

## Fungal Biodiversity Profiles 61 - 70

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**Abstract** - In this new series of Fungal Biodiversity Profiles, the authors describe nine species new to science, four Ascomycota, as well as one *Cantharellus* and four *Russula* (Basidiomycota). Among Ascomycota, the lichen forming *Cryptothecia odishensis* sp. nov. (Arthoniales) is reported from tropical forests in India, while first Indian reports are given for *C. atropunctata* and *C. exilis*, two species originally described from Australia, and for the tropical American *Myriostigma filicinum*. In Laboulbeniales, descriptions are provided for *Hesperomyces auriculatus* sp. nov., *Laboulbenia montana* sp. nov. and *Zodiomyces vermiformis* sp. nov. Among Basidiomycota, *Cantharellus subfloridulus* sp. nov. (Cantharellales) is described from the African rain forest, and detailed data are provided on

the holotype location of *C. addaiensis*. In Russulales, *Russula gnathangensis* sp. nov., *R. indohimalayana* sp. nov., *R. pseudokrombolzii* sp. nov. and *R. subalpinogrisea* sp. nov. are newly described from *Abies densa* forests in Indian Himalaya. Still among Asian Russulales, *Multifurca roxburghii* is epitypified with a recent collection from its original habitat and the recently described *M. albovelutina* is clearly a later synonym. In addition, the recently described *M. mellea* is most likely either a later synonym of *M. pseudofurcata* or of *M. orientalis*.

**Lichenized Ascomycota / Arthoniales / Cantharellales / epitypification / ITS / Laboulbeniales / Multifurca / phylogeny / Russula / Russulales / taxonomy /**

## ASCOMYCOTA

### 61. *Cryptothecia odishensis* R. Bajpai, S. Joseph, & Upreti, *sp. nov.* **Figs 1a-c**

*Mycobank*: MB 826864

*Systematic position*: Ascomycota, Arthoniales, Arthoniaceae

*Diagnosis*: the lichen *Cryptothecia odishensis* is characterized by thallus containing barbatic and gyrophoric acids, ascigerous areas not delimited; asci 2–4-spored, randomly scattered and immersed across the thallus, and with mostly curved muriform ascospores measuring 105–142 × 35–52 µm.

*Etymology*: The specific epithet refers to Odisha, the type locality.

*Holotype*: INDIA. Orissa [Odisha]. Jharsuguda district, Belpahar forest, Khadu Baba Ashram, alt. 250 m, 23 December 1993, *D.K. Upreti* 93-0212787 (LWG-holotypus).

*Thallus* crustose, corticolous, continuous, white to grey, 75–200 µm thick, cracked irregularly, projecting hyphal strands giving pruinose appearance, lacking isidia and soredia, ecorticate, densely inspersioned with crystals 10–25 µm. Medullary layer thin to indistinct, white, I+ blue. Prothallus distinct, whitish, fibrous, comprising mainly of interwoven and radiating hyphae, up to 2.5 mm wide. *Photobiont* a trentepohlioid alga, cells rounded to oblong, 5–8 µm wide. *Ascigerous areas* not delimited. Interascal tissues tightly entangled over the asci, I+ pale blue, KI+ blue. *Asci* frequent, scattered and immersed across the thallus, externally not visible, globose to sub globose, 2–4-spored, 150–175 × 100–150 µm. *Ascospores* hyaline, muriform, cells more or less equal in size, mostly curved, 105–142 × 35–52 µm, I–. *Pycnidia* not seen.

*Chemistry*: Thallus K–, C+ red, KC+ red, P–, UV–; barbatic and gyrophoric acids detected in TLC.

*Ecology and distribution*: The species is so far known from the type locality where it grows on the trees of tropical semi-evergreen forest.

*Commentary*: The genus *Cryptothecia* was established by Stirton (1877) and later on revised by Smith (1926) who split up the genus into two genera, *Cryptothecia* with muriform ascospores and *Stirtonia* with transversely septate ascospores. The genus *Myriostigma* has recently been reinstated for the *Cryptothecia candida* group which is characterized by the raised maculate ascomata-like fertile areas, 8-spored, thick-walled, globular and stalked asci and hyaline, bean-shaped muriform ascospores (Frisch *et al.*, 2014).

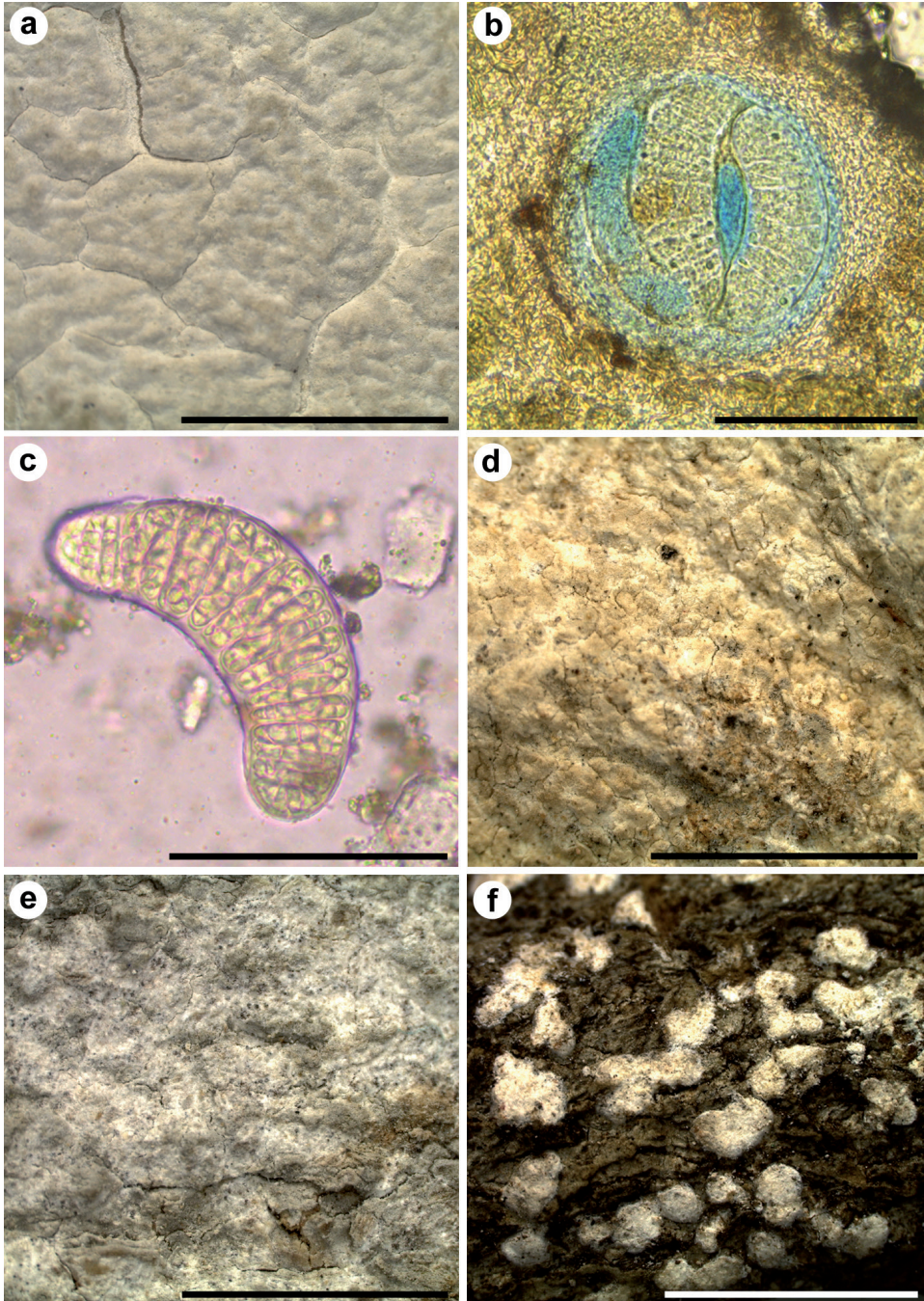


Fig 1. **a-c.** *Cryptothecia odishensis* (holotype). **a.** Thallus. **b.** Ascus with ascospores in LPCB. **c.** Ascospore; **d.** *Cryptothecia atropunctata*; **e.** *Cryptothecia exilis*; **f.** *Myriostigma filicinum*. Scales: **a** & **d-f** = 5 mm; **b** & **c** = 100  $\mu$ m.

The genus *Cryptothecia* in the wider sense is a strictly tropical group that prefers to grow on tree bark, shaded bamboo stems and leaves (Aptroot *et al.*, 2015). The genus is characterized by a byssoid thallus, patchy I+ blue medulla or thallus with trentepohlioid photobiont, broadly clavate to globose thick walled, a particular type of asci loosely dispersed or closely aggregated with ascigerous area and muriform ascospores with wavy septa. Some species of other genera, such as *Helminthocarpon*, closely resemble *Cryptothecia* but these differ in having an anastomosing hamathecium, corticated thallus and in containing lecanoric acids. Species in *Diorygma* differ in having simple paraphyses while *Herpothallon* have a heteromorous, felty thallus on a conspicuous prothallus and usually bear isidia, being rarely fertile.

Jagadeesh Ram & Sinha (2016) provided a world key to the genera *Cryptothecia* (65 spp.) and *Myriostigma* (7 spp.) which includes 35 species from India. Since then, six more species were added to the genus *Cryptothecia* (Cáceres & Aptroot, 2016; Neuwirth & Aptroot, 2016; Aptroot *et al.*, 2017; Seavey *et al.*, 2017).

*Cryptothecia odishensis* is close to *C. lunulata* (Zahlbr.) Makhija & Patw., in having similar lichen compounds (barbatic and gyrophoric acids) and mostly curved ascospores but the latter species has well-delimited ascigerous areas and smaller ascospores of  $33\text{--}66 \times 13\text{--}17 \mu\text{m}$  produced in eight-spored asci (Makhija & Patwardhan 1985, 1987). The new species can easily be distinguished from all other known species of *Cryptothecia* by its combination of barbatic and gyrophoric acids as lichen compounds, without delimited ascigerous areas, and large ( $> 100 \mu\text{m}$  long) curved muriform ascospores with 2–4-spored asci.

As yet unreported for India are also two Australian species: *Cryptothecia atropunctata* G. Thor and *C. exilis* G. Thor. The former species is characterized by whitish grey to green thallus firmly attached to the substratum, 8-spored asci with ascospores of  $70\text{--}92 \times 37\text{--}50 \mu\text{m}$ , and psoromic and confluent acids as lichen compounds. It is here newly reported for India with a collection from Tamil Nadu, Palni Hills, Senembaganurto Periakulum via short cut road, alt. 1650 m, on bark, 14 December, K.P. Singh 70-0904/B 1970, LWG (Fig. 1d). The other species, *Cryptothecia exilis*, is characterized by whitish grey thallus firmly attached to the substratum, 8-spored asci with ascospores of  $52\text{--}75 \times 33\text{--}35 \mu\text{m}$ , and psoromic acid as lichen compound (Thor, 1997). It is here also recorded as new to India with a collection from Assam, Dima Hasau district, Umrangso Power Corporation guest house campus, on bark, 05 May 2017, Upreti *et al.* 17-031340, LWG (Fig. 1e).

As for species now classified in *Myriostigma*, *M. filicinum* (Ellis & Everch.) Frisch & G. Thor is characterized by corticolous greenish grey to grey brownish thallus, distinctly raised rounded to irregular whitish ascigerous area, 8-spored asci with ascospores of  $42\text{--}85 \times 15\text{--}25 \mu\text{m}$  size, and perlatolic acid as lichen compound. Widely distributed in (sub)tropical South and Central America (Lücking *et al.*, 2006; Flakus, 2013), it is here newly reported for India from Arunachal Pradesh, West Siang district, Along, forest behind R. K. Mission, alt. 304 m, on bark, 19 November 2008, Upreti *et al.* 08-009215, LWG; Karnataka, Shimoga district, near Hebri, alt. 107 m, Lumbsch *et al.* 08-19733/P, 14 January 2008, LWG (Fig. 1f).

## 62. *Hesperomyces auriculatus* W. Rossi & M. Leonardi, *sp. nov.*

**Fig. 2**

*Mycobank*: MB 828671

*Systematic position*: Ascomycota, Laboulbeniomycetes, Laboulbeniales.

*Etymology*: from Latin *auricula* = small ear, because of the two peculiar ear-like preapical outgrowths.



Fig. 2. *Hesperomyces auriculatus*. **a.** Thallus from the type slide with preapical outgrowths in lateral view, **b.** Other thallus from the type slide with preapical outgrowths in antero-posterior view. Scale bars = 100  $\mu\text{m}$ .

*Diagnosis:* Differs from any other described species in the same genus for the two ear-like, preapical outgrowths.

*Holotype:* ECUADOR, Cotopaxi, Canton Sigchos, San Francisco de Las Pampas, Bosque Integral Otonga, alt. 2173 m, 12 July 2007, A. C. Proaño Castro & A. Barragán, on *Scotoscymnus* sp. (Coleoptera, Coccinellidae, Sticholotidinae) (FI WR3228a).

*Thallus* monoecious, tinged with very pale dirty yellow throughout. Basal cell of the receptacle longer than broad; suprabasal cell much smaller, subtrapezoidal, somewhat larger than the basal cell of the appendage beside it. Free appendage consisting of four cells, the lower two of which are sterile, subquadrate, the third of the same length but narrower, bearing laterally a single antheridium with a slender and falcate apex, the uppermost cell usually bearing two antheridia, more rarely one or three, one of which is terminal. Stalk cell of the perithecium narrow and distinctly constricted near the base; above the constriction it is abruptly broader and inflated. Basal cells of the perithecium relatively small and hardly distinguishable at maturity.

*Perithecium* rather slender, about four times longer than maximum width, usually bent inward, asymmetrical, with the dorsal (inner) margin almost straight, slightly tapering to the broad tip and blunt apex, bearing subapically and symmetrically two ear-like projections. Length from foot to perithecial tip 210–280  $\mu\text{m}$ ; from foot to tip of uppermost antheridium 100–110  $\mu\text{m}$ ; perithecium including outgrowths 40–50  $\times$  125–185  $\mu\text{m}$ .

*Additional examined material:* same data as the type (FI WR3228b, isotype).

*Notes:* The large, ear-like, preapical outgrowths make the new species easily distinguishable at first sight from all the others in the same genus (a complete list of which is given in Goldmann *et al.* 2013, p. 808).

**63. *Laboulbenia montana* W. Rossi & M. Leonardi, *sp. nov.***

**Fig. 3**

*Mycobank:* MB 828672

*Systematic position:* Ascomycota, Laboulbeniomycetes, Laboulbeniales.

*Etymology:* from Latin *montanus* = of the mountain, because the whole type series was found above 4,200 m altitude.

*Diagnosis:* Characterized by a combination of morphological features such as a compact thallus, insertion cell not connected to the perithecium, appendages repeatedly divided in stiff and blackened branchlets.

*Holotype:* ECUADOR, Volcán Imbabura, alt. 4200–4250 m, 31 July 1998, P. Moret, on elytra and median femora of *Blennidus (Agraphoderus) antisanae* (Bates) (Coleoptera, Carabidae), (FI WR2905).

Cells I, II, III, IV, V and VI dirty yellow, with darker shades on the upper portion of cell I and outer portion of cell III; the color of the perithecium varies from pale smoky gray to very dark brownish gray: in the latter case the thallus appears distinctly bicolored; branches of the appendages gradually darker from the base to the apex. Basal cell of the receptacle (cell I) relatively short and tapered in the lower portion, the shape varying from slender and straight to stocky and distinctly curved. Cell II usually longer, with almost parallel lateral margins, separated from cell III by a short, horizontal septum, and from cell VI by a much longer, oblique septum. Cell III small and irregularly trapezoidal, slightly longer than maximum width. Cell IV of about the same size as cell III, with the subtriangular cell V in its upper, inner angle. Insertion cell quite thick, not connected to the perithecium. Basal cell of the outer appendage large, slightly longer than broad, bearing apically two long branches, the outer of which is darker, caducous and dividing once or, more rarely, twice; the inner branch is persistent, more robust and divides 3–4 times. Basal cell of the inner appendage slightly smaller than the outer, giving rise apically to two branches, of which the outer is similar to the branches of the outer appendage, while the inner is short and bears apically elongate, bottle-shaped antheridia in younger thalli, which in older specimens are replaced by long and slender branchlets. Cell VI quadrangular, oblique, distinctly shorter than cell III. Perithecium stocky, free from the receptacle for 3/4 of its length on the inner side, asymmetrical, the inner side being distinctly convex, while the outer is almost straight, the tip large, not abruptly distinguished, rather coarse lipped, the subtruncate apex slightly turned inward. Length from foot to perithecial apex 280–460  $\mu\text{m}$ . Perithecium 55–95  $\times$  135–180  $\mu\text{m}$ . Longest appendage 740  $\mu\text{m}$ . Ascospores 95–100  $\mu\text{m}$ .

*Additional examined material:* ECUADOR, Pichincha, Volcán Rucu Pichincha, 4605 m, 0°09'40"S, 78°33'58"W, 19 April 2013, M. Aráuz, *B. (A.) mucronatus* Moret, (FI WR3968 & WR3969, paratypes).



Fig. 3. *Laboulbenia montana*. **a.** Thallus from the type slide, **b.** Paler and more branched thallus from the type slide. Scale bars = 100  $\mu$ m.

*Notes:* The apparently closest species to *Laboulbenia montana* is *L. latonae* Thaxt., found on the rove beetle (Staphylinidae) *Pseudocryptobium* (= *Latona*) *spinolae* (Guerin-Méneville) and recently recorded on *Pseudocryptobium* sp. from a few Ecuadorian mountains (Proaño Castro & Rossi 2008). While the new species is characterized by a compact thallus, *Laboulbenia latonae* is a larger and usually more elongate species, with thalli overcoming 1 mm and appendages also longer than 1 mm. The most obvious difference between the two parasites is found in the appendages, whose branchlets are undivided in *L. latonae* and repeatedly divided in *L. montana*.

It deserves to be highlighted that *Laboulbenia montana* was also collected at 4605 m a.s.l., which represents a record for the Laboulbeniales.

**64. *Zodiomyces vermiformis* W. Rossi & M. Leonardi, *sp. nov.***

**Fig. 4**

*Mycobank:* MB 828673

*Systematic position:* Ascomycota, Laboulbeniomycetes, Laboulbeniales.

*Etymology:* from Latin *vermis* = worm, and *forma* = shape, because of the elongate, subcylindrical and flexuous thallus resembling a worm.

*Diagnosis:* Differs from the other 4 described species in the same genus for its long and subcylindrical receptacle and the shapeless mass of cells growing around the foot.

*Holotype*: ECUADOR, Manabi, swamp “La Sabana” between San Antonio and Bachillero, light trap, 00°43'22.4”S, 80°10'15.4”W, , 14 July 2008, A. Barragán & W. Rossi, on *Helochaeres (Sindolus) femoratus* (Brullé) (Coleoptera, Hydrophilidae) (FI WR3295).

Receptacle subcylindrical, quite long and flexuous, enlarged distally, consisting of very numerous cells, the outer of which are broadly cubical, the inner distinctly longer than broad. Basal cell large, turbinate, surrounded by a rounded sucker-like anchoring structure, which is hyaline in not fully mature thalli. Older thalli produce an irregular and multilobed mass of spherical cells surrounds the base

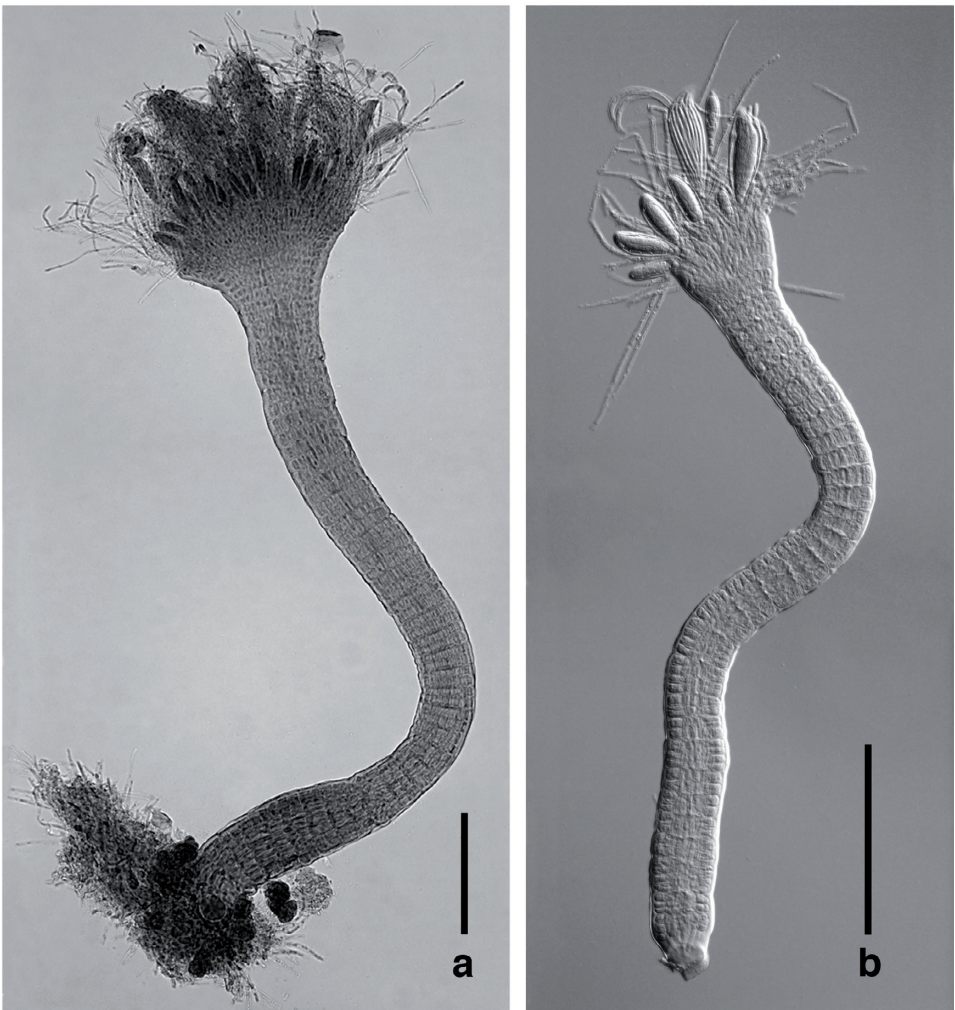


Fig. 4. *Zodiomyces vermiformis*. **a.** Old specimen stained with acid fuchsin (holotype), **b.** younger specimen bearing perithecia of different developmental stage: the one in the middle is mature, full of ascospores, and with the two arched perithecial appendages clearly visible (paratype no. WR3296). Scale bars = 100  $\mu$ m.



of the thallus. The upper, swollen area of the receptacle is composed of many small cells, from which arise a variable number of perithecia and long and slender, unbranched appendages. Perithecia supported by a slender “pedicel” consisting of two elongate, superposed cells, the upper of which is prolonged by a falcate, tapering outgrowth pointing upwards. Perithecium body broadly clavate, its stalk and basal cells indistinguishable at maturity, the tip rather abruptly tapered and distinctly bent towards the ventral side; each perithecium bears four long and slender appendages, a pair of which is born ventrally just below the tip and form a regular arch pointing downwards, while the other two arising from the dorsal side are straight and obliquely oriented outwards. Length from foot to tip of perithecial 675-880  $\mu\text{m}$ . Perithecia 14-16 x 50-52  $\mu\text{m}$ . Upper perithecial projections 35-41  $\mu\text{m}$ . Lower perithecial projections about 54  $\mu\text{m}$ .

*Additional examined material:* same data as the type (FI WR3296 & WR3297, paratypes).

*Notes:* The new species differs from the other four in the same genus described thus far for its elongate, subcylindrical receptacle and for the shapeless mass of cells growing around the foot in older specimens (Rossi *et al.* 2016). The indeterminate growth of the multilobed mass of cells at the base of the thallus is a very rare feature among the Laboulbeniales, which are usually characterized by a strictly determinate development.

## BASIDIOMYCOTA

### 65. *Cantharellus subfloridulus* Buyck & V. Hofst., *sp. nov.*

**Figs 5-10**

*Mycobank:* MB 828993

*Genbank:* MG450687 (*tef1*), MG450686 (*tef1*, holotype)

*Diagnosis:* differs from *C. floridulus*, which grows in the same habitat, in the less slender stipe, paler overall color, varying from orange-pink to sometimes pale yellow or even whitish, distinct yellowing of tissues with age and usual presence of well-developed anastomosing veins and ribs in between gill folds, also by the longer basidia and longer spores, measuring (6.7)7.1-7.64-8.1(8.5) x (4.6)4.7-4.93-5.2(5.4)  $\mu\text{m}$ ,  $Q = (1.33)1.45-1.55-1.65(1.74)$ , and colorless hyphal terminations.

*Etymology:* referring to the resemblance with *C. floridulus*

*Holotype:* CENTRAL AFRICAN REPUBLIC. Dzanga-Sangha Forest Reserve, near Bayanga, close to Bai-Hakou base camp, N 02.859934 - E 16.467492, under monospecific *Gilbertiodendron dewevrei* forest, on bare soil, 14 May 2016, Buyck 1650/BB16.016 (PC0125009)

*Basidiomata* up to 30 mm high, growing in dense clusters dispersed on the bare soil. **Pileus** 5-20(30) mm diam., often irregularly lobed or wavy, near the margin sometimes – particularly when wet – transparently striate from the gill folds underneath the thin context, becoming uplifted or even upturned with age, in the center flat to slightly depressed; surface glabrous, smooth to pitted-waxy, dull, typically a beautiful salmon pink, sometimes also paler and more yellowish orange, occasionally even whitish to cream (4A2-3). *Hymenophore* distinctly paler, pale yellowish to off-white (4A2), sometimes developing local yellow stains, composed of thin, unequal and quite well-developed gill-folds, but sometimes only of low veins, with frequent to occasional forkings, either smooth or strongly anastomosing

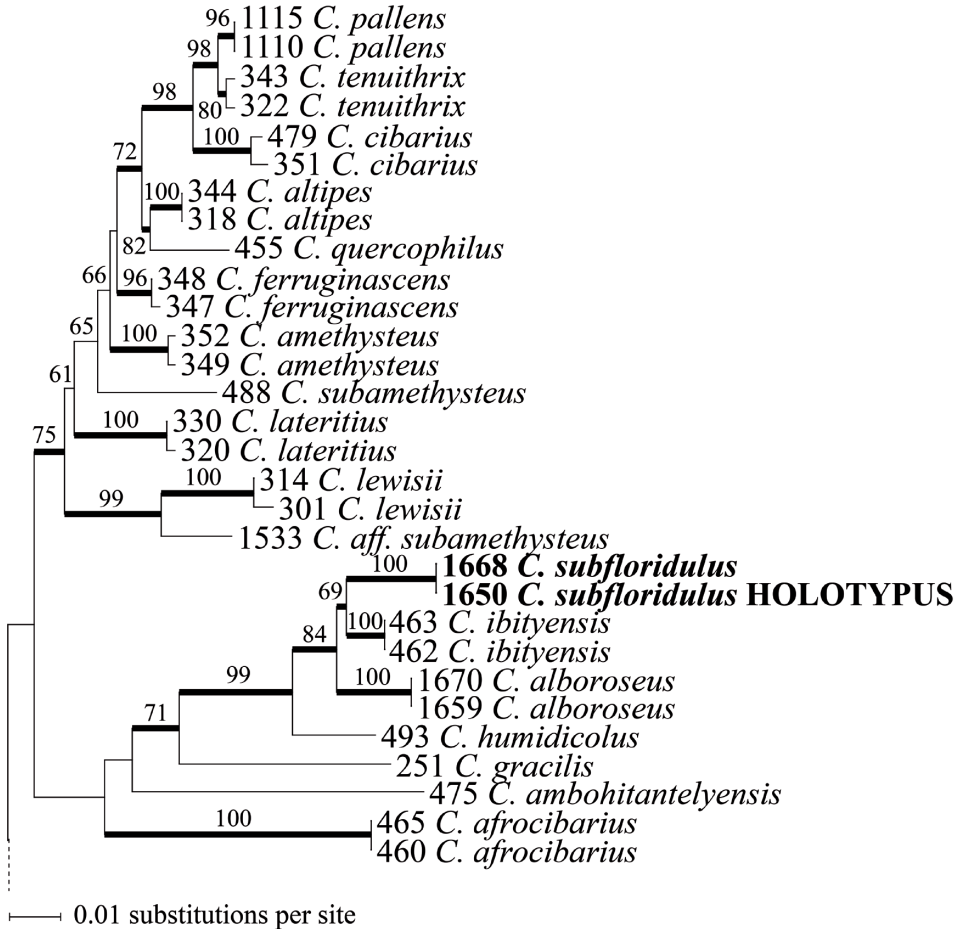


Fig. 5. Part of the phylogenetic tree based on an analysis of *tef1* sequences that was recently published (Buyck & Hofstetter 2018) showing *Cantharellus* subg. *Rubrinus* sect. *Heinemannianus* (lower clade) and *Cantharellus* subg. *Cantharellus* (upper clade). *Cantharellus subfloridulus* (in Buyck & Hofstetter 2018 - there still labeled as “*C. alboroseus*”) is sister to *C. ibityensis* with moderate support (MLbs=69%) and, together, both species form a significantly supported clade with *C. alboroseus* (MLbs=84). Only two of five sequenced collections were part of the analysis (see examined material). Branches in bold are significantly supported and numbers above branches give MLbootstrap support values.

in between folds, not abruptly delimited from the sterile stipe surface but fragmenting gradually in smaller patches. *Stipe* up to 15 mm high and 2-3(4) mm diam., subcylindrical or tapering downward, sometimes also slightly widening at the base, smooth, concolorous to slightly paler than the pileus, except in specimens with a very pale pileus where the stipe remains often pinkish to pale orange (6AB6-7), smooth and glabrous on the surface, but the base often hirsute to tomentose; the entire stipe becoming rapidly fistulose inside. *Context* very thin, pinkish, fibrous. *Smell* agreeable. *Taste* mild. *Spore print* distinctly yellowish, even more so when dry.

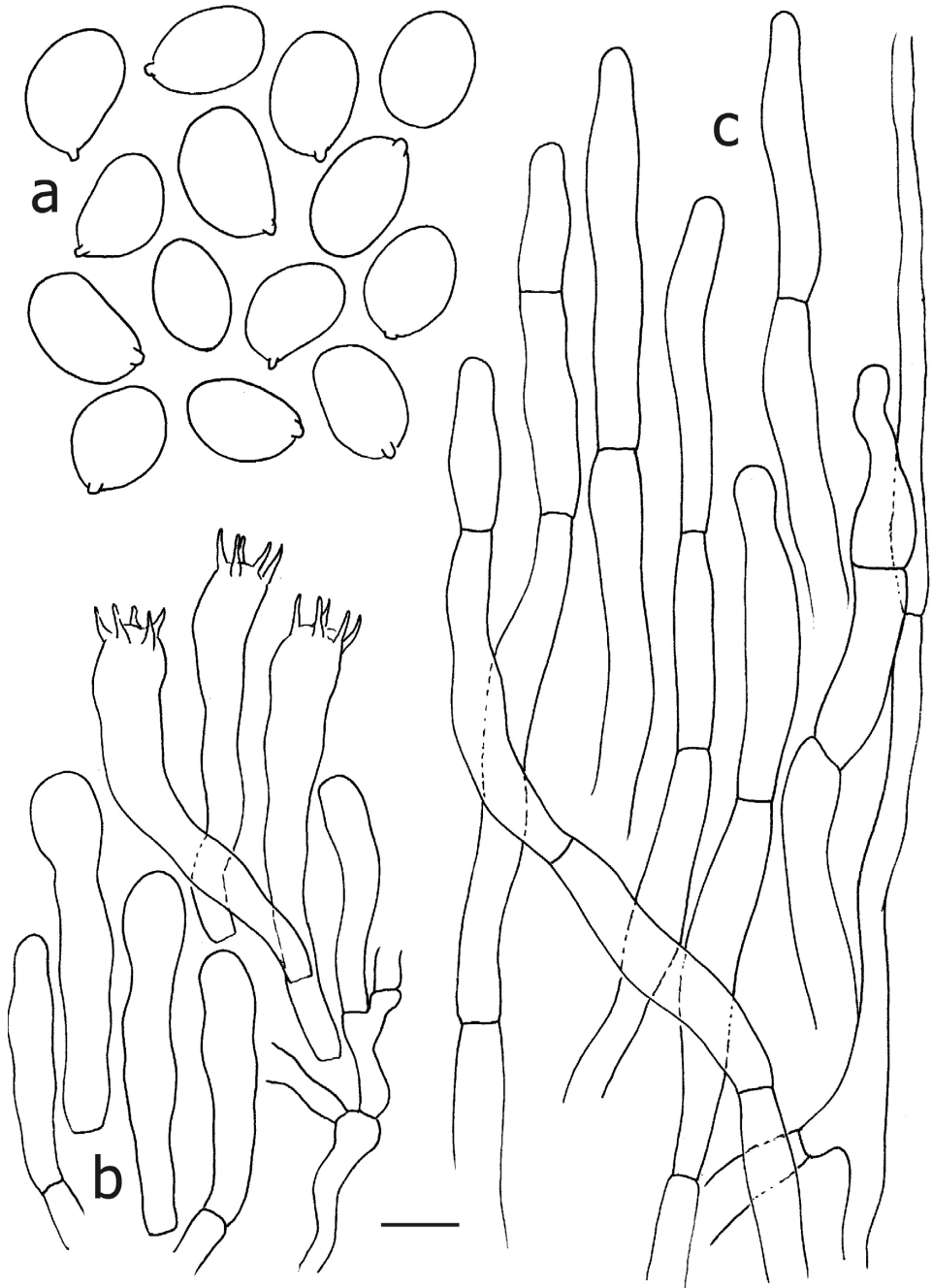


Fig. 6. *Cantharellus subfloridulus* (holotypus). **a.** Spores. **b.** Basidia and basidiola. **c.** Hyphal extremities of the pileipellis. Drawings B. Buyck. Scale bar = 10  $\mu\text{m}$ , but only 5  $\mu\text{m}$  for spores.

Spores ellipsoid, (6.7)7.1-7.64-8.1(8.5) x (4.6)4.7-4.93-5.2(5.4)  $\mu\text{m}$ ,  $Q = (1.33)1.45-1.55-1.65(1.74)$ , with a low, broadly obtuse apiculus. *Basidia* 41-55(-58)  $\times$  7.5-9  $\mu\text{m}$ , clavulate, principally 5-spored. *Cystidia* none. *Subhymenium* not very deep, filamentous although the cells are never very long, yet not wider than the basidium base. *Pileipellis* a loose and aerated layer of intermingled hyphae, rather forming a cutis-like structure than a trichodermal tissue, composed of branching, septate hyphae, colorless but with refringent contents; hyphal terminations thin-walled to distinctly refringent but never thick-walled, mostly (4)5-7(10)  $\mu\text{m}$  wide, with rather distant septa, composed of subcylindrical to locally slightly inflated cells; the terminal cell obtuse rounded, mostly slightly narrower near the top, some rather short, mostly 20-40(50)  $\mu\text{m}$  long. *Clamp connections* absent.

*Habitat*: growing in dense clusters composed of many dozens of fruiting bodies, often on steep slopes, on bare latosol or in sandy soil, under *Gilbertiodendron dewevrei*.

*Additional examined and sequenced material*: CENTRAL AFRICAN REPUBLIC. Dzanga-Sangha Forest Reserve, near Bayanga, close to Bai-Hakou base camp, N 02.859934- E 16.467492, under monospecific *Gilbertiodendron dewevrei* forest, on bare soil, 14 May 2016, Buyck 1651/BB16.017 (PC0125010); *ibid.*, 15 May 2016, Buyck 1642/BB16.027 (PC0125014); *ibid.*, 23 May 2016, Buyck 1668/BB16.106 (PC0125011); Buyck 1669/BB16.107 (PC0125012)

*Notes*: Other similarly colored, small Central African *Cantharellus* species with near-identical microscopic features from the same habitat are few: *C. alboroseus* Heinem., *C. minutissimus* Buyck & V. Hofst. (for both species, see Buyck *et al.* 2016), *C. floridulus* and *C. pseudofriesii* Heinem., two species still only known from the original description (Heinemann 1958), and possibly also *C. addaiensis* Henn. (see Buyck 2012). The equally similar *C. tenuis* Heinem. is not further considered because it has clamp connections (Eyssartier 2001).

*Cantharellus addaiensis*, as well as *C. pseudofriesii*, can be rapidly excluded for our collections because of the pinkish-red gill folds in both species. The neotypification of *C. addaiensis* (Buyck 2012) with a specimen collected in the savannas of Tanzania, might need some more explanation because the exact locality information for the original material was not further discussed. This original material, destroyed during the fire that ravaged all of Henning's fungi at Berlin-Dalh except for Uredinales and Fungi Imperfecti (see <https://www.bgbm.org/en/general-herbarium>), was collected by G. A. Schweinfurth and then sent to Hennings. In Mycobank ([www.mycobank.org](http://www.mycobank.org)) the original material is cited as "Schweinfurth nrs 2181 and 2265 collected in July 1869, Zaire", but we will show here that 'Zaire' as country is incorrect. The locality question is very important in this context as it determines whether *C. addaiensis* is possibly a rain forest species (and therefore might have been inadequately neotypified). The latter hypothesis is perfectly plausible as Schweinfurth did indeed collect in the *Gilbertiodendron dewevrei* rain forest of Ituri, in the north of the Democratic Republic of the Congo (ex-Zaire) across the border with South Sudan.

The protologue for *C. addaiensis* (see [www.biodiversitylibrary.org/page/506609#page/332/mode/1up](http://www.biodiversitylibrary.org/page/506609#page/332/mode/1up)) gives "*C. Africa, Bongoland, unter gebüsch zwischen Gir und Addai, unter Bambusa, 29 July 1869*". While searching on internet, we came across a payam (the second-lowest administrative division, just below county), named Gir, in Leer Co., South Sudan (see <http://www.ss.undp.org/content/dam/southsudan/library/Documents/CSAC%20Reports/UNDP-SS-Unity-consult-12.pdf>). The south of Leer Co. would agree with (1): Schweinfurth's own writings ([www.cimmay.us/schweinfurth.html](http://www.cimmay.us/schweinfurth.html)) where he reports extensively on weather



Fig. 7. *Cantharellus subfloridulus* (BB16.106). Field habit of a rare form with poorly veined hymenophore. Photo B. Buyck

conditions when staying near latitude N 7° 10" between March and August 1869 (period during which he collected *C. addaiensis*); this latitude crosses the southern part of Leer County; (2): The several thousands of Schweinfurth's plant specimens kept in Paris (P) show that Schweinfurth nrs 2181 and 2265 correspond to collections made in (South) Sudan, and for the month of July 1869, these were all collected in "Grosse Seriba Ghattas. Lande der Djur, Sudan" (South Sudan became independent from Sudan only in 2011). Finally, a summary of Schweinfurth's explorations in Africa can also be found on the site of the Berlin Dahl herbarium ([www.bgbm.org/en/node/127](http://www.bgbm.org/en/node/127)) and excludes a Zaire visit in 1869. Indeed, the Berlin website indicates that Schweinfurth did collect across the border from South Sudan, in the region of Ituri (Zaire), an area mostly covered by *Gilbertiodendron dewevrei* rain forest, but that he did so only in 1870, not in 1869. Therefore, we can exclude *C. addaiensis* as a possible correct identification for any of these reddish orange, very small rain forest chanterelles. The similarly colored *C. pseudofriesii* could well represent the rain forest twin (and possible sister) species of *C. addaiensis*, but so far, it has not been recollected again.

Microscopic features for all these small reddish orange chanterelles are not helping to distinguish among these various species. Example given, hyphal extremities of the pileipellis are near identical in all these species and the holotype for *C. floridulus* (see Eyssartier 2001) has exactly the same spore size as the neotype of *C. addaiensis*, while the holotype of *C. minutissimus* has a spore size that is comparable to that given for a *C. floridulus* collection from Gabon (Eyi N'dong *et al.* 2011). The latter *C. floridulus* collection from the equatorial rain forest in Gabon corresponds very well to the type description of *C. floridulus*, but it is distinctly

smaller (< 15 mm diam.) compared to the 40 mm diam. mentioned in the type description. Moreover, it reports a near-identical small size of the basidia (ca 30 µm) as for the *C. floridulus* holotype (a feature shared with *C. addaiensis*) whereas all of our collections (tab. 1) for *C. subfloridulus* have basidia that are mostly between 40-50 µm, and spores that are somewhat smaller than the measures given by Eyssartier (2001) for *C. floridulus*, but it is impossible to draw a clear line between features of each species. Sequence data are needed to decide whether the Gabon collection identified as *C. floridulus* might actually correspond to *C. minutissimus*.

In the absence of good microscopic differences, we have to look for possibilities to differentiate among these small red rain forest chanterelles in the field, which is mostly - although not always - a much better option. As noted already, *C. pseudofriesii* can be discarded on the account of its orange-red gill folds. Both *Cantharellus alboroseus* and *C. minutissimus* are typically much smaller compared to *C. floridulus* and also compared to our *C. subfloridulus* collections. At least *C. alboroseus* Heinem. (see Buyck *et al.* 216) should be easy to identify because of its more distant gills and reddening context. In addition, both *C. minutissimus* and

Table 1. Comparison of values obtained for spore and basidium size among the studied collections of the various species discussed in the preceding paragraphs.

	<i>Basidia</i>	<i>Spore length</i>	<i>Spore width</i>	<i>Q</i>
<i>C. alboroseus</i> <b>holotype</b>	53 × 9 40-50 (55) × 8-10	7-7.69-9 (Eyssart.)	4-4.94-5.5 (Eyssart.)	1.4-1.56-2.0 (Eyssart.)
<i>C. alboroseus</i> <b>epitype</b>	40-53 × 7-8	(6.9)7.1-7.39-7.7(7.9)	(4.0)4.1-4.42-4.7(5.0)	(1.4)1.56-1.68- 1.80(1.9)
<i>C. alboroseus</i> BB16.086	40-55 × 7-8	(6.2)6.6-6.93-7.3 (1.5)1.57-1.66-1.75(1.9)	(3.5)3.9-4.18-4.4(4.6)	(1.5)1.57-1.66- 1.75(1.9)
<i>C. subfloridulus</i> BB16.066		(7.08)7.3-7.71-8.1(9.0)	(4.4)4.7-5.03-5.3(5.6)	(1.38)1.45-1.54- 1.62(1.68)
<i>C. subfloridulus</i> BB 16.130		(7.1)7.2-7.41-7.6(7.9)	(4.6)4.8-5.13-5.4(5.8)	(1.26)1.36-1.45- 1.54(1.68)
<i>C. subfloridulus</i> 1650/BB 16.016 <b>holotype</b>	41-55(-58) × 7.5-9	(6.7)7.1-7.64-8.1(8.5)	(4.6)4.7-4.93-5.2(5.4)	Q = (1.33)1.45-1.55- 1.65(1.74)
<i>C. subfloridulus</i> 1642/BB16.027		(6.7)7.0-7.52-8.0(8.3)	4.6-4.94-5.2(5.8)	Q = (1.32)1.40-1.53- 1.65(1.74)
<i>C. floridulus</i> <b>holotype</b>	- 35 × 10 (heinem)	6-6.68-7 (Eyssart.) 6.5-7.7 (heinem)	4-4.85-5.5 (Eyssart.) 4.5-5.6 (heinem)	1.2-1.38-1.55 (Eyssart.) -
<i>C. cf floridulus</i> Eyi Ndong 2011	28-34 × 7-9	(5.7)5.6-6.5-7.3(8.1)	(3.4)3.5-4.0-4.5(4.7)	(1.41)1.40-1.61- 1.82(1.88)
<i>C. minutissimus</i> <b>Holotype</b>	38-47 × 5-7	(6.0)6.2-6.80-7.4(8.1)	(3.5)3.9-4.15-4.4(4.6)	(1.36)1.48-1.65- 1.82(1.95)
<i>C. pseudofriesii</i> <b>holotype</b>	35 × 7	5.5-6.2-7	3.0-3.73-4.5	1.3-1.67-2.0
<i>C. addaiensis</i> <b>neotype</b>	26-34(40) × 6-7.5	(5.6)6.1-6.7-7.3(8.1)	(4.0)4.2-4.8-5.3(5.8)	1.3-1.4-1.5(1.6)



Fig. 8. *Cantharellus subfloridulus* (BB16.027). Field habit of albino form with veined hymenophore. Photo B. Buyck

*C. alboroseus* seem to be more rare (or perhaps just overlooked) and known collections for both species are composed of very few individual fruiting bodies (unless the prolific Gabon collection of Eyi N'dong *et al.* corresponds to *C. minutissimus*), not forming the large and dense troops of fruiting bodies so characteristic of *C. subfloridulus*.

Nevertheless, *C. subfloridulus* illustrates once more the variability of the field aspect already observed for several other species in the genus. Indeed, our *C. subfloridulus* has a very variable overall color (Buyck 16.027 is an example of a nearly albino fruiting (figs 8, 10), but the stipe usually retains pink or orange flushes that reveal its correct identity), and also hymenophore development is quite variable (collection Buyck 16.106 was entirely composed of individuals lacking anastomosing veins in between the poorly differentiated radial gill folds (fig. 7), while in collection Buyck 16.016 all individuals had well-developed gill folds that were strongly anastomosing and veined in between, see fig. 9). As a consequence, we have long hesitated to identify our collections as *C. floridulus*, but there are finally several arguments that seem to argue strongly in favor of a separate species: (1) the color of *C. floridulus* was described by Heinemann (1958) as vermilion red (a rather dark, but intense red), which is quite different from the orange to pale pinkish colors of *C. subfloridulus* (the color of which ranges in shades going from the color of fresh to boiled salmon). We have seen dozens of collections in the field and never was the color close to vermilion red, on the contrary, it tends generally to discolor rapidly; (2) the stipe of *C. floridulus* is described as  $30 \times 2$  mm, which is  $15 \times$  longer than wide, in other words, a very elegant and slender stipe, compared to the  $3 \times$  to  $6 \times$



Fig. 9. *Cantharellus subfloridulus* (holotype). Form with distinctly anastomosing-interveined gill folds. Note the fistulose stipe and progressive discoloring to ochraceous with age (lower right corner). Photo B. Buyck



Fig. 10. *Cantharellus subfloridulus*, albino form (Buyck 16.027). Photo B. Buyck



longer than wide stipe of *C. subfloridulus*; (3) *C. floridulus* was described as smooth in between the gill folds, while the interstitial spaces in between gill folds of *C. subfloridulus* may indeed be smooth in rare cases, but the species usually develops a distinct to very strong veination in between gill folds; (4) basidia of our species are 1.5 to almost twice as long compared to those of *C. floridulus*; (5) mean spore length/width ratio is lower in *C. floridulus* compared to any of our measured collections for *C. subfloridulus*, especially because the mean spore length is approximately 1  $\mu\text{m}$  shorter in Heinemann's species (see table 1); (6) terminal cells of *C. floridulus* were described as brown in microscopic preparations, whereas in *C. subfloridulus* there is no pigment present; and, finally, (7) *C. subfloridulus* exhibits a distinct yellowing of its tissues, very strongly so when of advanced age, while the context of *C. floridulus* was simply described as white. The mention of a white spore print in the original description is in our opinion not an obstacle. Obtaining good spore prints is notoriously difficult in *Cantharellus*, even more so for very small species.

Our phylogenetic analyses (Fig. 5) confirm the placement of *C. subfloridulus* in subg. *Rubrinus*, more precisely as sister-species to the Malagasy *C. ibityensis* Buyck & V. Hofst. in sect. *Heinemannianus* Eyssart. & Buyck.

66. *Multifurca roxburghii* Buyck & V. Hofst., *Fungal Diversity* 28: 38. 2008

**Figs 11–13**

*Mycobank*: MBT384852

*Genbank*: MG674302 (ITS epitype)

*Systematic position*: Basidiomycota, Agaricomycetes, Russulales, Russulaceae

*Epitypification* (by K. Das, X-H Wang & B. Buyck): INDIA, Uttarakhand, Pauri, Thalısain, N 30°01.457 E 079°03.095', 1885 m asl., under *Pinus roxburghii* in temperate coniferous forest, 01 August, 2017, *Kanad Das*, KD 17-006 (CAL 1737, **epitypus hic designatus!**).

*Pileus* 30-80 mm diam., firm and thick, at first convex, plano-convex, then with depressed center, with strongly inrolled, somewhat wavy margin; surface dry, pruinose to distinctly fibrillose-squamulose, in the center sometimes cracking, elsewhere subtly uneven to pithy with slightly lower patches of more or less circular - ellipsoid spots of variable size that are more grayish as from soaked aspect, off-white (1A2-4A2), sometimes slightly dingy with maturity, gradually pale yellow (4A3) towards margin, orange yellow on application of KOH, not peeling easily, cartilaginous in consistency. *Gills* subdecurrent to decurrent, equal but dichotomously forked, close (10-12/cm at pileus margin), up to 4 mm high, interveined, smooth, turning light yellow to deep yellow (4A4-8) from stipe attachment outwards, unchanging on bruising, edge entire, concolorous. *Stipe* central, 23-33  $\times$  10-15 mm, stout, tough, cylindrical to slightly ventricose, tapering at base, white to yellowish white, pruinose, pithy to obscurely scrobiculate, unchanging on bruising, the entire lower half or three quarters strongly covered with adhering soil, hollowing inside. *Context* chalky white, firm, concentrically zoned above the gills. *Taste* mild. *Odor* fruity but slightly unpleasant. *Spore print* light orange (5A5-6).

*Basidiospores* subglobose to ellipsoid, 4.5-5.43-6.4  $\times$  3.9-4.43-5.1  $\mu\text{m}$  ( $n = 30$ ,  $Q = 1.11-1.23-1.35$ ); ornamentation composed of low convex warts connected with subtle lines or aligned into an incomplete reticulum; suprahilar spot distinct, inamyloid. *Basidia* 35-64  $\times$  8-9  $\mu\text{m}$ , narrowly clavate, widest at the tip, 4-spored; sterigmata 3-7  $\times$  1-1.5  $\mu\text{m}$ . *Pleurocystidia* large, 44-123  $\times$  6.5-13.5  $\mu\text{m}$ , embedded or occasionally emergent (up to 9.5  $\mu\text{m}$ ), fusiform-lageniform, minutely

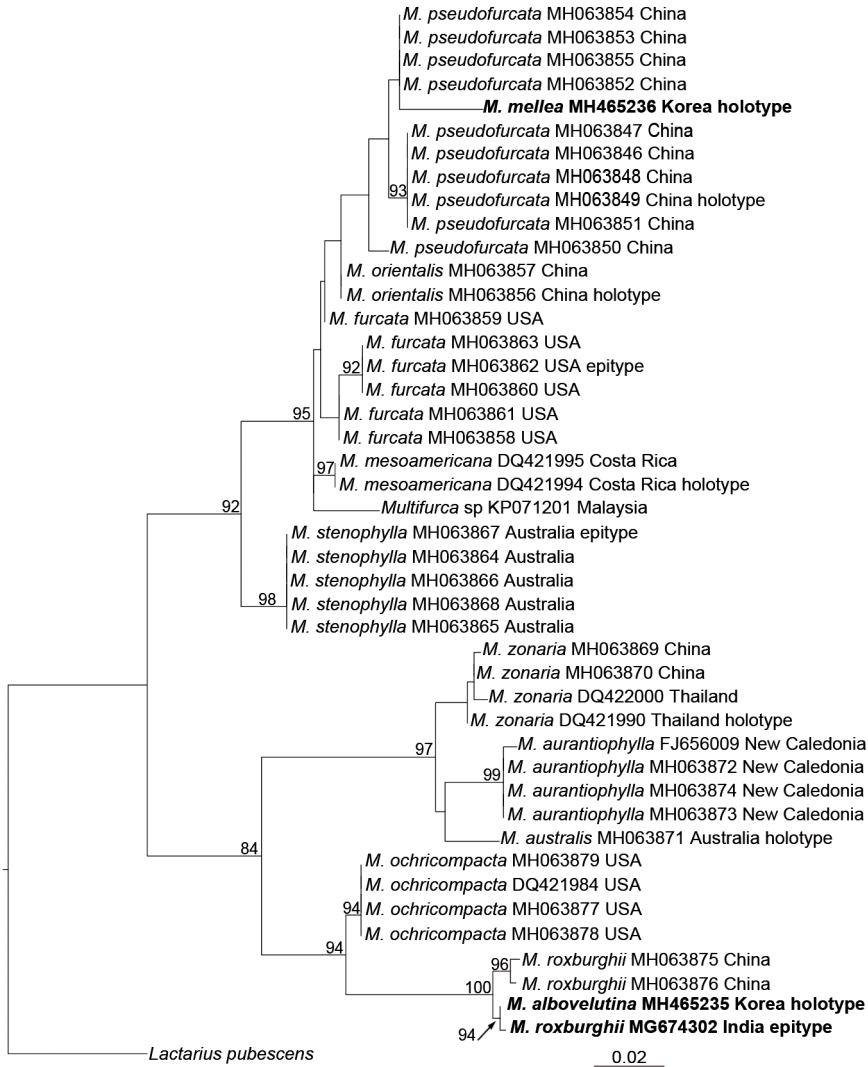


Fig. 11. Maximum Likelihood (ML) phylogram of *Multifurca* based on ITS sequence data, rooted with *Lactarius pubescens*. Bootstrap proportions higher than 70% are indicated above or near branches. Three sequences (in bold) are added to the dataset of Wang *et al.* (2018: Plos ONE 13: e0205840) to show the placement of the holotypes of *M. albovelutina* and *M. mellea* and the epitype of *M. roxburghii*. Sample labels are given in the order of species name, GenBank accession, geographical origin and typification (when applicable).

capitate to rostrate, often strongly inflated near or below the trama-subhymenium transition, thin-walled, filled with more or less crystalline contents. *Pseudocystidia* not observed. *Marginal cells* not differentiated; gill edge fertile. *Cheilocystidia* 32-59.5 × 6-10 μm, 13-21 μm emergent, cylindrical to fusoid with subcapitate to subappendiculate apices, thin-walled; contents more or less crystalline. *Hymenophoral trama* almost without sphaerocytes, but with a dense tissue of slender hyphae,

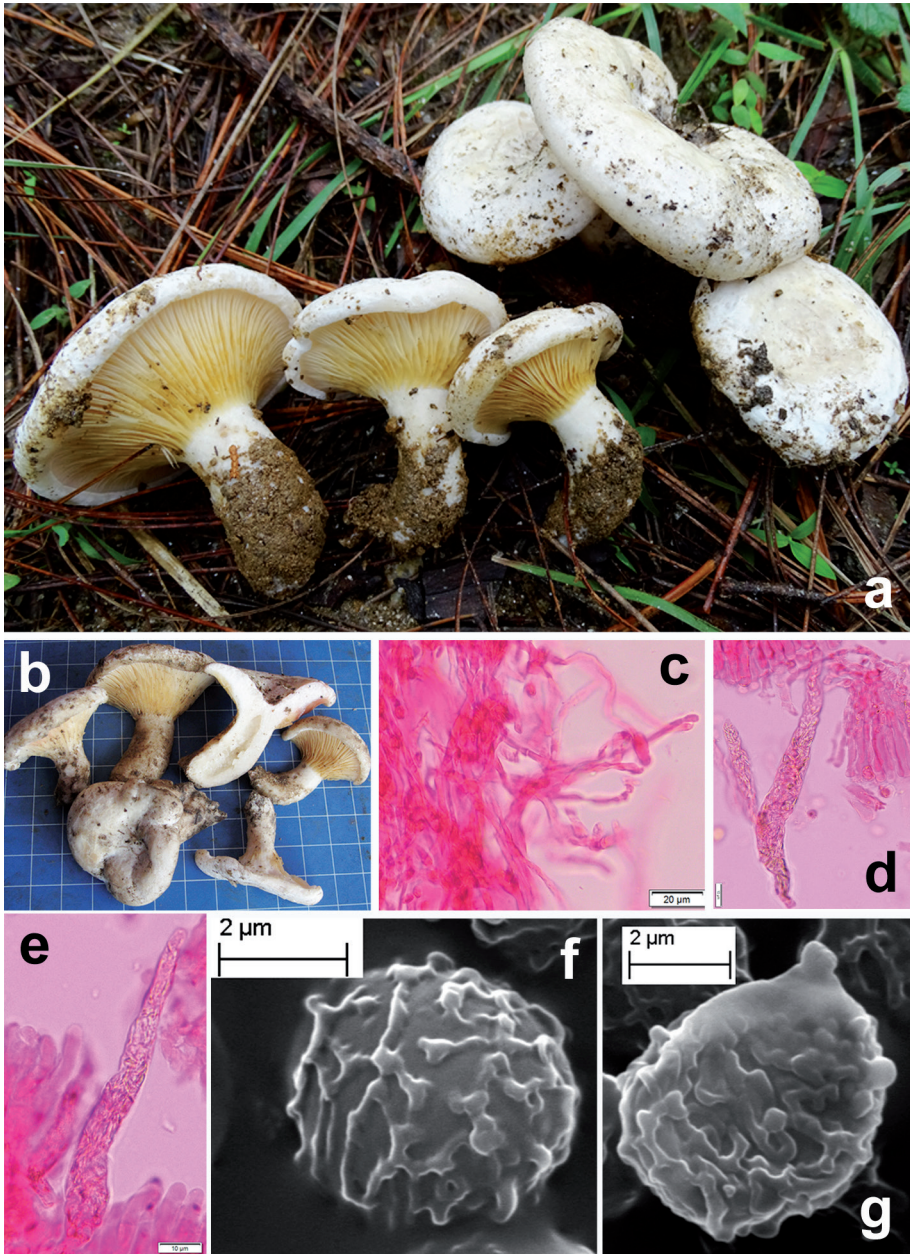


Fig. 12. *Multifurca roxburghii* (KD 17-006). **a-b.** Fresh basidiomata in the field and basecamp. **c.** Transverse section through pileipellis. **d-e.** Pleurocystidia. **f-g.** Basidiospores under SEM. Scale bars: c, d & e = 10  $\mu$ m, f & g = 2  $\mu$ m.

transiting into a poorly differentiated subhymenium. *Pileipellis* up to 295  $\mu$ m thick, poorly differentiated, entirely orthochromatic in Cresyl blue, composed of interwoven, horizontal to slightly ascending hyphae; hyphae septate, thin-walled; terminal cells

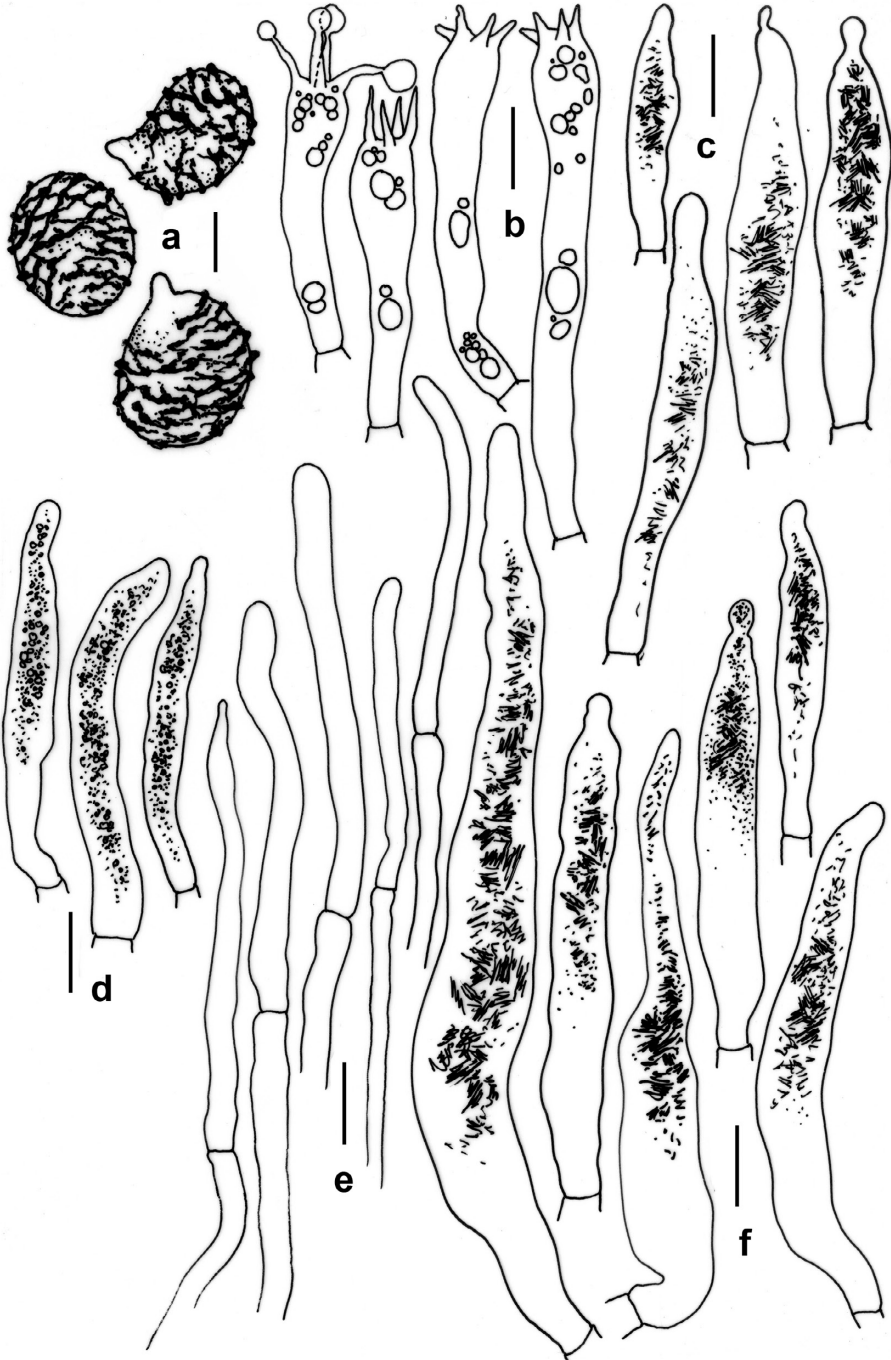


Fig. 13. *Multifurca roxburghii* (KD 17-006), microscopic features. **a.** Basidiospores. **b.** Basidia. **c.** Cheilocystidia. **d.** Caulocystidia. **e.** Terminal and subterminal cells in hyphae of pileipellis. **f.** Pleurocystidia. Scale bars: a = 2  $\mu$ m, b-f = 10  $\mu$ m.

41-68 × 3-5 µm, cylindrical to fusoid, with rounded tip. Pileocystidia 45-56 × 5-6.5 µm, cylindrical to subfusoid, contents oleiferous (but as well for most of the other hyphae of the pileus trama). *Caulocystidia* present, 74-90 × 10.5-19 µm, somewhat similar to pleurocystidia. *Clamp connections* absent.

*Notes:* *Multifurca roxburghii* was described from the Himalayan *Pinus roxburghii* forests in Himachal Pradesh. Our new collection is from neighbouring Uttarakhand and from exactly the same habitat. Morphological features of the new collection are very similar to those of the type as well as to those of the specimens recently described from China (Wang *et al.* 2018). The just published *M. albovelutina* Nam Kyu Kim, Hyun Lee & Young Woon Lim (Verbeken *et al.* 2018) from mixed *Pinus densiflora* stands in South Korea is clearly a later synonym based on its near-identical ITS sequence. Our phylogenetic analysis (Fig. 11) also shows that the second *Multifurca* species described in the same paper from South Korea, *M. mellea* Nam Kyu Kim & Wisitr., is a later synonym of either the Chinese *M. orientalis* Wang or the Chinese *M. pseudofurcata* Wang. The ITS sequence deposited for the holotype of *M. mellea* (Genbank MH465236) is most likely of bad quality as the long branch on which it sits is due to 13 unique substitutions and INDELS, among which 11 are either different from all other species of *M.* subg. *Furcata* or from all other known *Multifurca*.

**67. *Russula gnathangensis* K. Das, Hembrom & Buyck, *sp. nov.* Figs 14–16**

*Mycobank:* MB 828907

*GenBank:* MK253441 (ITS holotype), MK253442 (ITS)

*Systematic position:* Basidiomycota, Agaricomycetes, Russulales, Russulaceae.

*Etymology:* Referring to the type locality Gnathang, of East district in Sikkim (India).

*Diagnosis:* Distinct from all the known species of *Russula* mainly by nrITS data and the combination of yellowish white spore print, reddish golden or brownish orange glutinous pileus with darker centre, clavate reddish stipe, indistinctive odour, 2- to 4-spored basidia, comparatively large basidiospores (8.2-9.49-10.4 × 6.9-7.99-9.1 µm) with high (up to 2 µm) conical warts and occurrence under *Abies* sp.

*Holotype:* INDIA, Sikkim, East district, Memeinchu, N 27°21.108' E 88°49.660', 3539 m asl., under *Abies densa* in subalpine mixed forest, 2 August, 2018, Kanad Das, KD 18-001 (CAL 1733, **holotype!**).

*Pileus* 25-88 mm diam., at first hemispherical when young, becoming plano-convex to convex with a depressed centre, viscid or glutinous when moist, peeling up to ½ of radius in mature sample, reddish golden or brownish orange to caramel (6C5-6) or pompeian yellow (5C6) to honey yellow or oak brown (5D6), centre slightly darker or in combination with english red or venetian red (8D8) sometimes; margin decurved to plane when mature, obscurely or faintly striate. *Lamellae* adnexed, subdistant to rather close (6-8/cm at pileus margin) after maturity, forked near stipe apex or middle, yellowish white (3A2), unchanging on bruising; edge entire, marginate reddish; lamellulae rare. *Stipe* 30-75 × 10-25 mm, cylindrical to subclavate, surface dry, longitudinally venose, most completely pastel red (8A4) with chalky white (1-2A1) patches at base, unchanging when bruised but. *Context* solid to stuffed in stipe with age, chalky white (1-2A1), turning salmon (6A4) with FeSO<sub>4</sub> and orange red or high red or vivid red (8-9B8) with guaiacol. *Taste* indistinctive. *Odor* indistinctive. *Spore print* yellowish white (3A2).

*Basidiospores* 8.21-9.49-10.37 × 6.96-7.99-9.14 µm, (n = 30, Q = 1.06-1.17-1.28), usually subglobose to broadly ellipsoid; ornamentation partially amyloid,

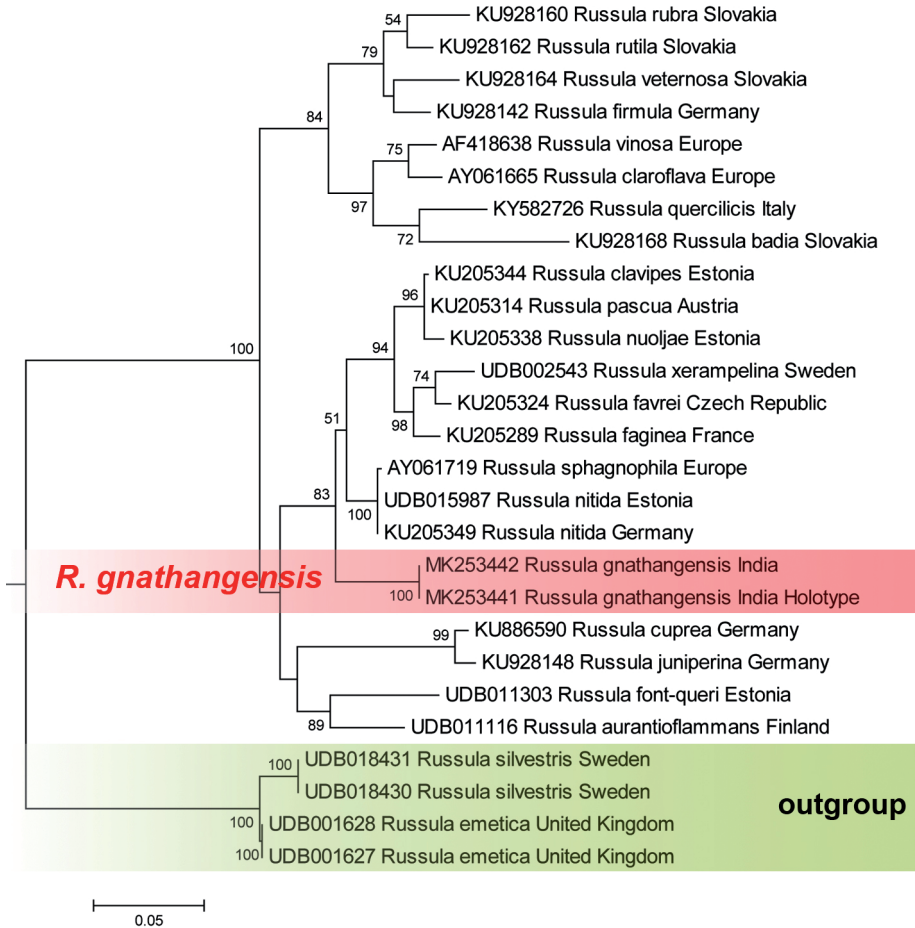


Fig. 14. Phylogram generated from Maximum Likelihood approach (ML) in raxmlGUI 1.2 (Silvestro & Michalak 2012, Stamatakis *et al.* 2008) with 1000 bootstrap replicates. One thousand bootstrap replicates were analyzed to obtain the nodal support values. Bootstrap support values (>50%) obtained from Maximum Likelihood (ML) analysis are shown above or below the branches at nodes. The Indian specimens of *Russula gnathangensis* having GenBank Accession Numbers MK253441 and MK253442 (nrITS-rDNA) are shown in red and bold in the tree.

up to 2  $\mu$ m high, composed of cylindrical (mostly with rounded apices) isolated very high to low warts, occasionally laterally fused; suprahilar plage amyloid. *Basidia* 32–46  $\times$  10–13  $\mu$ m, subclavate, 2- or 4-spored; mature sterigmata 7–10  $\times$  2–2.5  $\mu$ m. *Subhymenium* 20–35  $\mu$ m thick, made up of pseudoparenchymatous cells. *Pleurocystidia* common, 66.4–72.5  $\times$  9.2–11.3  $\mu$ m, emergent 3.8–19  $\mu$ m; elongate-ventricose, with fusoid to subfusoid apices, thin-walled, content dense, somewhat granulose. *Cheilocystidia* 33–45  $\times$  7–9  $\mu$ m, emergent 7–12  $\mu$ m, narrow clavate to narrow ventricose, with subfusoid, rounded to appendiculated apices, thin-walled, content dense. *Hymenophoral trama* composed of numerous sphaerocytes and connecting hyphae; *Pileipellis* up to 125  $\mu$ m thick, composed of abundant suberect cystidia and septate hyphae; pilear hyphae 3.6–4.2  $\mu$ m; terminal cells cylindrical with

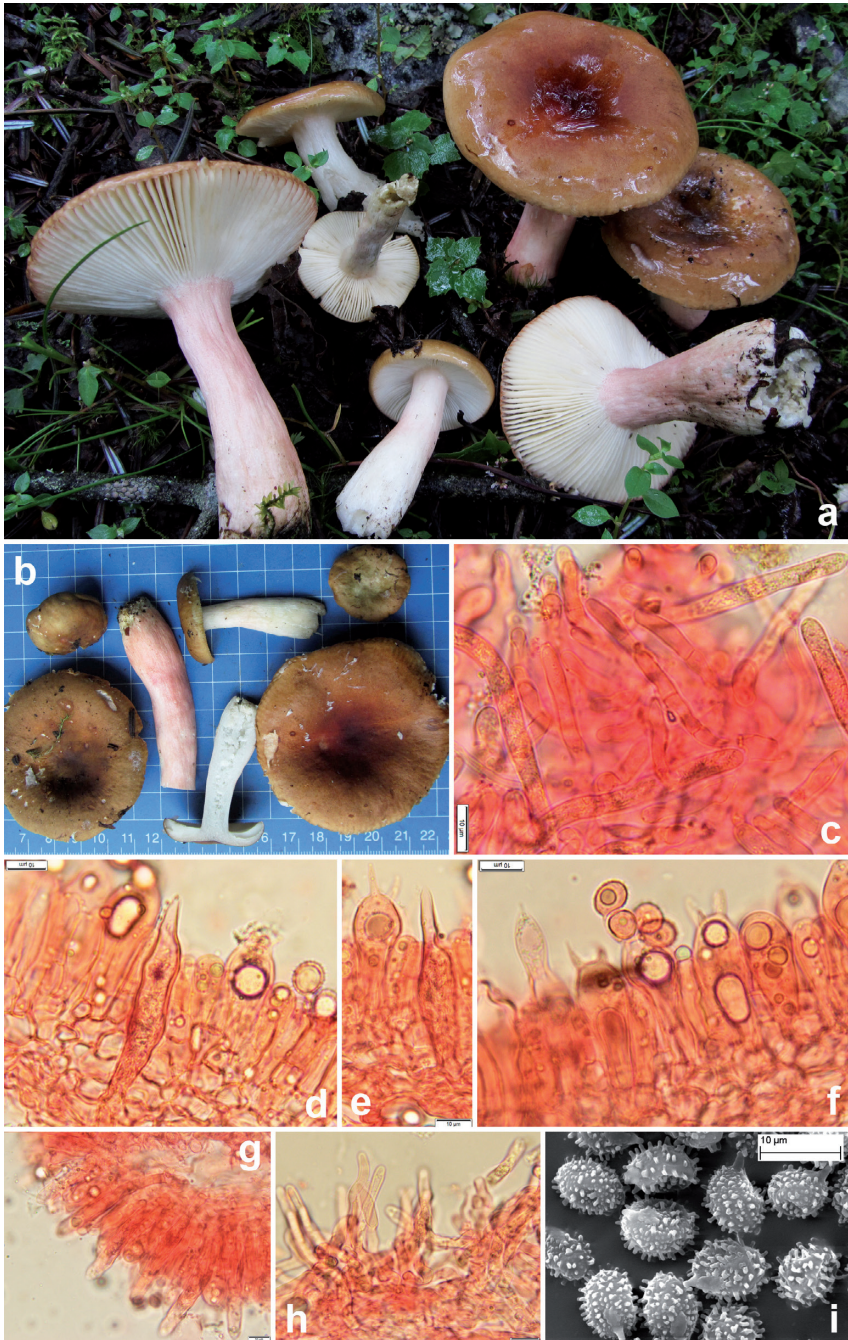


Fig. 15. *Russula gnathangensis* (KD 18-001). **a & b.** Fresh basidiomata in the field and basecamp. **c.** Transverse section through pileipellis. **d, e & f.** Hymenial layer showing basidia & pleurocystidia. **g.** Cheilocystidia. **h.** Transverse section through stipeipellis showing hyphal elements and caulocystidia. **i.** Basidiospores under SEM. Scale bars: **c, d, e, f, g & h** = 10  $\mu\text{m}$ , **h & i** = 2  $\mu\text{m}$ .

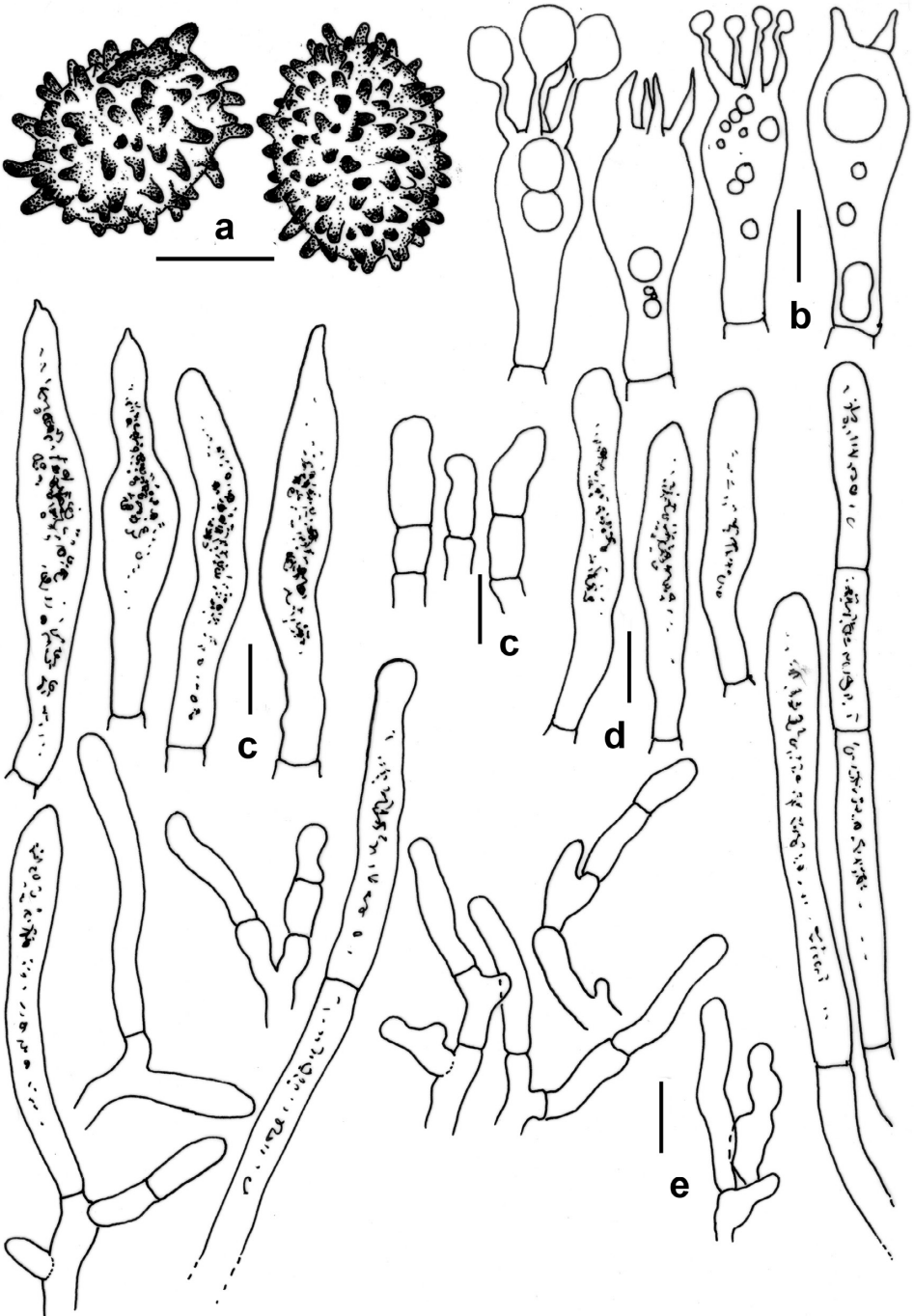


Fig. 16. *Russula gnathangensis* (KD 18-001), microscopic features. a. Basidiospores. b. Basidia. c. Pleurocystidia. d. Marginal cells. e. Cheilocystidia. f. Elements of pileipellis. Scale bars: a = 5  $\mu$ m, b-e = 10  $\mu$ m.



rounded apex, wide, septate, branched; pileocystidia 4.5-5.8  $\mu\text{m}$  cylindrical to narrowly subclavate with rounded apices. *Stipitipellis* up to 87  $\mu\text{m}$  thick, composed of parallel to subparallel hyphae and cystidia with erect tips. *Clamp connections* absent in all tissues.

*Specimens examined:* INDIA, Sikkim, East district, Memeinchu, N 27°21.108' E 88°49.660', 3539 m asl., under *Abies densa* in subalpine mixed forest, 2 August, 2018, *Kanad Das*, KD 18-001 (CAL 1733); *ibid.*, East district, Firing range forest of Gnathang, N 27°20.892' E 88°49.107', 3640 m asl., under *Abies densa* in subalpine mixed forest, 3 August, 2018, *Kanad Das*, KD 18-006 (CAL 1634).

*Notes:* Our new species, which is moreover a highly appreciated edible mushroom by local populations, is closely related to *R. nitida* (Pers.: Fr.) Fr. and *R. sphagnophila* Kaufmann, both constituting the ITS nBLAST top score results at 97% similarity. Compared to those two species, as well as to other species in subsect. *Betulinae* (Romagn.) Sarnari, it is easily differentiated by the isolated spines on the spores as well as by its association with *Abies densa*.

**68. *Russula indohimalayana* K. Das, I. Bera, A. Ghosh & Buyck, *sp. nov.***

**Figs 17-19**

*Mycobank:* MB 828905

*GenBank:* MK244692 (ITS holotype), MK244695 (ITS)

*Systematic position:* Basidiomycota, Agaricomycetes, Russulales, Russulaceae.

*Etymology:* Referring to the Indian Himalaya in Sikkim, the type locality.

*Diagnosis:* Distinct from all the known species of *Russula* mainly by nrITS data and the combination of greyish yellow to olivaceous pileus, white spore print, pleasant odour, presence of amyloid suprahilar appendage, basidiospores (7.5-9.12-10.3  $\times$  6.5-7.66-8.6  $\mu\text{m}$ ,) with 0.3-1.2  $\mu\text{m}$  high, conical to cylindrical warts and occurrence under *Abies densa*.

*Holotype:* INDIA, Sikkim, East district, Kyangnosla, N 27°22.365' E 88°44.072', 3411 m asl., under *Abies densa* in subalpine mixed (broadleaf and coniferous) forest, 08 August, 2018, *Kanad Das*, KD 18-060 (CAL 1729, **holotype!**).

*Pileus* 18-60 mm diam., hemispherical to convex when young, becoming plano-convex to applanate with a broadly depressed centre, sometimes uplifted (towards margin) with more maturity; surface glutinous to sticky, more glutinous at the center when moist, peeling up to 2/3 of radius when mature, greyish yellow (4B5-4C5) and slightly purplish towards margin with olive brown (4E8) fibrillose spots at centre, never discoloring in rain or at maturity; margin decurved, plane to uplifted with maturity, strongly tuberculately striate-sulcate. *Lamellae* adnexed to free, up to 8 mm thick, subdistant to rather close (6-10/cm at pileus margin) after maturity, rarely forked at the middle of lamellae, chalky white (1-2A1), thick, unchanging upon bruising; edge fimbriate, concolorous; lamellulae absent. *Stipe* 55-62  $\times$  15-18 mm, mostly subclavate to clavate sometimes with tapering base, surface dry, finely longitudinally venose, chalky white (1-2A1), unchanging when bruised. *Context* solid, chalky white (1-2A1), turning salmon (6A4) with  $\text{FeSO}_4$  and olivaceous with guaiacol. *Taste* indistinctive. *Odor* pleasant, faint. *Spore print* white (1A1).

*Basidiospores* 7.5-9.12-10.3  $\times$  6.5-7.66-8.6  $\mu\text{m}$  (n = 30, Q = 1.05-1.18-1.28), usually globose to broadly ellipsoid; ornamentation amyloid, 0.3-1.2  $\mu\text{m}$  high, composed of somewhat conical to cylindrical (mostly with rounded apices) warts connected or aligned through connectors or ridges to form nearly complete reticulum;

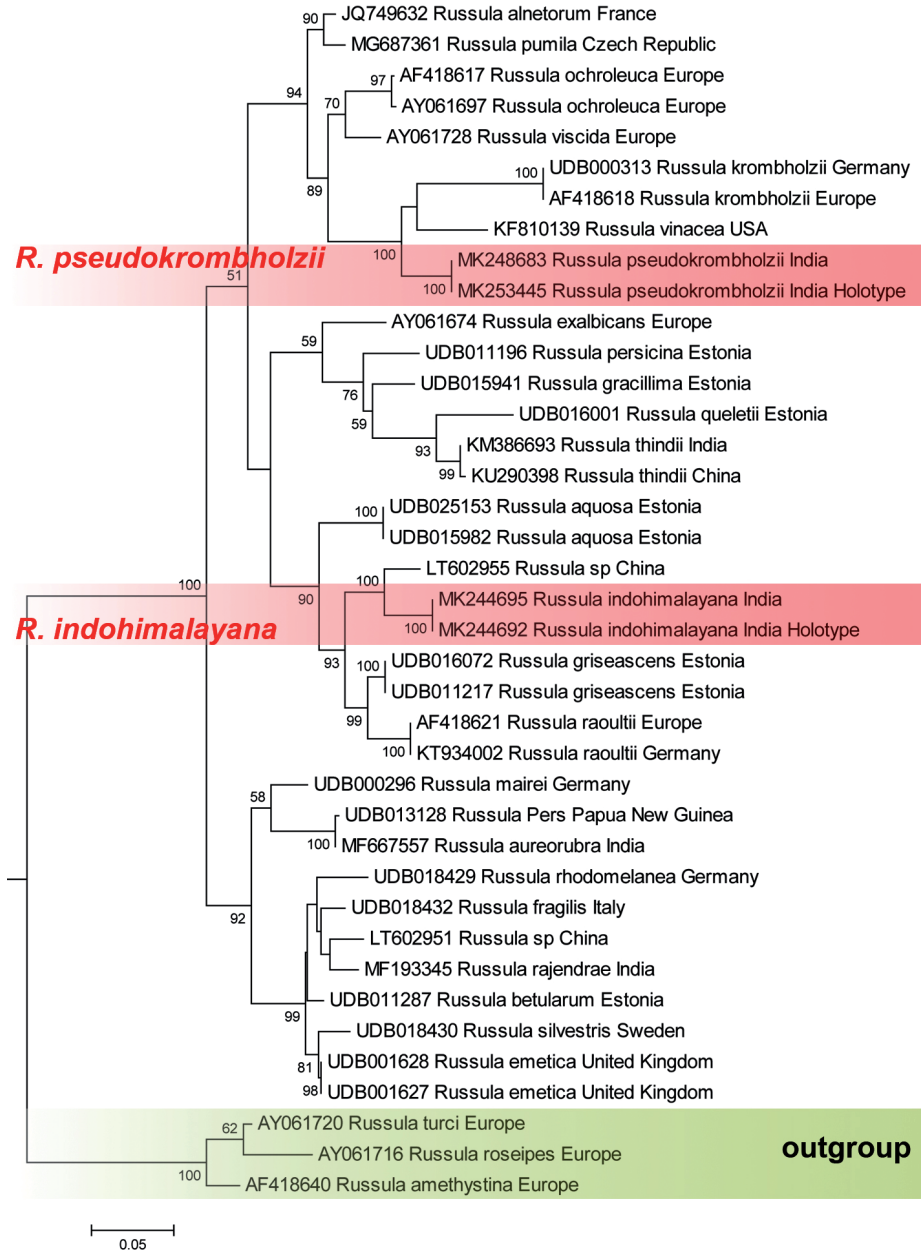


Fig. 17. Phylogram generated from Maximum Likelihood approach (ML) in raxmlGUI 1.2 (Silvestro & Michalak 2012, Stamatakis *et al.* 2008) with 1000 bootstrap replicates. One thousand bootstrap replicates were analyzed to obtain the nodal support values. Bootstrap support values (>50%) obtained from Maximum Likelihood (ML) analysis are shown above or below the branches at nodes. The Indian specimens of *Russula indohimalayana* having GenBank Accession Numbers MK244692 and MK244695 (nrITS-rDNA) and *Russula pseudokrombholzii* having GenBank Accession Numbers MK253445 and MK248683 (nrITS-rDNA) are shown in red and bold in the tree.

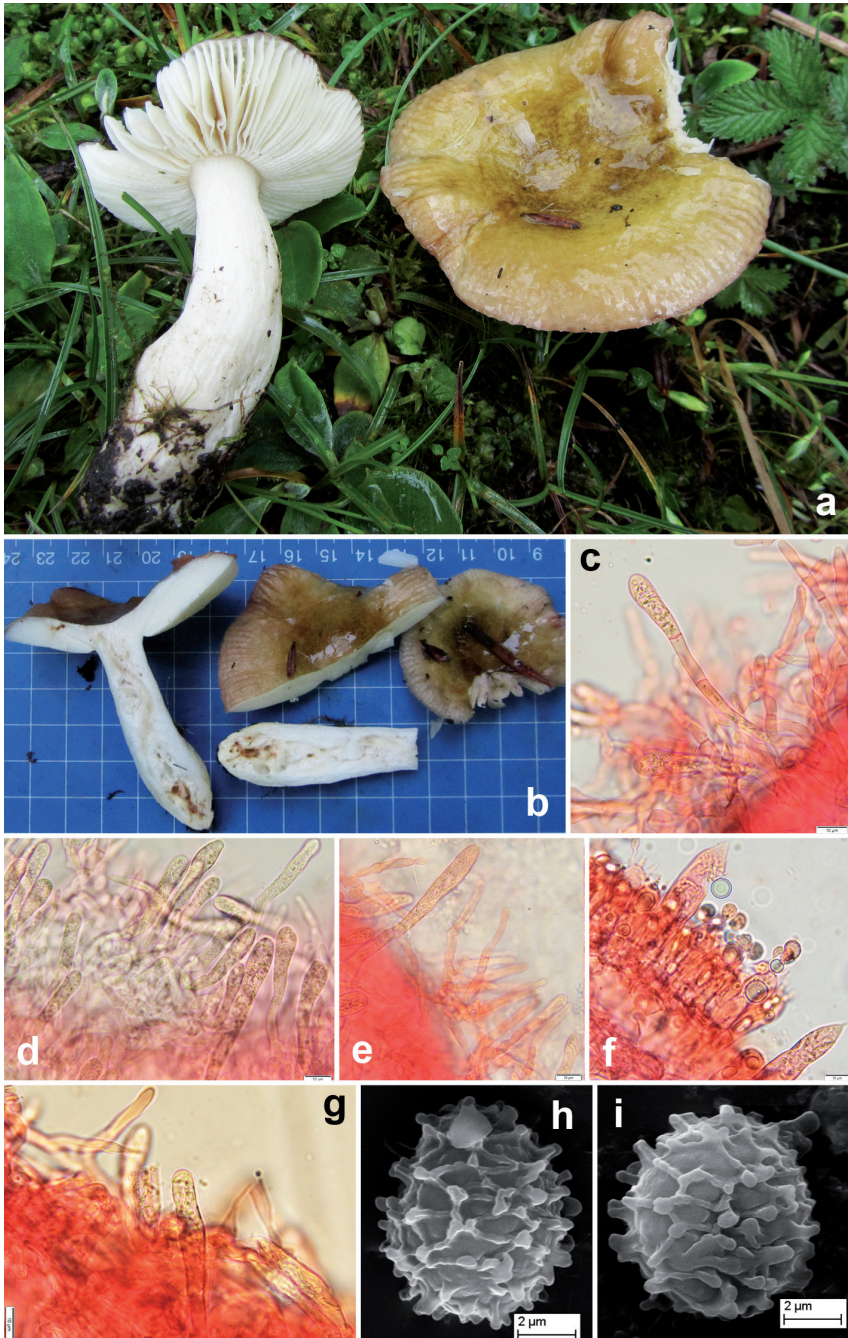


Fig. 18. *Russula indohimalayana* (KD 18-060). **a & b.** Fresh basidiomata in the field and basecamp. **c, d & e.** Transverse section through pileipellis. **f.** Hymenial layer showing basidia & pleurocystidia. **g.** Transverse section through stipitipellis showing hyphal elements and caulocystidia. **h & i.** Basidiospores under SEM. Scale bars: c, d, e, f & g = 10  $\mu$ m, h & i = 2  $\mu$ m.

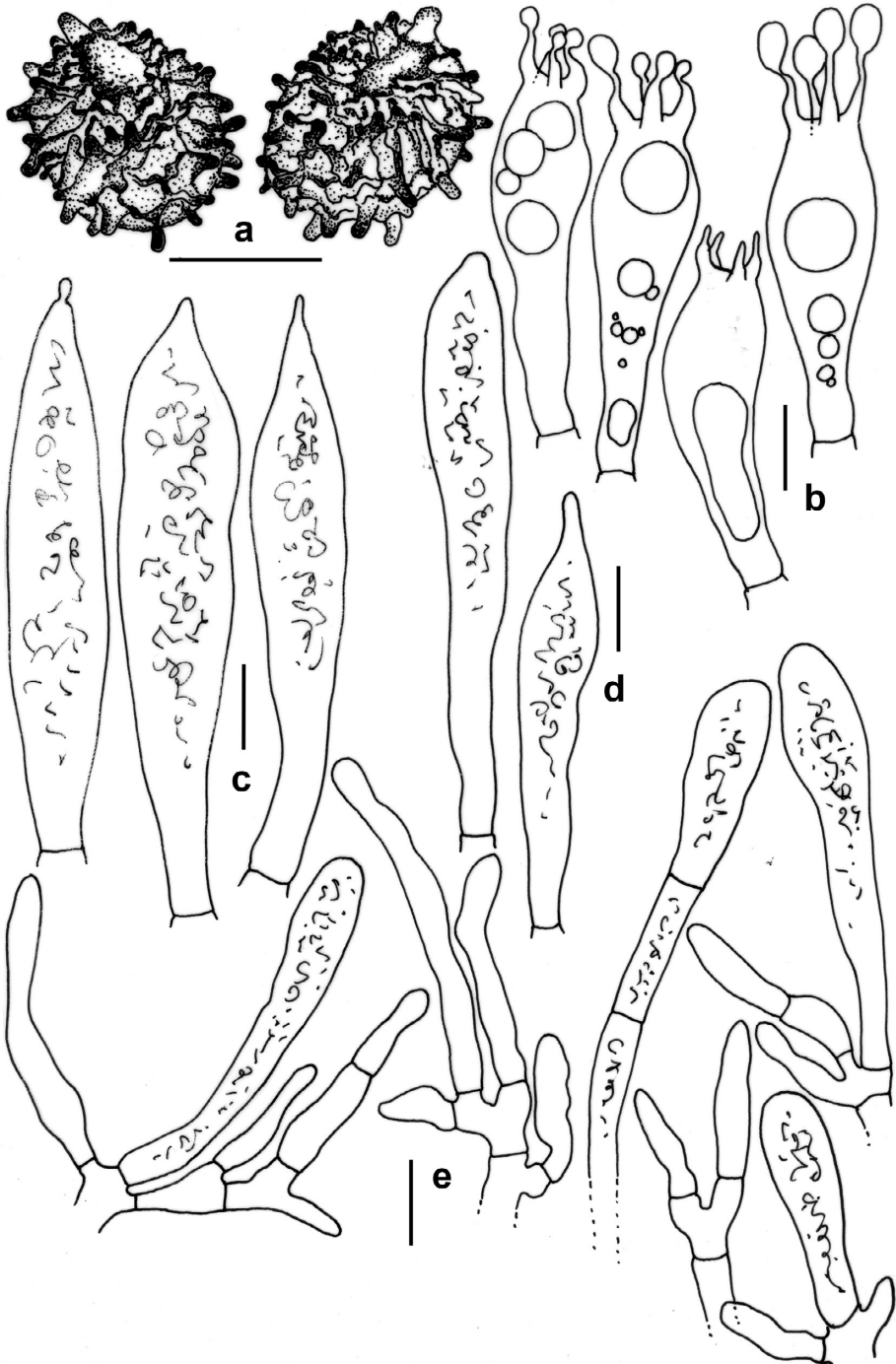


Fig. 19. *Russula indohimalayana* (KD 18-060), microscopic features. **a.** Basidiospores. **b.** Basidia. **c.** Pleurocystidia. **d.** Cheilocystidia. **e.** Elements of pileipellis. Scale bars: a = 5  $\mu$ m, b-e = 10  $\mu$ m.

suprahilar plage amyloid. *Basidia* 45-50 × 12-14.5 µm, subclavate to subventricose, 4-spored; mature sterigmata 5-8 × 1.5-2.5 µm. *Subhymenium* 25-30 µm thick, made up of pseudoparenchymatous cells. *Pleurocystidia* common, 55-77 × 10.6-14.3 µm, emergent 29.7-41.8 µm; ventricose with subfusoid, fusoid to appendiculated apices, content dense, fibrous. *Cheilocystidia* 40-75 × 8-10 µm, emergent 17-23 µm, narrow ventricose with fusoid to appendiculated apices, thin-walled, content dense, fibrous. *Hymenophoral trama* composed of numerous sphaerocytes and connecting hyphae. *Pileipellis* up to 170 µm thick, ixotrichoderm, composed of interwoven hyphae and pileocystidia becoming erect towards apex; pilear hypae 2.9-4.2 µm wide, erect to suberect, mostly cylindrical to subfusoid with rounded apex, branched, septate; pileocystidia 6.6-9.2 µm wide, clavate to ventricose, aseptate to multiseptate, with dense content, fibrous. *Stipitipellis* composed of interwoven hyphae and cystidia; caulocystidia up to 8 µm wide, subclavate, with dense content. *Clamp connections* absent in all tissues.

*Specimens examined:* INDIA, Sikkim, East district, Kyangnosla, N 27° 22.365 E 088°44.072', 3411 m asl., under *Abies densa* in subalpine mixed (broadleaf and coniferous) forest, 08 August, 2018, *Kanad Das*, KD 18-060 (CAL 1729); *ibid.*, East district, Kyangnosla, N 27° 22.365 E 088°44.072', 3411 m asl., under *Abies densa* in subalpine mixed (broadleaf and coniferous) forest, 08 August, 2018, *Kanad Das*, KD 18-066 (CAL 1730).

*Notes:* This new species is again another associate of *Abies densa* in the Himalaya mountains. Our phylogeny (Fig. 17) clearly places it in the core clade of *Russula* (Clade 7 in Buyck *et al.* 2018). Because of the discoloring pileus and microscopic features, it is not only genetically but also morphologically very close to some of the other discoloring species in this clade (*R. aquosa*, *R. montana*, *R. bicolor*, etc...) but none of the recently described Asian species appears to be concerned.

**69. *Russula pseudokrombholzii* K. Das, Hembrom, A. Ghosh & Buyck, *sp. nov.***

**Figs. 19-21**

*Mycobank:* MB 828909

*GenBank:* MK253445 (ITS holotype), MK248683 (ITS)

*Systematic position:* Basidiomycota, Agaricomycetes, Russulales, Russulaceae.

*Etymology:* Referring to morphological similarity with *R. krombholzii*, a European species.

*Diagnosis:* Distinct from similar looking *Russula krombholzii* mainly by nrITS data and the combination of characters like branched pileocystidia and occurrence under coniferous tree.

*Holotype:* INDIA, Sikkim, East district, opposite to firing range forest of Gnathang, N 27°18.605' E 88°48.794', 3885 m asl., under *Abies densa* in subalpine mixed forest, 5 August, 2018, *Kanad Das*, KD 18-21 (CAL 1731, **holotype!**).

*Pileus* 50-105 mm diam., at first hemispherical to convex at young, becoming plano-convex to applanate with a broadly depressed centre, gradually uplifted (towards margin) with more maturity; viscid when moist, mostly high red to vivid red (10B7-8) to deep or dark red (10C7-8), dark ruby (12F3) or blackish or with sometimes of pale yellow to light yellow (4A3-4) patches at centre; margin becoming decurved to plane when mature, sometimes slightly uplifted at maturity, strongly striate-sulcate. *Lamellae* adnexed to almost free, subdistant to rather close (8-9/cm at pileus margin) after maturity, forked near stipe apex, chalky white (1-2A1), unchanging on bruising; edge entire, concolorous; lamellulae present in

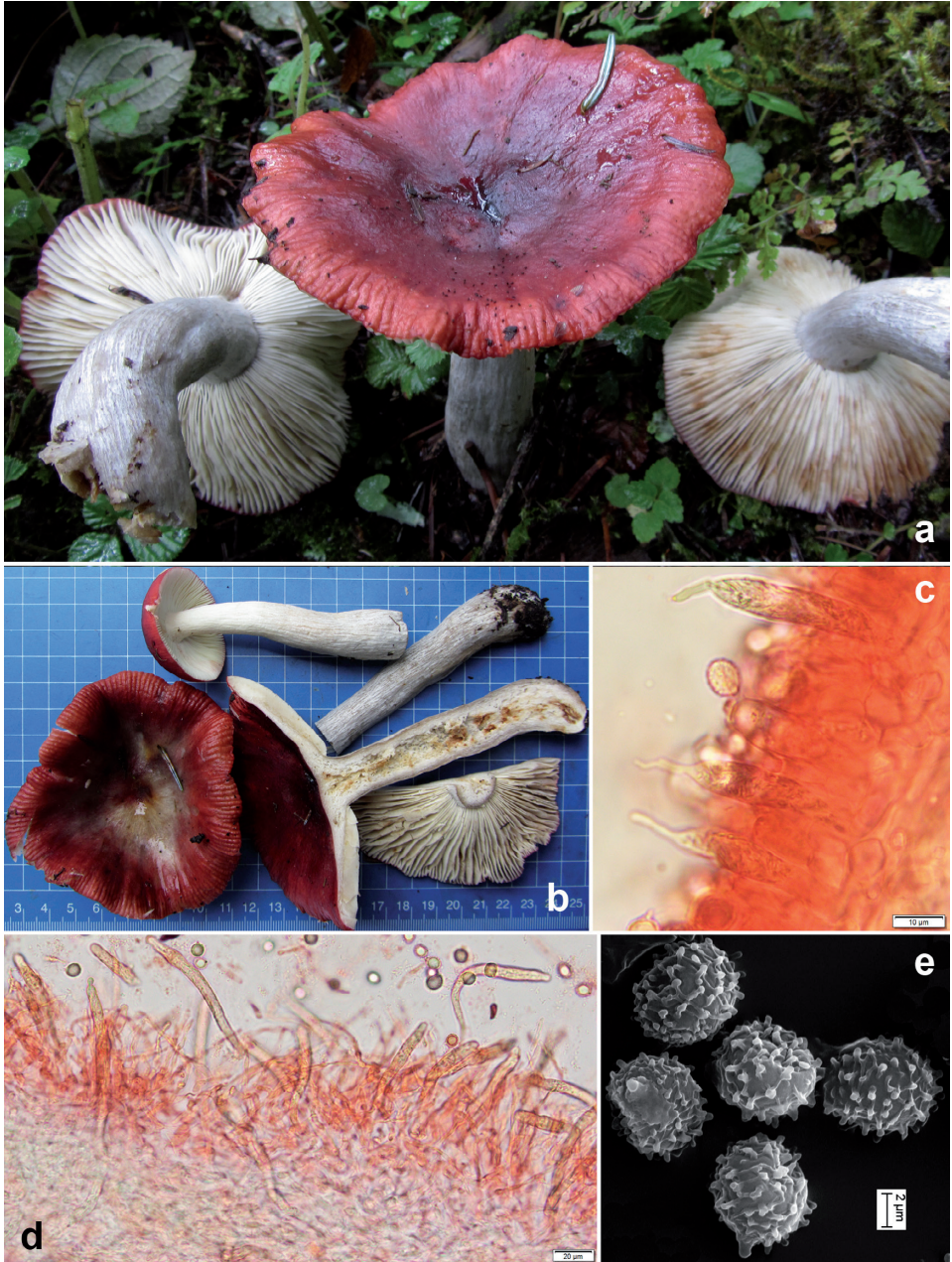


Fig. 20. *Russula pseudokrombolzii* (KD 18-21). **a & b.** Fresh basidiomata in the field and basecamp. **c.** Hymenial layer showing basidia & pleurocystidia. **d.** Transverse section through pileipellis. **e.** Basidiospores under SEM. Scale bars: c = 10  $\mu\text{m}$ , d = 20  $\mu\text{m}$ , e = 2  $\mu\text{m}$ .

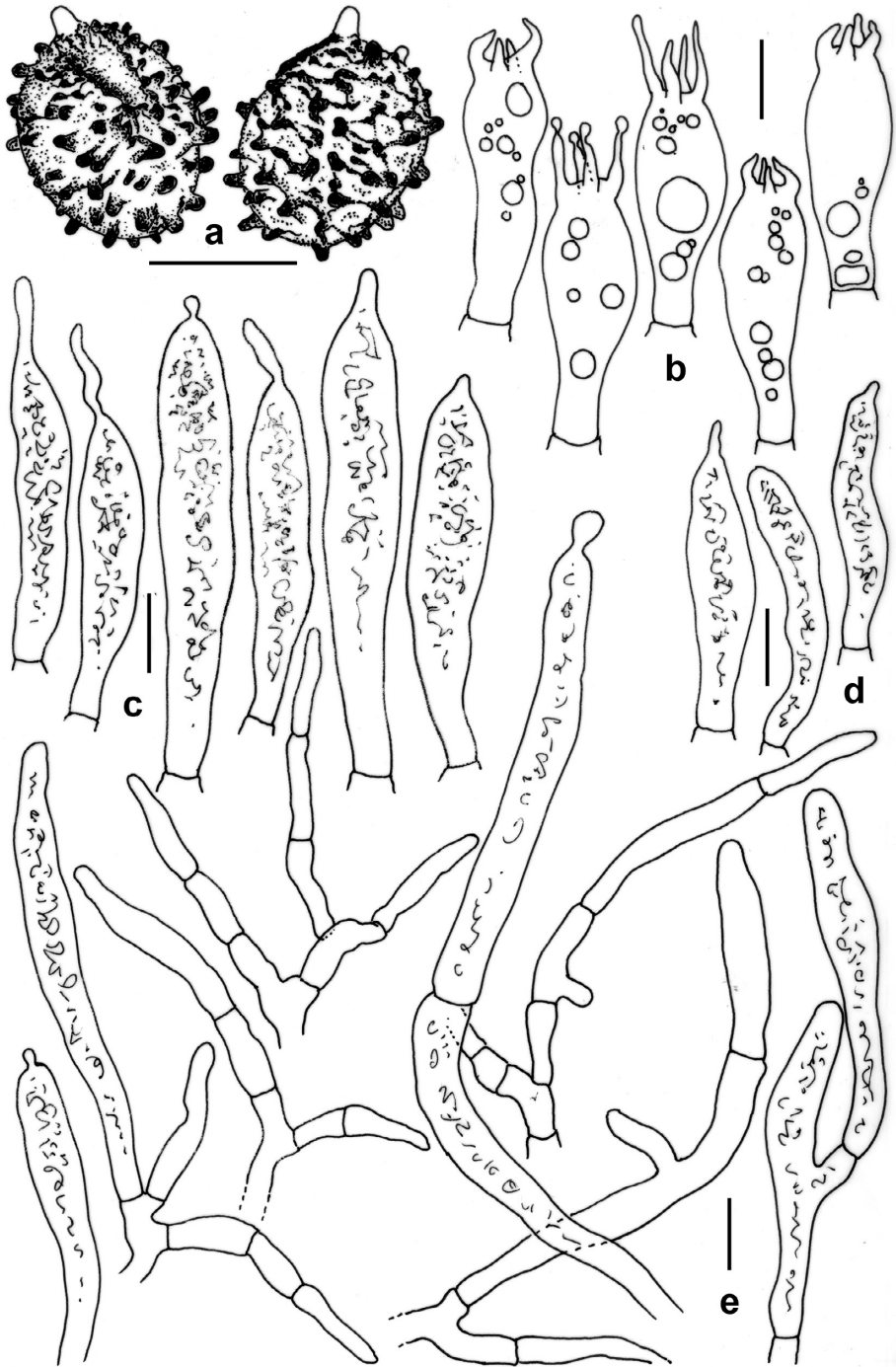


Fig. 21. *Russula pseudokrombolzii* (KD 18-21), microscopic features. **a.** Basidiospores. **b.** Basidia. **c.** Pleurocystidia. **d.** Cheilocystidia. **e.** Elements of pileipellis. Scale bars: a = 5  $\mu$ m, b-e = 10  $\mu$ m.

3 series. *Stipe* 70-110 × 20-24 mm, mostly cylindrical to subclavate, sometimes with abruptly tapering base, surface dry, finely longitudinally venose, chalky white (1-2A1), turning smoky grey with maturity. *Context* pithy to hollow in stipe, chalky white (1-2A1) to yellowish white (1A2), turning smoky grey with maturity, turning salmon (6A4) with FeSO<sub>4</sub>, faint yellow with KOH and dull red (8-9B3) with guaiacol. *Taste* bitter-acrid. *Odor* indistinctive. *Spore print* white (1A1).

*Basidiospores* 6.9-7.67-8.61 × 6.14-6.55-7.05 μm, (n = 20, Q = 1.06-1.16-1.23), usually subglobose to broadly ellipsoid; ornamentation amyloid, 0.2-0.6 μm high, composed of somewhat pyramidal to cylindrical (mostly with rounded apices) high to low warts connected through connectors or ridges to form partial or incomplete reticulum and with few isolated warts; suprahilar plage amyloid. *Basidia* 28.5-36 × 10-13 μm, subclavate to subventricose, 4-spored; mature sterigmata 4-11 × 2 μm. *Subhymenium* 20-30 μm thick, composed of pseudoparenchymatous cells. *Pleurocystidia* common, 45-65 × 7-11 μm, emergent 15.6-18.7 μm, subcylindrical with fusoid, subfusoid, capitate to appendiculated or lageniform apex, thin-walled, content dense, fibrous. *Cheilocystidia* 35-40 × 6.5-8.5 μm, subcylindrical with fusoid, subfusoid or appendiculated apices, thin-walled, content dense, fibrous. *Hymenophoral trama* composed of numerous sphaerocytes and connecting hyphae. *Pileipellis* up to 220 μm thick, composed of interwoven hyphae and cystidia becoming erect at apex; pilear hyphae up to 3.1 μm wide, septate, branched, terminal cells cylindrical to subfusoid; pileocystidia 5.8-8.7 μm wide, subcylindrical with fusoid, subfusoid or subcapitate apices, aseptate to single septate, sometimes branched, content dense. *Stiptipellis* composed of loosely interwoven hyphae and cystidia; hyphae 2-4 μm wide, subrepent or suberect, septate, branched; caulocystidia 70-150 × 7.5-8 μm, clavate with rounded to moniliform apex. *Clamp connections* absent in all tissues.

*Specimens examined*: INDIA, Sikkim, East district, opposite to firing range forest of Gnathang, N 27°18.605' E 88°48.794', 3885 m asl., under *Abies densa* in subalpine mixed forest (broadleaf and coniferous), 5 August, 2018, Kanad Das, KD 18-21 (CAL 1731); *ibid.*, East district, Kyangnosla, N 27° 22.365 E 088°44.072', 3411 m asl., under *Abies densa* in subalpine mixed forest, 08 August, 2018, Kanad Das, KD 18-067 (CAL 1732).

*Notes*: This new species is placed with strong bootstrap support (MLbs=99%) in subsect. *Ochroleucinae* Romagn. Its closest relatives appear to be the North American *R. vinacea* Burl. and the European *R. krombholzii* Shaffer, which is still often referred to as *R. atropurpurea* Krombh. (see Adamčík & Buyck (2011) for a nomenclatural history). *R. pseudokrombholzii* shares the greying stipe, overall colors and most of the other features with both these species, but ITS nBLAST results show it to be only 93% similar to *R. vinacea* and 92% to *R. krombholzii*, the two closest matches. It is unique in its association with *Abies densa*.

**70. *Russula subalpinogrisea* K. Das, I. Bera, A. Ghosh & Buyck, *sp. nov.***

**Figs 22-24**

*Mycobank*: MB 828910

*GenBank*: MK253444 (ITS holotype), MK253443 (ITS)

*Systematic position*: Basidiomycota, Agaricomycetes, Russulales, Russulaceae.

*Etymology*: Referring to a lookalike of *Russula grisea* that grows in the subalpine area.

*Diagnosis*: Distinct from all the known species of *Russula* mainly by nrITS data and the combination of characters: pileus with very thick gluten layer, yellowish white spore print, presence of two different types of pileocystidia in pileipellis,



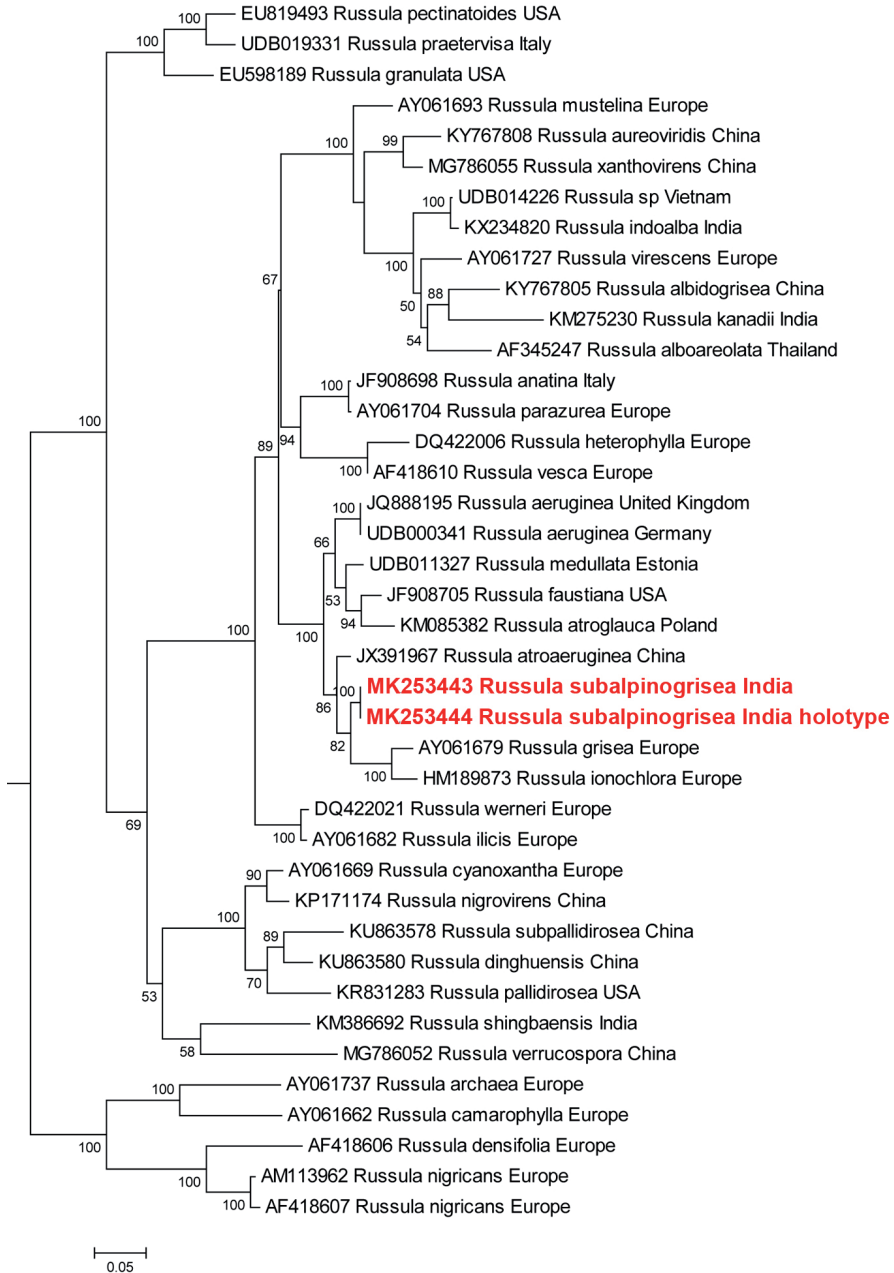


Fig. 22. Phylogram generated from Maximum Likelihood approach (ML) in raxmlGUI 1.2 (Silvestro & Michalak 2012, Stamatakis *et al.* 2008) with 1000 bootstrap replicates. One thousand bootstrap replicates were analyzed to obtain the nodal support values. Bootstrap support values (>50%) obtained from Maximum Likelihood (ML) analysis are shown above or below the branches at nodes. The Indian specimens of *Russula subalpinogrisea* having GenBank Accession Numbers MK253444 and MK253443 (nrITS-rDNA) are shown in red and bold in the tree.

presence of marginal cells in gill edge, larger basidiospores (6.16-7.56-9.45 × 5.85-7.10-8.38 μm,) with low (0.2-0.7 μm high) knob like ornamentations and occurrence under *Abies densa* in subalpine Himalaya.

*Holotype*: INDIA, Sikkim, East district, Chipsu, N 27°14.528' E 88°46.238', 3352 m asl., under *Abies densa* in subalpine mixed forest, 7 August, 2018, *Kanad Das*, KD 18-33 (CAL 1735, **holotype!**).

*Pileus* 95-130 mm diam., at first hemispherical to convex, becoming plano-convex to applanate with a broadly depressed centre with maturity; highly glutinous to sticky when moist, peeling up to 2/3 of radius in mature sample mostly vivid green to deep green (28A-E7) slightly paler, light green or pastel green (28A4-5) and darker at center rarely with mustard yellow to Naples yellow (3B6-7) patches, margin decurved to plane with maturity, faintly to strongly tuberculately striate with maturity. *Lamellae* adnexed, subdistant to rather close (5-10/cm at pileus margin) after maturity, frequently forked, yellowish white (1A2) with rusty spots, unchanging on bruising; edge entire, concolorous. *Stipe* 80-120 × 15-28 mm, cylindrical, mostly broader towards base sometimes broader towards apex, yellowish white (2A2) turning brown to dark brown (7E-F7) at base with handling. *Context* solid in stipe with maturity, chalky white (1-2A1), unchanging after bruising, turning salmon (6A4) with FeSO<sub>4</sub> and pale red (7A3) with guaiacol. *Taste* indistinct. *Odor* indistinct. *Spore print* yellowish white (1A2).

*Basidiospores* 6.16-7.56-9.45 × 5.85-7.10-8.38 μm, (n = 40, Q = 1.01-1.06-1.16), usually globose to subglobose or rarely broadly ellipsoid; ornamentation partially amyloid, 0.2-0.7 μm high, composed of somewhat knob like conic or rounded low warts, mostly connected with narrow connectors or ridges forming incomplete to nearly complete reticulum with few isolated warts; suprahilum distinct, inamyloid. *Basidia* 47-59 × 10.5-13.5 μm, subclavate to ventricose, 4-spored; mature sterigmata 3-4 × 1-1.5 μm. *Subhymenium* up to 20 μm thick, made up of pseudoparenchymatous cells. *Pleurocystidia* abundant, 67-103 × 7-11 μm, emergent 10.5-43 μm; subcylindrical, with subfusoid, capitate or rounded apices, thin-walled, content dense, fibrous. *Cheilocystidia* 50-79 × 8-10 μm, emergent 11-31 μm, obclavate to cylindrical with rounded to subfusoid apex content dense, fibrous. *Hymenophoral trama* composed of numerous sphaerocytes and connecting hyphae. *Pileipellis* up to 420 μm thick, mostly submerged under narrow to thick gluten (up to 70 μm thick beyond hyphal extremes), composed of densely interwoven pilear hyphae and pileocystidia; pilear hyphae 2.5-6.7 μm wide, frequently septate, branched, terminal cells cylindrical to subfusoid; pileocystidia towards margin 4.8-5.2 μm wide, frequent, aseptate, subclavate to subcylindrical with rounded to subcapitate to capitate apex, content dense; pileocystidia towards centre, comparatively narrow (up to 4.5 μm wide), long, multiseptate, mostly cylindrical with subcapitate apex. *Stipitipellis* 40-60 μm thick; composed of hyphae and caulocystidia, hyphae mostly repent, septate, branched and bearing caulocystidia; caulocystidia mostly repent, with dense content, sometimes erect at apex; trama composed of numerous nests of sphaerocytes and connecting hyphae. *Clamp connections* absent in all tissues.

*Specimens examined*: INDIA, Sikkim, East district, Chipsu, N 27°14.528' E 88°46.238', 3352 m asl., under *Abies densa* in subalpine mixed forest, 7 August, 2018, *Kanad Das*, KD 18-33 (CAL 1735); *ibid.*, East district, Chipsu, N 27°14.528' E 88°46.238', 3352 m asl., under *Abies densa* in subalpine mixed forest, 7 August, 2018, *Kanad Das*, KD 18-36 (CAL 1736).

*Notes*: This beautiful intensely green *Russula* with strongly viscose pileus reminds in the field some of the green species in subsect. *Cyanoxanthinae* Sing., all of which differ by their characteristic, metachromatic reaction in Cresyl blue.

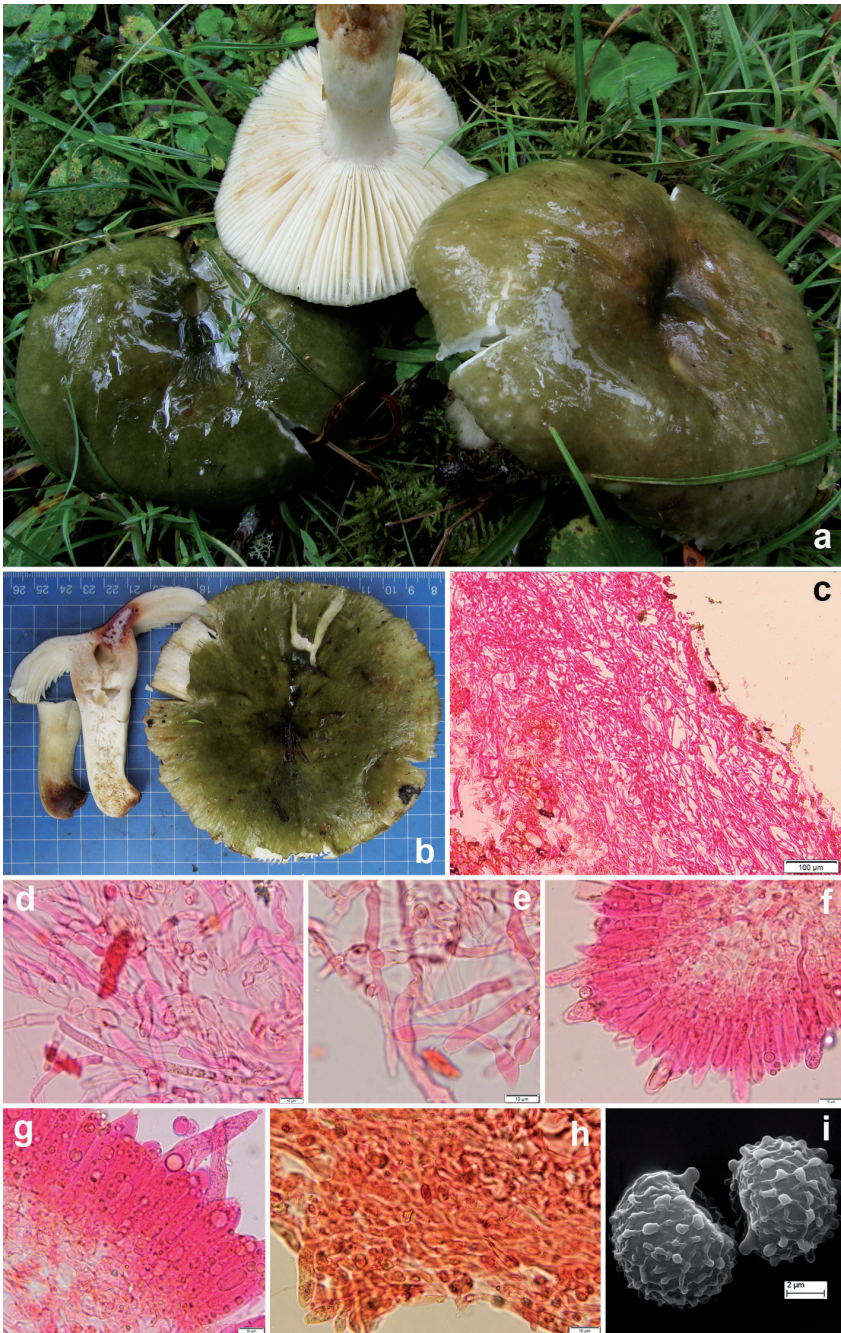


Fig. 23. *Russula subalpinogrisea* (KD 18-33). **a & b.** Fresh basidiomata in the field and basecamp. **c.** Transverse section through pileipellis. **d.** Elements of pileipellis from pileus centre. **e.** Elements of pileipellis from pileus margin. **f.** Cheilocystidia. **g.** Pleurocystidia. **h.** Transverse section through stipitipellis. **i.** Basidiospores under SEM. Scale bars: c = 100  $\mu\text{m}$ , d, e, f, g & h = 10  $\mu\text{m}$ , i = 2  $\mu\text{m}$ .

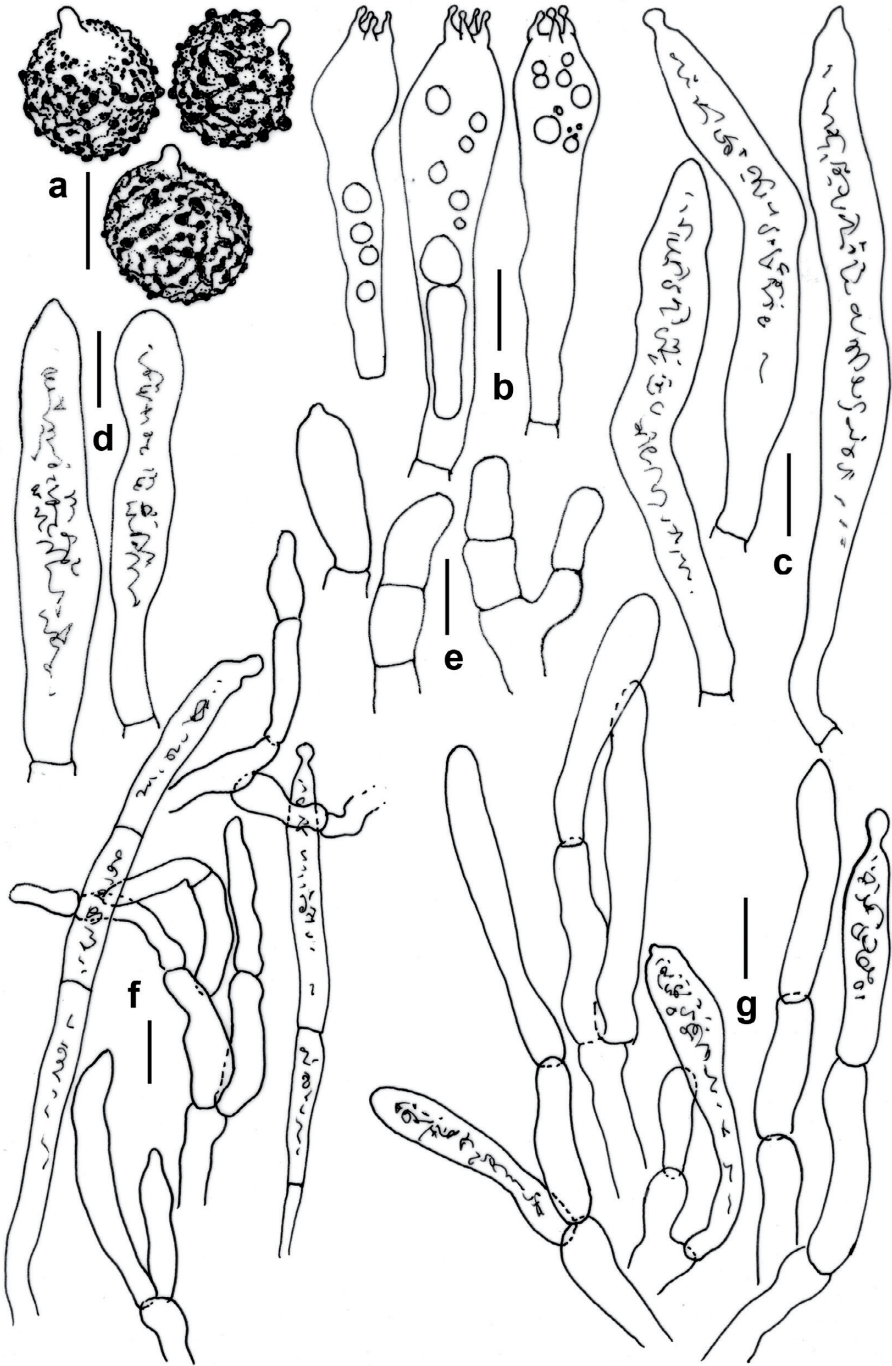


Fig. 24. *Russula subalpinogrisea* (KD 18-33), microscopic features. **a.** Basidiospores. **b.** Basidia. **c.** Pleurocystidia. **d.** Cheilocystidia. **e.** Marginal cells. **f.** Elements of pileipellis from pileus centre. **g.** Elements of pileipellis from pileus margin. Bars: a = 5  $\mu\text{m}$ ; b-g = 10  $\mu\text{m}$ .

BLAST top score results place it clearly among the frequently greenish species in subsect. *Griseinae*, such as *R. aeruginea*, *R. medullata*, or *R. atroglauca*, all of which are clearly different both genetically and morphologically in having different spore ornamentations. The highest top scores are with unidentified species from Western North America and Australia, as well as with some other Asian collections (similarity = 97% or lower).

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