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Fungal Biodiversity Profiles 51-60

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Abstract. In this new series of Fungal Biodiversity Profiles, the authors describe ten species new to science, nine basidiomycetes and one ascomycete, using both morphological and molecular data. Descriptions are provided for *Hydnum berkeleyanum* sp. nov. (Cantharellales), for *Lactarius ambiguus, L. furfuraceus, L. orientaliquietus, L. subhirtipes, Russula blennia, R. pseudociliata* (Russulales), *Marasmius pseudohypochrysoides*, *Radulomyces paumanokensis* (Agaricales) and *Urnula himalayana* (Pezizales).

Agaricales / Cantharellales / *Hydnum* / *Lactarius* / *Marasmius* / Pezizales / phylogeny / *Radulomyces* / *Russula* / Russulales / systematics / *Urnula*

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51. *Hydnum berkeleyanum* K. Das, Hembrom, A. Baghela & Vizzini **sp. nov.**
Figs 1-4

MycoBank: MB 824501
GenBank: MG972968 (ITS), MG972970 (LSU)
Systematic position: Basidiomycota, Agaricomycetes, Cantharellales, Hydnaceae.

Etymology: Commemorating Miles Joseph Berkeley for his contribution to Indian mycobiota.

Diagnosis: Distinct from all other similar looking *Hydnum* species mainly by its ITS and LSU sequence data and a combination of morphological features like moderately robust (pileus 25-80 mm in diam., stipe 30-55 × 8-14 mm) basidiomata with orange-brown pileus, long (2-9 mm) spines, globose to subglobose or broadly ellipsoid (Q = 1.01-1.17) basidiospores, trichoderm pattern of pileipellis and occurrence under trees of Fagaceae in mixed temperate forests.

Holotype: INDIA, Uttarakhand, Pauri district, Chourikhal, N 30° 01.553' E 79°00.477', 2188 m a.s.l., under *Quercus* in temperate broadleaf forest, 1 August, 2017, *Kanad Das & Manoj E. Hembrom,* KD-MEH 17-005 (CAL 1656, **holotype**!).

Basidiomata solitary to gregarious. *Pileus* 25-80 mm in diam., initially convex, plano-convex to plane at maturity, sometimes with irregular lobes or central depression or umbilicate; surface dry, velutinous, sometimes with small and erect scales at the margin, non-staining, azonate, combination of pale orange to light orange (5A3-4) with brown (6D8) centre which becoming paler gradually towards the margin to pale orange to light orange (5A3-4), rarely brownish orange (6C8) throughout at maturity; margin entire, becoming somewhat sinuous and lobed with age. *Stipe* 30-55 × 8-14 mm, eccentric to lateral, cylindrical, mainly tapering towards base, white (A1) at apex, gradually brownish towards the base, brown (7D8) at base. *Spines* adnexed to subdecurrent, 2-9 mm long (with some shorter spines on stipe), typically spinoid, not flattened, with acute (rarely subacute) apex, sometimes joined at the base, crowded, initially white (A1), becoming orange-white to pale orange (5A3) at maturity or on bruising, gradually more brownish when drying. *Context* chambered in pileus and stipe, white (A1), quickly becoming pale orange (5A3) on exposure, unchanging with 10% $FeSO_4$, and 5% KOH but turning greenish with guaiacol. *Odor* pleasant, slightly fruity. *Spore-print* white.

Basidiospores globose to subglobose or rarely broadly ellipsoid, 7.5-*8.4-8.5*-9.5 × 6.9-*7.9-8.0*-8.8 µm (n = 40; Q = 1.01-*1.06-1.08*-1.17), thin-walled, inamyloid, apiculus cubic. *Basidia* subcylindric to clavate, 4-spored, rarely two-spored, clamped, 26-60 × 7-9 µm; sterigmata up to 9 µm long. *Spine tip* sterile; hyphae composed of interwoven hyphae being parallel towards the apex; each hyphae cylindrical, septate, clamped and with subclavate to clavate apex, thin-walled, 4-6 µm wide at apex, without crystals. *Hymenophoral trama* composed of hyphae in parallel to interwoven pattern, hyphae 2-11 µm wide, clamped. *Pileipellis* composed of loosely interwoven erect to suberect hyphae forming a trichoderm pattern, hyphae cylindrical to swollen with pale yellow intracellular pigmentation, thin-walled, clamped, 2-9 µm wide, with cylindrical to subfusoid or appendiculate tips. *Stipitipellis* composed of erect to suberect hyphae forming a cutis pattern, hyphae mostly with orange intracellular pigmentation, clamped, 2-5 mm wide, with cylindrical to subfusoid or rarely appendiculate tips. *Contextual hyphae* interwoven, cylindrical to swollen with frequent constrictions, thin-walled, yellowish, clamped, 2-12 µm wide.

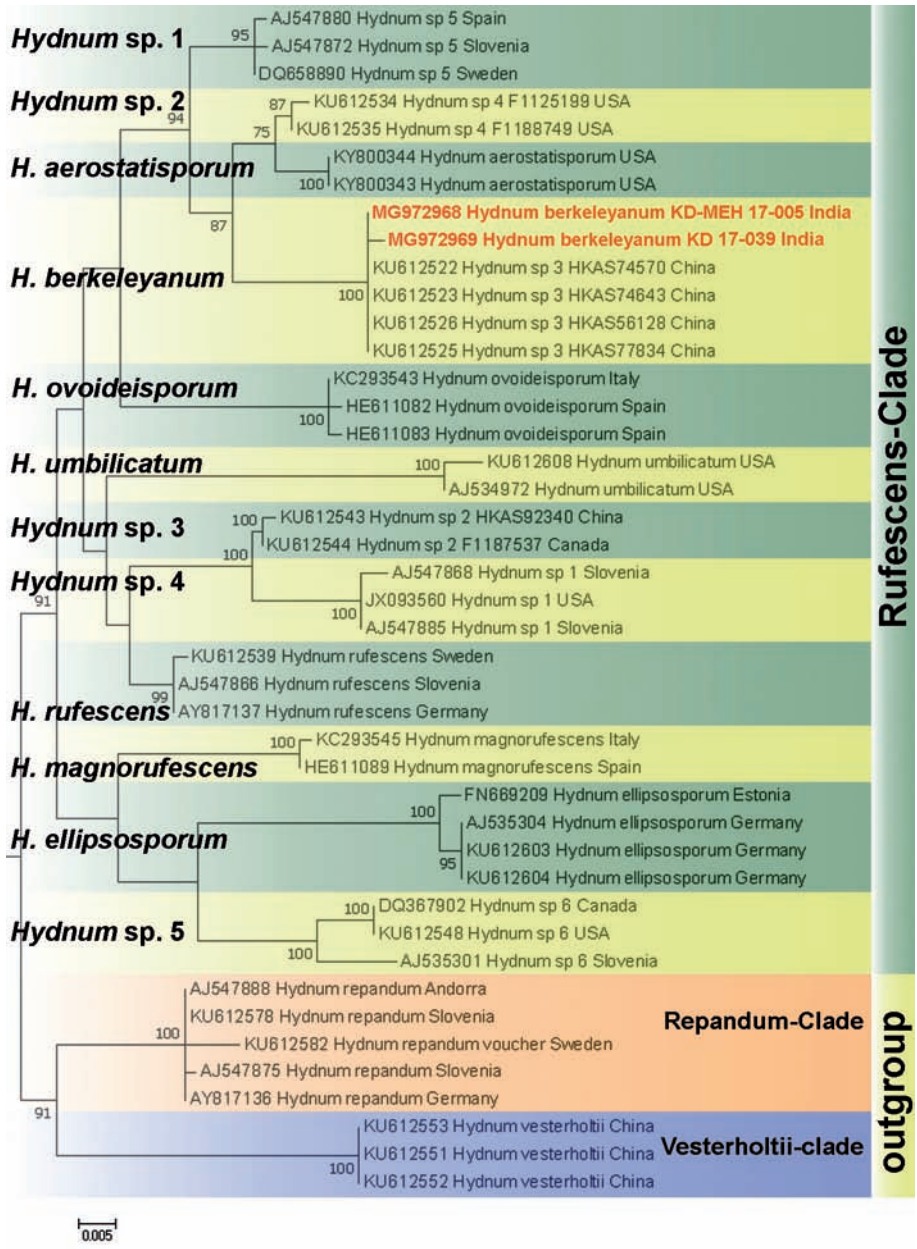

Fig. 1. Maximum Likelihood (ML) phylogram reconstructed using raxmlGUI 1.2 (Silvestro & Michalak 2012) of nrITS *Hydnum* sequences. One thousand bootstrap replicates were analyzed to obtain the nodal support values. Bootstrap support values (>50%) are shown above or below the branches at nodes. The two collections of the novel Indian species *Hydnum berkeleyanum* with GenBank accession numbers MG972968 and MG972969 are shown in red and bold in the tree. Five sequences from *H. repandum* (AJ547888, KU612578, KU612582, AJ547875, AY817136) and three sequences of *H. vesterholtii* (KU612553, KU612551, KU612552) belonging to Repandum-clade and Vesterholtii-clade respectively were considered as outgroup taxa.

Specimens examined: INDIA, Uttarakhand, Pauri district, Chourikhal, N 30° 01.553' E 79°00.477', 2188 m a.s.l., under *Quercus* sp. in temperate mixed (broadleaf and coniferous) forest, 1 August, 2017, *Kanad Das & Manoj E. Hembrom,* KD-MEH 17-005 (CAL 1656, holotype!); *ibid.*, Sikkim, South district, Kewzing, N 27°16.781' E 088°20.300', 1817 m a.s.l., under *Castanopsis* sp. in temperate broadleaf forest, 25 August, 2017, *Kanad Das,* KD 17-039 (CAL 1657, paratype!).

Notes: The present new species of "hedgehog mushroom" is edible and consumed in Western and Eastern Himalaya. Currently, based on multigene phylogeny, four well-supported lineages (Feng *et al.* 2016) are existing in this genus, they are Albomagnum-clade, Repandum-clade, Rufescens-clade and Versterholtii-clade (three are shown in our small ITS-based phylogenetic analyses). Our ITS-based phylogeny clearly shows that two Indian collections (KD-MEH 17-005 and KD 17-039, represented by MG972968 and MG972969 respectively in Fig. 1) of *H. berkeleyanum* along with four other Chinese collections (HKAS56128, HKAS77834, HKAS74570, HKAS74643) are recovered as a distinct species in the "Rufescens clade" in a strongly supported (100% bootstrap value) clade being sister to a clade consisting of two North American taxa: *H. aerostatisporum* Buyck, Lewis & V. Hofstetter (KY800344 and KY800343) and an undescribed species (KU612534 and KU612535). Similarly, in our supporting LSU-based phylogeny the two Indian collections (KD-MEH 17-005 and KD 17-039, represented by MG972970 and MG972971 respectively in Fig. 2) along with four other undescribed Chinese collections (KU612667, KU612665, KU612666, KU612664) are recovered as a distinct species in "Rufescens clade" in a moderately supported (65% bootstrap value) clade being sister to an undescribed American species ("*Hydnum* sp. 4", KU612663). Our dual phylogenetic analyses with the available sequences under "Rufescens clade" in the public database GenBank also indicate the existence of a couple of undetermined taxa but kept only as "*Hydnum* sp. 1", "*Hydnum* sp. 2" and "*Hydnum* species 6" in our LSU-based phylogeny (Fig. 2) as there are no supporting morphological data. Similarly, in our ITS-based analysis at least 5 undescribed species (labeled as "*Hydnum* sp. 1", "*Hydnum* sp. 2", "*Hydnum* sp. 3", *Hydnum* sp. 4 and "*Hydnum* sp. 5" in Fig. 1 by us) are existing where no morphological data are available till date.

A number of European or North American species, namely, *H. aerostatisporum*, *H. ellipsosporum* Ostrow & Beenken, *H. rufescens* Pers., *H. umbilicatum* Peck, *H. magnorufescens* Vizzini, Picillo & Contu, *H. ovoideisporum* Olariaga, Grebenc, Salcedo & M.P. Martín are quite similar in the field and may create confusion with this Indian (rather Asian) species but, they all are mainly separated by their ITS and/or LSU sequence data as shown in Figs. 1 & 2, respectively. Moreover, in the field *H. ovoideisporum* (reported from Europe) differs from the present novel species by smaller basidiomata (pileus 12-40 mm; stipe 20-40 × 2.5-9 mm) with bright orange coloured pileus (Olaraiga *et al.* 2012, Vizzini *et al.* 2013); *H. aerostatisporum* (from North America) has a more robust stipe (27-74 × 10-25 mm) and smaller basidiospores [(7.1)7.3-*7.69*-8.1(8.5) × (6.5)6.7-*7.07*-7.5(7.9) µm] (Buyck *et al.* 2017); *H. ellipsosporum* (from Europe) has typically ellipsoid basidiospores ("Q_m = 1.55-1.75") (Ostrow & Beenken 2004, Olariaga *et al.* 2012); *H. magnorufescens* which is phylogenetically distant from *H. berkeleyanum* (Fig. 1) possess a distinctively paler pileus (ochre to saffron coloured) (Vizzini *et al.* 2013); *H. umbilicatum* (from North America) shows smaller basidiomata (pileus 25-50 mm in diam.; stipe 20-70 × 5-10 mm), umbilicate pileus, indistinctive odour, "oval" basidiospores (mainly globose to subglobose in the present novel species) (Bessette *et al.* 1997) and *H. rufescens* (originally reported from Europe) has smaller

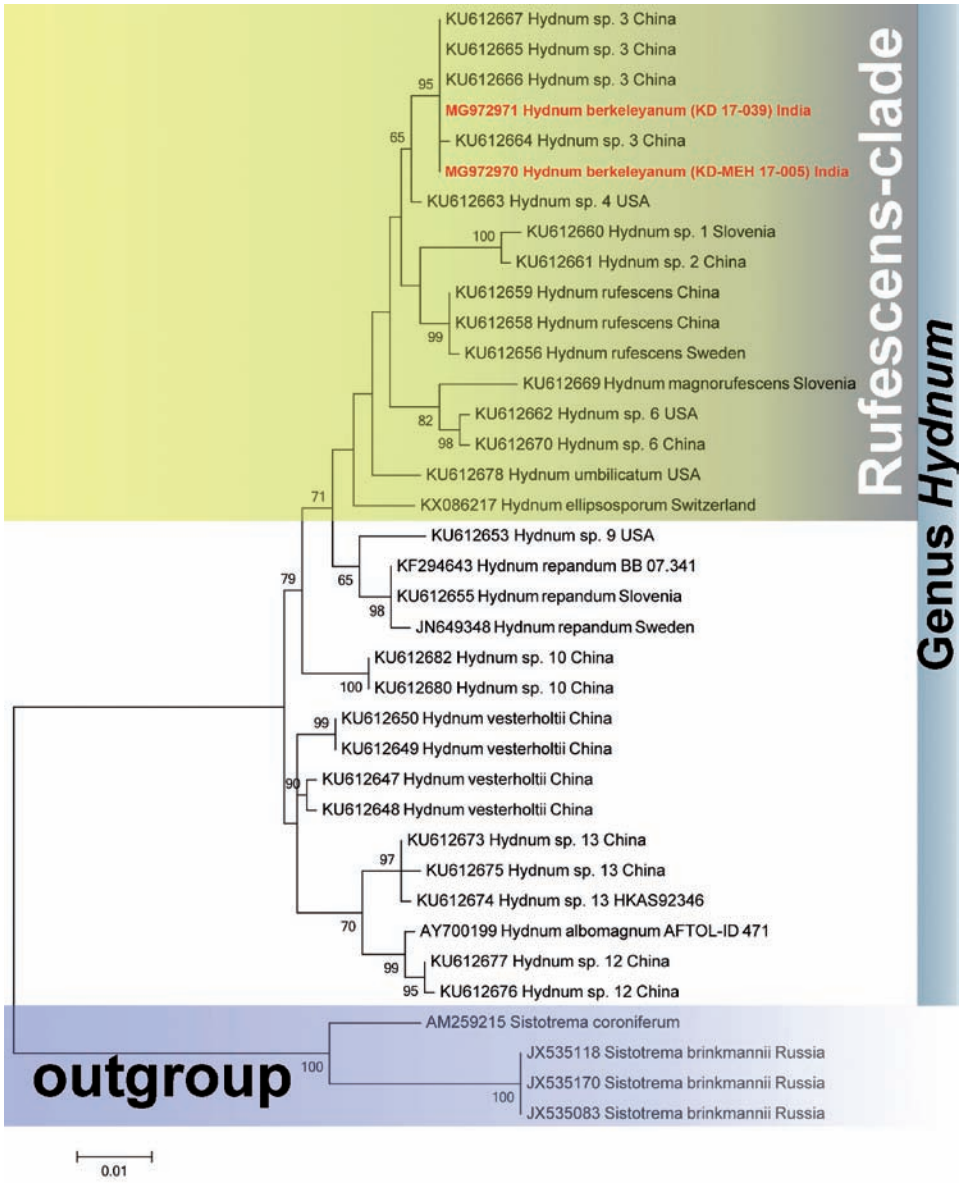

Fig. 2. Maximum Likelihood (ML) phylogram generated using MEGA.6 (Tamura *et al.* 2013) under Tamura 3-parameter model (Tamura 1992) based on nrLSU *Hydnum* sequences. One thousand bootstrap replicates were analyzed to obtain the nodal support values. Bootstrap support values (>50%) are shown above or below the branches at nodes. The two collections of the novel Indian species *Hydnum berkeleyanum* with GenBank accession numbers MG972970 and MG972971 are shown in red and bold in the tree. *Sistotrema brinkmannii* (JX535118, JX535170 and JX535083) and *S. coroniferum* (AM259215) were considered as outgroup taxa.

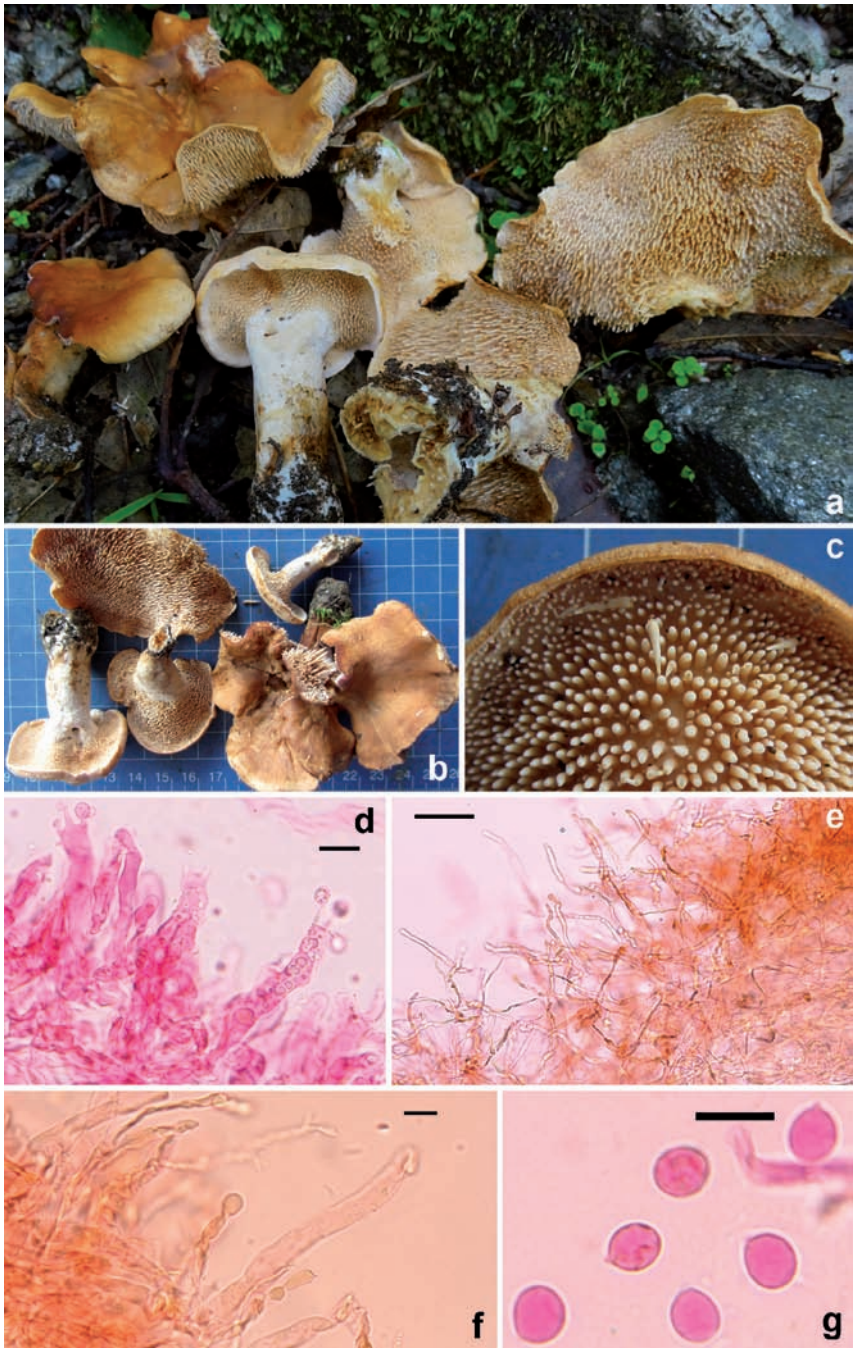

Fig. 3. *Hydnum berkeleyanum* (KD-MEH 17-005, **holotype**). **a & b.** Fresh basidiomata in the field and basecamp. **c.** Spinoid hymenophore. **d.** Basidia bearing basidiospores. **e.** Radial section through pileipellis. **f.** Transverse section through stipitipellis. **g.** Basidiospores. Scale bars: d, f & g = 10 µm, e = 50 µm

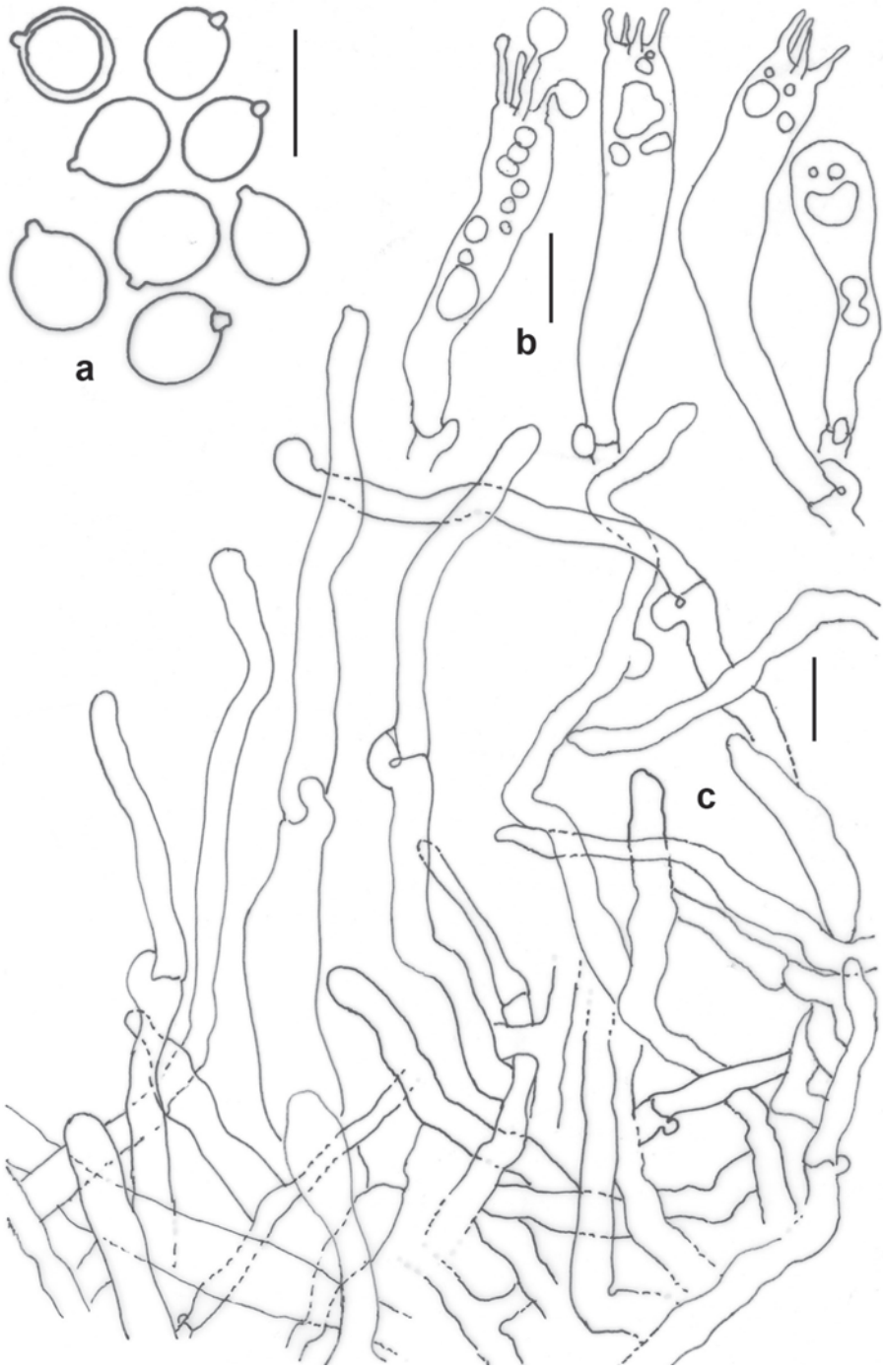

Fig. 4. *Hydnum berkeleyanum* (KD-MEH 17-005, **holotype**). **a.** Basidiospores. **b.** Basidia. **c.** Transverse section through pileipellis showing hyphal arrangement. Scale bars: a-c = 10 μm.

basidiomata (pileus up to 45 mm in diam.; stipe 10-45 × 1.5-15 mm), shorter (up to 5 mm long) spines and smaller basidiospores (6.3-8.1 × 5.4-6.3 µm) (Maas Geesteranus 1971). However, Maas Geesteranus (1971) while describing *H. rufescens* cited a number of Asian (from Pakistan, India, Tibet or Japan) specimens in his "Collections examined and reported" part. Similarly, two collections (from Uttarakhand) of *Hydnum* are also reported as *H. rufescens* by J.R. Sharma (Sharma 2012) considering their macro- and micromorphology. These two collections are separated as well by their smaller basidiomata (pileus 30–70 mm in diam.; stipe 8-30 × 3-10 mm), distinguishingly smaller (6-8.2 × 5.2-6 µm) basidiospores and shorter (1-3 mm) spines. Their identity/intercontinental conspecificity can only be confirmed once their sequence data are available.

52. *Lactarius ambiguus* X.H. Wang ***sp. nov.*** **Figs 5-6**

MycoBank: MB 826762.

GenBank: MH447587 (ITS holotype); MH447582–MH447586 and MH447588 (ITS paratypes)

Etymology: from Latin, referring to the ambiguous identity solely based on morphology.

Diagnosis: A small to medium-sized species recognized by the pileus with much darker center and paler margin, spores with clean ornamentation, an intricate (ixo-) trichoderm as the pileipellis and presence of macrocystidia. Associated with fagaceous trees. Subtropical China.

Holotype: CHINA. HENNAN: Luanchuan Co., Laojun Mt., Tenglongyu trail, elev. 1290 m, 13 Aug. 2015, coll. X.H. Wang, no. 3656 (HKAS 89929, KUN!).

Basidiomata small to medium-sized. *Pileus* 30–60 mm, at first convex, soon expanding with a depressed centre to infundibuliform, papillate or not; surface dry, glossy when wet, smooth, hygrophanous, dark olivaceous brown to brown (5E5, 6E7) in the center, fading to cream ochraeus or pinkish buff with age, at margin light yellow (4A3, 4A4), pale orange (5A3), grayish yellow (4B4, 4C5, 4C4), grayish orange (5B5), often with olivaceous tinge, with age becoming transparently striate. *Context* 1–2 mm thick, pale yellow (4A3). *Lamellae* 3–5 mm broad, slightly emarginate to short ducurrent, crowded when young, remaining so or medium crowded with age, pale yellow (4A3), plae orange (5A3), becoming light yellow (4A4) to grayish orange (5B4) in age, slowly changing to reddish brown or brown when bruised. *Stipe* 30–90 × 4–12 mm, central to eccentrical, equal or tapering upwards, hollow; surface pruinose, nearly dry, grayish orange (6B4–6B5), pale yellow to grayish orange (5A3–5B4, 5B5), grayish brown (6D3, 6D4, 6D3–6D4), brownish orange (7C4–7C5), palest at the top; base strigose with short white hairs when young, becoming reddish brown in age. *Latex* white, cream white or watery-milky, changing to watery, not discoloring, slightly bitter. *Spore print* not obtained.

Basidiospores (180/9/8) (6.5) 7.0–***7.6***–8.5 (9.0) × (5.5) 6.0–***6.3***–7.0 µm [Q = (1.06) 1.11–1.31 (1.45) , **Q** = 1.20 ± 0.06] [holotype (40/2/1): 7.0–***7.7***–8.5 × (5.5) 6.0–***6.3***–7.0 µm, Q = (1.15) 1.17–1.27 (1.31), **Q** = 1.22 ± 0.03], broadly ellipsoid to ellipsoid, rarely subglobose; ornamentation 0.5–1.0 (1.3) µm high, of medium dense elongate warts and clean ridges partly connected, often only forming close meshes or broken reticulum, less forming nearly complete reticulum, some aligned in a subzebroid pattern, isolated warts and free ridges common; plage not amyloid, rarely slightly distally amyloid. *Hymenophoral trama* of hyphoid cells and scattered colorless or yellowish brown lactiferous hyphae. *Basidia* 35–50 × 10–14 µm, 4-spored, clavate. *Pleuromacrocystidia* rare to common, more common towards lamellae base, emergent, rarely embedded in the basidia layer, protruding up to 70

Fig. 5. ***L****actarius ambiguus* (holotype). Photo X.H. Wang

µm, 60–100 (120) × 8–12 (14) µm, fusiform, cylindrical, some with a moniliform apex, with strongly refractive massy, crystalline or granular contents. *Hymenophoral pseudocystidia* rare to common, 2–4 (8) µm broad, slightly enlarged at the apex, not protruding, with refractive content, hyaline or pale yellowish brown. *Lamella edge* sterile; marginal cells 10–25 (35) × 4–10 µm, similar to basidioles in shape, clavate, cylindrical, rarely ventricose, hyaline; cheilomacrocystidia rare to common, not seen in some individuals, 26–47 × 5–7 (10) µm, subfusiform, cylindrical. *Pileipellis* an intricate (ixo-) trichoderm, 50–100 µm thick; hyphae of suprapellis 3–8 µm broad, hyaline, often gelatinized, terminal cells 13–65 × 3–8 µm, cylindrical, equal or slightly swollen at the middle part; hyphae of subpellis strongly gelatinized, 4–13 µm broad, some inflated to pyriform, ellipsoid or sausage-shaped. *Stipitipellis* a cutis, 30–50 µm thick, of closely packed hyphae; hyphae 3–6 µm broad, slightly gelatinized or not, cylindrical, equal, hyaline. *Trama of pileus and stipe* of hyphae and scattered colorless to yellowish brown lactiferous hyphae, with typical and abundant rosettes.

Additional specimens examined: HUBEI: Fang Co., Qiaoshang Town, Xihaoping, Xiping, under *Quercus* forest, 31 Jul. 2011, coll. X.H. Wang, no. 2941 (HKAS 73501); Xingshan Co., Longmenhe forest farm, 11 Jul. 2012, coll. X.B. Liu, no. 29 (HKAS 75640). SHAANXI: Mei Co., Yingtou Town, Haopingsi, Taibai Mt. Nature Researve, under *Quercus* forest, 4 Sept. 2010, coll. X.H. Wang, no. 2736 (HKAS 61932); Zhouzhi Co., Houzhenzi, Taibai Mt. Nature Reserve, under *Quercus*

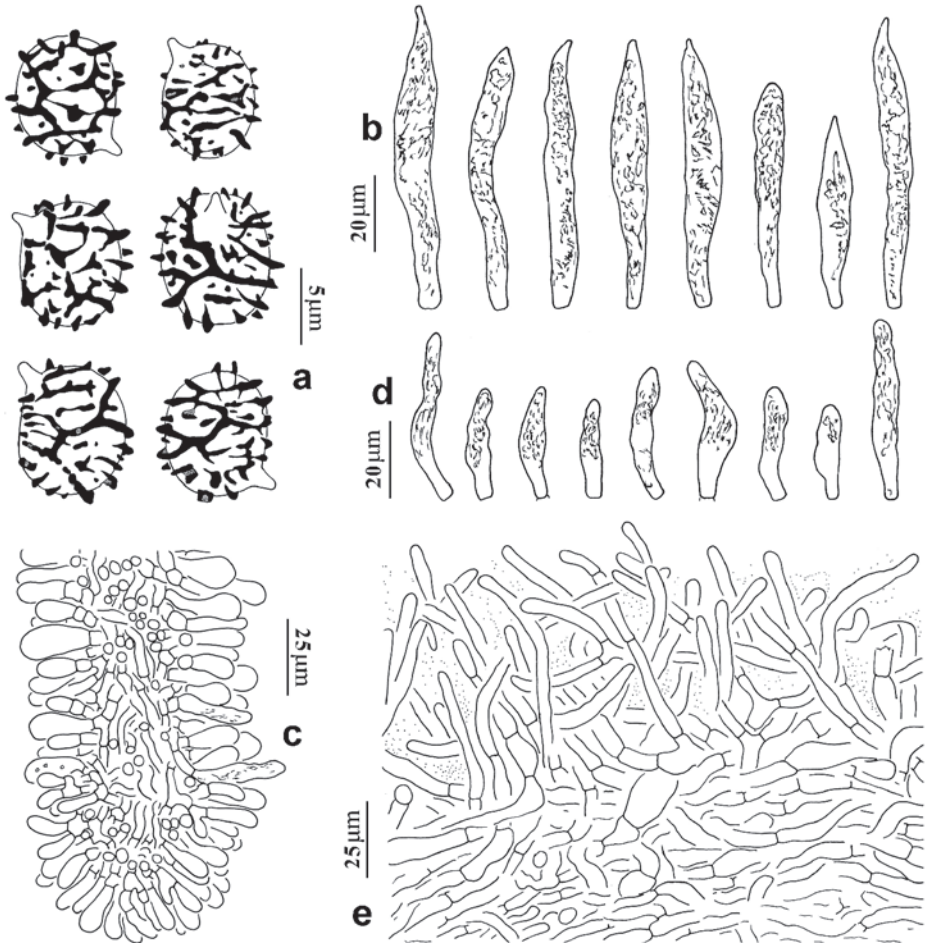

Fig. 6. *Lactarius ambiguus* (holotype). **a.** spores, **b.** pleuromacrocystidia, **c.** lamella edge, **d.** cheilomacrocystidia, **e.** pileipellis. Drawings X.H. Wang

forest, 7 Jul. 2011, coll. X.H. Wang, no. 2923 (HKAS 73484). TAIWAN: Nantou Co., Jenai Hsiang, in fagaceous trees, Aowanta forest park, N23°57'05.63'' E121°10'56.44'', elev. 1213 m, 3 Oct. 2016, coll. X.H. Wang, no. 4185 (HKAS 96770). YUNNAN: Weixi Co., Tacheng Town, Bazhu, in mixed forest of *Pinus yunnanensis* and fagaceous trees, 8 Sept. 2008, coll. X.H. Wang, no. 2252 (HKAS 60410); *ibid.*, 15 Oct. 2011, coll. X.H. Wang, no. 3220 (HKAS 75827).

Habit, habitat and distribution: solitary, fagaceous forests. Subtropical China.

Notes: This is a variable species. The pileus typically has a much darker center and paler margin. When fully matrue it can be nearly unicolored (pinkish buff or cream-ochraceus). The latex can be white, cream-white or watery. The spores are typically ellipsoid, but HKAS 73501 has subglobose spores (Q = 1.13 ± 0.04). Most specimens have a pileipellis lacking slime, HKAS 89929 (the holotype) has a

Fig.7. Bootstrap consensus tree generated by Neighbor-Joining (NJ) phylogenetic analysis, rooted with midpoint. NJ analysis was conducted in MEGA5, using bootstrap method (1000 replicates), p-distance as substitution model, transitions and transversions both included, uniform rates among sites, homogeneous pattern among lineages and pairwise deletion for gaps treatment. The bootstrap proportions higher than 70% are indicated above the nodes. New species are in bold. Initials proceeding the sample numbers of the new species refer to the collectors and the others are GenBank accessions.

pileipellis with mucus among the hyphae and HKAS 60410 even has a well-developed slime layer. The terminal cells of the pileipellis vary from 3–5 μm to 5–8 μm broad among different individuals and the spore ornamentation may consist of relatively isolated elements or form a broken to nearly complete reticulum. These variations make morphological identification difficult.

Lactarius ambiguus is similar to *L. cinnamomeus* W.F. Chiu (= *L. kesiyae* Verbeken & H.D. Hyde), *L. inconspicuous* H.T. Le & F. Hampe and *L. tangerinus* H.T. Le & De Crop in the general apperance and the structure of the pileipellis. *Lactarius ambiguus, L. inconspicuus* and *L. tangerinus* have a pileus with much darker center. The olivaceous tinge of *L. ambiguus*, however, is not reported on *L. inconspicuus* and *L. tangerinus* (Wisitrassameewong *et al.* 2015). *Lactarius inconspicuus* has yellowing latex and spores of *L. tangerinus* are more round (Q = 1.02–*1.09–1.13*–1.15). The contrast between the darker center and paler margin of *L. ambiguus* and the relatively dry pileus are good characters distinguishing it from *L. cinnamomeus*. *Lactarius cinnamomeus* and *L. inconspicuus* have well-developed slime on the pileus cuticle. A clear slimy layer was observed in only one specimen (HKAS 60410) of *L. ambiguus*.

Four sequences with 99% similarity were retrieved from GenBank. There are several characteristic substitutions and INDELs beween the clade formed by these sequences and that formed by the Chinese samples. Due to the unsolved phylogenetic relationship (Fig. 7) they are tentatively labelled as *L. ambiguus.* One of the them, KF433000 (sample KW016) was identified as *L. inconspicuus* by Wisitrassameewong *et al.* (2015).

53. *Lactarius furfuraceus* X.H. Wang ***sp. nov.*** **Figs 8-9**

MycoBank: MB 826763

GenBank: MH447566 (ITS holotype); MH447564, MH477565 and MH477567–MH447581 (ITS paratypes)

Systematic position: Basidiomycota, Agricomycotina, Russulales, Rusulaceae.

Etymology: from Latin, referring to the areolate-rimose pileus cuticle that produces a furfuraceus appearance.

Diagnosis: A small, slender, thin-fleshed species that can be recognized by the orange brown basidiocarps, areolate-rimose pileus, absence of rosettes in the pileus and stipe trama and bigger spores.

Holotype: CHINA. YUNNAN: Xinping Co., Ailao Mts. Nature Reserve, roadside from Gasa to Heping, N23°57’48.17’’ E101°31’14.60’’, elev. 2223 m, 12 Aug. 2017, coll. X.H. Wang, no. 4495 (HKAS 101915, KUN!).

Basidiomata small, slender, thin-fleshed. *Pileus* 20–30 (50) mm, at first convex with a conical papilla, later concave to infundibuliform, with clear sulcates when fully mature; surface dry, areolate-rimose, strongly hygrophanous, reddish brown, brown (7D8–7E8) when young, then brownish orange at margin (6C6–6D6) and light brown to brown (6D7, 6E7) in the center, paler when dry. *Context* very thin (< 0.5 mm), paler than stipe. *Lamellae* 1–3 (4) mm broad, decurrent, medium spaced, whitish with faint brownish tinge or pinkish brown when young, becoming light orange to grayish brown (5A4–5B5) when mature. *Stipe* 20–50 × 1–5 mm, equal, cylindrical, hollow; surface dry, smooth, reddish brown, light brown (7D6) at the apex, pale brown (7E8) below; base strigose with long paler or light brown (7D7) hairs. *Latex* scanty, watery or white becoming watery, not discoloring, mild. *Spore print* cream-colored.

Basidiospores (420/21/17) (7.0) 8.0–***8.5***–9.5 (10.5) × (6.5) 7.0–***7.5***–8.0 (9.0) µm [Q = (1.00) 1.06–1.24 (1.31) , **Q** = 1.14 ± 0.06] [holotype (40/2/1): (8.0) 8.5–***9.0***–9.5 (10.5) × 7.0–***7.7***–8.5 µm, Q = (1.11) 1.12–1.23 (1.25), **Q** = 1.17 ± 0.04], subglobose to broadly ellipsoid; ornamentation 1.0–1.5 (1.8) µm high, of conical warts and thick ridges connected by thin lines or ridges, forming an incomplete to complete reticulum, isolated warts and free ends present; plage distally amyloid. *Basidia* (35) 40–60 × 9–14 µm, 4-spored, clavate. *Pleuromacrocystidia* rare to common, emergent, (45) 55–80 (100) × (6) 8–12 µm, fusiform, sublanceolate or sublageniform, some with long tapering ± moniliform apex often. *Hymenophoral pseudocystidia* uncommon, 3–5 µm broad, filiform, slightly enlarged at the apex. *Lamella edge* sterile, rarely fertile; marginal cells similar to basidioles in shape, clavate, hyaline; cheilomacrocystidia absent. *Pileipellis* an incontinuous epithelium, more as an intricate cutis between piles of round cells when mature, continuous layer of globose cells only present in very young pileus; round cells of the epithelium 20–32 × 15–20 µm, globose, ellipsoid, hyaline to pale yellowish brown; repent hyphae of the cutis hyphoid, rarely ellipsoid or sausage-shape, 6–15 (20) µm broad. *Stipitipellis* a cutis; of closely packed, predominantly longitudinally arranged hyphae; hyphae (3) 4–12 µm wide, some inflated to sausage-shaped, yellowish brown. *Trama of pileus and stipe* composed of hyphae and scattered hyaline lactiferous hyphae, lacking rosettes, only with very few sphaerocystes in the central region of the stipe cortex.

Fig. 8. *Lactarius furfuraceus* (holotype). Field habit. Photo X.H. Wang

Additional specimens examined: CHINA. GUANGDONG: Ruyuan Co., Nanling forest park, Xiaohuangshan, 18 Sept. 2015, coll. B. Li, no. 116 (HKAS 89877). GUIZHOU: Jiangkou Co., Fangjing Mt., alt. 1680 m, 11 Aug. 2006, coll. X.H. Wang, no. 1997 (HKAS 51720); Jiangkou Co., Fanjing Mt., roadside from Jinding to Tongkuangchang, 7 Jul. 1988, coll. Z.L. Yang, no. 151 (HKAS 20771); Leishan Co., Leigong Mt. Nature Reserve, N26°23'06.7'' E108°11'39.4'', elev. 1856 m, 24 Jun. 2017, coll. X.H. Wang, no. 4257 (HKAS 101914). TAIWAN: Nantou Co., Meifeng water source area, N24°06'' E121°10', elev. 2100 m, 22 Jun. 1994, coll. W.N. Chou, no. CWN00585 (F0002329); Chiayi Co., Chuchi, Shihcho, Fujungshan, elev. 1800 m, 14 Aug. 2003, coll. W.N. Chou, no. CWN06333 (F0026116). YUNNAN: Baoshan, Gaoligong Mts. Nature Reserve, Nankang, 20 Jul. 2003, coll. X.H. Wang, no. 1587 (HKAS 43953); Baoshan, Longyang District, near Longshu chicken farm, 11 Aug. 2010, coll. T. Guo, no. 146 (HKAS 86674); Baoshan, Longyang District, Shuizhai, Haitang, 22 Jul. 2009, coll. L.P. Tang, no. 885 (HKAS 56842); Chuxiong, Zixi Mt., elev. 2400 m, 13 Aug. 2004, coll. H.D. Zheng, no. 04-559 (HKAS 45070); *ibid.*, 14 Aug. 2004, coll. H.D. Zheng, no. 04-566 (HKAS 45071); Kunming, Miaogaosi, N25°06'02.73'' E102°37'52.53'', elev. 2178 m, 28 Aug. 2005, coll. X.H. Wang, no. 1950 (HKAS 49570); Kunming, Qiongzhusi, N25°04'10.09'' E102°37'23.91'', elev. 2135 m, 8 Sept. 2006, coll. X.H. Wang, no. 2120 (HKAS 51842); *ibid.*, 8 Aug. 2007, coll. X.H. Wang, no. 2142 (HKAS 52364); Lincang Co., Wulao Mt., elev. 2000 m, 2 Jul. 2012, coll. X.H. Wang, no. 3378 (HKAS 75947); Lüchun Co., Huanglian Mt., Huanglianshan reservoir, coll. X.H. Wang, no. 3525 (HKAS 76062); Maguan Co., Dulong Town, Laojun Mt., N22°56'38'' E104°32'29'', elev. 1950 m, 11 Aug. 2016, coll. X.H. Wang 3916 (HKAS 96505); *ibid.*, N 22°57'30.60'' E104°32'16.30'', elev. 1916 m, coll. X.H. Wang, no. 4865 (HKAS 101927); *ibid.*, N 22°58'00.3'' E104°31'33.1'', elev. 1873 m, coll. X.H. Wang, no. 4866 (HKAS 101928); Pingbian Co., Dawei Mt. Nature Reserve, elev. 2650 m, 5 Jul. 1992, coll. P.G. Liu, no. 1324 (HKAS 25521); *ibid.*, 18 Jul. 2005, in *Castanopsis* forest, elev. 2000 m, coll. X.H. Wang, no. 1893 (HKAS 49527); *ibid.*, 9 Jul. 2012, coll. X.H. Wang, no. 3538 (HKAS 76073); Tengchong Co., Gaoligong Mts. Nature Reserve, roadside from Bawan to Tengchong, ca. 30 km to Bawan, 18 Jul. 2003, coll. X.H. Wang, no. 1568 (HKAS 43951); Tenchong Co., Mangbang, roadside from Baoshan to Tengchong, near 52 km landmark, 9 Aug. 2011, coll. X.T. Zhu, no. 469 (HKAS 73865); Xinping Co., Ailao Mts. Nature Reserve, Jinshan virgin forest park, N23°56'26'' E101°30'09'', elev. 2400 m, 13 Aug. 2017, coll. X.H. Wang, no. 4528 (HKAS 101916), no. 4529 (HKAS 101917), no. 4530 (HKAS 101918), no. 4535 (HKAS 101922); *ibid.*, N23°56'23.03'' E101°30'13.37'', elev. 2449 m, 13 Aug. 2017, coll. X.H. Wang, no. 4531 (HKAS 101919),; Zhenyuan Co., Ailao Mts. Nature Reserve, Heping Town, roadside from Zhenyuan to Xinping, 79 km to Zhenyuan county town, elev. 2000 m, 13 Aug. 2017, coll. X.H. Wang, no. 4548 (HKAS 101926).

Habit, habitat and distribution: in groups, common in fagaceous forests. Subtropical-tropical China.

Notes: This is one of the most common species of *L.* subg. *Russularia* in Chinese subtropical fagaceous forests. In the field, it can be easily recognized by the slender habit, the orange brown pileus with areolate-rimose cuticle that produces a furfuraceus appearance and watery latex. It is close to Asian *L. gracilis* Hongo, *L. squamulosus* Z.S. Bi & T.H. Li (syn: *L. glabrigracilis* Wissitrassameewong & Nuytinck) and *L. olivaceorimosellus* X.H. Wang *et al.* All these species have an areolate-rimose pileus and (almost) lack rosettes in the trama of pileus and stipe (Wang 2007; Wisitrassameewong *et al.* 2014; Shi *et al.* 2018). *Lactarius furfuraceus*

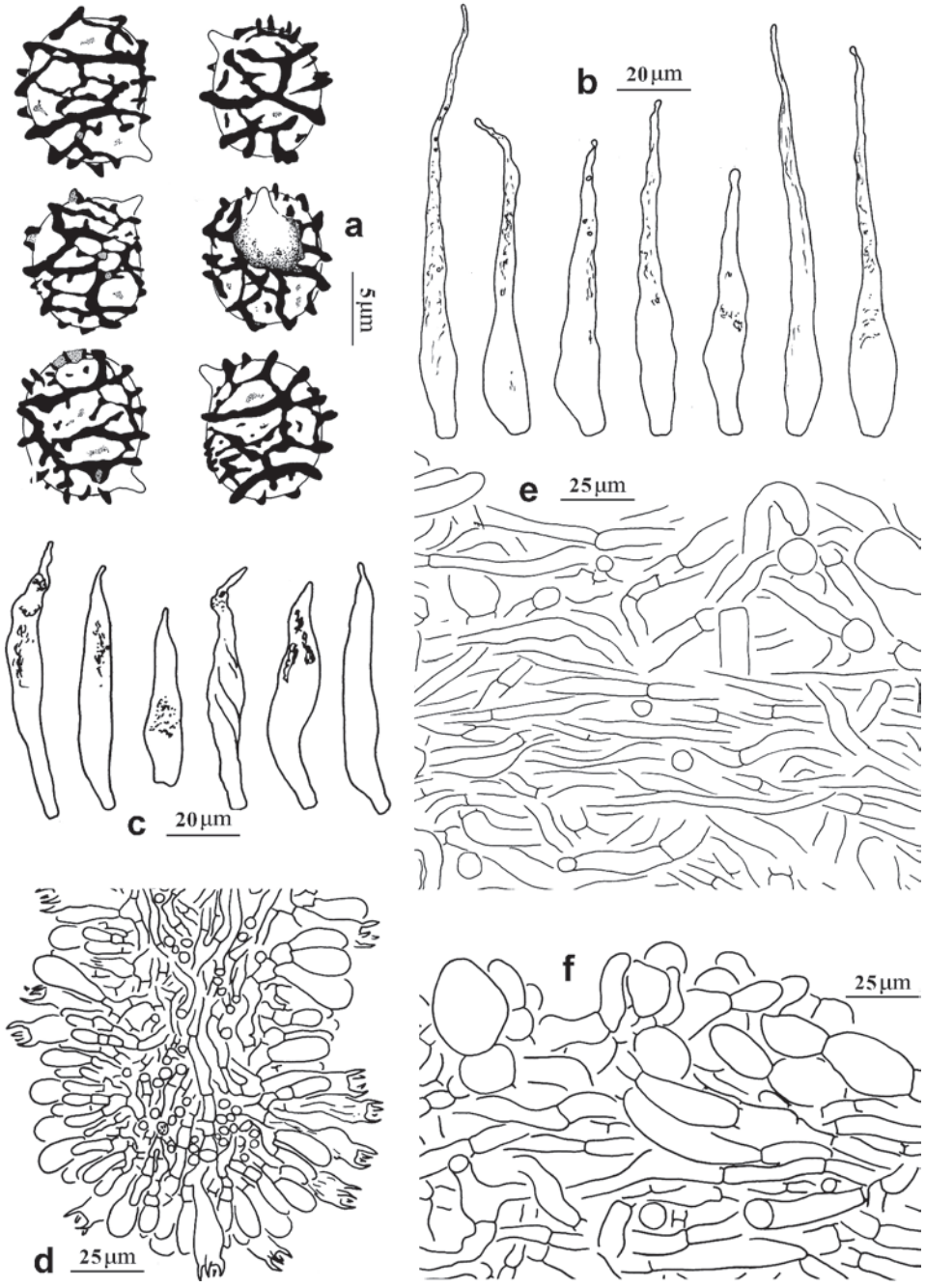

Fig. 9. *Lactarius furfuraceus*. **a.** spores, **b.** pleuromacrocystidia, **c.** pleuromacrocystidia (HKAS 51842); **d.** lamella edge (HKAS 52364), **e.** pileipellis, **f.** Pileipellis (HKAS 51842).a, b and e from holotype. Drawings X.H. Wang

is the only species that has an orange tinge and it has the biggest spores among these species. In North America, *L. areolatus* Hesler & A.H. Sm., *L. highlandensis* Hesler & A.H. Sm. and *L. rimosellus* Peck have areolate-rimulose pileus cuticle, but they all have distinctly heteromerous tissue of pileus and stipe and spores with nearly isolated ornamentation (Hesler & Smith 1979).

In the phylogenetic *L. furfuraceus* comprises two well-supported clades. However, no morphological difference was found between them.

54. *Lactarius orientaliquietus* X.H. Wang ***sp. nov.*** **Figs 10-11**

MycoBank: MB 826764.

GenBank: MH447589 (ITS holotype), MH447590–MH447592 (ITS paratypes)

Systematic position: Basidiomycota, Agricomycotina, Russulales, Rusulaceae.

Etymology: from Latin, referring to the Asian origin and similarity to *L. quietus.*

Holotype: CHINA. SICHUAN: Emei, Hongzhushan, under fagaceous trees, 10 Sept. 2010, coll. X.H. Wang, no. 2770 (HKAS 61966, KUN!)

Diagnosis: A small *Lactarius* with subviscid, zonate, dull brownish pileus, ellipsoid spores with warts and thick ridges forming a reticulum and numerous macrocystidia. The pileus tends to be subviscid and the pileipellis often has a well-delimitated slimy layer. By comparison, the spores are slightly smaller and the hyphae in the suprapellis are narrower.

Basidiomata small. *Pileus* 15–30 mm, at first hemispherical or convex with decurved margin, later expanding to shallowly concave, faintly to clearly zonate, reddish brown when young, dull ochraceous brown when mature; margin sub-transparently sulcate when fully mature; surface subviscid, rarely dry, hygrophanous. *Context* 1 mm thick, nearly concolorous with pileus in the upper part and with lamellae in the lower part. *Lamellae* 1.5–3 mm broad, slightly emarginate to short decurrent, crowded, cream-colored when young, grayish orange (5B4) when mature. *Stipe* 20–45 × 4–7 mm, equal or tapering upwards, cylindrical, nearly hollow; surface dry, ochraceous brown at the apex, brown (close to 6E4) at the lower part, strongly hygrophanous. *Latex* cream-white or watery, not discoloring. *Odor* none, rarely with odor of *L. quietus. Spore print* not obtained.

Basidiospores (100/5/4) 6.5–***7.4***–8.5 (9.0) × (5.0) 5.5–***6.0***–7.0 μm [Q = (1.04) 1.11–1.33 (1.45) , **Q** = 1.23 ± 0.06] [holotype (40/2/1): 6.5–***7.4***–8.0 (8.5) × 5.5–***6.0***–6.5 (7.0) μm, Q = (1.08) 1.14–1.27 (1.32), **Q** = 1.23 ± 0.07], broadly ellipsoid to ellipsoid; ornamentation 0.7–1.3 (1.5) μm high, medium acute, of rather thick and heavy warts and ridges often connected by thin lines, forming a reticulum, often with conical warts at the crossing point of ridges, isolated warts and free ends of ridges present; plage not amyloid. *Basidia* 30–50 × 10–14 μm, 4-spored, clavate, subfusiform. *Pleuromacrocystidia* common to numerous, 40–65 (80) × 7–12 μm, fusiform, cylindrical, subclavate, emergent or slightly protruding, apex acute or round, sometimes moniliform, with yellowish crystalline or massy contents. *Hymenophoral pseudocystidia* uncommon to common, 3–4 μm broad, hyaline, embedded in hymenium or protruding. *Lamella edge* sterile; marginal cells 10–25 (35) × 4–8 μm, similar to basidioles in shape, subclavate, cylindrical, hyaline; cheilomacrocystidia common to numerous, similar to pleuromacrocystidia in shape but smaller, 20–50 × 4–8 μm. *Hymenophoral trama* composed of hyphoid cells and scattered to numerous yellowish brown lactiferous hyphae. *Pileipellis* a transition from (ixo-) cutis to trichoderm, 50–100 μm thick, locally 160–200 μm thick, of

Fig. 10. *Lactarius orientaliquietus* (a.holotype; b. XHW 2964). Field habit. Photo X.H. Wang

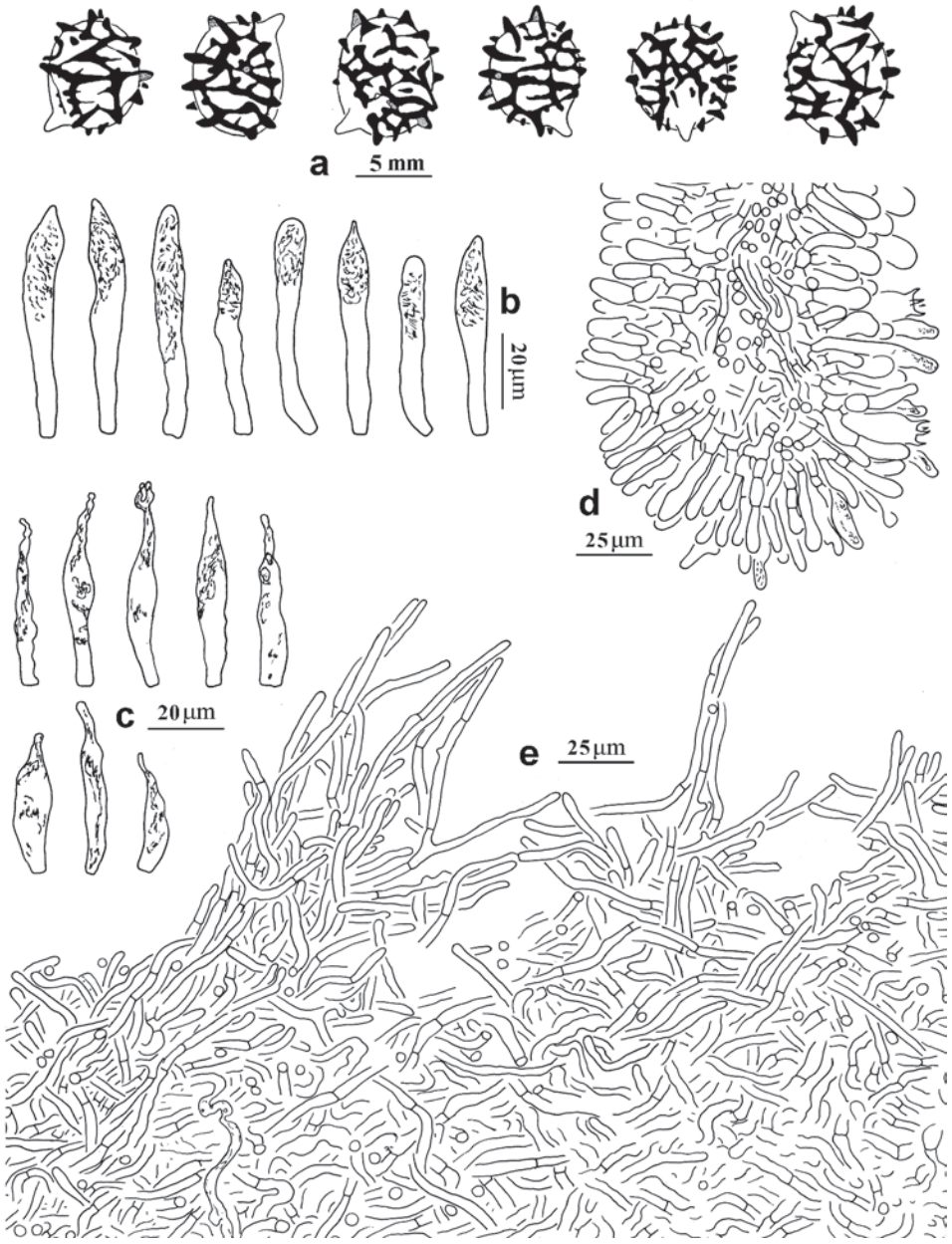

Fig. 11. *Lactarius orientaliquietus*. **a.** spores, **b.** pleuromacrocystidia, **c.** pleuromacrocystidia (HKAS 73539); **d.** lamella edge, **e.** pileipellis. a–c and e from holotype. Drawings X.H. Wang

loosely interwoven hyphae, (locally) covered with sparse slimy layer at some individuals; hyphae in suprapellis 3–5 μm broad, multi-branching, not gelatinized, pale yellowish brown, more yellowish brown near surface, terminal cells 10–55 ×

3–5 μm; hyphae of subpellis 4–7 μm broad, slightly gelatinized. *Stipitipellis* a cutis, 30–50 μm thick; hyphae 3–6 μm broad, closely packed, not or slightly gelatinized, hyaline to pale yellowish brown. *Trama of pileus and stipe* composed of hyphae, typical rosettes and scattered to abundant colorless to yellowish brown lactiferous hyphae.

Habit, habitat and distribution: in group, common in fagaceous forests. Subtropical China and South Korea.

Additional specimens examined: CHINA. YUNNAN: Maguan Co., Nanlao town, Xiaomalipo, N23°03'21.7'' E104°31'37.4'', elev. 1219 m, in *Quercus* forest, 17 Oct. 2017, coll. X.H. Wang, no. 4848 (HKAS 101925). SOUTH KOREA. SOEUL: Donggureung Nine Royal Tombs park, under *Quercus* trees, 15 Aug. 2011, coll. X.H. Wang, no. 2964 (HKAS 73521). INCHEON: Central Park, under *Quercus* trees, 16. Aug. 2011, coll. X.H. Wang, no. 2983 (HKAS 73539).

Notes: There are some variations among the specimens examined above. The holotype has a dry pileus, different from the subviscid pilei of HKAS 73521, 73539 and HKAS 101925. The milk is watery in the holotype, cream-white in HKAS 101925 and white in HKAS 73521. The macrocystidia of HKAS 101925 (50–80 × 9–12 μm) are bigger than those of the other three (40–60 × 7–10 μm). Only HKAS 101925 has a bug-like smell, similar to *L. quietus*.

This is the Asian counterpart of European *L. quietus.* The pileus of *L. orientaliquietus* tends to be subviscid and the pileipellis often has a well-delimited slimy layer. By comparison, the spores of *L. orientaliquietus* are slightly smaller and the hyphae in the suprapellis are narrower (ref. Heilmann-Clausen *et al.* 1998; Basso 1999). It seems that the "*Pentamogium* bugs"-like odor, which is characteristic of *L. quietus,* is not common in *L. orientaliquietus.*

55.*Lactarius subhirtipes* X.H. Wang ***sp. nov.*** **Figs 12-13**

MycoBank: MB 826767

GenBank: MH447554 (ITS holotype), MH447551–MH447553, MH447555–MH447563 (ITS paratypes)

Systematic position: Basidiomycota, Agricomycotina, Russulales, Rusulaceae.

Etymology: from Latin, referring to the macroscopical similarity to *L. hirtipes.*

Holotype: CHINA. SHANXI: Xia Co., Sijiao Town, Tanghui, Zhongtiao Mt., in *Quercus* forest, 15 Aug. 2015, coll. X.H. Wang, no. 3682 (HKAS 89953, KUN!)

Diagnosis: A species with slender brownish orange basidiocarps, polished pileus with a papilla, watery latex, small globose spores with relatively isolated and acute ornamentation and absence of macrocystidia.

Basidiomata small, slender, thin-fleshed. *Pileus* 20–40 (50) mm, at first convex with a conical papilla, later concave, shallowly infundibuliform in age; surface dry, glossy when wet, sometimes finely rugose, hygrophanous, brownish orange (7C6) when young, grayish orange to brownish orange when mature (6B5–6C5, 6B6–6C6), darker at the center. *Context* 1 mm thick, paler than lamellae. *Lamellae* 1.5–2 mm broad, decurrent, extremely crowded, grayish orange (5B6), becoming reddish brown when mature. *Stipe* 30–60 (90) × 2–5 (10) mm, equal or gradually enlarged downwards, cylindrical, hollow; surface dry, smooth, light brown (6D6) to brown (6D7–6E7); base often strigose with long paler hairs. *Latex* watery or white soon becoming watery, not discoloring, mild. *Odor* none. *Spore print* cream-ochraceous.

Basidiospores (220/11/10) (5.0) 5.5–***6.5***–7.0 (8.0) × (5.0) 5.5–***6.1***–6.5 (7.5) µm [Q = 1.00–1.11 (1.17) , **Q** = 1.05 ± 0.03] [holotype (40/2/1): (5.5) 6.0–***6.6***–9.5 (10.5) × 5.5–***6.3***–7.0 (7.5) µm, Q = (1.00) 1.03–1.08, **Q** = 1.05 ± 0.03], subglobose to globose; ornamentation 0.3–1.0 (1.3) µm high, of dense or medium dense conical warts and acute ridges partly connected, some forming closed meshes, not forming reticulum or forming very broken reticulum, isolated warts and free ridges common to numerous; plage not amyloid, rarely distally amyloid. *Basidia* 30–40 (45) × (7) 9–14 µm, 4-spored, clavate, cylindrical, subfusiform. *Macrocystidia* absent. *Hymenophoral pseudocystidia* uncommon to common, 3–5 µm broad, with slightly enlarged apex, with granular, cottony or amorphous contents, hyaline. *Lamella edge* sterile; marginal cells 8–20 × 4–8 µm, similar to basidioles in shape, clavate, cylindrical, ellipsoid, hyaline. *Pileipellis* a hyphoepithelium, 30–50 µm thick, pale yellowish brown; cells of subpellis 10–40 × 10–25 µm, pyriform, ellipsoid, globose; terminal cells of suprapellis 15–70 × 3–6 (11) µm, repent, cylindrical, rarely pyriform or fusiform, yellowish brown; hyphae beneath pileipellis 7–15 µm broad. *Stipitipellis* a cutis, of closely packed, predominantly longitudinally arranged hyphae; hyphae (3) 4–14 µm wide, some inflated or sausage-shaped, yellowish brown, often with slightly thickened wall (0.5-1.0 µm thick). *Trama* of lamellae, pileus and stipe composed of hyphae and scattered colorless lactifers, lacking rosettes.

Additional specimens examined: CHONGQING: Jiangjin District, N28°53’1.24’’ E106°20’7.64’’, elev. 254 m, 15 Jun. 2014, coll. Y.J. Hao, no. 1051 (HKAS 82842). GANSU: Cheng Co., Paosha Town, Dongying, elev. 1300 m, in

Fig. 12. *Lactarius subhirtipes* (holotype). Field habit. Photo X.H. Wang

Fagus forest, 23 Aug. 2011, coll. X.T. Zhu, no. 554 (HKAS 73949). HENAN: Luanchuan Co., Laojun Mt., Tenglongyu trail, elev. 1200 m, 13 Aug. 2015, coll. X.H. Wang, no. 3663 (HKAS 89936); Luanchuan Co., Tantou Town, Xiaohekou, elev. 540 m, 11 Aug. 2015, coll. X.H. Wang, no. 3630 (HKAS 89904), no. 3636 (HKAS 89910); Xinyang, Jigong Mt., Laoyingwo, elev. 295 m, 25 Aug. 2015, coll. X.H. Wang, no. 3784 (HKAS 90044). HUBEI: Shiyan, Maojian, Wayao, 7 Jul. 2013, coll. T. Guo, no. 682 (HKAS 81884). SHANDONG: Pingyi Co., Dawa forest farm, Dianzi section, elev. 400 m, in chestnut forest, 24 Aug. 2011, coll. X.H. Wang, no. 3016 (HKAS 73561); Pingyi Co., Menshang forest park, elev. 400 m, in *Quercus* forest, 24 Aug. 2011, coll. X.H. Wang, no. 3017 (HKAS 73562). SICHUAN: Tongjiang Co., Chenhe Town, elev. 650 m, 23 Jul. 1996, coll. M.S. Yuan, no. 2291 (HKAS 30731). TAIWAN: Nantou Co., Jenai Hsiang, Aowanta forest park, pine forest section, N23°56'41'' E121°11'30', elev. 1290 m, 3 Oct. 2016, coll. X.H. Wang, no. 4170 (HKAS 96758); *ibid.*, 3 Jul. 2003, coll. W.N. Chou, no. CWN 06243 (F0024489, TNM). YUNNAN: Maguan Co., Dalishu Town, Xiaonike, N23°06'06.2'' E104°07'32'', elev. 1637 m, under fagaceous trees, 12 Oct. 2017, coll. X.H. Wang, no. 4711 (HKAS 101924); Nanjian Co., Gonglang Town, Wangjiang, 3 Aug. 2015, coll. X.X. Ding, no. 25 (HKAS 90714).

Habit, habitat and distribution: in group, common in fagaceous forests. Subtropical-tropical China.

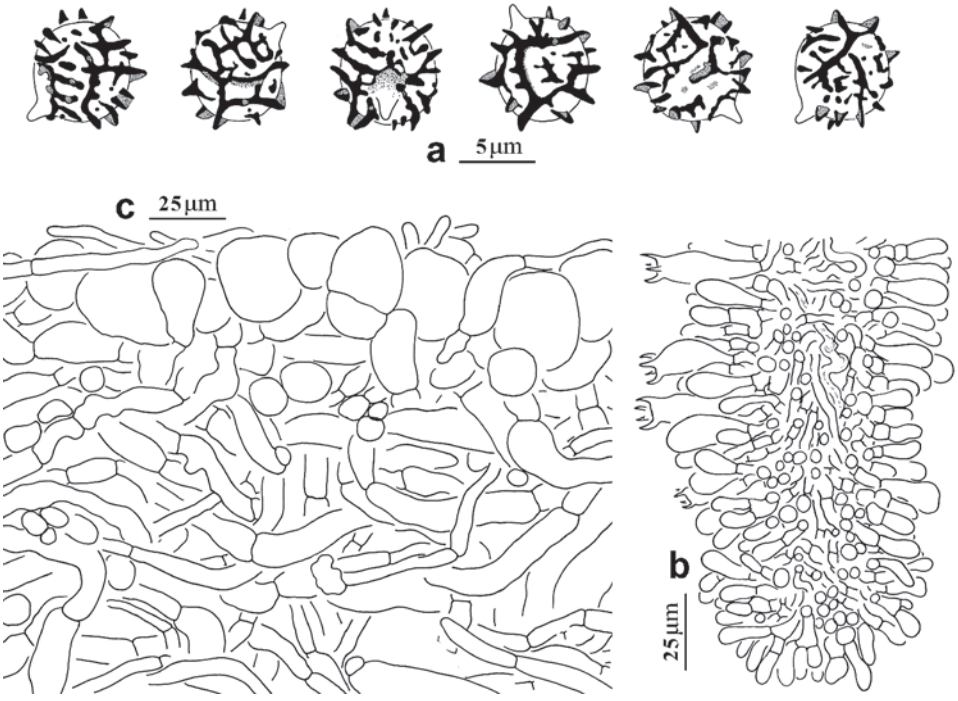

Fig. 13. *Lactarius subhirtipes* (holotype). **a.** spores, **b.** pleuromacrocystidia, **c.** pileipellis. Drawings X.H. Wang

Notes: This is one of the most widely distributed species in Chinese subtropical fagaceous forests. In the field it is easily confused with *L. hirtipes* J.Z. Ying, a species that has white, acrid latex (Wang & Liu 2002). The small globose spores with less reticulate ornamentation and absence of macrocystidia of *L. subhirtipes* are good microscopical characters to distinguish these two species. *Lactarius subhirtipes* is apparently similar to *L. atlanticus* Bon and *L. strigosipes* Montoya & Bandala, in the slender habit of the basidiocarps, strigose stipe base, globose spores and absence of macrocystidia. The European *L. atlanticus* has bigger spores with more reticulate ornamentation and shorter terminal cells of the pileipellis (Basso 1999; Triantafyllou *et al.* 2015) and the Mexican *L. strigosipes* has rosettes in the context (Montoya & Bandala 2008).

56. *Marasmius pseudohypochroides* K. Das & Antonín ***sp. nov.*** **Figs 14-16**

MycoBank: MB 826711

GenBank: MF554638 (nrITS).

Systematic position: Basidiomycota, Agaricomycetes, Agaricales, Marasmiaceae.

Etymology: referring to closeness with partially similarly looking *M. hypochroides*, another Asian species.

Diagnosis: *Marasmius pseudohypochroides* is distinct from the closest species *M. hypochroides* by nrITS sequence data and the combination of a distinctly larger pileus (16-110 mm diam.) with a prominent bell-shaped umbo and a considerably taller stipe (80-190 × 4-8 mm).

Holotype: INDIA, Sikkim, South district, between Rabangla and Damthang, Daze, N27°16.955' E88°21.796', alt. 2191 m a.s.l., on the ground on leaf-litter and dead twigs of *Castanopsis* sp. in a temperate broadleaf forest. 24 Aug. 2017, *K. Das* KD 17-18 (CAL 1628!).

Pileus 16-110 mm diam., initially conic or pyramidal to convex, then convex with a central broad umbo, finally plano-convex to applanate with a broad bell-shaped central umbo; surface rugulose, striate to sulcate, glabrous to subvelutinous, hygrophanous, somewhat translucent, light brown to brown (7D6-7) to reddish brown (8F7-8) at centre, reddish brown (8E7-6) towards margin, gradually, more paler, up to greyish orange (6B4) at margin; margin incurved when young, plane to uplifted in maturity; context yellowish white to cream, thin. *Lamellae* free to adnexed, up to 10 mm broad, distant (5-6/cm) with 4 series of lamellulae, intricately intervenose and anastomosing, white (1A1) when young, becoming yellowish white (3-4A2) in maturity; edges light brown to brown (6D6-7). *Stipe* 80-190 × 4-8 mm, central, cylindrical, wiry, with ridged surface, hollow, glabrous, non-insititious, translucent, apex buff, then greyish orange (5B3) with often strigose white basal mycelium when young, becoming reddish brown (8F8) to dark brown and with or without a whitish base at maturity. *Odor* and *taste* not distinctive. *Spore print* white when fresh, turning yellowish white (2A2) when dry.

Basidiospores (7.5-)7.6-**8.8-9.1**-10.7 × 4.9-**5.6-6.5**-7.5 µm [n = 15 x 2]; Q = 1.28-**1.39-1.55**-1.75, broadly ellipsoid to elongate, smooth, hyaline, inamyloid, thin- to slightly thick-walled (walls up to 1.2 µm thick). *Basidia* 38-55 × 8-11 µm, common, cylindrical to clavate, 4-spored, *basidioles* abundant, cylindrical to narrowly clavate. *Lamellae edge* fertile with basidia, basidioles and cheilocystidia. *Cheilocystidia* uncommon, like *Siccus*-type broom cells; broom cells main body 10-30 × 5-10 µm, cylindrical to clavate or pyriform, hyaline, inamyloid, thin-walled; apical setulae often long, 5-30 × 1-1.5 µm, cylindrical, inamyloid, subacute, brown to light brown, thin- to thick-walled. *Pleurocystidia* absent. *Hymenophoral trama*

composed of interwoven hyphae; hyphae 5-23 µm wide, often inflated. *Pileipellis* hymeniform, composed of densely arranged *Siccus*-type broom cells; broom cells main body 6-22 × 5-12 µm, cylindrical, narrowly to broadly clavate or pyriform, often branched, hyaline, inamyloid, thin- to thick-walled (walls up to 1 µm thick); apical setulae 5-20 × 1-2.5 µm, often crowded, cylindrical, subacute to acute, brown to dark brown, thick-walled. *Pileus trama* composed of interwoven hyphae; hyphae up to 20 µm wide, dextrinoid, cylindrical, sometimes inflated, smooth, hyaline, thin-walled. *Stipitipellis* hyphae 6-15 µm diam., cylindrical, light brown to brown, smooth, dextrinoid, thin- to thick-walled (walls 0.5-2.5 µm thick), non-gelatinous. *Caulocystidia* absent. *Clamp connections* present in all tissues.

Additional specimens examined: INDIA, Sikkim, South district, Ravangla, N27°18.086' E88°21.606', alt. 2011 m a.s.l., on the ground on leaf-litter and dead twigs of *Castanopsis* sp. in temperate broadleaf forest. 15 Aug. 2016, *K. Das* KD 16-001 (CAL 1627).

Notes: *Marasmius pseudohypochroides* is characterized by a large and robust, rugulose, striate to sulcate pileus, brownish orange to yellowish brown with a dark brown disc, distant lamellae with strong intervenation, cheilocystidia with very long setulae (5–30 µm), and the absence of pleurocystidia and caulocystidia. In the description, measurements are presented as (MIN) [KDx-2×SDx] – *KDx – KDy* – [KDy+2×SDy] (MAX) in which KDx = lowest mean value for the measured collections, KDy = greatest mean value and SDx/y = standard deviation of the lowest and greatest mean value respectively. MIN is the lowest value measured, MAX the highest value; MIN and MAX are only given when they exceed [KDx-2×SDx] or [KDy+2×SDy] respectively. Q stands for 'quotient length/width' and is given as MINQ – *Qx – Qy* – MAXQ in which Qx and Qy stand respectively for the lowest and the highest mean quotient for the measured specimens.

The morphologically similar and phylogenetically close Asian species, *M. hypochroides* Berk. & Broome, also known from India, differs by distinctly smaller basidiomata (pileus 17–56 mm diam; stipe 38-95 × 1-3 mm), larger basidiospores [(8-)9-12(-13) × 5-6(-8) µm] and sequence data of nrITS region (showing only 90% identity under 97% query coverage with *M. pseudohypochroides*) (Wannathes *et al.* 2009).

Another phylogenetically close species (Fig. 14) originally reported from Europe, *M. cohaerens* (Pers.) Cooke & Quél. also mostly grows in broadleaf forest and may be confused with the present species. It can, however, easily be separated by the distinctly smaller basidiomata (pileus 9-36 mm diam., stipe 50-90 × 0.7-4 mm), the unmistakable stipe with its white to yellowish brown upper half and the presence of setae in hymenium and pileipellis (Antonín and Noordeloos 2010). *Marasmius coklatus* Desjardin, Retn. & E. Horak has smaller basidiomata with a pileus which is 15-38(-60) mm broad and stipe 33-63(-95) × 3-5 mm; it also has narrower basidiospores (10-11 × 4.5-6 µm), two types of cheilocystidia and well-developed pleurocystidia of two types (Desjardin *et al.* 2000); *M. araneocephalus* Wannathes, Desjardin & Lumyong differs by smaller basidiomata (pileus measuring 20-42 mm broad and stipe 27-45 × 1-2 mm), smaller basidiospores (6-7(-8) × 3.5-4 µm), two types of cheilocystidia, the presence of pleurosetae and caulocystidia and two types of pileipellis cells (Wannathes *et al.* 2009). All other phylogenetically more or less close taxa, *M. nigrodiscus* (Peck) Halling, *M. brunneospermus* Har. Takah., *M. nivicola* Har. Takah., *M. maximus* Hongo and *M. oreades* (Bolton: Fr.) Fr. fundamentally differ by smooth pileipellis cells (Halling 1983, Antonín *et al.* 2010, Antonín and Noordeloos 2010).

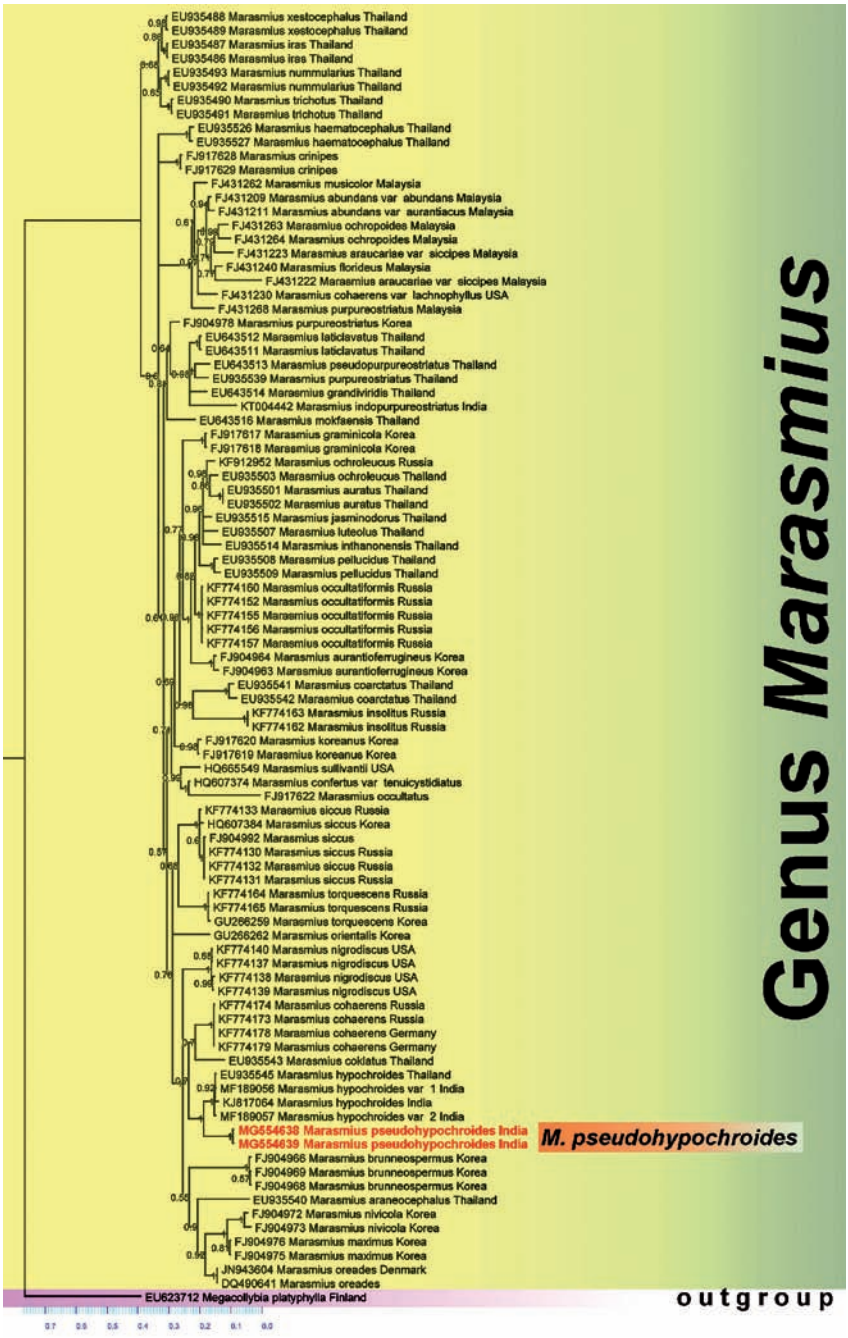

Fig. 14. Bayesian phylogram inferred from the ITS dataset based on MrBayes under TIMef model of nucleotide evolution. Support values (Bayesian posterior probability) are indicated above or below clade branches. Two collections of the new species *Marasmius pseudohypochroides* (GenBank nrs MG554638 and MG554639) are shown in red and bold font in the phylogram.

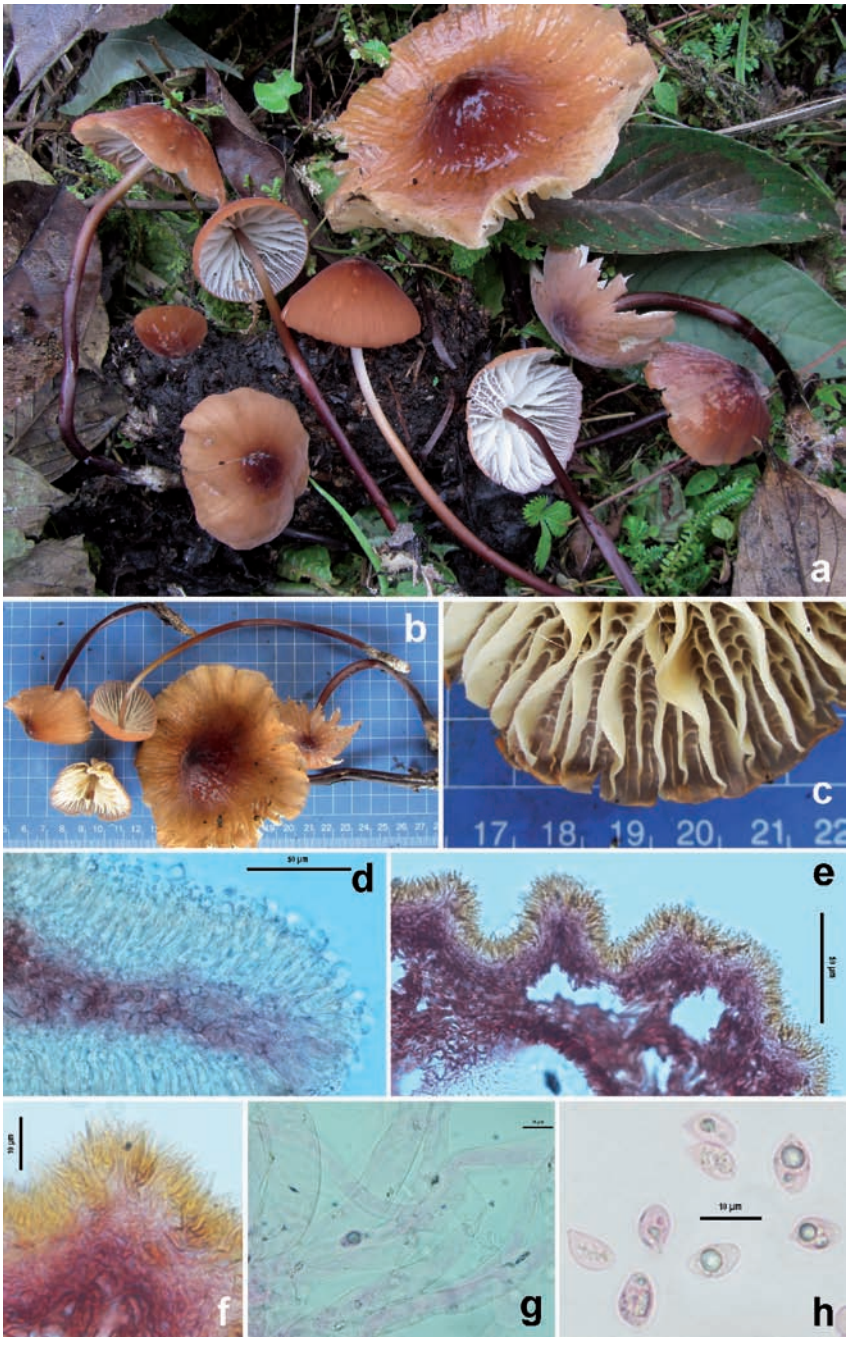

Fig. 15. *Marasmius pseudohypochroides* (KD 17-18, holotype). **a & b.** Fresh basidiomata in the field and basecamp. **c.** Lamellae. **d.** Hymenophoral trama. **e & f.** Transverse section through pileipellis. **g.** Clamped hyphae in hymenophoral trama. **h**. Basidiospores. Scale bars: d & e = 50 µm; f, g & h = 10 µm

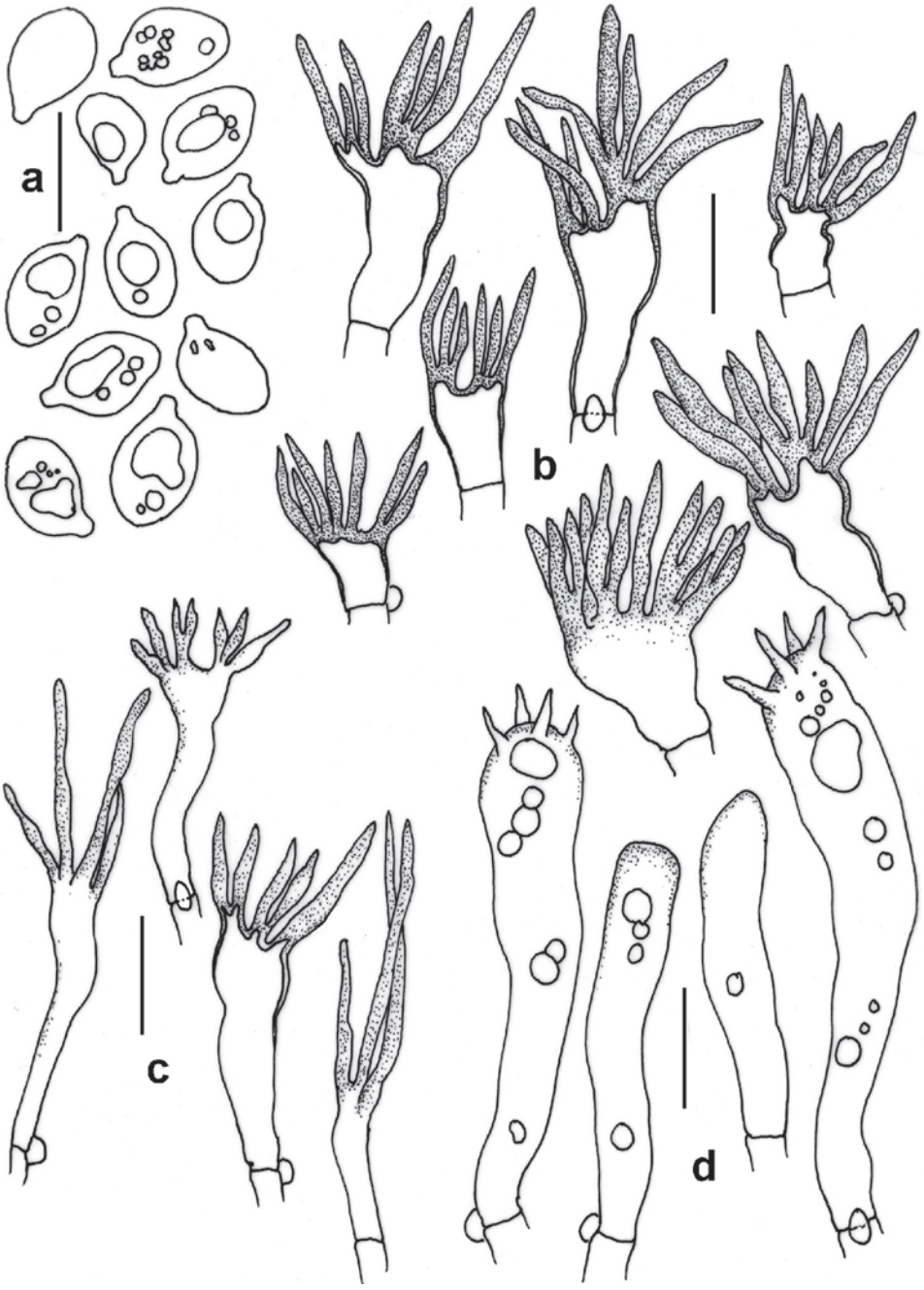

Fig. 16. *Marasmius pseudohypochroides* (from KD 17-18, holotype). Microscopic features: **a.** Basidiospores. **b.** Elements of pileipellis. **c.** Cheilocystidia. **d.** Basidia and basidioles. Scale bars: a-d = 10 μm.

57. *Radulomyces paumanokensis* J. Horman, B. Ortiz, & Nakasone, ***sp. nov***.
Figs. 17-19

MycoBank: MB 825443

GenBank: MG050101 (nrLSU); MG050100 (ITS).

Systematic positon: Basidiomycota, Agaricomycetes, Agaricales, Pterulaceae

Etymology: Paumanok is the Native American name for Long Island, the type locality.

Diagnosis: Different from other *Radulomyces* species by its compact, hemispherical to ovoid basidiocarps composed of an aggregation of fasciculate, branching, pendant spines.

Holotype: UNITED STATES, New York, Long Island, Welwyn Preserve County Park, Glen Cove, 40.880258, –73.639101, on bark of rotted hardwood log, 19 Nov. 2016, leg. *A. Norarevian* (NY 03304530, **holotype**; CFMR, **isotype**).

Basidiocarps a compact, hemispherical to ovoid cluster of radiating, branching, pendant spines, up to 50 × 50 mm, white, orange white to pale orange (5A(2–3), color names from Kornerup & Wanscher 1978) when fresh, pale orange (5A3), greyish orange (5B3), or orange grey (6B2) when dried. *Spines* slender, up to 20 mm long, firm, terete to compressed, fused at base then branching multiple times, finally tapering to subacute apices, brittle when dried; surface smooth to finely farinaceous; context dense, ceraceous, yellowish brown.

Hyphal system monomitic with clamped, generative hyphae. *Spines* composed of an inner core of agglutinated, distinct hyphae arranged in parallel, surrounded by a thickening subhymenium and hymenium; terminal hyphae at apex mostly undifferentiated but occasionally slightly capitate; tramal hyphae 2.3–3.5 µm diam, clamped, rarely branched, walls hyaline, thin to slightly thickened, smooth, weakly to distinctly cyanophilous. *Subhymenium* thickening, up to 90 µm thick, a dense tissue of short-celled, agglutinated hyphae perpendicular to spine axis; subhymenial hyphae 3–3.5 µm diam, clamped, branched, walls hyaline, thin, smooth, acyanophilous. *Hymenium* up to 45 µm thick, a dense palisade of basidia and hyphidia. *Hyphidia* simple, filamentous, rarely subcapitate, 20–35 × 3–3.5 µm, clamped at base, walls hyaline, thin, smooth. *Cystidia* rare, embedded, clavate, 42– 52 × 6.5–7 µm, clamped at base, walls hyaline, thin, smooth. *Basidia* scarce, clavate to cylindrical, sometimes nearly pleural, 25–31 × 5–7.5 µm, clamped at base, sometimes stalked, 4-sterigmate, walls hyaline, thin, smooth. *Basidiospores* globose to subglobose, (5.7–) 5.8–6.9 × (5.1–) 5.2–6.4 (–6.5) µm, average of type specimens 6.1–6.2 × 5.7–5.9 µm, Q = 1.1 ± 0.1, walls hyaline, thin to slightly thick, smooth, cyanophilous, not reacting in Melzer's reagent.

Habitat and distribution: On angiospermous wood in eastern New York.

Other specimen examined: New York, Long Island, E. Norwich, Muttontown Preserve, 40.8294, –73.5330, on rotten hardwood log, 02 Oct 2016, leg. J. Horman (NY 03304531, CFMR)

Notes: Species of *Radulomyces* are characterized by widely effused, adnate, crust-like basidiocarps, but *R. paumanokensis* is unique for its compact basidiocarps composed of numerous branched spines. Microscopically, *R. paumanokensis* displays features typical of *Radulomyces* including simple hyphidia and large basidiospores with cyanophilous walls. Two other species of *Radulomyces* also develop large spines — *R. copelandii* (Pat.) Hjortstam & Spooner and *R. molaris* (Chaillet ex Fr.) M.P. Christ. *Radulomyces copelandii* produces extensive, effused basidiocarps with slender, white to yellow spines, 8–12 mm long, and subglobose basidiospores, 6.4– 7 × 5.4–6.2 µm (Ginns & Millman 2011; Maekawa 1993). In contrast, *R.*

molaris develops effused basidiocarps with stout, gray to cream-colored spines, 1–5 mm long, and ellipsoid basidiospores, 8–12 × 6–7 (–8) µm (Bernicchia & Gorjón, 2010; Martini 2016).

Some *species* of *Mucronella* Fr. and *Deflexula* Corner also produce basidiocarps composed of fasciculate, pendant spines. In *Mucronella aggregata* Fr., the basidiospores are thin-walled and amyloid, whereas *Deflexula* species are dimitic with skeletal hyphae and large basidiospores (> 9 µm diameter) (Corner 1950).

Phylogenetically, *Radulomyces* belongs in the Pterulaceae (Agaricales) and is most closely related to *Radulotubus* Y.C. Dai, S.H. He & C.L. Zhao and *Aphanobasidium* Jülich. These three genera form a strongly supported clade that is sister to the *Pterula-Deflexula-Pterulicium-Merulicium-Coronicium* clade as demonstrated sequence analyses of the nrLSU or nuclear ribosomal large subunit (Zhao *et al*. 2016; data not shown). In Bayesian inference analyses of the ITS and nrLSU sequences alone or combined, *R. paumanokensis* always clustered with other

Fig. 17. Basidiocarp of *Radulomyces paumanokensis* (holotype). Photograph by Joel Horman. Scale bar = 10 mm.

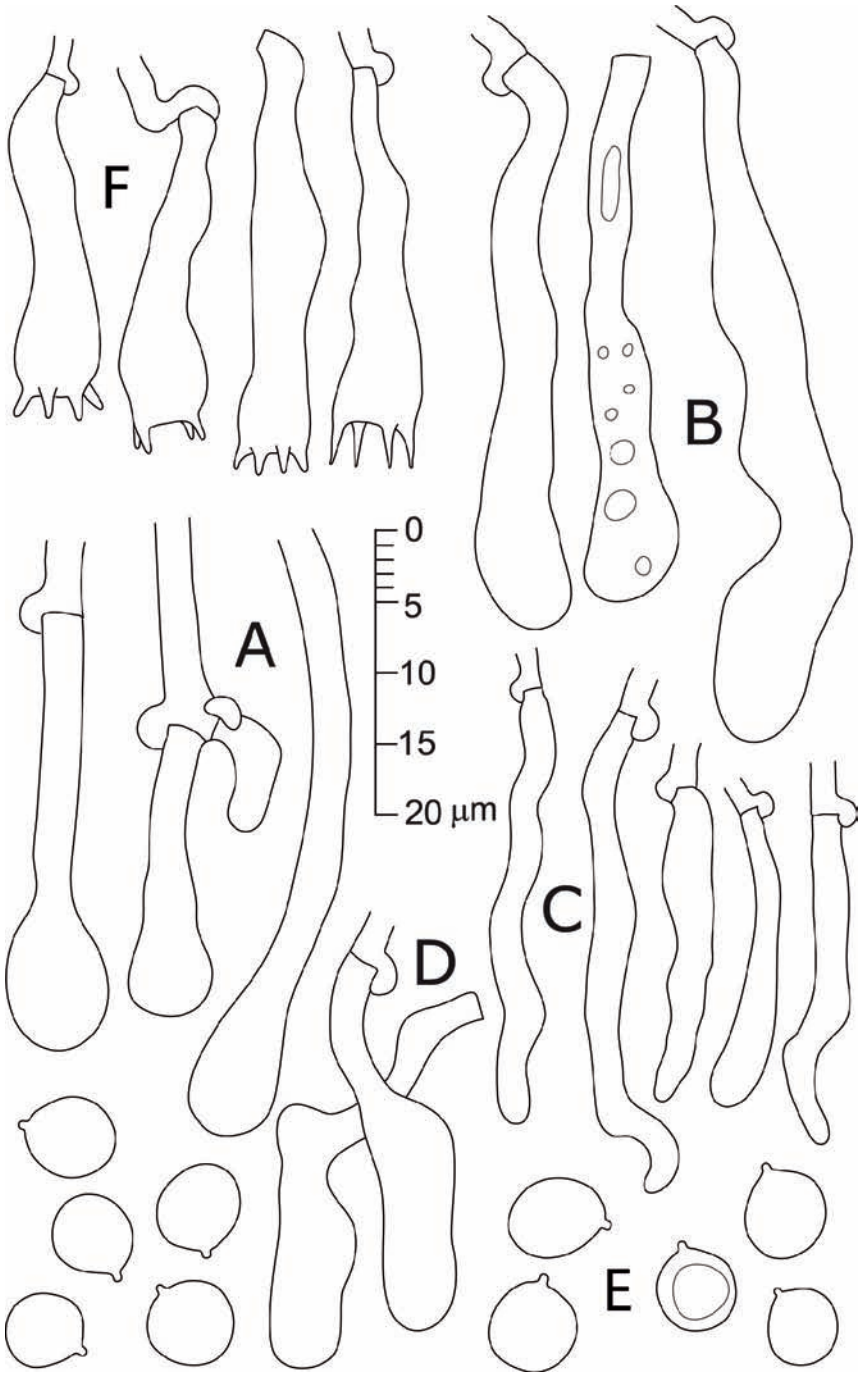

Fig. 18. *Radulomyces paumanokensis* (holotype, Norarevian 19-Nov-2016). **A**. Terminal hyphae from aculei apex. **B**. Cystidia. **C**. Hyphidia. **D**. Immature basidia. **E**. Basidiospores; from paratype. **F**. Mature basidia (from paratype, Horman 02-Oct-2016).

Radulomyces species. With ITS alone or a combined ITS-nrLSU dataset of *Radulomyces*, *Radulotubus* and *Aphanobasidium* species with *Pterula echo* as outgroup, *Radulomyces* formed a strongly supported clade that is sister to *Radulotubus* (Fig. 19). In Bayesian analysis of nrLSU sequences alone, however, *Radulotubus* was embedded in the *Radulomyces* clade (data not shown).

During our study, we discovered an ITS sequence of *R. copelandii* (MG722738) from northwest Georgia, near the Black Sea that is 99% identical to *R. paumanokensis.* We have not examined the voucher specimen from Georgia, but from sequence similarity alone, we conclude that these two taxa are conspecific; thus, the distribution of *R. paumanokensis* extends to Eurasia.

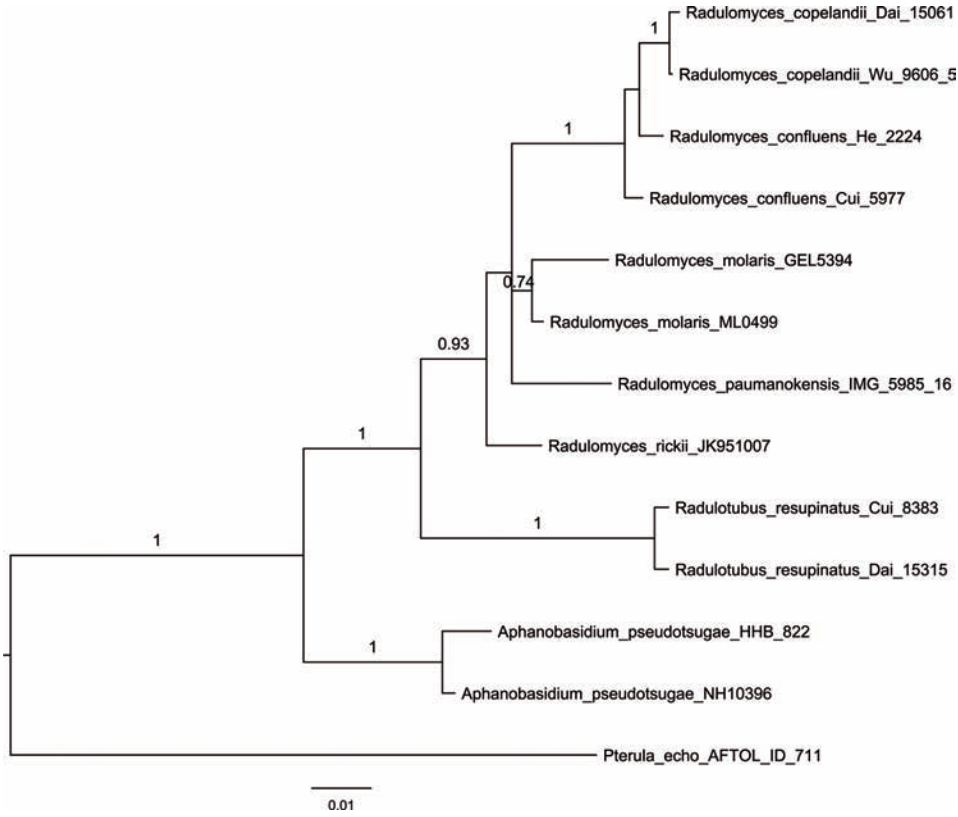

Fig 19. Bayesian consensus tree from the analysis of the combined ITS+nrLSU dataset. The combined dataset consisted of 12 ingroup sequences (representing species of *Radulomyces, Radulotubus* and *Aphanobasidium*) and one outgroup (*Pterula echo*) with a total of 1645 characters (719 ITS, 926 nrLSU). Phylogenetic analysis was conducted using MrBayes 3.2.6 (Ronquist *et al.* 2012) on XSEDE through CIPRES Science Gateway V. 3.3 (Miller *et al.* 2010), for 1 000 000 generations in two runs and four chains with trees sampled every 100 generations. Posterior probability values are given along branches. GenBank no. for ITS/nrLSU sequences: Dai 15061 KU535664/KU535672, Wu 9606-5 KU535663/KU535671, He 2224 KU535662/KU535670, Cui 5977 KU535661.KU535669, GEL 5394 –/AJ406571, IMG 5985-16 MG050100/MG050110, JK 951007 –/AY586706, Cui 8383 KU535660/KU535668, Dai 15315 KU535658/KU535666, HHB 822 GU187509/GU187567, *A. pseudotsuage* UC 2023143 KP814192/NH10396 AY586696, AFTOL-ID711 DQ494693/AY629315.

58. *Russula blennia* Buyck ***sp. nov.*** **Figs. 20–22**

Mycobank: MB 826913

GenBank: KU237556 (LSU), KU237404 (mitSSU), KU237701 (*RPB1*), KU237842 (*RPB2*), KU237987 (*tef1alpha*), MH545687 (ITS), all from holotype

Diagnosis: well-characterized by the combination of frequently forked gills, a felty, brownish-gray pileus, white stipe, spore ornamentation of isolated, high warts and spines, inamyloid but verrucose suprahilar spot and its habitat consisting of dense mountain forest types dominated by *Uapaca* species (mostly *U. densifolia*)

Holotype: MADAGASCAR. Central Plateau, special reserve of Ambohitantely, NW of Anatanarivo, 30 km from Ankazobe, in *Uapaca densifolia* - Sarcolaenaceae dense dry forest, along the botanical track, 20 January 2008, Buyck 08.066 (PC0124723)

Systematic position: Basidiomycota, Agaricomycetes, Russulales, Russulaceae

Etymology: named after the similarities in the field to European milk caps in the group of *Lactarius blennius*

Basidiomata isolated or in small groups. *Pileus* 24-64(75) mm diam., regular, slightly depressed in center, not becoming deeply infundibuliform, snooth near margin; surface felty-velutinous, becoming viscose when wet, never glutinous, separable for ½ to 2/3 from margin inwards, continuous and smooth in the pileus center, very finely cracked under a handlens to coarsely cracked – areolate closer to the margin, often superficially cracking and even deeply fissuring radially close to the very pileus margin when fully expanded, colored in tones of isabelline to dirty ochraceous, pale gray to pale or even dark brown. *Gills* adnate to subfree, equal but frequently forking at different distances from stipe, ca 3 mm high, anastomosing brittle, normally spaced (ca 1L/mm), sordid cream (4A2) but often with a clear pinkish tinge in the field, staining dark brown in old age; gill edge even, cystidiose under a hand lens, concolorous. *Stipe* central, (30)43-72 x (8)11-15 mm, cylindrical to slightly narrowing downward, smooth to longitudinally wrinkled, glabrous, very pale creamy to off-white, developing brownish-grayish stains when handled or with age, not very fragile, spongy-stuffed inside, developing sometimes whitish mycelium at the base. *Context* firm, whitish to pale yellowish, developing pale brown to pale gray punctuations or parts, turning faintly pinkish when cut, reacting yellowish to FeSO4. *Taste* mild or slightly like soap. *Odor* weak, somewhat fruity (apples) to slightly disagreeable. *Spore print* white.

Spores (sub)globose to shortly ellipsoid, (7.7)7.9-***8.27***-8.6(9.0) x (6.9)7.1-***7.40***-7.7(7.9)µm, Q = (1.05)1.07-***1.12***-1.16(1.21); ornamentation composed of strongly amyloid, isolated, high conical warts to even spines of variable dimensions, the largest ones up to 2 µm high, mixed with a variable number of much smaller interstitial warts; suprahilar spot not amyloid but distinctly verrucose and occupied by gradually smaller amyloid warts, in some more irregularly developed spores with lower and denser ornamentation and sometimes partly amyloid suprahilar spot; apiculus long and distinct. Basidia widest in their median part, 34-44 x 10-13 µm, four-spored; sterigmata robust and long, 7-10 x 2-2.5 µm. *Hymenial gloeocystidia* subcylindrical to fusiformous, mostly 50 - 70 x 8 – 9 µm, nearly always minutely capitate, near the gill edge very abundant, frequently obtuse rounded at the tip and often filled with bright yellowish contents, not shorter than on gill sides and up to 85 µm long (contrary to the general pattern in *Russula*), thin-walled; contents yellowing, amorphous-guttulate to shortly crystalline, SV-negative. *Subhymenium* pseudoparenchymatic, composed of small cells, neither deep nor particularly well-

developed. *Lamellar trama* almost entirely composed of sphaerocytes. *Marginal cells* not differentiated, but lamellar edge more or less sterile because of the abundant gloeocystidia. *Pileipellis* orthochromatic in cresyl blue, a dense trichoderm of ascending hyphal extremities, mostly aggregated in conical tufts at the surface, entirely filled with brownish-yellowish contents (concentrated in individual guttules when observed in Melzer for ex., but then becoming diffused, particularly after KOH treatment); hyphal extremities originating from strongly incrusted hyphae, composed of chains of 3 – 5 more or less inflated cells that are branching, normally 4 – 7 µm wide, but some - particularly near branching points - more inflated and up to 15 µm diam., sprouting or diverticulating at nearly every cell that is not terminal; terminal cell rarely longer than 40 µm, obtuse rounded, mostly slightly tapering near the end, subcylindrical to conical. Pileocystidia seemingly absent but actually rare and difficult to find, easiest to locate in the pileus center and best recognized by their typically globose – capitate tip, mostly long and cylindrical and originating at the same level as the hyphal extremities, measuring for ex. 100 x 5 µm, also shorter and sometimes conical when more terminal, without well-differentiated contents. *Clamp connections* absent in all tissues.

Additional examined material: MADAGASCAR. Central Plateau. Mandraka, on mountain crest in dense, monospecific, hygrophilous forest remnant of *Uapaca densifolia*, 3 Feb 1997, Buyck 97.219 (PC0125063); Central Plateau, special reserve of Ambohitantely, NW of Anatanarivo, 30 km from Ankazobe, in *Uapaca densifolia* - Sarcolaenaceae dense dry forest, along the botanical track, 20 January 2008, Buyck 08.067 (PC0125064), Buyck 08.068 (PC0125065).

Fig. 20. *Russula blennia* (holotype). Field habit. Photo B. Buyck

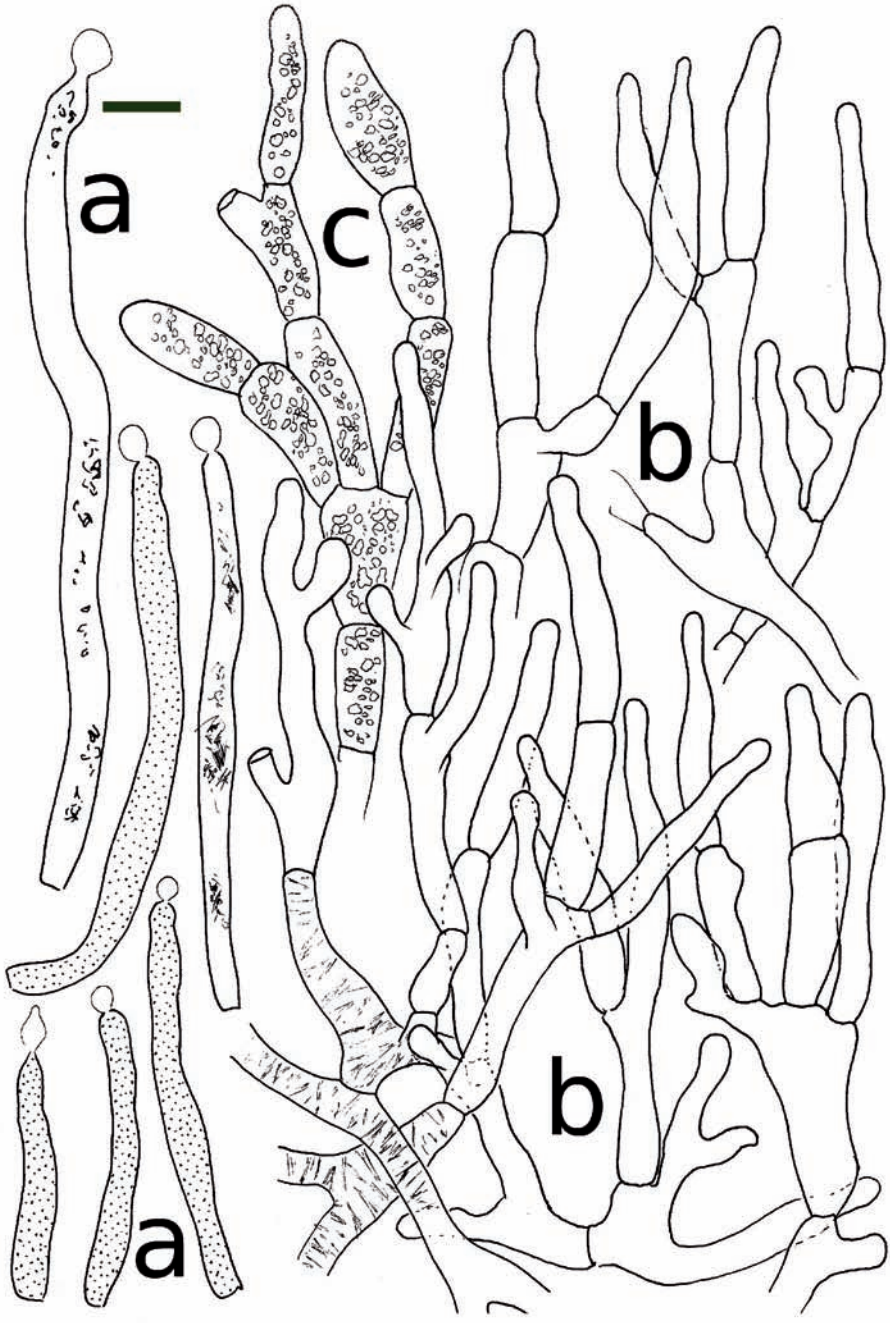

Fig 21. *Russula blennia* (holotype). Microscopic features. **a.** Pileocystidia (the longest ones originating near the base of the hyphal extremities); **b.** Hyphal extremities of the pileipellis; **c.** detail of a hyphal extremity of Buyck 97.219 showing the shorter, more inflated and more pigmented cells in that collection. Scale bar = 10 µm. Drawings B.Buyck.

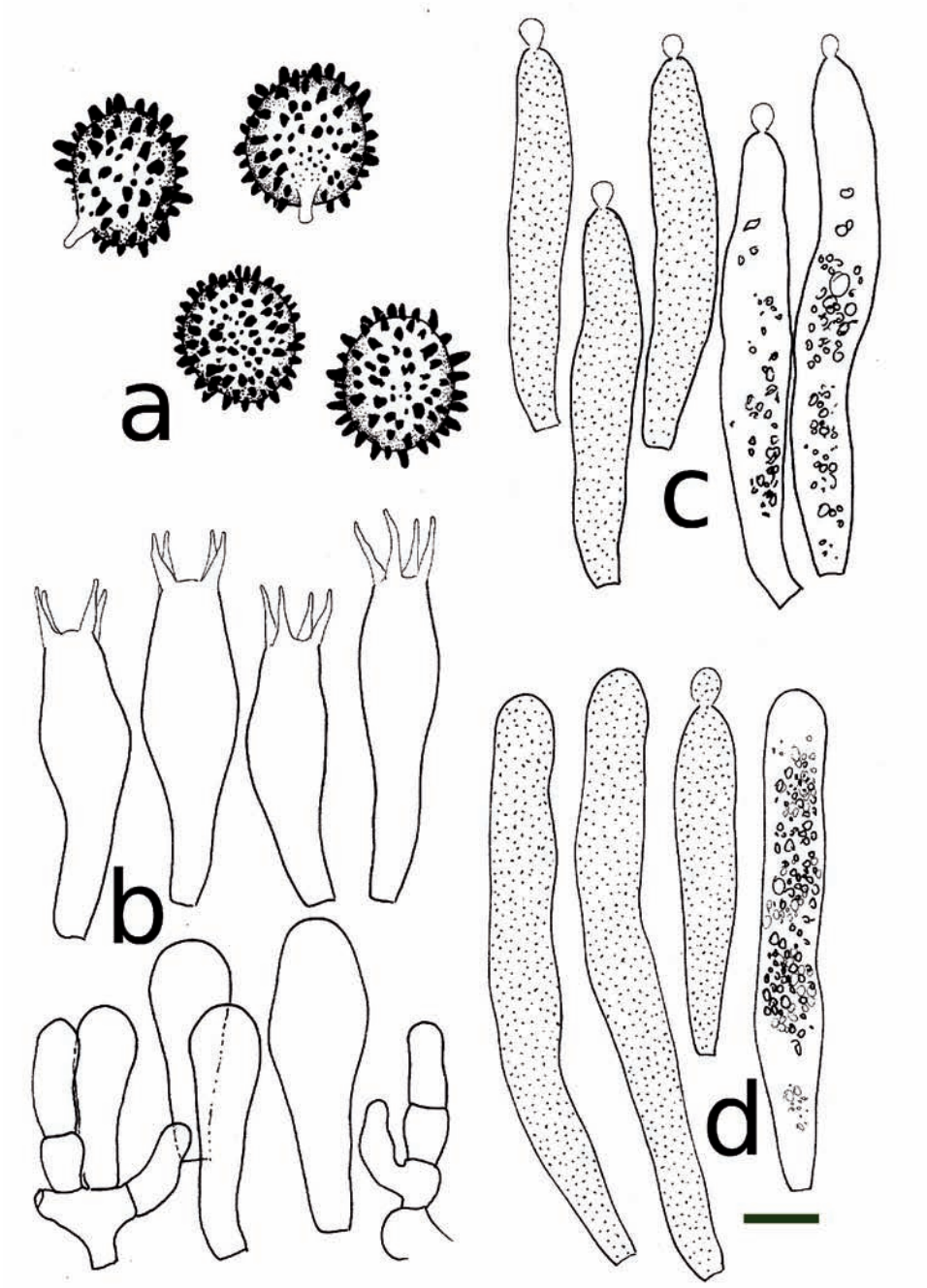

Fig 22. *Russula blennia* (holotype). Microscopic features. **a.** Spores; **b.** Basidia and basidiola; **c.** Gloeopleurocystidia; **d.** Cheilogloeocystidia. Cystidial contents are mostly schematic. Scale bar = 10 µm, but only 5 µm for spores. Drawings B. Buyck

Notes: This species seems well characterized by its habitat in which it can be locally common. It has phylogenetically been placed in *Russula* subg. *Malodora* (Buyck *et al.* 2018). With the exception of the North American *R. compacta* Peck (see Adamcik *et al.* 2018) and *R. griseobrunnea* McNabb, described from New Zealand, this subgenus entirely composed of Malagasy or mainland African species. Identical gloeocystidia as the pileocystidia, and equally rare, are present on the ectomycorrhizal outer mantle (see Buyck *et al.* 2018). This subgenus has recently been split in two sections, one of which, sect. *Edules* Buyck & V. Hofst. (in Das *et al.* 2017), is composed of species with frequently forking gills. Our species belongs in the latter section.

59. *Russula pseudociliata* Buyck ***sp. nov.*** **Figs. 23-25**

Mycobank: MB 826914

GenBank: KU237537 (LSU), KU237383 (mitSSU), KU237686 (*RPB1*), KU237823 (*RPB2*), KU237967 (*tef1alpha*), MH545688 (ITS), all from holotype

Diagnosis: differs from *R. annulatolutea* in the absence of a ring, the lack of reddish or purplish-lilac tinges on stipe and pileus, the clavate pileocystidia at the very pileus surface and in its association with trees that do not belong to Caesalpinaceae.

*Holotype:*MADAGASCAR. Central Plateau, Ambohitantely, in *Uapaca densifolia* - Sarcolaenaceae dense dry forest, 19 January 2008, Buyck 08.061 (PC 0124721)

Systematic position: Basidiomycota, Agaricomycetes, Russulales, Russulaceae

Etymology: named after its resemblance in the field to the African *R. ciliata*

Basidiomata in small groups. *Pileus* first strongly convex, developing already a striate margin when still closed, at maturity becoming deeply depressed; margin strongly striate-tuberculate, even to very slightly wavy, locally radially fissured; surface smooth, continuous, forming a fine, rubbery pellicle in the center, detachable over ½ radius, lemon yellow with shades of olive, more brownish in the center. *Gills* equal, adnate, up to 2.5 mm high, off-white, fragile, without interstitial anastomoses or forkings; gill edge finely uneven to cystidiose, concolorous. *Stipe* central, 25-37 x 6-9 mm, subcylindrical, tinged with the same yellowish olive as the pileus, particularly in the lower half, fragile, spongy inside, hollowing with age. *Context* whitish, unchanging, extremely thin (1 mm in the center). *Odor* insignificant. *Taste* mild. *Spore print* not obtained, certainly very pale.

Spores globose to subglobose, (6.7)6.9-***7.20***-7.5(7.9) x (6.0)6.2-***6.53***-6.8(7.1) µm, Q = (1.03)1.06-***1.10***-1.15(1.21); ornamentation strongly amyloid, reticulate to subreticulate, composed of rather spaced crests of aligned and mostly fused cylindrical to conical warts, up to 2 µm high, practically without any isolated warts or spines, subtle linear connections rare to absent; suprahilar spot inamyloid to partly amyloid in ill-developed spores, verrucose or with very low reticulation in the distal part; apiculus well-developed. *Basidia* rather short, (35)39-44(51) x 10-12 µm, widest in the middle portion, four-spored; sterigmata robust, mostly 7-10 x 2-3 µm. *Hymenial gloeocystidia* arising from the subhymenium or the underlying lamellar trama, on lamellar sides mostly 50-90(100) x 10-12(15) µm, minutely mucronate, thin-walled; near the gill edge distinctly shorter and mostly with thicker walls, generally 30-48 x 7-9 µm; contents quite abundant, crystalline. *Marginal cells* only occupying the very edge, mixed with gloeocystidia, resembling the terminal cells of the hyphal extremities of the pileipellis but somewhat larger, 7-8(10) µm diam., conical, lageniform, to shortly clavate or almost ellipsoid. *Subhymenium* a

pseudoparenchyma composed of rather small cells. *Lamellar trama* composed of voluminous sphaerocytes. *Pileipellis* orthochromatic in Cresyl blue, two-layered, with a distinctly delimited suprapellis of chains of inflated, short cells sitting on a well-delimited and strongly gelatinized subpellis of narrow hyphae that is abruptly separated from the voluminous sphaerocytes that make up nearly the entire underlying context. Suprapellis a trichoderm formed of nearly vertical hyphal extremities composed of chains of (3)4-5 very small, short, barrel-shaped to ellipsoid or more rarely near-cylindrical cells, 5-10 µm wide and all of more or less similar diam. or slightly narrowing upwards; the terminal cell 6-12(20) µm long, obtuse-rounded or more rarely somewhat papillate, with some cells giving the impression of being abruptly divided in two equal parts by a horizontal, secondary septum. Subpellis a loose tissue of very narrow hyphae, dispersed by an interstitial gelatinized matrix. Pileocystidia dispersed, not abundant but easily recognizable because of their contents, near the surface originating from the hyphal extremities, small and short, mostly 15-25 x 5-7 µm, generally clavate and obtuse-rounded at the tip, those immerged in the underlying subpellis up to 50 µm long and 4-6 µm diam., narrowly cylindrical or fusiformous to nearly conical, mostly minutely mucronate, all thin-walled; contents not abundant, concentrated in packets or part of the cystidium, finely granular to crystalline or amorphous, SV-negative. Cystidioid hyphae absent from subpellis and underlying context; oleiferous hyphae or hyphal fragments very apparent and frequent, running over long distances throughout the context. *Clamp connections* absent.

Notes: This species from Madagascar's Central Plateau is undeniably close to *R. annulatolutea* Beeli and *R. annulatosquamosa* Beeli, two annulate species described from the African central rain forest area in the Democratic Republic of the Congo (Beeli 1936). The former species was placed in *R*. subsect. *Paradermatinae*

Fig. 23. *Russula pseudociliata (holotype)*. Field habit. Photo B. Buyck

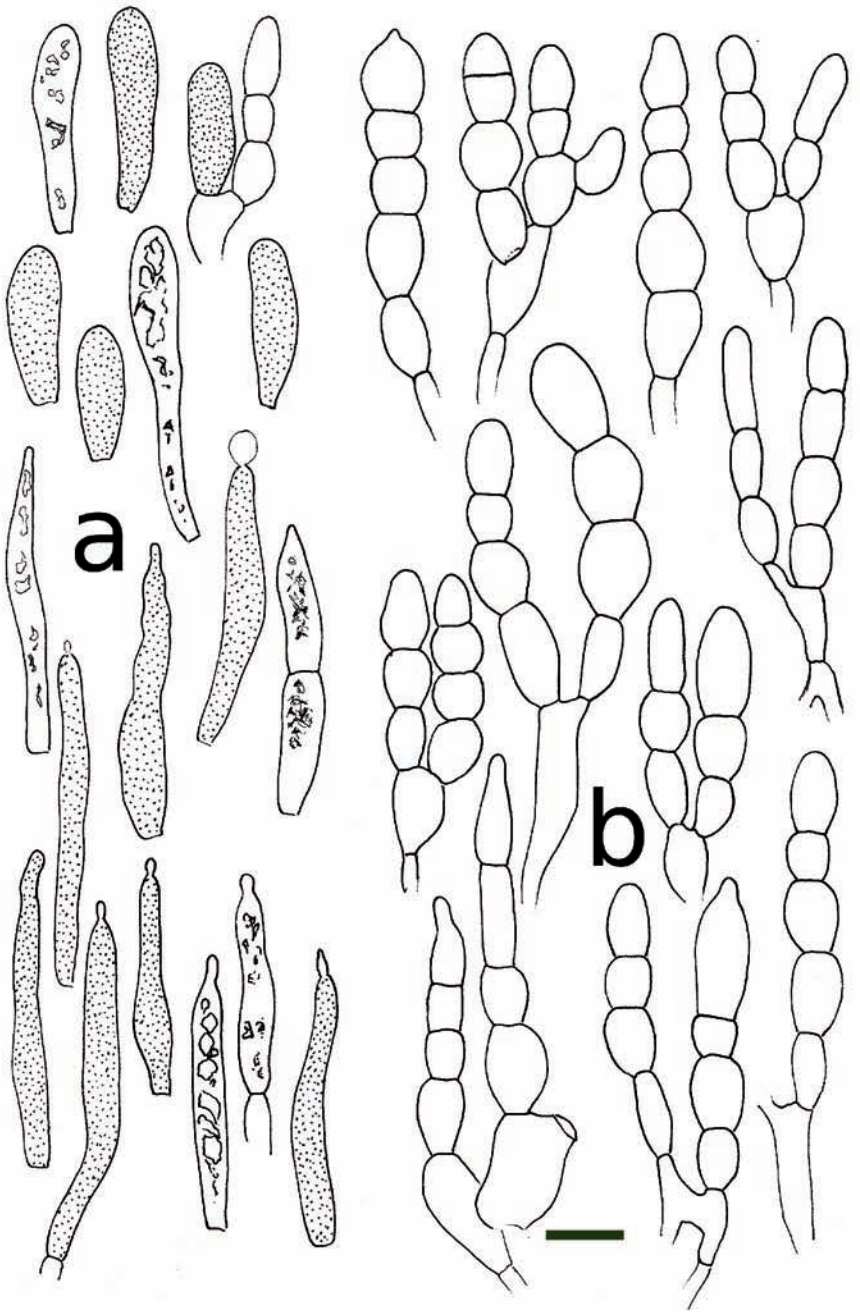

Fig 24. *Russula pseudociliata* (holotype). **a.** Pileocystidia (the longer ones at the bottom from the subpellis, near the top as terminal cells of hyphal extremities); **b.** Hyphal extremities of the pileipellis. Scale bar = 10 µm. Drawings B.Buyck.

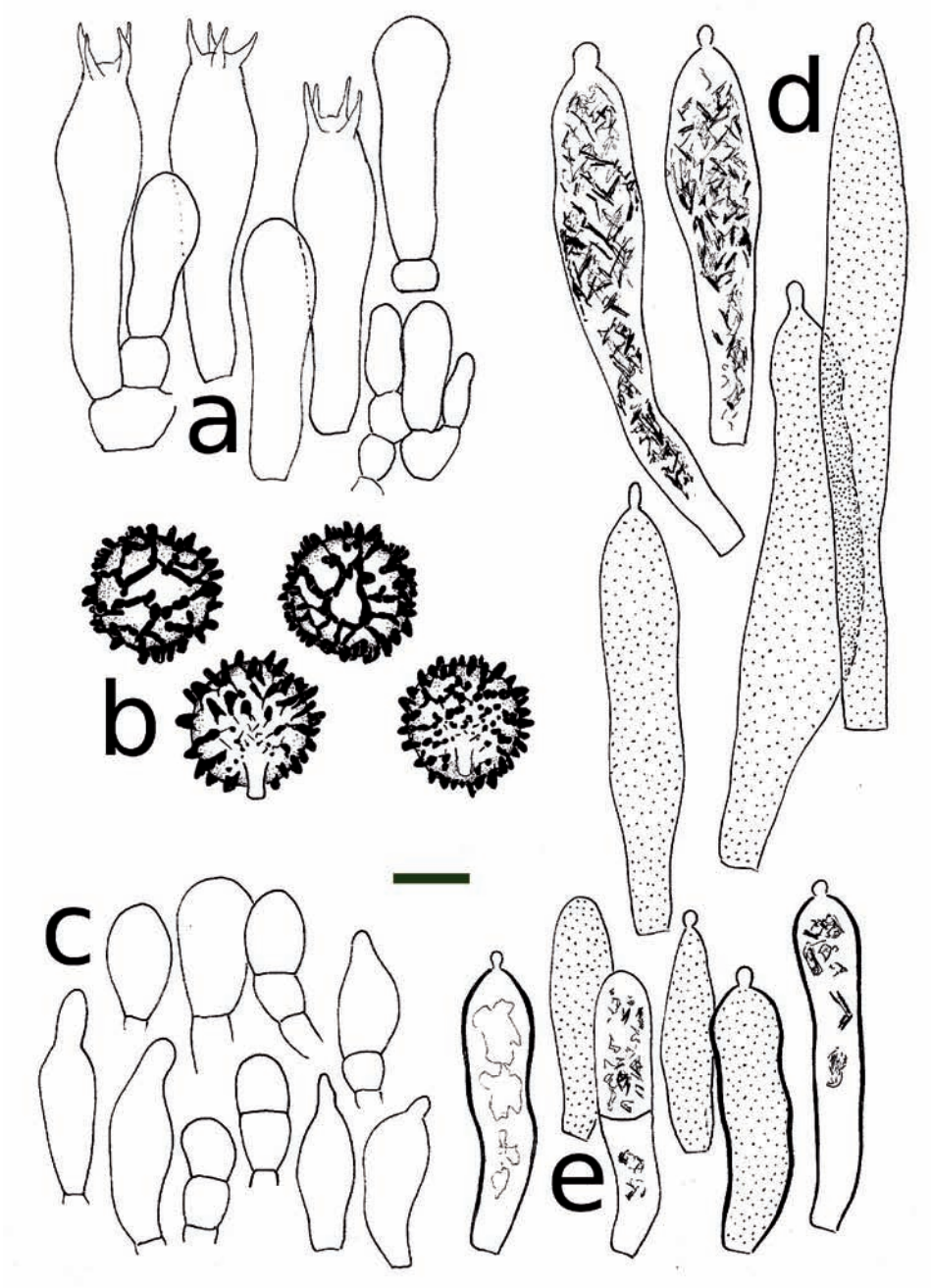

Fig 25. *Russula pseudociliata* (holotype). Microscopic features **a.** Basidia and basidiola; **b.** Spores; **c.** Marginal cells; **d.** Gloeopleurocystidia; **e.** Cheilogloeocystidia. Cystidial contents are mostly schematic. Scale bar = 10 µm, but only 5 µm for spores. Drawings B. Buyck.

Buyck although a large part of the holotype was missing (the entire hymenophore and most of the pileus) with the remainder of the type being strongly molded. The second species, *R. annulatosquamosa,* was placed in *R*. subsect. *Pseudoepitheliosinae* Buyck (see also Buyck 1994), a group of small, pellicular species with bright reddish-violet-purplish tinges on stipe and pileus and wider hyphal extremities composed of lesser cells giving the impression, in surface view, of an epithelium intermixed with distinct pileocystidia. Subsect. *Paradermatinae* was essentially differing in the larger number of cells composing the hyphal extremities and the exclusive presence of very narrow, unapparent, mucronate pileocystidia. Since then, we are more inclined to think that these differences are not that important as also suggested by our multigene phylogeny (Buyck *et al.* 2018) which places both *R. pseudocarmesina* (*Pseudoepitheliosinae*) and our new species in a fully supported clade together with species of the *R. annulata* Heim and *R. roseoalba* Buyck complex (subsect. *Heterophyllinae* s.l.).

60. *Urnula himalayana* K. Das & D. Chakr. **sp. nov.** **Figs. 26-28**

MycoBank: MB 824952

GenBank: MH179122 (ITS), MH179125 (LSU)

Systematic position: Ascomycota, Pezizomycetes, Pezizales, Sarcosomataceae.

Etymology: Referring to Himalaya, the type locality.

Diagnosis: Distinct from all other similar looking *Urnula* species mainly by its ITS and LSU sequence data and a combination of moderately robust (2-14 cm diam.), subsessile to distinctively stalked apothecia with entire to irregularly interrupted cup margin, a velvety external surface without warts becoming veined-folded toward stipe, large thick-walled ascospores (24-33.6 × 10-13.8 µm) and its occurrence on decaying *Castanopsis*-trunk in temperate broadleaf forests.

Holotype: INDIA, Sikkim, South District, Pipaley, N27°14.830' - E88°21.629', 2082 m a.s.l., on decaying tree-trunk of *Castanopsis* sp. in temperate broadleaf forest, 23 August, 2017, *Kanad Das,* KD 17(2)-17 (CAL 1673, **holotype**!).

Apothecia 2-14 cm diam., saucer- or bowl-shaped cup, subsessile to distinctively stalked; margin irregularly lobbed or interrupted, rarely entire. *Hymenium surface* reddish brown (9E4-5) or violet brown (10E4-10F3) to greyish brown (11E-F3) and greyish ruby (12E4), to dark brown with age. *External surface* velvety, towards juncture to stem folded or veined, veins joined to give reticulate appearance, blackish blue (19F5-20F4) to brownish black. *Stalk* (when present) up to 17 mm high, usually vertically corrugated or wrinkled.

Asci 300-410 × 14-17 µm, cylindrical, operculate, inamyloid, eight-spored with a tapered or attenuated base. *Paraphyses* filiform, not or slightly extending the length of the asci, 2-4 µm wide, cylindrical, closely septate; tips simple to branched, straight to curved, rounded to capitate with extracellular brownish, amorphous pigment in the upper part. *Hymenial hairs* cylindrical, as long as paraphyses, 3-5 µm wide, aseptate but with a basal septum; tips rounded to slightly subcapitate, curved to almost hooked; pale brownish, especially in the upper part due to the presence of same type of pigments as in paraphyses. *Ascospores* smooth, curved with rounded poles, allantoid to bean-shaped, wall 2 µm, 24-**29.2**-33.6 × 10-**12.1**-13.8 µm (n= 30, Q= 2.0-**2.37**-2.8). *Subhymenium* of a dense textura intricata of closely septate hyphae, up to 2 µm wide with thickened dark brown wall, 100-135 µm thick. *Medullary excipulum* of loose textura intricata immersed in a gelatinous matrix, with cylindrical, hyaline, septate hyphae, 4-6 µm wide, wall slightly thickened, 0.8 µm. *Ectal excipulum* of textura globosa to textura angularis, 50 µm

thick, made up of elements 17-126 µm wide and/ or high, cells are angular to irregular, wall up to 2 µm thick, very dark brown. *External hairs* mainly of two types: 1) short, hyphoid, cylindrical, 6-7 µm wide, septate, subhyaline to very pale yellowish-brown colored, wall 1.5 µm thick, heavily encrusted by an amber brown to dark brown pigments; 2) long, true hairs, 5-6 µm, thick walled (wall up to 1 µm thick), brown to dark brown, encrusted by the brown pigments. Subiculum dark brown. *Ectal excipulum (stalk)* similar to that of the cup. *External hairs (stalk)* long, cylindrical, septate, brown, thick-walled (up to 1.2 µm).

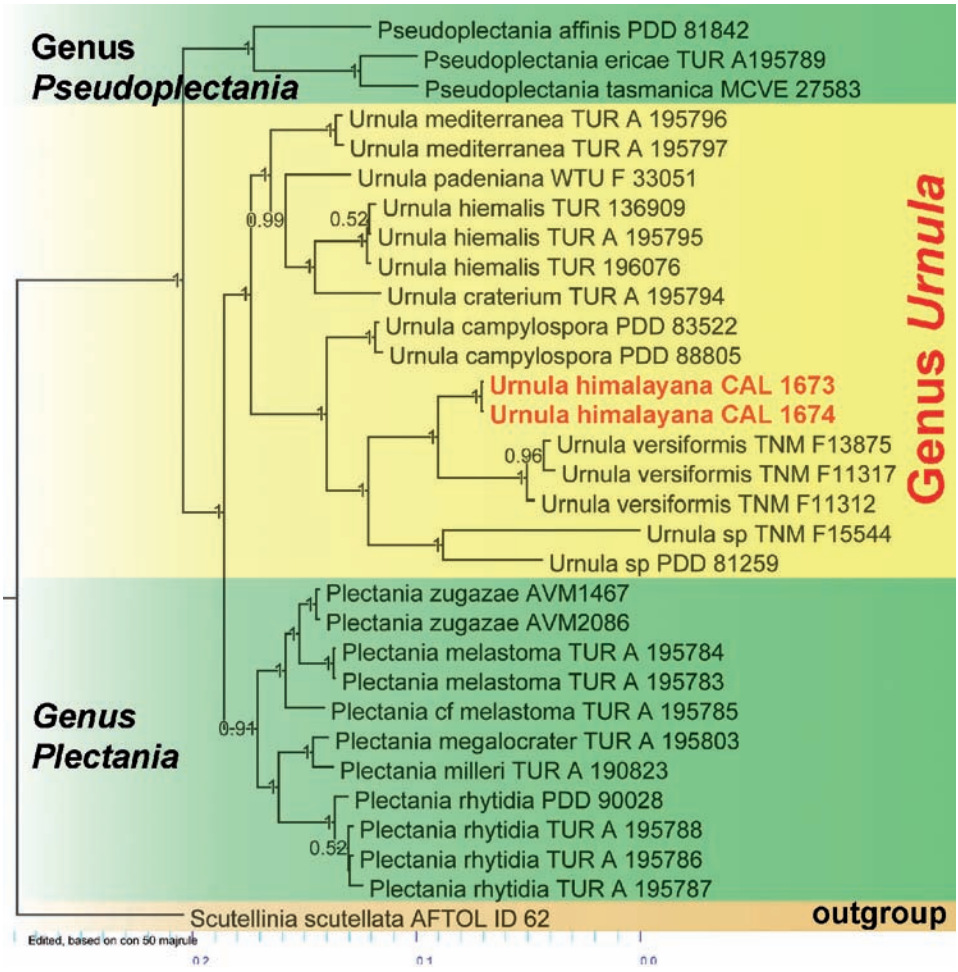

Fig. 26. Phylogram generated from Bayesian analysis of combined ITS-LSU sequences of *Urnula*, *Plectania* and *Pseudoplectania* (Sarcosomataceae) and *Scutellinia scutellata* (from Pyronemataceae, as outgroup) under a TIMef model. Posterior probabilities (BPP) were calculated in two simultaneous runs with Markov chain Monte Carlo (MCMC) algorithm (Largent & Simon 1999). Markov chains were run for 1000000 generations, saving a tree at every 100th generation. The analysis was terminated when the average standard deviation of split frequencies fell below 0.01. Two novel Indian species *Urnula himalayana* (voucher numbers CAL 1673 and CAL 1674 respectively) are shown in red and bold.

Table 1: Fungal names, collection information and GenBank accession numbers

Name of the species with voucher ID	LSU	ITS	Location
Plectania rhytidia (TUR-A 195787)	JX669851	JX669815	Italy
Plectania rhytidia (TUR-A 195786)	JX669849	JX669813	Italy
Plectania rhytidia (TUR-A 195788)	JX669852	JX669816	Italy
Plectania rhytidia (PDD 90028)	JX669871	JX669832	New Zealand
Plectania megalocrater (TUR-A 195803)	JX669845	JX669809	Greece
Plectania milleri (TUR-A 190823)	JX669848	JX669812	USA
Plectania zugazae (AVM1467)	JX669854	JX669817	Spain
Plectania zugazae (AVM2086)	JX669855	JX669818	Spain
Plectania melastoma (TUR-A 195784)	JX669850	JX669814	Italy
Plectania melastoma (TUR-A 195783)	JX669841	JX669805	Italy
Plectania cf. melastoma (TUR-A 195785)	JX669840	JX669804	USA
Urnula mediterranea (TUR-A 195796)	JX669844	JX669808	Italy
Urnula mediterranea (TUR-A 195797)	JX669864	JX669824	France
Urnula padeniana (WTU-F-33051)	JX669866	JX669825	USA
Urnula campylospora (PDD 83522)	JX669869	JX669830	New Zealand
Urnula campylospora (PDD 88805)	JX669870	JX669831	New Zealand
Urnula hiemalis (TUR 136909)	JX669867	JX669827	Finland
Urnula hiemalis (TUR 196076)	JX669868	JX669828	Finland
Urnula hiemalis (TUR-A 195795)	JX669873	JX669835	Finland
***Urnula himalayana* (CAL 1673)**	**MH179122**	**MH179125**	**India**
***Urnula himalayana* (CAL 1674)**	**MH179123**	**MH179124**	**India**

Urnula criterium (TUR-A 195794)	JX669857	JX669820	Italy
Urnula versiformis (TNM F13875)	Not available	KJ577536	Taiwan
Urnula versiformis (TNM F11317)	Not available	KJ577535	Taiwan
Urnula versiformis (TNM F11312)	Not available	KJ577534	Taiwan
Urnula sp. (TNM F15544)	Not available	KJ577537	Taiwan
Urnula sp. (PDD 81259)	Not available	JX669829	New Zealand
Pseudoplectania affinis (PDD 81842)	JX669865	JX669826	New Zealand
Pseudoplectania ericae (TUR-A195789)	JX669862	JX669822	Spain
Pseudoplectania tasmanica (MCVE 27583)	KF305732	KF305722	Australia
Scutellinia scutellate (AFTOL-ID 62)	DQ247806	DQ491492	--

Specimens examined: INDIA, Sikkim, South district, Pipaley, N27°14.830'E88°21.629', 2082 m a.s.l., on decaying tree-trunk of *Castanopsis* sp. in temperate broadleaf forest, 23 August, 2017, Kanad Das, KD 17(2)-17 (CAL 1673, holotype!); *ibid.*, Sikkim, South district, Kewzing, N27°16.781'E88°20.300', 2082 m a.s.l., on decaying tree-trunk of *Castanopsis* sp. in temperate broadleaf forest, 25 August, 2017, Kanad Das, KD 17-33 (CAL 1674, paratype!).

Notes: The family *Sarcosomataceae* Kobayasi is divided into six distinct genera: *Plectania* Fuckel, *Sarcosoma* Casp., *Galiella* Nannf. & Korf, *Urnula* Fr., *Pseudoplectania* Fuckel and *Donadinia* Bellem. & Mel.-Howel. Macro- and micromorphological features among these genera are very much overlapping and therefore, morphology alone is not sufficient to separate them. Genetic data are needed to correctly place these taxa.

The genus *Urnula* Fr. is one of the prominent and older genera in this family (Fries 1849). At present, it is represented by 12-13 species (www.indexfungorum.org, Carbone & Agnello 2013), with only six species reported in the latest (10th) edition of the Dictionary of Fungi (Kirk *et al.* 2008).

In our combined ITS-LSU phylogenetic (Bayesian) analysis (Fig. 26) sequences isolated from two of our Indian collections [MH179122, MH179125 as ITS and LSU respectively from KD 17-2-17 and MH179123, MH179124 as ITS and LSU respectively from KD 17-33, see Table 1] clustered together and nested among the other Asian species of *Urnula* being sister to three sequences from three collections of *U. versiformis* Y.Z. Wang & C.L. Huang (TNM F13875, TNM F11317, TNM F11312), however our species was recovered as a distinct taxon with strong support (BPP = 1). Again, the clade bearing *U. himalayana* (proposed novel species) and *U. versiformis* was sister to a clade that bears two other unknown (not yet

described) Asian species. Moreover, the clade bearing these four Asian species is sister to *U. campylospora* (Berk.) Cooke.

Morphologically, all the species of *Urnula* show very similar features in field. Even under microscope all have same arrangement of the excipulum, which is divided into a medullary excipulum (showing *textura intricate*) and an ectal excipulum (showing *textura subglobulosa-angularis* pattern with thin- to thik-walled

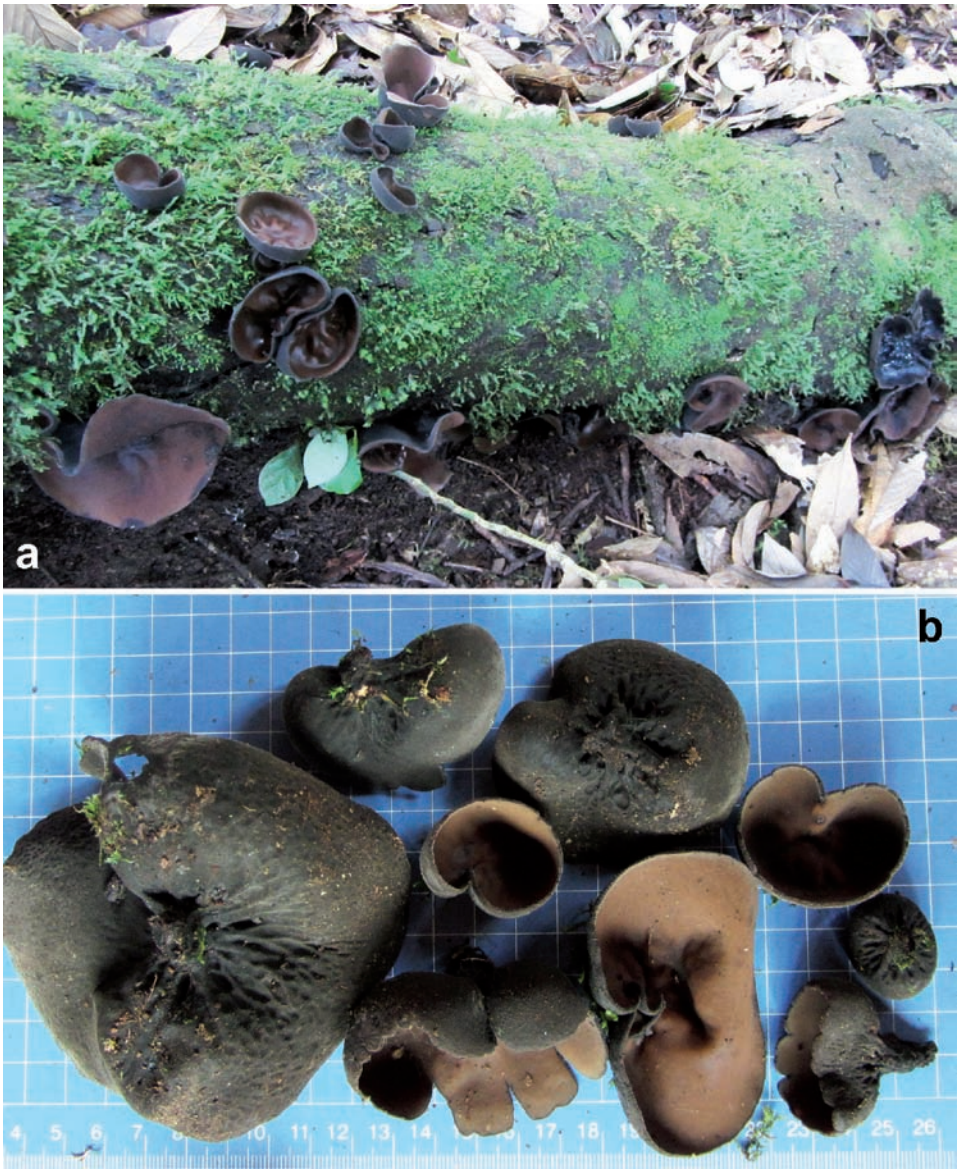

Fig. 27. *Urnula himalayana* (KD 17-2-17, **holotype**). **a.** Fresh basidiomata in the field. **b.** Fresh basidiomata on a workout table in the basecamp.

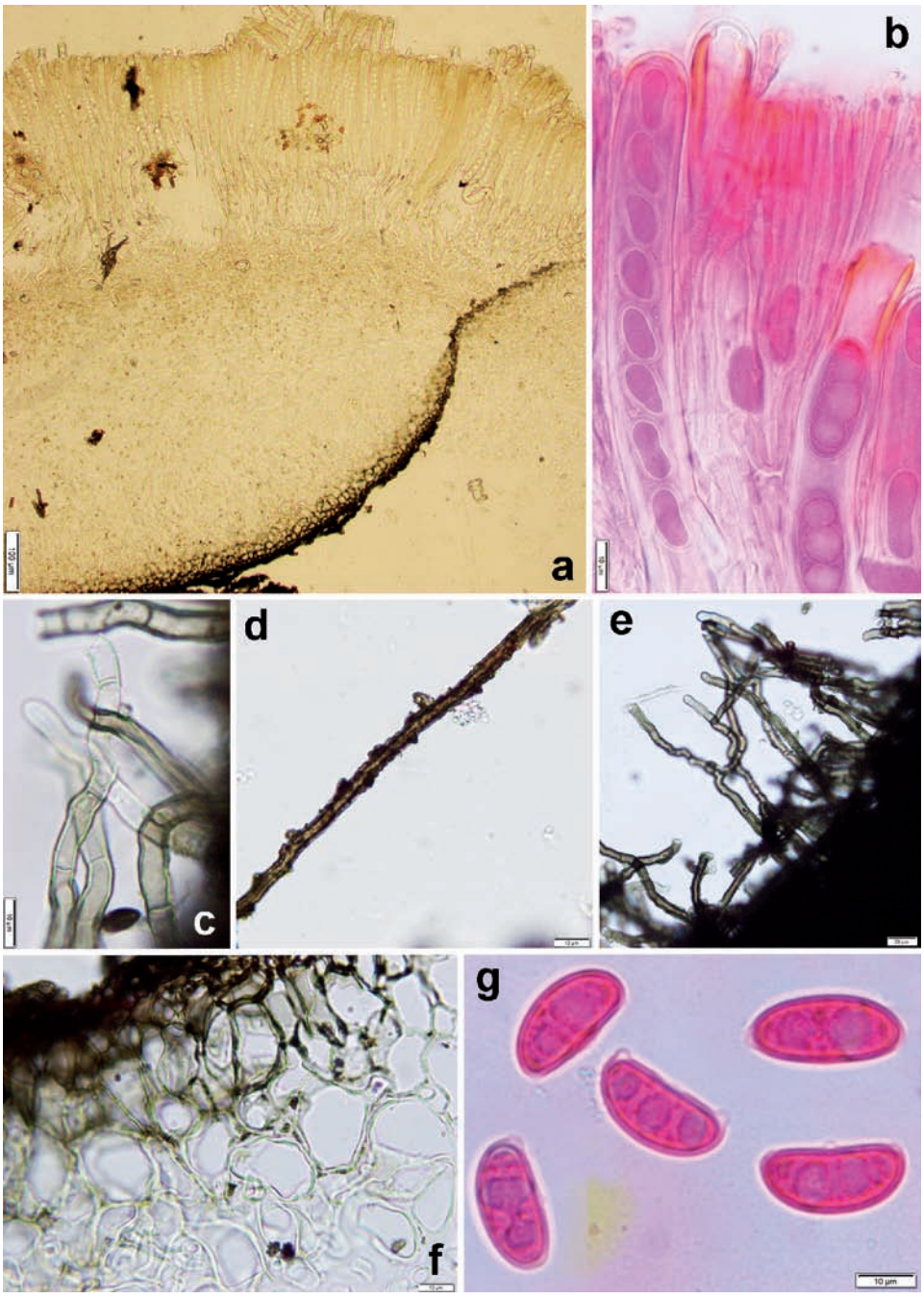

Fig. 28. *Urnula himalayana* (KD 17-2-17, **holotype**). **a.** Cross section through apothecia. **b.** Asci showing eight ascospores. **c.** Short external hairs. **d.** Long external hair. **e.** External hairs of stalk. **f.** Cells of *Ectal excipulum.* **g.** Ascospores. Scale bars: a = 100 µm, b-d, f-g = 10 µm, e = 20 µm.

hairs rising from the latter). Further, all the species possess unbranched or branched hymenial hairs and paraphyses (Carbone *et al.* 2013). Still, the combination of features like very large ascomata (apothecia) without any warty or horizontally corrugated external surface, subsessile to distinctly stalked base and allantoid ascospores are quite distinct. With similar morphology only known Asian species *U. versiformis* is separated from *U. himalayana* by possessing distinctively smaller (1.4–4 cm diam.) apothecia (Wang & Huang 2015). European species *U. campylospora* has significantly smaller (up to 5 cm) apothecia with horizontally corrugated external surface (Carbone & Agnello 2013).

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REFERENCES

ADAMČÍK S., JANČOVIČOVÁ S. & BUYCK B., 2018 — The Russulas described by Charles Horton Peck. Cryptogamie, Mycologie 39(1): 3 -108

ANTONÍN V. & NOORDELOOS M.E., 2010 — *A monograph of marasmioid and collybioid fungi in Europe.* Eching, Germany, 478 p.

ANTONÍN V., RYOO R. & SHIN H.-D. 2010 — Marasmioid and gymnopoid fungi of the Republic of Korea. 2. *Marasmius* sect. *Globulares*. *Persoonia* 24: 49-59.

BASSO M.T., 1999 — *Lactarius* Pers. *Fungi Europaei* 7: 1–845.

BEELI M., 1936 — Contribution à l'étude de la Flore mycologique du Congo. XI.- Fungi Goossensiani. *Bulletin du Jardin Botanique de Belgique* 14 : 83-91, Pl.2.

BERNICCHIA A. & GORJÓN S.P., 2010 — *Corticiaceae* s.l. *Fungi Europaei* n. 12. Ed. E. Candusso. Alassio, Italy. 1007 p.

BESSETTE A.E., BESSETTE A.R. & FISCHER D.W., 1997 — *Mushrooms of Northeastern North America*. 1st Ed., Syracuse University Press, USA.

BUYCK B., 1994 *Russula* II (Russulaceae). In: Rammeloo J, Heinemann P (Éds.). *Flore illustrée des Champignons d'Afrique Centrale*, 16:411–542, pl 69–87

BUYCK B., DUHEM B., DAS K., JAYAWARDENA R.S., NIVEIRO N., PEREIRA O.L., PRASHER I.B., ADHIKARI S., ALBERTÓl E.O., BULGAKOV T.S., CASTAÑEDA-RUIZ R.F., HEMBROM M.E., HYDE K.D., LEWIS D.P., MICHLIG A., NUYTINCK J., PARIHAR A., POPOFF O.F., RAMIREZ N.A., da SILVA M., VERMA R.K. & HOFSTETTER V., 2017 — Fungal Biodiversity Profiles 21-30. *Cryptogamie Mycologie* 38(1): 101-146.

BUYCK B., ZOLLER S. & HOFSTETTER V., 2018 — Walking the thin line… ten years later: the dilemma of above- versus below-ground features to support phylogenies in the Russulaceae (Basidiomycota). *Fungal Diversity* (online first), doi.org/10.1007/s13225-018-0397-5.

CARBONE M. & AGNELLO C. 2013 — Notes on *Urnula campylospora* (Pezizales). *Ascomycete.org* 5 (1): 25–32.

CARBONE M., AGNELLO C. & ALVARADO P. 2013 — Phylogenetic studies in the family Sarcosomataceae (Ascomycota, Pezizales). *Ascomycete.org* 5 (1): 1–12.
CORNER E.J.H., 1950 — A monograph of *Clavaria* and allied genera. *Beihefte zur Nova Hedwigia* 33: 1-740.
DAS K., GHOSH A., BHATT R.P., CHAKRABORTY D., HOFSTETTER V. & BUYCK B., 2017a — Fungal Biodiversity Profiles 41-50. *Cryptogamie, Mycologie* 38 (4): 527-547.
DESJARDIN D.E., RETNOWATI A. & HORAK E. 2000 — Agaricales of Indonesia. 2. A preliminary monograph of *Marasmius* from Java and Bali. *Sydowia* 52: 92-193.
FENG B., WANG X-H., RATKOWSKY D., GATES G., LEE S.S., GREBENC T. & YANG Z.L. 2016 — Multilocus phylogenetic analyses reveal unexpected abundant diversity and significant disjunct distribution pattern of the Hedgehog Mushrooms (*Hydnum* L.). *Scientific Reports*. DOI: 10.1038/srep25586
FRIES E.M. 1849 — *Summa Vegetabilium Scandinaviae*. Sectio posterior. 259-572. Stockholm, Leipzig, Bonnier.
GINNS J. & Millman L., 2011 — Mysterious Asian beauty conquers eastern Massachusetts. *Fungi* 4(3): 61-63.
HALLING R.E., 1983. — A synopsis of *Marasmius* section *Globulares* (Tricholomataceae) in the United States. *Brittonia* 35: 317-326.
HEILMANN-CLAUSEN J., VERBEKEN A., VESTERHOLT J., 1998 — The genus *Lactarius*. 2. Denmark. Svampetryk.
HESLER L.R, SMITH A.H., 1979 — North American species of *Lactarius*. Ann Arbor: University of Michigan Press.
KIRK P.M., CANNON P.F., MINTER D.W. & STALPERS J.A. — 2008 *Ainsworth & Bisby's dictionary of the fungi*. 10th Ed., CABI, UK.
KORNERUP A. & WANSCHER J.H., 1978 — *Methuen Handbook of Colour*. London, Eyre Methuen. 252 p.
KORNERUP A. & WANSCHER J.H., 1981 — *Methuen handbook of colour*. 3rd Ed. London, Methuen.
LARGENT B. & SIMON D.L., 1999 — Markov chain Monte Carlo algorithms for the Bayesian analysis of phylogenetic trees. *Molecular Biology* and *Evolution* 16: 750-759.
MAAS GEESTERANUS R.A., 1971 — *Hydnaceous fungi of the eastern old world*. North-Holland Publishing Company, UK, 582 pp.
MAEKAWA N., 1993 — Taxonomic study of Japanese Corticiaceae (Aphyllophorales) I. *Reports of the Tottori Mycological Institute* 31: 1-149.
MARTINI E., 2016 — *Radulomyces molaris. Excerpts from Crusts & Jells* 1(41): 1-8.
MILLER M.A., PFEIFFER W. & SCHWARTZ T., 2010 — Creating the CIPRES Science Gateway for inference of large phylogenetic trees. Proceedings of the Gateway Computing Environments Workshop (GCE), New Orleans, LA, pp 1-8.
MONTOYA L., BANDALA V.M., 2008 — A new species and new records of *Lactarius* (subgenus *Russularia*) in a subtropical cloud forest from eastern Mexico. *Fungal Diversity* 29: 61-72.
OLARIAGA I., GREBENC T., SALCEDO I. & MARTÍN M.P., 2012 — Two new species of *Hydnum* with ovoid basidiospores: *H. ovoideisporum* and *H. vesterholtii*. *Mycologia* 104: 1443-1455.
OSTROW H. & BEENKEN L., 2004 — *Hydnum ellipsosporum* spec. nov. (*Basidiomycetes*, *Cantharellales*) – ein Doppelgänger von *Hydnum rufescens* Fr. *Zeitschrift für Mykologie* 70(2), 137–156.
PHILLIPS R., 2006. — *Mushrooms*. Macmillan, England
RONQUIST F., TESLENKO M., VAN DER MARK P., *AYRES D.L., DARLING A., HOHNA S., LARGET B., LIU L., SUCHARD M.A. & HUELSENBECK J.P.,* 2012 — MrBayes 3.2: Efficient Bayesian phylogenetic inference and model choice across a large model space. *Systematic Biology* **61:** 539–542.
SHARMA J.R. 2012 — *Aphyllophorales of Himalaya*. Botanical Survey of India, Kolkata.
SHI S.F., WANG X.H., BAU T., 2018 — Three new species of *Lactarius* from northeastern China. *Mycoscience* 59: 206-217.
SILVESTRO D. & MICHALAK I., 2012 — raxmlGUI: a graphical front-end for RAxML. Org Divers Evol 12:335–337. doi:10.1007/s13127-011-0056-0
TAMURA K., STECHER G., PETERSON D., FILIPSKI A. & KUMAR S. 2013. MEGA6: Molecular Evolutionary Genetics Analysis version 6.0. *Molecular Biology and Evolution* 30: 2725–2729.
TRIANTAFYLLOU M., POLEMIS E., GONOU-ZAGOU Z., DIMOU D.M., DELIVORIAS P., ZERVAKIS G.I., 2015 — Taxonomic relationships among non-macrocystidiate taxa of *Lactarius* subg. *Russularia* from Europe with special reference to species from Greece. *Mycological Progress* 14: 78.

VIZZINI A., PICILLO B., ERCOLE E., VOYRON S. & CONTU M. 2013 — Detecting the variability of *Hydnum ovoideisporum* (*Agaricomycetes*, *Cantharellales*) on the basis of Italian collections, and *H. magnorufescens* sp. nov. *Mycosphere* 4(1): 32–44.

WANG X.H., 2007 — Type study on the *Lactarius* species published from China. *Mycologia* 99: 253–268.

WANG X.H., LIU P.G., 2002 — *Lactarius chichuensis* and *L. hirtipes,* two easily confused species. *Mycotaxon* 84: 391-400.

WANG Y.Z. & HUANG C.L. 2015 — A new species of *Urnula* (Sarcosomataceae, Pezizales) from Taiwan. *Nova Hedwigia* 101 (1–2): 49–55.

WANNATHES N., DESJARDIN D.E., HYDE K.D., PERRY B.A. & LUMYONG S., 2009 — A monograph of *Marasmius* (Basidiomycota) from Northern Thailand based on morphological and molecular (ITS sequences) data. *Fungal Diversity* 37: 209-306

WISITRASSAMEEWONG K., NUYTINCK J., FELIX H., HYDE K.D., VERBEKEN A., 2014. *Lactarius* subgenus *Russularia* (Russulaceae) in South-East Asia: 2. Species with remarkably small basidiocarps. *Phytotaxa* 188: 181−197.

WISITRASSAMEEWONG K., NUYTINCK J., LE H.T., DE CROP E., HAMPE F., HYDE K.D., VERBEKEN A., 2015 — *Lactarius* subgenus *Russularia* (Russulaceae) in South-East Asia: 3. new diversity in Thailand and Vietnam. *Phytotaxa* 207 (3): 215-241.

ZHAO C.-L., CHEN H., HE S.-H. & DAI Y.-C., 2016 — *Radulotubus resupinatus* gen. et sp. nov. with a poroid hymenophore in Pterulaceae (Agaricales, Basidiomycota). *Nova Hedwigia* 103(1-2): 265-278.