



New species and combinations of conidial fungi from the semi-arid Caatinga biome of Brazil

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With 31 figures and 1 table

Abstract: During a survey of conidial fungi carried out in aquatic and terrestrial habitats in the semi-arid Caatinga biome of Brazil, three new species were found on decaying plants. *Anungitopsis caatingensis* sp. nov. was found on decaying leaves collected in a terrestrial habitat. *Codinaea pindobacuensis* sp. nov. and *Stanjehughesia clavata* sp. nov. were found on decaying leaves and decaying bark collected in freshwater, respectively. Descriptions, illustrations and comments are presented, including a key to accepted species of *Anungitopsis*. Three species of *Janetia* are transferred to *Linkosia* and two species are proposed as synonyms: *Minimelanolocus machili* is synonymous with *Cacumisporium pleuroconidiophorum* and *Janetia curviapicis* is synonymous with *Stanjehughesia hamatiella*.

Key words: Biodiversity, hyphomycetes, taxonomy, tropical microfungi.

Introduction

The Brazilian semi-arid region is located almost exclusively in the northeastern part of Brazil and covers portions of eight states. This extension of drylands is located between 3–17°S and 35–45°W and occupies an area of 900,000 km², which corresponds to 8% of the Brazilian territory (Giulietti et al. 2006). The climate is hot and dry with a seasonal rainfall limited to three months and less than 750 mm/year (Costa et al. 2007). The evapotranspiration potential is high, between 1,500 and 2,000 mm/year, which expose the vegetation to a hydric deficit (Velloso et al. 2002). Consequently, the species have evolved physiological and reproductive adaptations to live in this region

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(Oliveira et al. 2012), such as loss of leaves during the dry season (Queiroz 2006). The Caatinga, a biome exclusive of Brazil, is situated in the Brazilian semi-arid region and is characterized by a seasonal xerophilous thorn woodland/shrubland (Velloso et al. 2002, Giuliatti et al. 2006, Costa et al. 2007). However, other types of vegetation occur such as semi-deciduous forests, savanna and 'campos rupestres' (Barbosa et al. 2008).

In the last decade many studies investigated the diversity of conidial fungi on leaf litter in the Caatinga, with reports of several new species and new records for Brazil (Gusmão & Grandi 2001; Gusmão & Barbosa 2003; Barbosa & Gusmão 2005; Gusmão et al. 2005, 2008; Castañeda-Ruiz et al. 2006; Barbosa et al. 2007, 2008; Marques et al. 2007; 2008; Cruz et al. 2007a, b; 2008, 2012; Leão-Ferreira & Gusmão 2010, 2013; Almeida et al. 2011; Santa Izabel et al. 2011). The diversity of conidial fungi in aquatic habitats in this region was surveyed by Barbosa & Gusmão (2011) and Almeida et al. (2012), revealing new records for not only Brazil, but also South America and the Neotropics.

Particularly, saprobic dematiaceous hyphomycetes are highly rich in species and diagnostic morphological characteristics. The diversity of these fungi can, therefore, be surveyed comparatively quickly so that new discoveries are made based on field collection and morphological expertise (Leão-Ferreira et al. 2013, Heredia et al. 2014, Monteiro & Gusmão 2014, Qu et al. 2014, Xia et al. 2014).

The goal of this study was to contribute to the growing knowledge regarding the diversity of conidial fungi in terrestrial and aquatic habitats in the semi-arid Caatinga biome of Brazil.

Materials and methods

Samples of leaf litter were collected in freshwater and on land at Serra da Fumaça (10°74'S, 40°36'W), Bahia state, Brazil. Terrestrial and submerged leaf litter were placed in separate paper bags and plastic bags, respectively, and transported to the laboratory within 24 hours. The plant material was washed in tap water and placed on moist filter paper in glass Petri dishes (100 mm diam.). The dishes were then placed in plastic containers (150 L capacity) filled with 200 ml sterile water and 2 ml glycerol and incubated at room temperature. The plant material was examined at regular intervals for the presence of microfungi over a two month incubation period. Slide mounts were prepared in PVL resin (15 g polyvinyl alcohol, 100 ml water, 40 ml lactic acid, 40 ml phenol). All material has been deposited in the Herbarium of Universidade Estadual de Feira de Santana (HUEFS). Measurements of fungal structures (n=25) and digital images were made using a BX51 Olympus microscope equipped with brightfield and Nomarski interference optics and a DP25 Olympus digital camera. Images were processed using Adobe Photoshop. Drawings were made directly from digital images using the technique described by Barber & Keane (2007).

Results and discussion

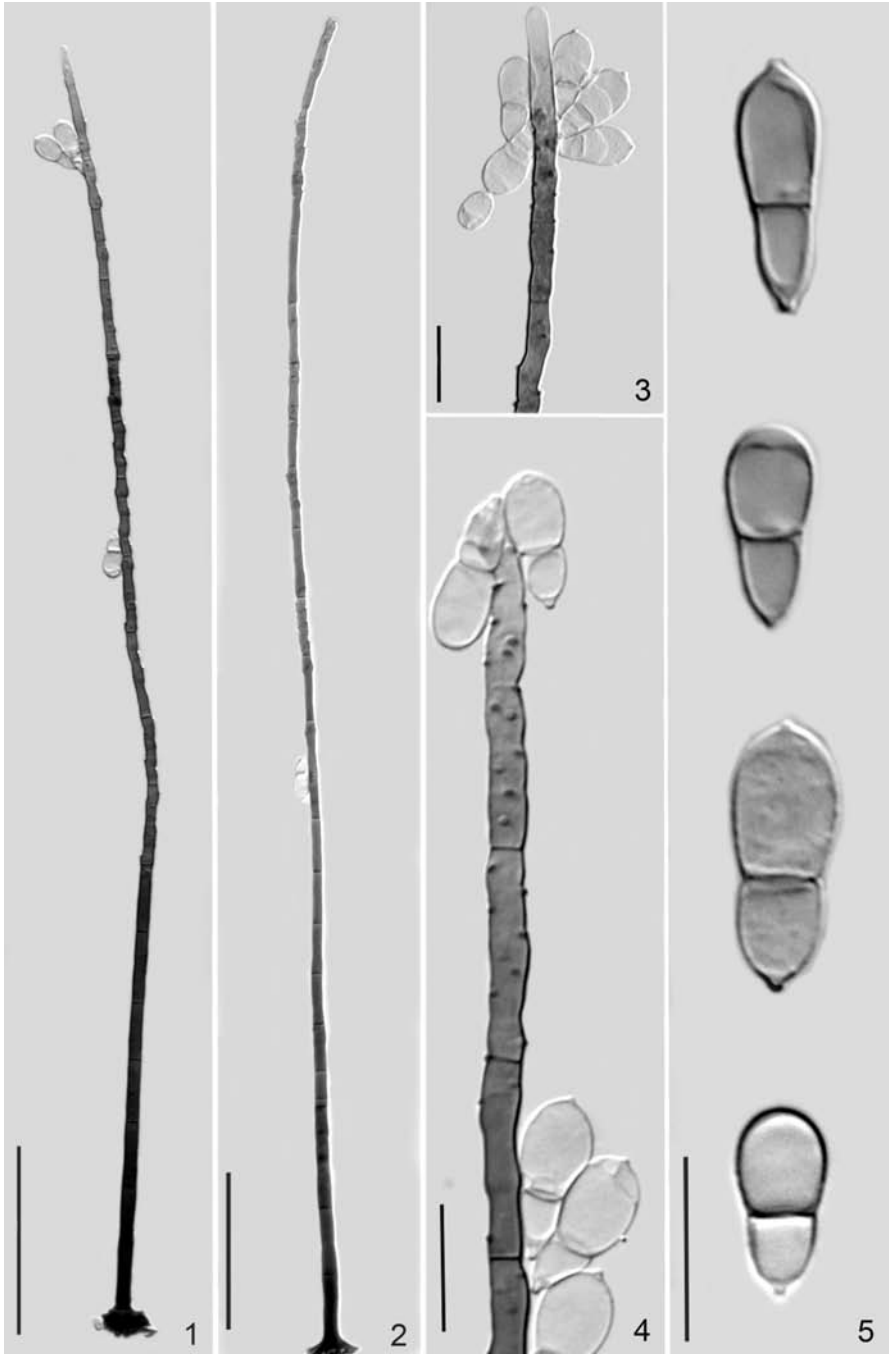
Taxonomy

Anungitopsis caatingensis D.A.C.Almeida & Gusmão, **sp. nov.**

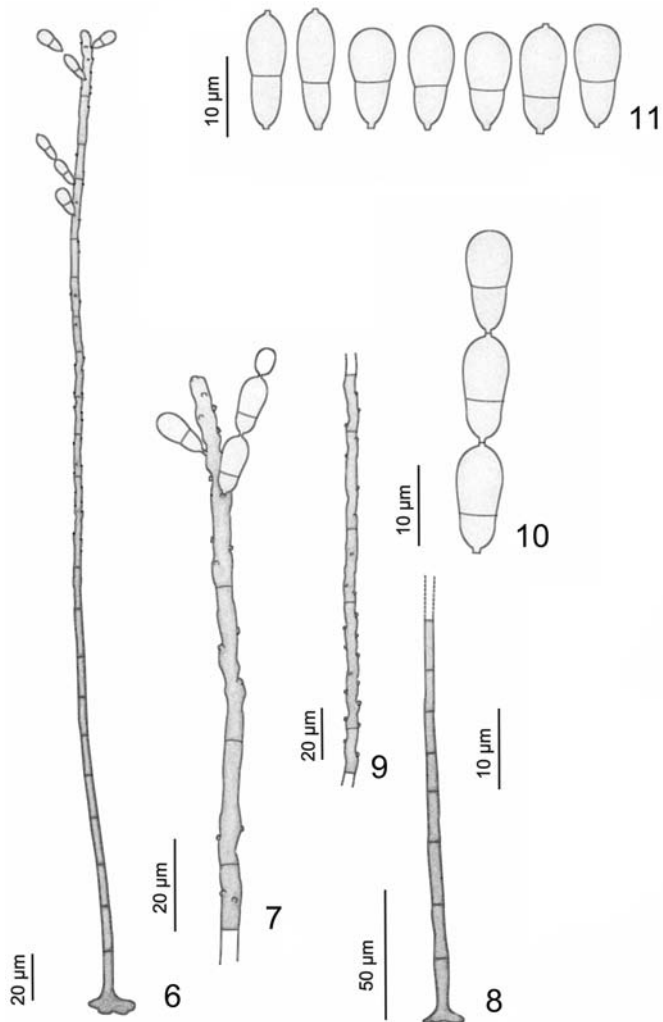
Figs 1–11

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CONIDIOPHORES macronematous, mononematous, simple, cylindrical, erect, straight or flexuous, smooth, 16–27-septate, brown at base, pale brown toward the apex,



Figs 1–5. *Anungitopsis caatingensis*. 1–2. General aspect. 3–4. Apex of the conidiophores and conidia. 5. Conidia. Bars = 50 μm (1–2), 10 μm (3–5).



Figs 6–11. *Anungitopsis caatingensis*. 6. General aspect. 7. Apex of the conidiophore. 8. Base of the conidiophore. 9. Conidiogenous cells. 10. Unbranched chains of conidia. 11. Conidia.

310–480 × 4–5 µm. CONIDIOGENOUS CELLS sympodially polyblastic, terminal, integrated, cylindrical, inconspicuously denticulate, smooth, pale brown. Seccession schizolytic. CONIDIA holoblastic, in acropetal, unbranched chains, obovoid, simple, dry, smooth, 1-septate, constricted at septum, with a denticle at the base, often with a denticle at the apex, subhyaline, 11–15 × 3–5.5 µm.

TELEOMORPH: Unknown.

ETYMOLOGY: Referring to the biome in which it was collected.

HOLOTYPE: Brazil, Bahia, Pindobaçu, Serra da Fumaça, on decaying leaves of an unidentified dicotyledonous plant, 18 Sep. 2008, leg. D.A.C.Almeida (HUEFS 155074).

The genus *Anungitopsis* R.F.Castañeda & W.B.Kendr. was erected by Castañeda & Kendrick (1990) to accommodate two species collected on decaying leaves from Cuba: *A. inaequiseptata* W.B.Kendr. & R.F.Castañeda and *A. speciosa* R.F.Castañeda & W.B.Kendr. (type species). Another six species were added to the genus: *A. amoena* R.F.Castañeda & Dugan (Ho et al. 1999), *A. dimorphospora* R.F.Castañeda & W.B.Kendr. (Castañeda & Kendrick 1991), *A. gomerensis* R.F.Castañeda, Gené & Guarro (Castañeda-Ruiz et al. 1996), *A. intermedia* Crous & W.B.Kendrick (Crous et al. 1997), *A. triseptata* (Matsush.) R.F.Castañeda & W.B.Kendr. (Castañeda & Kendrick 1991) and *A. pantelleriae* Rambelli & Ciccarone (Rambelli et al. 2009, Rambelli 2011). *Anungitopsis amoena* and *A. intermedia* were transferred to *Fusicladium* Bonord. by Crous et al. (2007), based on phylogenetic analyses of 28S nrDNA gene (LSU).

Anungitopsis caatingensis is similar to *A. gomerensis* in having obovoid conidia. However, the conidia of *A. gomerensis* are shorter (8–11 µm) and versicolorous, with a pale brown basal cell and brown apical cell. Furthermore, *A. gomerensis* also can be distinguished by conidiogenous cells with conspicuous or inconspicuous denticles, while in *A. caatingensis* the denticles are always inconspicuous. The other species of *Anungitopsis* are easily differentiated from *A. caatingensis* by shape and pigmentation of the conidia.

Key to accepted species of *Anungitopsis*

- 1 Conidiophores with intercalary, barrel-shaped to spherical cells *A. speciosa*
- 1' Conidiophores without intercalary, barrel-shaped to spherical cells 2
- 2 Conidia up to 2-septate 3
- 2' Conidia with more than 2 septa 5
- 3 Conidia obovoid 4
- 3' Conidia clavate, 22–33 × 4–5.5 µm *A. inaequiseptata*
- 4 Conidia concolorous, 11–15 × 3–5.5 µm *A. caatingensis*
- 4' Conidia versicolorous, 8–11 × 4–5 µm *A. gomerensis*
- 5 Conidia hyaline, 20–30 × 5–6 µm *A. pantelleriae*
- 5' Conidia pigmented 6
- 6 Conidia cylindrical, 22–33 × 4–5.5 µm *A. triseptata*
- 6' Conidia naviculate or fusiform, 13–17 × 3–4.5 µm *A. dimorphospora*

***Codinaea pindobacuensis* D.A.C.Almeida & Gusmão, sp. nov.** Figs 12–18

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CONIDIOMATA synnematosus, erect, straight or flexuous, septate, brown, pale brown at apex, with conidiophores diverging at apex, 240–645 × 12–21 µm. CONIDIOPHORES macronematous, simple, cylindrical, smooth, septate, brown, pale brown to subhyaline at apex, 140–645 × 3–6.5 µm. CONIDIOGENOUS CELLS monophialidic, terminal, determinate, inconspicuous, smooth, pale brown to subhyaline, with cylindrical a collarette.



Figs 12–14. *Codinaea pindobacuensis*. 12. General aspect. 13. Conidiogenous cells. 14. 1-septate (arrow) and 0-septate conidia. Bars = 50 µm (12), 10 µm (13–14).

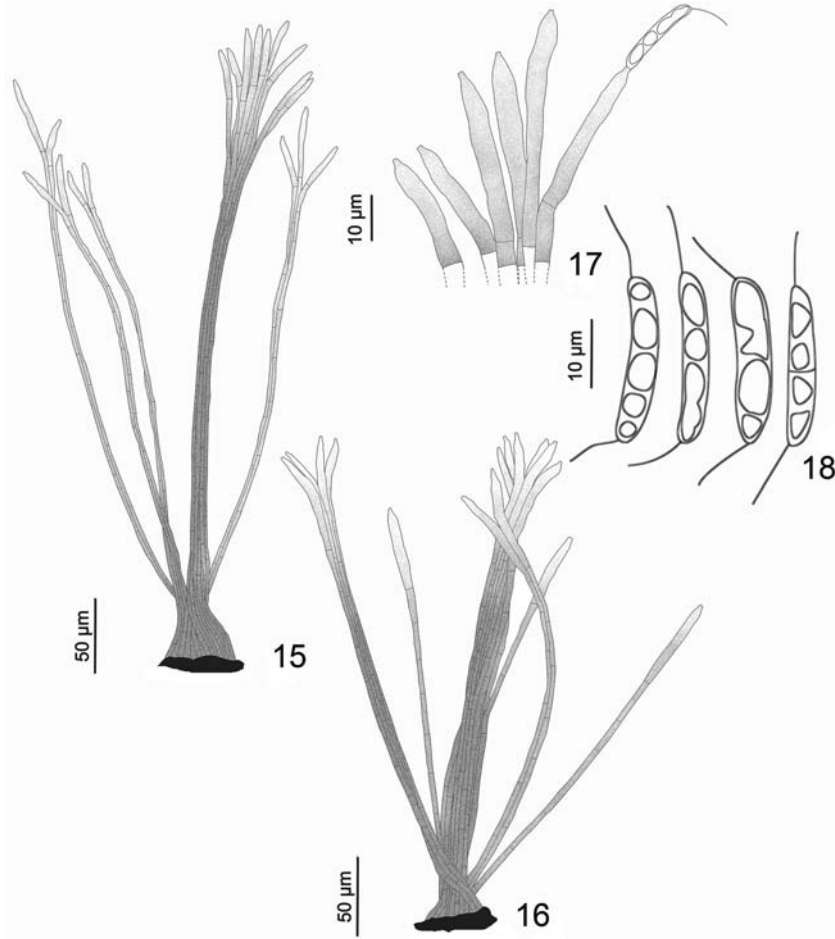
CONIDIA cylindrical to lunate, simple, smooth, hyaline, 0–1-septate, guttulate, $21\text{--}30 \times 3\text{--}6 \mu\text{m}$, with a setula at each end, $7.5\text{--}12 \mu\text{m}$ long, accumulating in slimy mass.

TELEOMORPH: Unknown.

ETYMOLOGY: Referring to the city from where it was collected.

HOLOTYPE: Brazil, Bahia, Pindobaçu, Serra da Fumaça, on submerged decaying leaf of an unidentified dicotyledonous plant, 16 Dec 2008, leg. D.A.C.Almeida (HUEFS 155077).

In a phylogenetic analysis based on the LSU gene performed by Réblová & Winka (2000), the species of *Dictyochoeta* Speg. grouped in two subclades according to the presence or absence of setulae. Based on that study, Réblová (2000) suggested that *Codinaea* Maire, a genus previously treated as synonymous with *Dictyochoeta* (Gamundí et al. 1977), should be recognized to include species with setulae, while *Dictyochoeta* should include those species without setulae. Although this proposal has not been broadly accepted (Whitton et al. 2000, Cruz et al. 2008), recently Seifert et al. (2011) and Li et al. (2012) considered the genus *Codinaea* as valid. We also follow



Figs 15–18. *Codinaea pindobacuensis*. 15–16. General aspect. 17. Conidiogenous cells and conidium. 18. Conidia.

the treatment of Réblová (2000), Seifert et al. (2011) and Li et al. (2012). Réblová (2000) also suggested that *Codinaea* might be reduced to a synonym of *Menispora* Pers. and *Dictyochaeta* to a synonym of *Chloridium*; however neither combination was formalized.

Only two species of *Dictyochaeta* produce synnemata, *D. obesispora* (S.Hughes & W.B.Kendr.) Whitton, McKenzie & K.D.Hyde (Hughes & Kendrick 1968, Whitton et al. 2000) and *D. dendroidea* Kuthub. (Kuthubutheen 1987). *Codinaea pindobacuensis* differs from these species in possessing synnemata with up to 35 conidiophores, monophialidic conidiogenous cells, guttulate, longer, 0–1-septate conidia and longer setulae (Table 1).

Table 1. Synopsis of the species of *Codinaea* and *Dictyochaeta* with synnemata.

Species	Synnemata			Conidia			
	Size (µm)	No. of conidiophores	Conidiogenous cells	Size (µm)	Septum	Guttulate	Setulae (µm)
<i>C. pindo-bacuensis</i>	Up to 645 × 12–21	Up to 35	Monophialidic	21–30 × 3–6	0–1	Yes	7.5–12
<i>D. obesispora</i>	Up to 700	Up to 45	Polyphialidic	17–21 × 5.4–6.2	0	No	Up to 6.4
<i>D. dendroidea</i>	Up to 600 × 12	Up to 25	Polyphialidic	12.5–16 × 2.4–3.2	0	No	Up to 6

***Stanjehughesia clavata* D.A.C.Almeida & Gusmão, sp. nov.**

Figs 19–27

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CONIDIOPHORES micronematous. CONIDIOGENOUS CELLS monoblastic, integrated, determinate, lageniform, smooth, brown, solitary or grouped, 6–11(–14) × 6–8 µm; truncated apex, 3–4 µm wide. Seccession schizolytic. CONIDIA holoblastic, solitary, cylindrical to clavate, the basal two cells gradually tapering, simple, dry, smooth, 6–10-euseptate, constricted at septum, 6–9 distoseptate, distosepta intercalated among eusepta, brown, 60–97 × 8–12 µm; basal cell smooth, brown, 4–6 × 3–4 µm, apex 4–6 µm wide.

ETYMOLOGY: Referring to the conidial shape.

TELEOMORPH: Unknown.

HOLOTYPE: Brazil, Bahia, Pindobaçu, Serra da Fumaça, on submerged decaying bark, 19 Nov. 2008, leg. D.A.C.Almeida (HUEFS 155078).

Stanjehughesia clavata and *S. curviapicis* are the only species in the genus that produce conidia with both eusepta and distosepta. However, *S. clavata* differs in having larger, clavate to cylindrical conidia with a straight apex. These two species also could be accommodated in *Linkosia* or in a new genus, however we choose to keep them in *Stanjehughesia* until molecular data can clarify their phylogenetic relationships.

***Stanjehughesia curviapicis* (Goh & K.D.Hyde) D.A.C.Almeida & Gusmão, comb. nov.**

Figs 28–31

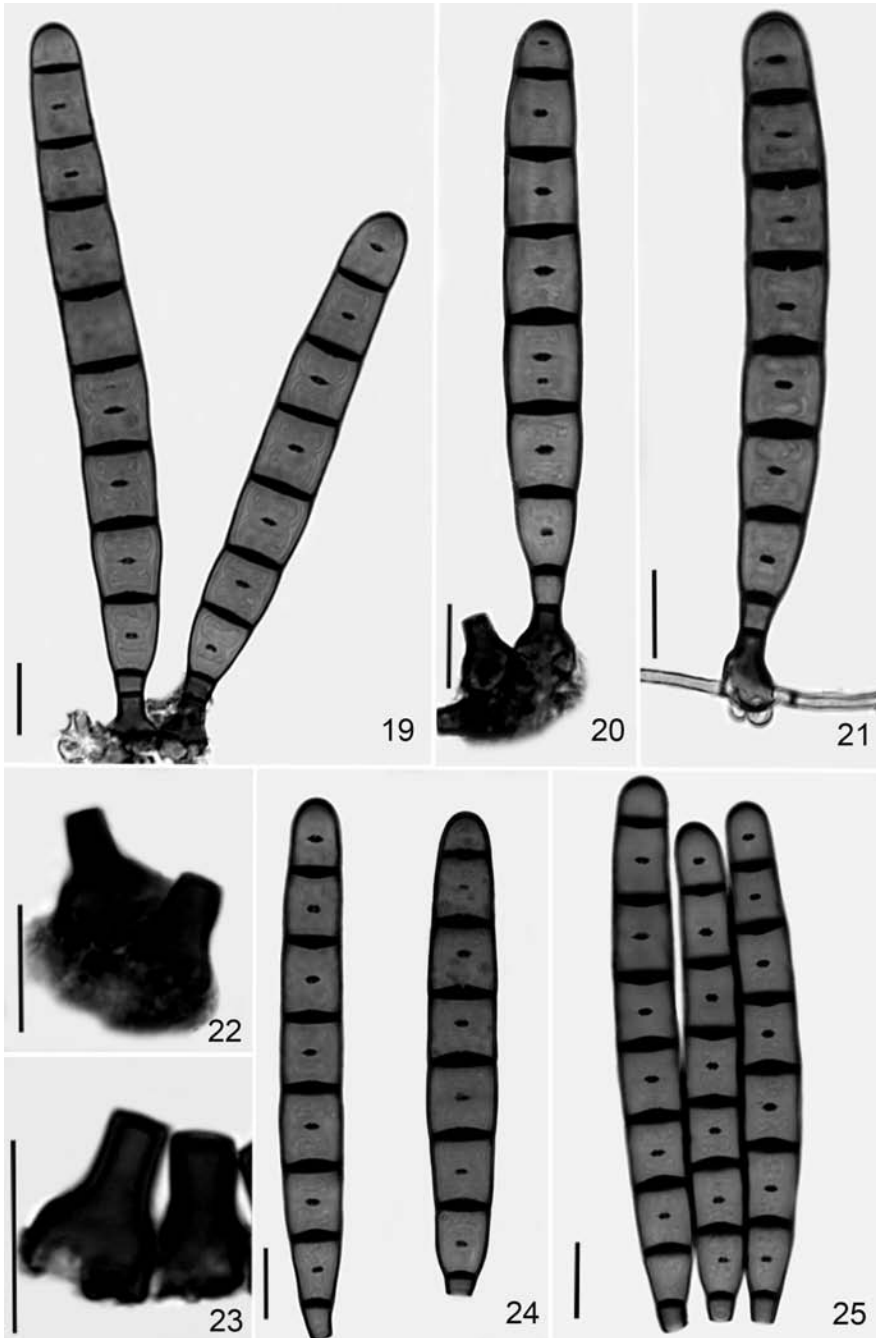
≡ *Janetia curviapicis* Goh & K.D.Hyde, Mycologia 88(6): 1015. 1996.

= *Stanjehughesia hamatiella* W.P.Wu, Fung. Divers. Res. Ser. 94: 228. 2005, **syn. nov.**

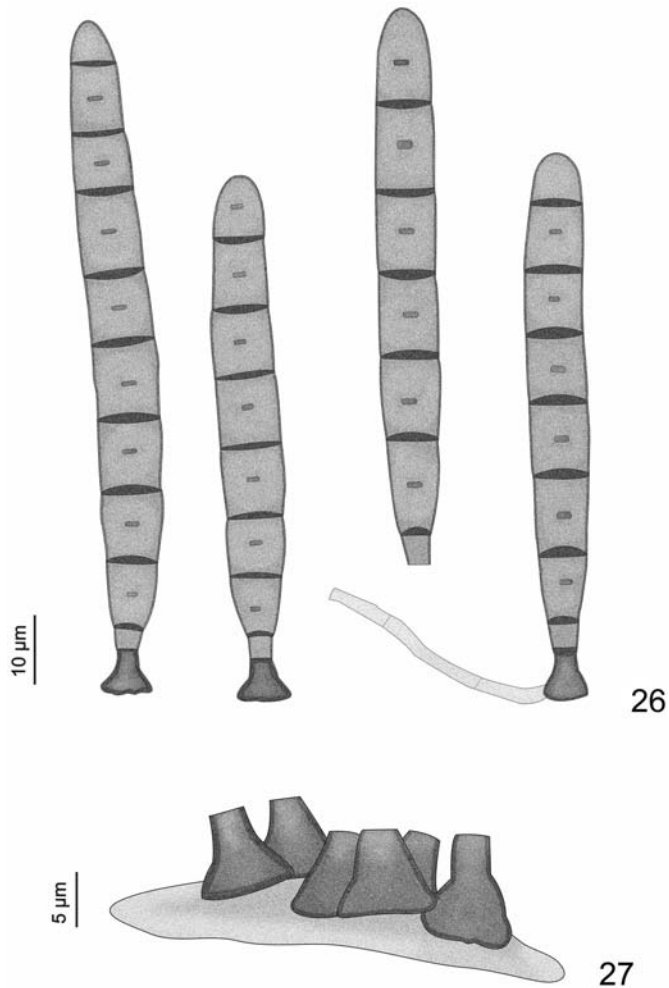
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KNOWN DISTRIBUTION: Australia (as *Janetia curviapicis*, Goh & Hyde 1996), China (Wu & Zhuang 2005), and Brazil (as *Janetia curviapicis*, Gusmão 2010).

SPECIMENS EXAMINED: Australia, Queensland, Cow Bay, on submerged wood, April 1995, leg. T.M.Hyde and K.D.Hyde (Holotypus: BRIP 23223). Brazil, Bahia, Santa Terezinha, Serra da Jibóia,



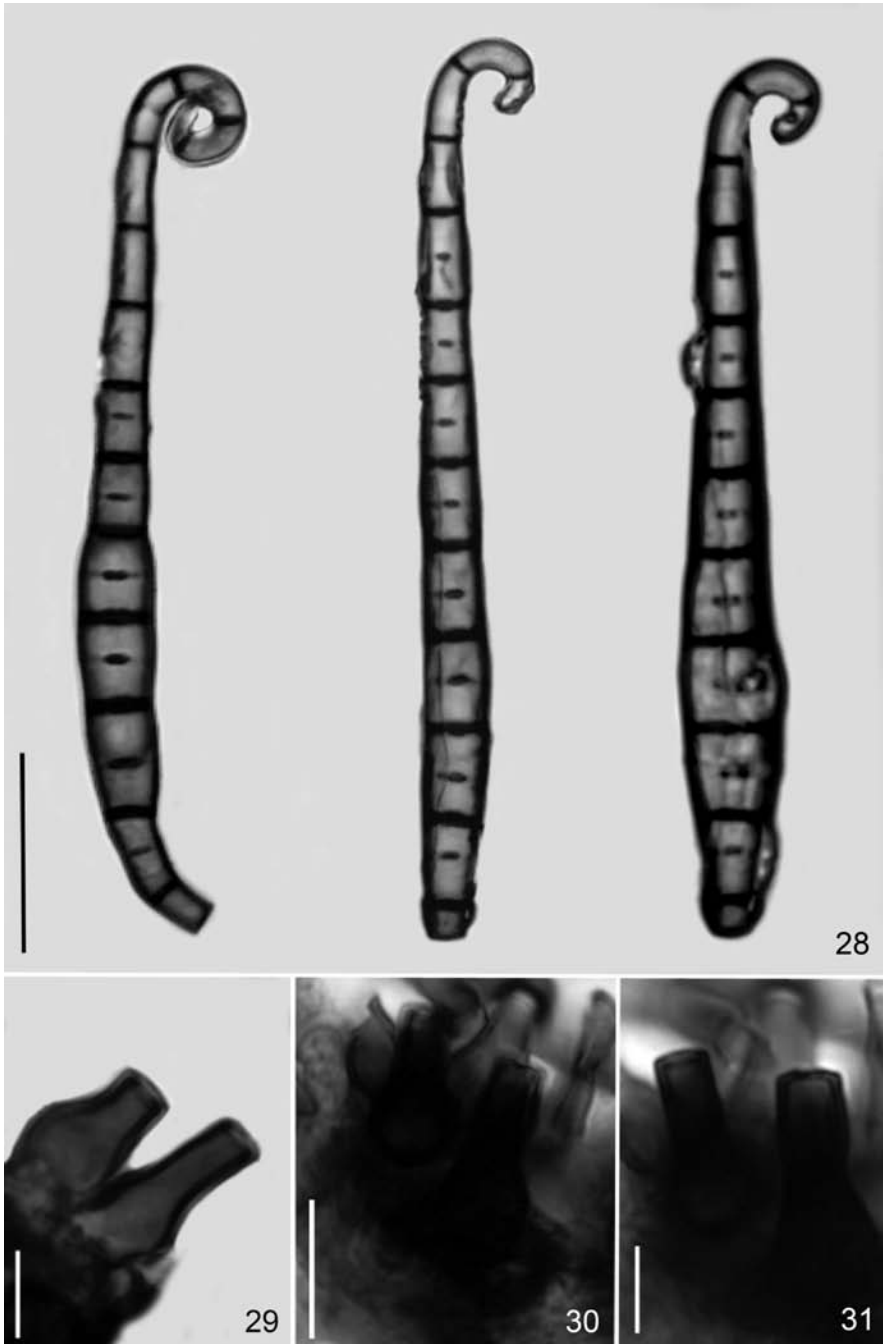
Figs 19–25. *Stanjehughesia clavata*. 19–21. General aspect. 22–23. Conidiogenous cell. 24–25. Conidia. Bars = 10 μm (19–25).



Figs 26–27. *Stanjehughesia clavata*. 26. General aspect. 27. Conidiogenous cells.

on decaying bark, 07 Nov. 2008, leg. P.O.Fiuza (HUEFS141576); on decaying twig, 23 Sep. 2008, leg. P.O.Fiuza (HUEFS 141576).

Stanjehughesia hamatiella, described by Wu & Zhuang (2005), was collected on branches of bamboo in China. The hamate conidium was considered by Wu & Zhuang (2005) to be the diagnostic characteristic to separate *S. hamatiella* from other species of *Stanjehughesia*. The only difference that could be found between *S. hamatiella* and *J. curviapicis* is the condition of the conidiogenous cell, monoblastic in the former and polyblastic in the latter. However, we examined the holotype of *J. curviapicis* (Figs 28–31) and we conclude that the conidiogenous cells are monoblastic. After we



Figs 28–31. *Stanjehughesia curviapicis* from holotype. 28. Conidia. 29–31. Conidiogenous cells. Bars = 20 μm (28), 5 μm (29–31).

compared the description and illustration of *S. hamatiella* presented by Wu & Zhuang (2005) with the holotype of *J. curviapicis* and two specimens of *S. hamatiella* found in Brazil, we conclude that *S. hamatiella* is identical to *J. curviapicis* and these two species should be synonymized.

Cacumisporium pleuroconidiophorum (Davydkina & Melnik) R.F.Castañeda, Heredia & Iturr., Mycotaxon 100: 332. 2007.

≡ *Pyriculariopsis pleuroconidiophora* Davydkina & Melnik, Mikol. Fitopatol. 23(2): 112. 1989.

= *Cacumisporium curvularioides* R.F.Castañeda & W.B.Kendr., Univ. of Waterloo Biol. Ser. 35: 16. 1991.

= *Minimelanolocus machili* K.Zhang & X.G.Zhang, Mycotaxon 109: 97. 2009, **syn. nov.**

KNOWN DISTRIBUTION: Argentina (as *C. curvularioides*, Godeas & Arambarri 2007), Former Republic of the Soviet Socialist Union (as *Pyriculariopsis pleuroconidiophora*, Farr et al. 2012), China (as *Minimelanolocus machili* Zhang et al. 2009a), Cuba (as *C. curvularioides*, Castañeda-Ruiz & Kendrick 1991), Mexico, and Venezuela (Castañeda-Ruiz et al. 2007a).

The genus *Cacumisporium* Preuss was established by Preuss (1851) for *C. tenebrosum* Preuss, which was treated as a synonym of *C. capitulatum* (Corda) S.Hughes by Hughes (1958). Currently, seven species are accepted in the genus: *C. capitulatum*, *C. pleuroconidiophorum* (Castañeda-Ruiz et al. 2007a), *C. rugosum* K.M.Tsui, Goh, K.D.Hyde & Hodgkiss (Tsui et al. 2001), *C. sigmoideum* Mercado & R.F.Castañeda (Mercado-Sierra & Castañeda-Ruiz 1987), *C. spooneri* P.M.Kirk (Kirk 1992), *C. tropicale* R.F.Castañeda, Gusmão & Stchigel (Castañeda-Ruiz et al. 2007b) and *C. uniseptatum* Wongs., H.K.Wang, K.D.Hyde & F.C.Lin (Wongsawas et al. 2009).

Zhang et al. (2009a) described *Minimelanolocus machili* on dead branches of *Machilus grijsii* in China. Based on the description and illustration presented by Zhang et al. (2009a) and Castañeda-Ruiz et al. (2007a), we conclude that *Minimelanolocus machili* is identical to *C. pleuroconidiophorum*.

Linkosia bacilliformis (Gamundí, Aramb. & Gaiotti) D.A.C.Almeida & Gusmão, **comb. nov.**

≡ *Janetia bacilliformis* Gamundí, Aramb. & Gaiotti, Darwiniana 22(1–3): 201. 1979.

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Linkosia canescens (B.Sutton & Pascoe) D.A.C.Almeida & Gusmão, **comb. nov.**

≡ *Janetia canescens* B. Sutton & Pascoe, Aust. Syst. Bot. 1(2): 136. 1988.

Mycobank MB 804867

Linkosia refugia (B.Sutton & Pascoe) D.A.C.Almeida & Gusmão, **comb. nov.**

Mycobank MB 804868

≡ *Janetia refugia* B.Sutton & Pascoe, Aust. Syst. Bot. 1(2): 133. 1988

Hernandez-Gutierrez & Sutton (1997) proposed the genus *Linkosia* A.Hern. Gut. & B.Sutton to accommodate a species segregated from *Sporidesmium* Link, *L. cocco-*

thrinacis (A.Hern. Gut. & J.Mena) A.Hern. Gut. & B.Sutton. *Linkosia* is characterized by obclaviform to obclaviform-rostrate, distoseptate, solitary conidia produced on conidiophores, which are reduced to a monoblastic, ampulliform conidiogenous cell. Six species have been recently added to the genus: *L. fusiformis* W.P.Wu, *L. multisepta* W.P.Wu, *L. obclavata* W.P.Wu (Wu & Zhuang 2005), *L. mori* K.Zhang & X.G.Zhang (Zhang et al. 2009b), *L. ponapensis* (Matsush.) R.F.Castañeda, Saikawa & Gené (Matsushima 1981, Castañeda-Ruiz et al. 2000) and *L. hibisci* Jian Ma & X.G.Zhang (Ma et al. 2011).

The genus *Janetia* was erected by Ellis (1976) to include *J. euphorbiae* M.B.Ellis, the type species, and for a species transferred from *Sporidesmium*, *J. faureae* (Piroz.) M.B.Ellis. *Janetia* was circumscribed by Ellis (1976) as having conidiophores reduced to polyblastic, denticulate, intercalary conidiogenous cells and solitary, dry, obclavate, brown, multiseptate conidia. Gamundí et al. (1979) expanded the circumscription of *Janetia* to include *J. bacilliformis* Gamundí, Aramb. & Gaiotti, a species with monoblastic or rarely polyblastic conidiogenous cells and distoseptate conidia. An additional three species with these features were added to the genus: *J. canescens* B.Sutton & Pascoe, *J. refugia* B.Sutton & Pascoe (Sutton & Pascoe 1988) and *J. synnematososa* Sivan. & W.H.Hsieh (Sivanesan & Hsieh 1990). To date, 20 species have been described in the genus (Goh & Hyde 1996, Calduch et al. 2002, Xu & Guo 2002, Dornelo-Silva & Dianese 2003). Wu and Zhuang (2005) treated *J. synnematososa*, which produces synnemata, as synonymous with *Morrisiella indica* Saikia & A.K.Sarbhoj, the type species of the monotypic genus *Morrisiella*. Recently, Hernández-Restrepo et al. (2013) transferred *Janetia obovata* M.Calduch, Gené, Abdullah & Guarro to *Bactrodesmiastrum* based on the phylogenetic analysis of D1/D2 sequence segments of the LSU. Goh & Hyde (1996) formalized an expanded generic concept of *Janetia* to include species producing monoblastic or polyblastic conidiogenous cells and euseptate or distoseptate conidia. We do not agree with this broader generic concept of *Janetia* and we consider it more appropriate to transfer the species of *Janetia* with distoseptate conidia to *Linkosia*. This criterion also was utilized by Subramanian (1992) to separate *Sporidesmium*, which possesses euseptate conidia, from *Ellisembia* Subram., which has distoseptate conidia. Thus, the three new combinations above are proposed.

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