.** Conidiophores; divergently branched from young sporodochial pustules (c), addressed in sporodochia or sporodochial aggregates (d, e); sometimes connected by anastomoses (d). **f.** Sterile or fertile hyphae from margin of sporodochia that extend beyond the sporodochial hymenium (compare with Fig. 60 e, f). **g.** Conidia. – a: Welden 3765, G.J.S. 2188; b: G.J.S. 2188; c–f: CBS 102033; g: CBS 249.78 and 102033. a, b: natural substratum; c–g: 7–10-d-old OA culture. Scale bars = 10  $\mu$ m; the shorter bar applies to a, c–f, the longer to b, g.

palms, 00°49' N, 63°19' W, 60 m alt.; on living vine; 13 Mar 1984; G.J.S. (NY, G.J.S. 898; G.J.S. isolate 84-267). – Mun. Alto Alegre. Em direção Savana do Furo Santa Rosa, 03°24' N, 61°26' W; sobre casca de árvore viva; 20 Jun 1986; K.F. Rodrigues *et al.* (NY, Rodrigues 1066). – Vic. Manaus, Reserva Forestal Ducke; on bark; 10 Nov 1977; G.J.S., D. Hosford (Dumont-Br 232, CBS 249.78). – Vic. Manaus, Reserva Forestal Ducke; on bark; May 1978; G.J.S., D. Hosford, W. Buck, E. Ferreira (Dumont-Br 28, CBS 246.78). – FRENCH GUIANA. Saül, ca 10 km SW of Saül toward Mt. Galbao, 200–350 m alt.; on bark; Jan–Feb 1986; G.J.S., J.R. Boise (CAY, FH, NY, G.J.S. 2680; G.J.S. isolate 86-38). – Saül, ca 10 km SW of Saül toward Mt. Galbao, 200–350 m alt.; on bark of

recently dead tree; Jan–Feb 1986; G.J.S., J.R. Boise (CAY, NY, G.J.S. 2665; G.J.S. isolate 86-34). – GUYANA. East Berbice-Corentyne Region, VI, subregion VI-5, Canje River, north half of Cow Savanna, 1 km N of Digitima Creek, 05°37' N, 57°35' W, 0–25 m alt.; on recently dead vine; 14 Apr 1987; G.J.S., J. Pipoly, G. Gharbarran, G. Bacchus (BRG, NY, G.J.S. 5461). – East Berbice-Corentyne Region, VI, subregion VI-5, Torani Canal, 5–12 km W of Canje River, 05°48' N, 57°31' W, 0–25 m alt.; on recently dead vine; 18,19 Apr 1987; G.J.S., J. Pipoly, G. Gharbarran, G. Bacchus (BRG, NY, G.J.S. 5495). – PANAMA. Prov. Panama, vic. Altos de Pacora, 26–31 km N of Pan American Highway, on old road to Mandinga, 700–730 m alt.; on bark; 30 Jun 1975; K.P.D., S.E. Carpenter, S.A. Mori

(Pa 1621). – MAURITIUS. Bois du Lait; on bark (BPI 737867; IMI 3663387; G.J.S. isolate 95-26; CBS 102033). – MEXICO. Edo. Veracruz, in forest near Campamento Hermanos Cedillo, Oxpanapa region; 16 Jul 1976; A.L. Welden & T.E. Weiser (NY; Welden 3765). – U.S.A. PUERTO RICO: South of El Verde, Hyw. 186, km 17, turn-off to Rd. 911, El Yunque, 530 m alt.; on bark; 9 Jun 1970; R.P. Korf *et al.* (NY, Korf 3959; CUP). – TRINIDAD. Port of Spain; 1912–1913; R. Thaxter. St. Augustine; on cacao; 3 Aug 1923; D.H. Linder (NY, Linder 16). – VENEZUELA. Edo. Barinas: Reserva Forestal Ticoporo, near Miri; on unidentified wood; 27 Jul 1971; K.P.D., G.J.S., L. Borjas (NY, Dumont-VE 3222; C.T.R. isolate 71-315). – On unidentified wood; 27 Jul 1971; K.P.D., G.J.S., L. Borjas (NY, Dumont-VE 3222; C.T.R. isolate 71-315). – Amazonas: Neblina Base Camp on Río Baria, 00°49'50" N, 66°09'40" W, 140 m alt.; on bark; 27 Jan 1985 (BPI, A.Y.R. 2409A). – Edo. Mirinda: Vic. of El Bachiller, ca 19 km W of point where Río Cupira crosses Rt. 9, between Caracas and Cumana; on unidentified vine; 5 Jul 1972; K.P.D., G.J.S., R.F. Cain, G. Morillo (NY, Dumont-VE 3935; C.T.R. isolate 72-89; CBS 322.78). – INDONESIA. North-Sulawesi: Eastern Dumoga-Bone National Park, vic. 'Hog's Back Camp, 00°35' N, 123°51' E, 492 m alt.; on bark of recently dead tree; 30, 31 Oct 1985; G.J.S. (BO, NY, G.J.S. 2188; G.J.S. isolate 85-167).

**Notes:** Samuels (1976a) listed several species with orange perithecia being connected to anamorphs forming sporodochia and green-coloured conidial masses. Rossman (1983) classified some of these species in the *Nectria ralfsii*-group. Both authors emphasized the similarities of these species to the *Nectria ochroleuca*-group (also in Rossman, 1996 and Samuels *et al.*, 1990). Two of these species, *N. ralfsii* Berk. & Broome and *N. pityrodes* (Mont.) Mont., are here accepted in *Bionectria*, with the former classified in subgenus *Bionectria* and the latter in the newly proposed subgenus *Myronectria*.

Samuels (1988b) introduced another species group with myrothecium-like anamorphs, striate ascospores, but with sterile, branched interthecial elements. Of this group, '*Nectria chlorogloea* Samuels and '*N. septomyrothecii* are still not reclassified but are possibly closely related to *Peethambara* Subram. & D.J. Bhat (with anamorphs in *Didymostilbe* Henn.; *Bionectriaceae*). As '*N. chlorogloea* and '*N. septomyrothecii*, *Peethambara spirostriata* (Rossman) Rossman possesses sterile interthecial elements and a short, plug-like stroma, which is located only between the outermost bark cells (Samuels, 1988b: Figs 25, 28 for '*N. chlorogloea* and '*N. septomyrothecii*; Schroers, unpubl., for *P. spirostriata*).

The connections of *Nectriopsis bactridioides* (Berk. & Broome) Samuels and *Nectriopsis lasioderma* (Ellis) Samuels [= *Nectriopsis infusaria* (Cooke & Harkness) Doi] to myrothecium-like anamorphs, suggested by Tulloch (1972) for the first species and by Doi (1978) for the latter species, were questioned by Samuels (1988a). Instead it was concluded that the myrothecium-like anamorphs belonged to *B. pityrodes*, which was parasitized by or associated with the *Nectriopsis* species (Samuels, 1988a). To my knowledge,

ascospores of *N. bactridioides* and *N. lasioderma* have not been grown in culture again to reconfirm either putative connection.

Hypocrealean fungi with green-coloured conidial masses have been classified in the *Hypocreaceae* [e.g. anamorphs of *Trichoderma* and *Gliocladium* (Rehner & Samuels, 1994, 1995; Rossman *et al.*, 2001) and *Bionectriaceae* (Schroers, 2000), however, not in genera of the *Nectriaceae*. Additional taxa such as *Myrothecium inundatum* Tode : Fr., the type species of *Myrothecium*, *Peethambara sundara* Subram. & D.J. Bhat (anamorph *Didymostilbe sundara* (Subram. & D.J. Bhat) Seifert), *Albosynnema elegans* E.F. Morris, and *Didymostilbe echinofibrosa* (E.F. Morris) Rossman, all linked to the *Bionectriaceae* according to morphological evidence, form a paraphyletic assemblage at the base of a clade comprising taxa of the *Hypocreaceae*, *Clavicipitaceae*, and *Bionectriaceae* based on LSU rDNA sequence data (Rossman *et al.*, 2001). While the absence of such green pigmentations could be of importance for the characterization of the *Nectriaceae*, at least some genera that do form greenish pigmented conidial masses [e.g., *Peethambara* (*Didymostilbe*), *Bionectria* (*Clonostachys*), and *Hypocrea* (*Trichoderma*)] have variably pigmented conidial masses, among which the greenish shade apparently is just an additional phenotype.

No teleomorphs have been linked to the other *Myrothecium*- or *Hymenopsis* species listed by Tulloch (1972). Some of the species of these complexes are treated as coelomycetes (Sutton, 1980; Nag Raj, 1993). The phylogenetic position of most of them has not been studied.

The perithecial wall in *B. pityrodes* consists of three regions of which the middle region is composed of hyphae (Fig. 59 d, h), as is typical of species of subgenus *Bionectria*. A difference between the subgenera is seen in the stroma-perithecial wall interface and the morphology of the stroma. While in species of subgenus *Bionectria* the cells of the stroma are angular and merge with those of the outer perithecial region, cells of the stroma of *B. pityrodes* are somewhat hyphal, prosenchymatous, and apparently merge with the hyphae of the middle region (Fig. 59 e). The smooth and mostly bean-shaped ascospores (Figs 60 a, b, 61 b) also differ from the mostly warted or striate and ellipsoidal spores of most of the other taxa in *Bionectria*. The anamorph differs by (i) cupulate sporodochia, the margin of which consists of sterile or fertile hyphae forming a palisade that slightly extends beyond the main sporodochial hymenium (Figs 59 b, 60 d–f, 61 f), (ii) bridges frequently formed between cells of the subhymenium (Fig. 61 d), (iii) subabruptly narrowing phialide tips (Figs 60 c, 61 c–f), and (iv) symmetrical or almost symmetrical conidia (Fig. 61 g). While the characteristic phialide tips and the conidial shape are also found in other species of *Bionectria*, the cupulate sporodochia are unique to *Bionectria/Clonostachys*.



The isolated position of *B. pityrodes* among the other taxa of the genus is supported by analyses of rDNA sequences (Schroers, 2000). Based on these deviating character patterns, a new subgenus, *Myronectria*, is proposed for *B. pityrodes*. The subgenus *Myronectria* is unispecific; however, one other holomorphic specimen from Florida (BPI 1107405, G.J.S. 90-242) differed

slightly in sequence data of the 28S rDNA (Rossman *et al.*, 2001) and possibly represents another species closely related to *B. pityrodes*. Its conidiophores and conidia are indistinguishable from those of *B. pityrodes*, but the strain sporulates sparsely and no sporodochia were observed. The taxon could not be fully characterized because no mature asci and ascospores were found.

### BIONECTRIA SUBGEN. ZEBRINELLA Schroers, *subgen. nov.* — Species 26–32.

Perithecia e stromate in substratis lignosis erumpente exorientia, dense coarctata vel raro solitaria, globosa vel subglobosa, verruculosa vel raro levigata, pallide lutea vel pallide aurantiaca sed verrucis pallidioribus praedita. Cellulae stromatis hyphis similes, prosenchymaticae. Tunica perithecii e duobus stratis composita; stratum exterius et verrucae e cellulis globosis vel angularibus composita; stratum medium deficiens, stratum interius e cellulis lobatissimis constans. Ascosporeae ellipsoideae, uniseptatae, striatae, raro levigatae. Anamorphosis *Clonostachys*. Conidiophoris dimorphicis vel monomorphiceis; sporodochia absentia; conidiophora primaria solitaria, verticillii similia vel anguste penicillata, capitula conidiorum ferentia; conidiophora secundaria penicillata, solitaria, columnas imbricatas conidiorum ferentia. Phialides intercalares sub phialidibus terminalibus praesentes vel absentes. Conidia unicellularia, ovoidea vel ellipsoidea, plerumque utrinque rotundata, hilo invisibili vel fere medio.

Type species: *Bionectria grammicospora* (Ferd. & Winge) Schroers & Samuels.

Etymology: *Zebrinella*, referring to the regularly striate, zebra-like ascospores.

Anamorphs: *Clonostachys* (sesquicillium-like, gliocladium-like).

**Perithecial stroma** erumpent, prosenchymatous. **Perithecia** crowded, rarely solitary, globose to subglobose, normally higher than wide, in orange hues, with warted surface. **Perithecial warts** less intensely pigmented than the perithecial wall, whitish, somewhat tapering towards the tip (longitudinal sections); cells merging with the cells of the outer perithecial wall region, globose to subglobose, frequently smaller toward the tip of the warts; cell-walls thin, mostly uniformly thickened ca 1 µm thick, frequently not firmly connected between adjacent cells. **Perithecial wall** composed of two region. Outer region not obviously intergrading with the cells of the stroma; cells mostly subglobose, rarely angular, similar and merging with the cells of the warts. Inner region similar as in subgenus *Bionectria*. **Asci** clavate, 8-spored; apex flat to rounded, with a ring or without a ring, particularly if ascospores are relatively large, biseriate above, uniseriate below. **Ascospores** 1-septate, equally 2-celled, ellipsoidal, slightly tapering toward the ends, straight or slightly curved, striate, rarely smooth; striae oriented lengthways, usually covering the whole length of the spores, mostly unbranched, rarely once-branched,

straight or slightly sinuous. **Colonies** (particularly on OA) in intense yellow to chrome-yellow (3A8) and frequently yellowish green or greyish yellow (3C3–7) hues. **Conidiophores** monomorphic or dimorphic, narrowly or divergently penicillate, rarely unbranched, acremonium-like; phialides cylindrical to narrowly flask-shaped, phialidic aperture to 4.5 µm wide. Intercalary phialides rare, bearing several or one terminal phialide. **Conidial masses** on primary conidiophores in round heads, pale orange, watery, on secondary conidiophores in short imbricate columns that may collapse to slimy masses. **Conidia** hyaline, ellipsoidal, straight; distal end or both ends broadly rounded; hilum median or invisible. **Aerial mycelium** on the natural substratum sparse. **Aerial mycelium** in culture sparse, conidiophores mostly arising from the agar surface. **Sporodochia** not observed. **Perithecia** homothallic or perithecia not seen in culture, if formed, solitary, with the base surrounded by tufts of white aerial mycelium.

**Habitat:** Teleomorphs on bark of recently dead trees; some anamorphs isolated from soil.

**Notes:** Samuels (1988b) monographed species with orange perithecia and striate ascospores and distinguished seven groups. For the holomorphic species of one of these groups (*N. grammicospora*-group) and for a few other species, the subgenus *Zebrinella* with *Clonostachys*- or *gliocladium*-like anamorphs is proposed here. The other groups distinguished by Samuels (1988b) are classified today in *Hydropisphaera*, *Protocreopsis*, *Albonectria*, and *Peethambara*, or remain to be reclassified (Rossman *et al.*, 1999).

Two additional species were included in the *N. grammicospora*-group, *N. cf. grammicospora* (Samuels, 1988b: 315) and *N. neogrammicospora* (Samuels, 1988b: 322) because of their similar teleomorph. They differ, however, by their acremonium- or fusarium-like anamorphs. Neither is here accepted in *Bionectria* and both remain unclassified in 'Nectria'.

The subgenus *Zebrinella* is morphologically similar to subgenus *Bionectria*. It is characterized by perithecial walls that consist of two regions (all included species lack the middle, hyphal region seen in most species of subgenus *Bionectria*), mostly warted perithecia,

striate, rarely smooth or warted ascospores, erumpent stromata consisting of prosenchymatous cells, dimorphic or monomorphic, non-sporodochial conidiophores, rather symmetrical, ellipsoidal, generally straight conidia with  $\pm$  median or invisible hila, and white, yellowish, to pale orange, non-greenish conidial masses. The conidial columns, although present in species with secondary conidiophores, are less conspicuously formed than in species of other subgenera and may collapse early to a slimy mass.

Several tendencies of character-state changes can be observed in the subgenus *Zebrinella*. An overall increase in size of ascospores (and asci) and conidia appears correlated with a decreasing plasticity of conidiophores and a decreasing frequency of intercalary phialides. In contrast to species of subgenus *Bionectria*, several species in subgenus *Zebrinella* also form simple, acremonium-like conidiophores that are considered homologous to the primary conidiophores in subgenera *Zebrinella* and *Bionectria*. Extremes are found in (i) *B. lucifer* characterized, by large spores and monomorphic conidiophores, while its ascomata and ascospores match to the overall patterns found in subgenus *Zebrinella* (warted perithecia, striate ascospores) and (ii) *B. levigata* having smooth and crowded perithecia and smooth to warted ascospores, which may fit better in subgenus *Bionectria*.

Species of the subgenera *Epiphloea* and *Uniparientina* consistently form intercalary phialides typically below a single terminal phialide and mostly form monomorphic conidiophores. In subgenus *Bionectria*, intercalary phialides are absent or rarely formed and the conidiophores of most species are dimorphic. With respect to the intercalary phialides and the conidiophore dimorphism, the subgenus *Zebrinella* is intermediate between the subgenera *Bionectria* and *Epiphloea*. Depending on the species, conidiophores can be monomorphic, weakly dimorphic, or clearly dimorphic and intercalary phialides are either formed as in subgenus *Epiphloea* or are  $\pm$  lacking. The intermediate position of the subgenus *Zebrinella* was illustrated elsewhere (Schroers, 2000: Fig. 5).

## 26. *Bionectria grammicospora* (Ferd. & Winge) Schroers & Samuels, *comb. nov.* — Figs 62 a–h, 63 a, b.

- ≡ *Nectria grammicospora* Ferd. & Winge in Raunkiaer, Bot. Tidsskr. 29: 11. 1908.
- ≡ *Creonectria grammicospora* (Ferd. & Winge) Seaver, Mycologia 1: 192. 1909.

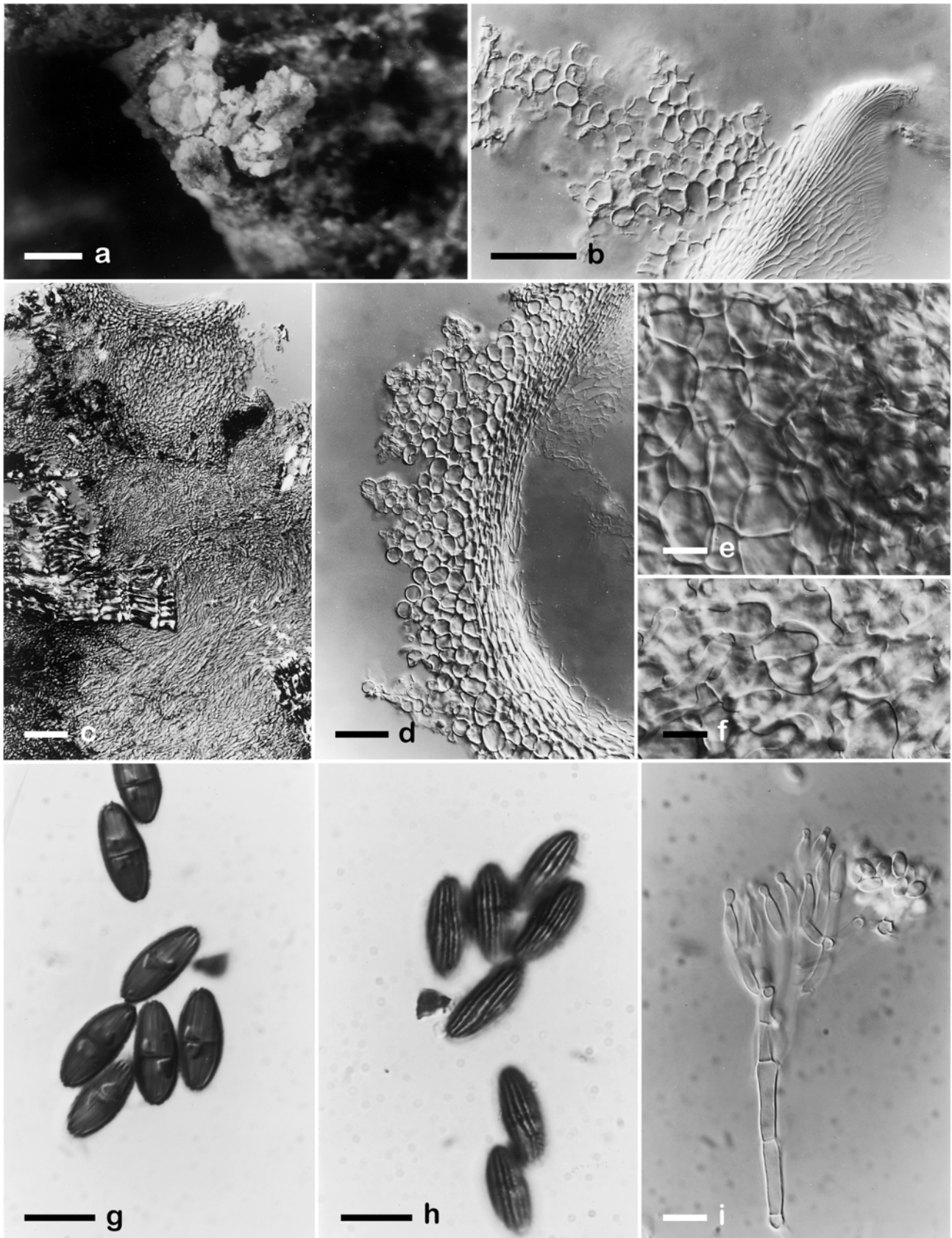
Anamorph: *Clonostachys grammicospora* Schroers & Samuels, *stat. nov.* — Figs 62 i, 63 c–f.

Conidiophora absentia vel pauca, monomorphica vel dimorphica, illis *C. solani* similia. Coloniae 24°C post 7 dies 25–35 mm diam. Conidiorum massa in conidiophoris primariis capitula aquosa, in secundariis capitulata vel tholiformia, raro catenas imbricatas formans, dilute aurantiaca. Conidia (4–)5.4–6–6.8(–8.8)  $\times$  (1.8–)2.6–2.8–3(–4)  $\mu$ m.

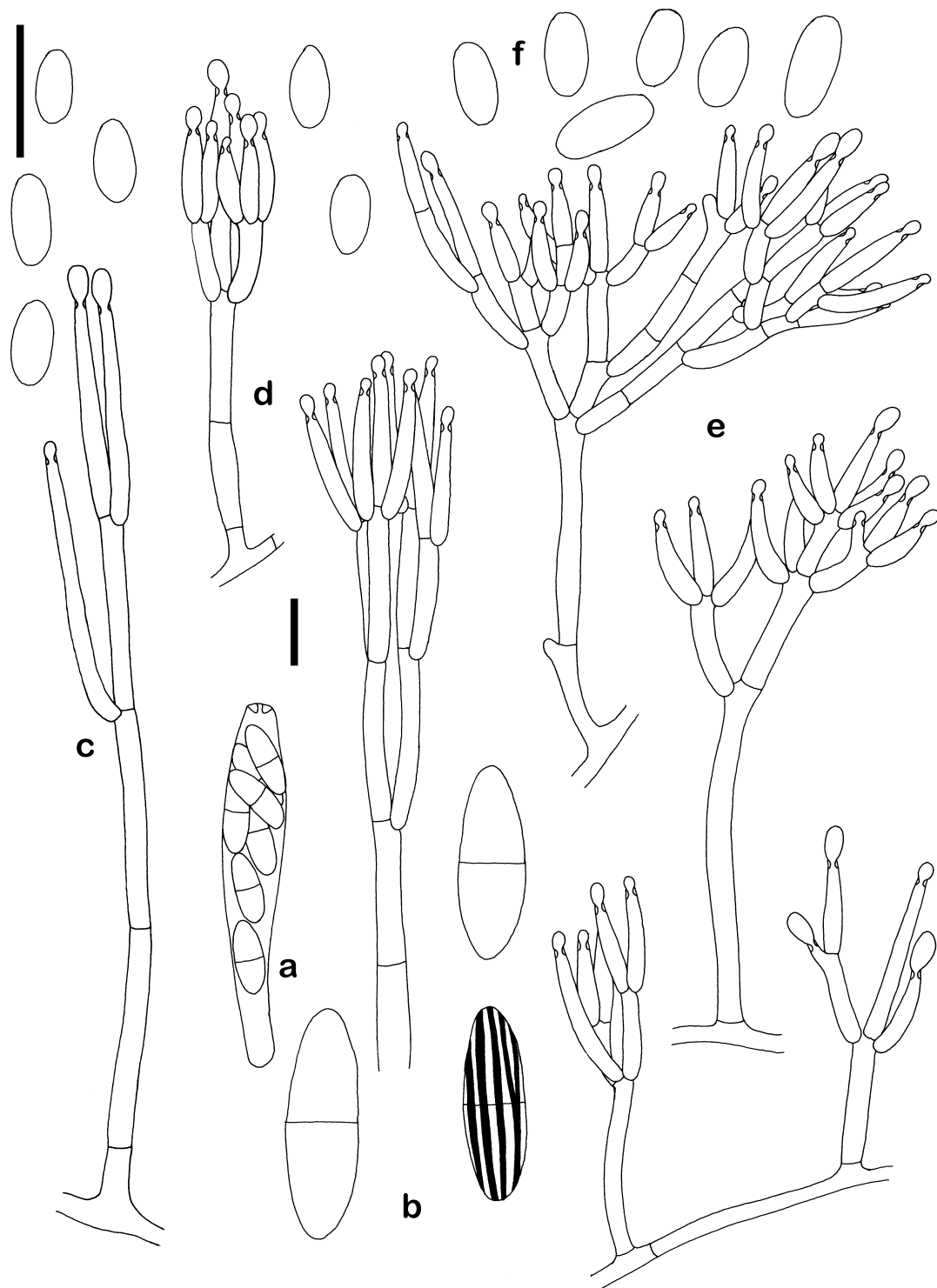
Holotypus anamorphosis: Herb. CBS; cultura sicca, isolata ex specimine Samuels 3285 (NY); cultura viva CBS 209.93.

**Description from natural substratum:** **Stroma** generally well-developed, erumpent, bearing perithecia; cells prosenchymatous, densely hyphal. **Perithecia** crowded in groups of 10–20(>20), globose to subglobose, (200–)250–450  $\mu$ m high, 200–350(–400)  $\mu$ m diam, laterally or rarely apically pinched when dry, yellowish, mostly light orange to brownish orange, slightly papillate, scaly to warted. **Perithecial warts** whitish to pale orange, up to 100  $\mu$ m high; cells subglobose to globose, of the same type as the cells of the outer perithecial wall region, (6–)8.5–9.5–10.5(17)  $\times$  (5–)6.5–8–9(–13)  $\mu$ m (n = 128), with uniformly thickened walls. **Perithecial wall** 30–50  $\mu$ m thick composed of two regions. Outer region 10–25  $\mu$ m or 1–3 cells thick, with cells directly merging with the cells of the warts; cells globose to subglobose, (9–)11–13.5–15.5(–21)  $\times$  (5.5–)8–10–11(–18)  $\mu$ m (n = 67), with uniformly thickened walls around 1.5  $\mu$ m thick; vacuoles not observed. Middle region lacking. Inner region 30–50 thick. **Asci** clavate, (44–)48–55–59(–75)  $\times$  (6.5–)9–10–10.5(–13)  $\mu$ m (n = 62), 8-spored; apex flat, edges generally rounded, ring clearly visible. **Ascospores** ellipsoidal, striate, striae parallel, straight or once-branched, (8.2–)10.6–11.6–12.6(–17.6)  $\times$  (3–)3.8–4.2–4.6(–6.2)  $\mu$ m (n = 61). **Sterile mycelium** invisible. **Sporodochia** not observed.

**Description from culture:** **Colonies** reaching 25–35 mm diam in 7 d at 24°C; optimum for growth 24–27°C (35 mm diam), maximum 30°C (CMA). Colony reverse light yellow (3A4–5), sometimes with greenish tinge (1AB7); yellow pigment present in reserve but not diffusing into the medium outside the colony; older colonies fading or turning pale orange particularly in the centre (OA); after incubation under UV-light in orange hues (OA, PDA). Colony surface similar in pigmentation to the colony reverse or less pigmented, very finely dusty to granulose because of a sparse aerial mycelium. **Conidiophores** absent, sparse, or



**Fig. 62.** *Bionectria grammicospora* / *Clonostachys grammicospora*. **a.** Habit of crowded perithecia. **b–d.** Sections through perithecia and stroma; perithecial wart with globose, uniformly thin-walled cells (**b**); perithecial stroma with prosenchymatous cells (**c**); lateral perithecial wall showing two regions, cells globose, inwards angular (**d**). **e.** Subsurface view of outer perithecial wall region. **f.** Subsurface view of inner perithecial wall region. **g, h.** Discharged ascospores stained with cotton blue in optical section (**g**) and surface view (**h**). **i.** Penicillate conidiophore. – **a, c, e, f:** G.J.S. 1301; **b:** G.J.S. 4411; **d:** G.J.S. 7664; **g, h:** G.J.S. 4937; **i:** Dumont-VE 2077. All from natural substratum. **a:** DM; **b–i:** DIC. Scale bars: **a** = 200  $\mu\text{m}$ ; **b, d** = 30  $\mu\text{m}$ ; **c** = 50  $\mu\text{m}$ ; **e–i** = 10  $\mu\text{m}$ .



**Fig. 63.** *Bionectria grammicospora* / *Clonostachys grammicospora*. **a.** Almost mature ascus. **b.** Discharged ascospores. **c.** Primary, sparsely branched, adpressed conidiophore with relatively long phialides. **d.** Intermediate conidiophores with narrow, adpressed penicilli and relatively short phialides, intergrading with secondary conidiophores. **e.** Secondary conidiophores with mostly divergent branches, containing few intercalary phialides. **f.** Conidia with median or hardly visible hilum. – a, c: BPI 737845 (CBS 915.97), b: G.J.S. 7664, BPI 737845; d: G.J.S. 90-198; e: G.J.S. 90-198, C.T.R. 71-298, CBS 915.97; f: G.J.S. 90-198, CBS 207.93. Scale bars = 10  $\mu\text{m}$ ; the shorter bar applies to a, c–e, the longer to b, f.

abundant, monomorphic or dimorphic. Primary conidiophores narrowly penicillate, adpressed, mono- to terverticillate; stipe 50–100  $\mu\text{m}$  long, 3.5–6.5  $\mu\text{m}$  wide at the base; penicillus 40–100  $\mu\text{m}$  high; phialides straight to slightly curved, almost cylindrical, slightly tapering towards the tip, sometimes with a short collarette, (11–)17.2–21.4–24.6(–43.4)  $\mu\text{m}$  long, (1.8–)

1.8–2.2–2.4(–2.8)  $\mu\text{m}$  wide at base, (1.2–)1.4–1.4–1.6(–1.8)  $\mu\text{m}$  wide near aperture ( $n = 43$ ). Secondary conidiophores absent or present, solitary, ter- to quaterverticillate, branches divergent, phialides somewhat divergent; metulae 7.5–11–17  $\mu\text{m}$  long, 2.2–2.6–3.2  $\mu\text{m}$  wide; phialides in loose whorls of 2–5, straight or slightly curved, flask-shaped, widest in the lower third,

slightly tapering in the upper part towards the tip, without a collarette, (4.4–)9.8–11.2–12.6(–18.6)  $\mu\text{m}$  long, (1.4–)2–2.2–2.4(–3.2)  $\mu\text{m}$  wide at base, (1.4–)2.4–2.6–2.8(–3.6)  $\mu\text{m}$  at widest point, (1–)1.4–1.4–1.6(–2.4)  $\mu\text{m}$  wide near aperture ( $n = 96$ ); intercalary phialides sometimes observed, bearing one or several terminal phialides, to 4  $\mu\text{m}$  long. Intermediate conidiophores with adpressed penicilli and relatively short phialides occasionally present. **Conidial masses** on primary conidiophores in watery heads, those on secondary conidiophores in heads, dome-shaped, or rarely in imbricate chains, pale orange. **Conidia** ellipsoidal to ovoidal, distally broadly rounded, apex minutely tapering, with a median, invisible, or rarely somewhat laterally displaced hilum, (4–)5.4–6–6.8(–8.8)  $\times$  (1.8–)2.6–2.8–3(–4)  $\mu\text{m}$  ( $n = 344$ ). **Sporodochia** not observed. **Perithecia** homothallic or perithecia not seen in culture; perithecia solitary, pale to light orange, rough to finely warted; warts light orange, not contrasting with the perithecial wall, eventually surrounded by white mycelium at the base; ascospore mass off-white to creamy, appearing as a thick slimy round cap on the perithecium; perithecial base somewhat immersed in the agar, surrounded by aerial mycelium that is more abundant than in other parts of the colony.

**Isotype for *Nectria grammicospora*:** U.S.A. VIRGIN ISLANDS: St. Thomas; on bark; 1905; C. Raunkiaer (NY; Raunkiaer 3103). **Type for *Clonostachys grammicospora*:** FRENCH GUIANA. *Ca* 17 km SW of Saül toward Mt. Galbao, 350 m alt.; on trunk of standing dead tree; Jan 1986; G.J.S. [herb. CBS; dried culture of CBS 209.93 (G.J.S. isolate 86-123), derived from ascospores of Samuels 3285 (NY)].

**Known distribution:** The neotropics, Indonesia; probably pantropical.

**Habitat:** On bark of recently dead trees, or bark of living liana, rarely on herbaceous stems.

**Published descriptions and illustrations:** Samuels (1988b).

**Additional specimens/strains examined:** BRAZIL. Estado do Amazonas, Pico Rondon, Perimetral norte km 211, Vine Forest *ca* 3 hour walk from Funai post, 01°32' N, 62°48' W, *ca* 1200 m alt.; G.J.S., J. Pipoly, J. Guedes (BPI 802605). – Para Belém Ilha do Combu, Estação Experimental Combu, 01, 30°60' N, 48°27' W, 0 m alt.; on bark; Jan 1989; G.J.S., K.F. Rodrigues (NY; G.J.S. 6218). – FRENCH GUIANA. Montagne de Kaw, route de l'Est, km 27, 04°60' N, 52°40' W; on live liana; 21 Mar 1986; G.J.S., C. Feuillet (CAY, NY; G.J.S. 4411; G.J.S. isolate 86-323). – Paul Isnard Area, *ca* 150 km S of St. Laurent du Moroni, Citron, Mt. Lucifer, 04°70' N, 53°90' W; on bark of recently dead tree; 7–14 Mar 1986; G.J.S., P. Searwar (CAY, NY; G.J.S. 4193; G.J.S. isolate 86-287). – Piste de Saint-Elie, km 16 on road between Sinnamary and St. Elie, 'ECEREX', ORSTOM research area; on bark of living liana; 20–29 Feb 1986; G.J.S. (NY; G.J.S. 3925; G.J.S. isolate 86-238). – Km 16 on road between Sinnamary and St. Elie, 'ECEREX', ORSTOM research area; on twigs

of recently dead tree; 20–29 Feb, 1 Mar 1986; G.J.S. (NY; G.J.S. 3972; G.J.S. isolate 86-247). – Saül, Circuit Grand Fosse, primary forest on well drained slope, decaying wood, dry and hard, 03°60' N, 53°20' W, 300–350 m alt.; on living vine; 10 Feb 1986; G.J.S. (CAY, NY; G.J.S. 3641; G.J.S. isolate 86-185). – *Ca* 10 km SW of Saül toward Mt. Galbao, 200–350 m alt.; on recently dead tree; Jan, Feb 1986; G.J.S., J.R. Boise (CAY, NY; G.J.S. 2649; G.J.S. isolate 86-25). – On herbaceous stem; Jan–Mar 1986; G.J.S. (NY; G.J.S. 3731; G.J.S. isolate 86-200; CBS 207.93). – St. Laurent-du-Marouini, Canton de Maripasoula, along Route de Belizon, 03°42' N, 53°12' W, 200 m alt.; on bark; 14 Sept 1994; S.M. Huhndorf (BPI 737845; G.J.S. isolate 94-75, CBS 915.97). – INDONESIA. North Sulawesi, Dumoga-Bone Natl. Park, Gunung Muajat, Danau Alia, cloud forest with *Quercus*, tree ferns and rotan palms; 00°45' N, 124°25' E, *ca* 1499 m alt.; on petiole; 26 Oct 1985; G.J.S. (NY; G.J.S. 2432; G.J.S. isolate 85-218). – VENEZUELA. Amazonas: Cerro de la Neblina, Summit camp #5, valley at north base of Pico Phelps, cloud forest, 00°49' N, 66°00' W, 1000–1250 m alt.; on bark; G.J.S. (NY; G.J.S. 1301). – Edo. Aragua: *ca* 14 km above Maracay, on the Maracay–Choroni Rd., Parque Nac. Henry Pittier; on unidentified wood; 12 Jul 1971; K.P.D., J.H. Haines, G.J.S. (NY; Dumont-VE 2029; C.T.R. isolate 71-298). – *Ca* 19 km above Maracay, on the Maracay–Choroni Rd., Parque Nac. Henry Pittier; on fruit; 13 Jul 1971; K.P.D., J.H. Haines, G.J.S. (NY; Dumont-VE 2077; C.T.R. isolate 71-313). – Edo. Miranda: Parque Nacional Guatopo, between Agua Blanca and La Cruceta, 10°03' N, 66°26' W, 500–600 m alt.; on bark; 27–30 Nov 1990; G.J.S., B. Hein, S.M. Huhndorf (B, BPI, USB, VEN, NY; G.J.S. 7664; G.J.S. isolate 90-198). – Edo. Sucre: Along Rio Aguas Calientes, 30 min walk N of Maraval, NW of Irapa; on unidentified wood; 8 Jul 1972; K.P.D., R.F. Cain, G.J.S., G. Morillo, A. Villegas (NY; Dumont-VE 4373; C.T.R. isolate 72-92).

**Notes:** *Bionectria grammicospora* has warted perithecia (Fig. 62 a), thin-walled, almost globose cells in the perithecial warts (Fig. 62 b) and in the outer region of the perithecial wall (Fig. 62 d), and striate ascospores (Fig. 62 h). The teleomorphs of *B. grammicospora*, *B. grammicosporopsis*, and *B. subquaternata* are almost indistinguishable. Although the size ranges of ascospores may overlap, the spores are typically wider in *B. grammicosporopsis* and longer in *B. subquaternata*.

Colonies derived from ascospores are diverse in their abilities to form perithecia and conidiophores. Sparse conidiophore production or a complete absence was noted in strains that form perithecia (e.g. CBS 207.93). Others produced mainly primary, adpressed conidiophores (Fig. 63 c, d), but secondary, rather divergently branched conidiophores with relatively short phialides and sometimes intercalary phialides (Fig. 63 e) were observed as well. Based on the conidiophore dimorphism, the anamorph of *B. grammicospora* is similar to species of subgenus *Bionectria*, but differs in having symmetrical conidia with an almost media invisible hilum. The anamorph of *B. grammicospora* can be distinguished from others of subgenus *Zebrinella* based on conidial size (shorter and/or narrower in *B. subquaternata*, *B. lucifer*, *B. grammicosporopsis*), growth speed (relatively fast in comparison to *B. grammicosporopsis*, *C. intermedia*, and *B. levigata*), and predominance of primary conidiophores (in comparison to *C. intermedia* and *B. levigata*).

**27. *Bionectria grammicosporopsis*** (Samuels) Schroers & Samuels, *comb. nov.* — Figs 64, a–j, 65 a–c, 66 a, b.

≡ *Nectria grammicosporopsis* Samuels, *Brittonia* 40: 318. 1988.

Anamorph: *Clonostachys grammicosporopsis* Schroers & Samuels, *stat. nov.* — Figs 65 d, 66 c, d.

*Clonostachydi grammicosporae* similis. Conidiophora monomorphica, penicillata adpressa. Coloniae lente crescentes, post 7 dies 24°C circa 5 mm diam. Conidia (4.8–)6.6–7.6–8.4(–11.6) × (2.2–)3–3.4–3.6(–4.6) µm.

Holotypus anamorphosis: PDD; cultura sicca, isolata ex specimine PDD 50042 (PDD); isotypus herb. CBS; cultura viva CBS 114.87.

**Description from natural substratum:** **Stroma** well-developed, erumpent, bearing perithecia; cells prosenchymatous, densely hyphal. **Perithecia** crowded in groups of up to 50 or more, globose to subglobose, 300–450 µm diam, not or laterally pinched when dry, orange to brownish orange or reddish brown, small-papillate, ostiolar region contrasting in colour with the perithecial warts, with a scaly to warted surface. **Perithecial warts** whitish to pale orange, up to 100 µm high; cells subglobose to globose, of the same type as the cells of the outer perithecial wall region, (7.5–)9–11–12.5(–18) × (4.5–)6–7.5–9(–12) µm (n = 34); walls generally uniformly thickened around 1.5 µm thick or sometimes unevenly thickened up to 8 µm thick. **Perithecial wall** 40–50 µm thick composed of two regions. Outer region 30–40 µm or ca 3 cells thick, cells merging with the cells of the warts; cells globose to subglobose, (8.5–)11–12–13(–17) × (5.5–)7.8–9–10(–12.5) µm (n = 48), with uniformly thickened ca 1.5 µm thick walls; vacuoles not observed. Middle region lacking. Inner region 10–20 thick. **Asci** clavate, (55–)66.5–72–76.5(–100) × (8.5–)10.5–12–13.5(–15) µm (n = 51), 8-spored; apex flat, edges rounded, ring clearly visible. **Ascospores** ellipsoidal, striate, striae parallel, straight or branched, (9–)12.6–13.8–15(–18.4) × (3.6–)4.6–5–5.6(–7.4) µm (n = 160). **Sterile mycelium** not conspicuously developed. **Sporodochia** not observed.

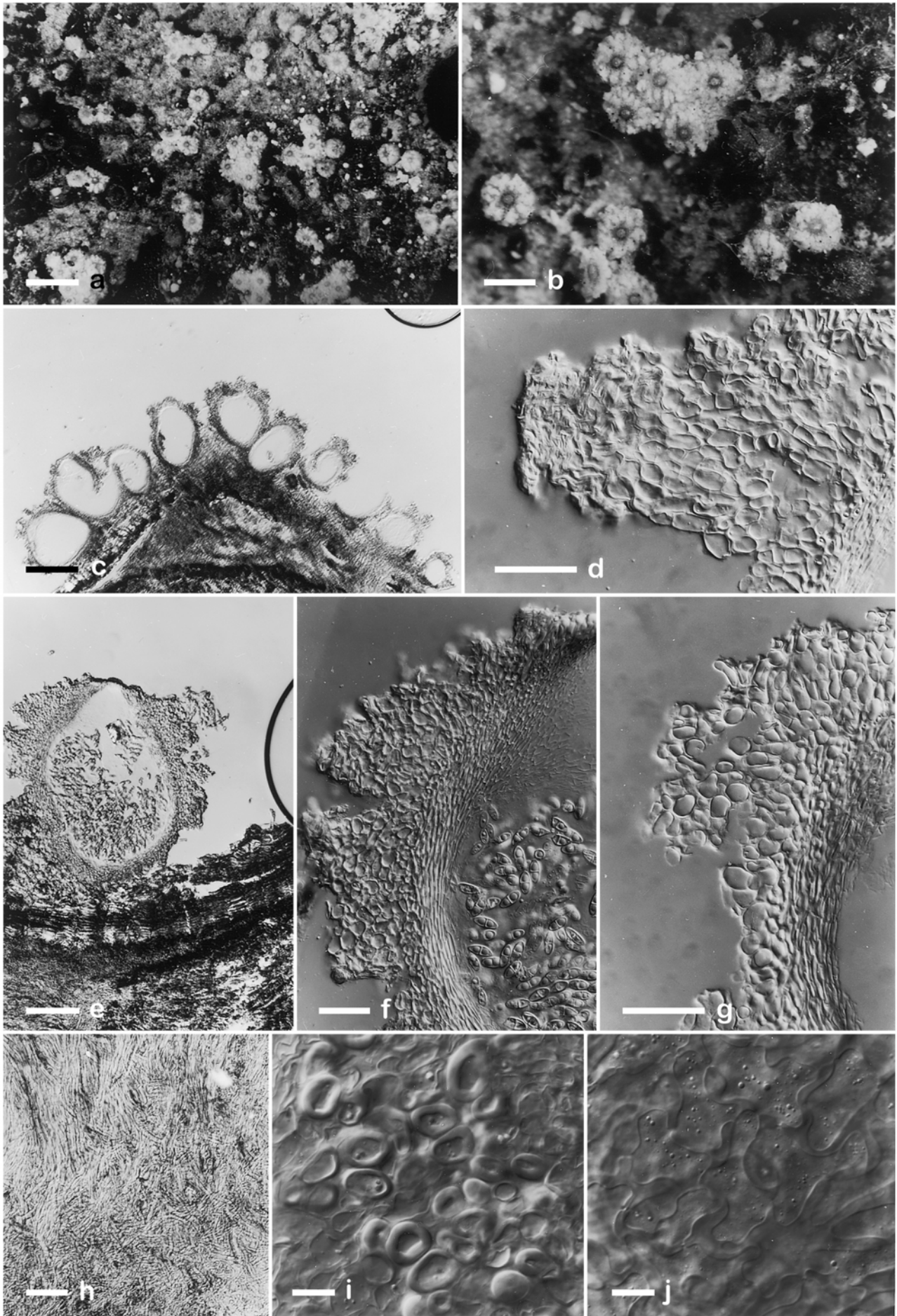
**Description from culture:** **Colonies** reaching 5–15 mm diam in 7 d at 24°C; optimum for growth 18–21°C, not growing at (27–)30°C (CMA). Colony reverse on OA light yellow (3A4–5), sometimes green-

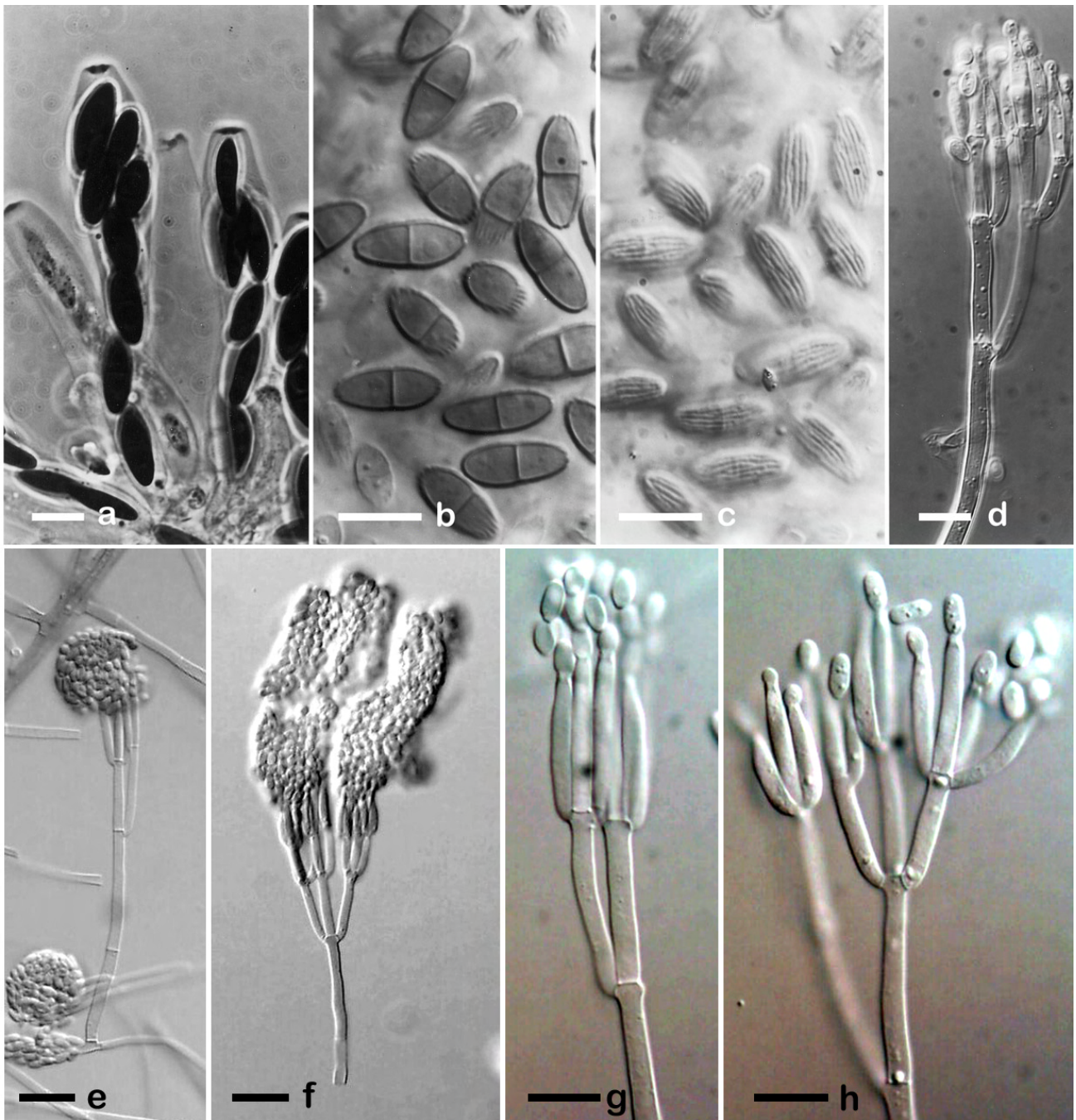
ish yellow (1B6) at the colony margin, pigment not visible outside the colony; older colonies and after incubation under UV-light pale to light orange (5A3–4). Colony surface of freshly isolated strains whitish, yellowish, or pale orange, granular to cottony because of the conidial masses and the more abundantly formed aerial mycelium consisting of strands of hyphae; subcultured strains without or with sparsely formed aerial mycelium, finely granular, pale yellow to pale orange because of the conidial masses, similar in pigmentation to the colony reverse. **Conidiophores** of freshly isolated strains dimorphic; both types of conidiophores intergrading; subcultured strains can be monomorphic. **Primary conidiophores** formed on the agar surface or by the aerial mycelium, narrowly penicillate, adpressed, mostly biverticillate, forming heads of conidial masses; stipes up to 100 µm long, ca 5 µm wide at base; phialides straight or straight and slightly curved near base, almost cylindrical, 20–30 µm long, around 3 µm wide at base, 1.6–1.8 µm wide near aperture. **Secondary conidiophores** generally arising from the aerial mycelium, narrowly penicillate or with slightly divergent branches and phialides, forming columns of conidia, bi- to quaterverticillate; stipes of similar dimensions as those of the primary conidiophores; phialides narrowly flask-shaped with widest point in the lower part, slightly tapering toward the tip or almost cylindrical, straight or slightly curved, without a visible collarette, (4–)11.8–14.2–16(–22) µm long, (2–)2.2–2.4–2.6(–3) µm wide at base, (2.6–)2.6–3–3.2(–3.6) µm at widest point, (1–)1.4–1.6–1.8(–2) µm wide near aperture (n = 66); intercalary phialides not observed. **Conidial masses** in heads or columns, white to pale or light orange. **Conidia** ellipsoidal to ovoidal, broadly rounded, with a median or invisible hilum, (4.8–)6.6–7.6–8.4(–11.6) × (2.2–)3–3.4–3.6(–4.6) µm (n = 152). **Sporodochia** not observed. **Perithecia** not observed.

**Type for *Nectria grammicosporopsis*:** NEW ZEALAND. Southland: Catlins State Forest Park, L. Wilkie; on bark; 18 Apr 1985; G.J.S., P.K. Buchanan, L.M. Kohn (PDD 50042; G.J.S. isolate 85-29, CBS 114.87, ex ascospores). **Type for *Clonostachys grammicosporopsis*:** dried culture ex CBS 114.87, filed together with type of *N. grammicosporopsis* (PDD 50042); isotype: herb. CBS.

**Known distribution:** Australia and New Zealand.

**Fig. 64. *Bionectria grammicosporopsis*.** a, b. Habit of solitary or crowded perithecia. c–h. Sections through perithecia or stroma. c. Perithecia on erumpent stroma. d. Perithecial wart; cells subglobose to angular, smaller toward the tip, mostly uniformly thin-walled. e. Perithecium. f, g. Lateral perithecial wall; cells of the outer region globose to angular. h. Erumpent stroma; cells prosenchymatous. i. Surface view of perithecial wall, showing partly unevenly thickened walls, not seen in other species of subgenus *Zeb-rinella*. j. Subsurface view of inner perithecial wall. — a, b: PDD 50021; c, e, f, h: PDD 44441; d, g, i: PDD 50052; j: PDD 50052. All from natural substratum. a, b: DM; others: DIC. Scale bars: a = 750 µm; b = 300 µm; c = 250 µm; e = 100 µm; d, f, g = 30 µm; h = 50 µm; i, j = 10 µm.





**Fig. 65.** *Bionectria grammicosporopsis* / *Clonostachys grammicosporopsis*. **a.** Almost mature, clavate asci, apical ring visible. **b, c.** Discharged ascospores in optical section (**b**) and surface view (**c**). **d.** Addressed conidiophore. **e, g.** Primary conidiophores with adpressed branches and phialides (**g**) forming a globose head of conidia (**e**). **f, h.** Secondary conidiophore with slightly divergent branches and phialides (**g**) forming columns of conidia (**f**). – **a, d:** PDD 50021; **b, c:** PDD 35789. **e–h:** CBS 102423. **a–d:** natural substratum; **e–h:** 10-d-old OA cultures. **a:** PC; others: DIC. **a:** stained with cotton blue. Scale bars: **a–d, g, h** = 10  $\mu$ m; **e, f** = 20  $\mu$ m.

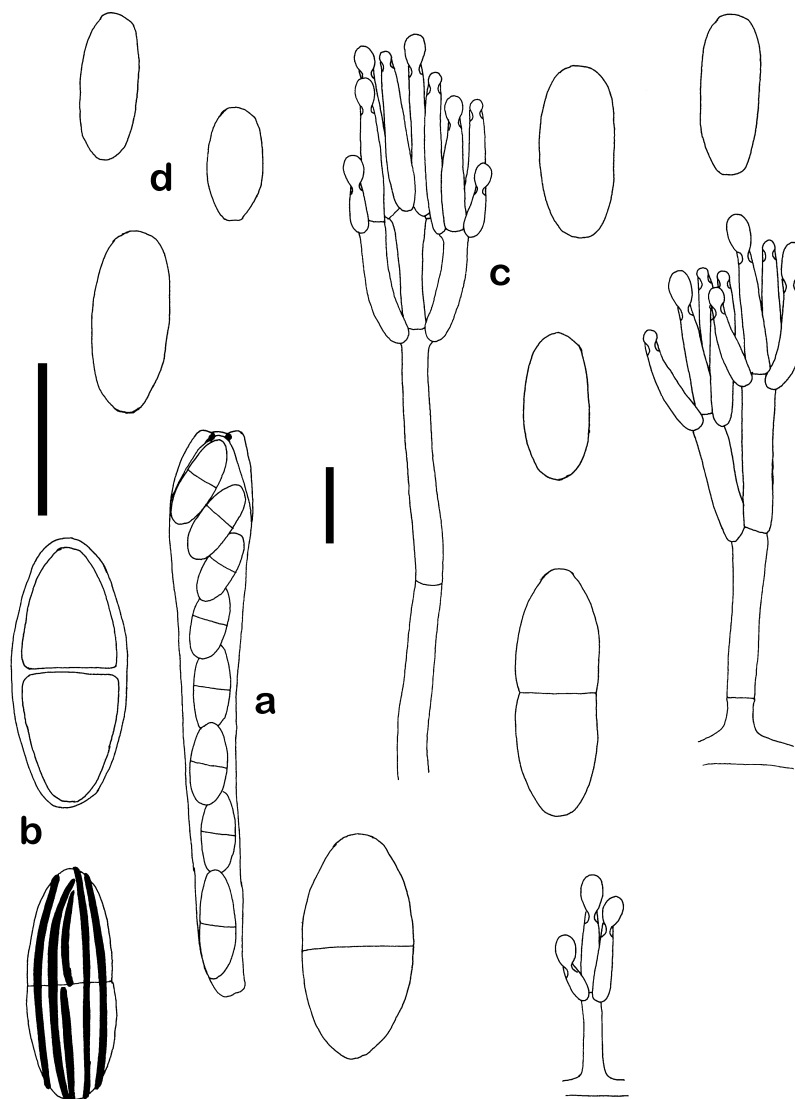
**Habitat:** On bark of recently dead, dying, or nearly dead trees (Samuels, 1988b).

**Published descriptions and illustrations:** Samuels (1988b).

**Additional specimens/strains examined:** AUSTRALIA. NEW SOUTH WALES: Blue Mountains Nat. Park; on bark of recently dead tree; Aug 1999; G.J.S. (BPI; CBS 102421). – Ibid. (BPI; CBS 102423). – VICTORIA: Yarra Ranges National Park, Acheron Way, Somes Park, 575 m alt.; on bark; 24

Aug 1999; G.J.S. (BPI; G.J.S. 8618; CBS 102843). – Ibid. BPI; G.J.S. 8620; CBS 102834). – Otway National Park, along Great Ocean Road, Mait's Rest Rainforest Walk, ca 300 m alt.; on bark; 26 Aug 1999; G.J.S. (BPI; G.J.S. 8621; CBS 102835). – Vic. Healesville, Toolangi State Forest, Myer's Creek Rd., Wirrawalla Rainforest Walk and Myrtle Walking Track in Myrtle Gully, 575 m alt., with *Nothofagus cunninghamii* and *Eucalyptus regnans* and tree-ferns; on bark; 23 Aug 1999; G.J.S. (BPI; G.J.S. 8606). – NEW ZEALAND. AUCKLAND: Waitakere Ranges, Lower Nihotupu Dam.; on *Hoheria populnea*; 7 Nov 1976; G.J.S. (NY; ex PDD 35789; culture 76-196). – Bay of Plenty: Urewera Nat. Park, L. Waikaremoana, Ngamoko





**Fig. 66.** *Bionectria grammicosporopsis* / *Clonostachys grammicosporopsis*. **a.** Almost mature ascus. **b.** Discharged ascospores. **c.** Addressed conidiophores. **d.** Broadly rounded conidia with median or invisible hilum. – a: PDD 50042; b: PDD 50075, PDD 44441; c, d: CBS 114.87, CBS 115.87. a, b: natural substratum; c, d: ca 14-d-old OA culture. Scale bars = 10 µm; the shorter bar applies to a, c, the longer to b, d.

Track; on bark of *Coprosma* sp.; 4 Nov 1982; G.J.S., P.K. Buchanan, P.R. Johnston (PDD 44441; G.J.S. isolate 82-276; CBS 111.87). – Coromandel, Tapu-Coroglen Rd., trail to Mt. Mau-  
maupaki, 450 m alt.; on bark; 11 Jan 1985; G.J.S., P.K. Buchanan, H. Hertel, H. Mayrhofer (PDD 50021; G.J.S. isolate 85-2). – Gisborne, Urewera, Nat. Park, L. Waikaremoana, Tawa Loop Trail; on bark; 13 May 1985; G.J.S., L.M. Kohn (PDD 50075; G.J.S. isolate 85-66). – Ibid.; vic. Motor camp, Black Beach Track; on *Beilschmiedia tawa*; G.J.S., R.H. Petersen, A.P. Hawthorne, P.R. Johnston; 30 Apr 1983 (PDD 42065). – WESTLAND: Mt. Aspiring Nat. Park, Haast Pass, Roaring Billy Forest Walk; on *Metrosideros* sp.; 28 Apr 1985; G.J.S., L.M. Kohn (PDD 50054; G.J.S. isolate 85-44, CBS 115.87).

**Notes:** *Bionectria grammicosporopsis*, *B. grammicospora*, and *B. subquaternata* are similar in characters of their teleomorphs, but differ slightly in their size ranges of the ascospores (see discussion under *B. grammicospora*).

The conidiophores of *B. grammicosporopsis* were initially considered monomorphic based on subcultured strains. Only addressed conidiophores with glo-

bose conidial masses were observed (Figs 65 e, g, 66 c) likely homologous to primary conidiophores of other species in *Bionectria*. In fresh isolates (CBS 102421 102423), however, a second type of conidiophore was found with addressed (Fig. 65 d) or somewhat divergent branches of the penicillus (Fig. 65 f, h), and slightly shorter phialides that form conidial columns (Fig. 65 f). Because of the columnar conidial masses, these conidiophores are regarded homologous to the secondary conidiophores of other species in *Bionectria*. In overall, however, both types of conidiophores intergrade and may only be distinguished by their shape of the conidial masses. The presence of secondary conidiophores in fresh isolates is possibly correlated with the formation of strands of aerial mycelium from which these conidiophores arise. In contrast, aerial mycelium in subcultured strains is only sparsely formed or lacking.

The secondary conidiophores of *B. grammicosporopsis* have generally more addressed branches

than those of *B. grammicospora*. The conidiophores of these species are indistinguishable otherwise. The two species differ in the width of their conidia [mostly more than 3 µm in *B. grammicosporopsis* (Fig. 66 d) and less than 3 µm in *B. grammicospora* (Fig. 63 f)] and particularly in their growth rates in culture, which is characteristically slow in *B. grammicosporopsis*. While *B. grammicospora* is a rather common species in tropical regions, *B. grammicosporopsis* seems to be restricted to Australia and New Zealand.

Strains of *B. grammicosporopsis* examined so far have identical sequences in the rDNA (ITS and partial LSU). In contrast, several nucleotide differences were found among the strains of *B. grammicospora* sequenced. Because apomorphic characters in the rDNA are absent in *B. grammicosporopsis* sequences but more numerous in those of *B. grammicospora*, *B. grammicosporopsis* apparently has been derived more recently. The middle of the ITS-1 region of *B. grammicosporopsis* is particularly characterized by a gap of 22 bp contrasting with all other species of *Bionectria*. The gap therefore is more likely an apomorphic character for *B. grammicosporopsis*. Considering that both species are closely related, which is indicated by their similar morphology, *B. grammicosporopsis* is likely to have derived from *B. grammicospora*.

**28. *Bionectria subquaternata*** (Berk. & Broome) Schroers & Samuels, *comb. nov.* — Figs 67 a–j, 68 a, b.

≡ *Nectria subquaternata* Berk. & Broome, J. Linn. Soc. London 14: 116. 1873.

Anamorph: *Clonostachys subquaternata* Schroers & Samuels, *stat. nov.* — Figs 67 k, 68 c, d.

*Clonostachydi grammicosporae* similis. Conidiophora monomorphica, penicillata adpressa, raro dimorphica. Phialides sursum ad 3.8 µm latae. Conidia (5–)9.2–14.8–20.4(–28.6) × (2.6–)4–6.4–8.6(–12.2) µm.

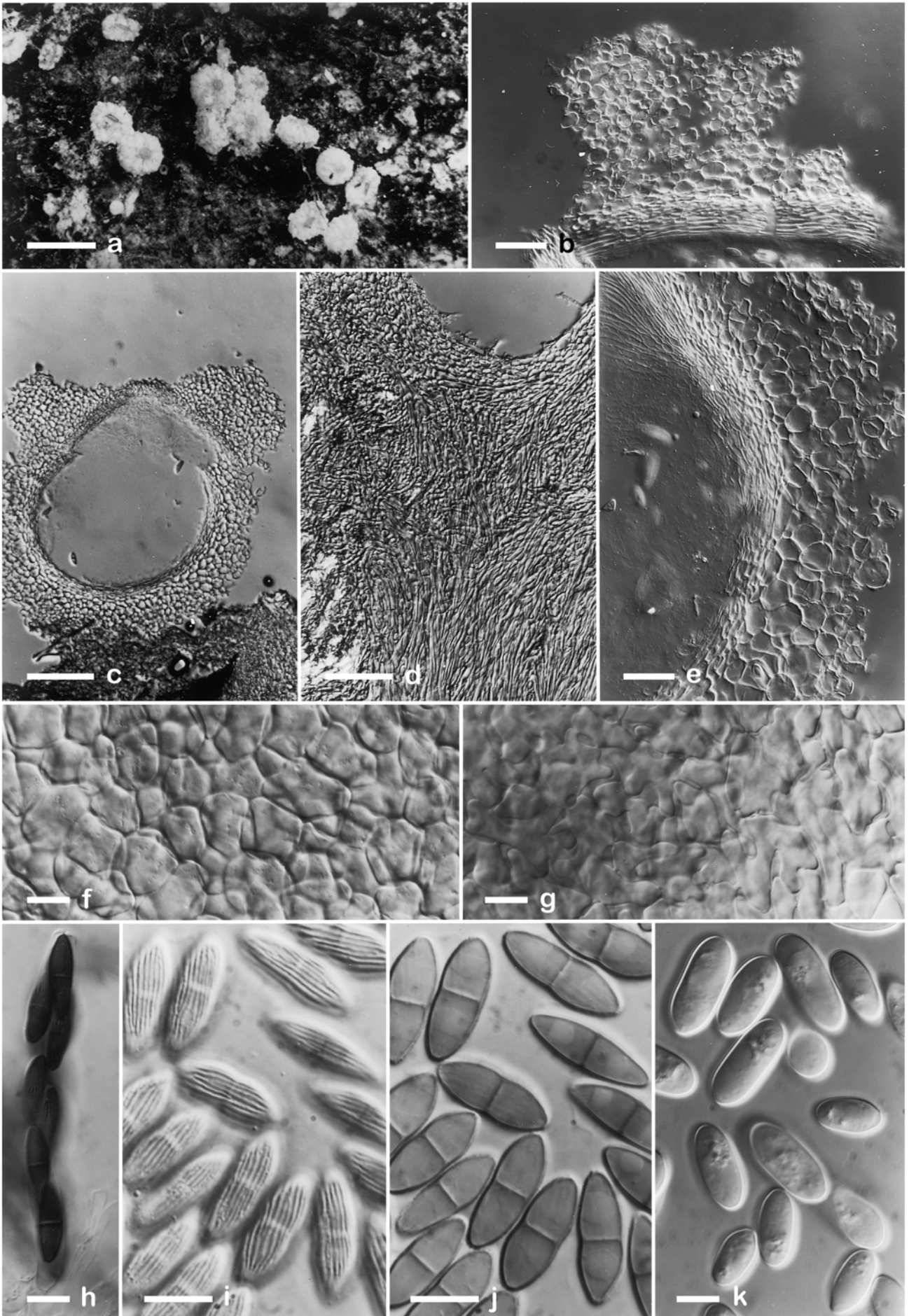
Holotypus anamorphosis: BPI; cultura sicca, isolata ex specimine BPI 749138 (BPI); isotypus herb. CBS; cultura viva CBS 100003.

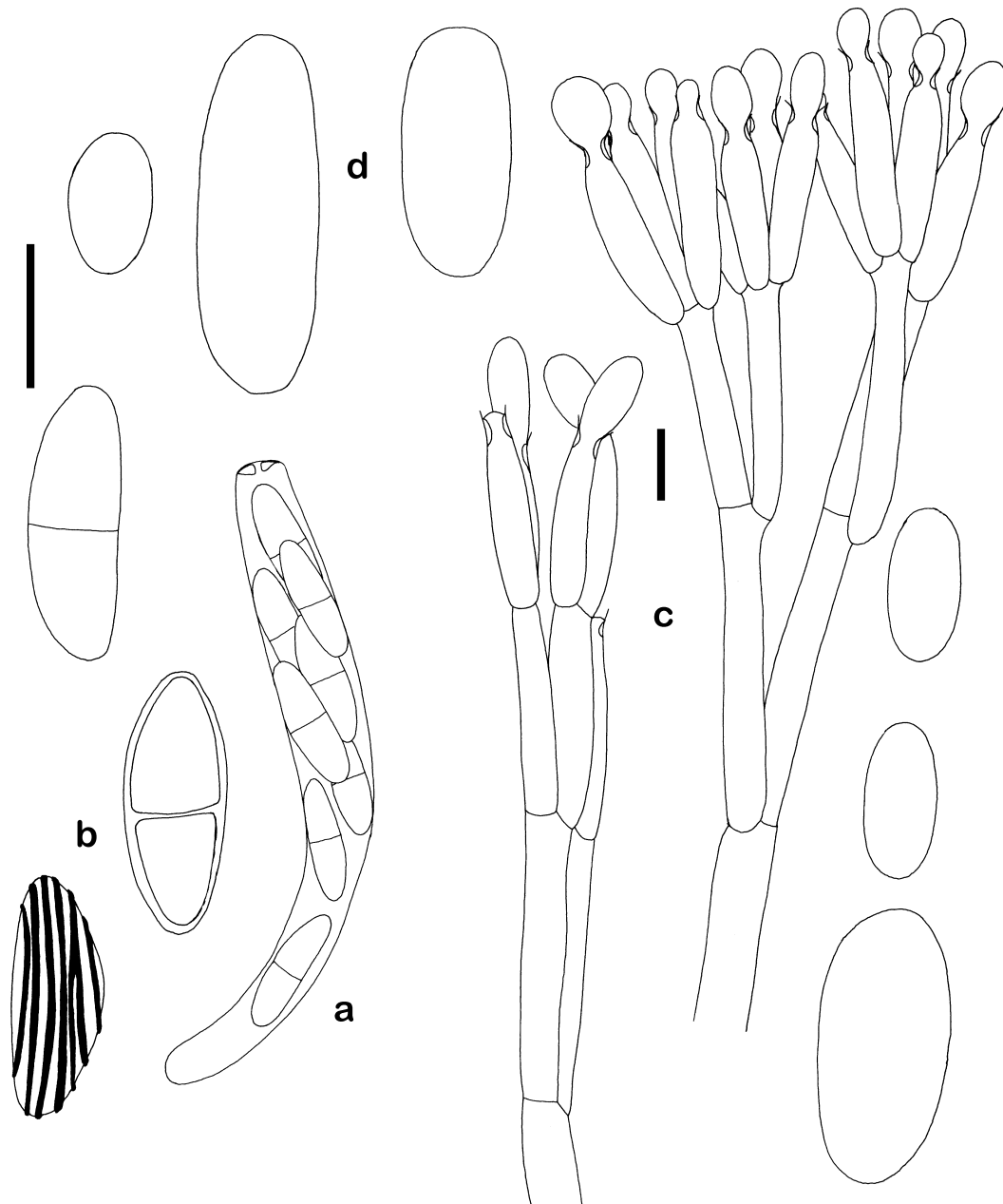
**Description from natural substratum:** **Stroma** superficial or erumpent, bearing perithecia; cells prosenchymatous, densely hyphal, frequently close to or on the ascumata of other ascomycetes. **Perithecia** solitary or crowded in groups of up to 20, globose to subglo-

bosc, 350–400(–600) µm diam, laterally or apically pinched when dry, yellowish orange, pale or light orange, rarely brownish orange, small-papillate, ostiolar region contrasting in colour or not contrasting with the rest of the perithecial wall, warted to scaly. **Perithecial warts** whitish to pale orange, to 200 µm high and to 200 µm diam; the largest warts typically around the ostiole; cells globose to subglobose, (6–)9–11–12.5(–16) × (5–)7.5–9–10(–14) µm. **Perithecial wall** ca 40–70 µm thick composed of two regions. Outer region 35–50 µm or to 5 cells thick; cells angular to subglobose, (6.5–)11.5–14–16.5(–25) × (3.5–)8.5–10.5–12.5(–18.5) µm, with uniformly thickened walls around 1.5 µm thick. Middle region lacking. Inner region 20–30 µm thick. **Asci** clavate, (51.5–)63.5–71–77(–110) × (9–)11.5–12.5–13.5(–18) µm (n = 51), 8-spored; apex broadly rounded slightly flat with rounded edges; ring visible. **Ascospores** ellipsoidal, striate; striae parallel, straight or once branched, (10–)15.4–17–18.6(–26) × (3.6–)5.2–6–6.6(–9.6) µm (n = 396). **Sterile mycelium** invisible. **Sporodochia** not observed

**Description from culture:** **Colonies** reaching ca 25 mm diam in 7 d at 24°C; optimum for growth 27°C, not growing at 33/36°C (CMA). Colony reverse light yellow (3A5) to pale orange (5A3) (OA, PDA). Colony surface similar in pigmentation to the reverse or less pigmented, waxy (OA); aerial mycelium not observed, sporulation sparse. **Conidiophores** apparently monomorphic, arising from the colony surface or sparse aerial mycelium, adpressed or with slightly divergent primary branches, bi- to quaterverticillate; stipe 100–300 µm long, ca 8 µm wide at base; branching part to 100 µm high; metulae 25–35 × 3–5 µm; phialides generally in whorls of 2–3, cylindrical or slightly tapering toward the tip, or slightly widening in the lower third, frequently with a small collarette, (10.8–)15–20.4–25.8(–31) µm long, (2–)2.6–3.2–3.6(–4.2) µm wide at base, (1.8–)2.8–3.2–3.6(–4.4) µm at widest point, (1.6–)2.2–2.6–3(–3.8) µm wide near aperture (n = 42); intercalary phialides not observed. **Conidial masses** pale yellow to pale orange, formed as a head on the penicilli. **Conidia** hyaline, ellipsoidal, ends broadly rounded, mostly without a visible hilum, (5–)9.2–14.8–20.4(–28.6) × (2.6–)4–6.4–8.6(–12.2) µm (n = 180). **Sporodochia** not observed. **Perithecia** sometimes observed in culture, solitary, with slightly warted surface.

**Fig. 67. *Bionectria subquaternata* / *Clonostachys subquaternata*.** **a.** Habit of solitary or crowded perithecia. **b–e.** Sections through perithecia and stroma. **b.** Perithecial wart; cells globose, uniformly thin-walled. **c.** Perithecium. **d.** Perithecial base and prosenchymatous stroma. **e.** Lateral perithecial wall showing two regions with ± globose cells in outer region. **f.** Subsurface view of outer perithecial wall region showing subglobose to angular cells. **g.** Subsurface view of inner region. **h.** Almost mature ascus in optical section. **i, j.** Discharged ascospores in surface view (i) and optical section (j). **k.** Conidia. — a: BPI 749138; b, d: Thwaites 173A (type); c, e, k: BPI 749144; f–h: Dumont-VE 2865; i, j: Dumont-VE 1767. All from natural substratum. a: DM; others: DIC; h–j stained with cotton blue. Scale bars: a = 500 µm; b, e = 30 µm; c = 100 µm; d = 50 µm; f–k = 10 µm.





**Fig. 68.** *Bionectria subquaternata* / *Clonostachys subquaternata*. **a.** Almost mature ascus. **b.** Discharged ascospores. **c.** Penicillate, adpressed conidiophores with wide phialidic apertures. **d.** Conidia with median or invisible hilum and broadly rounded ends. – **a:** Dumont-VE 2865; **b:** Dumont-VE 6914, Dumont-VE 2862; **c:** H.J.S. 51, H.J.S. 47A (CBS 100003); **d:** Dumont-VE 2862, CBS 100003. **a, b:** natural substratum; **c, d:** ca 14-d-old OA cultures. Scale bars = 10 µm; the shorter bar applies to **a, c**, the longer to **b, d**.

**Type for *Nectria subquaternata*:** SRI LANKA. Thwaites 173a (K). **Type for *Clonostachys subquaternata*:** U.S.A. PUERTO RICO: Caribbean National Forest: Luquillo Mts., El Verde Research Area; on bark of recently dead *Casearia arborea*; 19 Feb 1996; G.J.S., H.-J. Schroers, D.J. Lodge (dried culture ex CBS 100003, derived from ascospores of BPI 749138 and filed with it (BPI); isotype: herb. CBS).

**Known distribution:** The neotropics, Indonesia, Sri Lanka.

**Habitat:** On bark of recently dead trees.

**Published descriptions and illustrations:** Samuels (1976a, 1988b).

**Additional specimens/strains examined:** BRAZIL. Rio Grande do Sul, Novo Petropolis; on bark; 21 Dec 1923; J. Rick (NY). – COLOMBIA. Dpto. Boyacá: along the Tunja–Ramiriqui-Paez Rd., vic. of km post 74 from the crossing of the Tunja–Nuevo Colón Rd., ca 1280 m alt.; on bark of branch; 13 Sept 1976; K.P.D., P. Buriticá, M.I. Umaña (NY; Dumont-CO 7764). – FRENCH GUIANA. Paul Isnard Area, ca 150 km S of St. Laurent du Moroni, Citron, Mt. Decou Decou, 04°70' N, 53°90' W; on bark of recently dead tree; 11, 12 Mar 1986; G.J.S., P. Searwar (CAY, NY; G.J.S. 4215; G.J.S. isolate 86-290). – Saül, ca 15 km SW of Saül toward Mt. Galbao, 600–650 m alt.; on bark of recently dead tree; Jan 1986; G.J.S., J.R. Boise (CAY, NY; G.J.S. 2862; G.J.S. isolate 86-56). – Moist

primary forest, ca 200 m alt.; on bark; 3–16 Feb 1987; G.J.S. (NY; G.J.S. 3542). – Upper Marouini River, 2.5 km W of Monpé Soula, between the Marouini R. and a large granitic rock, ca 15 min walk W of river, 02°37' N, 54°00' W, 250 m alt.; on bark; 26 Aug 1987; G.J.S., J.-J. de Granville, L. Allorge, W. Hahn, M. Hoff, A. Weizmann (CAY, NY; G.J.S. 6066, as paratype for *N. lucifer*). – Luquillo Mts., El Verde Research Area, La Prieta Creek; on recently dead palm trunk; 20 Feb 1996; G.J.S., H.-J. Schroers, D.J. Lodge (BPI 749144, CBS, H.J.S. 51). – VENEZUELA. Edo. Aragua: Parque Nac. Henry Pittier, Ravine, 2.5 km S of Rancho Grande, on Rancho Grande–Maracay Rd.; on unidentified wood; 5 Jul 1971; K.P.D., J.H. Haines, G.J.S. (NY; Dumont-VE 1370). – Edo. Bolívar: on road between El Dorado and Sta. Elena, ca 118 km S of El Dorado, trail, up N-facing slope of Uei-Tepui, from old military camp 'Ciento Veinticinco'; on bark; 5 Aug 1972; K.P.D., R.F. Cain, G.J.S., C. Blanco (NY; Dumont-VE 6914; C.T.R. isolate 72-181, CBS 108.87). – Edo. Lara, Parque Nac. Yacambu, along road, 19 km SE of Sanare; on unidentified wood; 9 Jul 1971; K.P.D., J.H. Haines, G.J.S., J. Leal (NY; Dumont-VE 1767). – Edo. Mérida: ca 4 km inside San Javier del Valle resort, 7 km NE of Mérida; on unidentified wood; 24 Jul 1971; K.P.D., G.J.S., L. Borjas (NY; Dumont-VE 2865; C.T.R. isolate 71-349; CBS 107.87).

**Notes:** *Bionectria subquaternata* is similar to *B. grammicospora* and *B. grammicosporopsis* but has longer ascospores (Figs 67 j, 68 b). However, some specimens with size ranges overlapping those of *B. grammicospora* (e.g. G.J.S. 2862 and Dumont-VE 1370 with ascospores of  $12.5\text{--}15.5 \times 4\text{--}6 \mu\text{m}$ ) were identified as *B. subquaternata* based on anamorph characters, which include variably sized but generally large conidia (Figs 67 k; 68 d) and relatively wide phialidic apertures (Fig. 68 c).

Conidiophores in *B. subquaternata* apparently are monomorphic, generally adpressed (Fig. 68 c), forming globose conidial masses. They therefore are probably homologous to the primary conidiophores formed by *B. grammicospora* (Fig. 63 c), *B. grammicosporopsis* (Fig. 65 e, g) and species of subgenus *Bionectria* (e.g. Figs 37 c, 41 c). The lack of secondary conidiophores and the lacking or sparsely formed aerial mycelium may be degenerations resulting from in-vitro cultivations. However, neither on the natural substratum nor in fresh isolates, secondary conidiophores were observed. On the other hand, primary and secondary conidiophores tend to intergrade in species of the subgenus *Zebrinella* (Figs 63 c–e, 65 d–h). Therefore, it is possible that a conidiophore dimorphism, although present, has been overlooked till now.

Petch (1938) mistook *Nectria subquaternata* for *Nectria keithii* Berk. & Broome, an error already noticed by Booth (1959).

## 29. *Bionectria lucifer* (Samuels) Schroers & Samuels, *comb. nov.* — Figs 69 a–i, 70 a, b.

≡ *Nectria lucifer* Samuels, Brittonia 40: 320. 1988.

Anamorph: *Clonostachys lucifer* Schroers & Samuels, *stat. nov.* — 69 j, k, 70 c, d.

*Clonostachydi grammicosporae* similis. Conidiophora monomorphica, penicillata adpressa. Phialides ad apicem  $5 \mu\text{m}$  latae. Conidia  $(9.8\text{--})12\text{--}13.2\text{--}14.2\text{--}20 \times (5\text{--})6.4\text{--}7\text{--}7.2\text{--}9 \mu\text{m}$ .

Holotypus anamorphosis: BPI; cultura sicca, isolata ex specimine BPI 749139 (BPI); isotypus herb. CBS; cultura viva CBS 100008, G.J.S. isolate 96-52.

**Description from natural substratum:** **Stroma** superficial on bark to somewhat erumpent, bearing perithecia; cells prosenchymatous, densely hyphal. **Perithecia** mostly solitary to somewhat aggregated, not crowded, globose to subglobose,  $500\text{--}700 \mu\text{m}$  high,  $400\text{--}600 \mu\text{m}$  diam, not pinched when dry, orange to brownish orange to reddish brown, ostiolar region mostly not contrasting in colour, small-papillate, warted to scaly. **Perithecial warts** frequently of the same colour as the perithecial wall, rarely whitish, normally higher than wide,  $100\text{--}200 \mu\text{m}$  high,  $100\text{--}150 \mu\text{m}$  diam at base; cells subglobose to globose, of the same type as the cells of the outer perithecial wall region,  $(7.5\text{--})11.5\text{--}18\text{--}15\text{--}28.5 \times (4.5\text{--})8.5\text{--}11\text{--}13.5\text{--}19.5 \mu\text{m}$ , smaller toward the tip of the warts, uniformly thin-walled. **Perithecial wall**  $80\text{--}120 \mu\text{m}$  thick, composed of two regions. Outer region  $45\text{--}75 \mu\text{m}$  or to 6 cells thick; cells subglobose to globose, rarely angular,  $(6.5\text{--})11.5\text{--}14\text{--}16.5\text{--}25 \times (3.5\text{--})8.5\text{--}10.5\text{--}13\text{--}18.5 \mu\text{m}$ , with uniformly thickened walls around  $1.5 \mu\text{m}$  thick. Middle region lacking. Inner region  $10\text{--}20 \mu\text{m}$  thick. **Asci** clavate to broadly clavate,  $(85\text{--})100\text{--}115\text{--}124\text{--}160 \times (18\text{--})19\text{--}20.5\text{--}21.5\text{--}23.5 \mu\text{m}$  ( $n = 28$ ), with 8 or fewer spores; apex narrowly rounded, ring visible in young asci, invisible in mature asci. **Ascospores** ellipsoidal, with straight or somewhat sinuous striae,  $(21.4\text{--})27\text{--}28.8\text{--}30.6\text{--}37 \times (6\text{--})8.8\text{--}9.4\text{--}10\text{--}13.8 \mu\text{m}$  ( $n = 278$ ). **Sterile mycelium** invisible. **Mononematous conidiophores** frequently close to the perithecia, frequently on other hypocrealean ascomycetes. **Sporodochia** not observed.

**Description from culture:** **Colonies** reaching ca 15 mm diam in 7 d at  $24^\circ\text{C}$ ; optimum for growth  $27^\circ\text{C}$ , not growing at  $33^\circ\text{C}$  (CMA). Colony reverse light yellow (3A5) to pale orange (5A3), in older colonies greenish yellow (2B7); after incubation under UV-light in orange hues (OA, PDA). Colony surface similar in pigmentation to the reverse or less pigmented, waxy (OA); aerial mycelium and sporulation sparse or not observed. **Conidiophores** monomorphic, gliocladium-like, arising from the colony surface or the sparse aerial mycelium, not observed after subculturing, stipe to

200 µm long, 8–12 µm wide at base; branching part to 50 µm high, ca 30 µm broad; metulae (10.6–)13–13.6–14.6(–16.6) × (4.2–)4.6–5.2–5.6(–6.8) µm; phialides generally in whorls of 3–5, cylindrical or slightly widening in the lower third, straight, without a collarette, (10.8–)14.2–16–17.8(–20.8) µm long, (3–)3.6–4–4.4(–5.4) µm wide at base, (3–)4.2–4.6–5(–6) µm at widest point, (2.4–)3.2–3.6–3.8(–5) µm wide near aperture (n = 38); intercalary phialides not observed. **Conidial masses** in round, watery to somewhat slimy, hyaline or pale yellow to pale orange heads. **Conidia** hyaline, broadly ellipsoidal to ovoidal, with both ends ± broadly rounded, mostly without a visible hilum, (9.8–)12–13.2–14.2(–20) × (5–)6.4–7–7.2(–9) µm (n = 56). **Sporodochia** not observed. **Perithecia** not observed.

**Type for *Nectria lucifer*:** ECUADOR. Chimborazo, on the Bucay–Riobamba Rd., 5 km from Bucay (General Elizalde), ca 600 m alt.; on bark; 28 Jul 1975; K.P.D., S.E. Carpenter, P. Buriticá (NY; Dumont-EC 1524). **Type for *Clonostachys lucifer*:** U.S.A. PUERTO RICO: Caribbean National Forest, Luquillo Mts., El Verde Research Area; on bark of recently dead *Casearia arborea*; 19 Feb 1996; G.J.S., H.-J. Schroers, D.J. Lodge [dried culture ex CBS 100008 (= G.J.S. isolate 96-52), filed together with BPI 749139; isotype: herb. CBS].

**Known distribution:** The neotropics.

**Habitat:** On bark of recently dead trees, or bark of living liana.

**Published descriptions and illustrations:** Samuels (1988b).

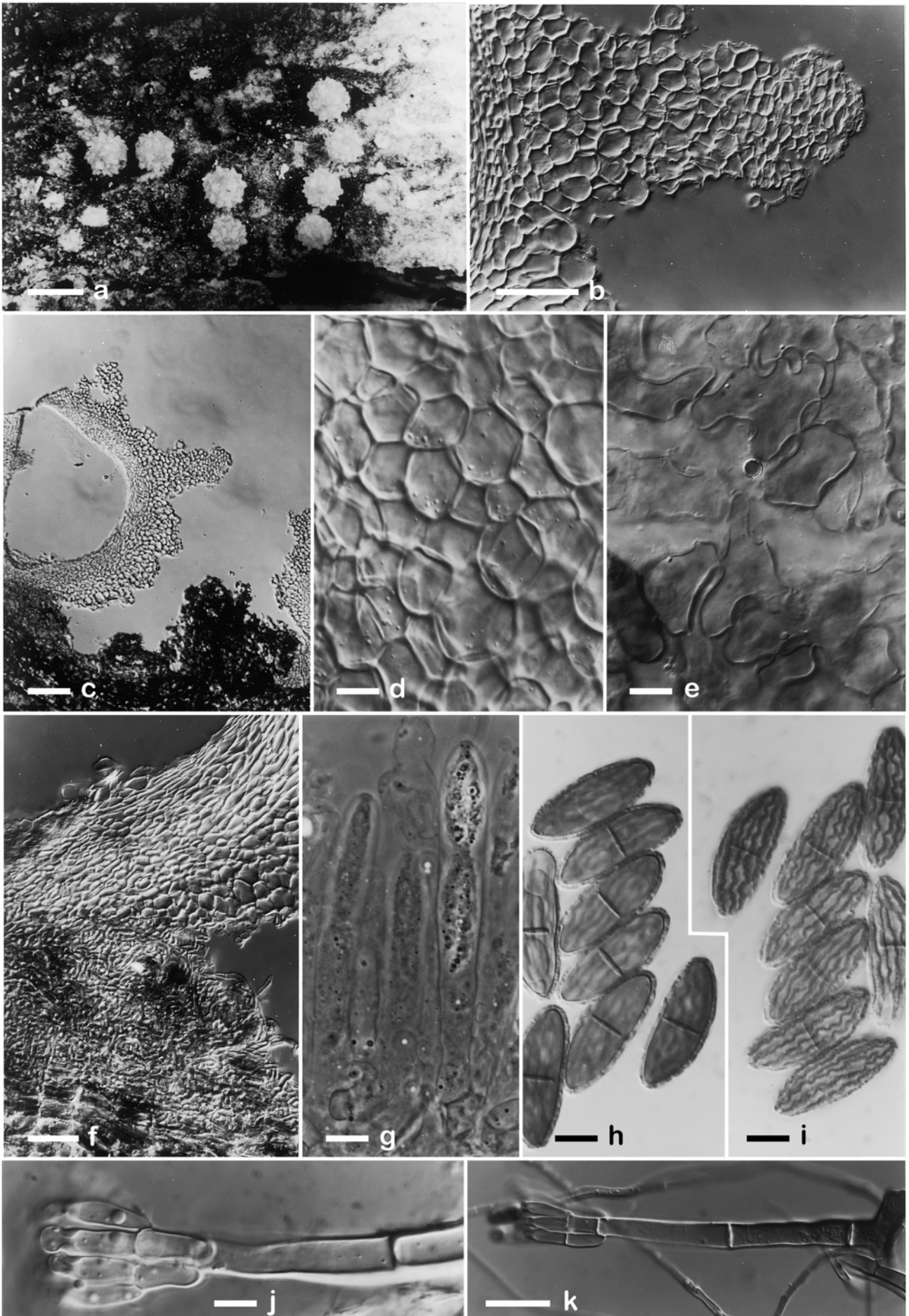
**Additional specimens/strains examined:** COLOMBIA. Dpto. Meta: Ca 1.5 km toward San Luis de Cubarral, from the junction of the Villavicencio–San Martín Rd., ca 790 m alt.; on bark; 8 Jan 1976; K.P.D., P. Buriticá, J. Luteyn (NY; Dumont-CO 2321). – ECUADOR. Prov. Pichincha: Río Palenque Biology Station, 56 km from Quevedo, on Santo Domingo–Quevedo Rd., ca 200 m alt.; on bark; 21 Jul 1975; K.P.D., S.E. Carpenter, P. Buriticá (NY; Dumont-EC 896). – FRENCH GUIANA. Km 16 on road Sinnamary–St. Elie, ‘ECEREX’, ORSTOM research area; on bark of liana; 2–29 Feb 1986; G.J.S. (NY; G.J.S. 3898; G.J.S. isolate 86-233). – Ca 17 km SW of Saül toward Mt. Galbao, 350 m alt.; on living woody vine; 24–28 Jan 1986; G.J.S., J. Boise (NY; G.J.S. 3362; G.J.S. isolate 86-133, CBS 126.87). – Upper Marouini River, vic. Roche Koutou, 02°55' N, 54°04' W, 400 m alt.; on bark; 18

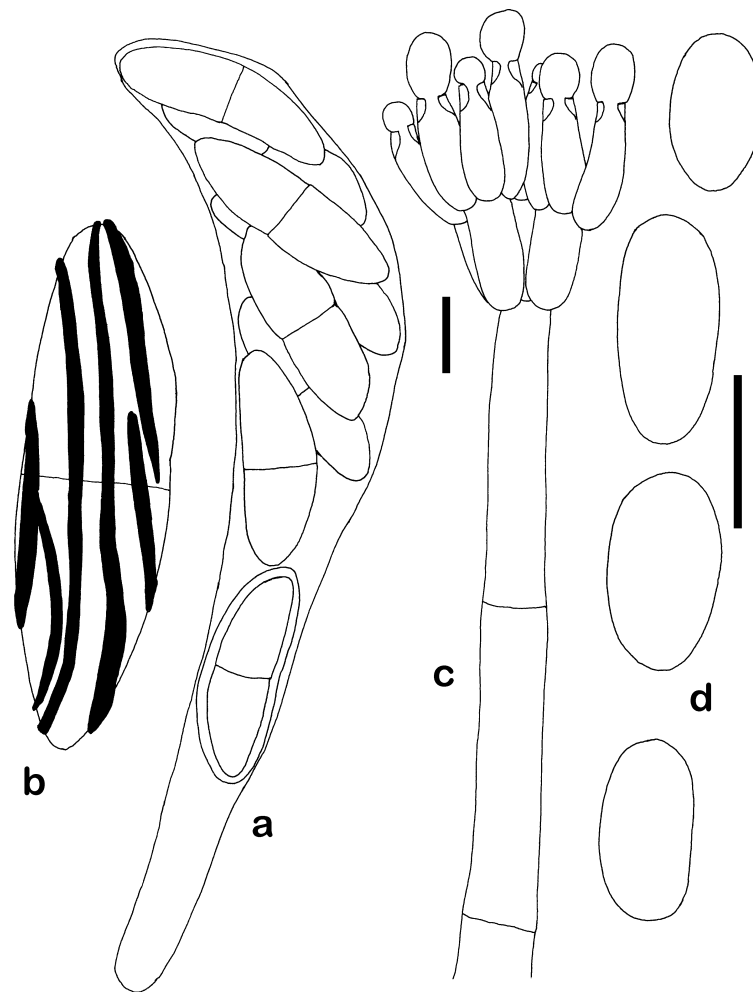
Aug 1987; G.J.S., J.-J. de Granville, L. Allorge, W. Hahn, M. Hoff (CAY, NY; G.J.S. 5891; paratype). – Mt. Wokomung, on ridge leading NW toward summit, ½–1 h walk from Base Camp; forest tall, well drained below, wet, with palms above; on bark; 1 Jul 1989; G.J.S., B.M. Boom, G. Bacchus (BRG, NY; G.J.S. 6393; G.J.S. isolate 89-74). – Wokomung Base Camp, ca 8 h walk NE of Kopinang Village in tall, wet forest, dominated by *Euphorbiaceae*; on bark of recently dead *Euphorbiaceae*; Jun–Jul 1989; G.J.S., B.M. Boom, G. Bacchus (BRG, NY; G.J.S. 6426). – GUYANA. Cuyuni-Mazaruni Region, VII, Mazaruni Subregion, VII-2, vic. Chinoweing village, 05°32' N, 60°07' W, 650–750 m alt.; on bark; 20–23 Feb 1987; G.J.S., J. Pipoly, G. Gharbarran, J. Chin (BRG, NY; G.J.S. 4708; G.J.S. isolate 87-6; paratype). – Mt. Ayanganna, gorge N of central-eastern side, 05°25' N, 59°50' W, 650–750 m alt.; on bark of recently dead tree; 13 Mar 1987; G.J.S., J. Pipoly, G. Gharbarran, J. Chin, R. Edwards (NY; G.J.S. 5153). – JAMAICA. Hanover Parish, Dolphin Head Mountain, vic. Askenish, ca 300 m alt.; on bark; 22 Jan 1971; Korf *et al.* (NY; CUP-MJ 931, A.Y.R. 511). – PERU: Dpto. Huanuco. Vic. km post 3 from Tingo Maria on the Tingo Maria–Monzon Rd., ca 850 m alt.; on indet. vine; 3 Jul 1976; K.P.D., S.E. Carpenter, M.A. Sherwood, P. Buriticá (NY; Dumont-PE 597). – Luquillo Mts., El Verde Research Area; on bark of recently dead *Casearia arborea*; 19 Feb 1996; G.J.S., H.-J. Schroers, D.J. Lodge (BPI 749140, CBS; H.J.S. 48A). – VENEZUELA. Edo. Bolívar: Ca 118 km S of El Dorado on road between El Dorado and Sta. Elena, trail up N facing slope of Uei-Tepui from old military camp ‘Ciento Vienticinco’; on bark; 5 Aug 1972; K.P.D., R.F. Cain, G.J.S., C. Blanco (NY; G.J.S. 6999).

**Notes:** *Bionectria lucifer* is classified in subgenus *Zebrinella* because of perithecial wall anatomy, ascospore ornamentation, and stroma morphology. As in *B. grammicospora*, *B. grammicosporopsis*, and *B. subquaternata*, the perithecial warts consist of subglobose to angular cells that become smaller toward the tip of the wart (Fig. 69 b), the perithecial walls consist of two regions (Fig. 69 d, e, f), the stroma is prosenchymatous (Fig. 69 f), and the ascospores are striate (Figs 69 i, 70 b). The teleomorph differs from other species of subgenus *Zebrinella* by solitary perithecia (Fig. 69 a).

The monomorphic conidiophores of *B. lucifer* differ considerably from those of other *Bionectria* species in having wide and relatively short phialides formed in a short penicillus (Figs 69 j, k, 70 c). The conidiophore in *B. lucifer* is considered homologous to the primary conidiophores in *Bionectria* because conidial masses are held in heads. The lack of secondary conidiophores could be related to culture conditions and the lack of aerial mycelium as was discussed for *B. grammicosporopsis* and *B. subquaternata*. However, secondary

**Fig. 69. *Bionectria lucifer* / *Clonostachys lucifer*.** a. Habit of solitary perithecia. b. Perithecial wart; cells subglobose, getting smaller toward the tip, uniformly thin-walled. c. Longitudinal section through perithecium. d. Subsurface view of outer perithecial wall region showing subglobose to angular cells. e. Subsurface view of inner perithecial wall region. f. Section through perithecial base, cells of stroma prosenchymatous. g. Immature asci with slightly visible ring. h, i. Discharged ascospores in optical section (h) and surface view (i). j, k. Conidiophores, found on perithecium in nature (j), from culture (k). a, b, c, f, k: BPI 749139; d: G.J.S. 2321; e: Dumont-PE 597; g: BPI 749140; h, i: Dumont-EC 896; j: G.J.S. 6426. All except k: natural substratum. a: DM; g: PC; others: DIC. Scale bars: a = 250 µm; b, f, k = 30 µm; c = 100 µm; d, e, g–j = 10 µm.





**Fig. 70.** *Bionectria lucifer* / *Clonostachys lucifer*. **a.** Almost mature ascus. **b.** Discharged, striate ascospore. **c.** Gliocladium-like conidiophore, with wide phialidic apertures. **d.** Broadly rounded conidia with invisible hila. – a: G.J.S. 3898; b: G.J.S. 3362; c: G.J.S. 6393; d: G.J.S. 3362, G.J.S. 6393. All from natural substratum. Scale bars = 10  $\mu$ m; the shorter bar applies to a, c, the longer to b, d.

conidiophores were observed, neither on the natural substratum nor in freshly isolated strains. The monomorphic conidiophores, adpressed penicilli, and watery, slightly pigmented heads of conidial masses are

reminiscent of *Gliocladium sensu stricto*. The conidial characters of *B. lucifer* (Fig. 70 d) are similar to those of *B. subquaternata*, but the conidial size is less variable.



### 30. *Bionectria levigata* Schroers, *sp. nov.* — Figs 71 a–h, 72 a, b, 73 a–c.

Anamorph: *Clonostachys levigata* Schroers, *stat. nov.* — Fig. 72 c–i.

*Bionectria ochroleuca* et *B. solani* similis; peritheciis levigatis, sed strato medio perithecorum deficiens et cellulis stromatis prosenchymaticis. Ascosporae ellipsoideae, uniseptatae, levigatae,  $(9.8\text{--}11.2\text{--}11.8\text{--}12.4(-15.6) \times (2.6\text{--}3.2\text{--}3.4\text{--}3.8(-4)) \mu\text{m}$ . Anamorphosis *B. grammicosporae* similis sed conidiophora primaria acromonii similia vel verticillata, secundaria ramis primariis divergentibus. Phialidibus intercalariis nonnumquam praesentibus. Coloniae 24°C post 7 dies ca 15 mm diam. Conidia  $(4\text{--}5.6\text{--}6\text{--}6.4(-7.6) \times (2.0\text{--}2.4\text{--}2.6\text{--}2.6(-3)) \mu\text{m}$ .

Holotypus teleomorphosis: BPI 748344. Holotypus anamorphosis: BPI; cultura sicca, isolata ex specimine BPI 748344; isotypus herb. CBS; cultura viva CBS 101916.

Etymology: Latin *levigatus* (= smooth) referring to the smooth perithecia, unusual in subgenus *Zebrinella*.

**Description from natural substratum: Perithecial stroma** well-developed, erumpent through bark or the outer cortex of potato tuber or potato stem, to 2 mm broad and ca 1.2 mm high; cells prosenchymatous, hyphal,  $\pm$  vertically arranged, discontinuous with the cells of the perithecial wall. **Perithecia** crowded, in groups of up to 40 or more, 350–680  $\mu\text{m}$  high, 250–400  $\mu\text{m}$  diam, globose or subglobose to obovoid, ampulliform when dry, orange to brownish orange to reddish, not papillate, smooth. **Perithecial wall** 30–45  $\mu\text{m}$  thick, composed of two regions. Outer region 10–20  $\mu\text{m}$  or 4–6 cells thick; cells not intergrading with the hyphal stroma, with evenly thin walls around 1.5  $\mu\text{m}$  thick. Middle region of hyphal cells lacking. Inner region 10–15  $\mu\text{m}$  thick. **Asci** 40–65  $\times$  5.5–8.0  $\mu\text{m}$  (60–75  $\times$  7–8  $\mu\text{m}$  according to Booth, 1959); ascus apex narrowly rounded, ring visible at least when immature. **Ascospores** ellipsoidal to oblong ellipsoidal, smooth,  $(9.8\text{--}11.2\text{--}11.8\text{--}12.4(-15.6) \times (2.6\text{--}3.2\text{--}3.4\text{--}3.8(-4)) \mu\text{m}$  (n = 32) [ascospores from potato: smooth or warty,  $(8.2\text{--}11\text{--}11.6\text{--}12.2(-16) \times (3.4\text{--}3.8\text{--}4.2\text{--}4.4(-5.2)) \mu\text{m}$  (n = 75)].

**Description from culture: Colonies** reaching 15–20 mm diam in 7 d at 24°C; optimum for growth 21–24°C, growth maximum 27°C. **Colony** reverse on OA after incubation in daylight pale to light yellow (3A3–4), on PDA with a greyish yellow hue (3C4); pigmentation less intense when incubated in darkness; pale orange when incubated under UV-light (5A2–3). Colony surface felty to floccose, with a yellow pigmentation translucent from the agar; aerial mycelium sparsely formed, consisting of hyphae or hyphal strands bearing conidiophores; surface structures and sporulation best developed on OA and in daylight condition; on CMD structures and sporulation more

sparsely developed; on PDA felty, aerial mycelium forming strands, sporulation weak. **Conidiophores** indistinctly dimorphic, formed from the agar surface or the aerial mycelium. Primary conidiophores simple, acromonium-like, or infrequently branched; stipes around 40  $\mu\text{m}$  long or shorter, to 5  $\mu\text{m}$  wide at base; phialides almost cylindrical, somewhat narrowing towards the tip, 20–35  $\mu\text{m}$  long, 2–3  $\mu\text{m}$  wide at base, 1–1.5  $\mu\text{m}$  wide at the tip, divergent if occurring in whorls, without a visible collarette. Secondary conidiophores formed in loose aggregates, somewhat penicillate; branches divergent; phialides typically adpressed, in whorls of 3–5, also divergent at acute angles, flask-shaped, widest in the lower third, narrowing continuously upwards, without a visible collarette,  $(7.6\text{--}10.6\text{--}13\text{--}14.6(-23)) \mu\text{m}$  long,  $(1.6\text{--}2.0\text{--}2\text{--}2.4(-3)) \mu\text{m}$  wide at base,  $(1.8\text{--}2.4\text{--}2.6\text{--}2.8(-3.2)) \mu\text{m}$  at widest point,  $(1)1.2\text{--}1.4\text{--}1.6(-2.2) \mu\text{m}$  wide near aperture (n = 26). **Conidial masses** hyaline to pale yellow, turning pale orange, in round heads (primary conidiophores) or narrow columns (secondary conidiophores). **Conidia** hyaline, smooth, ellipsoidal to broadly ellipsoidal, almost polysymmetrical with almost broadly rounded ends; hilum not or hardly visible, median or minutely displaced,  $(4\text{--}5.6\text{--}6\text{--}6.4(-7.6) \times (2.0\text{--}2.4\text{--}2.6\text{--}2.6(-3)) \mu\text{m}$  (n = 61). Conidiomata and perithecia not observed.

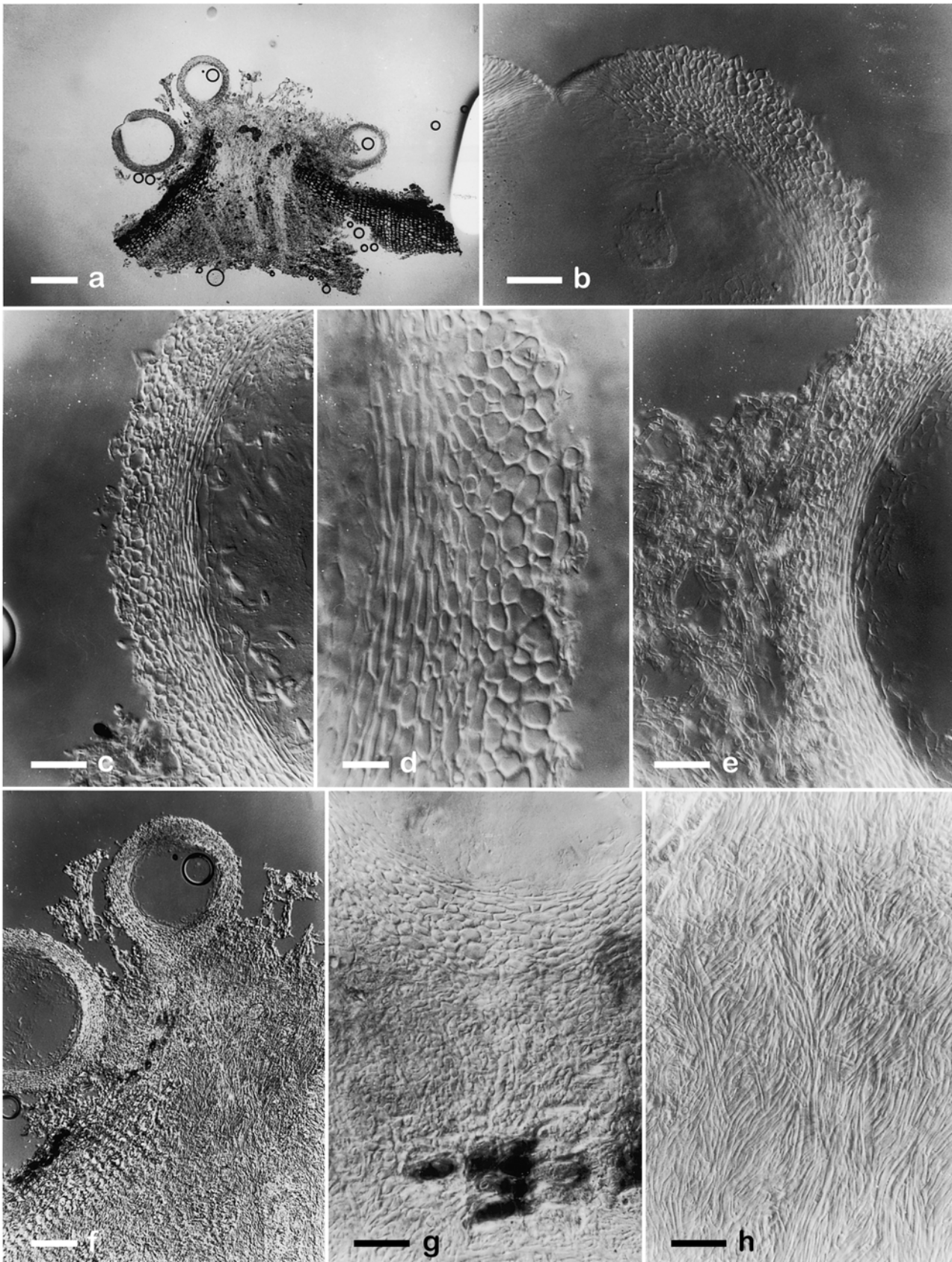
**Type for *Bionectria levigata*:** FRANCE. Pyrénées Atlantiques, Îlot de Sauveterre de Béarn, 100 m alt.; on bark of ?dead *Buxus sempervirens*; 10 Jan 1993; G.J.S., F. Candoussau (BPI 748344; ex-type strain: CBS 101916, derived from ascospores). **Type for *Clonostachys levigata*:** dried culture ex CBS 101916, filed together with type of *B. levigata* (BPI 748344); isotype: herb. CBS.

**Known distribution:** Europe.

**Habitat:** Bark of *Buxus sempervirens* or leaves or stems of potato.

**Additional specimen/isolates examined:** FRANCE. Pyrénées Atlantiques: Îlot de Sauveterre de Béarn (64); on branch of ?dead *Buxus sempervirens*; F. Candoussau; F.C. 4861-1; 10 Jan 1993 (BPI 802561; G.J.S. isolate 93-4, CBS 948.97). – Isle de Sauveterre de Béarn, 100 m alt.; on bark of ?dead *Buxus sempervirens*; G.J.S., F. Candoussau, 25 Oct 1998 (BPI; H.J.S. 305a). – ENGLAND: Kew Gardens, from leaf litter of *Buxus sempervirens*, Nov 1967, W. Gams, (CBS 203.69, anamorph only). **Specimens formerly listed under *Nectria solani*:** UK. Yorks.: Bolton Percy; on potato; May 1943; W.G. Bramley (IMI 56769; slides of longitudinal sections). – Bolton Percy; on potato; Jul 1943; W.G. Bramley (K). – Malton; on potato; 25. Sept 1957; W.G. Bramley (IMI 70653b).

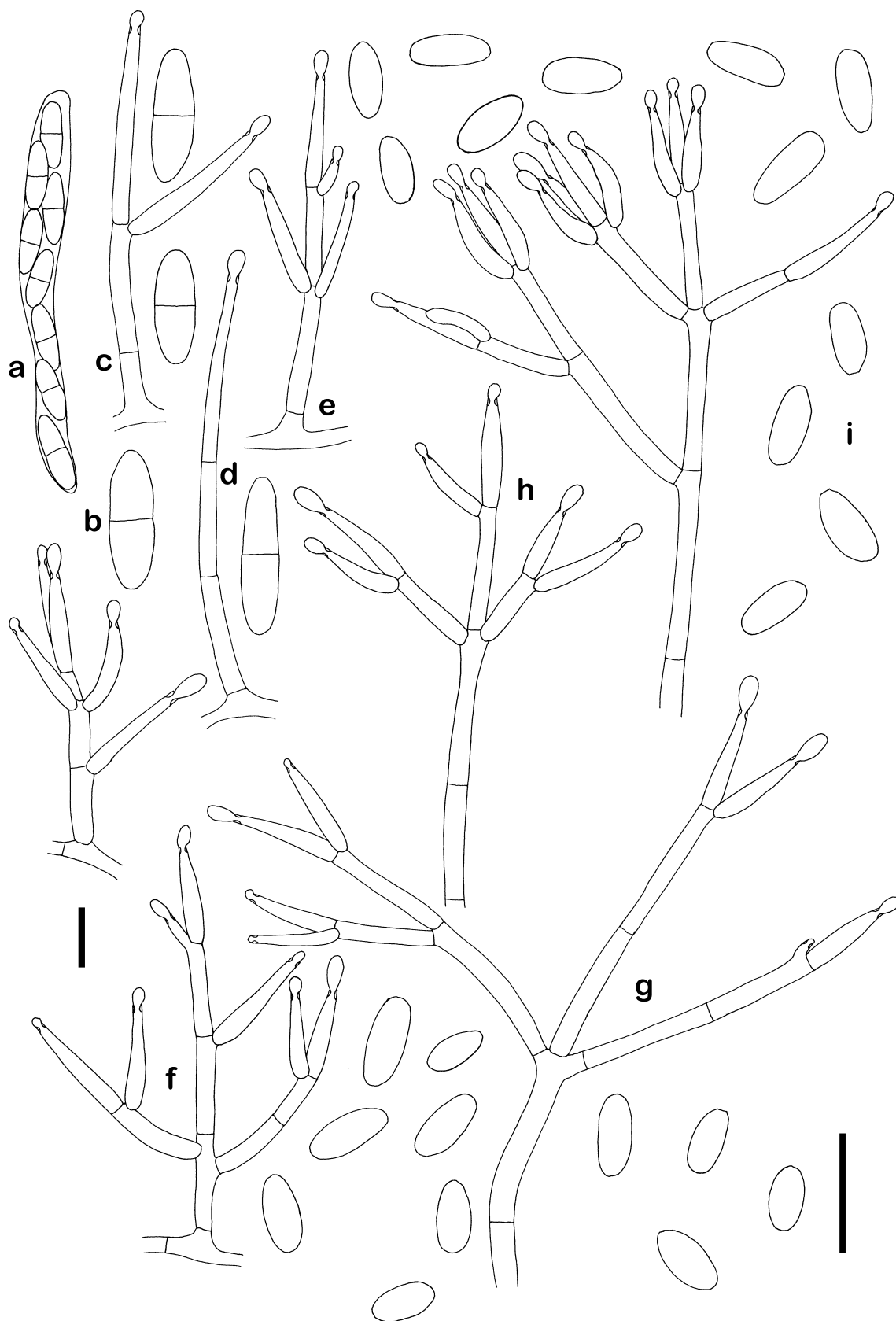
**Notes:** *Bionectria levigata* differs from other species in subgenus *Zebrinella* by smooth perithecia (Figs 71



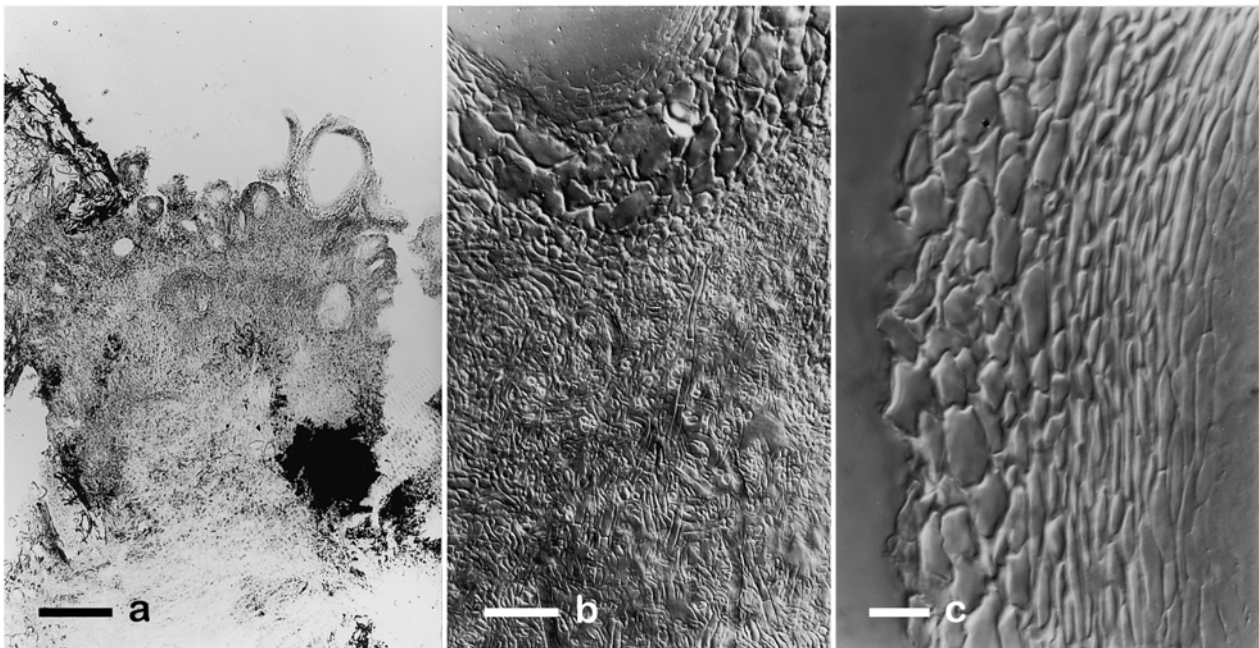
**Fig. 71.** *Bionectria levigata* (from *Buxus*, France). **a–h.** Sections through perithecia and stroma. **a.** Perithecia on erumpent stroma. **b.** Ostiole. **c, d.** Lateral perithecial wall showing two regions. **e.** Mycelium between perithecia. **f.** Stroma. **g.** Perithecial base; prosenchymatous cells of stroma discontinuous with cells of perithecial wall. **h.** Prosenchymatous cells of stroma. – All: BPI 748344, DIC. Scale bars: a = 250 µm; b, c, e, g = 30 µm; d = 10 µm; f = 100 µm.

a–f, 73 a, c) and smooth (Fig. 72 b) to warty (not shown) ascospores. Other characters including the perithecial wall, which consists of two regions (Figs 71

d, 73 c), the prosenchymatous stroma (Figs 71 h, 73 b), and the non-continuous interface of the perithecial wall and stroma (Figs 71 g, 73 b), allow classification of *B.*



**Fig. 72.** *Bionectria levigata* / *Clonostachys levigata*. **a.** Almost mature ascus. **b.** Discharged, smooth ascospores. **c–e.** Simple branched, sometimes acromonium-like, short-stiped primary conidiophores. **f–h.** Divergently branched secondary conidiophores with sometimes addressed whorls of phialides and intercalary phialides. **i.** Straight, almost symmetrical conidia with median or hardly displaced hila. – a, b: BPI 748344, natural substratum; others: CBS 948.97, 5–9 day-d-old OA cultures. Scale bars = 10  $\mu$ m; the shorter bar applies to a, c–h, the longer to b, i.



**Fig. 73.** *Bionectria levigata* (from potato, UK). **a.** Stroma erumpent through cortex of potato stem. **b.** Perithecial base; cells of outer perithecial wall region not continuous with prosenchymatous stroma. **c.** Lateral perithecial wall consisting of two regions. a, b: W.G. Bramley 1943; c: IMI 56769. All from natural substratum. Scale bars: a = 250 µm; b = 30 µm; c = 10 µm.

*levigata* in subgenus *Zebrinella*, which is also supported by analyses of DNA sequences (Fig. 2; Schroers, 2000: Fig. 1, as '*Nectria*' sp. 6). The species is represented by a few specimens from France and one conidial isolate from UK, all originating from *Buxus*.

The conidiophores are dimorphic, although the two types are only weakly differentiated. The primary conidiophores are sparsely branched, sometimes acromonium-like (Fig. 72 c–e), and may intergrade with the morphological patterns of the more frequently and divergently branched secondary conidiophores (Fig. 72 f–h). The anamorph resembles *Clonostachys intermedia* (Fig. 74) but differs in size range of conidia and divergent branches of the conidiophores.

Based on similarities in stroma morphology (compare stroma morphology in Figs 71 g, h and 73 b) and perithecial wall anatomy (Figs 71 d, 73 c), several specimens from potato formerly identified as *Nectria solani* Reinke & Berthold were reidentified as *B. levigata*. Representative strains from potato, however, are not available to confirm this classification. The specimens from potato differ most strongly by having warted ascospores, while spores are typically smooth in specimens from *Buxus* and striate in other species of subgenus *Zebrinella*.

The specimen BPI 802561 is a mixed collection containing few perithecia of *B. levigata* being covered by those of *B. ochroleuca*. The ex ascospore strain provided by Samuels is identical to the ex-type strain of *B. levigata* and the anamorphic isolate CBS 203.69 (from *Buxus* in UK). Thus the ascospores apparently were isolated from a smooth perithecium of specimen BPI 802561.

### 31. *Clonostachys intermedia* Schroers, *sp. nov.* — Fig. 74 a–f.

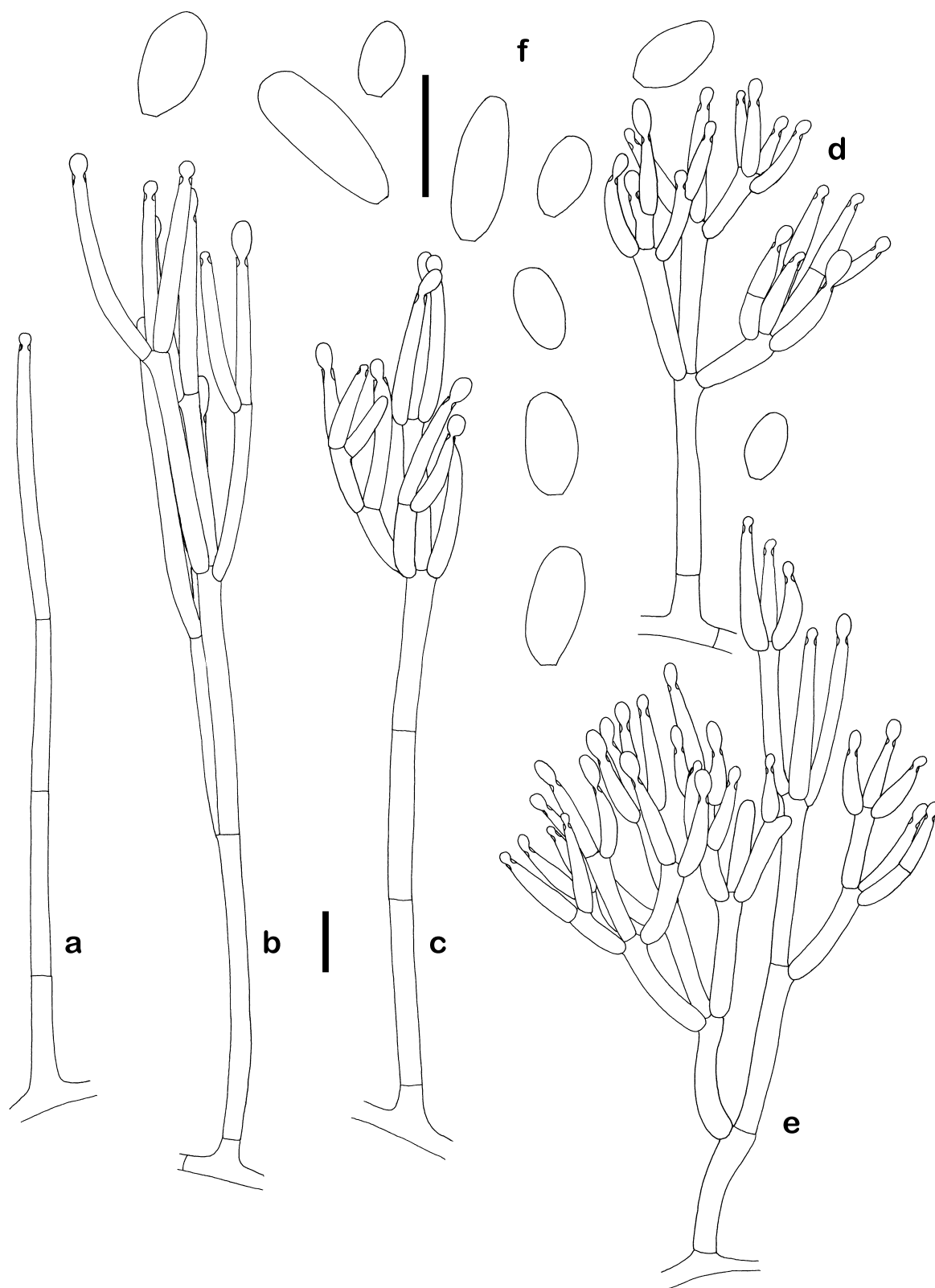
Anamorphosi *Bionectriae grammicosporae* similis sed coloniis lente crescentibus (ca 20 mm diam post 7 dies). Phialidibus intercalariibus nonnumquam praesentibus. Conidiis magis variabilibus, (5.4–)6.2–8.4–9.6(–15) × (2.6–)3.2–4–4.6(–5.4) µm.

Holotypus anamorphosis: Herb. CBS; cultura sicca, ex CBS 508.82; cultura viva CBS 508.82.

Etymology: *Intermedius*, referring to its intermediate position, showing characters of subgenus *Bionectria* (conidiophore dimorphy) as well as subgenus *Zebrinella* (conidial shape).

Teleomorph: Unknown.

**Description from culture:** Colonies reaching 17–21 mm in 7 d at 24°C; optimum for growth 18–24°C, maximum 30°C. Colony reverse on OA after incubation in daylight intensely deep light yellow (3A5) to olive-yellow (3BC7); PDA with an olive-yellow tinge (3C7); pigmentation less intense when incubated in darkness; light orange when incubated under UV-light (5A5). Colony surface dusty to granulose, yellow because of the pigmentation in the agar; aerial mycelium little developed, on OA and CMD almost absent, not forming strands; surface structures and sporulation best developed on OA in daylight; on PDA felty, aerial mycelium forming strands, sporulation weak. **Conidiophores** dimorphic, arising from the agar surface or the weakly produced aerial mycelium. **Primary conidiophores** simple (acromonium-like) to terverticillate, branches and phialides adpressed or minutely divergent; stipes 40–110 µm long, 3–5 µm wide at base;



**Fig. 74.** *Clonostachys intermedia*. **a–c.** Primary conidiophores; simple (acremonium-like) (a), penicillate, addressed (b, c). **d, e.** Secondary conidiophores penicillate, slightly divergently branched. **f.** Almost straight conidia with almost median hilum. – All from 9-d-old OA culture of CBS 508.82. Scale bars = 10  $\mu\text{m}$ ; the shorter bar applies to a–e, the longer to f.

penicillus to 150  $\mu\text{m}$  high; phialides 25–46  $\mu\text{m}$  long, 2.2–3  $\mu\text{m}$  wide at base, 1.4–1.8  $\mu\text{m}$  wide near aperture ( $n = 13$ ), without a visible collarette. **Secondary conidiophores** up to quaterverticillate, branches divergent at acute angles, stipe 20–60  $\mu\text{m}$  long, 3–4.5  $\mu\text{m}$  at base; penicillus 40–100  $\mu\text{m}$  high, to 70  $\mu\text{m}$  wide; phi-

alides in whorls of up to 5, narrowly flask-shaped, widest in the lower third, narrowing continuously upward, without a visible collarette, (8.8–)12.4–14.8–15.6(–28.8)  $\mu\text{m}$  long, (2.4–)2.6–2.8–2.8(–3.4)  $\mu\text{m}$  wide at base, (2.6–)3–3–3.2(–3.4)  $\mu\text{m}$  at widest point, (1–)1.4–1.4–1.6(–1.6)  $\mu\text{m}$  wide near aperture ( $n = 16$ ).

**Conidial masses** on primary conidiophores in round hyaline; on penicillate conidiophores initially in short columns, then collapsing to white to pale yellow domes, comprising conidia from several adjacent conidiophores. **Conidia** hyaline, smooth, oblong-ellipsoidal to broadly ellipsoidal, or ovoidal, almost symmetrical with broadly rounded ends; hilum not or hardly visible, median or minutely displaced, (5.4–)6.2–8.4–9.6(–15) × (2.6–)3.2–4–4.6(–5.4) μm (n = 61). **Conidiomata** not observed. **Perithecia** not observed.

**Type:** NETHERLANDS. Noordoost-polder, Nagele; from agricultural soil; H. Nylander nr. 718 (herb. CBS; dried culture ex CBS 508.82).

**Known distribution:** Netherlands, known only from the type locality.

**Habitat:** Agricultural soil.

**Notes:** *Clonostachys intermedia* is characterized by primary conidiophores that are either unbranched, acremonium-like (Fig. 74 a), or penicillate and ± narrowly adpressed (Fig. 74 b). While the primary conidiophores dominate in young colonies and particularly on media of lower nutrition content (CMA), more divergently branched, secondary conidiophores (Fig. 74 d, e) holding columns of imbricate conidia dominate in older colonies. Both kinds of conidiophores are generally also distinguishable by length-ranges of their phialides, however, they may also intergrade morphologically (Fig. 74 c).

Classification of *C. intermedia* in subgenus *Zebrinella* is supported by the overall symmetrical conidia (Fig. 74 c), the intensely yellow to somewhat greenish reverse of colonies, and analyses of rDNA sequences (Schroers, 2000). *Clonostachys intermedia* is similar to *B. grammicospora* and *B. levigata* but differs in growth speed of the colonies and size range of the conidia.

### 32. *Clonostachys chlorina* Schroers, *sp. nov.* — Fig. 75 a–b.

Anamorphosis *B. grammicosporae*, *B. grammicosporopsidi*, *B. levigatae*, et *C. intermediae* similis. Conidiophoris plusminusve monomorphiceis, divergentibus, phialidibus intercalariibus abundantibus. Conidia (6.2–)7–7.2–7.4(–8.8) × (3.2–)3.6–4–4.2(–4.4) μm.

Holotypus anamorphosis: Herb. CBS; cultura sicca, isolata ex CBS 287.90; cultura viva CBS 287.90.

Etymology: Latin *chlorinus* referring to the yellowish green colony reverse.

Teleomorph: Unknown.

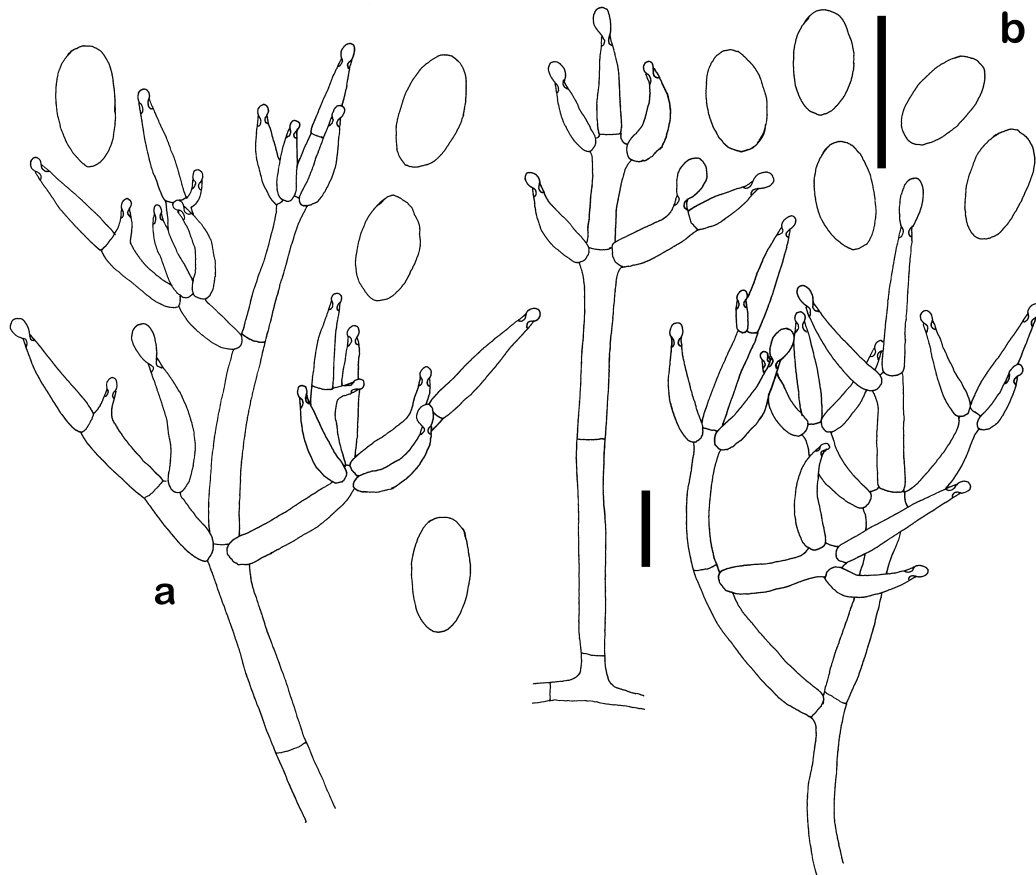
**Description from culture:** Colonies reaching 20–25 mm in 7 d at 24°C; optimum for growth (21–)24 (–27)°C, maximum 30°C. **Colony reverse** pale to light yellow (3A6 on OA, 2A5 on CMD), in older colonies golden, greyish to greenish yellow (2B5), or yellowish brown (5E5) on PDA. **Colony surface** powdery to finely granular or smooth because of the conidiophores and conidial masses; aerial mycelium abundant or sparse. **Conidiophores** dimorphic. **Primary conidiophores** acremonium-like or sparsely branched (not shown). **Secondary conidiophores** verticillate to penicillate, arising from the agar surface or the sparsely formed mycelium, decreasing in density toward the colony margin, with divergent branches and ± divergent phialides; stipe *ca* 20–50 μm long, 4 μm wide at the base; phialides in whorls of 2–5, flask-shaped, widest at base or in the lower third, (9.4–)14.8–16.4–18(–21.4) μm long, 2.0–3.2 μm wide at base, 3.5 μm wide in the lower third, 1–1.6 μm wide near aperture (n = 29); intercalary phialides common, cylindrical, *ca* 13 × 3–4 μm; lateral necks to 5 μm long, below solitary, terminal phialides. **Conidia** forming round masses or short columns, smooth, 1-celled, broadly ellipsoidal to ovoidal, with an almost median or invisible hilum, (6.2–)7–7.2–7.4(–8.8) × (3.2–)3.6–4–4.2(–4.4) μm (n = 30). Perithecia not observed in culture.

**Type:** BRAZIL. Pará: Belém, Capitão Poço near Belém; from washed soil under *Theobroma cacao*; L. Pfenning No. 173 (herb. CBS; dried culture ex CBS 287.90).

**Known distribution:** Brazil (Pará), known only from the type locality.

**Habitat:** Soil.

**Notes:** *Clonostachys chlorina* was initially identified as the anamorph of *Nectria impariphialis* (*Bionectria* subgenus *Epiphloea*) because of the abundantly formed intercalary phialides (Fig. 75 a). In contrast to *B. impariphialis* [conidia ellipsoidal to oblong-ovoidal, mostly 7.5–10 μm long (Samuels, 1989: Figs 30, 31)], the conidia of *C. chlorina* are broadly ellipsoidal, symmetrical, broadly rounded, have median or invisible hila, and are mostly less than 7.5 μm long (Fig. 75 b). The conidial shape and the yellowish green colony pigmentation allows classification of *C. chlorina* in subgenus *Zebrinella*, which is also supported by rDNA sequences (Schroers, 2000: Fig. 1, as '*Nectria*' sp. 7). In contrast to other species of subgenus *Zebrinella* that form a yellow-green pigment towards their colony margin and sometimes only in older colonies, cultures of *C. chlorina* are pigmented yellowish green throughout. Among the anamorphs of subgenus *Zebrinella*, intercalary phialides are most abundant in *C. chlorina*,



**Fig. 75.** *Clonostachys chlorina*. **a.** Divergently branched conidiophores, intercalary phialides frequent. **b.** Conidia. – All from 14-d-old OA culture of CBS 287.90. Scale bars = 10 µm; the shorter bar applies to a, the longer to b.

while they are still frequently found in *B. levigata* and *C. intermedia*, rarely in *B. grammicospora*, and absent in *B. grammicosporopsis*, *B. subquaternata*, and *B. lucifer*. Because of the intercalary phialides and the symmetrical shape of the conidia in *C. chlorina*, the

subgenera *Zebrinella* and *Epiphloea* intergrade morphologically (Schroers, 2000: arrow 2 in Fig. 5). The intermediate morphological character pattern in *C. chlorina* is a main reason for the broad generic circumscription of *Clonostachys*.

#### **BIONECTRIA SUBGEN. EPIPHLOEA** Schroers, *subgen. nov.* — Species 33–42.

Perithecia e stromate minusculo superficiali exorientia, in substratis herbaceis vel lignosis, solitaria vel gregaria, globosa vel subglobosa, levigata, pallide lutea vel pallide aurantiaca, a KOH haud mutata. Tunica perithecorum e duobus regionibus et uno strato superficiali cellularum indistinctarum cum stromate basiali continuarum constans. Stratum exterius e cellulis angularibus vel subglobosis, stratum interius e cellulis applanatis, e superficie visis lobatis. Asci clavati, apice simplici vel annulo refringente praediti, 8-spori. Ascospores uniseptatae, ellipsoideae vel fusiformes, hyalinae, verruculosae vel striatae. Anamorphosis modo *Sesquicillii*: phialidibus intercalaribus abundantibus. Conidia non-septata vel raro uni-septata, leviter curvata vel ovoidea vel ellipsoidea, heteropolaria, hilo laterali sed subbasali.

Type species: *Bionectria rossmaniae* Schroers.

Etymology: Greek *epiphloeos* (= upon bark) referring to the superficial habit of stroma and perithecia in most species.

Anamorph: *Clonostachys* (sesquicillium-like).

= *Sesquicillium* W. Gams, Acta Bot. Neerl. 17: 455. 1968.

**Perithecial stroma** superficial on leaves, lichens or bark, rarely erumpent through bark; cells epidermoid to hyphal. **Perithecia** solitary, gregarious or loosely aggregated, crowded if formed on an erumpent stroma, globose to subglobose, 200–400 µm diam, pale yellow, pale orange to light orange, apically or laterally pinched when dry, not papillate, glabrous; ostiolar region somewhat sunken and slightly darker (brownish), contrasting when dry, rarely surrounded by a ring-like structure as a result of a subapically thickened perithecial wall. **Perithecial wall** to 50 µm thick, consisting of two regions and an outermost cell layer consisting of indistinct cells that apparently continue into the perithecial stroma. Outer region of globose to subglobose to somewhat angular cells, ca 5 cells thick; cells with uniformly thickened walls around 1.5 µm thick. **Asci** narrowly to broadly clavate, 8-spored; apex flat or rounded, with or without visible ring. **Ascospores**

broadly ellipsoidal to fusiform, spinulose, warted, or striate, 1-septate, equally 2-celled. **Conidiophores** macronematous, mononematous, monomorphic penicillate or indistinctly dimorphic, penicillate and verticillium-like, mostly arising from the agar surface or from more sparsely formed aerial mycelium. Penicillus bi- to quaterverticillate; branches of the penicillus divergent or adpressed; terminal whorls consisting of narrowly flask-shaped phialides and/or intercalary phialides bearing a solitary terminal phialide. Mycelium or conidiophores rarely with setae. **Conidia** 1-celled, rarely 2-celled, smooth, hyaline, ovoidal, ellipsoidal, or fusiform, slightly curved or straight, generally with a slightly laterally displaced hilum, arranged in imbricate chains forming columns.

**Habitat:** Perithecia on decaying leaves of various deciduous trees or herbaceous plants, on bark of recently dead trees; sometimes in direct association with ascomata of other ascomycetes or lichens; anamorph also isolated from soil.

**Published descriptions:** Gams (1968, 1971), Samuels (1989).

**Notes:** Teleomorphs of species forming *Sesquicillium* anamorphs were described by Juel (1925) and Samuels (1989). The type species of *Sesquicillium*, *S. buxi* (Schmidt in Link) W. Gams (Gams, 1968), is the anamorph of *Nectriella coronata* Juel (Juel, 1925) (here classified in *Bionectria* subgenus *Uniparietina*), which matches *Nectriopsis* because of a single perithecial wall region. Samuels (1989) described tropical teleomorphs with *Sesquicillium* anamorphs that differ from *N. coronata* by having fleshy perithecial walls with an additional wall region. For these species, the subgenus *Epiphloea* is introduced. This subgenus is segregated from other taxa in *Bionectria* based on characters of the teleomorph. The perithecia mostly are solitary, smooth, and almost globose (Fig. 78 b). The stromata bearing the smooth, solitary, and globose perithecia are superficial (Fig. 83 c) and consist of  $\pm$  prosenchymatous cells that apparently continue into the outermost cell layer but not into the two main regions of the perithecial wall (Fig. 76 d). The outermost cells differ from those of the main outer perithecial wall region. While the cells in the latter are subglobose to angular (e.g. Fig. 79 g), the outermost cells are epidermoidal in surface view (Fig. 78 f) but hardly recognizable in sections while the innermost are homologous to the innermost region found in other nectrioid taxa. *Bionec-*

*tria sesquicillii* sometimes forms perithecia crowded on a common, sometimes erumpent stroma (Fig. 87 d).

The penicillate conidiophores in subgenus *Epiphloea* contain numerous intercalary phialides formed below terminal phialides as is typical of *Sesquicillium buxi*, the type species of *Sesquicillium* W. Gams (1968). Samuels (1989) therefore classified the anamorphs in *Sesquicillium*. The mostly monomorphic conidiophores in subgenus *Epiphloea* are similar to the secondary conidiophores found in other subgenera of *Bionectria*. All are penicillate and form columns of imbricate conidia. Because of these overall similarities and because intercalary phialides are also formed by some species in subgenera *Zebrinella* and *Bionectria*, at the same places in the penicilli, the secondary conidiophores and the intercalary phialides of all species are considered homologous. Therefore, *Sesquicillium* is no longer retained separate from *Clonostachys*. At least in one species, *B. sesquicillii*, primary, verticillium-like conidiophores are formed, although less frequently than in species of the subgenus *Bionectria*. This dimorphism also corroborates classification of the sesquicillium-like anamorphs in *Clonostachys*. The superficial habit of ascocarps and stromata, thus the main distinction between subgenus *Epiphloea* and the subgenera *Bionectria* and *Zebrinella*, was interpreted as an adaptation to the substrata (Schroers, 2000). Although the teleomorph in some species also is formed on bark of recently dead trees, they occur typically on decaying leaves or lichens in subgenus *Epiphloea*. Because such substrata are more ephemeral than woody substrata, they may not favour or require the formation of erumpent stromata. In contrast, the subcortically developing mycelium of species in the subgenera *Bionectria* and *Zebrinella* may require the formation of stromata to break through the bark and to form exposed sporodochia and/or ascocarps.

Species in subgenus *Epiphloea* lack sporodochia and green-coloured conidial masses. Contrasting to the other subgenera in *Bionectria*, some species form setae that arise from the conidiophores or creeping mycelium. Anamorphs of subgenus *Epiphloea* are homogeneous in colony growth rate (around 20 mm diam in 7 d at 24°C), similar branching patterns of conidiophores, white to pinkish colony pigmentation, and relatively weak production of aerial mycelium. Recognition of species in subgenus *Epiphloea* is based on size differences of ascospores and conidia and partly on the branching of the secondary conidiophores and presence or absence of setae. In one species, *C. setosa*, 1-septate conidia occur.



**33. *Bionectria rossmaniae*** Schroers, *sp. nov.* — Figs 76 a–k, 77 a, b.

Anamorph: *Clonostachys rossmaniae* Schroers, *stat. nov.* — Fig. 77 c, d.

Cellulae strati exterioris ad  $25 \times 15 \mu\text{m}$ . Ascospores (7.4–)10–10.8–11.6(–13.8)  $\times$  (2.2–)3–3.2–3.6(–4.6)  $\mu\text{m}$ , *B. sesquicillii* similis, sed striis brevibus ornamentatae. Anamorphosi *Bionectriae sesquicillii* similis sed conidia comparate latiora [L/W (1.6–)2–2.3(–3.3)]; *Clonostachydi buxi* similis sed conidia leviter curvata, hilo laterali (nec cymbiformia), (4.2–) 4.6–5–5.4(–6.6)  $\times$  (2–)2.2–2.4–2.4(–2.8)  $\mu\text{m}$ .

Holotypus teleomorphosis: Specimen G.J.S. 3970 (NY). Holotypus anamorphosis: NY; cultura sicca, isolata ex specimine G.J.S. 3970; isotypus herb. CBS; cultura viva CBS 211.93.

Etymology: Named in honour of Dr A.Y. Rossman.

**Description from natural substratum:** **Perithecial stroma** superficial, consisting of densely packed hyphae continuous with the outermost cell layer of the perithecial wall; cells  $< 5 \mu\text{m}$  diam. **Perithecia** solitary to gregarious, subglobose to globose, to 300(–400)  $\mu\text{m}$  diam, not pinched when dry, pale yellow to brownish orange, smooth, minutely papillate, mostly with a darker (brownish) contrasting ostiolar region. **Perithecial wall** 30–45  $\mu\text{m}$  thick, thinner toward the base and thicker toward the ostiole. Outermost cell layer that continues into the stroma mainly observed in the lower part of the perithecial wall. Outer region 20–30  $\mu\text{m}$  or 4 cells thick; cells subglobose to angular, thin-walled, increasing in size toward the interior: outer cells 4–10  $\times$  3–7  $\mu\text{m}$  (n = 84), inner cells 10–25  $\times$  7–15  $\mu\text{m}$  (n = 69); vacuoles not observed. Inner region ca 15  $\mu\text{m}$  thick. **Asci** narrowly clavate to almost cylindrical, (42.5–)49.5–54–59(–65.5)  $\times$  (5.5–)6.5–7–7.5(–9)  $\mu\text{m}$  (n = 26), 8-spored; ascus apex flat, with rounded edges and a visible ring. **Ascospores** ellipsoidal, equally 2-celled, not constricted or with age slightly constricted at the septum, colourless, striate, with short, intricately arranged striae, (7.4–)10–10.8–11.6(–13.8)  $\times$  (2.2–)3–3.2–3.6(–4.6)  $\mu\text{m}$  (n = 142). **Sterile mycelium** sometimes formed near the perithecial base. **Conidiophores** visible on some specimens, densely aggregated, formed on a sparsely developed mycelial mat.

**Description from culture:** **Colonies** reaching 15–20 mm in 7 d at 24°C; optimum for growth (21)24–27(30)°C (18–22 mm diam); maximum 30/33°C. Colony reverse unpigmented or pale orange. Colony surface finely powdery because of scattered conidiophores and conidial masses. **Conidiophores** monomorphic, penicillate, arising from the agar surface or aerial mycelium, decreasing in density toward the colony margin, di- to quaterverticillate, branches, metulae, and phialides almost adpressed to divergent at acute angles; stipe 40  $\mu\text{m}$  long, 3–4.5  $\mu\text{m}$  wide at the base; penicillus to 50  $\mu\text{m}$  high, 60  $\mu\text{m}$  wide; metulae

6.4–13.4  $\times$  2.6–3.2  $\mu\text{m}$ ; intercalary phialides below solitary terminal phialides, in whorls of 2–4, almost cylindrical, 4.6–11.6  $\times$  2.4–3.4  $\mu\text{m}$  (n = 49); lateral necks 2–3.5  $\mu\text{m}$  long (n = 20); terminal phialides flask-shaped, widest at base or in the lower third, (6.2–)7.2–8–8.6(–13)  $\mu\text{m}$  long, (1.6–)2–2.2–2.4(–3)  $\mu\text{m}$  wide at base, ca 3.5  $\mu\text{m}$  wide at widest point, (0.8–)1–1–1.2(–1.4)  $\mu\text{m}$  wide near aperture (n = 49). **Conidia** 1-celled, ellipsoidal to ovoidal, mostly with a laterally displaced hilum, (4.2–)4.6–5–5.4(–6.6)  $\times$  (2–)2.2–2.4–2.4(–2.8)  $\mu\text{m}$  (n = 89). Perithecia not observed.

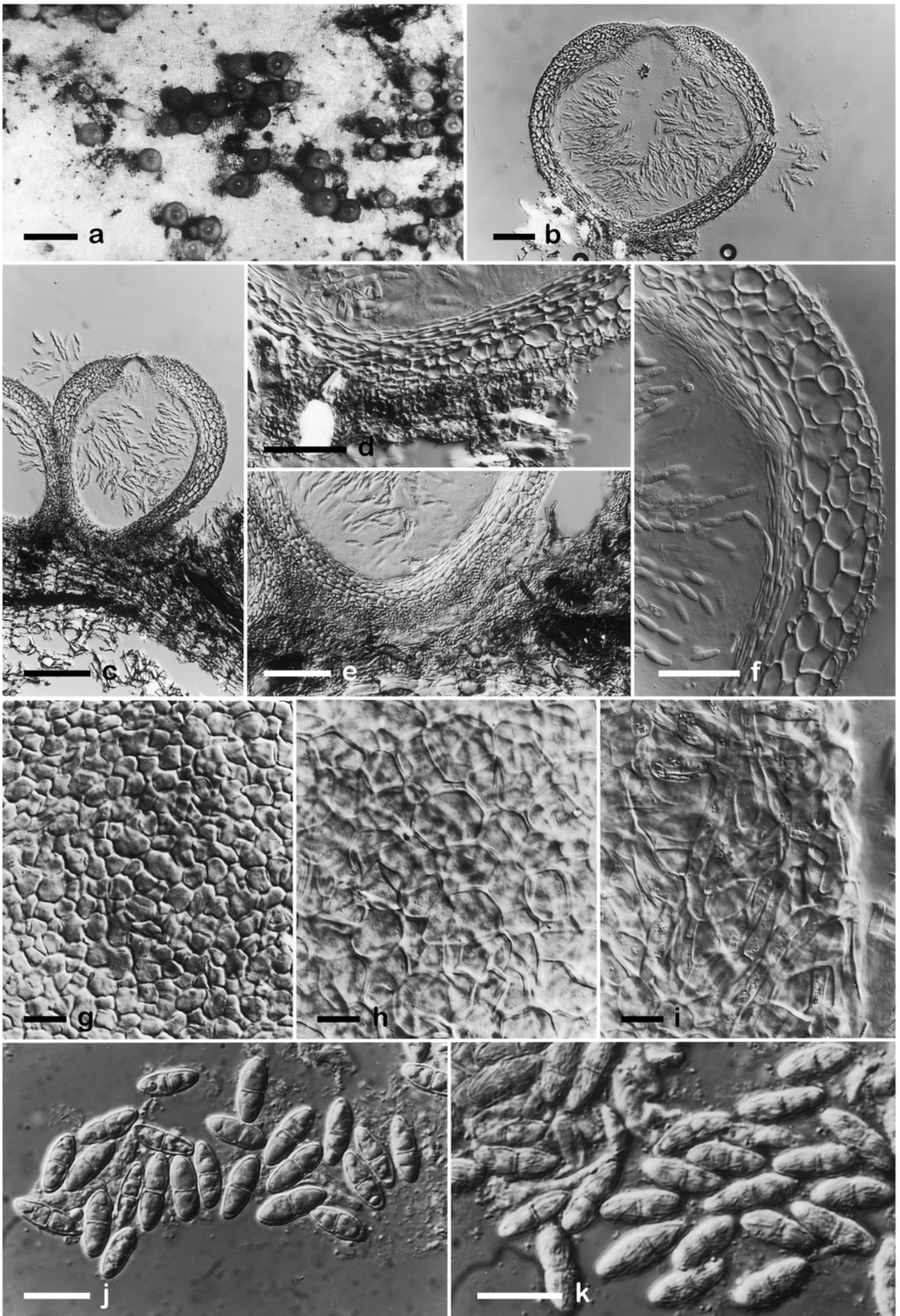
**Type for *Bionectria rossmaniae*:** FRENCH GUIANA. Piste de Saint-Elie, km 16 on road between Sinnamary and St. Elie, 'Ecerex', Orstom research area, 05°20' N, 00°53' W; on twigs of recently dead tree; Feb, Mar 1986; G.J.S. (NY; G.J.S. 3970; G.J.S. isolate 86-246; CBS 211.93, derived from ascospores). **Type for *Clonostachys rossmaniae*:** dried culture ex CBS 211.93, filed together with type of *B. rossmaniae* (NY); isotype: herb. CBS.

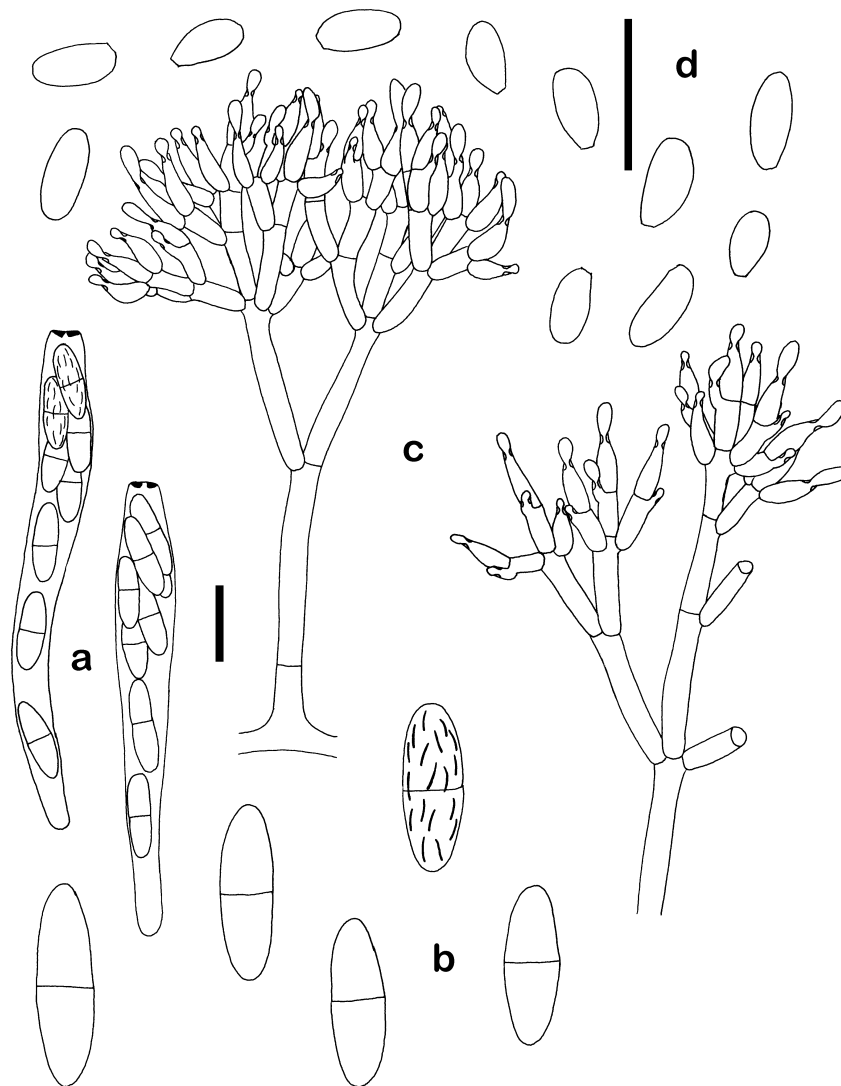
**Known distribution:** The neotropics.

**Habitat:** On bark of recently dead woody plants.

**Additional specimens/strains examined:** BRAZIL. Amazonas: 0–3 km N of km 211 of Perimetral Norte Highway, ca 1 km NE of Funai Post toward summit of Pico Rondon, 01°32' N, 62°48' W; on vine; 3 Feb 1984; G.J.S. (NY; G.J.S. 98). – Reserva Florestal Ducke, km 26 on the Manaus–Itacoatiara Rd.; on bark; 10 Nov 1977; G.J.S., D.R. Hosford (NY; Br 235A; CBS 250.78). – ECUADOR. Prov. Pastaza: ca 2 km from Puyo, on the Ambato–Puyo Road, ca 1230 m alt.; on indet. herbaceous stem; 24 Jul 1975; K.P.D., S.E. Carpenter, P. Buriticá (NY; Dumont-EC 1451). – FRENCH GUIANA. On bark of living liana; Jan, Mar 1986; G.J.S. (NY; G.J.S. 4274; G.J.S. isolate 86-302, CBS 210.93). – Saül, ca 10 km SW of Saül toward Mt. Galbao, 200–350 m alt.; on bark of recently dead tree; Jan, Feb 1986; G.J.S., J.R. Boise (CAY, NY; G.J.S. 2657; G.J.S. isolate 86-31, 86-37). – VENEZUELA. Edo. Mérida: 2.5 km from Jaji, on Jaji–La Mesa Rd.; on unidentified wood; 23 Jul 1971; K.P.D., G.J.S., L. Borjas (NY; Dumont-VE 2763). – Along Río Mawarinuma, Puerto Chimo, ca 5 km upstream from Neblina base camp, along river and on track up slope, 00°50' N, 66°07' W, 140–550 m alt.; on leaf of *Loranthaceae*; 24–25 Apr 1984; G.J.S. (NY; G.J.S. 1638).

**Notes:** Specimens of *B. rossmaniae* were formerly included under *B. sesquicillii*. *Bionectria rossmaniae* is characterized by superficial perithecia (Fig. 76 c–e), the cells of the outer perithecial region that increase in size toward the interior, reaching  $25 \times 15 \mu\text{m}$  (Fig. 76 f, g, h), and striate ascospores (Fig. 76 k). In contrast, *B. sesquicillii* has warted ascospores, relatively small cells in the outer region that are of constant size, and crowded perithecia formed on an erumpent stroma. The anamorphs of both species are more or less indistinguishable. The penicilli in *B. rossmaniae* (Fig. 77 c) may be somewhat wider and the conidia are





**Fig. 77.** *Bionectria rossmaniae* / *Clonostachys rossmaniae*. **a.** Almost mature asci. **b.** Discharged ascospores. **c.** Conidiophores. **d.** Conidia. – **a:** G.J.S. 3970, G.J.S. 2657; **b:** G.J.S. 3970, Br 235A; **c:** CBS 211.93, CBS 250.78; **d:** CBS 210.93, CBS 211.93. **a, b:** natural substratum; **c, d:** 7–10-d-old OA culture. Scale bars = 10  $\mu$ m; the shorter bar applies to **a, c**, the longer to **b, d**.

somewhat shorter and wider (Fig. 77 d) than those of *B. sesquicillii* (Fig. 88 c, e). The anamorphs of both species were classified as *S. cf. buxi* (Samuels, 1989) because their conidiophores and conidial size ranges are similar in *S. buxi*. They can be distinguished from

that species by the shape of the conidia, which possess a laterally displaced hilum (Figs 77 d, 88 e) whereas the conidia in *C. buxi* are symmetrical, almost cymbiform (Fig. 97 d).

**Fig. 76.** *Bionectria rossmaniae*. **a.** Habit of solitary to aggregated, globose perithecia on lichen. **b–f.** Sections through perithecia. **b, c.** Whole perithecia. **d, e.** Perithecial base consisting of densely packed hyphae with cells discontinuous with those of the perithecial wall. **f.** Lateral perithecial wall showing two regions; cells of outer wall region becoming larger inwards. **g–i.** Subsurface views. **g, h.** Cells of outer perithecial wall, below surface (**g**), larger cells further inward (**h**). **i.** Hyphal cells close to perithecial base (squash mount). **j, k.** Discharged ascospores in optical section (**j**) and surface view (**k**), showing short somewhat intricately arranged striae. – **a, b, d:** Dumont-VE 2657; **c, e, f:** G.J.S. 4274; **g, h, i:** G.J.S. 3970; **j, k:** G.J.S. 98. All from natural substratum. **a:** DM; **b–k:** DIC. Scale bars: **a** = 500  $\mu$ m; **b, e** = 50  $\mu$ m; **c** = 100  $\mu$ m; **d, f** = 30  $\mu$ m; **g–k** = 10  $\mu$ m.

**34. *Bionectria impariphialis*** (Samuels) Schroers, *comb. nov.* — Fig. 78 a–h.

≡ *Nectria impariphialis* Samuels, Mem. New York Bot. Gard. 49: 279. 1989.

Anamorph: *Clonostachys impariphialis* (Samuels) Schroers, *comb. nov.* [Figs 30, 31 in Samuels (1989)].

≡ *Sesquicillium impariphiale* Samuels, Mem. New York Bot. Gard. 49: 279. 1989.

**Description from natural substratum:** **Perithecial stroma** superficial on the substratum, consisting of hyphae arranged in a *textura epidermoidea* that continues into the outermost cell layer of the perithecial wall. **Perithecia** easily removable, solitary to aggregated, not crowded, globose, to 400 µm diam, not pinched when dry, smooth, light orange, not papillate, with a somewhat darker ostiolar region when dry; some perithecia seated on the superficial, black stroma of another ascomycete. **Perithecial wall** to 50 µm thick. Outer region *ca* 25 µm or *ca* 5 cells thick; cells angular to subglobose, thin-walled, 5–15 × 4–11 µm; vacuoles not observed. Inner region to 25 µm thick. **Asci** clavate, (52.5–)63.5–69.5–75(–90) × (9–)11.5–12.5–14.5(–18) µm (n = 32), 8-spored; ascus apex broadly rounded, without a visible ring. **Ascospores** slightly bent or ellipsoidal, equally 2-celled, not constricted or slightly constricted at the septum with age, colourless, finely warted, with almost rod-shaped, intricately arranged warts, (15.2–)17.8–18.6–19(–23) × (4.4–)5.6–6–6.4(–7.2) µm (n = 66). **Sterile mycelium** surrounding the perithecial base, white, covering parts of the substratum as a thin hyphal mat. **Conidiophores** loosely aggregated, adpressed or divergently branched; intercalary phialides below solitary terminal phialides, in whorls, sometimes in whorls together with terminal phialides; terminal phialides narrowly flask-shaped, widest at base or in the lower third, 6.4–14 µm long, 2–4 µm wide at base, 0.9–1.6 µm wide near aperture; intercalary phialides cylindrical, 10–17 × 2.5–3.5 µm; lateral necks to 4 µm long. **Conidia** in short white columns, smooth, 1-celled, ellipsoidal to oblong-ovoidal, with a slightly visible, almost median hilum, (5.6–)7.6–9.6–10(–12) × (3–)3.4–3.6–3.8(–4.6) µm (n = 55).

**Type for both morphs:** FRENCH GUIANA. Upper Marouini River, 2 km N of Oumanfou-Langa Soula, 150 m alt., 02°53' N, 54°00' W; on lichen on bark; 23 Aug 1987; G.J.S., J.J. de Granville, L. Allorge, W. Hahn, M. Hoff (NY; G.J.S. 5981; G.J.S. isolate 87-156).

**Known distribution:** The neotropics (French Guiana).

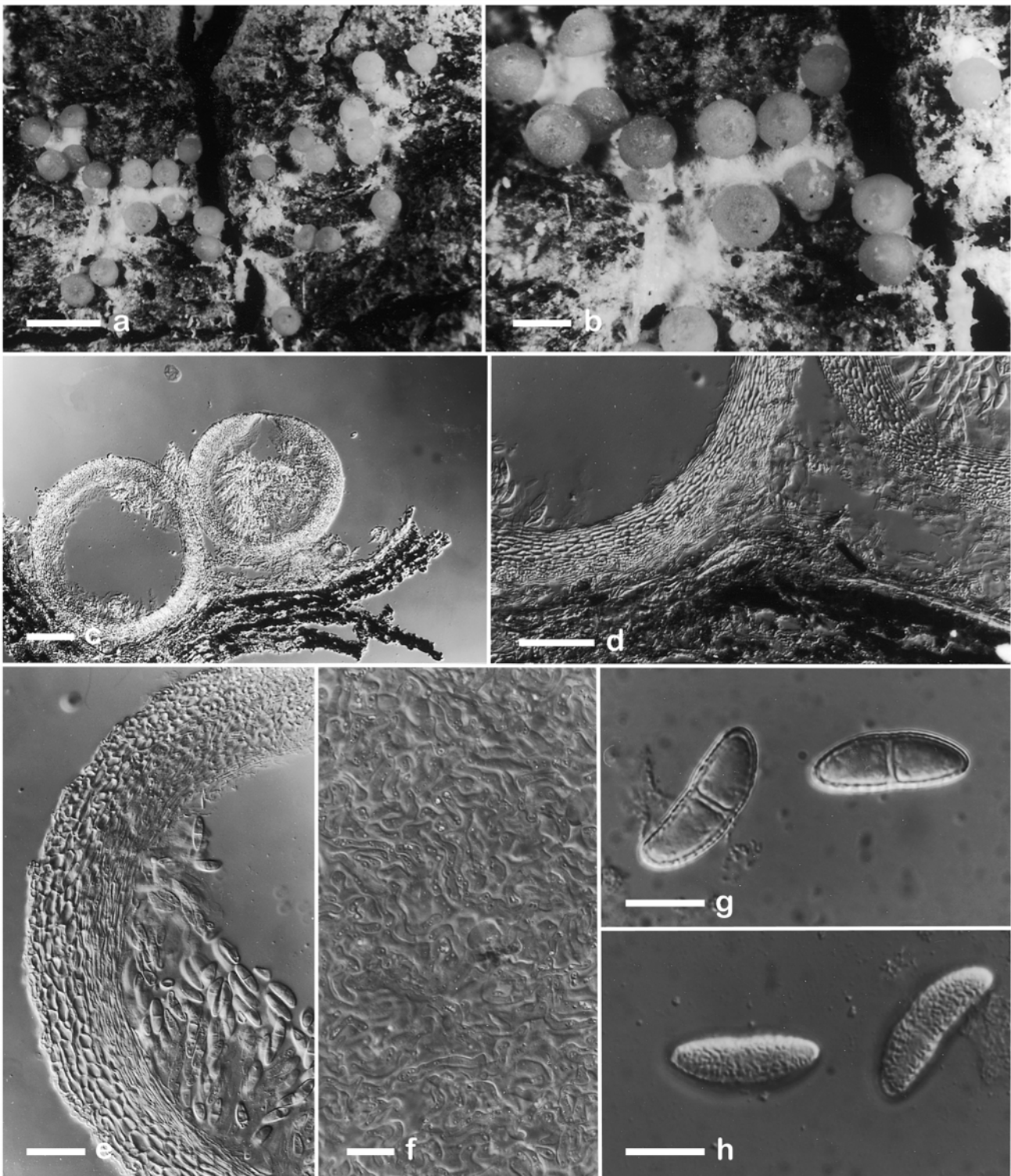
**Habitat:** Perithecia on lichens on bark or on bark of living liana.

**Published descriptions:** Samuels (1989).

**Additional specimen examined:** FRENCH GUIANA. Piste de Saint-Elie, km 16 on road between Sinnamary and St. Elie, 'Ecerex', Orstom research area, 05°20' N, 00°53' W; on bark of living liana; Feb, Mar 1986; G.J.S. (CAY, NY; G.J.S. 4015).

**Notes:** *Bionectria impariphialis* differs from *B. rossmaniae* by larger ascospores, ascospore ornamentation (Fig. 78 h) and uniformly sized cells in the outer perithecial wall region (Fig. 78 e).

The anamorph described from the natural substratum matches the description provided by Samuels (1989). The dried material that is preserved with the type material (G.J.S. 87-156) and the purported ex-type strain (CBS 178.88) differ from the anamorph of *B. impariphialis* as seen on the natural substratum and described by Samuels (1989) and are possibly contaminated. Conidiophores of the dried material are acromonium-like (sparsely branched, phialides 9.5–36.5 µm long, up to 3.5 µm wide at base, 1–2 µm wide at tip) and lack intercalary phialides; the conidia are symmetrical, have broadly rounded ends, and measure 5.5–12.0 × 3.0–4.5 µm. The living purported 'ex-type strain' of *B. impariphialis* forms adpressed whorls of phialides that are 25–45 µm long and symmetrical conidia that are 4.5–6.0 × 2.5 µm. One other specimen, G.J.S. 4015, is similar to the type specimen in teleomorphic characters. Since the perithecia of that specimen were associated with conidiophores that are similar or identical to those found on the type material and to those described by Samuels (1989), I consider the latter as representative of *B. impariphialis*.



**Fig. 78. *Bionectria impariphialis*.** **a, b.** Habit of solitary to aggregated, globose perithecia; mycelial mat on substratum between perithecia. **c–e.** Sections through perithecia and perithecial base. **c.** Whole perithecia. **d.** Perithecial base, loosely connected to substratum, cells continuous with perithecial base. **e.** Lateral perithecial wall showing two regions. **f.** Surface view of outermost perithecial cell layer (*textura epidermoidea*). **g, h.** Discharged ascospores in optical section (**g**) and surface view (**h**); ascospores minutely warted, warts somewhat rod-shaped. – All: G.J.S. 5981. All from natural substratum. **a, b:** DM, **c–h:** DIC. Scale bars: **a** = 750  $\mu\text{m}$ ; **b** = 300  $\mu\text{m}$ ; **c** = 100  $\mu\text{m}$ ; **d** = 50  $\mu\text{m}$ ; **e** = 30  $\mu\text{m}$ ; **f–h** = 10  $\mu\text{m}$ .

**35. *Bionectria parviphialis*** (Samuels) Schroers, *comb. nov.* — Figs 79 a–j, 80 a, b.

≡ *Nectria parviphialis* Samuels, Mem. New York Bot. Gard. 49: 282. 1989.

Anamorph: *Clonostachys pseudosetosa* (Samuels) Schroers, *comb. nov.*, sesquicillium-like. — Figs 79 k, 80 c, d.

≡ *Sesquicillium pseudosetosum* Samuels, Mem. New York Bot. Gard. 49: 282. 1989.

**Description from natural substratum:** **Perithecial stroma** superficially covering the substratum, consisting of densely packed hyphae. **Perithecia** superficial, strongly connected to the minute perithecial bases, sometimes seated on or near the stroma of other, immersed ascomycetes, in small groups of up to 10 or solitary, globose, 280–400 µm diam, laterally and particularly subapically pinched or not pinched when dry, smooth, pale yellow to pale orange, minutely papillate or not papillate, with a slightly contrasting ostiolar region when dry. **Perithecial wall** ca 50 µm thick. Outer region ca 25 µm or 3–4 cells thick; cells subglobose to angular, thin-walled, around 12 µm diam, getting larger inwards (up to 20 µm diam); vacuoles not observed. Inner region to 20 µm thick. **Asci** clavate, (54–)65–74–80(–106) × (9.5–)11–15–18(–21) µm (n = 12), 8-spored; ascus apex rounded, with a barely visible ring. **Ascospores** ellipsoidal, tapering towards the ends, equally 2-celled, not constricted at the septum, colourless, smooth or coarsely warted (warts to 1.3 µm diam), ends apparently surrounded by a gelatinous cap, (13.2–)16.2–18.8–21.6(–24.8) × (4.4–)5.6–6.8–8(–10) µm (n = 68). **Sterile mycelium** surrounding the perithecia not observed. **Conidiophores** formed on creeping hyphae, monomorphic, penicillate, bi- to quarterverticillate; stipe to 60 µm high, to 4.5 µm broad at base; penicillus 40–60 µm high, to 70 µm broad; branches of the penicillus divergent, phialides mostly adpressed; metulae 8–14 × 3–4 µm; intercalary phialides below solitary terminal phialides, in whorls, sometimes in whorls together with terminal phialides, cylindrical, 5–10 × 4 µm wide; lateral necks to 3 µm long; terminal phialides broadly flask-shaped, widest near the middle, or almost cylindrical in the lower part and narrowing above, 6.5–12 µm long, 3–4 µm at wid-

est point, 1–1.5 µm wide near aperture. **Conidia** in short white columns, smooth, 1-celled, ellipsoidal to fusiform, apex minutely tapering, with a displaced and slightly laterally protruding hilum, (8–)10–11.2–12.4(–15.2) × (3–)3.4–3.8–4(–4.6) µm (n = 109). Sterile ending hyphae arising laterally from stipes of conidiophores or the mycelium on the substratum, unbranched, to 300 µm long, 4–5 µm wide at base, of constant width but narrowing in the upper part.

**Description from culture:** **Colonies** transparent to light orange (CMD), with abundant (OA, PDA) or without (CMD) aerial mycelium, with (OA, PDA) or without (CMD) sporulation; conidial masses in light orange slime or concentric rings. **Conidia** (8.7–)11.2–15.2(–17.5) × (3.3–)3.5–4.5(–4.7) µm [reproduced from Samuels (1989)].

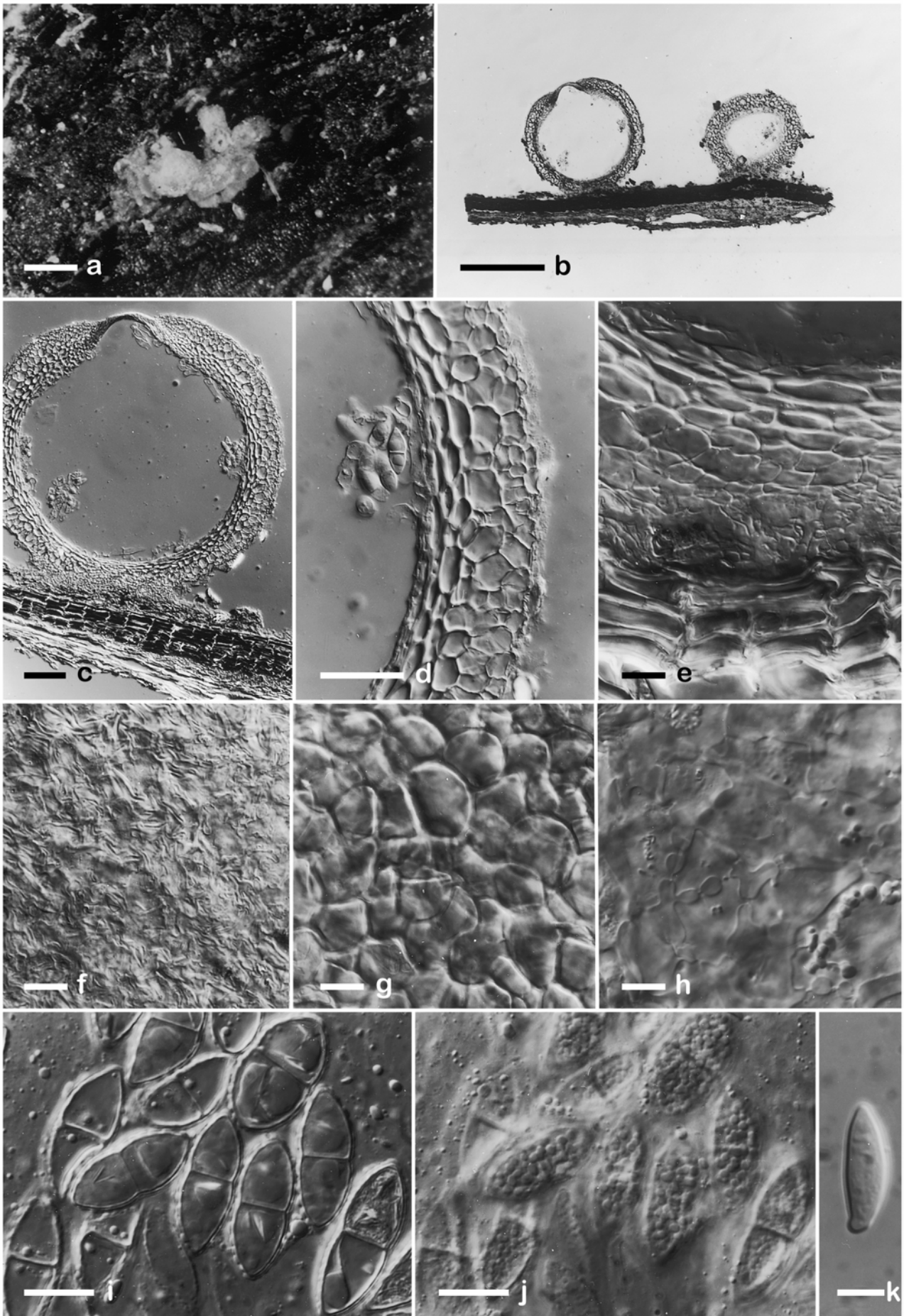
**Type for both morphs:** COLOMBIA. Dpto. Magdalena: Sierra Nevada de Santa Marta, between Palo Alto (1700 m alt.) and Refugios de la Sierra (1850 m alt.); on immersed ascomycete on bark, 19 Jun 1978, K.P.D., L. Ryvarde, F. Oberwinkler, P. Buriticá, M. Pulido (NY; Dumont-CO 8971; ATCC 66902; ICMP 7799).

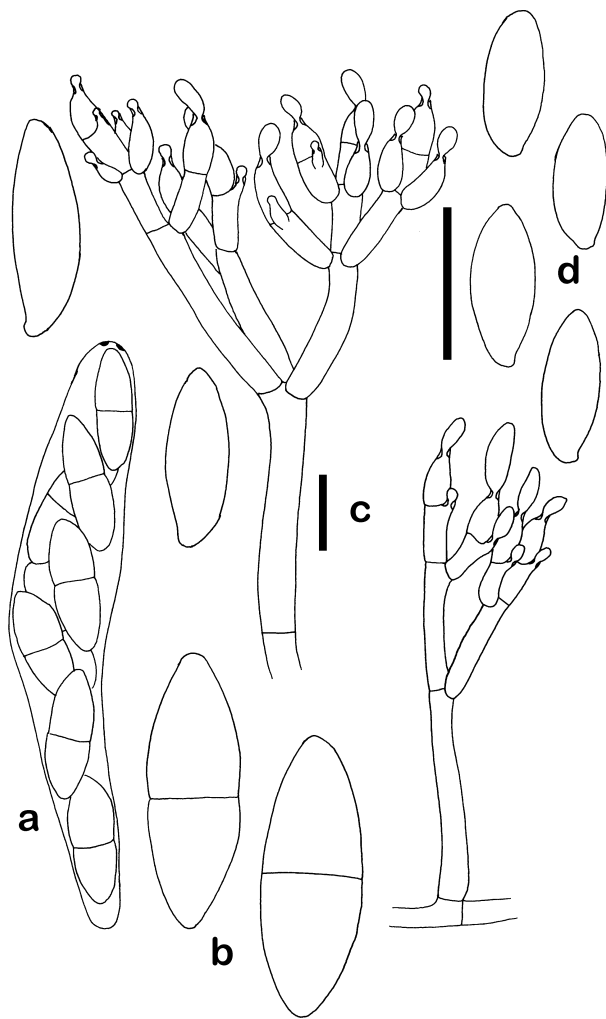
**Known distribution:** The neotropics (Colombia, French Guiana, Guyana). **Habitat:** Perithecia on other ascomycetes on bark or on branchlets of recently dead trees; anamorph without perithecia observed on branches of recently dead tree.

**Published description:** Samuels (1989).

**Additional specimens/strains examined:** GUYANA. Cuyuni-Mazaruni Region, VII, Mazaruni Subregion, VII-2, headwaters of Kangu River, W branch ca 4 km NW of eastern peak of Mt. Ayanganna, first talus slope on sandstone, 05°25' N, 60°30' W, 700 m alt.; on branchlets of recently dead tree; 5–7 Mar 1987; G.J.S., J. Pipoly, G. Gharbarran, J. Chin, E. Edwards (NY; G.J.S. 5063). – FRENCH GUIANA. Saül, ca 15 km of Saül (03°60' N, 53°20' W) toward Mt. Galbao (03°50' N, 53°20' W), 600–650 m alt.; on twigs of recently dead tree; Jan 1986; G.J.S., J.R. Boise (CAY, NY; G.J.S. 3093, anamorph only). – Saül, ca 15 km SW of Saül (03°60' N, 53°20' W), toward Mt. Galbao (03°50' N, 53°20' W), 600–650 m alt.; on decaying stem of *Piper* sp.; 14, 18, 29 Jan 1986; G.J.S., J.R. Boise (NY; G.J.S. 3109; containing only the anamorph, together with perithecia of *B. grammicospora*).

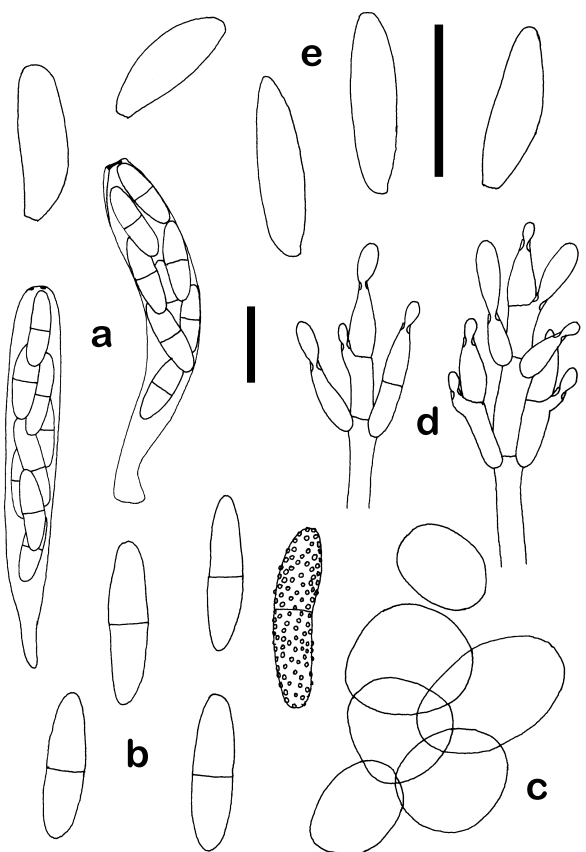
**Fig. 79. *Bionectria parviphialis* / *Clonostachys pseudosetosa*.** **a.** Habit of solitary to aggregated perithecia. **b–e.** Sections through perithecia and perithecial base. **b, c.** Globose perithecia. **d.** Lateral perithecial wall. **e.** Perithecial base. **f–h.** Surface and subsurface views of perithecial wall. **f.** Outermost cell layer, showing indistinct cells with somewhat hyphal character. **g.** Cells of outer perithecial wall region below those shown in f. **h.** Cells of inner perithecial wall region showing 'pseudopores'. **i, j.** Discharged ascospores in optical section (i) and surface view (j), coarsely warted. **k.** Ellipsoidal conidium with tapering end and slightly laterally protruding and displaced hilum. – h. G.J.S. 5063; others: Dumont-CO 8971. All from natural substratum. a: DM, b: LM, c–k: DIC. Scale bars: a = 300 µm; b = 250 µm; c = 50 µm; d = 30 µm; e–k = 10 µm.





**Fig. 80.** *Bionectria parvipialis* / *Clonostachys pseudosetosae*. **a.** Almost mature ascus. **b.** Discharged, smooth ascospores. **c.** Conidiophores with intercalary phialides. **d.** Conidia. **a, b:** Dumont-CO 8971; **c:** G.J.S. 5063 and 3109; **d:** G.J.S. 5063 and 3109. All: natural substratum. Scale bars = 10  $\mu\text{m}$ ; the shorter bar applies to **a, c**, the longer to **b, d**.

**Notes:** *Bionectria parvipialis* is characterized by the size and shape of ascospores and conidia. The relatively large ascospores differ from those of *B. imparipialis* by slightly tapering ends (Fig. 79 i). Whether the ascospore warts (Fig. 79 j) are typical of the species is uncertain because Samuels (1989) did not describe such warts and ascospores of other specimens were smooth or only indistinctly warted. The relatively large conidia (Figs 79 k, 80 d) have a distinct laterally displaced hilum and are of similar length but wider than those of *B. tornata* (Figs 81 e, 82 d). No conidiophores were observed in culture and no dried culture is found in the package of the type. Lyophilized material obtained from PDD (ICMP 7799) did not grow. The colony characteristics are reproduced from Samuels (1989) and the illustrated conidiophores (Fig. 80 c) that correspond with those described by Samuels (1989) were drawn from the natural substratum. Setae as illustrated by Samuels (1989: Fig. 36) were not seen.



**Fig. 81.** *Bionectria tornata* / *Clonostachys asymmetrica*. **a.** Almost mature ascus. **b.** Discharged, fusiform ascospores. **c.** Cells of outer perithecial wall region in surface view. **d.** Parts of conidiophores. **e.** Conidia. — All from type of *Pseudonectria tornata* (No. 2899), natural substratum. Scale bars = 10  $\mu\text{m}$ ; the shorter bar applies to **a, c, d**, the longer to **b, e**.

**36. *Bionectria tornata* (Höhnelt) Schroers, *comb. nov.*** — Figs 81 a–c, 82 a, b, 83 a–i.

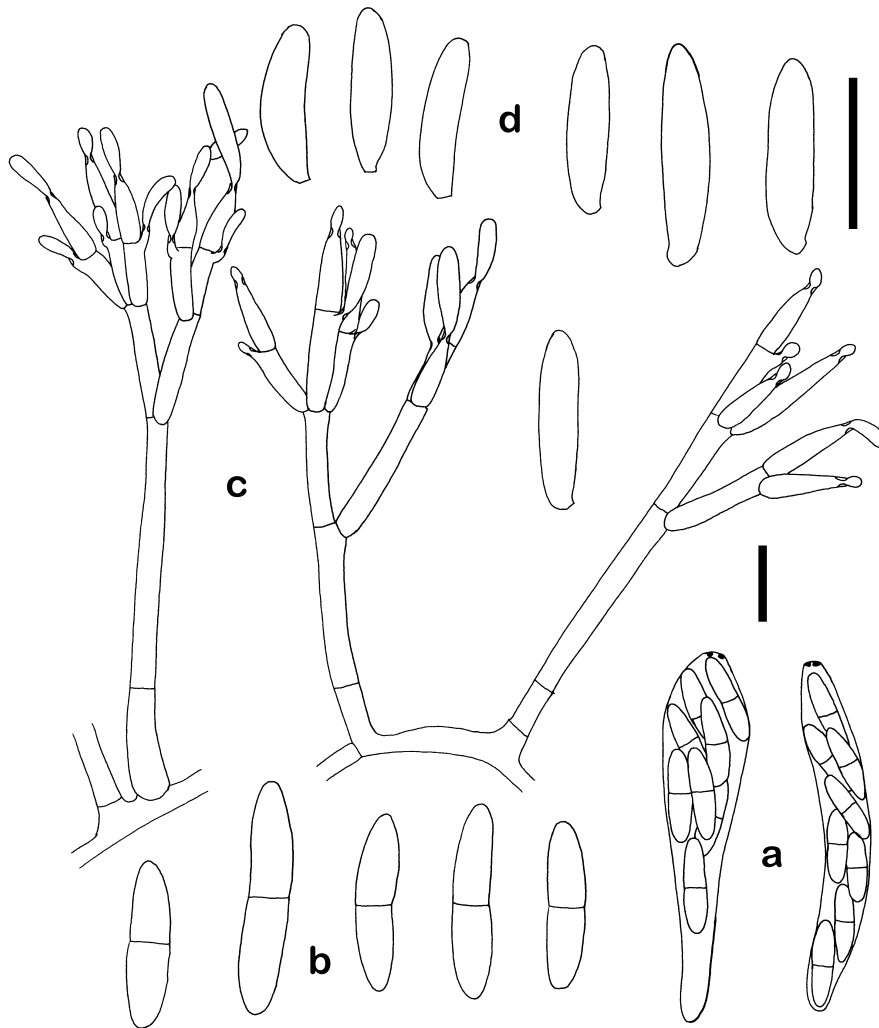
≡ *Pseudonectria tornata* Höhnelt, Sitzungsber. Kaiserl. Akad. Wiss., Math.-Naturwiss. Cl., Abt. 1, 118: 1471. 1909.  
= *Nectria sesquiphialis* Samuels, Mem. New York Bot. Gard. 49: 276. 1989 (Fig. 19–25).

Anamorph: *Clonostachys asymmetrica* (Samuels) Schroers, *comb. nov.*, sesquicillium-like. — Figs 81 d, e, 82 c, d.

≡ *Sesquicillium asymmetricum* Samuels, Mem. New York Bot. Gard. 49: 276. 1989.

**Description from natural substratum:** **Perithecial stroma** superficial, consisting of densely packed hyphae that form a *textura epidermoidea* and continue into the outermost cell layer of the perithecial wall. **Perithecia** superficial, easily removed from the substratum, scattered, solitary to gregarious, globose to subglobose, 200–300  $\mu\text{m}$  diam, laterally pinched when dry, smooth, pale yellow, minutely papillate. **Perithecial wall** 25–35  $\mu\text{m}$  thick. Outer region 20–30  $\mu\text{m}$  or 2–3 cells thick; cells subglobose, thin-walled, up to 26  $\times$  18.5  $\mu\text{m}$ ; vacuoles not observed. Inner region *ca* 5–

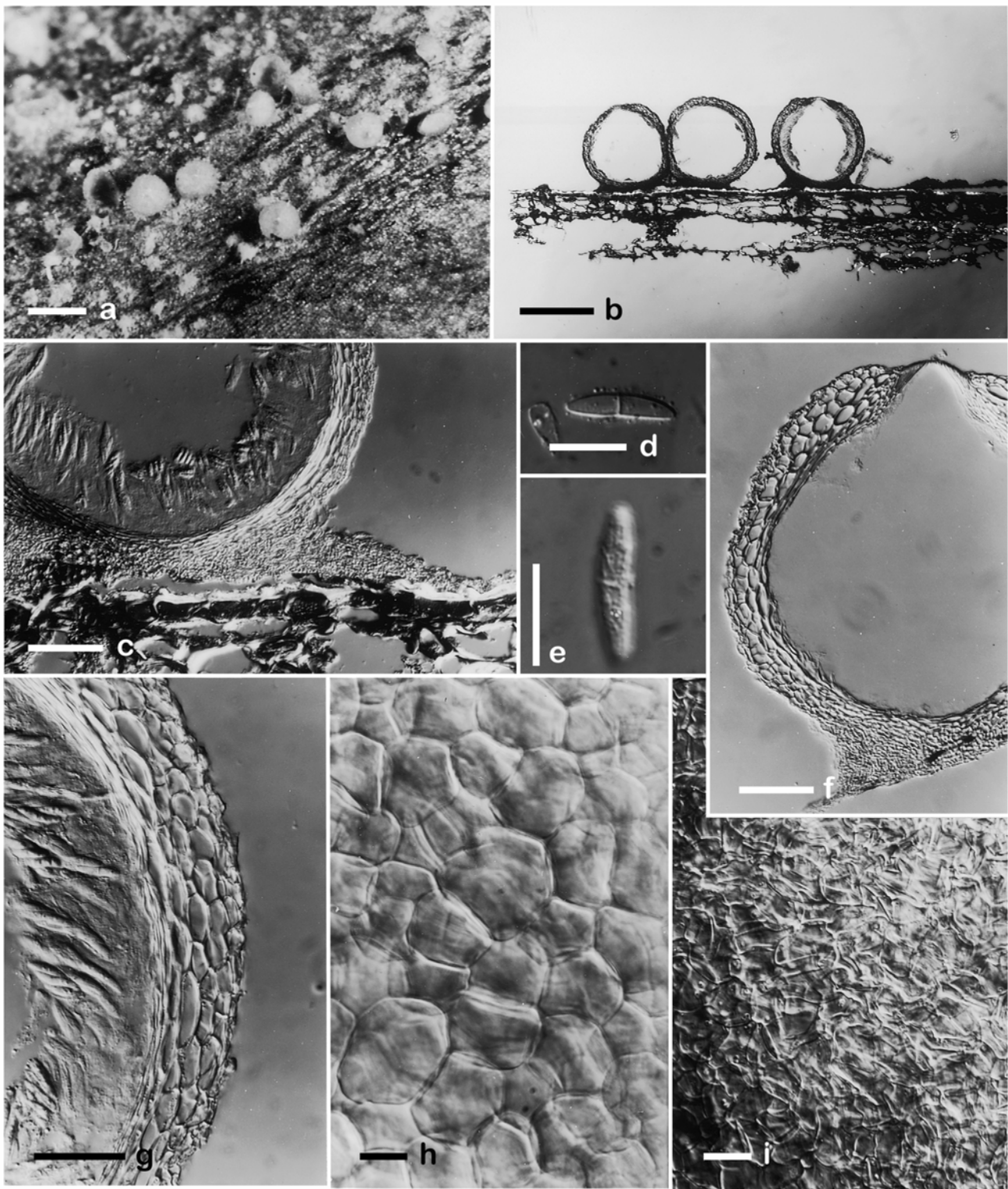




**Fig. 82.** *Bionectria tornata* / *Clonostachys asymmetrica*. **a.** Almost mature asci. **b.** Mature, fusiform ascospores. **c.** Conidiophores. **d.** Oblong-ellipsoidal to fusiform conidia, hilum laterally displaced. All from natural substratum. **a, c** (left), **d** (left): Dumont-CO 4402; **b**: Dumont-CO 4402, Dumont-VE 7184; **d, c** (right): Dumont-VE 7184. Scale bars = 10  $\mu\text{m}$ ; the shorter bar applies to **a, c**, the longer to **b, d**.

10  $\mu\text{m}$  thick. **Asci** clavate, (35–)43–48.5–52.5(–69)  $\times$  (5.5–)7.0–8–8.5(–11)  $\mu\text{m}$  ( $n = 34$ ), 8-spored; ascus apex flat to rounded, ring inconspicuous. **Ascospores** ellipsoidal to fusiform, equally 2-celled, not constricted at the septum, colourless, warted or smooth, (9.0–)9.6–10.4–10.8(–12.8)  $\times$  (2–)2.4–2.6–2.7(–3.0)  $\mu\text{m}$  ( $n = 37$ ) [type of *P. tornata*], (10.8–)12.4–13.8–15.6(–20.8)  $\times$  (2–)2.6–2.8–3(–4)  $\mu\text{m}$  ( $n = 76$ ) [type of *N. sesquiphialis* and additional specimens]. **Conidiophores** penicillate, with almost adpressed conidiogenous cells; terminal phialides *ca* 10  $\mu\text{m}$  long, *ca* 4  $\mu\text{m}$  wide at base, 1.0–1.3  $\mu\text{m}$  wide at base; intercalary phialides *ca* 9  $\times$  2.6–3.6  $\mu\text{m}$ ; lateral necks to 3  $\mu\text{m}$  long. **Conidia** smooth, 1-celled, ellipsoidal, somewhat curved, with a somewhat tapering distal end and with a laterally displaced hilum, (8.8–)11–12.6–14(–19.2)  $\times$  (2.4–)2.8–3–3.2(–3.8)  $\mu\text{m}$  ( $n = 51$ ) [conidia associated with the type of *P. tornata* 8–12.4  $\times$  2.6–3.6  $\mu\text{m}$  ( $n = 19$ )]. Sterile hyphae (setae) not seen. **Sterile mycelium** surrounding the perithecia not seen.

**Description from dried culture of the type: Colonies** transparent (CMD), without aerial mycelium, off-white (PDA), densely finely powdery because of the conidial masses on densely gregarious conidiophores, aerial mycelium sparse. **Conidiophores** monomorphic, arising from the agar surface, solitary, somewhat aggregated (CMD), or densely gregarious (PDA), penicillate, bi- to quaterverticillate, slightly divergent to adpressed; stipe 30–60  $\mu\text{m}$  long, to 4  $\mu\text{m}$  wide at base; penicillus to 50  $\mu\text{m}$  high, 50  $\mu\text{m}$  wide; metulae 9–15  $\times$  2.8–3.5  $\mu\text{m}$ ; intercalary phialides below solitary terminal phialides, in whorls, sometimes in whorls together with terminal phialides, almost cylindrical, 8–10  $\mu\text{m}$  long, to 3.5  $\mu\text{m}$  wide; lateral necks to 4  $\mu\text{m}$  long; terminal phialides flask-shaped or almost cylindrical, narrowing above, (8.8–)10.6–12–13.4(–14.5)  $\mu\text{m}$  long, (3.0–)3.1–3.3–3.5(–3.8)  $\mu\text{m}$  wide at widest dimension, about 1  $\mu\text{m}$  wide near aperture. **Conidia** forming long narrow imbricate chains or columns; conidia smooth, 1-celled, ellipsoidal to slightly curved; hilum laterally displaced; distal end slightly narrowing, (8.9–)10.9–12.5–13.9(–19.3)  $\times$  (2.4–)2.8–3.0–3.2(–3.8)  $\mu\text{m}$  ( $n = 58$ ).



**Fig. 83. *Bionectria tornata*.** a. Habit of solitary to aggregated perithecia. b, c, f, g. Sections through perithecia and perithecial base. b. Whole perithecia. c. Perithecial base and substratum. d, e. Discharged ascospores in optical section (d) and surface view (e). f, g. Ostiolum and lateral perithecial wall and. h. Subsurface view of outer perithecial wall region. i. Surface view of outermost cells of perithecial wall. – a–c, g–i: G.J.S. 6322; d–f: Dumont-VE 7184. All from natural substratum. a: DM, b: LM, c–i: DIC. Scale bars: a = 300  $\mu$ m; b = 250  $\mu$ m, c, f = 50  $\mu$ m; d, e, h, i = 10  $\mu$ m; g = 30  $\mu$ m.

**Type for *Pseudonectria tornata*:** INDONESIA. Java, Tjibodas; on decaying leaves of *Pandanus* sp. **Type for *Clonostachys asymmetrica*:** VENEZUELA. Edo. Bolivar: km 110–111 S of El Dorado on road El Dorado–St. Elena; on leaf of *Zingiberaceae*; 6 Aug 1972; K.P.D., R.F. Cain, C. Blanco, G.J.S. [NY; dried cul-

ture of C.T.R. isolate 72-193 (= ATTC 66892), derived from ascospores of Dumont-VE 7184, type of *N. sesquiphialis*, and filed with it (NY).

**Known distribution:** Pantropical (Indonesia, Venezuela, Colombia).

**Habitat:** Known from decaying leaves of herbaceous plants, including *Pandanus*, *Zingiberaceae*, and *Equisetum* sp.

**Published descriptions:** Von Höhnelt (1909), Samuels (1989).

**Additional specimens/strains examined:** COLOMBIA. Dpto. Cundinamarca: Vic. km post 36 from Zipaquira on the Zipaquira–Pacho Rd., 2680 m alt.; on stem of *Equisetum* sp.; 9 Jun 1976; K.P.D., S.E. Carpenter, M.A. Sherwood, L.A. Molina (NY; Dumont-CO 4402). – Dpto. Antioquia: Buenos Aires, Providencia, Río Anorí; on petiole of unidentified monocotyledonous plant; 5 Jul 1974; K.P.D., J.H. Haines, F. Velásquez, R. Fonnegra (NY; Dumont-CO 660). – GUYANA. Mt. Wokomung, Wokomung base camp, ca 8 h walk NE of Kopinang Village in wet forest dominated by *Euphorbiaceae*, 05°05' N, 59°50' W, 1070 m alt.; on decaying leaf of *Anthurium* sp.; Jun–Jul 1989; G.J.S., B.M. Boom, G. Bacchus (NY; G.J.S. 6322; G.J.S. isolate 89-67).

**Notes:** *Bionectria tornata* has narrowly ellipsoidal to fusiform ascospores (Figs 81 b, 82 b, 83 d, e) and conidia that are similar to but narrower than those of *B. parvipialis* (Figs 81 e, 82 d). Penicilli of the conidiophores are rather narrow, mostly adpressed (Figs 81 d, 82 c). The specimen Dumont-CO 660, formerly identified as *Nectria sesquicillii* (Samuels, 1989) is identified here as *B. tornata* because of the length of the conidia (to 16  $\mu\text{m}$ ), fusiform ascospores (11.1–13.3–16  $\times$  2.0–2.7–3.2  $\mu\text{m}$ ), and characters of the perithecial wall (cells of the outer perithecial wall region to 16  $\mu\text{m}$  diam). The synonymy of *N. sesquiphialis* and *B. tornata* is based on characters of both the teleomorph and the anamorph such as the shape and size of the conidia and the shape of the ascospores (compare Fig. 81 and Fig. 82). For *B. tornata* only parts of the conidiophores were found on the natural substratum associated with the perithecia.

### 37. *Bionectria lasiacidis* (Samuels) Schroers, *comb. nov.* — Figs 85 a–i, 86 a, b.

$\equiv$  *Nectria lasiacidis* Samuels, Mem. New York Bot. Gard. 49: 273. 1989.

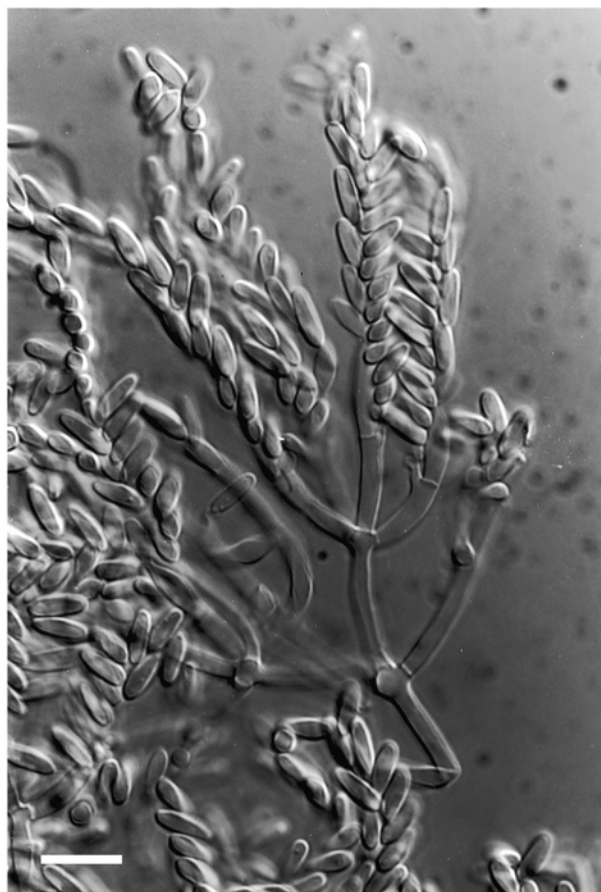
Anamorph: *Clonostachys lasiacidis* Schroers, *stat. nov.* — Figs 84, 86 c, d; Samuels (1989): Figs 17, 18.

*Clonostachydi rossmaniae* similis sed ramis primariis divergentibus et conidiis longioribus differens. Conidia (5.6–)6.4–7–7.6(–8.2)  $\times$  (1.8–)2.2–2.4–2.8(–3.2)  $\mu\text{m}$ .

Holotypus anamorphosis: NY; cultura sicca, isolata ex specimen G.J.S. 5864 (NY).

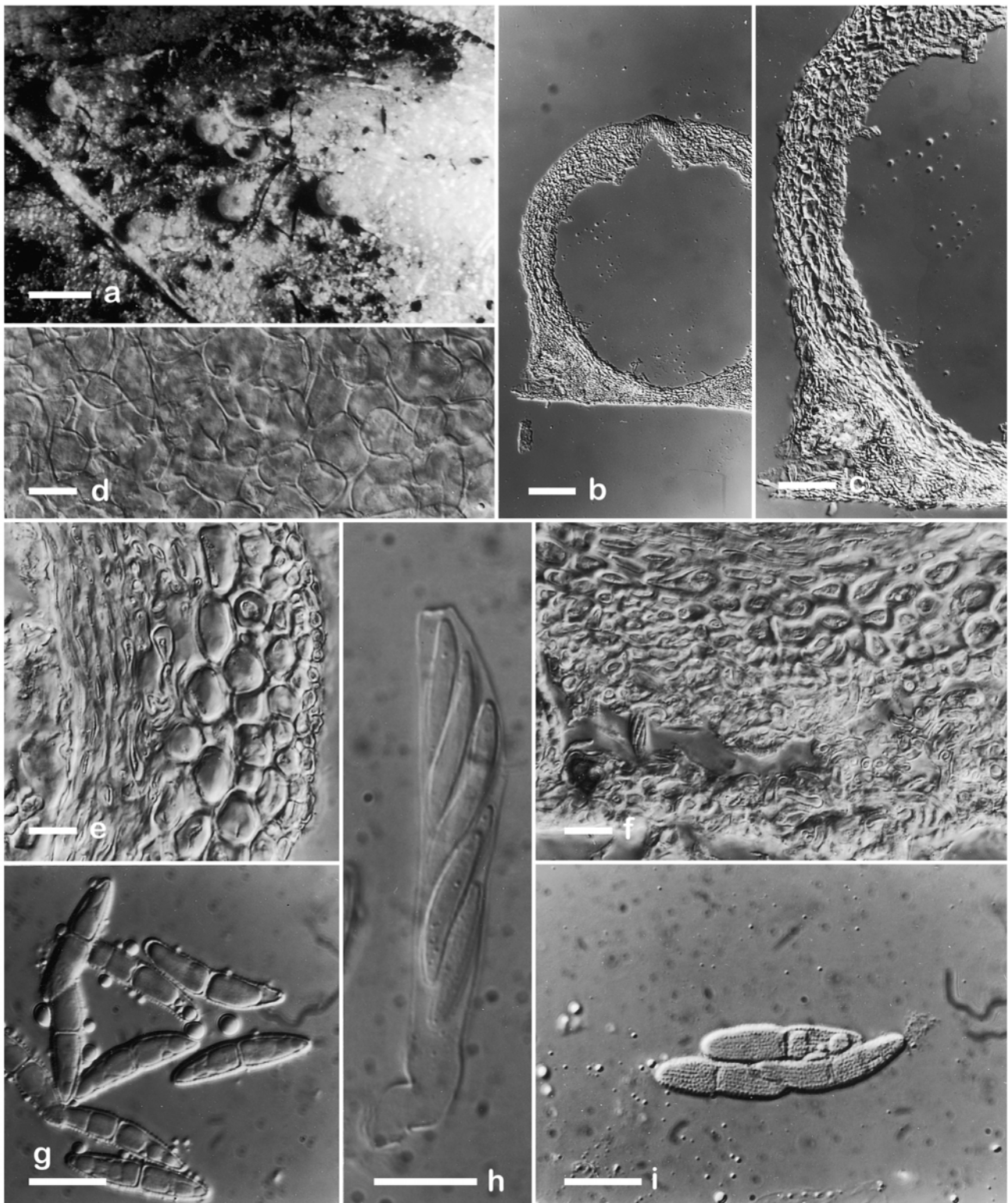
**Description from natural substratum:** **Perithecial stroma** superficial on the substratum, consisting of densely packed hyphae continuous with the outermost cell layer of the perithecial wall. **Perithecia** broadly connected to the substratum but easily removed, soli-

tary to loosely aggregated in groups, globose to subglobose, somewhat broader than high, 250–300  $\mu\text{m}$  diam, slightly apically to subapically pinched when dry, smooth, pale yellow to pale orange, whitish when old, with small papilla; papilla/ostiole region slightly darker when dry. **Perithecial wall** ca 55  $\mu\text{m}$  thick, composed of two main regions and an outermost, up to 5(–10)  $\mu\text{m}$  thick cell layer. Main outer region around 40  $\mu\text{m}$  or 4–5 cells thick; cells globose to subglobose, thin-walled, 3.5–7.5  $\times$  2.5–7  $\mu\text{m}$ , slightly larger inwards, 6.5–16.5  $\times$  3.5–12  $\mu\text{m}$ ; vacuoles not observed. Inner region to 15  $\mu\text{m}$  thick. **Asci** narrowly to broadly clavate, (44.5–)53.5–64–75(–85)  $\times$  (8.5–)9.5–11.5–13.5(–16.5)  $\mu\text{m}$  (n = 18), 8-spored; ascus apex flat; ring visible. **Ascospores** oblong-ellipsoidal to fusiform, slightly tapering at the ends, equally 2-celled, not constricted at the septum, colourless, smooth or finely spinulose, with warts arranged in fine rows, (13.6–)17–18–19(–21.4)  $\times$  (2.6–)3.4–3.6–3.8(–4.4)  $\mu\text{m}$  (n = 43). **Sterile mycelium** surrounding the perithecia not observed. Loose, thin layer of strongly divergently branched hyphae creeping on the substratum giving rise to conidiophores.



**Fig. 84.** *Bionectria lasiacidis* / *Clonostachys lasiacidis*. Conidiophore with conidial columns. — From dried culture of G.J.S. 5864. Scale bar = 10  $\mu\text{m}$ .

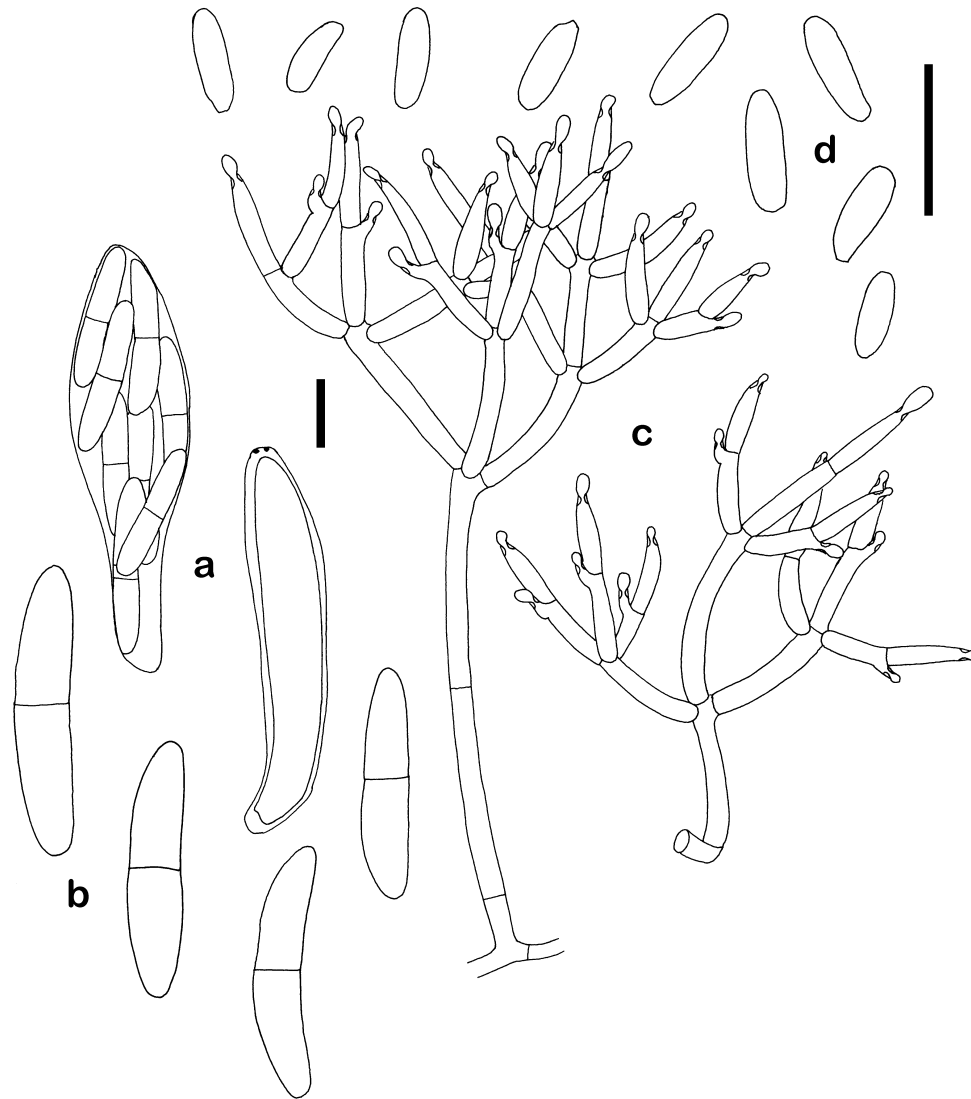
**Description from culture:** **Colonies** transparent to light orange (CMD), with abundant (OA, PDA) or without (CMD) aerial mycelium, with (OA, PDA) or without (CMD) sporulation; conidial masses in light-



**Fig. 85. *Bionectria lasiacidis*.** **a.** Habit of solitary to aggregated, globose perithecia. **b, c, e, f.** Sections through perithecia and base. **b.** Whole perithecium. **c, e.** Lateral perithecial wall. **c, f.** Perithecial base consisting of densely packed hyphae, not merging with the outer perithecial wall region. **d.** Subsurface view of outer perithecial wall region. **g, i.** Discharged ascospores in optical section (**g**) and surface view (**i**); ascospores minutely warted, warts arranged in striae. **h.** Almost mature ascus in optical section. – All from G.J.S. 5864, natural substratum. **a:** DM, **b–i** DIC. Scale bars: **a** = 250  $\mu\text{m}$ ; **b** = 50  $\mu\text{m}$ , **c** = 30  $\mu\text{m}$ ; **d–i** = 10  $\mu\text{m}$ .

orange slime (according to Samuels, 1989). **Conidiophores** from dried cultures or natural substratum monomorphic, penicillate, bi- to quaterverticillate, arising from aerial hyphae or from the agar surface; stipe to 60  $\mu\text{m}$  high, to 4.5  $\mu\text{m}$  broad at base; penicillus

40–60  $\mu\text{m}$  high, to 70  $\mu\text{m}$  broad; primary branches divergent, intercalary and terminal phialides generally divergent; metulae 8–14  $\times$  3–4  $\mu\text{m}$ ; intercalary phialides below solitary terminal phialides, in whorls, almost cylindrical, 6–13  $\times$  3  $\mu\text{m}$ ; lateral necks to 3  $\mu\text{m}$



**Fig. 86.** *Bionectria lasiacidis* / *Clonostachys lasiacidis*. **a.** Immature and almost mature asci. **b.** Ascospores. **c.** Conidiophores with divergently branched penicillus and phialides. **d.** Ellipsoidal conidia; hilum slightly laterally displaced. – All from G.J.S. 5864. **a, b:** natural substratum; **c, d:** dried CMD culture. Scale bars = 10  $\mu\text{m}$ ; the shorter bar applies to **a, c**, the longer to **b, d**.

long; terminal phialides broadly flask-shaped, widest near the middle, 8.4–13.8  $\mu\text{m}$  long, 2.2–3  $\mu\text{m}$  wide at widest point, 1.0–1.6  $\mu\text{m}$  wide near aperture. **Conidia** forming long, narrow, imbricate columns, 1-celled, ellipsoidal, almost straight; distal end more broadly rounded, with a slightly laterally displaced hilum, smooth, (5.6–)6.4–7–7.6(–8.2)  $\times$  (1.8–)2.2–2.4–2.8(–3.2)  $\mu\text{m}$  ( $n = 72$ ). Sterile hyphae (setae) not observed.

**Type for *Nectria lasiacidis*:** FRENCH GUIANA. Ca 3 h walk W of Marouini River, toward Roche Koutou, 02°55' N, 54°03' W, 150–350 m alt., on dead culms of *Lasiacis ligulata*; 18 Aug 1987; G.J.S. (NY, isotype CAY; G.J.S. 5864; G.J.S. isolate 87-149, CBS 179.88). **Type for *Clonostachys lasiacidis*:** dried culture ex specimen G.J.S. 5864 (G.J.S. isolate 87-149) and filed with it (NY).

**Known distribution:** The neotropics (French Guiana, only known from the type locality).

**Habitat:** On dead culms of *Lasiacis ligulata* Hitchc. & Chase.

**Published descriptions:** Samuels (1989).

**Notes:** *Bionectria lasiacidis* is similar to *B. tornata* in having narrowly ellipsoidal to fusiform ascospores and conidia. Conidia of *B. lasiacidis* are shorter (Fig. 86 d) and the ascospores (Figs 85 g, 86 b) are longer than in *B. tornata*. Ascospores in *B. lasiacidis* are finely warted, with warts being arranged in narrow rows (Fig. 85 i), but also smooth ascospores were seen. The conidia in *B. lasiacidis* are similar to those of *C. phyllophila* (Fig. 90 c). While *B. tornata* and *C. phyllophila* have almost adpressed penicilli, those in *B. lasiacidis* are divergently branched (Figs 84, 86 c). As a consequence of this divergent branching pattern, *B. lasiacidis* forms several narrow conidial columns from a single penicillus (Fig. 84), while *C. phyllophila* mostly forms one column from a more adpressed penicillus.

**38. *Bionectria sesquicillii*** (Samuels) Schroers, *comb. nov.* — Figs 87 a–h, 88 a, b.

≡ *Nectria sesquicillii* Samuels, Mem. New York Bot. Gard. 49: 268. 1989.

Anamorph: *Clonostachys sesquicillii* Schroers, *stat. nov.* — Figs 87 i, 88 c–e; Samuels (1989): Figs 9, 10, 12, 13.

*Clonostachydi rossmaniae* similis sed conidiophora dimorphica; conidiophora primaria verticillii similia, rara. Conidia illis *C. rossmaniae* similia, sed angustiora [L/W 2.2–2.7(–4.2)], (4.2–)5–5.8–6(–9.6) × (1.6–)2.2–2.2–2.4(–3) µm.

Holotypus anamorphosis: NY; cultura sicca, isolata ex specimen G.J.S. 4825 (NY); cultura viva CBS 180.88.

**Description from natural substratum:** **Perithecial stroma** erumpent or barely erumpent through bark, or superficial when formed on leaf surfaces; cells of the stroma either angular or hyphal, about 5 µm diam, forming a pseudoparenchymatous to prosenchymatous texture, continuous or not continuous with the cells of the outer perithecial wall. **Perithecia** crowded in groups of up to 20 or solitary, globose, 250–300 µm diam, laterally or apically pinched when dry, smooth, pale yellow to brownish orange, not papillate, without a darker contrasting ostiolar region. **Perithecial wall** 25–35 µm thick, composed of two regions. Outermost region up to 20 µm or up to 3 cells thick; cells angular to subglobose, outwards (6.5–)8.5–9.5–11(–13) × (4–)6.5–7.5–8.5(–10.5) µm (n = 52), inwards of similar size; vacuoles not observed. Inner region to 10 µm thick. **Asci** narrowly clavate to almost cylindrical, (35–)45–49–53(–63) × (5–)7–8–9(–13) µm (n = 49), 8-spored; ascus apex more rounded than flat; ring visible. **Ascospores** ellipsoidal, equally 2-celled, not constricted or slightly constricted at the septum with age, colourless, finely warted, (8.2–)10–10.8–11.4(–14.4) × (2.2–)2.8–3.2–3.2(–4.4) µm (n = 135). **Sterile mycelium** inconspicuous. **Conidiophores** scattered on the substratum or arising from sparse aerial hyphae, sometimes densely disposed in spots of ca 300 µm diam.

**Description from culture:** **Colonies** reaching ca 20 mm diam on all media in 7 d at 24°C; optimum for growth (21)24–27(30)°C (ca 20 mm diam); maximum 30/33°C. Colony reverse on OA and PDA not pigmented or with time becoming pale orange (5A3) under daylight, to light orange (5A4) under UV; pigmentation on CMD inconspicuous. Colony surface powdery to finely granular because of the conidiophores and conidial masses, or smooth and sparsely sporulating; aerial mycelium scarce. **Conidiophores** dimorphic, penicillate or with a verticillium-like aspect, arising from the agar surface or the sparse aerial mycelium. Penicillate conidiophores bi- to quaterverticillate, branches and phialides divergent or somewhat divergent; stipe 20–45 µm long, to 3.5 µm wide at the base;

penicillus to 40 µm high, 40 µm wide; metulae 11.2–18.8 × 2.4–3.2 µm; intercalary phialides below solitary terminal phialides, in whorls, sometimes in whorls together with terminal phialides, almost cylindrical, 6.4–12.2 × 2.4–3.6 µm; lateral necks mostly to 3(–5) µm long (n = 24); terminal phialides flask-shaped, widest at base or in the lower third, (7.2–)7.8–9.2–10.4(–13.4) µm long, (1.4–)1.8–2–2.4(–2.6) µm wide at base, up to 3.5 µm at widest point, (0.8–)1–1.2–1.4(–1.6) µm wide near aperture (n = 28). Verticillium-like conidiophores sparsely formed among the penicillate conidiophores; stipes longer than the penicillus; branches and phialides divergent or somewhat divergent, cylindrical, slightly tapering towards the apex, 11.8–14.6–18.8 µm long, 2.2–3 µm wide at base, 1–1.5 µm wide near aperture, in whorls of 2–3, frequently associated with side branches and adpressed conidiogenous cells similar to those of the penicillate conidiophore. **Conidia** forming imbricate chains or more complex, white columns, smooth, 1-celled, ellipsoidal to oblong ellipsoidal, with a rather broadly rounded apex, (4.2–)5–5.8–6(–9.6) × (1.6–)2.2–2.2–2.4(–3) µm (n = 124). Perithecia not observed. **Submerged sporulation** observed in older colonies from short conidiophores; conidia sometimes remaining attached to the phialide tip of sparsely branched submerged conidiophores.

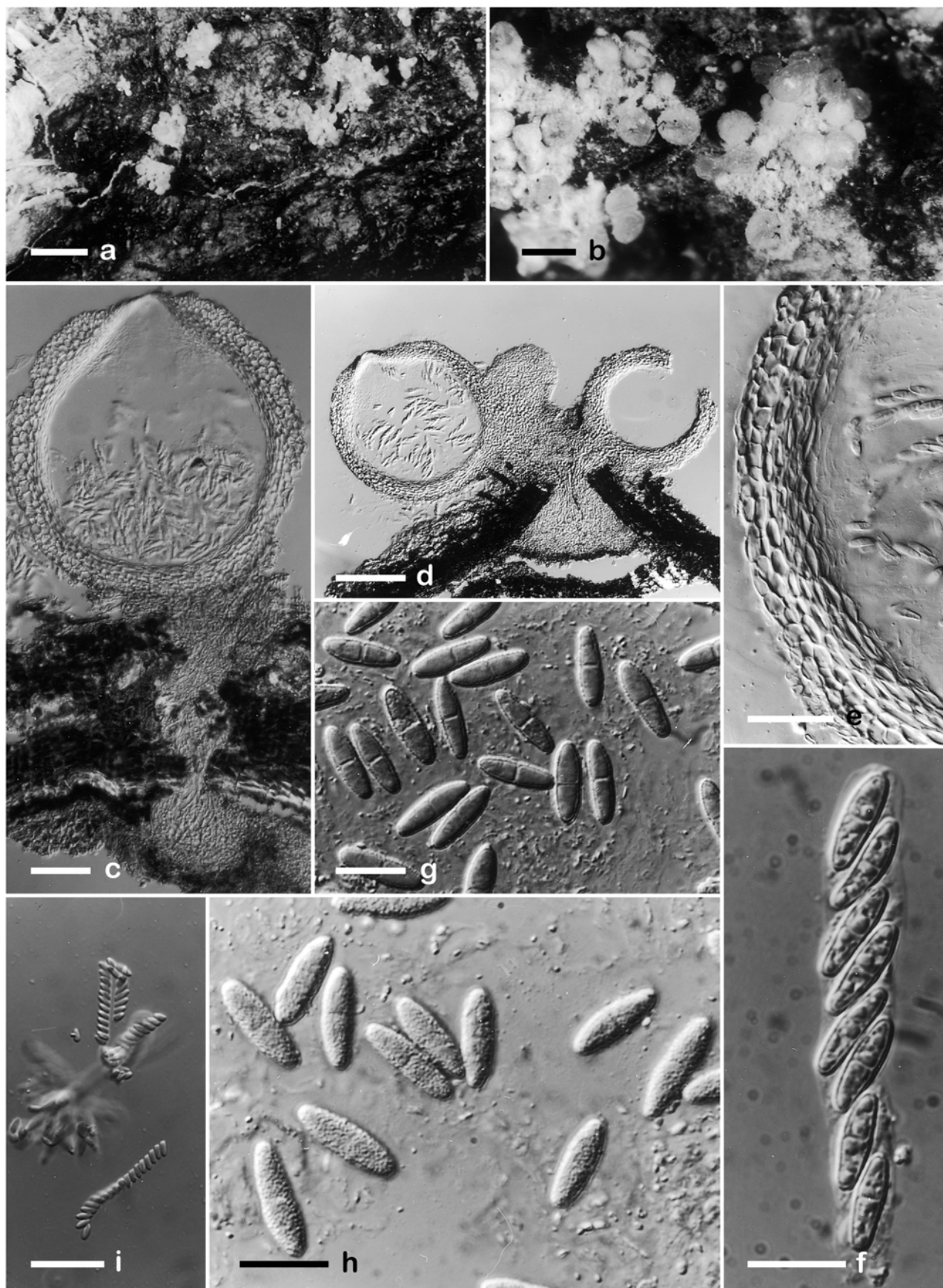
**Type for *Nectria sesquicillii*:** GUYANA. Cuyuni-Mazaruni Region, No. VII, Mazaruni Subregion, No. VII-2, foothills immediately S of Mt. Ayanganna, ca 1 km W of Pong River, 05°28' N, 60°04' W, 550–600 m alt.; on twigs and lichen; 26 Feb 1987; G.J.S., J. Pipoly, G. Gharbarran (NY; G.J.S. 4825; G.J.S. isolate 87-23, CBS 180.88). **Type for *Clonostachys sesquicillii*:** dried culture ex specimen G.J.S. 4825 (G.J.S. isolate 87-23) and filed with it (NY).

**Known distribution:** The neotropics (Guyana, French Guiana, Venezuela).

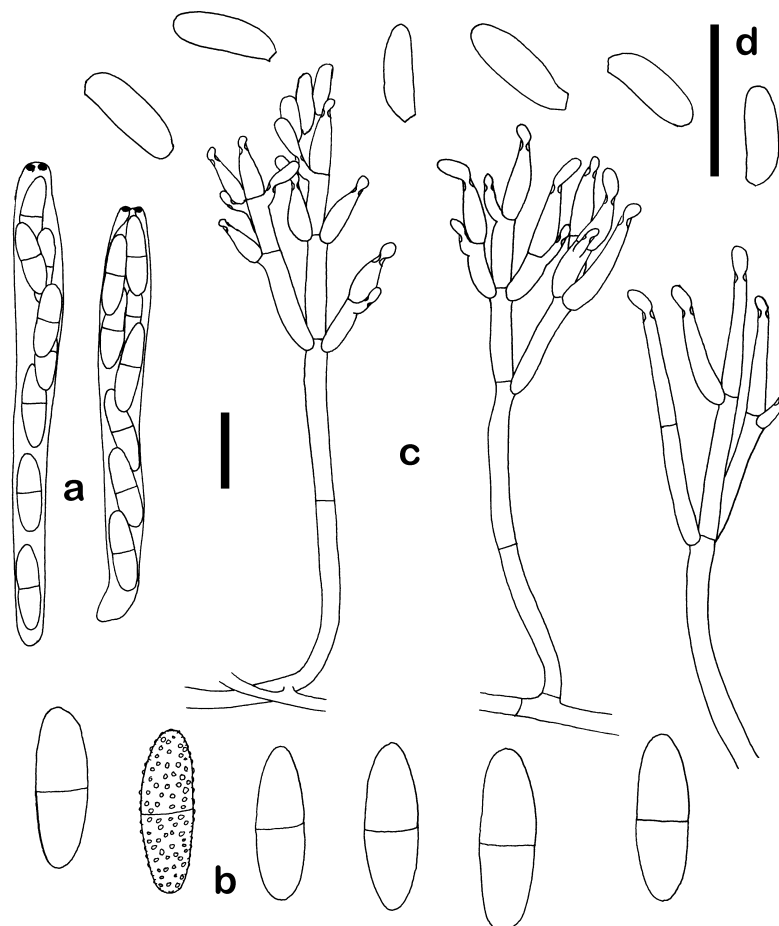
**Habitat:** On bark of recently dead woody plants or decaying leaves.

**Published description:** Samuels (1989).

**Additional specimens/strains examined:** GUYANA. Cuyuni-Mazaruni Region, No. VII, Mazaruni Subregion, No. VII-2, foothills immediately S of Mt. Ayanganna, ca 1 km W of Pong River, 05°28' N, 60°04' W, 550–600 m alt.; on recently dead tree; 26 Feb 1987; G.J.S., J. Pipoly, G. Gharbarran (NY; G.J.S. 4828A; G.J.S. isolate 87-27, 181.88). – FRENCH GUIANA. Saül, ca 15 km SW of Saül, 03°50' N, 53°20' W, 600–650 m alt. (NY; G.J.S. 2914). – Montagne de Kaw, Route de l'Est, km 27, 04°60' N, 52°40' W; on branches of recently dead tree; 21 Mar 1986; G.J.S., C. Feuillet (CAY, NY; G.J.S. 4424). – Along Río Mawarinuma, just outside Cañon Grande, vic. of Neblina base camp, 00°50' N, 66°10' W, ca 140 m alt.; on decaying leaf, Apr–May 1984; G.J.S. (NY; G.J.S. 1684).



**Fig. 87.** *Bionectria sesquicillii* / *Clonostachys sesquicillii*. **a, b.** Habit of crowded perithecia. **c, d.** Sections through perithecia and stroma from different specimens; stroma prosenchymatous (c) or pseudoparenchymatous (d); cells of stroma discontinuous with perithecial wall (c). **e.** Lateral perithecial wall, cells in outer region of  $\pm$  constant size. **f.** Ascus; ring visible. **g, h.** Discharged ascospores in optical section (g) and surface view (h), finely warted. **i.** Imbricate conidial chains. – a–c, e, f, h, i: G.J.S. 4825; d, g: G.J.S. 4424. i: dried culture; others: natural substratum. a, b: DM; others: DIC. Scale bars: a = 1250  $\mu$ m; b = 300  $\mu$ m; c = 50  $\mu$ m; d = 100  $\mu$ m; e, i = 30  $\mu$ m; f, g, h = 10  $\mu$ m.



**Fig. 88.** *Bionectria sesquicillii* / *Clonostachys sesquicillii*. **a.** Almost mature asci. **b.** Discharged ascospores. **c.** Secondary conidiophores. **d.** Primary, verticillium-like conidiophores. **e.** Conidia. — **a:** G.J.S. 1684, G.J.S. 4825 (right); **b, c, d:** CBS 180.88; **e:** CBS 180.88 and 181.88. Scale bars = 10  $\mu\text{m}$ ; the shorter bar applies to **a, c**, the longer to **b, d**.

**Notes:** Unlike other species of subgenus *Epiphloea*, perithecia in *B. sesquicillii* can be densely crowded (Fig. 87 a, b) and are at least sometimes formed on an erumpent stroma (Fig. 87 d). Sometimes primary verticillium-like conidiophores with somewhat longer phialides (Fig. 88 d, right; Samuels, 1989: Fig. 12) are intermingled with secondary conidiophores (Fig. 88 c). The intermediate morphological character pattern of *B. sesquicillii* links the subgenus *Epiphloea* with the subgenera *Bionectria* and *Zebrinella*. Additional characteristics of *B. sesquicillii* are discussed under *B. rossmaniae*.

**39. Clonostachys candelabrum** (Bon.) Schroers, *comb. nov.*, sesquicillium-like — Fig. 89 a, b.

≡ *Verticillium candelabrum* Bon., *Handb. Allg. Mykol.*: 97. 1851.

≡ *Sesquicillium candelabrum* (Bon.) W. Gams, *Acta Bot. Neerl.* 17: 457. 1968.

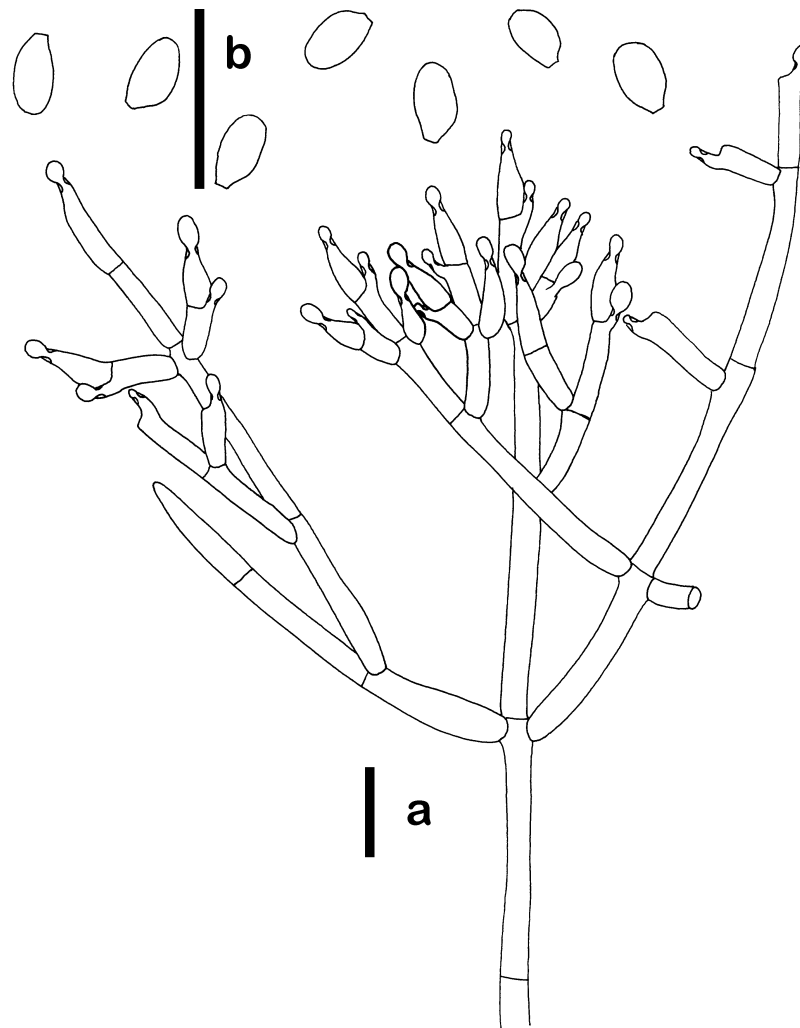
Teleomorph: Unknown.

**Description from culture:** Colonies reaching 30 mm diam in 7 d at 24°C; growth optimum 18–24°C; maximum 27/30°C. Colony reverse on OA and CMD pale

yellowish (1–2A3) to pale orange (5A3). Colony surface white powdery to granulose because of the conidiophores and conidial masses; aerial mycelium sparsely produced or absent. **Conidiophores** monomorphic, penicillate to verticillate, ter- to quaterverticillate; stipes to 100  $\mu\text{m}$  high, to 4  $\mu\text{m}$  wide at base; penicillus to 130  $\mu\text{m}$  high and wide; primary branches divergent, forming independent side-branches; terminal branches and phialides divergent or adpressed; intercalary phialides below solitary terminal phialides, in whorls, sometimes in whorls together with terminal phialides, almost cylindrical, of similar size range to the terminal phialides; lateral necks to 3  $\mu\text{m}$  long; terminal phialides flask-shaped, or cylindrical but narrowing in the upper part, 5–8–12  $\mu\text{m}$  long, 3–4  $\mu\text{m}$  at widest point, *ca* 1  $\mu\text{m}$  wide near aperture, sometimes collapsing in relatively young colonies. **Conidia** in white imbricate columns, smooth, 1-celled, ellipsoidal to subglobose, ovoidal, with a barely recognizable lateral hilum or basally rounded, 3–5.5  $\times$  1.8–3.4  $\mu\text{m}$ . Setae not observed.

**Neotype for *Verticillium candelabrum*:** Rabenhorst ‘*Fungi europaei*’ No. 2148, on leaves of *Laurus nobilis*, leg. P.A. Saccardo, Selva, 1875 (B), designated by Gams (1968).





**Fig. 89.** *Clonostachys candelabrum*. **a.** Conidiophore with divergent primary branches and divergent or adpressed metulae and phialides. – **b.** Conidia. From CBS 204.69, 10-d-old OA culture. Scale bars = 10  $\mu$ m.

**Known distribution:** Temperate and tropical.

**Habitat:** Ubiquitous saprotroph, isolated from soil, root collar of *Pinus nigra*, needles of *Pinus pinaster* in sand dunes, root of *Avena sativa*, leaf litter of *Buxus sempervirens*, dead stem of *Equisetum hiemale* and others (Domsch *et al.*, 1980), particularly also from keratinous substrata such as horse hair.

**Published descriptions:** Gams (1968), Domsch *et al.* (1980).

**Additional strains examined:** NETHERLANDS. Wheat-field soil; J.H. van Emden; 20 Jan 1967 (CBS 504.67). – U.K.: Kew Gardens, Nov 1967, W. Gams (CBS 204.69). – U.S.A. PUERTO RICO: Caribbean National Forest, Luquillo Mts., Big Tree Trail; on unidentified, old xylariaceous stroma; 23 Feb 1996; G.J.S., H.-J. Schroers (CBS, H.J.S. 101; CBS 918.97).

**Notes:** *Clonostachys candelabrum* is characterized by divergent branches of the conidiophores and mostly adpressed but also sometimes divergent phialides (Fig. 89 a). Because of the divergent branches, generally several narrow conidial columns arise from one

penicillus. Conidia in *C. candelabrum* are relatively short compared to those of other species of the subgenus and sometimes appear ovoidal and symmetrical and with both ends rounded. Nevertheless, most conidia show at least a slightly visible, laterally displaced hilum (Fig. 89 b).

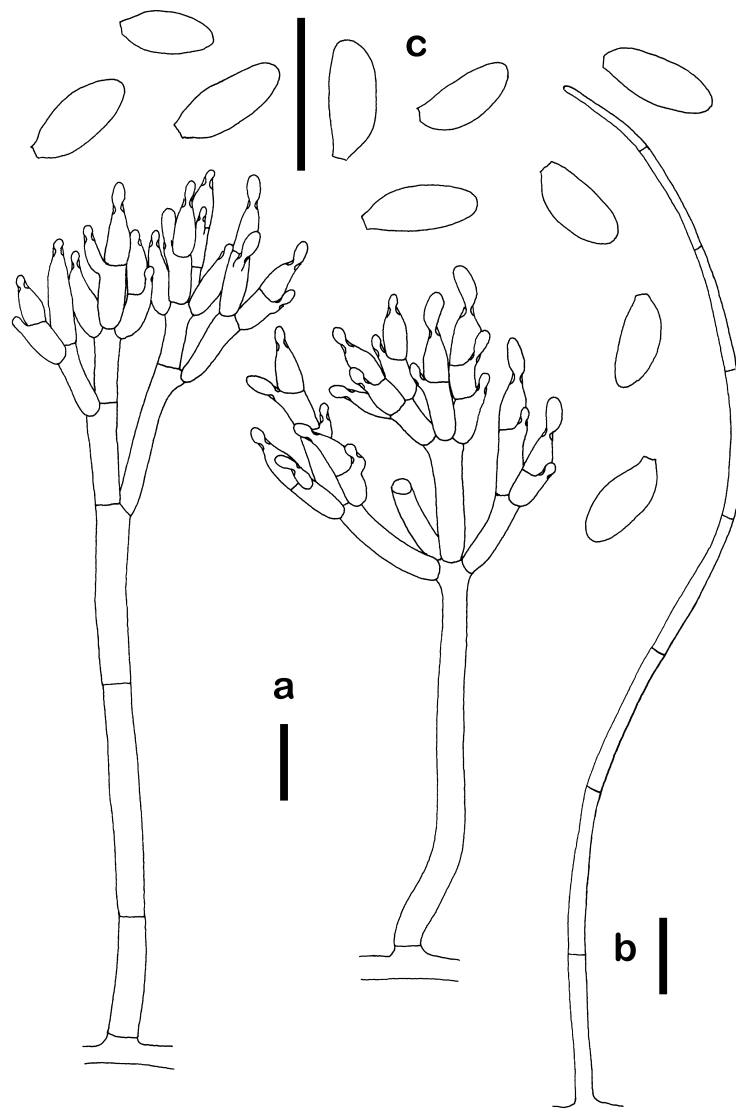
#### 40. *Clonostachys phyllophila* Schroers, *sp. nov.* — Fig. 90 a–c.

Anamorposibus *C. rossmaniae* et *C. buxi* (*B. coronatae*) similis, sed setis e mycelio vel conidiophoris exorientibus differens. *Clonostachydi candelabro* similis sed penicilli plus minusve adpressi. Conidia (5.4–)5.8–6.4–7(–8.8)  $\times$  (2.2–)2.6–2.8–3(–3.2)  $\mu$ m, ovoidea vel ellipsoidea, leviter curvata, hilo plus minusve lateraliter disposito.

Holotypus: Herb. CBS; cultura sicca, isolata ex CBS 921.97; cultura viva CBS 921.97.

Etymology: Greek *phyllophilus*, referring to the substratum, decaying leaves.

Teleomorph: Unknown.



**Fig. 90.** *Clonostachys phyllophila*. **a.** Conidiophores with  $\pm$  adressed penicilli. **b.** Seta. **c.** Conidia. – a: CBS 921.97 and CBS 662.83 (right); b: CBS 921.97; c: CBS 921.97 and 162.97. All from *ca* 14-d-old OA cultures. Scale bars: a, c = 10  $\mu$ m; b = 25  $\mu$ m.

**Description from culture:** Colonies reaching 16 mm in 7 d at 24°C; optimum for growth 21–24°C (20  $\mu$ m diam); maximum at 27/30°C. Colony reverse on OA and CMD pale yellowish (1–2A3) or unpigmented, in older colonies pale orange, on PDA somewhat olivaceous (3E3). Colony surface with structures best developed on PDA and OA, structures on CMD absent or sparsely produced; surface white because of the conidial masses, or yellow or olive-like because of translucent pigmentation of the agar, powdery to granulose because of more or less densely scattered conidiophores and setae; aerial mycelium sparse, with long, white, unbranched setae arising vertically, mainly among and probably also from individual conidiophores. **Conidiophores** monomorphic, penicillate, formed throughout the colony but less frequent near the colony margin, arising from the agar surface, sparse aerial hyphae, or laterally from the basal part of setae; stipes to 100  $\mu$ m high, to 5  $\mu$ m wide at base; penicillus to 50  $\mu$ m high and wide, to quaterverticillate; branches of the penicillus divergent to adressed;

ultimate branches adressed; metulae 5.8–12  $\times$  2.8–3.8  $\mu$ m; intercalary phialides regularly occurring below solitary terminal phialides, in whorls, sometimes in whorls together with terminal phialides, sometimes in chains of two, almost cylindrical, 4.4–9.0  $\times$  3.8  $\mu$ m wide; lateral necks to 3  $\mu$ m long; terminal phialides cylindrical but narrowing apically, narrowly flask-shaped, (5.4–)6.6–7.2–7.4(–9)  $\mu$ m long, (2.6–)3–3.2–3.4(4)  $\mu$ m at widest point, *ca* 1  $\mu$ m wide near aperture. **Conidia** forming white imbricate columns, smooth, 1-celled, ellipsoidal, at least in the lower part slightly curved, with a laterally displaced hilum, with a rather broadly rounded distal end, (5.4–)5.8–6.4–7(–8.8)  $\times$  (2.2–)2.6–2.8–3(–3.2)  $\mu$ m (n = 84); columns rather thick, one per penicillus/conidiophore. **Setae** unpigmented, to 300  $\mu$ m long, to 7.5  $\mu$ m wide at base, gradually tapering in the upper third, not branched. Perithecia not observed.

**Type:** FRANCE. Forêt des buis, Coudrée (Haute Savoie), *Buxus* forest; on fallen leaves of *Viscum album*;

Sept 1996; H.-J. Schroers & T. Gräfenhan (herb. CBS; dried culture of CBS 921.97).

**Known distribution:** France, Puerto Rico, Japan, Spain.

**Habitat:** On dead leaves of various plants.

**Additional specimens/strains examined:** JAPAN. Tokyo; Shinjuku Gyoen Garden, on decaying sclerophyll leaf; Sept 1983; W.G. (CBS 662.83). – SPAIN. leaf litter; Jul 1996; R.F. Castañeda (CBS 162.97, INIFAT C96/90). – CUBA: 19 Mar 1996; R.F. Castañeda (CBS 685.96, INIFAT C96/37).

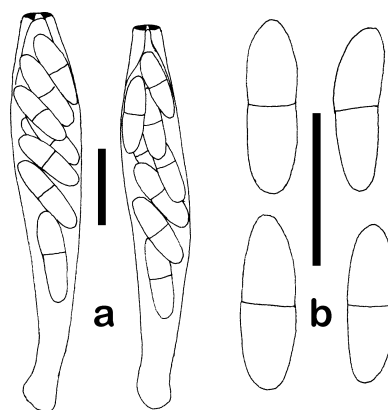
**Notes:** *Clonostachys phyllophila* is characterized by setae that arise from creeping hyphae (Fig. 90 b) or rarely from penicilli or stipes of the conidiophores. The penicilli initially form several narrow conidial chains that may join to form a thick column on adpressed branches or phialides (CBS 921.97, Fig. 90 a, left), while several narrow conidial chains may remain if the penicilli are more divergent (CBS 685.96, not shown). Strain CBS 662.83 forms clusters of conidiophores from distinct spots, resulting in loose aggregates of conidiophores and setae. In older colonies, particularly on PDA, a brownish prosenchymatous stroma was observed near the agar surface, as in *B. setosa*. The relatedness of *C. phyllophila* and *B. setosa* also is suggested by the setae formed in both species. However, no close phylogenetic relatedness of the two is indicated by sequence data of the rDNA (Schroers, 2000). While *C. phyllophila* clustered among other species of subgenus *Epiphloea*, *B. setosa* fell between subgenus *Epiphloea* and a clade comprising the subgenera *Astromata*, *Zebrinella*, and *Bionectria*. *Clonostachys phyllophila* and *B. setosa* differ in conidial size and shape while the branching patterns of conidiophores in both are practically indistinguishable. Conidia in *C. phyllophila* (Fig. 90 c) are almost indistinguishable from those of other species of the subgenus but are slightly wider than those of *B. lasiacidis* (Fig. 86 d) and *B. sesquicillii* (Fig. 88 e), and slightly longer than in *B. rossmaniae* (Fig. 77 d).

**41. *Bionectria setosa*** Schroers, *sp. nov.* — Figs 91 a, b, 92 a–e.

Anamorph: *Clonostachys setosa* (B.P.R. Vittal) Schroers, *comb. nov.*, sesquicillium-like. — Fig. 93 a–c.

≡ *Sesquicillium setosum* B.P.R. Vittal, Kavaka 2: 46. 1974, Fig. 1, A–F.

*Bionectria rossmaniae* similis sed peritheciis brunneis. Ascospores  $(8.8\text{--}10.2\text{--}13) \times (2.4\text{--}3\text{--}3.8)$   $\mu\text{m}$ . Anamorphosis *Clonostachys setosa* (B.P.R. Vittal) Schroers.



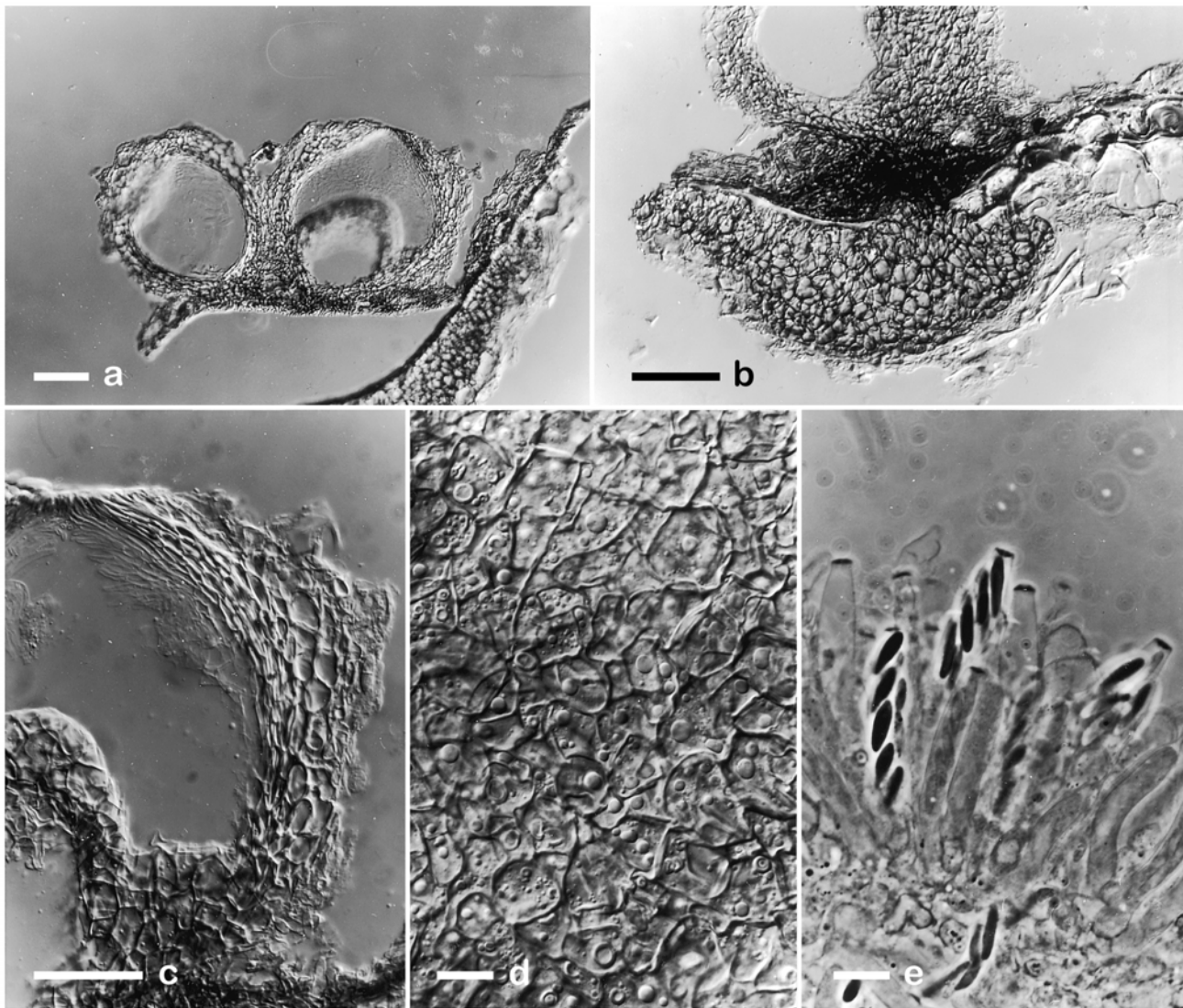
**Fig. 91. *Bionectria setosa*.** a. Almost mature asci. b. Discharged ascospores. — All from BPI 748342, natural substratum. Scale bars = 10  $\mu\text{m}$ .

Holotypus teleomorphosis: BPI 748342.

**Etymology:** Latin *setosus*, referring to the epithet of the anamorph.

**Description from natural substratum: Perithecial stroma** superficial, flat; cells of stroma forming a *textura epidermoidea*. **Perithecia** broadly connected to the stroma, solitary to loosely aggregated, globose, to 200  $\mu\text{m}$  diam, brown, smooth, slightly laterally pinched or not when dry, not papillate, ostiolar region slightly tapering in dried condition. **Perithecial wall** 20–30  $\mu\text{m}$  thick, consisting of 2 regions. Outer region up to 15  $\mu\text{m}$  or 2–3 cells thick; cells angular to globose,  $(9.5\text{--}11.5\text{--}13\text{--}14\text{--}17.5) \times (7\text{--}8\text{--}10\text{--}11\text{--}15.5)$   $\mu\text{m}$  ( $n = 16$ ), thin-walled, containing small vacuoles. Inner region *ca* 10  $\mu\text{m}$  thick, consisting of 1–3 layers of flat cells. **Asci** narrowly clavate,  $45\text{--}53 \times 6.5\text{--}9$   $\mu\text{m}$  ( $n = 4$ ), 8-spored; apex flat; ring visible. **Ascospores** ellipsoidal, smooth or possibly minutely striate,  $(8.8\text{--}10.2\text{--}13) \times (2.4\text{--}3\text{--}3.8)$   $\mu\text{m}$  ( $n = 13$ ). Mycelium and conidiophores not found.

**Description from culture: Colonies** reaching 25–30 mm diam in 7 d at 24–27°C; optimum for growth 24–27°C, maximum 33/36°C. Colony reverse on CMD slightly pigmented, on OA and PDA in yellow (1A4, 4A2–3), or, if incubated under UV-light, orange hues (to 5–6A5), or in older colonies, olive-brown to brown (4D–E–F4). Colony surface smooth to powdery to finely felty because of conidiophores arising from the agar surface, conidial masses, and erect hyphae with setae. Aerial mycelium scanty, apart from the setae almost absent; colonies, particularly on OA/PDA eventually (not seen in all strains) becoming brown, particularly on OA, because of the stromatic tissue developing in the agar or on the agar surface, first in spots, later covering most parts of the colony; stromata only sparsely developed on CMD. **Setae** continuously tapering towards the tip, 300–600  $\mu\text{m}$  long or longer, to 7  $\mu\text{m}$  broad near the base, 2  $\mu\text{m}$  near the tip, hyaline, arising from creeping hyphae or from the



**Fig. 92. *Bionectria setosa*.** a–c. Sections through perithecia and perithecial base. a. Perithecia on flat stroma. b. Perithecial stroma and base; subcortical stroma possibly belonging to another fungus. c. Lateral perithecial wall. d. Subsurface view of outer perithecial wall region. e. Immature asci showing apical ring. – All from BPI 748342, natural substratum. a–d: DIC, e: PC. Scale bars: a, b = 50  $\mu\text{m}$ ; c = 30  $\mu\text{m}$ ; d, e = 10  $\mu\text{m}$ .

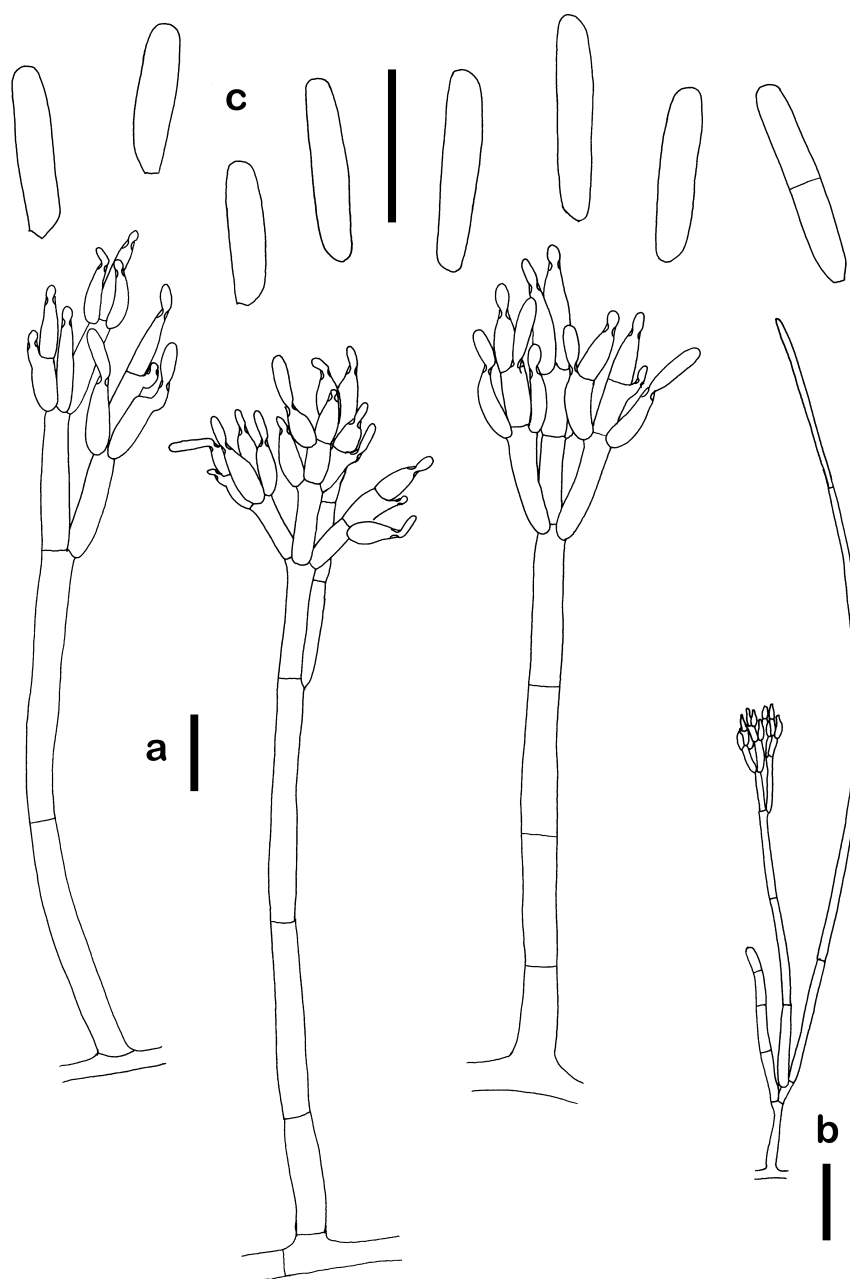
lower part of a conidiophore. **Conidiophores** monomorphic, penicillate, mono- to terverticillate, branches almost adpressed, arising from the agar surface or the stroma; stipe 50–150  $\mu\text{m}$  long, 3–5.5  $\mu\text{m}$  wide; penicillus 30–60  $\mu\text{m}$  high, to 40  $\mu\text{m}$  wide; metulae (6–)8–12.8–16(–17.2)  $\times$  (2.8–)3.2–3.4–3.4(–3.8)  $\mu\text{m}$ ; intercalary phialides below solitary terminal phialides, in whorls, sometimes in whorls together with terminal phialides, sometimes in chains of two, cylindrical, 6–11  $\times$  3–4  $\mu\text{m}$  wide ( $n = 15$ ); lateral necks 1.4–3.2  $\mu\text{m}$  long; terminal phialides solitary on intercalary phialides or in whorls, (5.4–)8–9.0–9.8(–13.4)  $\mu\text{m}$  long, (2.4–)2.8–3.2–3.4(–4.2)  $\mu\text{m}$  wide at base, (1–)1–1.2–1.4(–1.6)  $\mu\text{m}$  wide near aperture ( $n = 40$ ). **Conidia** forming thick, short, white to yellowish white columns that arise from one penicillus or conidiophore, 0–1-septate, hyaline, cylindrical, straight, obliquely extruding from the phialide, with minutely laterally displaced or invisible hila, (8.6–)10.2–12–13.4(–19.2)  $\times$  (2–)2.6–2.6–2.6(–3.2)  $\mu\text{m}$ . Perithecia not seen.

**Type for *Bionectria setosa*:** U.S.A. PUERTO RICO: Caribbean National Forest, Luquillo Mts., ca 300 m up the river, near bridge crossing river below El Verde Research station; on decaying twig on ground in wet area; H.-J. Schroers; 26 Feb 1996 (BPI 748342; CBS 917.97). Type for *Sesquicillium setosum*: INDIA. Tamil Nadu, Chingleput, Vandalur; from litter of *Atlantia monophylla*; May 1970; B.P.R. Vittal (Herb. MUBL No. 2260), not obtainable. **Neotype** designated herewith: dried culture of CBS 917.97, derived from ascospores of BPI 748342, type specimen of *B. setosa*, and filed with it (BPI).

**Known distribution:** Pantropical (India, New Caledonia, the neotropics).

**Habitat:** Teleomorph known from partly decayed twig; anamorph from forest leaf litter, or twigs.

**Published descriptions:** Vittal (1974).



**Fig. 93.** *Bionectria setosa* / *Clonostachys setosa*. **a, b.** Conidiophores (a), with seta arising from basal part of conidiophore stipe (b). **c.** Conidia, rarely with a median septum. – a: CBS 496.90 (left), CBS 917.97 (middle), CBS 834.91 (right); b: CBS 917.97. c: CBS 917.97 and 834.91. From 7–10-d-old OA cultures. Scale bars: a, c = 10  $\mu$ m; b = 50  $\mu$ m.

**Additional strains examined:** TRINIDAD AND TOBAGO. Nariva Swamp; from twig; Aug 1981; D.J. Stradling, P.J. Fisher (CBS 395.82, ex conidia). – CUBA. Granma; on *Trophis racemosa*; 14 Mar 1991; R.F. Castañeda (CBS 834.91; INIFAT C91/96, ex conidia).

**Notes:** *Bionectria setosa* is characterized by superficial stromata / perithecia (Fig. 92 a) and perithecial walls with two regions (Fig. 92 c); therefore it is classified in subgenus *Epiphloea*. The brown colour of the perithecia is unusual for *Bionectria* but also found in *B. pseudostriata*. The cells of the outer perithecial wall region contain coloured drops (Fig. 92 d) as is typical of most species in subgenus *Bionectria*. As in most species of *Bionectria*, the asci have an apical ring (Figs 91 a, 92 e).

A similarly coloured pseudoparenchymatous stroma was also found in the agar, close to the agar surface of colonies grown from ascospores and, although to a lesser extent, the conidial isolates. No perithecia were observed in culture, although round, primordium-like structures were found in the brown stroma. The characters of conidiophores and conidia of all strains observed are indistinguishable from those in Vittal's original description. Vittal (1974) gave conidial length measurements of 9–16  $\mu$ m and similar measurements were obtained in the original colonies derived from ascospores. After subculturing, the ascospore isolates and other conidial isolates from the CBS, showed length ranges of only 8.5–13.0  $\mu$ m. Conidial septation

was reported by Vittal for at least some conidia, which was confirmed by observations of additional fresh strains (W. Gams, pers. comm.). However, no such septation was found in subcultured strains (CBS), but few septate conidia were observed in the ascospore isolate (Fig. 93 c). Repeated subculturing of *B. setosa* strains obviously causes the formation of shorter and 1-celled conidia.

Among the few species in subgenus *Epiphloea* forming setae (e.g. Fig. 93 b), *B. setosa* is distinguished by the almost cylindrical shape of the conidia. In the setose *C. phyllophila* and *B. parviphialis*, but also in other species of subgenus *Epiphloea*, the conidia are slightly curved and have a somewhat flattened side. The overall branching pattern of the conidiophores of *B. setosa* (Fig. 93 a) is essentially indistinguishable from other species in subgenus *Epiphloea*. Generally, thick conidial columns are formed on the addressed penicilli.

Based on sequence analyses of the rDNA (Schroers, 2000: Fig. 1, as *Bionectria* sp. 3) and *tub2*/ITS (Fig. 2: F), *B. setosa* clusters outside a clade comprising species of subgenus *Epiphloea* and a clade comprising the subgenera *Astromata*, *Zebrinella*, and *Bionectria*. However, its classification in subgenus *Epiphloea* is clearly supported by morphological characters of both the teleo- and the anamorph.

The conidiophores in species of *Cylindrocladium* Morgan (teleomorph: *Calonectria* De Not., *Nectriaceae*) are setose and similarly penicillate as those of *C. setosa*, but they differ in having thin-walled vesicles formed at the tip of the setae, abundant chlamydospores in culture, lack of intercalary phialides, and lack of laterally displaced conidial hila.

#### 42. *Bionectria gibberosa* Schroers, *sp. nov.* — Figs 94 a–g, i, 95 a–b.

Anamorph: *Clonostachys* cf. *setosa*, sesquicillium-like (connection not confirmed by ascospore isolation). — Figs 94 h, 95 c, d.

*Bionectriae rossmaniae* similis sed cellulis strati exterioris minoribus quam 10 µm, a regione interiore differentibus. Perithecia levia, ostiolum intumescens circumdatum. Paries lateralis circa 30 µm crassus, prope ostiolum abrupte ad 65 µm incrassatus. Ascospores (9–)11–12–13(–15) × (2–)3–3.5–4(–5.5) µm. Anamorphosis in substrato naturali visa, *Clonostachydi setosae* similis. Conidia (7.6–)10–10.8–11.4(–14.4) × (1.8–)2.2–2.4–2.6(–3) µm.

Holotypus: Specimen BPI 1113174 (BPI).

Etymology: Latin *gibberosus*, referring to the hump-like bulge around the perithecial ostiole.

**Description from natural substratum:** **Perithecial stroma** superficial, consisting of densely packed hyphae that possibly continue into the outermost cell layer of the perithecial wall, firmly connected to the

substratum. **Perithecia** solitary to gregarious, sometimes also on or near black fungal stromata, subglobose to globose, somewhat broader than high, to 280 µm diam, with a hump-like thickening around the ostiole, pinched laterally to subapically below the hump when dry, smooth, pale yellow to pale orange, with darker (brownish) contrasting ostiolar region, not papillate. **Perithecial wall** laterally *ca* 30 µm, subapically to 65 µm thick, consisting of two regions, and an outermost cell layer that continues into the basal stroma. Outer region *ca* 20 µm or *ca* 4 cell layers thick; cells subglobose to angular, somewhat epidermoid, thin-walled, outwards 4.5–10 × 2–6.5 µm, inwards 6.5–21.5 × 5.5–18 µm. Inner region to 10 µm thick. **Asci** clavate, (43–)52.5–55–59(–65.5) × (6.5–)7.5–8–8.5(–10.5) µm (n = 28), 8-spored; ascus apex rather flat; ring visible. **Ascospores** ellipsoidal, equally 2-celled, not constricted at the septum, colourless, smooth, (9–)11–12–13(–15) × (2–)3–3.5–4(–5.5) µm (n = 55). **Sterile mycelium** surrounding the perithecial base not observed. **Conidiophores** scattered on the perithecia or arising from inconspicuous hyphae on the substratum, solitary to aggregated; penicillus *ca* 50 µm high, to 30 µm broad; branches of the penicillus and phialides addressed; metulae 10–17 × 3–4 µm; intercalary phialides in whorls, sometimes together with terminal phialides, each below solitary terminal phialides, sometimes in chains of two or three, cylindrical, 8–13 × 3 µm wide; lateral necks to 3 µm long; terminal phialides cylindrical, narrowing in the apical part or somewhat flask-shaped, (5.2–)6.6–7.6–8.4(–11) µm long, (1.6–)2.2–2.4–2.6(–3.2) µm wide at widest point, *ca* 1 µm wide near aperture. **Conidia** forming white imbricate chains or columns, smooth, 1-celled, oblong-ellipsoidal to almost cylindrical, (7.6–)10–10.8–11.4(–14.4) × (1.8–)2.2–2.4–2.6(–3) µm; distal end rather broadly rounded; hilum median or slightly laterally displaced (n = 88, measured from the natural substratum). Sterile hyphae (setae) arising from the penicillus or stipe, to 250 µm long, to 4 µm wide at base, hyaline, narrowing slightly in the upper part.

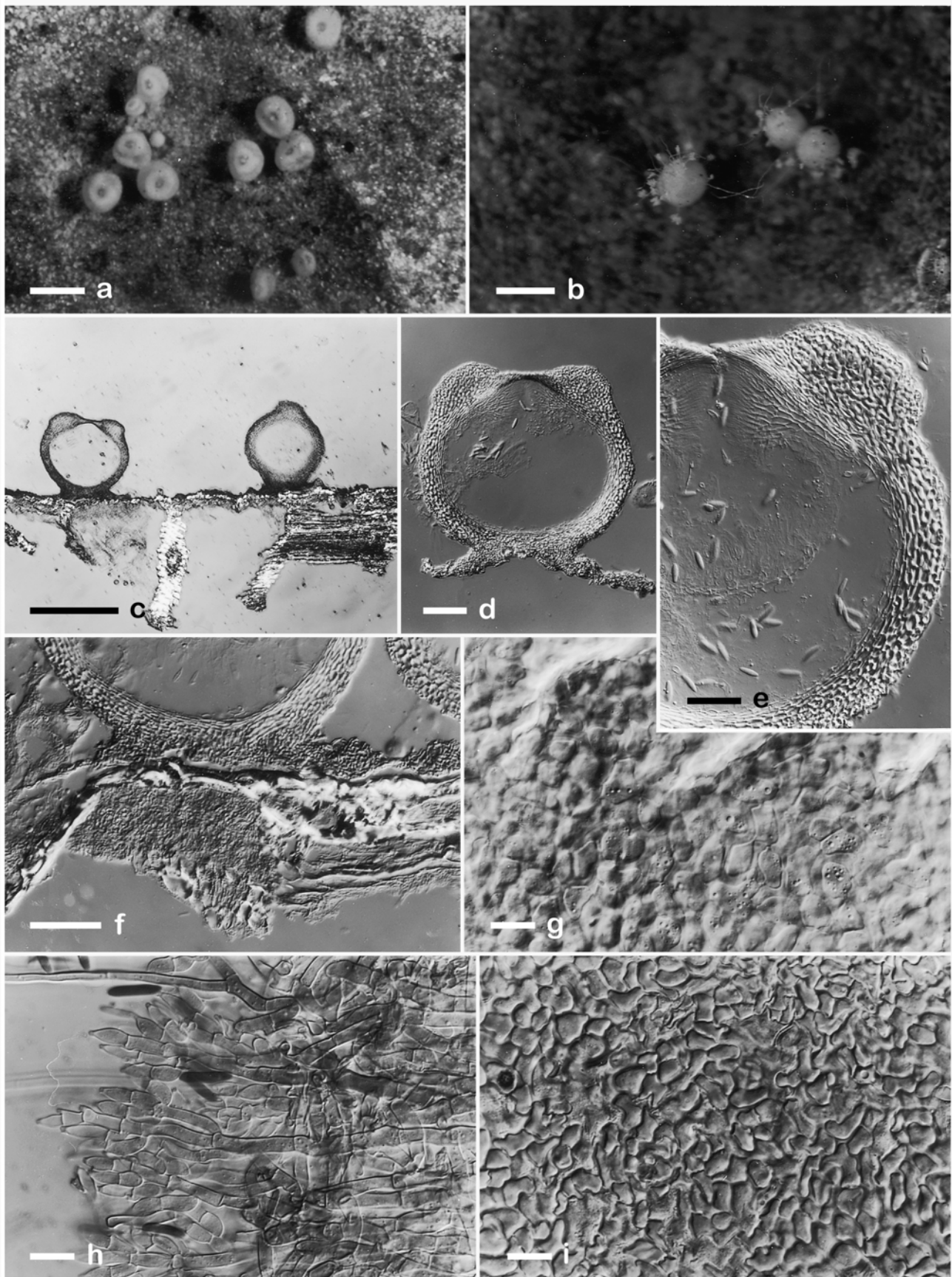
**Type:** U.S.A. Florida: Gainesville; on leaf of *Magnolia* sp.; Aug 1985; A.Y.R. (BPI 1113174; 577A; A.Y.R. 2611).

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

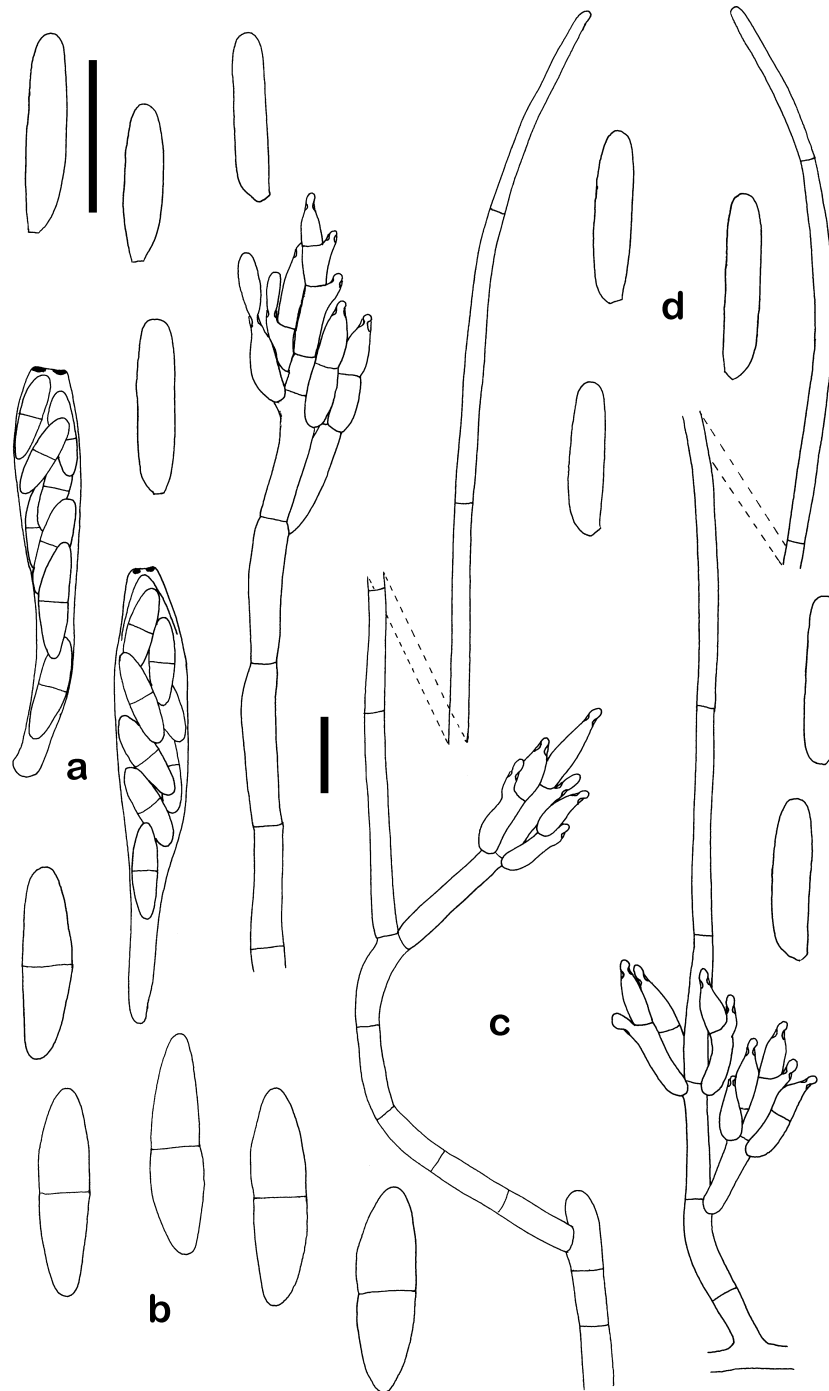
**Habitat:** On dead leaves of *Magnolia* sp.

**Additional specimen examined:** U.S.A. Florida: Alachua Co., San Felasco Hammock State Preserve; on fallen leaves of *Magnolia* sp.; 10 Aug 1985; C.T.R. (NY; C.T.R. 85-66).

**Notes:** *Bionectria gibberosa* is characterized by a subapically abruptly thickened perithecial wall (Fig. 94 c–e), which appears hump-like when seen in longitudinal sections. The pinching of the dried perithecia enhances this morphology of the perithecial wall, be-



**Fig. 94.** *Bionectria gibberosa* (?) *Clonostachys* cf. *setosa*. **a, b.** Habit of solitary to aggregated perithecia; perithecia gregarious, subapically pinched, with paler hump and darker ostiole (**a**), and bearing conidiophores (**b**). **c–f.** Sections through perithecia and perithecial base. **c.** On leaf surface. **d.** Whole perithecium. **e.** Lateral perithecial wall and ostiole. **f.** Base of perithecium. **g.** Inner perithecial wall region in subsurface view; cells globose to angular with 'pseudopores'. **h.** Aggregates of sesquicillium-like conidiophores, with setae arising from lower parts of conidiophores, and conidia. **i.** Subsurface view of outer perithecial wall region; cells angular to somewhat epidermoidal, taken from cell layer immediately below surface. – All from natural substratum of C.T.R. 85-66. **a, b:** DM, **c:** LM, **d–i:** DIC. **h.** stained in cotton blue. Scale bars: **a** = 300 μm; **b, c** = 250 μm, **d, f** = 50; **e** = 30 μm; **g–i** = 10 μm.



**Fig. 95.** *Bionectria gibberosa* / *Clonostachys* cf. *setosa*. **a.** Almost mature asci. **b.** Discharged ascospores. **c.** Conidiophores. **d.** Conidia. – a: C.T.R. 85-66 (left), BPI 1113174 (right); b: C.T.R. 85-66, BPI 1113174; c: C.T.R. 85-66 (left two), BPI 1113174 (right); d: C.T.R. 85-66, BPI 1113174. All from natural substratum. Scale bars = 10  $\mu$ m; the shorter bar applies to a, c, the longer to b, d.

cause the wall collapses below the thickened hump while the apical part of the perithecium becomes slightly exposed (Fig. 94 a). In contrast to most other species of subgenus *Epiphloea*, the perithecial wall has rather small cells of constant size (Fig. 94 e). The outer and the inner regions are only weakly differentiated (Fig. 94 e), however, no ‘pseudopores’ were found in the cells of the outer region (compare Fig. 94 g and Fig. 94 i). The species is included in subgenus *Epiphloea* because of superficially formed perithecia (Fig. 94 c, f), morphological similarities of the perithecial stroma (Fig. 94 f), and its assumed

sesquicillium-like anamorph (Figs 94 h, 95 c, d). The morphology of asci and ascospores is consistent with those of *Bionectria* in general (Fig. 95 a, b).

Setose conidiophores (Figs 94 h, 95 c), cylindrical conidia with slightly laterally displaced hila (Fig. 95 d), and occurrence of intercalary phialides (Figs 94 h, 95 c) are essentially indistinguishable from *C. setosa*. In both specimens of *B. gibberosa* such conidiophores were associated with the perithecia (Fig. 94 b). Although not proven, it is assumed that a *C. setosa*-like anamorph is associated with *B. gibberosa*.



**BIONECTRIA SUBGEN. UNIPARIETINA** Schroers, *subgen. nov.* — Species 43–44.

Perithecia e stromate minusculo superficiali substratis herbaceis affixo exorientia, solitaria vel gregaria, obpyriformia vel subglobosa, levigata, pallide lutea vel pallide aurantiaca, a KOH haud mutata. Tunica perithecii ex uno strato composita. Setae ostiolum circumdantes, curtae, hyphales, plusminusve undulosae. Asci clavati; apice simplici vel annulo minimo praediti, 8-spori. Ascospores unicellulares, ellipsoideae vel fusiformes, hyalinae, levigatae vel verruculosae. Anamorphosis *Clonostachys* (*Sesquicillium*).

Type species: *Bionectria coronata* (Juel) Schroers, *comb. nov.*

Etymology: *Uniparietina*, referring to the perithecial wall consisting of one main region.

Anamorph: *Clonostachys* (*Sesquicillium* W. Gams).

**Perithecial stroma** superficial on leaves; cells consisting of densely packed hyphae, forming a *textura epidermoidea*. **Perithecia** superficial on the stroma or with the lower part embedded in densely packed hyphae, solitary, gregarious, or loosely aggregated but not crowded, subglobose or obpyriform, to 200 µm diam, pale yellow to pale orange, not changing colour in KOH, minutely papillate. **Perithecial setae** short, somewhat undulate setae arising from the surface particularly in the upper part. **Perithecial wall** thinner than 30 µm, consisting of one region and an additional outermost cell layer continuous with the perithecial base; cells of the outermost cell layer epidermoid in surface view, those of the wall region subglobose to angular to lobed, flat in longitudinal sections, with 'pseudopores' in the walls visible particularly in subsurface view. **Asci** clavate, 8-spored; ascus apex rounded, with or without a ring. **Ascospores** ellipsoidal to fusiform, shorter than 15 µm, 1-celled or 1-septate, smooth or spinulose; ascospores biserial above, uniserial below.

**Known distribution:** Temperate (Europe) or tropical (Venezuela).

**Habitat:** Perithecia typically formed on decaying leaves or decaying herbaceous plant material.

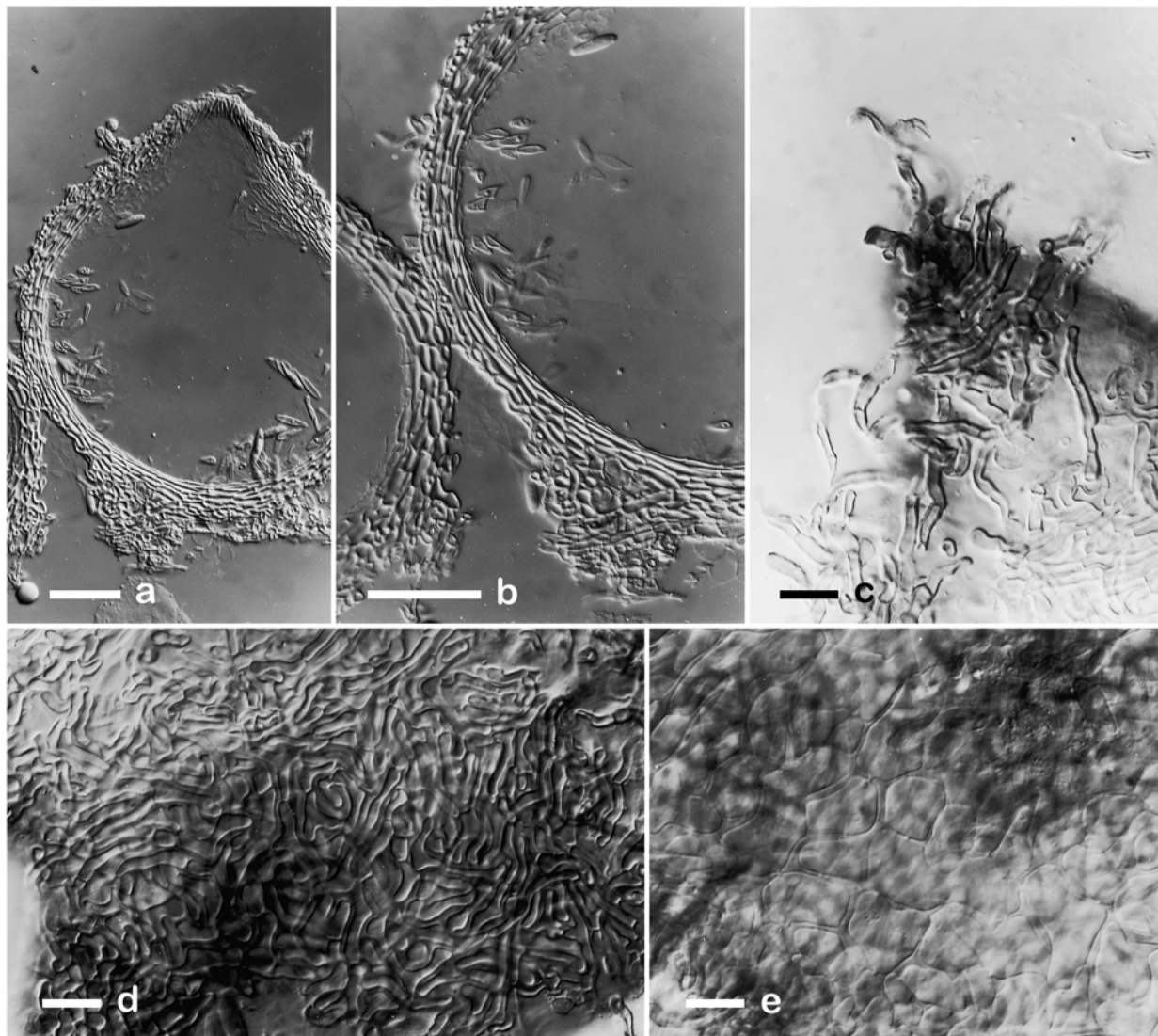
**Notes:** *Bionectria* subgenus *Uniparietina* is based on *Nectriella coronata* Juel (Juel, 1925). Its anamorph (Fig. 97 c, d) is the type species of *Sesquicillium*, *S. buxi* (Schmidt in Link) W. Gams (Gams, 1968). *Bionectria coronata* is the most deviant element in *Bionectria*. It may overlap with species of *Nectriopsis* in its simple perithecial wall (Fig. 96 a, b). Because of its aseptate ascospores (Fig. 97 b) and setae that arise from the perithecial apex (Fig. 96 c), *B. coronata* was transferred to *Pseudonectria* (*Nectriaceae*) by Lowen (in Rossman *et al.*, 1993). *Bionectria coronata* originally was classified in *Nectriella* Sacc. subgenus *Notariisiella* Sacc. 1883, which was described for species

with aseptate ascospores and perithecia covered with setae. Because *Nectriella* Sacc. is an illegitimate homonym of the earlier described genus *Nectriella* Nitschke ex Fuckel, a new genus, *Pseudonectria*, was introduced by Seaver (1909a), and *Nectriella rous seliana* (Mont.) Sacc., the type species of *Nectriella* Sacc. subgenus *Notariisiella* Sacc. was transferred to this new genus by Clements & Shear (1931). The genus *Nectriella* Nitschke ex Fuckel, based on *N. fuckelii* Nitschke ex Fuckel is accepted in the *Bionectriaceae* (Rossman *et al.*, 1999), characterized by immersed perithecia.

The two species accepted in *Pseudonectria*, *P. rous seliana* (Mont.) Wollenw. and *P. pachysandricola* Dodge, have variably pigmented, frequently greenish perithecia, broad setae (to 8 µm) with relatively thick walls (to 2 µm), and volutella-like anamorphs. Species in *Pseudonectria* show no or only a weak colour reaction in KOH (Rossman *et al.*, 1993, 1999). In fresh material of *P. rous seliana*, setae with a red tip were observed that turn deeper red in KOH and pale yellowish in lactic acid (Schroers, unpubl.). This positive KOH reaction may support the classification of *Pseudonectria* in the *Nectriaceae* (Rossman *et al.*, 1999).

In contrast to *Pseudonectria*, *Bionectria coronata* has pale yellow to pale orange perithecia, a hairy collar of short, curly, thin-walled (walls to 0.5 µm) and rather narrow (to 2–4 µm) hyphae/setae (Juel, 1925: Taf. 1, 2; Fig. 96 c), a *Sesquicillium* anamorph (Fig. 97 c, d), and is so far only known from *Buxus*. The classification of *N. coronata* in *Bionectria*, despite its strongly deviating characters of the teleomorph, is supported by inferences from rDNA sequence analyses that place it among species of the subgenus *Epiphloea* (all with sesquicillium-like anamorphs) (Fig. 2; Schroers, 2000: Fig. 1). To account for the differences in the teleomorphs, the subgenus *Uniparietina* is proposed.

Explanations for the relationship of *B. coronata* and species of the subgenus *Epiphloea* are speculative: the cells of the outer perithecial wall region of species in the subgenus *Epiphloea* could be interpreted as derivatives of the inner region. In this case the entire perithecial wall in species of subgenus *Epiphloea* and *B. coronata* would be homologous. Homology of the perithecial walls in the subgenera *Uniparietina* and *Epiphloea* also is indicated by the outermost cell layer in *B. coronata*, which is similarly epidermoidal (Fig. 96 d, compare for example with Fig. 78 f). Another explanation concerns the geographic distribution of the species and host-plant relationships. While teleomorphs of the subgenus *Epiphloea* have been described only from tropical locations and from various substrata including decaying leaves, lichens, and bark (Samuels, 1989), *B. coronata* is of temperate distribution and only known from dead leaves of *Buxus*. In assuming strict host specificity of *B. coronata* on



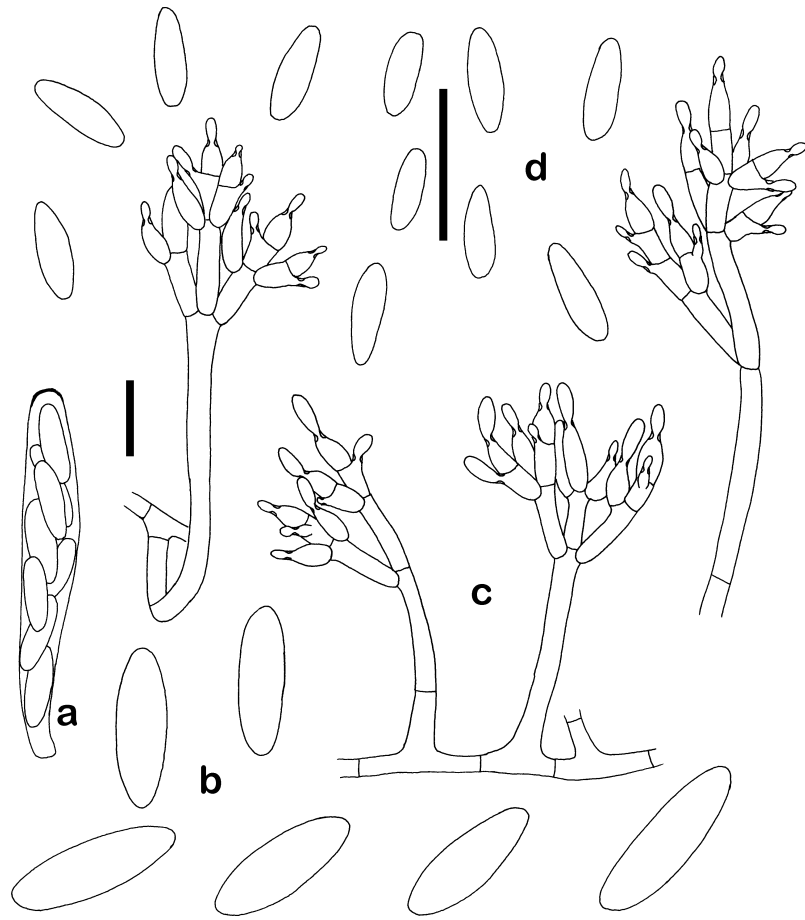
**Fig. 96. *Bionectria coronata*.** a, b. Section through perithecium; perithecial wall consists of one region; base of perithecium consists of densely aggregated hyphae. c. Hyphae surrounding ostiole in squash preparation. d. Outermost perithecial cell layer in surface view possibly continuous with cells of perithecial base forming *textura epidermoidea*. e. Cells below those shown in d subglobose, with 'pseudopores'. – All: BPI 802521, natural substratum, DIC. Scale bars: a, b = 30  $\mu$ m; c–e = 10  $\mu$ m.

*Buxus* and recognizing the isolated phylogenetic position of members of the *Buxaceae*, which is indicated by 18S rDNA analyses (Soltis *et al.*, 1997), *B. coronata* might be interpreted as being isolated and possibly phylogenetically as old as its host-plant. In assuming also that the perithecial wall anatomy of *B. coronata* is conserved, its morphology could be similar to that of the common ancestor of the *Bionectria*-taxa.

*Bionectria aurantia* is similar to *B. coronata* in the perithecial setae (Fig. 98 c) and perithecial wall anatomy (Fig. 99 a, c) and is therefore also classified in subgenus *Uniparietina*. Because no anamorph is known for *B. aurantia*, and because of its 1-sepate, warted ascospores (Fig. 98 b), this classification needs additional support.

*Nectria*-like species with perithecia bearing hyphae or setae are highly diverse and are today classified for example in *Sphaerostilbella* (*Hypocreaceae*), *Cosmospora*, *Pseudonectria* Seaver (both *Nectriaceae*),

*Nectriella* Nitschke ex Fuckel, *Pronectria* Clem., *Protocreopsis* Doi, and *Bryonectria* Döbbeler (all *Bionectriaceae*). This heterogeneity partly reflects morphological differences of the perithecial hyphae or setae. In *Sphaerostilbella* spp., short, blind-ending hyphae sometimes arise from the outermost cells of the perithecial wall (Seifert, 1985: Fig. 49 g). In *Nectriella* and *Cosmospora* spp., setae are short, straight, and are restricted to the area around the ostiole or to the uppermost part of the perithecium [e.g. *Cosmospora dingleyae* Lowen (Rossman *et al.*, 1999: Plate 26 b) and *Nectriella anisospora* Lowen (Lowen, 1989: Fig. 4 a)]. In *Protocreopsis* spp., perithecia are embedded within a dense plait of hyphae with only the ostiole visible at the surface. Perithecial setae *per se*, being formed in non-related nectrioid taxa, obviously are not indicative of natural relatedness, but still can be used to characterize naturally related species groups if their occurrence is correlated with other characters.



**Fig. 97. *Bionectria coronata* / *Clonostachys buxi*.** a. Almost mature ascus with a slightly thickened apical wall. b. Discharged aseptate ascospores. c. Conidiophores. d. Conidia. — a: BPI 802521; b: BPI 802521, FC 408; c: CBS 288.62 (left), CBS 202.69 (middle), CBS 696.93 (= BPI 802521, right); d: CBS 202.69 and 696.93. From 10–14-d-old OA cultures. Scale bars = 10  $\mu$ m; the shorter bar applies to a, c, the longer to b, d.

**43. *Bionectria coronata* (Juel) Schroers, *comb. nov.*** — Figs 96 a–e, 97 a, b.

- ≡ *Nectriella coronata* Juel, Ark. Bot. 19: 4. 1925.
- ≡ *Pseudonectria coronata* (Juel) Lowen, Mycologia 85: 693. 1993.

Anamorph: *Clonostachys buxi* (Schmidt in Link : Fr.) Schroers, *comb. nov.* — Fig. 97 c, d.

- ≡ *Fusidium buxi* Schmidt in Link, Linné Spec. Plant. 2: 97. 1825.
- ≡ *Fusisporium buxi* (Schmidt in Link : Fr.) Fr., Syst. mycol. 3: 447. 1832.
- ≡ *Verticillium buxi* (Schmidt in Link : Fr.) Auersw. & Fleischh., Hedwigia 6: 9. 1867.
- ≡ *Ramularia buxi* (Schmidt in Link : Fr.) Fuckel, Symb. mycol. p. 97. 1870.
- ≡ *Paecilomyces buxi* (Schmidt in Link : Fr.) Bezerra, Acta bot. Neerl. 12: 63. 1963.
- ≡ *Sesquicillium buxi* (Schmidt in Link: Fr.) W. Gams, Acta Bot. Neerl. 17: 455. 1968.

**Perithecial stroma** superficial on the substratum, consisting of densely packed hyphae forming a *textura epidermoidea*, probably continuous with the outermost cell layer of the perithecial wall. **Perithecia** superficial on a flat hyphal layer, easily removed, solitary or

loosely aggregated, globose but tapering above, ca 200  $\mu$ m high, 160  $\mu$ m diam, laterally pinched when dry, smooth, pale yellowish to yellowish orange, slightly papillate. **Perithecial setae** short, septate, slightly undulate, up to 40  $\mu$ m long, up to 4  $\mu$ m wide at base, tapering towards the tip, with up to 1.5  $\mu$ m thick smooth walls, arising from the apical part of the perithecia and surrounding the ostiole. **Perithecial wall** 15–20  $\mu$ m thick consisting of one region and an outermost cell layer probably arising from the hyphal stroma; cells flat in longitudinal section, subglobose to angular in subsurface view, with ‘pseudopores’ in the walls. **Asci** narrowly clavate, (39–)42.5–44.5–46(–50)  $\times$  (5–)6–6.5–7(–8)  $\mu$ m (n = 15), 8-spored; apex rounded, ring invisible. **Ascospores** ellipsoidal to cymbiform (very slightly tapering at both ends), 1-celled, colourless, smooth, (8.8–)10.4–11.4–12(–14.8)  $\times$  (2.6–)3–3.2–3.4(–4)  $\mu$ m (n = 64). **Conidiophores** numerous among the perithecia.

**Description from culture:** Colonies reaching ca 15 mm in 7 d at 24°C; optimum for growth (18–)21(–24)°C, maximum 30°C. Colony reverse unpigmented (CMD) or pale yellowish to pale orange (OA, PDA). Colony surface finely granular because of the conidial

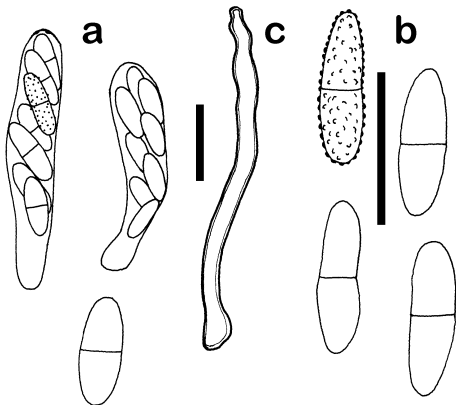
masses on scattered conidiophores, or almost smooth in colony parts with sparse sporulation. Aerial mycelium scanty. **Conidiophores** densely covering the agar, arising from the agar surface or from scanty aerial mycelium, best produced on OA, monomorphic, penicillate, mono- to terverticillate; stipe *ca* 100  $\mu\text{m}$  long, *ca* 3  $\mu\text{m}$  wide; penicillus to 30  $\mu\text{m}$  high, 40  $\mu\text{m}$  wide; metulae 5–13  $\mu\text{m}$  long, 2.6–4.4  $\mu\text{m}$  wide; intercalary phialides below solitary terminal phialides, in whorls, sometimes in whorls together with terminal phialides, sometimes in chains of two, cylindrical, 4.2–6  $\mu\text{m}$  long, 2.4–3.6  $\mu\text{m}$  wide ( $n = 13$ ); lateral necks 2–4  $\mu\text{m}$  long ( $n = 31$ ); terminal phialides broadly bottle-shaped or almost cylindrical in the basal part, and narrowing in the upper third, (4.2–)5.8–7.8–9.8(–11.6)  $\mu\text{m}$  long, (2–)2.4–3–3.2(–3.4)  $\mu\text{m}$  wide at base, (0.8–)1–1.4–1.6(–2)  $\mu\text{m}$  wide near aperture ( $n = 40$ ). **Conidia** forming short white or orange-white columns, 1-celled, smooth, hyaline, almost cymbiform, straight, proximal end possibly slightly more tapering than the distal end; hilum median or minutely laterally displaced, (5.4–)6.4–6.8–7(–8)  $\times$  (1.6–)1.8–2–2.4(–2.6)  $\mu\text{m}$ . Setae, stroma, sporodochia, and perithecia not observed.

**Type for *Nectriella coronata***: SWEDEN. Uppsala, Botanical Garden; on leaves of *Buxus sempervirens* L.; 10 Oct 1924; O. Juel (S; Isotype: BPI). **Neotype for *Fusidium buxi***: GERMANY. Leipzig; Auerswald (B), designated by Gams (1968).

**Known distribution**: Europe.

**Habitat**: On decaying fallen leaves of *Buxus sempervirens*.

**Published descriptions**: Juel (1925), Gams (1968), Rossman *et al.* (1993).



**Fig. 98. *Bionectria aurantia*.** a. Almost mature and immature (right) asci. b. Discharged ascospores. c. Somewhat undulate seta from perithecial wall. – All: Tjibodas No. 447, natural substratum. Scale bars = 10  $\mu\text{m}$ ; the shorter bar applies to a, c, the longer to b.

**Additional specimens/strains examined**: FRANCE. Pyrénées Atlantiques, Îlot de Sauveterre de Béarn 64, 39°37' N, 77°40' W, 400 m alt.; on leaves of *Buxus sempervirens*; 17 Oct 1993; F. Candoussau No. 272 (BPI 802521; CBS 696.93; G.J.S. isolate 93-53, ascospore isolate). – On leaves of *Buxus sempervirens*; 27 Oct 1993; F. Candoussau No. 4851 (BPI 802542). – On *Buxus sempervirens*, together with *Gibberella* sp.; 10 Dec 1995; F. Candoussau No. 408 (BPI). – Forêt des buis, Coudrée (Haute Savoie), *Buxus* forest; on dead leaves of *Buxus sempervirens*, together with *Pseudonectria rousseliana*; 25 Sept 1996; H.-J. Schroers 195 (herb. CBS, with dried OA-culture derived from ascospores). – UK. England, Kew Gardens; on leaves of *Buxus sempervirens*; Nov 1967; W. Gams 1218 (CBS 202.69; conidial isolate). – NETHERLANDS. On *Buxus sempervirens*; J.L. Bezerra (CBS 288.62; conidial isolate).

**Notes**: The species is easily recognizable because of its substrate specificity, superficial habitat on the substratum, hyphal crown, and lack of ascospore septation. (Fig. 97 b). Perithecia of *B. coronata* generally are associated with the sesquicillium-like conidiophores

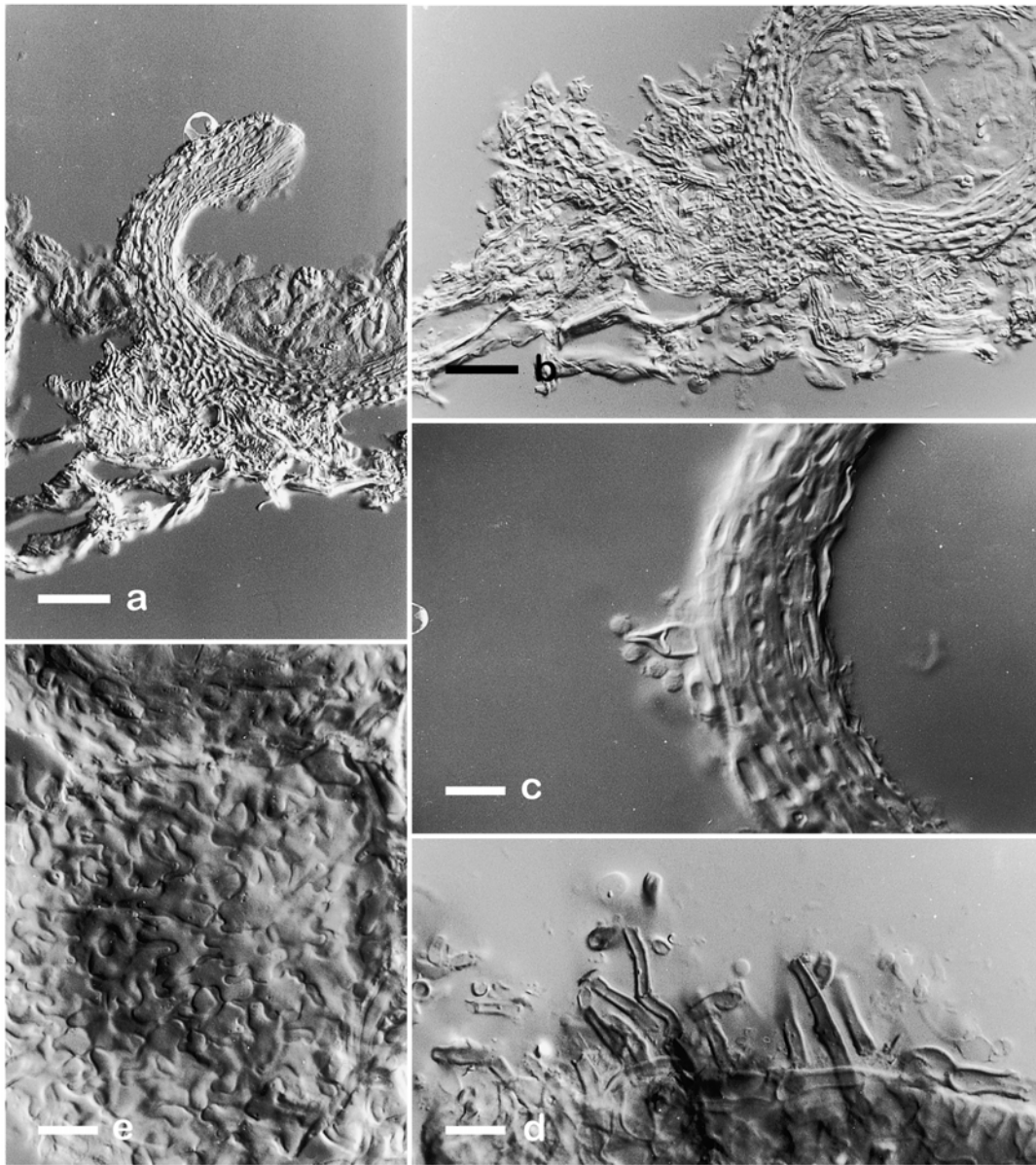
The ascospores, although larger in size, match the conidia in shape (compare Fig. 97 b and Fig. 97 d) and can be mistaken when isolated. *Bionectria coronata* is frequently associated with *Pseudonectria rousseliana* on the same specimens. Although formerly classified in *Pseudonectria* (Rossman *et al.*, 1993), *B. coronata* differs from *P. rousseliana* and *P. pachysandricola* by numerous characters of the teleomorph and the anamorph (see discussion under '*Bionectria* subgenus *Uniparietina*').

**44. *Bionectria aurantia*** (Penz. & Sacc.) Rossman, Samuels & Lowen, *Mycologia* 85: 698. 1993 — Figs 98 a–c, 99 a–e.

≡ *Nectriella aurantia* Penz. & Sacc., *Malpighia* 11: 509. 1897.

Anamorph: Unknown.

**Perithecial stroma** superficial on the substratum, consisting of densely packed hyphae that partly embed the perithecial base. **Perithecia** easily removed, gregarious to solitary, subglobose to globose, to 200  $\mu\text{m}$  diam, laterally pinched or not pinched when dry, smooth, pale yellow to orange, not papillate. **Hyphae/setae** arising from the perithecial wall, 0- to 1-septate, slightly undulate, to 45  $\mu\text{m}$  long, to 4  $\mu\text{m}$  wide at base, tapering in the upper part and towards the tip, with to 1  $\mu\text{m}$  thick walls. **Perithecial wall** 20–25  $\mu\text{m}$  thick consisting of one region; cells flat to oblong-ellipsoidal in longitudinal section, angular, subglobose, or lobed in subsurface view, with 'pseudopores' in the walls. **Asci** broadly clavate, 25–35(–45)  $\times$  6–10  $\mu\text{m}$ , 8-spored; apex broadly rounded, ring visible or not. **Ascospores** ellipsoidal, 1-septate, colourless, smooth to finely warted to spinulose, 8–11  $\times$  2.2–3.6  $\mu\text{m}$ . **Conidiophores** not observed on the natural substratum.



**Fig. 99.** *Bionectria aurantia*. **a–c.** Section through perithecium and perithecial base. **a.** perithecial wall consisting of one region. **b.** Perithecial base consisting of hyphae. **c.** Lateral perithecial wall with tooth-like hypha arising from an outer cell. **d.** Hyphae arising from outer perithecial wall in squash mount. **e.** Subsurface view of perithecial wall showing lobed cells and ‘pseudopores’. – All: Tjibodas No. 447, natural substratum, DIC. Scale bars: a, b = 30  $\mu$ m; c–e = 10  $\mu$ m.

**Type for *Nectriella aurantia*:** INDONESIA. Java, Tjibodas; on dry twig; 7 Mar 1897; Penzig no. 447 (PAD).

**Known distribution:** Indonesia.

**Habitat:** On dry twig.

**Published descriptions:** Rossman *et al.* (1993).

**Notes:** *Bionectria aurantia* is similar to *B. coronata* because of the somewhat undulate setae arising from the perithecia (Figs 98 c, 99 d) and the simple perithecial wall (Fig. 99 a, c). However, denticle-like cells were also seen arising from the perithecial wall (Fig. 99 c). *Bionectria aurantia*, however, differs from *B. coronata* in having 1-septate and warted ascospores (Fig. 98 b) that are similar to those formed in most other species of *Bionectria*. Neither anamorph nor cultures are known for *B. aurantia* to confirm its placement in *Bionectria*.

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