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New species and new records of Clavariaceae (Agaricales) from Brazil

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ABSTRACT

Fourteen species in three genera of Clavariaceae from the Atlantic Forest of Brazil are described (six *Clavaria*, seven *Clavulinopsis* and one *Ramariopsis*). *Clavaria diverticulata*, *Clavulinopsis dimorphica* and *Clavulinopsis imperata* are new species, and *Clavaria gibbsiae, Clavaria fumosa* and *Clavulinopsis helvola* are reported for the first time for the country. Illustrations of the basidiomata and the microstructures are provided for all taxa, as well as SEM images of ornamented basidiospores which occur in *Clavulinopsis helvola* and *Ramariopsis kunzei*. A key to the Clavariaceae of Brazil is also included.

Key words: clavarioid; morphology; taxonomy

Introduction

Clavariaceae Chevall. (Agaricales) comprises species with various types of basidiomata, including clavate, coralloid, resupinate, pendant-hydnoid and hygrophoroid forms (Hibbett & Thorn 2001, Birkebak *et al.* 2013). The family was first proposed to accommodate mostly saprophytic club and coral-like fungi that were previously placed in *Clavaria* Vaill. ex. L., including species that are now in other genera and families, such as *Clavulina* J.Schröt. (Clavulinaceae, Cantharellales), *Ramaria* Fr. ex. Bonord. (Gomphaceae, Gomphales) and *Scytinopogon* Singer (Scytinopogonaceae, Trechisporales) (Burt 1922, Coker 1923, 1947, Singer 1945b). Since Clavariaceae was defined by Chevallier (1826) the circumscription of the family has changed. The most species-rich genera in the family are *Clavaria* Fr., *Clavulinopsis* v. Ov. and *Ramariopsis* Donk (Corner 1970, Dentinger & McLaughlin 2006, Kautmanová *et al.* 2012, Birkebak *et al.* 2013). The other genera currently included in the family are *Camarophyllopsis* Herink, *Clavicorona* Doty, *Hirticlavula* J.H. Petersen & Læssøe, *Hyphodontiella* Å. Strid and *Mucronella* Fr. (Birkebak *et al.* 2013, Petersen *et al.* 2014).

Clavariaceae now includes ca. 110 known species that are mostly distributed in temperate regions in the northern hemisphere (Burt 1922, Coker 1923, Corner 1950, 1970, Thind 1961, Thind & Rattan 1967, Petersen 1964, 1965, 1968, 1975, 1978, 1988, Petersen 1999, García-Sandoval *et al.*, 2005, Dentinger & McLaughlin 2006, Shiryaev 2009, Kautmanová *et al.* 2012, Olariaga *et al.* 2015). Compared with temperate regions of Europe or North America, there are few collections from tropical and subtropical regions, although it is believed that the family is very diverse in these areas (Corner 1950).

In Brazil, studies about Clavariaceae are scarce compared to those from the Northern Hemisphere. The most significant studies for the country were made in Amazonia by Corner (1950), Singer (1945a) and De Lamônica-Freire (1979), and in the Atlantic Forest by Rick (1959, Rio Grande do Sul), Bononi (1979, São Paulo), Corner (1970, Rio de Janeiro) and De Meijer (2006, 2009, Paraná). These studies account for twenty-two species and most of them lack complete descriptions.

With the goal of expanding the knowledge of clavarioid fungi from the Atlantic Forest, this work presents detailed descriptions and illustrations of fourteen species of Clavariaceae from this region, including three new records for the country and three new species (*Clavaria diverticulata*, *Clavulinopsis dimorphica* and *Clavulinopsis imperata*). A key to the twenty three taxa of club-shaped and branched Clavariaceae known from Brazil is provided.

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Material & Methods

Field trips were conducted between March 2011 and August 2014, mostly during the rainy season, in the states of Paraná, Rio Grande do Sul and Santa Catarina. Macromorphological characters were studied from fresh specimens whenever possible. Color codes (e.g., 2B19) were based on Kornerup & Wanscher (1978). Micromorphological characters were observed from sections of dried basidiomata using an Olympus CX21 microscope and a 1000× immersion oil lens. Descriptive terms follows Corner (1947), Largent *et al.* (1977) and Vellinga & Noordeloos (2001). All microscopic structures were observed in water, 3% potassium hydroxide, Melzer's solution, and Congo Red. Measurements were made in a solution of Congo Red and 5% potassium hydroxide. Basidiospore measurements excluded ornamentation. Twenty-five representatives of each microstructure studied were measured for each collection. Q refers to the mean value of the basidiospore length/width ratio. To analyze the presence and distribution of hyphae pigmentation, sections of dried basidiomata were treated in an alcohol-water solution (Largent *et al.* 1977) and observed in water and 5% potassium hydroxide (alkaline solution). The classification according to the pigments distribution followed Largent *et al.* (1977) and Singer (1986). The descriptions are based on all collections studied. Illustrations of microscopic features were based on digital photographs. Drawings were done by the first author; photos were taken by the first author unless otherwise indicated.

Scanning electron microscopy (SEM) was conducted at the Laboratório Central de Microscopia Eletrônica (LCME/UFSC). Fragments of the hymenophore were removed from dried basidiomata, mounted on aluminum stubs using carbon adhesive tabs, and coated with 30 nm of gold. The fragments were examined with a scanning electron microscope operating at 10 keV.

Voucher material was deposited at FLOR. The section "Specimens examined" lists specimens collected during this work and additional specimens studied, which were from BPI, FLOR, INPA, JPB, K, MBM, PACA, RBGE and URM. For the new species, specimens are listed in the section "Holotype." The section "Reference exsiccata studied" lists specimens of other taxa that were used for taxonomic comparison. Nomenclature is based on the CABI (http://www.indexfungorum.org. Accessed 14 Dec 2014) and CBS (http://www.cbs.knaw.nl/databases/. Accessed 14 December 2014) databases. Herbarium abbreviations follow Thiers (continuously updated). Generic concepts follow Corner (1950) since García-Sandoval *et al*. (2005) concluded that it was the most natural circumscription for *Clavulinopsis* and *Ramariopsis*.

Results

The following fourteen species (Fig. 1), distributed in three genera, were found: *Clavaria* (*Ca.*) (6 spp.), *Clavulinopsis* (*Cs.*) (7) and *Ramariopsis* (1). *Clavaria fumosa* Pers., *Ca. gibbsiae* Ramsb. and *Clavulinopsis helvola* (Pers.) Corner are recorded for the first time for Brazil. *Clavaria diverticulata*, *Clavulinopsis dimorphica* and *Cs. imperata* are described as new to science.

Taxonomy

Clavaria diverticulata A.N.M. Furtado & M.A. Neves, ***sp. nov.***
MB 816056

Diagnosis:—This species is characterized by a coralloid, light yellow to greenish yellow basidiomata, with cylindric irregular branches, divided 2−4 times; oblong hyaline basidiospores (6.0−8.0 × 3.0−5.0 µm); basidia secondarily septate with one or more septa, clampless, 4-sterigmate*;* context with clampless hyphae of three types: inflated hyphae (7.0−12 µm wide), with oleaginous contents; noninflated (1.5−6.0 µm wide) secondarily septate hyphae; and diverticulate hyphae with intraparietal pigment slightly yellow, spiraled

Etymology:—The name refers to the diverticulate hyphae located in the context of the branches and stipe.

Holotype:—BRAZIL. Rio Grande do Sul: São Francisco de Paula, Floresta Nacional de São Francisco de Paula (FLONA), 29º22'58"S, 50º22'32"W, 12 April 2014, *A.C. Magnago 1044* (FLOR 56317).

Basidiomata (Fig. 1a) 4.0−6.5 cm tall, solitary to caespitose, light yellow (1A4) to greenish yellow (1B8), drying pale yellow (4A3); branches 2.0−4.0 mm wide, smooth, cylindric, irregular, divided 2−4 times, branching polychotomous below and dichotomous above, internodes diminishing gradually; axils U-shaped, apex subacute to

blunt; basidiomata branched from the base. Context concolorous with external surface, solid, rather tough; taste and smell absent.

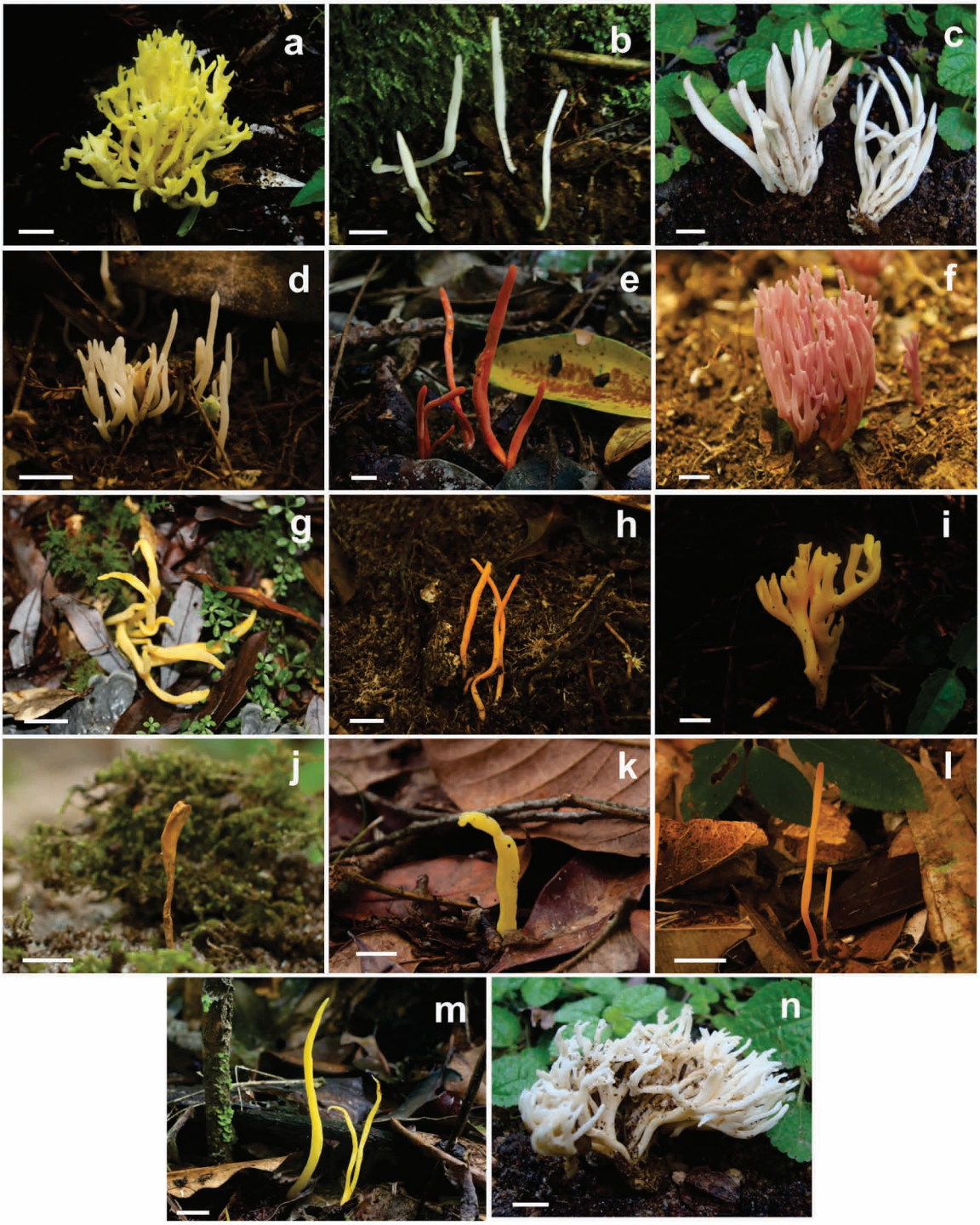

FIGURE 1. Photographs of basidiomata in the field. **a** *Clavaria diverticulata* (ACM 1044); **b.** *Ca. fragilis* (ACM 1041); **c.** *Ca. fumosa* (ACM 598); **d.** *Ca. gibbsiae* (ANMF 484); **e.** *Ca. subglobosa* (MAN 732); **f.** *Ca. zollingeri* (ANMF 365); **g.** *Clavulinopsis amoena* (KEL 21); **h.** *Cs. aurantiocinnabarina* (ANMF 382); **i.** *Cs. dimorphica* (ACM 1051); **j.** *Cs. helvola* (KEL 34); **k.** *Cs. imperata* (ANMF 482); **l.** *Cs. laeticolor* (ANMF 495); **m.** *Cs. spiralis* (MAN 1077); **n.** *Ramariopsis kunzei* (ACM 596). Bars = 1.0 cm. Photographs by Altielys C. Magnago (A, B, C, I, N) and Raquel Friedrich (G).

Basidiospores (Fig. 2a) 6.0−8.0 × 3.0−5.0 µm (Q=1.73), oblong, hyaline, smooth, thin-walled, uniguttulate, sometimes multiguttulate, inamyloid; hilar appendage 1.0 µm long. Basidia (Fig. 2b) 49−57 × 9.0−12 µm, clavate, becoming secondarily septate with one or more septa, clampless; 4-sterigmate 5.0−8.0 µm long. Cystidia absent. Hymenium ≤ 65 µm thick and thickening upwards, absent in stipe. Subhymenium ≤ 87 µm thick; hyphae 6.5−8.0 µm

wide, short, loosely interwoven, clampless. *Context* (Fig. 2cde) consisting of parallel hyphae, clampless, of three types: a) inflated hyphae 7.0−12 µm wide, sometimes with oleaginous contents; b) noninflated hyphae 1.5−6.0 µm wide, secondarily septate, thin-walled to slightly thick-walled, with intraperietal pigments slightly yellow and c) diverticulate hyphae (acanthohyphae) frequent, 2.5−15 µm wide, thin-walled, with intraparietal pigment slightly yellow, spiraled and projecting up to 2 µm from the surface.

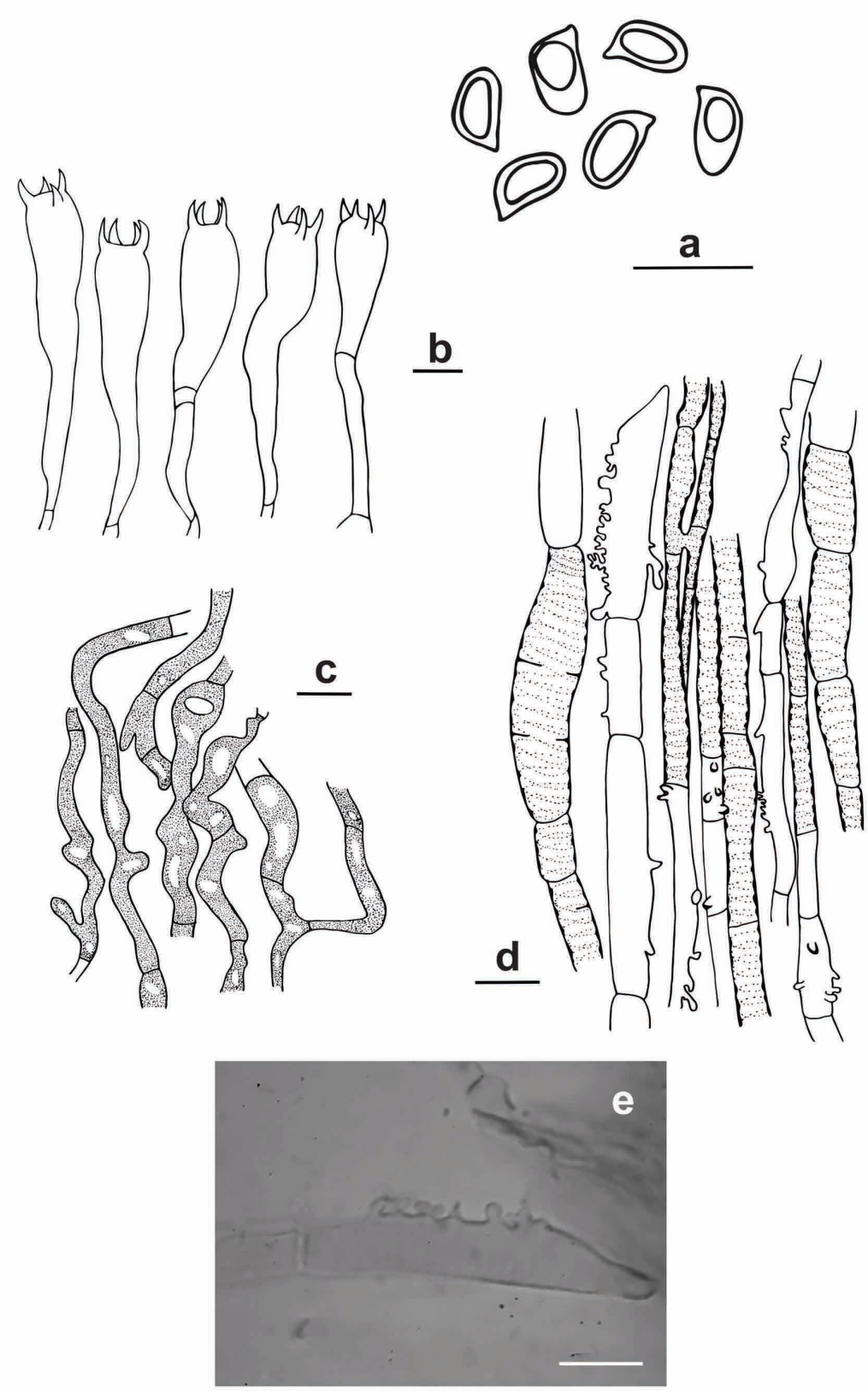

FIGURE 2. Microcharacters of *Clavaria diverticulata* (ACM 1044). **a.** Basidiospores; **b.** Basidia; **c.** Hyphae with oleaginous contents; **d.** Hyphae from the context; diverticulate hyphae with intraparietal pigments and secondarily septate; **e.** Diverticulate hyphae. Bars = 10 µm.

Habitat and distribution:—On soil among litter in *Araucaria angustifolia* (Bertol.) Kuntze moist forest. Known only from the type locality.

Remarks:—Based on the clampless basidia, *Clavaria diverticulata* is included in subgenus *Clavaria* (Corner 1950, 1970). *Clavulinopsis corniculata* (Shaeff.) Corner and *Ramariopsis crocea* (Pers.) Corner are similar to *Clavaria diverticulata* but both lack the diverticulate hyphae and the incrustations on the inner wall of hyphae in the context. Furthermore, the basidiospores in *Clavulinopsis corniculata* are globose, and in *Ramariopsis crocea* they are subglobose and nodulose (Corner 1950). *Clavaria pumanquensis* Lazo shares the branched basidiomata and has the same sized basidiospores (5.5−8.5 × 3.5−5.0 µm), but it is creamy white to yellowish pink and has bisporic basidia (Lazo 1972). Macroscopically, *Ca. diverticulata* could be mistaken as a non-stipitate variety of *Clavaria martiniii* Corner, which was described from Panama (Corner 1967b, 1970). Both species have basidiospores of the same size (5.5−7.0 × 3.0−3.7 µm), and a context that lacks gloeohyphae and diverticulate hyphae however, *Ca. martinii* has cristate, subfasciculate apices, and basidiospores with a shorter hilar appendage (up to 0.5 µm long) with intraparietal pigment. Additionally, *Ca. diverticulata* has secondarily septate basidia that are not present in *Ca. martinii*. The presence of diverticulate hyphae has not been described for *Clavaria* by other authors (e.g., Burt 1922; Corner 1957, 1967a, 1967b; Petersen 1964; Kautmanová *et al.* 2012; Birkebak *et al.* 2013). This morphological feature could have taxonomic significance for the genus and we suggest that related species should always be checked for this character which we consider to be diagnostic for *Ca. diverticulata*.

Clavaria fragilis Holmsk. in Fries (1821: 484)

Basidiomata (Fig. 1b) 1.0−5.0 × 0.3−0.5 cm, unbranched, gregarious, in small fascicules of 3−4 or solitary. Clavula whitish (1A1), cylindric, becoming flattened and sulcate, often flexuous; apex acute to obtuse, concolorous with clavula; stipe short 2.5–3.5 x 1–2 mm, slightly narrow, translucent. Context white (1A5), first solid then hollow, very brittle; taste and smell absent.

Basidiospores (Fig. 3a) 4.5−5.5 × 2.0−3.5 µm (Q=1.57), ellipsoid, hyaline, smooth, thin-walled, uniguttulate, inamyloid; hilar appendage up to 1.0 µm long. Basidia (Fig. 3b) 31−39 × 6.0−8.0 µm, clavate, clampless; 4-sterigmate 4.0−5.0 µm long. Cystidia absent. Hymenium ca. 38 µm thick, absent in stipe. Subhymenium up to 30 µm thick; hyphae 1.5−4.0 µm wide, loosely interwoven, clampless. Context with parallel hyphae 17−25 µm wide, clampless; hyphae shorter next to subhymenium, secondarily septate, constricted at primary septa, thin-walled, compact.

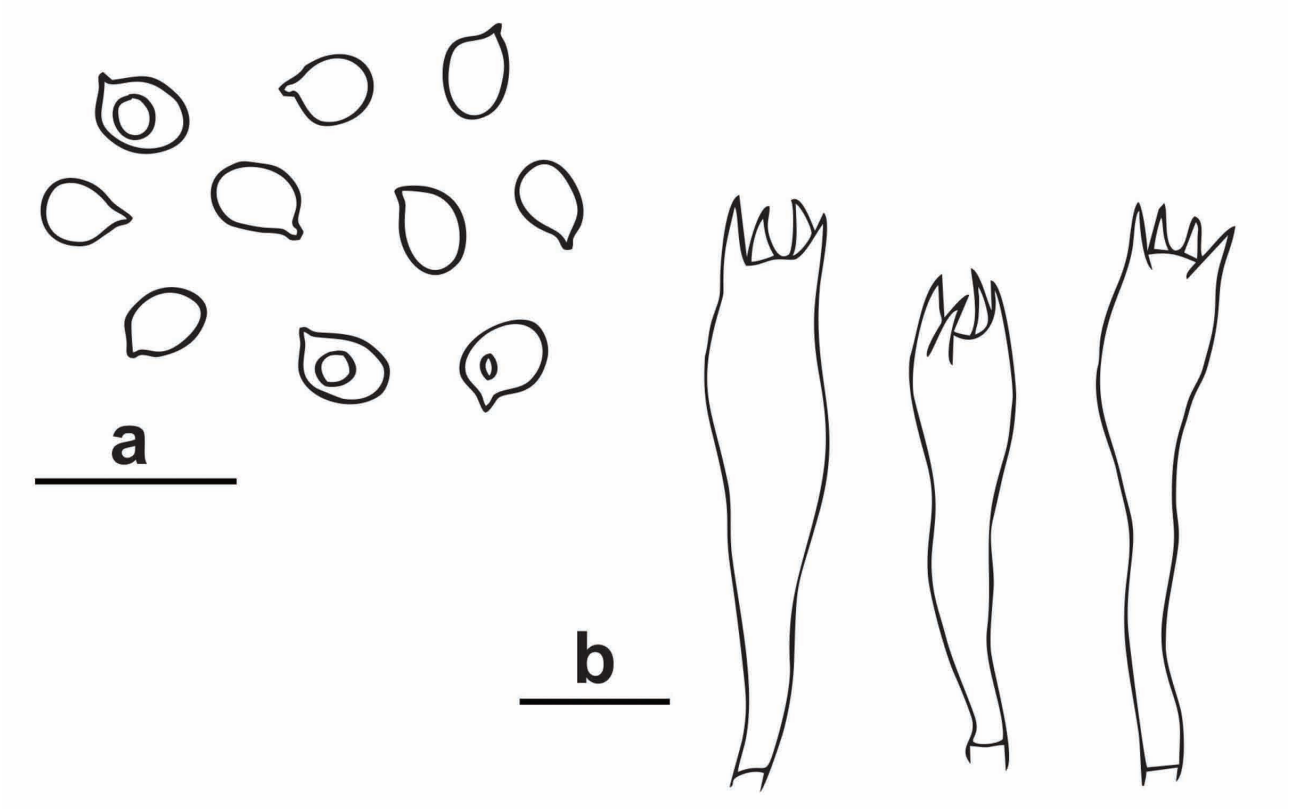

FIGURE 3. Microcharacters of *Clavaria fragilis* (ACM 1041). **a.** Basidia; **b.** Basidiospores. Bars = 10 µm.

Habitat and distribution:—In the Atlantic Forest, this species is found on soil with moss. In Brazil it is known from the states of Paraná (De Meijer 2006), Rio Grande do Sul (Corner 1967b as *Clavaria vermicularis* Sw.) and Santa Catarina (present study). Also known from Argentina, Australia, Bolivia, Bonin Islands, Ceylon, China, Costa Rica, USA (Corner 1950, 1967b), India (Thind 1961), Java, Japan (Corner 1970), Switzerland (Breitenbach & Kränzlin 1986), Denmark, Finland, Iceland, Norway, Sweden (Hansen & Knudsen 1997), Estonia (Shiryaev 2009), Spain (Olariaga 2009), Morocco, Pakistan, Russia and South Africa (Outcoumit *et al.* 2014),

Specimens examined:—BRAZIL. Rio Grande do Sul: São Francisco de Paula, Floresta Nacional de São Francisco de Paula (FLONA), 29º22'58.5"S, 50º22'32"W, 12 April 2014, *A.C. Magnago 1041* (FLOR 56150).

Additional specimens examined:—BRAZIL. Rio Grande do Sul: no location, n.d., *J.E. Rick n.n.* (BPI 294648). Paraná: São José dos Pinhais, Roça Velha, 05 February 2001, *A.A.R. De Meijer 3964* (MBM). USA. Ohio: Cincinnati, 03 November 1920, *C.G. Lloyd n.n.* (BPI 332898), *ibid.*, 05 September 1920, *C.G. Lloyd n.n.* (BPI 332897).

Remarks:—This species is widespread, edible and the type of the genus (Corner 1950). *Clavaria fragilis* is easily recognized by its white and brittle basidiomata (Burt 1922). Based on Corner's classification (1950), our specimen (*A.C. Magnago 1041*) is similar to *Ca. fragilis* var. *gracilis* because of the habit and the slightly smaller basidiospores (5.0−7.0 × 3.0−4.0 µm in *Ca. fragilis*), which also agrees with the specimens described by Burt from the USA (Burt 1922). The North American specimens described by Coker (1923) are taller than those from other localities. This common species could be mistaken for a less stout *Clavaria fumosa* Pers., which has wider basidiospores (5.0−7.0 × 4.0−5.0 µm) and a fuliginous basidioma (Corner 1967b). A close morphological species is *Clavaria pampeana* Speg., but it has smaller basidiomata (7−28 × 0.5−1.0 mm) subglobose and larger basidiospores (7.0−10 × 6.0−8.0 µm) and clamped basidia with sterigmata about 6.0−8.5 µm long (Singer 1969).

Clavaria fumosa Persoon (1796: 31)

Basidiomata (Fig. 1c) 1.5−7.5 × 0.2−0.7 cm, unbranched, densely caespitose. Clavula whitish (1A1) to pale cream (5A2) or reddish grey (9B2), whitish towards the sterile base, cylindric then subclavate, becoming compressed and slightly fusiform, slender; apex acute then obtuse, light brown (5D5); stipe indistinct or absent. Context white (5A1), brittle; taste and smell absent.

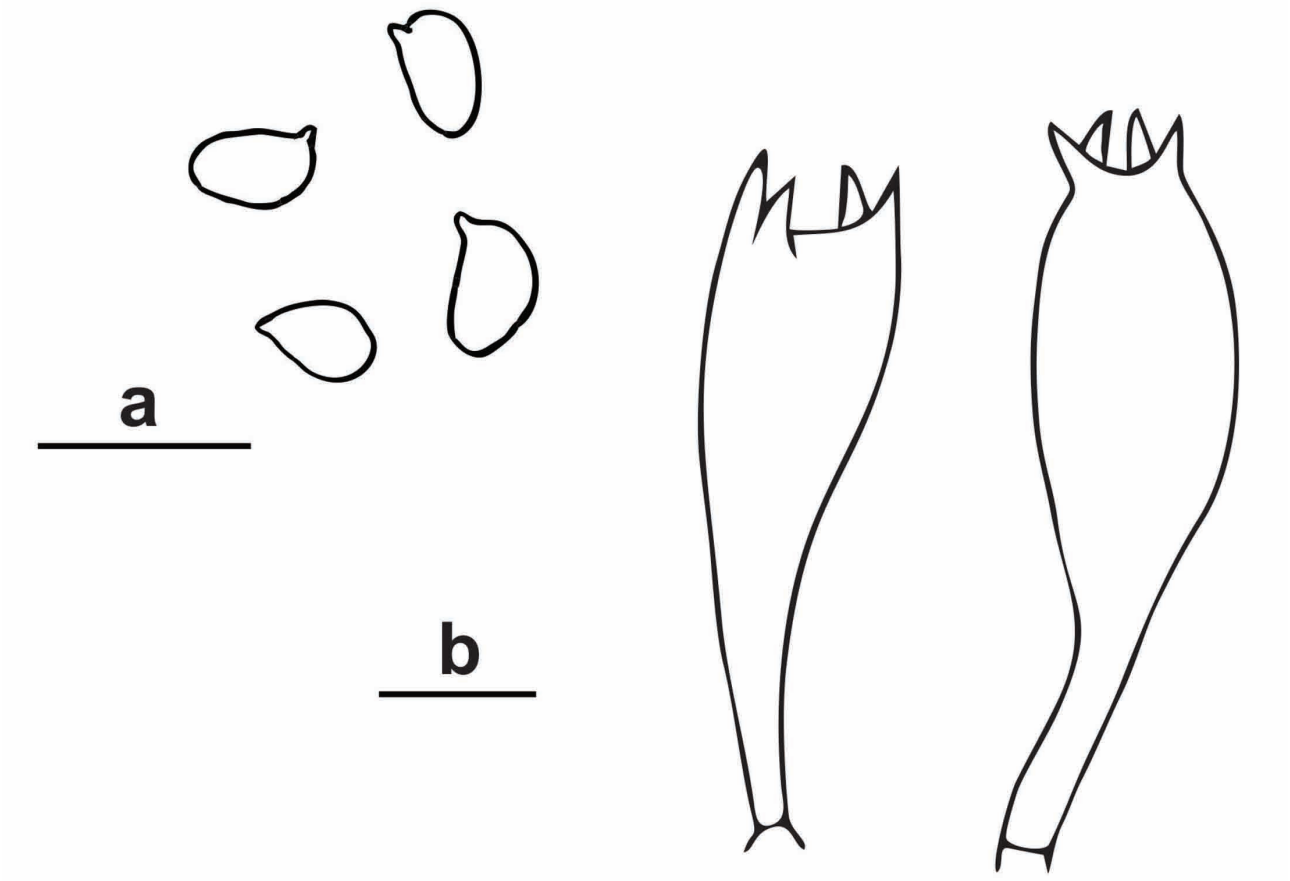

FIGURE 4. Microcharacters of *Clavaria fumosa* (ACM 598). **a.** Basidia; **b.** Basidiospores. Bars = 10 µm.

Basidiospores (Fig. 4a) 5.0−8.0 × 4.0−5.0 µm (Q=1.45), ellipsoid, hyaline, smooth, thin-walled, uniguttulate, inamyloid; hilar appendage up to 1.0 µm long. Basidia (Fig. 4b) 55−63 × 8.0−13 µm, clavate, clampless; 4-sterigmate 5.0−8.0 µm long. Cystidia absent. Hymenium 45.5−100 µm thick, absent in stipe. Subhymenium up to 50 µm thick; hyphae 2.0−4.0 µm wide, partially clamped, secondarily septate, loosely interwoven. Context with subparallel hyphae 5.0−28 µm wide, clampless; hyphae secondarily septate, inflated, constricted at primary septa, thin-walled.

Habitat and distribution:—In the Atlantic Forest, this species is found on bare soil. In Brazil it is known only from Santa Catarina (present study). It also occurs in Java, USA and Russia (Corner 1950), Bolivia (Corner 1970), Switzerland (Breitenbach & Kränzlin 1986), Denmark, Iceland, Norway, Sweden (Hansen & Knudsen 1997), Estonia (Shiryaev 2009) and Spain (Olariaga 2009).

Specimens examined:—BRAZIL. Santa Catarina: Florianópolis, Morro da Lagoa, Trilha do Jipe, 27º59'43"S, 49º47'83"W, 09 April 2013, *A.C. Magnago 598* (FLOR 56154).

Additional specimens examined:—ENGLAND, 1923, *E.J.H. Corner n.n.* (K 161399); SOLOMON ISLANDS. Ysabel, 21 September 1965, *E.J.H. Corner n.n.* (BPI 264669, isotype).

Remarks:—*Clavaria fumosa* is characterized by cream fuliginous basidioma with a brown apex and an indistinct or absent stipe. When young, the pale basidioma has a pinkish apex (Corner 1950, 1970). Corner (1970) stated that this species might be restricted to temperate regions; however, he reported *Ca. fumosa* for Bolivia, based on a collection made by Singer, and for Java and the Solomon Islands (Corner 1967a). A close morphological species is *Clavaria rubicundula* Leathers, but the basidiomata are violaceous pink, the basidiospores measure 3.0−4.0 µm in width and the basidia are smaller (35−50 × 5.5−7.5 µm) (Leathers 1956). *Clavaria fumosa* seems to be a color variety of *Ca. fragilis* but the latter is white and has smaller basidiospores (4.5−5.0 × 2.0−3.5 µm) (Corner 1967b).

Clavaria gibbsiae Ramsb. in Gibbs (1917: 187)

Basidiomata (Fig. 1d) 2.0−6.5 × 0.2−0.6 cm, unbranched or on one basidioma furcate, densely caespitose. Clavula white (1A1) to pale cream with age (5A2), subclavate; apex generally blunt, subacute; stipe 1.0−3.0 × 1.0−2.0 mm, distinct, smooth. Context solid, waxy, slightly brittle; taste and smell absent.

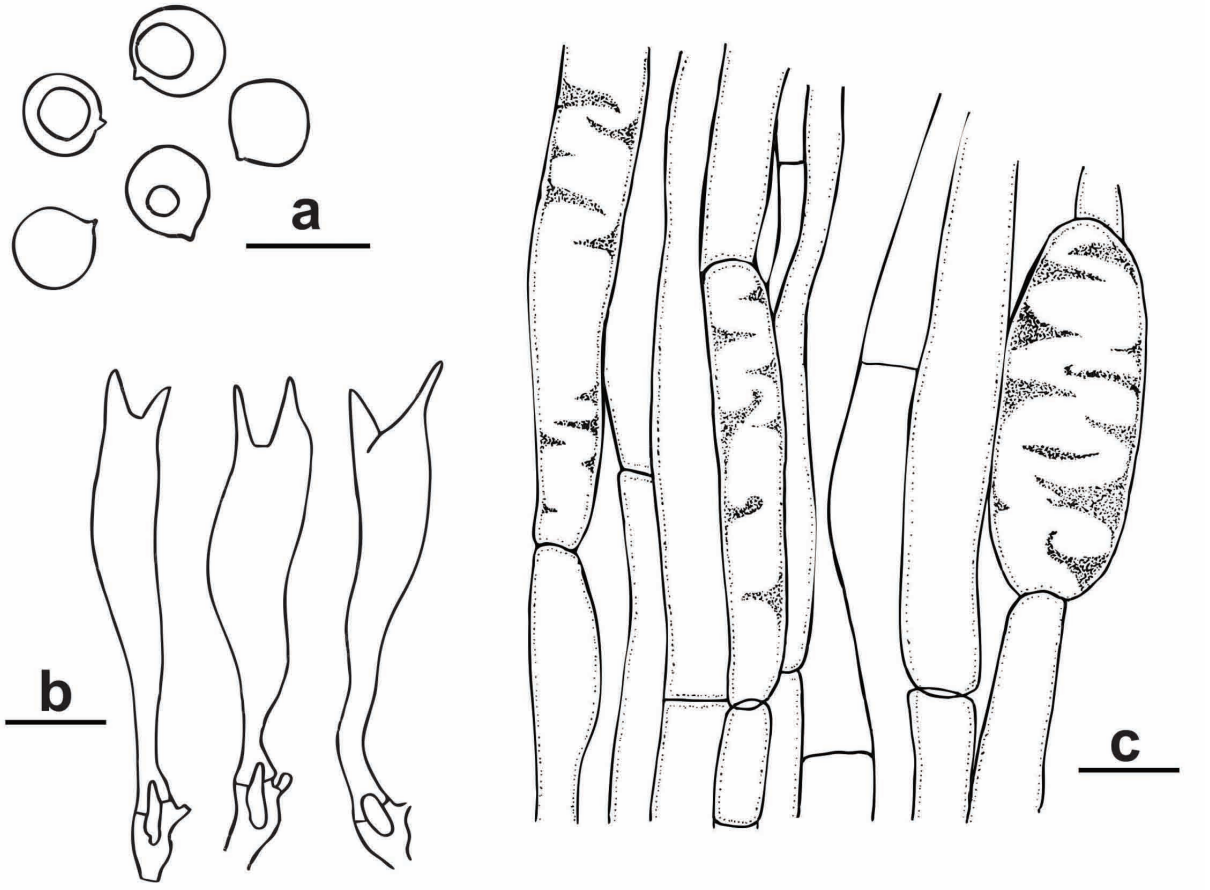

FIGURE 5. Microcharacters of *Clavaria gibbsiae* (ANMF 484). **a.** Basidiospores; **b.** Basidia; **c.** Hyphae from the context with intraparietal pigments. Bars = 10 µm.

Basidiospores (Fig. 5a) 6.5−8.0 × 6.5−7.5 µm (Q=1.11), subglobose, hyaline, smooth, thin-walled, uniguttulate, inamyloid; hilar appendage up to 1.0 µm long. Basidia (Fig. 5b) 30−40 × 6.0−8.0 µm, clavate, furcate at the base and with a loop-like basal clamp; 2-sterigmate 6.0−9.0 µm long. Cystidia absent. Hymenium 52−130 µm thick, absent in stipe. Subhymenium up to 45 µm thick; hyphae 1.5−4.0 µm wide, clampless, densely interwoven. Context (Fig. 5c) with parallel hyphae; hyphae 12−23 µm wide, clampless, much inflated and constricted at the septa, not secondarily septate, thin-walled, loosely attached, with slightly yellow irregular intraparietal pigments; longitudinal narrow hyphae 3.0−6.0 µm wide, not interweaving.

Habitat and distribution:—In the Atlantic Forest, this species is found on soil in the shade. In Brazil it is known only from Santa Catarina (present study). It has also been recorded from Africa, Malaysia and New Guinea (Corner 1950).

Specimens examined:—BRAZIL. Santa Catarina: Florianópolis, Morro da Lagoa, Trilha do Jipe, 27º59'43"S, 49º47'83"W, 12 November 2013, *A.N.M. Furtado 363* (FLOR 56148); Santa Amaro da Imperatriz, Hotel Plaza Caldas da Imperatriz, Trilha da Cachoeira, 27º70'39"S, 48º80'37"W, 21 March 2014, *A.N.M. Furtado 458* (FLOR 56144), *ibid.*, 10 April 2014, *A.N.M. Furtado 484* (FLOR 56153). Paraná: Piraquara, Morro do Canal, 25º50'91"S, 48º97'75"W, 26 January 2014, *A.C. Magnago 910* (FLOR 56143).

Additional specimens examined:—MALAYSIA. Tembeling: Pahang, Malaya, 07 November 1930, *E.J.H. Corner n.n.* (BPI 294160).

Remarks:—According to Corner's infrageneric classification (1970), *Clavaria gibbsiae* belongs to subgenus *Holocoryne* (Fr.) Bonord. because of the presence of clamps at the base of the basidia. This is probably a widespread and common tropical species (Corner 1950) that can be mistaken for *Ca. fragilis*, which is also white but differs by the shape and size of the basidiospores (ellipsoid and smaller, 4.5−5.5 × 2.0−3.5 µm, in *Ca. fragilis*), number of sterigmata and the absence of inner wall incrustations (Burt 1922).

Clavaria subglobosa (Corner) A.N.M. Furtado & M.A. Neves, ***comb. & stat. nov.***
Basionym: *Clavaria rosea* var. *subglobosa* Corner (1950: 691).
MB 816057

Clavaria rosea var. *grandispora* Corner (1967: 41).

Basidiomata (Fig. 1e) 2.5−9.5 × 0.2−0.6 cm, unbranched, solitary, gregarious to caespitose. Clavula reddish orange (7B8) to brownish red (8C8) or vivid red (9A8), drying brownish orange (8C6), flattened, becoming cylindric at apex, with a subtle groove; apex concolorous, acute then fusiform and blunt; stipe very short (4.0−5.0 × 2.0 mm) but distinct, paler, slightly strigose. Context brittle, pale orange (6A6), fistulose, (first solid then hollow); taste and smell absent.
Basidiospores (Fig. 6a) 6.0−7.5 (−9.0) × 5.5−7.0 (−8.0) µm (Q=1.09), subglobose, hyaline, smooth, thin-walled, aguttulate, inamyloid; hilar appendage up to 1.0 µm long. Basidia (Fig. 6b) 82−94 × 7.0−10 µm, cylindric-elongate, clampless; sterigmata (2−)4, 7.0−12 µm long. Cystidia absent. Hymenium 90−110 µm thick, distinctly thicker towards apex, absent in stipe. Subhymenium 40−60 µm thick; hyphae 2.5−4.0 µm wide, clampless. Context with parallel hyphae, 6.0−7.0 µm wide, clampless, cylindric, sparsely secondarily septate, sometimes constricted at primary septa, thin-walled, H−connections frequent.

Habitat and distribution:—In the Atlantic Forest this species is found on soil covered with litter, under trees. In Brazil it is known from Rio de Janeiro (Corner 1967b), Paraná (De Meijer 2010) and Santa Catarina (present study). It is also known from England, France, Germany (Corner 1950), Morocco and Trinidad (Corner 1967b).

Specimens examined:—BRAZIL. Santa Catarina: Florianópolis, Morro da Lagoa, Trilha do Jipe, 27º59'43"S, 49º47'83"W, 16 March 2011, *Neves, M.A. 732* (FLOR 56146), *ibid.*, 16 March 2015, *Furtado, A.N.M. 526* (FLOR 56147).

Additional specimen examined:—BRAZIL. Rio de Janeiro: no location, 8 December 1948, *E.J.H. Corner n.n.* (BPI 294512, as *Ca. rosea*).

Remarks:—*Clavaria subglobosa* is easily recognized in the field by its vivid color that contrasts with the litter. The species varies in color from a pale to vivid pink, reddish rose, reddish orange to brownish orange, and its basidiospores range in size (from 5.0−9.0 × 4.0−8.0 µm). This led Corner (1967b) to create three varieties for *Clavaria rosea* Dalman (var. *grandispora*, var. *subglobosa* and var. *pallida*). The latter variety has typical ellipsoid basidiospores, which are slightly flattened adaxially, and inflated hyphae (up to 25 µm wide). *Clavaria rosea* var. *subglobosa* and *Ca. rosea* var. *grandispora* have subglobose to broadly ellipsoid basidiospores (basidiospores 5.0−8.0 × 4.0−6.5 µm for *Ca. rosea* var. *subglobosa* and 7.0−8.5 × 6.0−7.5 µm for *Ca. rosea* var. *grandispora*), which are not flattened, and narrow hyphae (Corner 1950, 1970). *Clavaria rosea* var. *grandispora* was described from Brazil and has reddish orange basidiomata.

Clavaria rosea var. *subglobosa* is from India and has pale red basidiomata (Corner 1970). Considering that the hyphal system and the basidiospore morphology are important characteristics to delimitate a species (Corner 1950, 1970, Petersen 1967), we consider the use of the variety rank inappropriate for the taxon and propose the new combination *Clavaria subglobosa*. *Clavaria incarnata* Weinm. and *Ca. messapica* Agnello, Kautmanová & M. Carbone are closely related species but they differ from *Ca. subglobosa* because they have clamped basidia (Agnello *et al.* 2014).

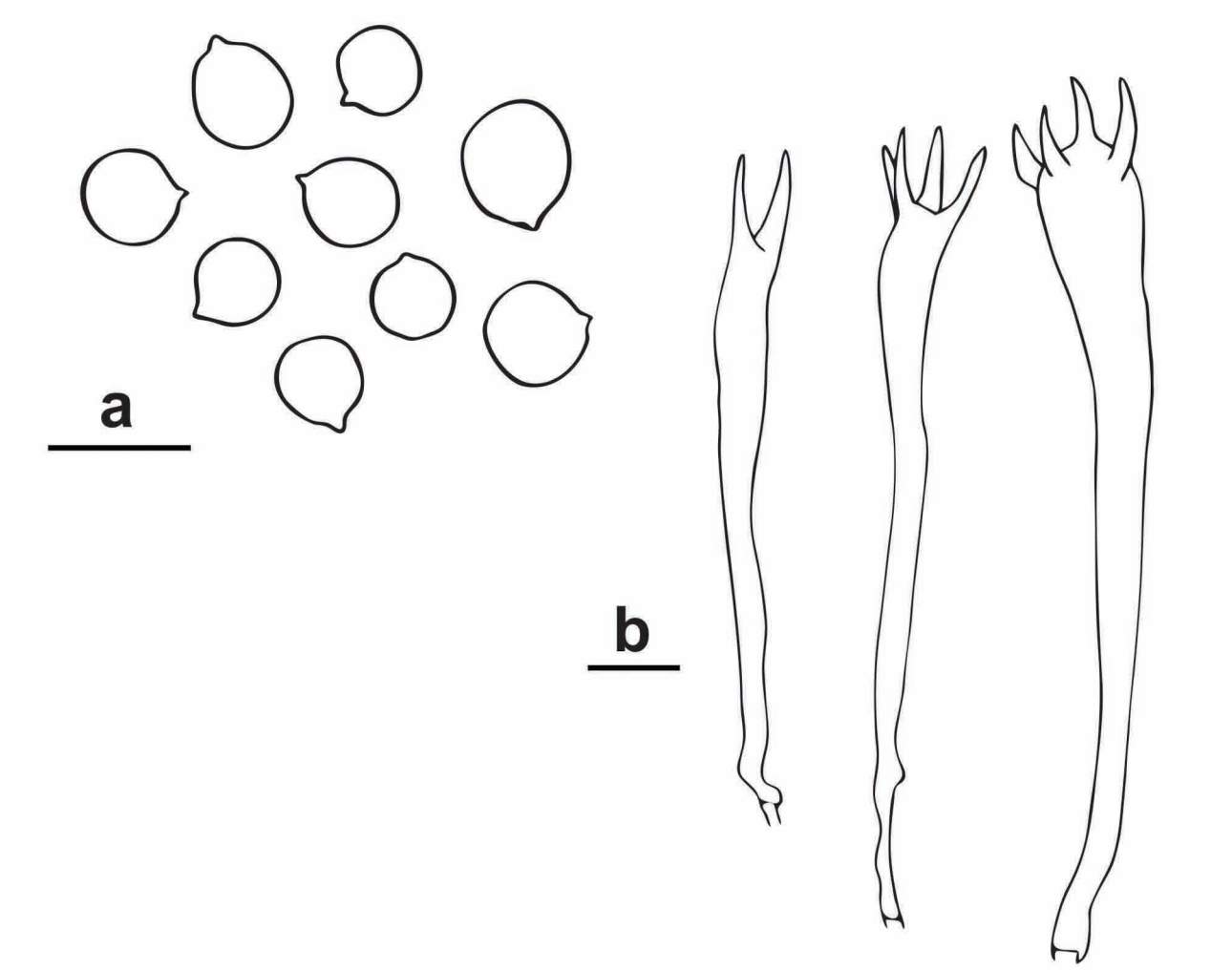

FIGURE 6. Microcharacters of *Clavaria subglobosa* (MAN 732). **a.** Basidiospores; **b.** Basidia. Bars = 10 µm.

Clavaria zollingeri Léveille (1846: 155)

Basidiomata (Fig. 1f) 2.0−7.5 cm high, gregarious, caespitose, purple (15C7) or deep purple (15D8) to grayish ruby (12E5), magenta (13D5), rose (12B6) or purplish red (14C7), drying pale yellow (4A3), blunt or becoming subulate above, irregular, more or less fastigiate, branched; branches 1.0−3.0 mm wide, cylindric; axils rounded, divided 1−4 times, polychotomous below, apices concolorous with the branches; stipe 10−25 × 2.0−3.0 mm, often branched from the base. Context concolorous with the branches; taste and smell absent.

Basidiospores (Fig. 7a) 6.0−7.0 × 4.0−6.0 µm (Q=1.23), broadly ellipsoid, hyaline, smooth, thin-walled, uniguttulate, inamyloid; hilar appendage up to 1.0 µm long, often sublateral. Basidia (Fig. 7b) 38−60 × 9.0−13 µm, clavate, multiguttulate, clampless; sterigmata (2−)4, 5.0−7.0 µm long. Cystidia absent. Hymenium 40−100 µm thick, absent in stipe. Subhymenium up to 40 µm thick; hyphae 5.0 µm wide, clampless, gradually inflating up to 10 µm wide. Context (Fig. 7c) with subparallel hyphae; hyphae 5.0−22 µm wide, clampless, barrel-shaped, frequently secondarily septate, slightly constricted at primary septa, walls slightly thickened, smooth, H-connections frequent.

Habitat and distribution:—In the Atlantic Forest this species is found on soil in the shade. In Brazil it is known from Amazonas (De Lamônica-Freire 1979), Paraná (De Meijer 2006, 2009), Santa Catarina, Rio Grande do Sul (present study) and São Paulo (Bononi *et al.* 1981). Known at least from Europe and North America (Olariaga, 2009) but likely well distributed worldwide.

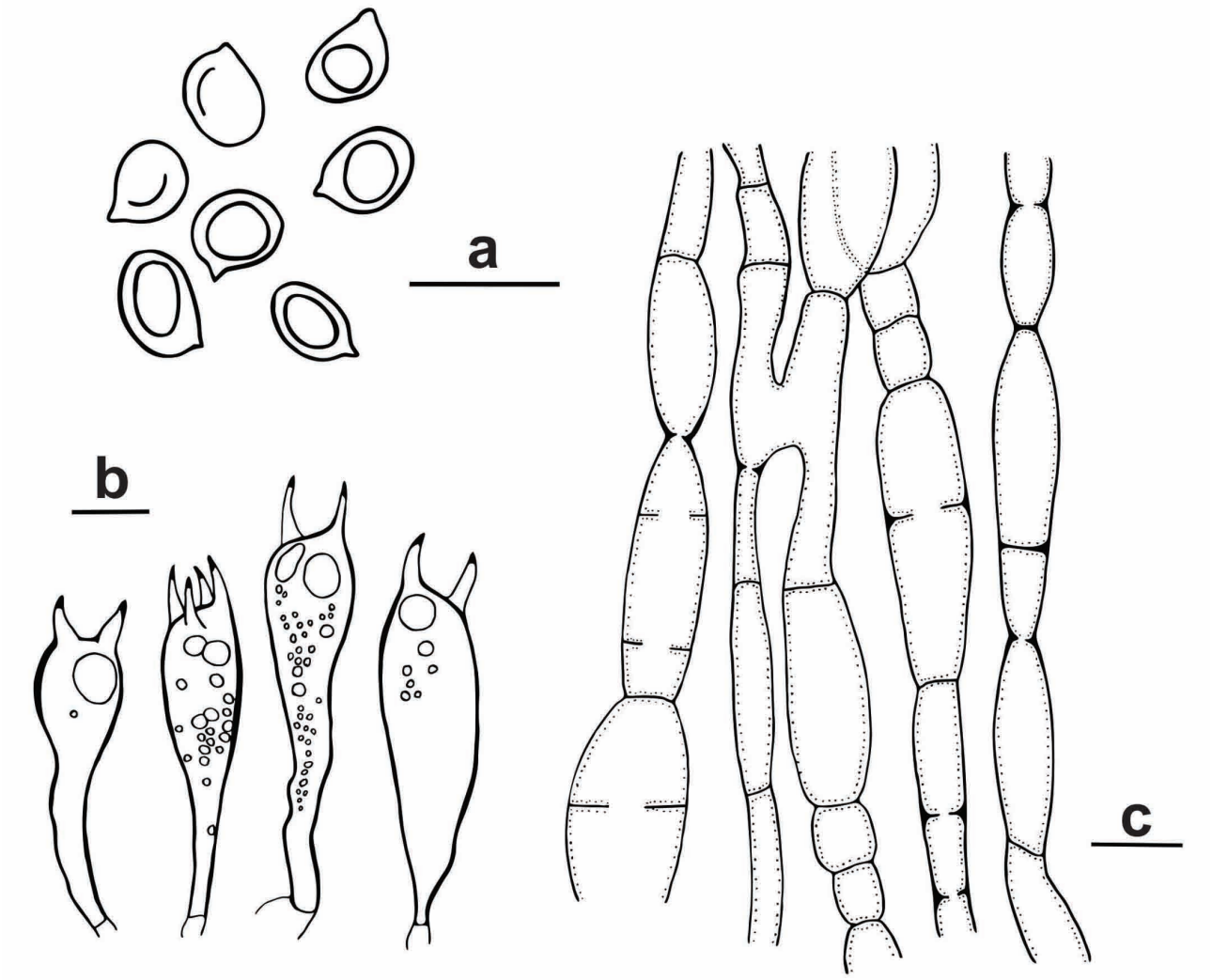

FIGURE 7. Microcharacters of *Clavaria zollingeri* (ANMF 365). **a.** Basidiospores; **b.** Basidia; **c.** Secondarily septate hyphae. Bars = 10 µm.

Specimens examined:—BRAZIL. Santa Catarina: Florianópolis, Morro da Lagoa, Trilha do Jipe, 27º59'43"S, 49º47'83"W, 12 November 2013, *A.N.M. Furtado 365* (FLOR 56149), *ibid.*, 03 December 2013, *A.N.M. Furtado 391* (FLOR 56155); Florianópolis, Trilha para Lagoinha do Leste, 27º59'43"S, 49º47'83"W, 21 May 2014, *A.N.M. Furtado 499* (FLOR 56145). Rio Grande do Sul: São Francisco de Paula, Floresta Nacional de São Francisco de Paula (FLONA), 29º22'58"S, 50º22'32"W, 12 April 2014, *A.C. Magnago 1039, 1043* (FLOR 56151, 56152).

Additional specimens examined:—BRAZIL. Rio Grande do Sul: no location, n.d., *J.E. Rick n.n.* (BPI 332489). Paraná: São José dos Pinhais, Roça Velha, 31 March 2001, *A.A.R. De Meijer 4070* (MBM). Amazonas: Manaus, Reserva Florestal Ducke, 15 June 1978, *E.M.H. Freire 202* (INPA 79050), *ibid.*, 21 April 1977, *R. Singer B9763* (INPA 69937), *ibid.*, 08 June 1978, *E.M.H. Freire 187* (INPA 79037).

Remarks:—*Clavaria zollingeri* is easily found in the forest because of its vivid purplish color. *Clavaria zollingeri* exhibits a lot of morphological variation, is widely distributed and is one of the few branched species of *Clavaria s. str.* Unpublished molecular data show that the tropical collections under this name may be a different species (Olariaga, pers. comm.). The dimension and shape of the basidiospores vary from author to author (Coker 1923, Corner 1967b, Gerault 2005, Shiryaev 2009). This species could be confused with the brittle *Clavulina amethystina* (Bull.) Donk from Europe (Olariaga *et al.* 2009), but it differs microscopically by the bispored basidia and the non-secondarily septate hyphae in the context. *Ramariopsis pulchella* (Boud.) Corner also has a purplish, branched basidioma, but differs by its minutely verrucose basidiospores, clamps in all parts of the basidioma and the presence of crystals in the context at the base of the stipe (Petersen 1988).

Clavulinopsis amoena (Zollingeri & Moritzi 1844: 380) Corner (1950: 352)

Basidiomata (Fig. 1g) 2.5−5.0 × 0.2−0.4 cm, unbranched, caespitose. Clavula light yellow (1A5) to greenish yellow (1A7), paler toward the apex, cylindric and blunt or subclavate, becoming longitudinally rugulose; apex blunt and whitish (5A1); stipe 5.0−15 × 1.0−2.0 mm, generally white-villose or strigose at the base. Context waxy, solid becoming hollow; smell and taste unknown.

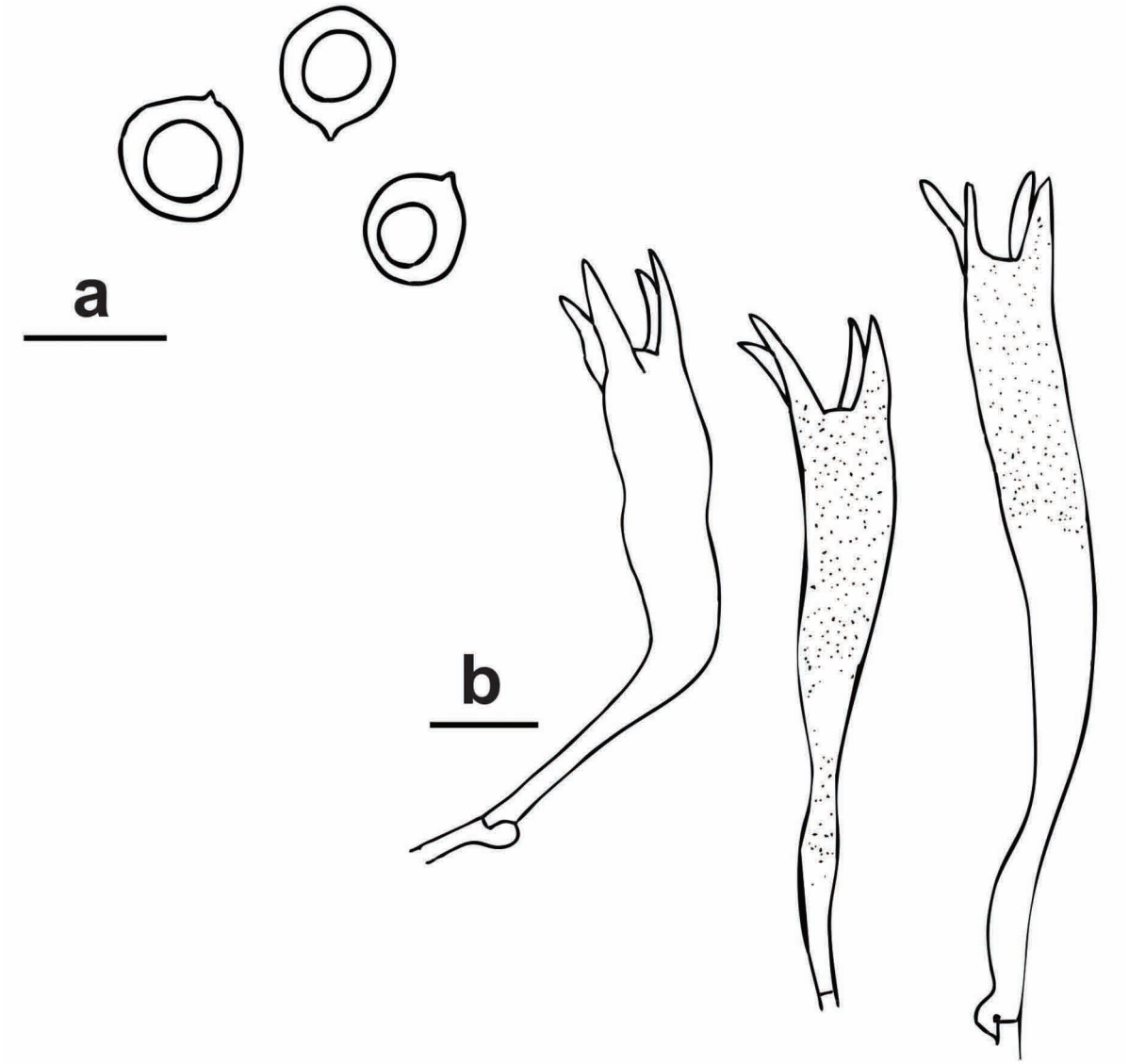

FIGURE 8. Microcharacters of *Clavulinopsis amoena* (KEL 21). **a.** Basidiospores; **b.** Basidia. Bars = 10 µm.

Basidiospores (Fig. 8a) 7.0−9.0 × 7.0−8.5 µm (Q=1.05), globose to subglobose, hyaline, smooth, thin-walled, uniguttulate, with a large guttule that becomes greenish yellow at maturity, inamyloid; hilar appendage to 1.0 µm long. Basidia (Fig. 8b) 46−93 × 8.0−10 µm, subclavate, longer in old hymenia, clamped; 4-sterigmate 9.0−12 µm long. Cystidia absent. Hymenium 40−70 µm thick at base, thickening towards apex, absent on stipe. Subhymenium to 50 µm thick, composed of narrow hyphae 1.5−3.0 µm wide, inflating to 15 µm wide, clamped, with small orange granules that turn green with iodine. Context composed of parallel inflated hyphae 7.0−15 µm wide, partially clamped, thin-walled and longitudinal interweaving hyphae 2.0−7.0 µm wide, derived from the inflated hyphae and binding them together.

Habitat and distribution:—In the Atlantic Forest this species is found on soil with litter. In Brazil it is known from Amazonas, Rio Grande do Sul (Corner 1970) and Santa Catarina (present study). Also known from Bolivia, Colombia, Japan, Panama, Peru (Corner 1970), Solomon Islands (Corner 1967a), Australia, Bonin Islands, Ceylon, Java, Malaysia (Corner 1950), India (Thind & Rattan 1967), Congo (Corner 1966) and USA (Petersen 1979).

Specimens examined:—BRAZIL. Santa Catarina: Urubici, Parque Nacional de São Joaquim (PNSJ), Trilha da Pedra, 28º08'40"S, 49º42'82"W, 17 February 2013, *R.C.S. Friedrich 21* (FLOR 56164).

Additional specimens examined:—BRAZIL. Rio Grande do Sul: Nova Petrópolis, 1923, *J.E. Rick n.n.* (BPI 294820). USA. Pennsylvania: Pocono, 1931, *C.B. Stifler n.n.* (BPI 293702). MALAYSIA. Sabah: Kota Kinabalu, 20 April 1964, *E.J.H. Corner n.n.* (BPI 294819), *ibid.*, 03 May 1964, *E.J.H. Corner n.n.* (BPI 294817). SOLOMON ISLAND. Guadalcanal: Popomanasia, 26 May 1965, *E.J.H. Corner n.n.* (BPI 294816).

Remarks:—*Clavulinopsis amoena* is easily identified by the presence of a short, whitely villous or strigose stipe, globose to subglobose basidiospores, the guttule becoming intense greenish yellow at maturity and small orange granules in the subhymenial hyphae that turn green when exposed to iodine (Corner, 1950). Corner (1950) discussed in detail the variation found in *Cs. amoena* and how it differs from other species. In the field, *Cs. amoena* can be mistaken for *Cs. spiralis* (Jungh.) Corner and also looks like a bright yellow form of *Cs. fusiformis* (Sowerby) Corner. The basidiomata of these three species begin as tufts of slender, cylindric and filiform structures with acute apices. With maturation they become fusiform to clavate as the hyphae inflate and the hymenium thickens. *Clavulinopsis fusiformis* differs by its golden to brownish yellow mature basidiomata and broadly ellipsoid to pip-shaped basidiospores, with a larger hilar appendage (1.0−2.0 µm long) (Corner 1966). *Clavulinopsis spiralis* differs from *Cs. amoena* only by its smaller basidiospores (5.5−7.0 × 4.5−6.5 µm) (Corner 1967a).

Clavulinopsis aurantiocinnabarina (Schweinitz 1832: 183) Corner

Basidiomata (Fig. 1h) 4.0−6.3 × 0.1−0.2 cm, unbranched, caespitose, sometimes gregarious. Clavula golden yellow (5B7) to deep orange (6A8), fading to buff orange (6A5), cylindric, flattened and rugulose; apex subacute to blunt; stipe indistinct. Context deep orange (6A8), not fading, slightly brittle; smell and taste unrecorded. Basidiospores (Fig. 9a) 6.0−7.0 × 6.0−6.5 µm (Q=1.07), subglobose, hyaline, sometimes pale yellow, smooth, thin-walled, uniguttulate, inamyloid; hilar appendage up to 1.0 µm long. Basidia (Fig. 9b) 43−51 × 7.0−9.0 µm, cylindric-clavate, clamped, immersed in a paraphysoid hymenium; sterigmata (2−) 4, 5.0−9.0 µm long, often with elongate aborted sterigmata. Cystidia absent. Hymenium 70−130 µm thick, with small and irregular crystals. Subhymenium 50−75 µm thick, composed of narrow hyphae 1.5−3.5(−4.0) µm wide, clamped, not inflated. Context with subparallel, hyaline and thin-walled hyphae, clamped; hyphae to 14 µm wide, slightly inflated at the center of the context, and hyphae to 5.0 µm wide, not inflated, next to the subhymenium. Surface of sterile base in two layers; cortical layer to 120 µm thick, perpendicular to medullary layer, with cylindric interwoven hyphae 2.5−3.5 µm wide, loosely attached, thick-walled, clamped; medullary layer composed of slightly inflated and subparallel hyphae, hyphae 7.0−12 µm wide, interwoven with narrow hyphae up to 5.0 µm wide, clamped.

Habitat and distribution:—In the Atlantic Forest this species is found on soil with litter, in the shade. In Brazil it is known from Amazonas (De Lamônica-Freire 1979), Paraná (De Meijer 2006) and Santa Catarina (present study). Also known from Canada, China, Panama, Venezuela, Trinidad (Corner 1950, 1970) and Thailand (Maneevun & Sanouamuang 2010).

Specimen examined:—BRAZIL. Santa Catarina: Florianópolis, Morro da Lagoa, Trilha do Jipe, 27º59'43"S, 49º47'83"W, 03 December 2013, *A.N.M. Furtado 392* (FLOR 56176).

Additional specimens examined:—BRAZIL. Pernambuco: Recife, IPA, 14 June 1951, *J.N, Silva n.n.* (URM 499). Amazonas: Manaus, *Campus* do INPA, 26 January 1978, *H. Caldas de Souza* & *M.M.N. Braga n.n.* (INPA 72737); Itacoatiara, Reserva Florestal Ducke, 26 May 1978, *E.M.H. Freire n.n.* (INPA 79031). USA. Ohio: Maumee Valley, 1922, *W.R. Lowater n.n.* (BPI 295438), *ibid.*, *L.D. von Schweinitz n.n.* (K 175527).

Remarks:—*Clavulinopsis aurantiocinnabarina* is unmistakable in the field, due to its vivid yellow-orange color and non-existent stipe. The stratified sterile surface is diagnostic of this species (Corner 1950). Petersen (1968) comments that the rich orange and reddish pink states of *Cs. amoena* are a pale form of *Cs. aurantiocinnabarina*. Both of these species have subglobose basidiospores, which are slightly wider in *Cs. amoena*, and inflated hyphae in the trama (Petersen 1968). However, *Clavulinopsis amoena* is lighter in color and has a distinct strigose stipe and indistinct sterile base (Corner 1970, Maneevum & Sanoamuang 2010).

Clavulinopsis dimorphica A.N.M. Furtado & M.A. Neves, ***sp. nov.***
MB 816058

Diagnosis:—Basidiomata branched, solitary, yellow, orange-yellow to deep orange; branches subfastigiate, viscid, subcylindric, divided 2−3 times; basidiospores dimorphic, hyaline, oblong (8.0−9.5 × 3.5−5.5 µm) to broadly ellipsoid (6.5−7.5 × 4.0−6.0 µm); basidia dimorphic, clamped, 1 or 4-sterigmata; surface of sterile base covered by a trichodermal pellis composed of clampless cylindric hyphae (2.0−5.0 µm wide).

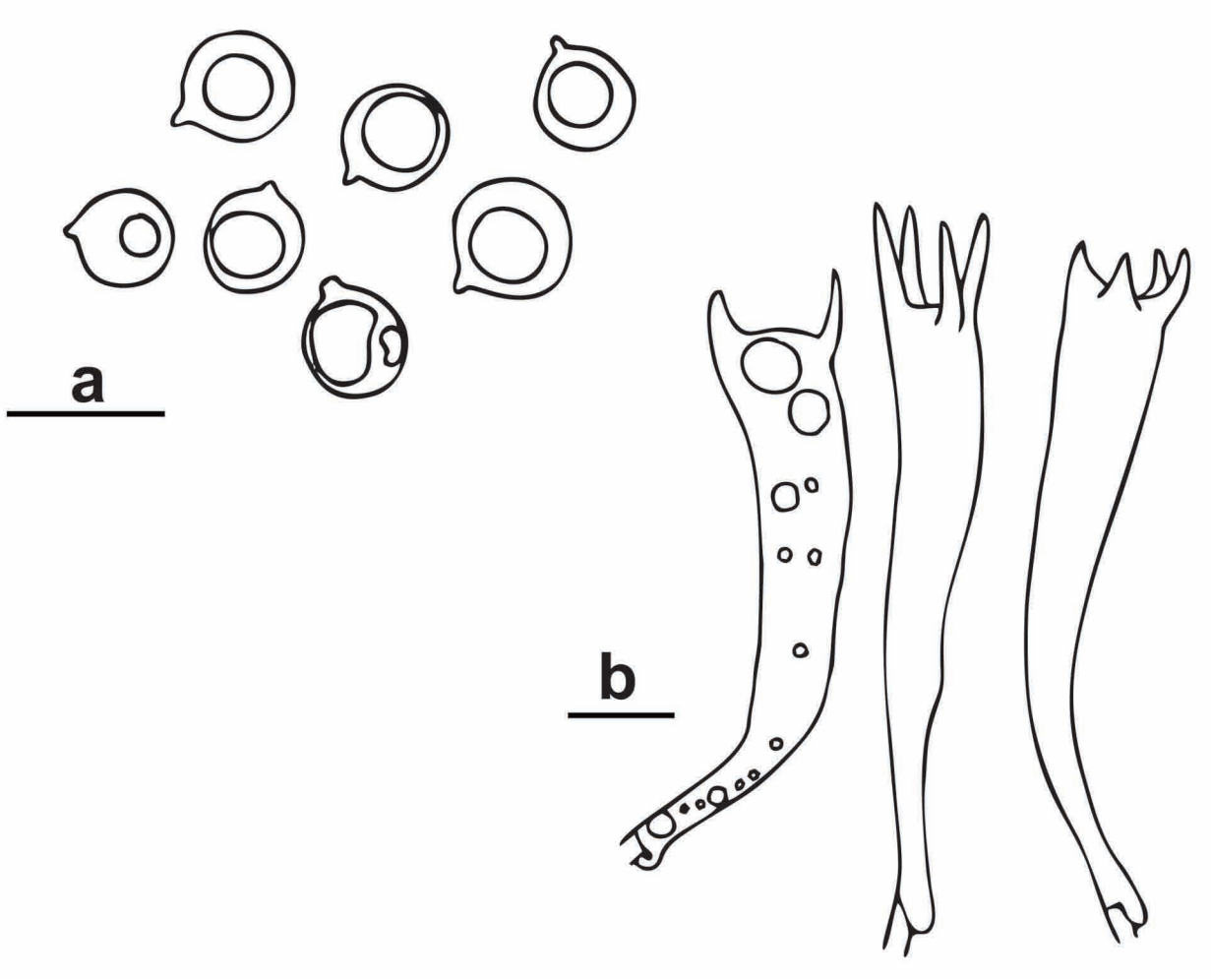

FIGURE 9. Microcharacters of *Clavulinopsis aurantiocinnabarina* (ANMF 382). **a.** Basidiospores; **b.** Basidia. Bars = 10 µm.

Etymology:—The name refers to the dimorphism of the basidia and basidiospores.

Holotype:—BRAZIL. Rio Grande do Sul: São Francisco de Paula, Floresta Nacional de São Francisco de Paula (FLONA), 29º22'58"S, 50º22'32"W, 10 April 2014, *A.C. Magnago 1051* (FLOR 56316).

Basidiomata (Fig. 1i) to 6.0 cm high, branched, solitary, yellow (3B7), orange-yellow (4B8) to deep orange (5A8), drying pale yellow (2B4); branches 3.0−5.0 mm wide, subfastigiate, smooth, viscid, subcylindric, firm, divided 2−3 times, dichotomous upwards, internodes gradually diminishing, axils U-shaped; apices concolorous with the branches, bifid and blunt or somewhat subulate; stipe 15 × 6.0 mm, smooth, slightly grooved at the base, concolorous with the branches. Context concolorous with the branches, solid, rather tough; smell and taste absent.

Basidiospores (Fig. 10a) dimorphic, the majority 8.0−9.5 × 3.5−5.5 µm (Q= 1.91), oblong, some 6.5−7.5 × 4.0−6.0 µm (Q=1.29), broadly ellipsoid, both hyaline, smooth, thin-walled, uniguttulate, inamyloid; hilar appendage 0.5 µm long, sublateral. *Basidia* (Fig. 10b) 50−64 × 6.0−10 µm, clavate-elongate, multiguttulate, clamped; sterigmata 1 or 4, 21−32 µm and 4.0−7.0 µm long respectively. Cystidia absent. Hymenium 75 µm in width, thickening towards the apex up to 160 µm, absent in stipe. Subhymenium hardly differentiated. Context with subparallel to interweaving hyphae 3.5−10 µm wide, clamped and thin-walled. Surface of sterile base covered by a trichodermal pellis composed of clampless cylindric hyphae 2.0−5.0 µm wide.

Habitat and distribution:—On the soil with litter, in the moist Atlantic Forest with *Araucaria angustifolia*. Known only from the type locality.

Remarks:—The size of both the hilar appendage and the basidiospore wall are important taxonomic characters used to identify species of *Clavulinopsis* (Corner 1950). The presence of a short hilar appendage is commonly associated with species of subg. *Paraclavaria* if the basidiospores are ellipsoid, and with species of subg. *Clavulinopsis* if the basidiospores are subglobose to broadly ellipsoid (Corner 1950, 1970, Petersen 1978). The dimorphism and the shapes of the basidiospores of *Clavulinopsis dimorphica* do not fit Corner's infrageneric classification (Corner 1970). Also,

it has been suggested that the spore morphology has changed several times during the diversification of the genus and should not be used to separate groups (Kautmanová *et al*. 2012). *Clavulinopsis corniculata* and *Cs. dimorphica* have branched, yellowish basidiomata; however *Cs. corniculata* has globose basidiospores (5.5−6.0 × 5.0−5.5 µm) and only four-spored basidia (Petersen 1979). Some parthenogenetic basidiomata with one or two sterigmata can be found in *Cs. corniculata*, but these have subglobose spores and clampless basidia (Olariaga 2009, Maas Geesteranus 1976).

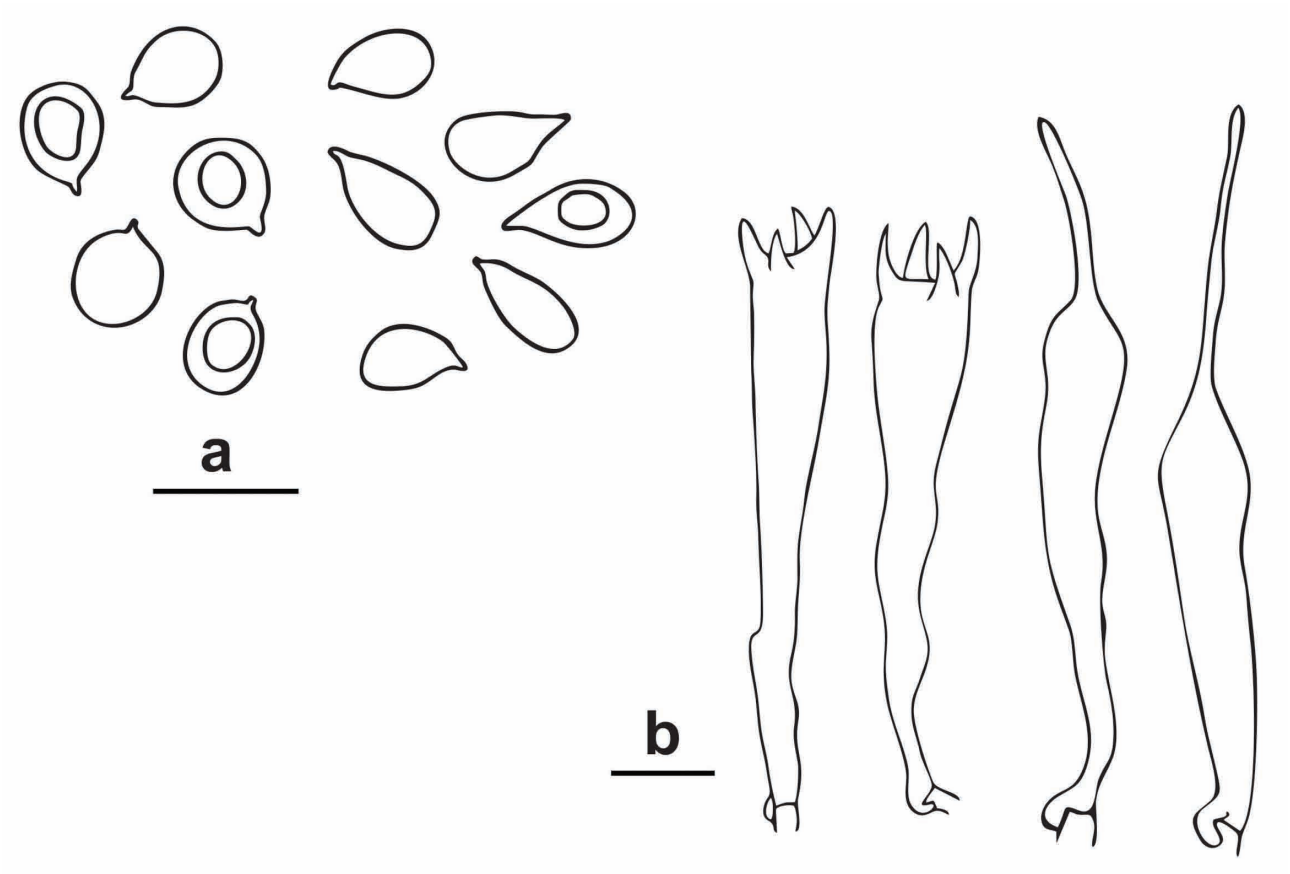

FIGURE 10. Microcharacters of *Clavulinopsis dimorphica* (ACM 1051). **a.** Basidiospores; **b.** Basidia. Bars = 10 µm.

Clavulinopsis helvola (Persoon 1797: 69) Corner (1950: 372)

Basidiomata (Fig. 1j) 6.0 × 0.1−0.5 cm, unbranched, solitary. Clavula light yellow (2A5) to orange yellow (4B7), fading to buff orange (6A5), subcylindric, apex blunt; stipe 10 × 1.0−2.0 mm, distinct at the narrower basal part of the basidioma, pale yellow (4A3). Context white to yellowish, solid, subfloccose, waxy; smell and taste absent.

Basidiospores (Fig. 11ac) 5.0−7.0 × 4.2−6.5 µm (Q=1.29), subglobose to broadly ellipsoid, hyaline, thin-walled, uniguttulate, sharply angular to tuberculous, with spines or warts 1.0−1.5 µm long, inamyloid; hilar appendage indistinct. Basidia (Fig. 11b) 38−59 × 7.0−11 µm, subclavate, clamped; (2−)4 sterigmata 7.0−9.0 µm long. Cystidia absent. Hymenium 70−125 µm thick, absent in stipe. Subhymenium 25−50 µm thick, composed of closely interwoven hyphae 3.0−4.0 µm wide, clamped; tortuous; basidia in clusters or bouquets. Context with subparallel hyphae; branching and anastomosing abundantly, of two different widths: 5.0−10 µm wide, slightly constricted at the septa, and 2.5−3.0 µm wide, not inflated, both interweaving, hyaline, clamped and thin-walled.

Habitat and distribution:—In the Atlantic Forest this species is found on soil with litter. In Brazil it is known only from Santa Catarina (present study). Also known from South Africa, Australia, Japan, USA (Corner 1950), India (Thind & Rattan 1967), Switzerland (Breitenbach & Kränzlin 1986), Denmark, Finland, Iceland, Norway, Sweden (Hansen & Knudsen 1997), France (Gerault 2005), Estonia (Shiryaev 2009), Spain (Olariaga 2009) and Tahiland (Maneevun & Sanoamuang 2010).

Specimens examined:—BRAZIL. Santa Catarina: Florianópolis, Morro da Lagoa, Trilha do Jipe, 27º59'43"S, 49º47'83"W, 01 July 2013, *R.C.S. Friedrich 34* (FLOR 56177).

Additional specimens examined:—UGANDA. Kyetume: Kyagwe, Banana plantation, 1915, *R.A. Dummer n.n.* (BPI 294872). INDIA. Jabber Khet: Mussoorie, Uttar Pradesh, 07 September 1968, *S.S. Rattan n.n.* (BPI 294868).

BRAZIL. Rio Grande do Sul: Parecí Novo, 1918, *J.E. Rick n.n.* (BPI 294557).

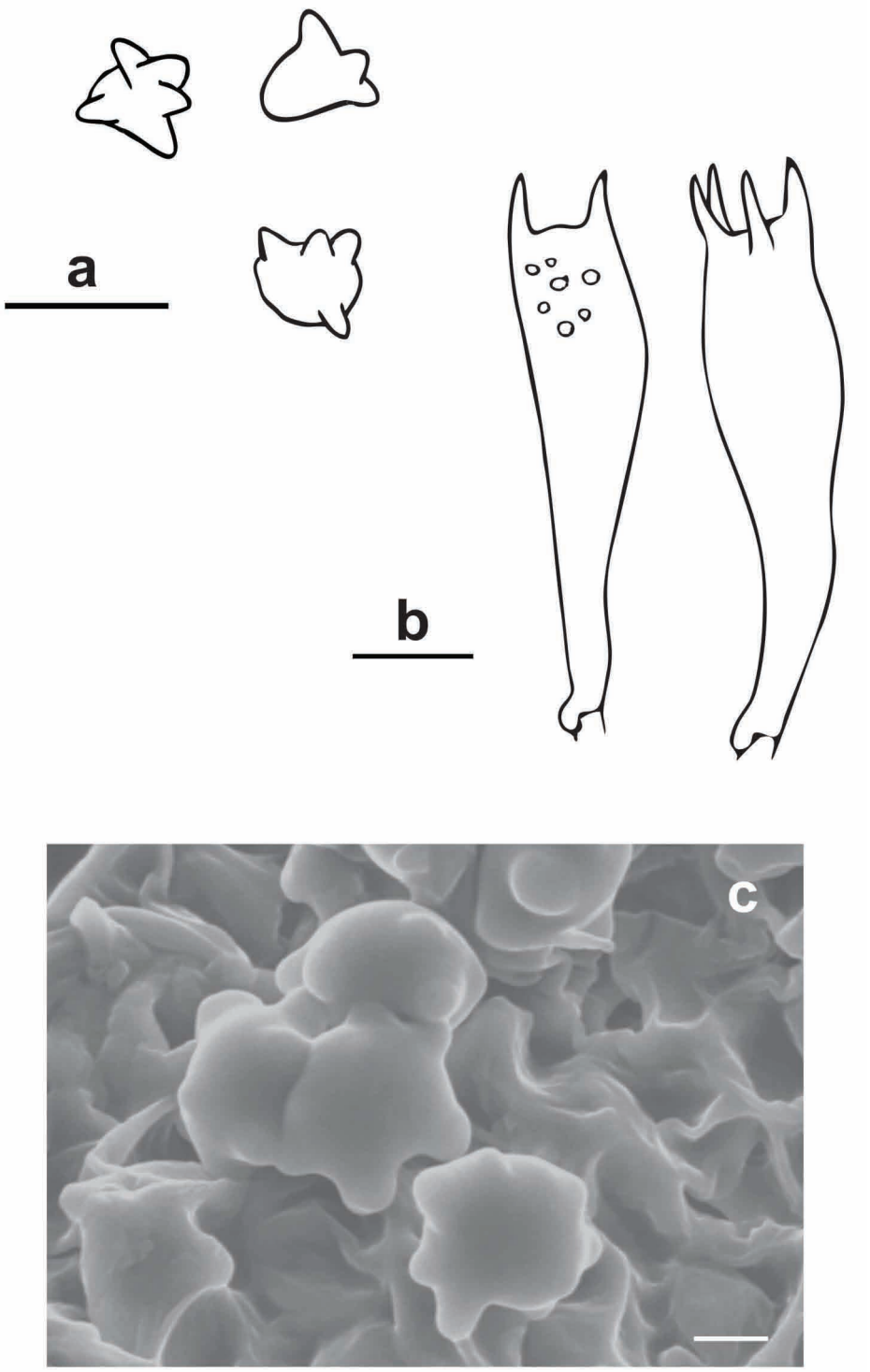

FIGURE 11. Microcharacters of *Clavulinopsis helvola* (KEL 34). **a.** Basidiospores; **b.** Basidia; **c.** SEM of the basidiospores. Bars (**a**, **b**) = 10 µm (**c**) = 2.0 µm.

Remarks:—*Clavulinopsis helvola* is easily recognized by its unbranched, club-shaped, yellow basidiomata and spiny basidiospores (Petersen 1968). This is the only species of *Clavulinopsis* with spiny basidiospores. Although the basidiospores of this species vary in size (4.0−7.2 × 3.6−7.0 µm), our measurements agree with those observed by several other authors (Corner 1950, Petersen 1968, Pegler & Young 1985, Adamčík 2009). Petersen (1978) included *Cs. helvola* in a subgenus of *Ramariopsis* (= *Ramariopsis helvola* (Pers. : Fr.) R.H. Petersen) based on the basidiospores with thick tuberculous ornamentation. Pegler & Young (1985) recognized several types of basidiospore ultrastructure and observed that all members of *Ramariopsis s. str.* have warts formed by the tunica. Spines of *Ramariopsis helvola* are formed from the growth of the corium. Therefore, the species is placed in *Clavulinopsis*. *Clavulinopsis laeticolor* (Berk.

& M.A. Curtis) R.H. Petersen is similar to *Cs. helvola* based on the color of the basidioma; however, *Clavulinopsis laeticolor* has smooth, ellipsoid, pip-shaped basidiospores (Petersen 1968).

Clavulinopsis imperata A.N.M. Furtado & M.A. Neves, ***sp. nov***.
MB 816059

Diagnosis:—This species is characterized by its unbranched, light yellow to greenish yellow strigose basidiomata; subglobose hyaline basidiospores (6.0−8.0 × 6.0−7.5 µm) with a large guttule that becomes greenish yellow in mature basidiospores; basidia clamped, 4-sterigmate; context with subparallel, inflated, irregularly thick-walled hyphae; clamps scattered and inconspicuous.

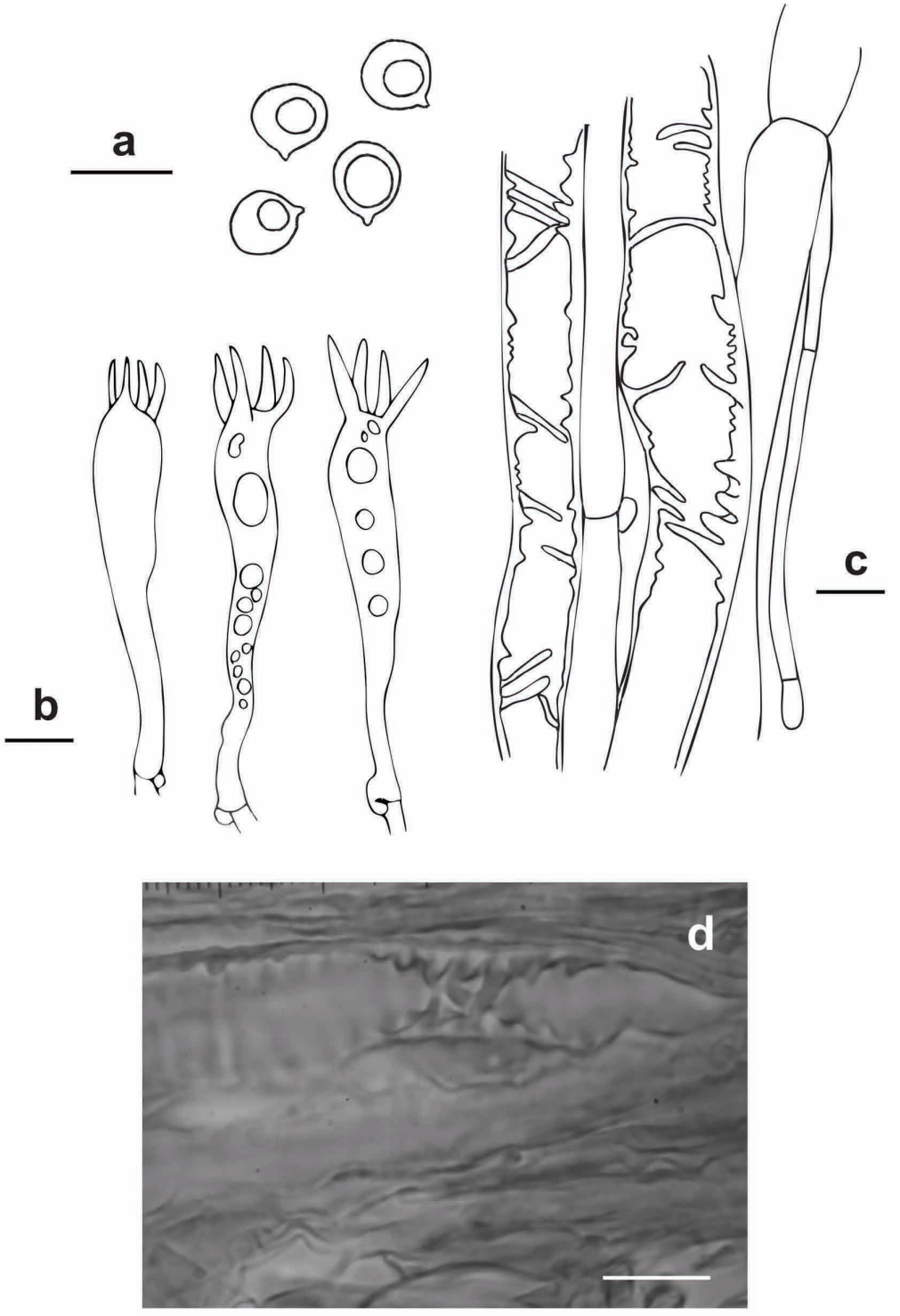

FIGURE 12. Microcharacters of *Clavulinopsis imperata* (ANMF 482). **a.** Basidiospores; **b.** Basidia; **c.** Hyphae with irregularly thickened wall; **d.** Hyphae with irregularly thickened walls. Bars = 10 µm.

Etymology:—The name refers to the type location, Santo Amaro da Imperatriz.

Holotype:—BRAZIL. Santa Catarina: Santo Amaro da Imperatriz, Hotel Plaza Caldas da Imperatriz, Trilha da Pousada, 27º70'39"S, 48º80'37"W, 26 July 2013, *A.N.M. Furtado 482* (FLOR 56313).

Basidiomata (Fig. 1k) 2.7−5.5 × 0.3−0.8 cm, unbranched, solitary. Clavula light yellow (2A5) to greenish yellow (2B8), spathulate, flattened, strigose, apex subacute; stipe 1.0 × 0.3 cm, fairly distinct, slightly strigose at the base. Context solid, becoming hollow, pale yellow (1A3); smell and taste unknown.

Basidiospores (Fig. 12a) 6.0−8.0 × 6.0−7.5 µm (Q=1.08), subglobose, hyaline, smooth, thin-walled, uniguttulate, with a large guttule that becomes greenish yellow at maturity, inamyloid; hilar appendage up to 1.0 µm long. Basidia (Fig. 12b) 43−54 × 7.0−10 µm, subclavate, clamped; 4-sterigmate, 6.0−12 (−20) µm long. Cystidia absent. Hymenium 65−75 µm thick, absent in stipe. Subhymenium 25−37 µm thick, composed of inflated hyphae 9.5−11 µm wide, partially clamped. Context (Fig. 12cd) with subparallel 7.0−15 µm wide, inflated, thin-walled but with many irregularly thick-walled hyphae (Fig. 12d), hyaline, clamps scattered and inconspicuous.

Habitat and distribution:—In the Atlantic Forest this species is found on soil with litter. Known only from the type locality.

Remarks:—In the field, *Clavulinopsis imperata* can be mistaken for *Cs. amoena* due to the morphology of the basidiomata, especially because of its greenish yellow color. However, *Cs. amoena* typically has thin-walled hyphae and small orange granules in the subhymenial hyphae that become green when exposed to iodine (Corner 1950). *Clavulinopsis spiralis* is also similar, but differs from *Cs. imperata* by its smaller basidiospores (5.5−7.0 × 4.0−6.5 µm) and the absence of irregularly thick-walled hyphae (Corner 1950, Petersen 1968, 1978). The presence of irregularly thick-walled hyphae in the context has not been described in previous works about *Clavulinopsis* (Corner 1950, 1967a, 1967b, 1970, Petersen 1968, 1978, 1979) and is a characteristic that should be checked in other species of the genus.

Clavulinopsis laeticolor (Berkeley. & M.A. Curtis 1869: 338) R.H. Petersen (1965: 522)

Basidiomata (Fig. 1l) 1.5−9.5 × 0.1−0.6 cm, unbranched, solitary, gregarious, fasciculate in small tufts. Clavula yellowish orange (4B7) to deep orange (6A8) or reddish orange (7B8), drying deep orange (6A8), cylindric and acute, often somewhat flattened, compressed, sometimes rugulose; apices concolorous with clavula but discoloring to brownish orange (6C7) in age, blunt; stipe 10−25 × 1.0−2.0 mm, distinct, finely subtomentose when dry, often with white mycelium at the base. Context pale, often hollow, floccose, not brittle; smell and taste absent.

Basidiospores (Fig. 13a) 5.5−8.0 × 3.5−6.0 µm (Q=1.56), ellipsoid to pip-shaped, hyaline (old basidiospores stain yellow), smooth, slightly thick-walled, uniguttulate, inamyloid; hilar appendage prominent 1.0−2.0 µm long, often sublateral. Basidia (Fig. 13b) 32−58 × 4−10 µm, clavate-elongate, clamped; (1−)4 sterigmata, 4.0−13 µm long (−17 µm on monosporic basidia). Cystidia absent. Hymenium 35−125 µm thick, absent in stipe. Subhymenium ca. 45 µm thick, with tortuous hyphae 1.5−4.0 µm wide, clamped, producing basidia in clusters or bouquets. Context (Fig. 13c) with parallel hyphae 3.0−13.0 µm wide, clamped, not constricted at the septa, with yellowish orange irregular intraparietal pigments on the medullary hyphae, slightly thick-walled, clamped. Surface of sterile base covered by projecting cylindrical hyphae to 3.0 µm wide, clamped.

Habitat and distribution:—In the Atlantic Forest this species is found on soil with litter and on road banks, in the shade. In Brazil it is known from Amazonas (De Lamônica-Freire 1979), Rio Grande do Sul (Rick 1959, present study) and Santa Catarina (present study). The species is also known from China, Germany, Great Britain, The Netherlands, Italy, USA (Corner 1950, Petersen 1965), Estonia (Shiryaev 2009), France (Corner 1950, Gerault 2005), Spain (Tabarés & Rocabruna 1991), Switzerland (Breitenbach & Kränzlin 1986), India (Corner 1970, Swapna *et al.* 2008), Australia (Petersen 1979), Argentina, Austria, Bolivia, Chile, Costa Rica, Jamaica, Panama, New Zealand, Peru, Sweden (Corner 1970), Malaysia (Corner 1970, Petersen 1978, 1988), Denmark, Finland, Norway (Hansen & Knudsen 1997) and Thailand (Maneevun & Sanoamuang 2010).

Specimens examined:—BRAZIL. Paraná: Piraquara, Morro do Canal, 25º50'91"S, 48º97'75"W, 26 January 2014, *A.C. Magnago 911* (FLOR 56158). Rio Grande do Sul: São Francisco de Paula, Floresta Nacional de São Francisco de Paula (FLONA), 29º22'58"S, 50º22'32"W, 13 April 2014, *A.C. Magnago 1052, 1054* (FLOR 56168, 56169). Santa Catarina: Florianópolis, Morro da Lagoa, Trilha do Jipe, 27º59'43"S, 49º47'83"W, 12 November 2013, *A.N.M. Furtado 364* (FLOR 56170), *ibid.*, 01 July 2013, *R.C.S. Friedrich 33* (FLOR 56178), *ibid.*, 16 January 2014, *A.N.M. Furtado 385* (FLOR 56161); Florianópolis, Trilha para Lagoinha do Leste, 27º59'43"S, 49º47'83"W, 21 May 2014, *A.N.M. Furtado 494, 495* (FLOR 56159, 56160); Florianópolis, Ilha do Campeche, 27º69'64"S, 48º46'51"W, 06 July 2013, *E.R.Dreschler-Santos 1085* (FLOR 56171); Florianópolis, Trilha para Naufragados, 16 January 2014, *A.N.M. Furtado 440* (FLOR 56166); Santo Amaro da Imperatriz, Hotel Plaza Caldas da Imperatriz, Trilha da Pousada, 27º70'39"S,

48º80’37”W, 26 July 2013, *A.N.M. Furtado 315, 316* (FLOR 56156, 56157); Águas Mornas, Sítio Portal, 17 December 2013, *C. Heisecke 201* (FLOR 56165); São Francisco do Sul, Parque Estadual do Acaraí, 26º31’22”S, 48º55’68”W, 05 August 2014, *F.Mafalda-Freire 242* (FLOR 56172), *ibid.*, 05 August 2014, *J.A. Duque 71, 79* (FLOR 56173, 56174).

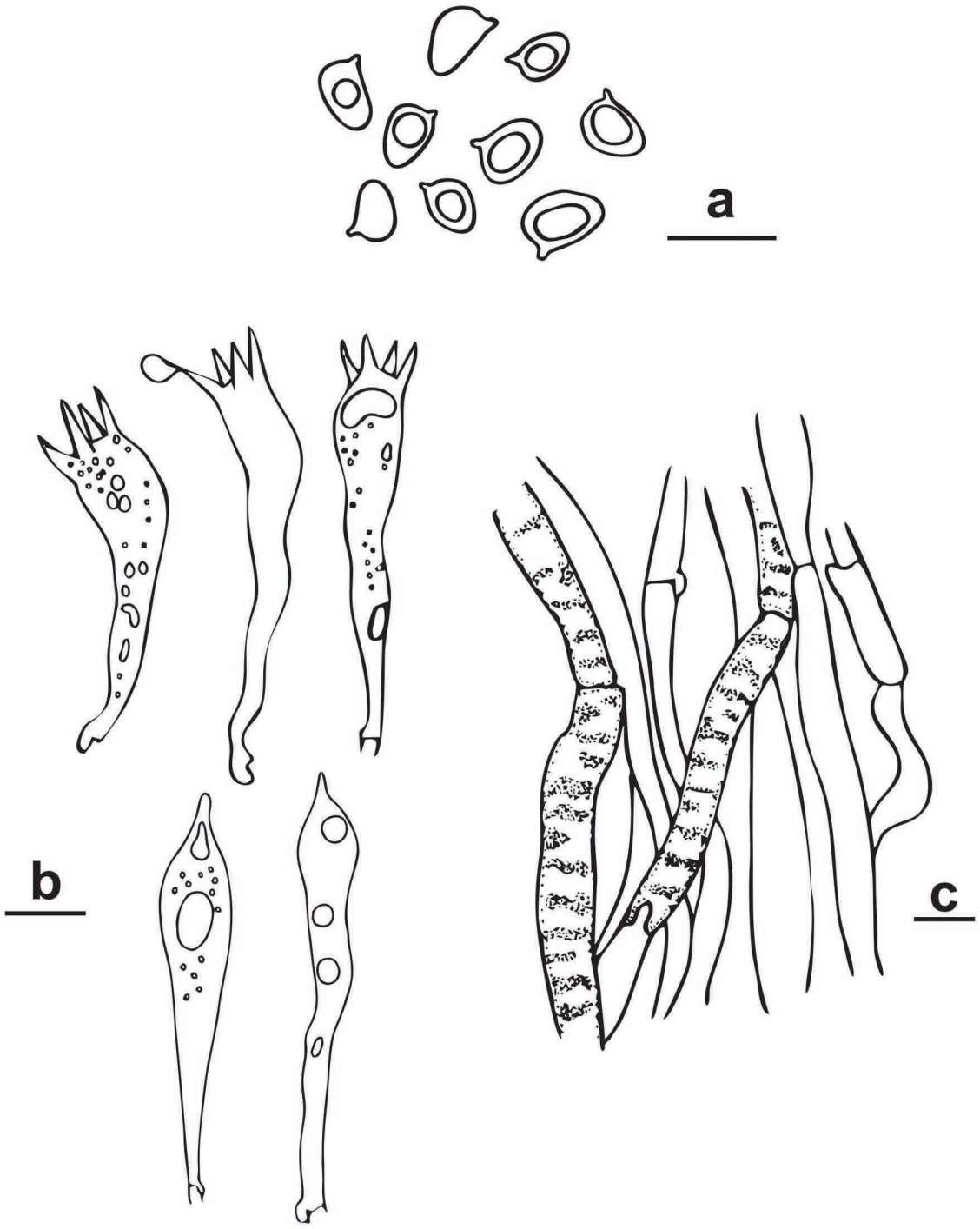

FIGURE 13 Microcharacters of *Clavulinopsis laeticolor* (ANMF 495). **a.** Basidiospores; **b.** Hyphae with intraparietal pigments; **c.** Basidia. Bars = 10 µm.

Additional specimens examined:—BRAZIL. Rio Grande do Sul: *J. Rick n.n.* (Lloyd Catalogue n. 30205, 57698). Amazonas: Manaus, Estrada para Caracaraí km 45, 22 May 1978, *R. Singer n.n.* (INPA 79015), *ibid.*, 21 June 1977, *E.M.H. Freire n.n.* (INPA 79021). INDIA. Dhanaulti, Mussoorie, Uttar Pradesh, 31 August 1968, *S.S. Rattan n.n.* (BPI 294884). SLOVAKIA. Lysá, 2005, *V. Kautman n.n.* (K 158310). USA. New York: Northville & Chittenango Falls, n.d., *E.J.H. Corner n.n.* (BPI 284886, holotype).

Remarks:—*Clavulinopsis laeticolor* is conspicuous in the field due to its bright orange color that contrasts with the soil and leaf litter. The species is easily characterized by its gregarious to fasciculate basidiomata, which become

finely subtomentose when dried and have distinct stipes (Petersen 1965). Although some characteristics can be very variable, such as the color of the basidiomata and the size of the basidia, the context and basidiospores are constant in the species (Petersen 1979). *Clavulinopsis laeticolor* is similar to *Cs. fusiformis*, a widely distributed taxon (Corner 1970). *Clavulinopsis fusiformis* differs by its densely fasciculate to caespitose habit, indistinct stipe and globose to subglobose basidiospores (Corner 1950). As previously discussed, *Cs. helvola* shares some macromorphological characteristics with *Cs. laeticolor*, but *Cs. helvola* has subglobose to broadly ellipsoid basidiospores that are sharply angular to echinulate-warted and 5.5−7.2 × 4.5−5.7 µm (Petersen 1968). The presence of incrustations on the inner walls of the hyphae is here described for the first time for this species for the majority of the specimens found in southern Brazil (e.g., FLOR 56158, 56168, 56169, 56170, 56161, 56159, 56160, 56171, 56156, 56157, 56165, 56172, 56173). We do not consider the presence of this character sufficient to distinguish these collections as a distinct species. The incrustations could be due to environmental or chemical changes that induce their formation and were not observed in any of the other herbarium specimens studied. These structures can only be seen in 3% KOH plus Congo Red.

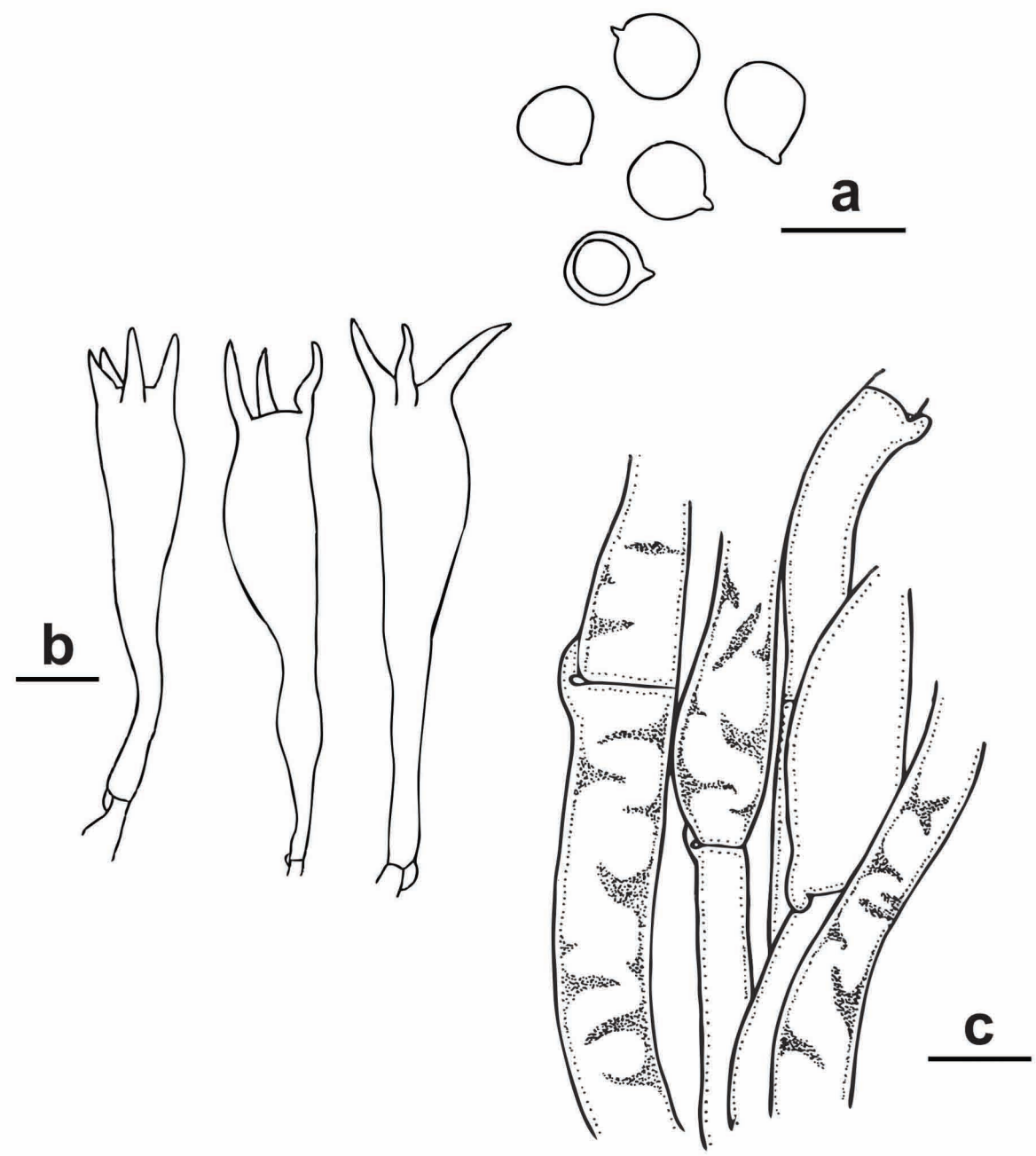

FIGURE 14. Microcharacters of *Clavulinopsis spiralis* (MAN 1077). **a.** Basidiospores; **b.** Basidia; **c.** Hyphae with intraparietal pigments. Bars = 10 µm.

Clavulinopsis spiralis (Junghuhn 1838: 32) Corner (1950: 388)

Basidiomata (Fig. 1m) 4.0−10 × 0.1−0.4 cm, unbranched, caespitose, rare, gregarious. Clavula light yellow (4A5), cylindric or subfusiform, often compressed, longitudinally rugulose, twisted and flexuous, apices white (1A1) and acute, becoming light yellow (1A5) with age, greenish yellow (1A7) and blunt when mature; stipe 2.0−15 × 1.0−2.0 mm, indistinct, slightly strigose at base. Context waxy, solid becoming hollow; smell and taste unrecorded.

Basidiospores (Fig. 14a) 5.5−7.0 × 4.5−6.0 µm (Q=1.04), globose, hyaline, smooth, thin-walled, uniguttulate, with a large guttule, inamyloid; hilar appendage up to 1.0 µm long. Basidia (Fig. 14b) 35−62 × 5.0−13 µm, clavate, clamped; (3−)4-sterigmate 6.0−11 µm long. Cystidia absent. Hymenium 40−155 µm thick at first, absent in stipe. Subhymenium to 42.5 µm thick. Context (Fig. 14c) with parallel hyphae to 13 µm wide, clamped, inflated, slightly thick-walled, with many narrow, longitudinal and interweaving hyphae 2.0−7.0 µm wide with yellowish irregular intraparietal pigments, clamped.

Habitat and distribution:—In the Atlantic Forest this species is found on soil in the shade. In Brazil it is known from Amazonas (De Lamônica-Freire 1979), Paraná (De Meijer 2006, as *Clavulinopsis* aff. *spiralis*) and Santa Catarina (present study). Also known from Congo (Corner 1966), Australia, Ceylon, Java, Malaysia and Trinidad (Corner 1950, 1970).

Specimens examined:—BRAZIL. Santa Catarina: Itapoá, Reserva Volta Velha, 26º08'50"S, 49º04'07"W, 18 November 2012, *M.A. Neves 1077* (FLOR 56163); Florianópolis, Parque Municipal das Dunas da Lagoa da Conceição, 27º60'83"S, 48º45'58"W, 19 March 2013, *A.N.M. Furtado 301* (FLOR 56162).

Additional specimens examined:—AUSTRALIA. Victoria, Carnegie: n.d., *J.T. Paul n.n.* (BPI 332533). BRASIL. Amazonas: Manaus, Estrada para Caracaraí Km 115, 22 May 1978, *R. Singer n.n.* (INPA 79016), *ibid*., 20 July 1978, *R. Singer n.n.* (INPA 80976). MALAYSIA. Gunong Panti: Johore, 20 April 1930, *E.J.H. Corner n.n.* (BPI 294893).

Remarks:—Based on macroscopic characteristics *Cs. spiralis* could be mistaken for a pale form of *Cs. amoena*. However, the subhymenial hyphae of *Cs. amoena* have small granules that turn green when exposed to iodine and the basidiospores of this species are wider (7.0−9.0 × 7.0−8.5 µm) and subglobose (Corner 1950). Meijer (2006) collected specimens in Paraná that he named *Cs.* aff. *spiralis*. Unfortunately the four collections deposited at MBM were on loan when the manuscript was prepared and we could not have access to them.

Ramariopsis kunzei (Fries 1821: 474) Corner (1950: 640)

Basidiomata (Fig. 1n) 4.5−6.0 cm high, solitary to gregarious, white (1A1) or pale yellow (1A2), branched up to four times at the apex; branches 1.0−3.0 mm wide, polychotomous below, becoming narrow and dychotomous above, erect, more or less parallel to the main axis, cylindric; axils narrowly U-shaped, apices acute to blunt, never cristate; stipe 5.0−25 × 2.0−6.0 mm, distinct, becoming pale yellow (1A2), shortly villose-tomentose. Context slightly brittle, tough when dry; taste and smell unrecorded.

Basidiospores (Fig. 15ac) 3.5−4.5 × 3.0−3.5 µm (Q=1.15), subglobose to broadly ellipsoid, hyaline, minutely echinulate to asperulate, spines 0.3−0.5 µm long, uniguttulate, slightly dextrinoid; hilar appendage short (less than 0.5 µm). Basidia (Fig. 15b) 25−38 × 4.0−7.0 µm, clavate, clamped; 2-sterigmate 4.0−5.0 µm long. Cystidia absent. Hymenium *ca.* 40 µm thick at first, thickening upwards to 150 µm, absent in stipe. Subhymenium to 28.5 µm thick, composed of loosely interwoven hyphae to 5.0 µm wide, clamped and thin-walled. Context with subparallel hyphae 12−15 µm wide, clamped, inflated, thin-walled. Surface of sterile base formed by loosely interwoven hyphae 2.0−4.5 µm wide, clamped, thin-walled.

Habitat and distribution:—It is widespread in temperate, tropical and subtropical forests (Corner 1967a). In the Atlantic Forest this species is usually found on soil and occasionally on decayed wood. In Brazil it is known from Paraná (De Meijer 2006), Rio Grande do Sul (Rick 1959) and Santa Catarina (present study). Also reported for Borneo, Ceylon, China, Colombia, Costa Rica, Cuba, Guadalupe, Jamaica, Java, Panama, Philippines, New Zealand, Solomon Islands (Corner 1950, 1970), USA (Burt 1922), Canada (Coker 1923), India (Thind 1961), Spain (Tabarés & Rocabruna 1991), Czechoslovakia, Denmark, Estonia, France, Germany, Great Britain, Ireland, The Netherlands, Sweden (Jülich 1984), Iceland and Norway (Hansen & Knudsen 1997).

Specimens examined:—BRAZIL. Santa Catarina: Florianópolis, Morro da Lagoa, Trilha do Jipe, 27º59'43"S, 49º47'83"W, 09 April 2013, *A.C. Magnago 595, 596* (FLOR 56180, 56181).

Additional specimens examined:—BRAZIL. Rio Grande do Sul: São Leopoldo, 1927, *J.E. Rick n.n.* (BPI 332539, 332540; PACA 12460, as *Clavaria kunzei* Fr.), *ibid.*, 1932, *J.E. Rick n.n.* (PACA 17221, 17225, 17235 as *Clavulina cartilaginea* (Berk. & M.A. Curtis) Corner). MALAYSIA. Sabah: Kinabalu, 21 January 1964, *E.J.H. Corner n.n.* (BPI 294906). SOLOMON ISLANDS. San Cristobal: Warahito River, 23 July 1965, *E.J.H. Corner n.n.* (BPI 294905).

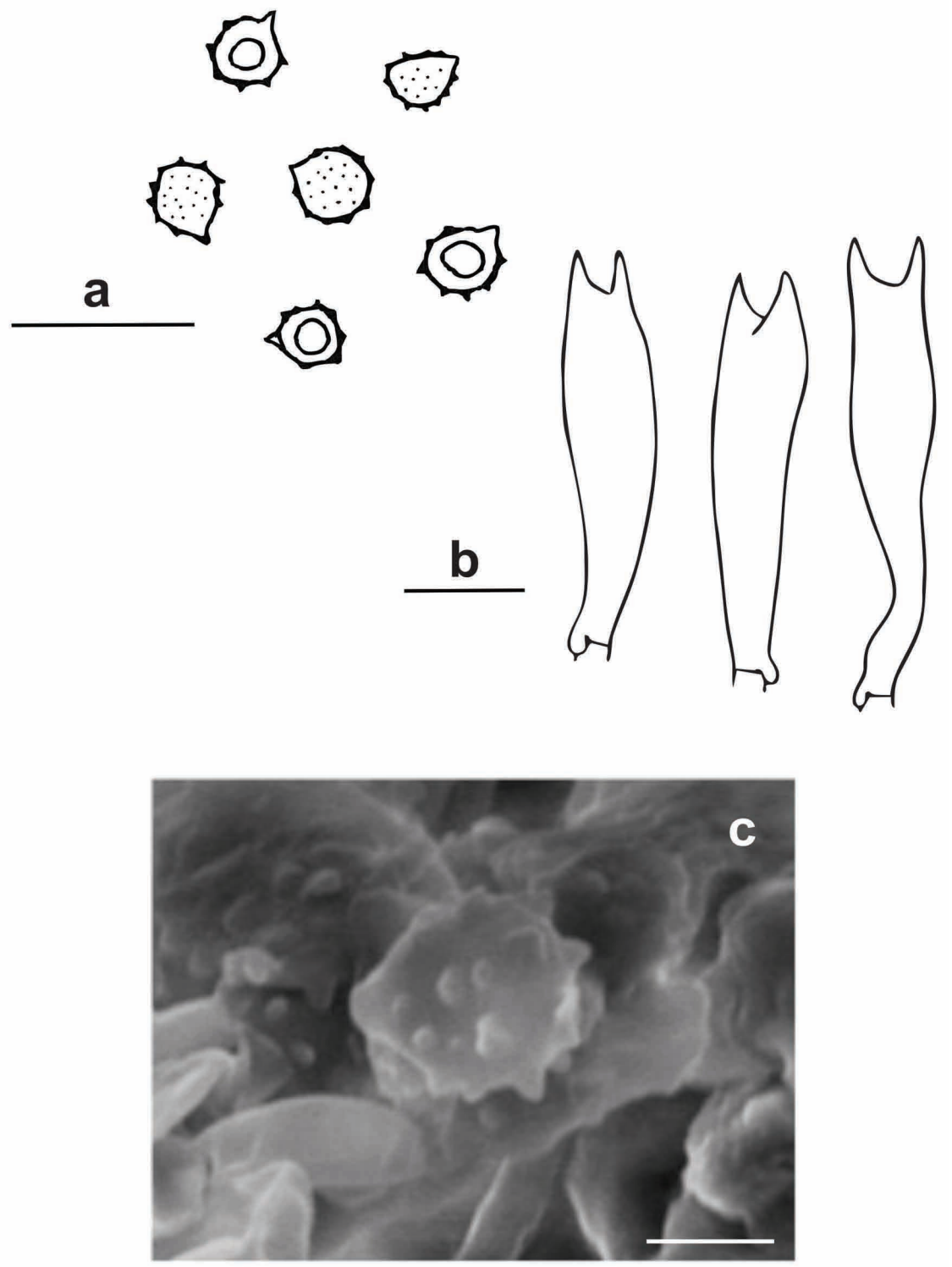

FIGURE 15. Microcharacters of *Ramariopsis kunzei* (ACM 596). **a.** Basidiospores; **b.** Basidia; **c.** SEM of the basidiospores. Bars (**a**, **b**) = 10 µm (**c**) = 2.0 µm.

Remarks:—This species is very variable in size, shape, color and basidiospore dimensions, but the stipe is always villous or tomentose and the dried basidioma darkens in potash (Corner 1950, 1970). Some basidiomata are pure white, but often they become yellowish, pink or pale yellow (Thind 1961, Jülich 1984, Olariaga 2009). Basidiospore size varied widely in the collections studied (3.0−3.5 × 2.5−3.0 µm for Rick's collection; 5.0−6.5 × 4.5−5.7 µm for the collections from Malaysia and Solomon Islands). The collections from Malaysia and the Solomon Islands are probably a distinct taxon. The Brazilian collections seem to have slightly smaller basidiospores than the collections from other localities. *Ramariopsis kunzei* has four-spored basidia (Cotton 1907). Thind (1961) described and reported a similar

specimen with two-spored basidia and clampless hyphae from Mussoorie, India. Olariaga & Salcedo (2012) elevated *R. kunzei* var. *bispora* Schild to the species level based on the two-spored basidia, absence of clamps (attributed to the process of parthenogenesis), smaller basidiomata and lack of pinkish patches in mature specimens. Despite the two-spored basidia, the Brazilian collections studied have clamped hyphae throughout the basidiomata, including the basal tomentum hyphae, and the basidiomata change color when mature. Additionally, *R. bispora* has crystals among the context hyphae which were not observed in *R. kunzei*, and the tomentum hyphae of our collection has intermediaries measures between *R. bispora* (2.5−3.0 µm diam.) and the typical variety of *R. kunzei* (3.0−4.0 [5.5] µm diam.).

Key to club-shaped and branched Clavariaceae species from Brazil

1. Basidiomata pendent; spore walls amyloid ..... *Mucronella calva* (from Acre, Rondônia [Capelari & Maziero 1998] and São Paulo [Bononi *et al.* 1979])
- Basidiomata not pendent; spore walls inamyloid 2

2. Hyphae without clamps, often secondarily septate, or with a loop-like clamp at the base of the basidia ..... 3 (*Clavaria*)
- Hyphae clamped, not secondarily septate 10

3. Basidiomata phycophilous 4
- Basidiomata not phycophilous 5

4. Basidiomata pink (9A3) to orange-pink (8A5), longitudinally sulcate; spores 9.0−12 × 4.0−5.5 µm, pink in the mass ..... *Ca. helicoides* (from Rio Grande do Sul [Bononi *et al.* 1981])
- Basidiomata white (1A1) to pale cream (1A2), smooth; spores 6.0−9.0 × 2.7−4.0 µm, hyaline ..... *Ca. neofossicola* (from Mato Grosso [Corner 1970] and São Paulo [Bononi *et al.* 1981])

5. Basidiomata unbranched 6
- Basidiomata branched 9

6. Basidia with a wide loop-like clamp at the base ..... *Ca. gibbsiae*
- Basidia without clamps 7

7. Basidiomata deep orange (7B8) to red (9A8), typically caespitose ..... *Ca. subglobosa*
- Basidiomata white (1A1) to pale cream (1A2) or reddish grey (9B8), not caespitose 8

8. Basidiomata rather robust, fuliginous (9B8), becoming light brown (5D5) when older; basidiospores 5.0−8.0 × 4.0−5.0 µm ..... *Ca. fumosa*
- Basidiomata fragile, pure white (1A1); basidiospores smaller, 4.5−5.5 × 2.0−3.5 µm ..... *Ca. fragilis*

9. Basidiomata light yellow (1A4) to greenish yellow (1B8); basidiospores narrowly ellipsoid, context hyphae diverticulate ..... *Ca. diverticulata*
- Basidiomata purple (15C7) to deep purple (15D8); basidiospores broadly ellipsoid, context hyphae smooth-walled ..... *Ca. zollingeri*

10. Basidiospores smooth or sharply angular to tuberculous; basidiomata unbranched in some species ..... 11 (*Clavulinopsis*)
- Basidiospores regularly nodulose-verrucose or echinulate; basidiomata branched ..... 21 (*Ramariopsis*)

11. Basidiospores verrucose-angular ..... *Cs. helvola*
- Basidiospores smooth 12

12. Basidiospores 9.0−11 × 8.0−9.0 µm; basidia 15−18 µm wide, contextual hyphae strongly inflated (17−27 µm wide ..... *Cs. inflatissima* (from Amazonia [De Lamonica-Freire 1979])
- Basidiospores smaller; basidia up to 13 µm wide, contextual hyphae less inflated (up to 15 µm wide 13

13. Basidia urniform ..... *Cs. carneola* (from São Paulo [Corner 1970])
- Basidia elongate and cylindric to subcylindric 14

14. Basidiomata orange-yellow (4B7), orange (6A5), pinkish orange (8A5) to deep orange (6A8) 15
- Basidiomata white tinged yellow (2A5) to pale yellow (1A3) or greenish yellow (2B8) 19

15. Basidiomata unbranched 16
- Basidiomata branched 18

16. Basidiospores ellipsoid to pip-shaped; solitary to gregarious ..... *Cs. laeticolor*
- Basidiospores globose, subglobose to broadly ellipsoid; caespitose 17

17. Basidiospores subglobose, with a short hilar appendage (0.5−1.0 µm long) ..... *Cs. aurantiocinnabarina*
- Basidiospores broadly ellipsoid, with a prominent hilar appendage (1.5−2.0 µm long) ..... *Cs. fusiformis*

18. Basidiospores and basidia dimorphic ..... *Cs. dimorphica*
- Basidiospores and basidia of the same size and shape ..... *Cs. corniculata* (from Mato Grosso [Corner 1970], Paraná [De Meijer 2006] and Rio Grande do Sul [Rick 1959])

19. Growing solitary or in small groups; context hyphae irregularly thick-walled ..... *Cs. imperata*
- Typically caespitose; context hyphae with walls regularly thickened 20

20. Subhymenium with small orange granules that become greenish when exposed to iodine; basidiospores 7.0−9.0 × 7.0−8.5 µm ..... *Cs. amoena*
- Subhymenium without orange granules; basidiospores slightly smaller, 6.0−8.0 × 6.0−7.5 µm ..... *Cs. spiralis*

21. Basidiomata purple (15C7) to deep purple (15D8) ..... *R. pulchella* (from Rio de Janeiro [Corner 1970])
- Basidiomata white (1A1) to orange-yellow (4B7) 22

22. Basidiomata wholly white (1A1) to pale yellow (1A2); stipe villose-tomentose ..... *R. kunzei*
- Basidiomata yellow (3B7) to orange-yellow (4B8); stipe smooth ..... *R. crocea*, (from Rio Grande do Sul [Rick 1959])

Reference studied exsiccata:—USA. Idaho: Priest River, July 1915, *J.R. Weir n.n.* (BPI 294510). SINGAPORE. Botanic Garden, 16 December 1931, *E.J.H. Corner n.n.* (BPI 294878); *Clavulina amethystina*: ENGLAND. no location, 1977, *O.H. Frazer n.n.* (K 146709). USA. Washington: Bremerton, 21 January 1931, *J.B. Flett n.n.* (BPI 295409); *Clavulinopsis corniculata*: BRAZIL. no location, n.d., *J.E. Rick n.n.* (BPI 332515, 332517); *Cs. fusiformis*: BRAZIL. Amazonas: Manaus, Campus do INPA, 20 May 1977, *E.M.H. Freire n.n.* (INPA 69936), *ibid.*, 21 June 1977, *E.M.H. Freire n.n.* (INPA 79021) *ibid.*, 22 May 1978, *R. Singer n.n.* (INPA 79015), *ibid.*, Reserva Florestal Ducke, 20 July 1978, *R. Singer n.n.* (INPA 80977). USA. Vermont: Town of Essex, Indian Brook Reservoir, 11 September 2011, *M. Sundue n.n.* (FLOR 40809); *Ramariopsis crocea*: BRAZIL. Rio Grande do Sul: São Leopoldo, 1931, *J.E. Rick n.n.* (BPI 294900, as *Ca. guarapiensis*). INDIA. Khadrala: Mahasu: Himachal Pradish, 25 August 1971*, I.P.S. Khurana n.n.* (BPI 294899); *R. pulchella*: INDIA. Narkanda. Mahasu: Himachal Pradesh, 17 August 1971, *I.P.S. Khurana n.n.* (BPI 294927).

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