

Lei Cai · Kevin D. Hyde

Anamorphic fungi from freshwater habitats in China: *Dictyosporium tetrasporum* and *Exserticlava yunnanensis* spp. nov., and two new records for *Pseudofuscophialis lignicola* and *Pseudobotrytis terrestris*

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Abstract This article describes two new anamorphic fungi from freshwater habitats, *Dictyosporium tetrasporum* sp. nov. and *Exserticlava yunnanensis* sp. nov., based on morphological characters. Both species are illustrated with light micrographs and compared with similar taxa. *Pseudofuscophialis lignicola* and *Pseudobotrytis terrestris* are reported as new records from freshwater habitats.

Key words Freshwater fungi · Lignicolous fungi · Systematics · Taxonomy

Introduction

Reproduction in ascomycetes occurs in two different sexual phases, i.e., the teleomorphic state in which fungi reproduce meiotically (sexually), and the anamorphic state in which fungi reproduce mitotically (asexually). Less taxonomic attention has been paid to fungi that exist predominantly in their asexual state (Kendrick 1992). Anamorphs, however, are important in both ecological function and industrial utilization, because they usually reproduce faster and form more spores than teleomorphs (Kendrick 1992).

Submerged woody substrata and leaves are essential components in freshwater ecosystems (Jacobson and Jacobson 1999; Fryar et al. 2005; Pascoal et al. 2005; Sakayaroj et al. 2005). Wood-inhabiting fungi are important in freshwater ecosystems because they have the ability to decompose organic material and play an important role in nutrient cycling (Chamier 1985; Wong et al. 1998; Abdel-Raheem and Shearer 2002; Tsui and Hyde 2003; Vijaykrishna et al.

2006). Our study of fungal biodiversity in streams in mainland China yielded four interesting anamorphic fungi, *Dictyosporium tetrasporum* and *Exserticlava yunnanensis* spp. nov., and the new records *Pseudofuscophialis lignicola* and *Pseudobotrytis terrestris*. Each species is provided with description and illustrations, and new species are compared with similar taxa.

Materials and methods

Submerged woody substrata were collected by L. Cai from several small streams in Yunnan, China. Samples were processed and examined following the methods described in Cai et al. (2003a). Single-spore isolations were made on cornmeal agar (CMA) (Choi et al. 1999). Cultures were deposited in The University of Hong Kong Culture Collection (HKUCC) and type specimens were deposited in The University of Hong Kong Type Material Collection (HKU (M)). Observations and photographs were made from materials mounted in water. Conidia were measured at their widest point. The range between minimum and maximum values for microscopic measurements is given. Mean values are in brackets, with *n* being the number of measurements.

Taxonomy

Dictyosporium tetrasporum L. Cai & K.D. Hyde, sp. nov.
Figs. 1–5

Sporodochia in substrato naturali punctiformia, dispersa, nigra, granulata, 350–700 µm diametro. Conidiophora micronematosa, mononematosa, leptoderma, septata, ramosa, pallide brunnea, brevia. Cellulae conidiogenae determinatae, 3–4 µm latae. Secessio conidiorum rhexolytica. Conidia 23.5–40 × 16–21.5 µm, complanata, cheiroidea, laevia, euseptata, ad septa leviter constricta, atro-brunnea, 12–27-cellularia, in (3–)4-seriebus composita. Appendix nulla.

L. Cai (✉)¹ · K.D. Hyde

Centre for Research in Fungal Diversity, Department of Ecology & Biodiversity, The University of Hong Kong, Hong Kong SAR, China

Present address:

¹Novozymes China, No. 14, Xinxu Road, ShangDi Zone, HaiDian District, Beijing 100085, China
Tel. +86-10-6298-7888, ext. 306; Fax +86-10-6298-0085
e-mail: mrcailei@gmail.com

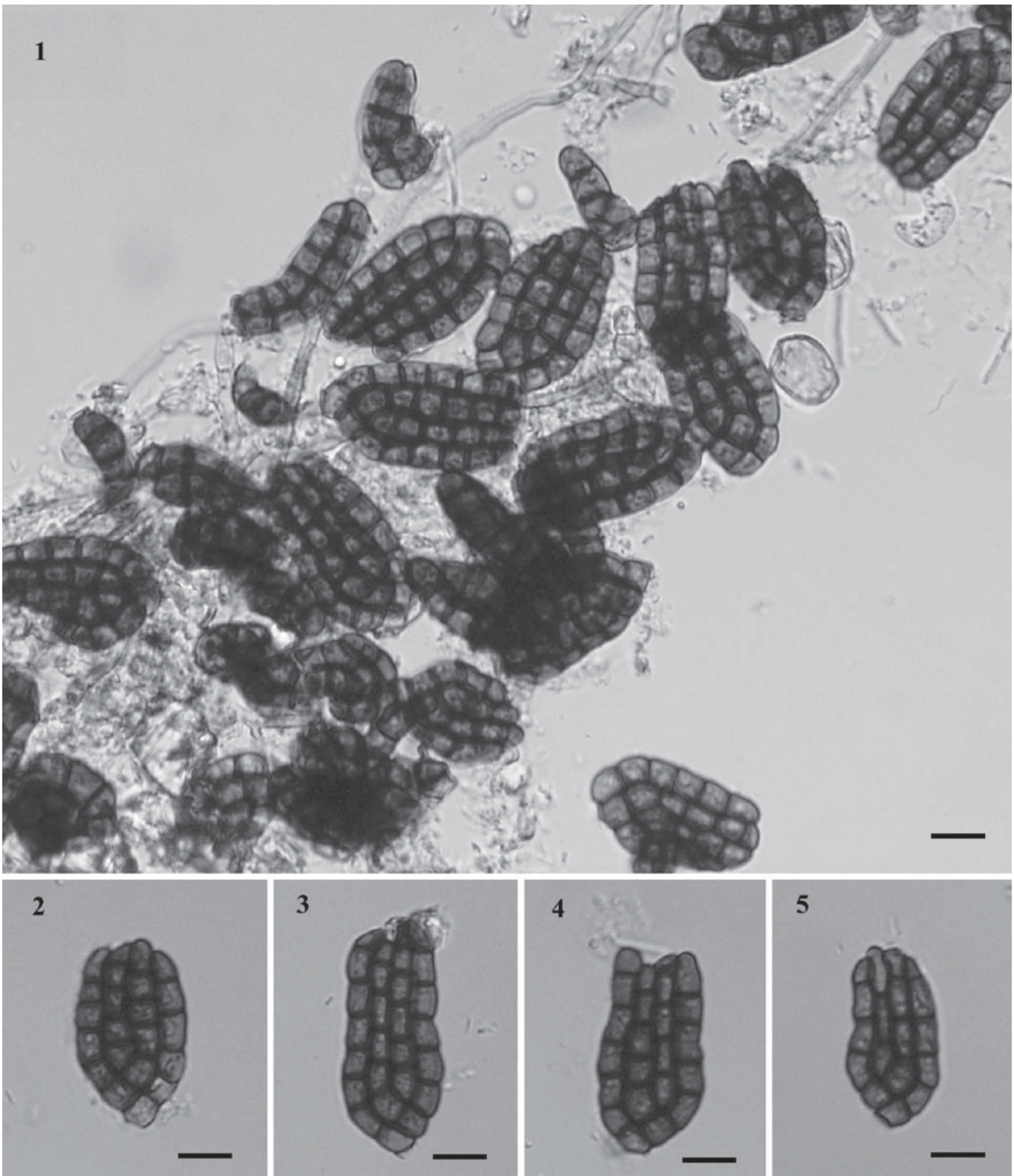


Fig. 1–5. *Dictyosporium tetrasporum* (from holotype). **1** Squash mount of sporodochium. **2–5** Conidia. Bars 1–5 10 μ m

Etymology: *tetrasporum*, referring to the four rows of cells in conidia.

Sporodochia on natural substratum punctiform, scattered, black, granular, 350–700 μ m in diameter. Conidiophores micronematous, mononematous, thin-walled,

septate, branched, pale brown, short, some persistent at conidial maturity. Conidiogenous cells cylindrical, determinate, 4–5 μ m wide. Conidial secession rhexolytic. Conidia 23.5–40 \times 16–21.5 μ m (\bar{x} = 32.5 \times 18.5 μ m, n = 25), complanate, one-celled thick, cheiroid, smooth-walled, euseptate,

medium brown, becoming dark brown with maturity, consisting of 12–27 cells arranged in (3–)4 rows, slightly constricted at the septa, the outer rows are usually shorter, appendage absent (Figs. 2–5).

Habitat: Saprobic on submerged woody material.

Known distribution: China.

Teleomorph: Unknown.

Material examined: China, Yunnan, Xishuangbanna, on submerged wood, Jan. 26, 2003, L. Cai, CAI-1F10 (Holotype: HKU(M) 10857). No culture obtained despite several attempts.

Notes: *Dictyosporium* Corda is characterized by sporodochial colonies, micronematous conidiophores and pigmented, cheiroid conidia with or without appendages. *Dictyosporium* species may have teleomorphs in the Massarinaceae, Pleosporales as shown by rDNA sequences (Tsui et al. 2006). Goh et al. (1999) revised *Dictyosporium* and 22 species were accepted. Eight species were subsequently added into this genus (Arambarri et al. 2001; Cai et al. 2003a,b; Photita et al. 2002; Zhao and Zhang 2003; Kodsueb et al. 2006).

Dictyosporium tetrasporum is comparable to *D. brahmaswaroopii* M.D. Mehrotra and *D. schizostachyifolium* Bat. & M.L. Farr, which also produce conidia with four rows of cells. *Dictyosporium tetrasporum*, however, differs from them in having much larger conidia ($23.5\text{--}40 \times 16\text{--}21.5\mu\text{m}$ vs. $17.5\text{--}24 \times 12.5\text{--}19\mu\text{m}$ and $15\text{--}17 \times 11\text{--}12\mu\text{m}$) (Goh et al. 1999). *Dictyosporium nigroapice* Goh, W.H. Ho & K.D. Hyde and *D. tetraserialae* Goh, Yanna & K.D. Hyde also have conidia with four rows of cells, but the conidia in these species are provided with distinct hyaline appendages, and furthermore the conidia of *D. nigroapice* have darker pigmentation at the apex of the inner rows (Goh et al. 1999).

***Exserticlava yunnanensis* L. Cai & K.D. Hyde, sp. nov.**

Figs. 6–10

Coloniae effusae, brunneae. Mycelium partim superficiale, partim in substrato immersum, ex hyphis ramosis septatis laevibus brunneis compositum. Conidiophora macronematosa, mononematosa, erecta, solitaria, laevia, crassitunicata, septata, non ramosa, $75\text{--}275 \times 4.5\text{--}6\mu\text{m}$, percurrente proliferantia. Cellulae conidiogenae polyblasticae, integratae, terminales. Conidia $13.5\text{--}23 \times 8.5\text{--}11.5\mu\text{m}$, acrogena, holoblastica, sicca, laevia, crassitunicata, 1-distoseptata; cellula basalis brunnea vel atro-brunnea, globosa vel subglobosa, basi truncata; cellula apicalis hemispherica, pallide brunnea vel subhyalina. Seccissio conidiorum schizolytica.

Etymology: *yunnanensis*, in reference to the province where the type was found.

Colonies effuse, brown, glistening. Mycelium partly immersed, partly superficial, consisting of branched, septate, smooth, thin- to thick-walled, dark brown hyphae. Conidiophores macronematous, mononematous, $112.5\text{--}175 \times 5\text{--}8\mu\text{m}$, with a relatively swollen base, terminally swollen, $7.5\text{--}10\mu\text{m}$ wide, brown to dark brown, paler toward the apex, smooth, thick-walled, 4–6-septate, unbranched, cylindrical, straight, erect, solitary, percurrent proliferations

(Figs. 6, 7). Conidiogenous cells polyblastic, integrated, terminal, determinate, cylindrical, proliferating sympodially without progression and giving rise to a cluster of conidia (Fig. 8). Conidia acrogenous, holoblastic, $16\text{--}22 \times 10\text{--}13\mu\text{m}$ ($\bar{x} = 18.5 \times 12\mu\text{m}$, $n = 30$), dry, smooth, thick-walled, 1-distoseptate, not constricted at the septum, basal cell large, brown to dark brown, globose to subglobose with truncate base; apical cell small, pale brown to subhyaline, hemispherical (Figs. 9, 10). Conidial secession schizolytic.

Habitat: Saprobic on submerged woody material.

Known distribution: China.

Teleomorph: Unknown.

Material examined: China, Yunnan, Xishuangbanna, on submerged wood in a small forest stream, July 14, 2003, L. Cai, CAI-7FB30 (holotype: HKU(M): 10858). No culture was obtained despite several attempts.

Notes: This species is characterized by the simple, erect, septate, smooth conidiophores, which bear a single, polyblastic, funnel-shaped conidiogenous cell at the apex, and thick-walled, distoseptate conidia. These morphological characters restrict this species to the genus *Exserticlava* S. Hughes (Hughes 1978; Kirk 1985). *Exserticlava* currently includes five species and has recently been reviewed by Tsui et al. (2001). A recent study by Fernández and Huhndorf (2005) established the connection between *Exserticlava* anamorphs and *Chaetosphaeria* teleomorphs. *Exserticlava yunnanensis* is most similar to *E. globosa* V. Rao & de Hoog and *E. uniseptata* Bhat & B. Sutton, species that also produce 1-septate conidia. *Exserticlava yunnanensis* can be distinguished from *E. globosa* as the latter produces conidia that are globose and concolorous. *Exserticlava uniseptata* can be distinguished from *E. yunnanensis* in the concolorous conidia in which the basal cell is smaller than the apical cell.

***Pseudobotrytis terrestris* (Timonin) Subram., Proc. Indian Acad. Sci., Sect. B, 43: 277, 1956.**

(Figs. 11–16)

Colonies effuse, brown, glistening. Mycelium partly immersed, partly superficial, consisting of branched, septate, smooth, dark brown hyphae. Conidiophores macronematous, mononematous, unbranched, straight or flexuous, multiseptate, smooth, brown to dark brown, subhyaline to hyaline at the apices, $77\text{--}400 \times 2.5\text{--}3\mu\text{m}$, swollen to $7\text{--}8\mu\text{m}$ at the base (Figs. 11, 12). Conidiogenous cells polyblastic, discrete, umbellately arranged over the swollen apex of the stipe, determinate, clavate, denticulate, denticles cylindrical (Figs. 11–13). Conidia $6.5\text{--}9 \times 2.5\text{--}3.5\mu\text{m}$ ($\bar{x} = 7.5 \times 3\mu\text{m}$, $n = 30$), solitary, dry, formed on denticles that cover the swollen tip of each conidiogenous cell, oblong rounded at the ends or ellipsoidal, pale brown, smooth, 1-septate; hilum slightly protuberant (Figs. 14–16).

Habitat: Saprobic on bamboo or wood in freshwater and terrestrial habitats.

Known distribution: China, Congo, Europe, Jamaica, New Zealand, North America.

Teleomorph: *Porosphaerella* species.

Material examined: China, Yunnan, Kunming, Xiaobailong forest, submerged in a small stream, Feb. 9, 2003, L. Cai, CAI-7FB37. Living culture in HKUCC 10096.

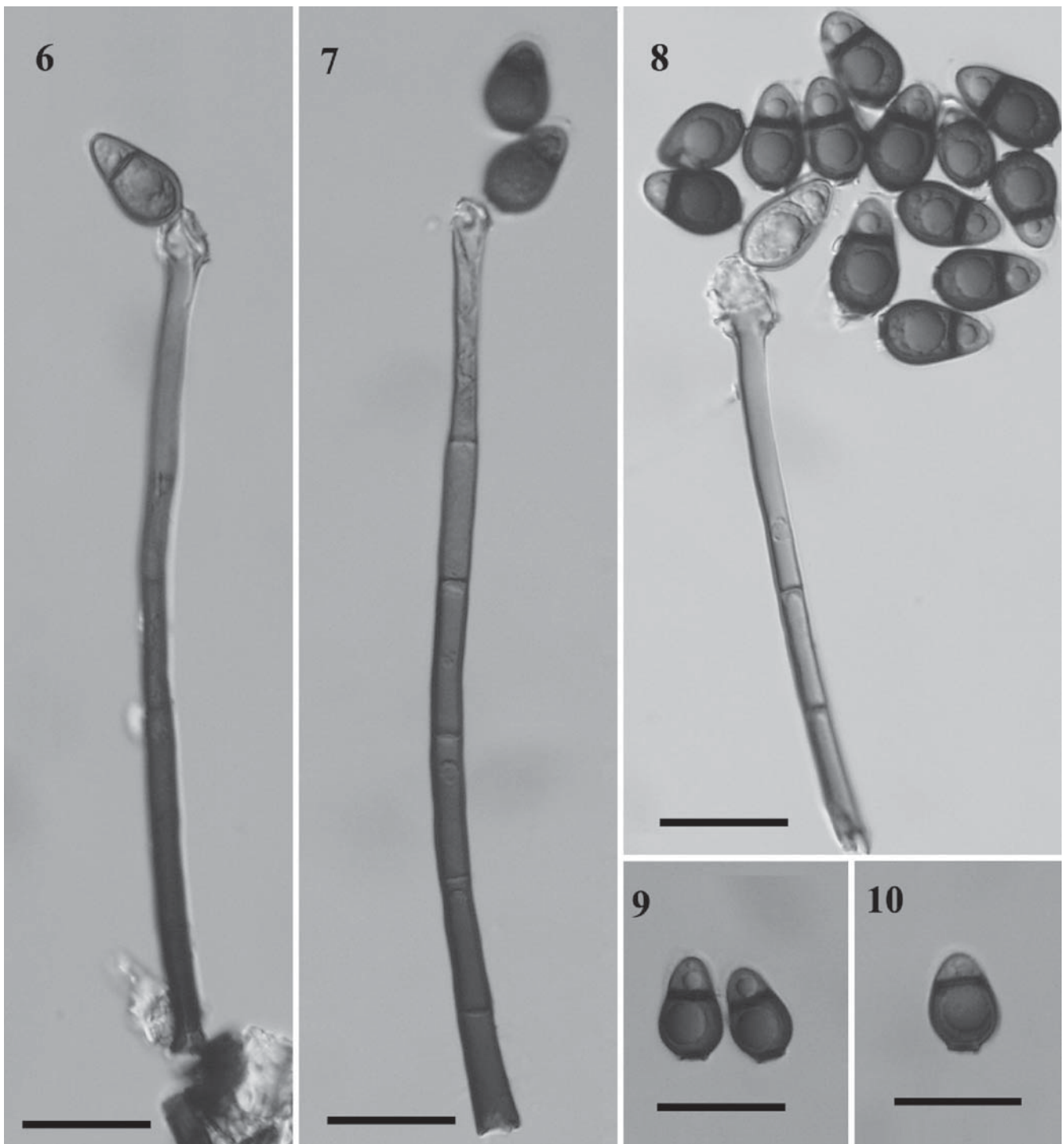


Fig. 6–10. *Exserticlava yunnanensis* (from holotype). 6–8 Conidiophores bearing conidia. 9, 10 Conidia. Bars 6–10 20µm

Notes: This is the first report of this fungus from bamboo and a freshwater habitat. This collection agrees well with the original description of *Pseudobotrytis terrestris* (Timonin 1940). *Pseudobotrytis terrestris* has recently been connected to its teleomorph, *Porosphaerella borinquensis* (Chaetosphaeriaceae), in vitro (Fernández and Huhndorf 2004).

Pseudofuscephialis lignicola Sivan. & H.S. Chang, Mycol. Res. 99: 711, 1995 Figs. 17–23

Colonies consist of solitary conidiophores scattered over the substrate surface, dark brown (Fig. 17). Setae absent. Conidiophores 200–370µm long, up to 16µm wide at the base, 6–10µm wide toward the apex, macronematous,



Fig. 11–16. *Pseudobotrytis terrestris*. **11–13** Conidiophores and conidiogenous cells. Notes umbel of polyblastic conidiogenous cells with denticles. **14–16** Conidia. Bars **11–16** 20 μ m

mononematous, brown to dark brown, slightly lighter towards the apex, cylindrical, single or occasionally branched, erect, solitary, smooth-walled, simple, straight or slightly curved, 4–10-septate, wall and septa slightly thickened, basal cells slightly swollen, terminated by a single phialide (Figs. 18, 19). Conidiogenous cells enteroblastic, monophtalidic, integrated with the apex of the conidiophores, terminal, percurrent. Collarete conspicuous, green to deep green, funnel-shaped, distally thin-walled, 20–40 \times 9–16.5 μ m, narrowing to 3.7–5 μ m at base, not proliferating (Fig. 20). Conidia 32.5–52.5 \times 7.5–12.5 μ m (\bar{x} = 45 \times 11 μ m, n = 30), acrogenous, aggregated in mass at the tip of conidiophores, fusiform, straight or slightly curved, 3-septate, light brown to brown, thin-walled, end cells subhyaline, slightly constricted at the septa, with a large guttule in each of the central cells, apical cells rounded, basal cells somewhat acute or conical shaped (Figs. 21–23).

Habitat: Saprobic on decaying wood in terrestrial and freshwater habitats.

Known distribution: China.

Teleomorph: Unknown.

Material examined. China, Yunnan, Xishuangbanna, Menglun, on submerged wood in a small forest stream, Sept. 15, 2002, L. Cai, CAI-9BNE31. No culture was obtained despite several attempts.

Note: In morphology, this collection agrees well with the original description (Sivanesan and Chang 1995). This is the first time this species has been reported from a freshwater habitat.

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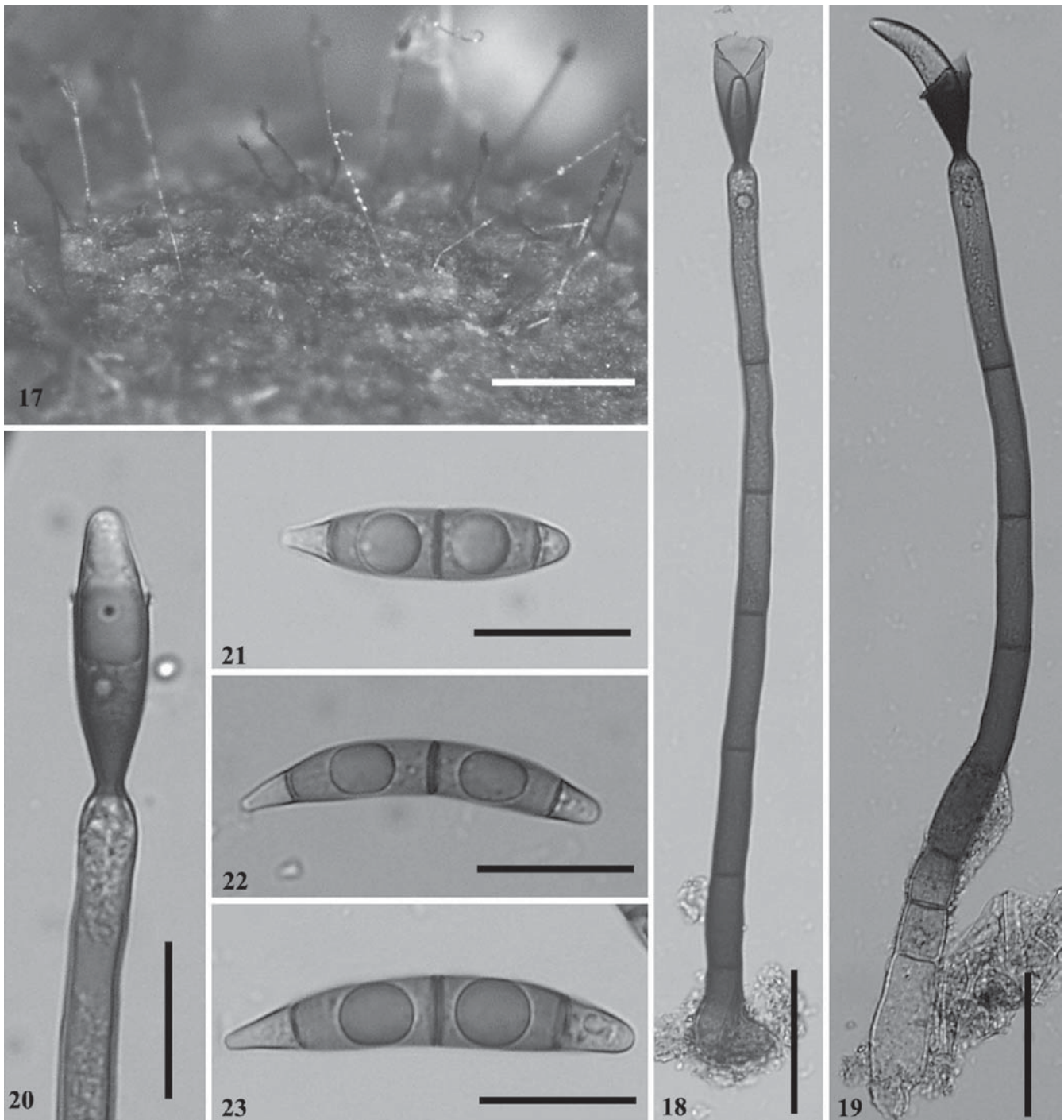


Fig. 17–23. *Pseudofuscophialis lignicola*. **17** Colonies on submerged wood. **18, 19** Conidiophores bearing conidia. **20** Conidiogenous cell. Note the remarkable collarette. **21–23** Conidia. Bars **17** 200 μ m; **18, 19** 40 μ m; **20–23** 20 μ m

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