
Lactarius (Russulaceae) in Kumaon Himalaya. 1. New species of subgenus *Russularia*

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Das, K., Sharma, J.R. and Montoya, L. (2004). *Lactarius (Russulaceae) in Kumaon Himalaya. 1. New species of subgenus *Russularia**. Fungal Diversity 16: 23-33.

Three new species of *Lactarius* (*L. sanjappae*, *L. mukteswaricus* and *L. verbekena*) are described based on collections made in India. Illustrations of their macro- and microscopic features and data on their ecological distribution are presented.

Key words: ectomycorrhiza, India, macrofungi, *Russulales*, taxonomy.

Introduction

Intensive explorations in deciduous, mixed and coniferous forests in different regions of Kumaon Himalaya by the authors during the last decade have revealed a rich macrofungal diversity in the region. This is related mainly to the diversity of ectotrophic hosts, substrata, and concomitant conditions of the forests and climate prevailing in the area. Taxonomic studies of Indian macrofungi have recently been in decline (Hyde, 2003) and research in this subject area is essential to biodiversity and conservation issues. There has been little systematic exploration of the mycota of India until the last 25 years (Das and Sharma, 2002). Seventy-two species of *Lactarius* including the three new taxa proposed herein are currently known from India. Most of them have been collected in North-western Himalayan forests, in fact, all the species of subgenus *Russularia* (Fr.) Kauffman (1918) known to occur in the country have been detected in this geographical region.

Materials and methods

The present study is based on periodical field work undertaken in the Nainital and Champawat districts of Kumaon Himalaya by the authors during the monsoon season (June to October) in 2002. Macroscopic characters of

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fresh specimens were studied. Microscopic study was carried out on dry samples, mounted in 5% KOH, Melzer's reagent, Lactophenol cotton blue, Congo red and Carbol fuchsin. Terminology for the microstructures in part follows Heilmann-Clausen *et al.* (1998). Colour codes are described according to Kelly and Judd (1955). For spore measurement, 20 spores per collection (n = 20) were studied and Q value (L/W ratio) was calculated considering the mean value of length and width. Line drawings of the basidiomata were made by K. Das and microscopic line drawings were prepared by K. Das and L. Montoya, with the aid of a camera lucida. Herbaria housing the cited collections are abbreviated in accordance with Holmgren *et al.* (1990). For scanning electron microscopy (SEM) preparations we followed Montoya and Bandala (2003).

Results

The study of specimens of subgenus *Russularia* collected in different associations in the subtropical to temperate deciduous forests of the Nainital and Champawat districts, revealed three undescribed species belonging to sections *Russularia* Fr., *Tabidi* Fr. and *Olentes* Bat., respectively. The three species were found in association with *Quercus leucotrichophora* A. Camus (*Fagaceae*).

Sixty-nine *Lactarius* species have previously been reported from India (Atri *et al.*, 1994; Rawla, 2002; Das and Sharma, 2002, 2003). Seven species, including the three new species proposed here, belong to subgenus *Russularia*.

Description of the species

***Lactarius sanjappae* K. Das, J.R. Sharma & Montoya, sp. nov.** (Figs. 1, 4)

Etymology: In recognition to M. Sanjappa for his contributions to plant taxonomy.

Pileus 30-50 mm diam., applanatus vel infundibuliformis, azonatus, rugosus, rufobrunneus. *Lamellae* subdecurrentes, confertae, luteae. Stipes 40-110 × 5-7 mm, cylindricus, pileo concolor. *Inodorus*. *Latex* aquosus albusque. *Sporae* 7.5-8.8 × 6.2-7.6 μm, subgloboae vel ellipsoideae, subreticulatae vel reticulatae, crestis et verrucis haud connexis instructae, amyloideae. *Pleuromacrocystidia* 48-74 × 7-10 μm, fusiformia vel oblanceolata. *Cheilomacrocystidia* 30-50 × 6-8 μm, lanceolata vel fusiformia. Pileipellis hyphoepithelium, hyphis cylindratis ascendentibus, dispersus et fasciculatisque composita; subpellis cellulis inflatis instructa. INDIA, Uttaranchal, Nainital, Mukteswar, 20 August 2002, K. Das, KD2129 (**holotypus**, BSD).

Pileus 30-50 mm diam., plane, soon becoming deeply depressed to funnel shaped, typically without an umbo or papilla; pileipellis mat, dry, azonate, radially rugose-wrinkled to venose, often pitted; veins distinct forming a broken reticulum; pale reddish-brown to pale brown, paler towards margin, veins darker, deep to dark brown; margin incurved, wavy. *Lamellae*

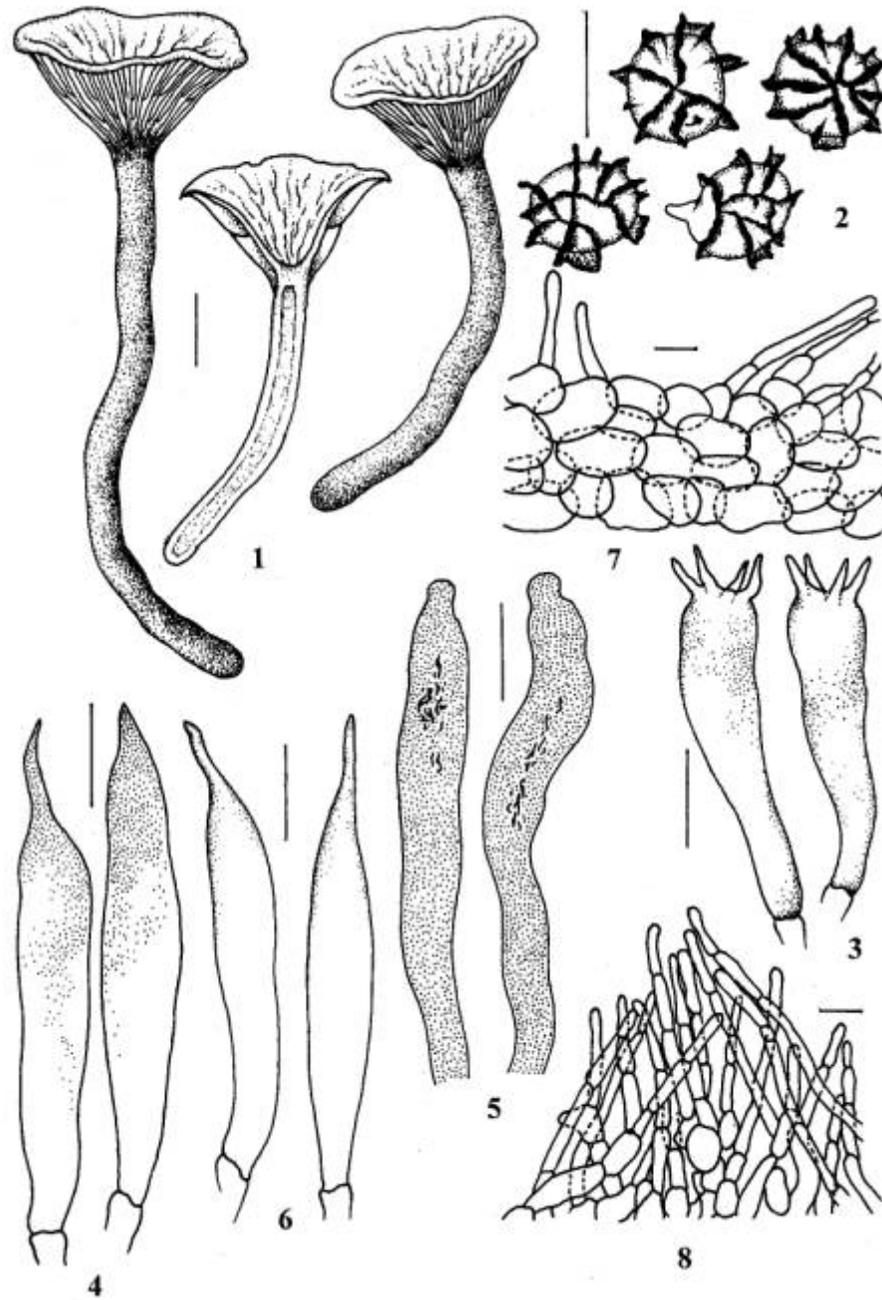


Fig. 1. *Lactarius sanjappae* (from holotype). 1. Basidiomes. 2. Basidiospores. 3. Basidia. 4. Pleuromacrocystidia. 5. Pleuropseudocystidia. 6. Cheilomacrocystidia. 7, 8. Cross-section of pileipellis. Bars: 1 = 10 mm; 2-8 = 10 μ m.

subdecurrent, close (*ca.* 6 per cm at margin), pale orange-yellow to light brown, lamellulae of different sizes. *Stipe* 40-110 × 5-7 mm, cylindric, concolorous, rather darker towards base. *Context* solid to stuffed but not hollow, medium orangish-yellow to light brown. *Latex* copious, watery to milky white, unchanging. *Odor* mild. *Spore print* not obtained. *Basidiospores* 7.5-8.8 × 6.2-7.6 μm, (Q = 1.15-1.23) broadly ellipsoid; ornamentation amyloid, 0.8-1.2 (-1.8) μm high, a partial to a complete reticulum with isolated ridges and warts, plage not distinct; under SEM reticulum is composed of continuous bands, with irregular margin, with some free extremes. *Basidia* 28-40 × 5-10 μm, subclavate to clavate, 4-spored; sterigma up to 6.5 μm long. *Pleuromacrocystidia* 48-74 × 7-10 μm, fusiform to oblanceolate, acute to rostrate, emerging 12-20 μm; contents refractive. *Pleuropseudocystidia* cylindric to subclavate, rounded at apex, up to 6 μm broad, numerous. Lamellar edges composed of basidia and cystidia. *Cheilomacrocystidia* 30-50 × 6-8 μm, lanceolate to narrowly fusiform. *Hymenophoral trama* cellular, with sphaerocytes and hyphae, laticifers up to 12 μm broad. *Pileipellis* a hyphoepithelium; subpellis a stratum up to 58 μm thick, composed of irregularly shaped, subsodiametric cells, frequently arranged in 3-6 layers, elements 15-35 × 10-20 μm; suprapellis of anticlinal, scattered, septate elements, frequently arranged in tufts (even in mature specimens), terminal cells 14-25 × 4-5 μm, thin walled.

Material examined: INDIA, Uttaranchal, Nainital, Mukteswar, 20 August 2002, K. Das, KD2129 (**holotype**, BSD); *ibid.*, Mukteswar, 22 August 2002, K. Das, KD2172 (BSD).

Ecology: *Lactarius sanjappae* is found under *Quercus leucotrichophora* in subtropical to temperate deciduous forests of Uttaranchal. *Lactarius verbekena* (see below) was also found at the type locality of the present species.

Notes: Morphologically, *Lactarius sanjappae* is characterized by the distinctly radially rugose-wrinkled pileus surface and the slender habit of its basidiomes. The pileipellis is composed of a hyphoepithelium and trichodermial tufts. This latter character is unique to this taxon among the known species of the sections *Tabidi* (Heilmann-Clausen *et al.*, 1998) and *Rhysocybella* Bon (Basso, 1999).

***Lactarius mukteswaricus* K. Das, J.R. Sharma & Montoya, sp. nov.**

(Figs. 2, 4)

Etymology: From the Mukteswar, referring to the type locality.

Pileus 30-50 mm diam., convexus dein applanatus, papilla conica instructus, rufobrunneus. *Lamellae* subdecurrentes vel decurrentes, moderate distantes, brunneoaurantiacus vel rufobrunneus. *Stipes* 30-65 × 5-8 mm, cylindricus. *Odor* in sicco condimento similis. *Latex* aquosus albus. *Sporae* in cumulo albae, 7.5-9 × 5.8-8 μm, subglobosae vel late ellipsoidae, subreticulatae vel reticulatae, verrucis haud connexis

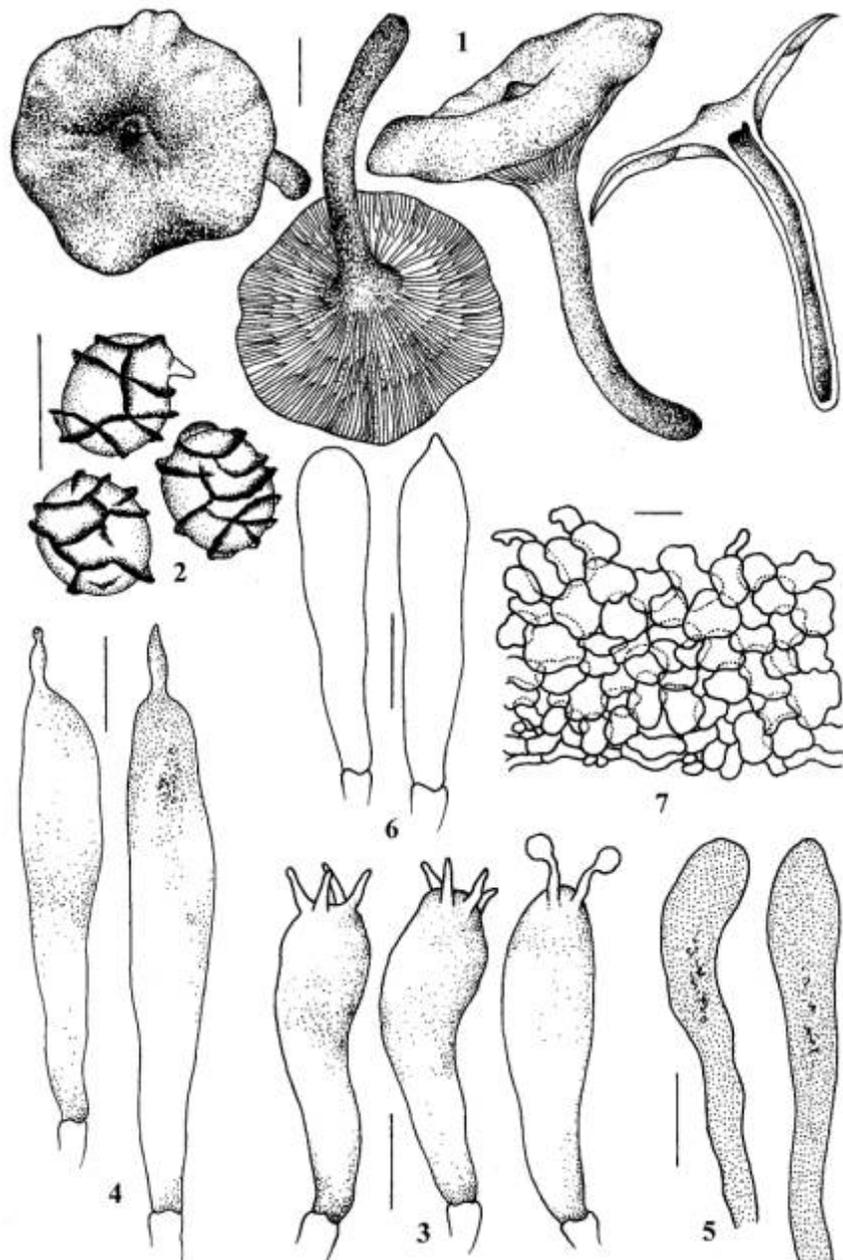


Fig. 2. *Lactarius mukteswaricus* (from holotype). **1.** Basidiomes. **2.** Basidiospores. **3.** Basidia. **4.** Pleuromacrocystidia. **5.** Pleuropseudocystidia. **6.** Cheilomacrocystidia. **7.** Cross-section of pileipellis. Bars: 1 = 10 mm; 2-7 = 10 μ m.

instructa. *Pleuromacrocystidia* 50-80 × 7-12 µm, moderate abundantia, oblongata vel fusiformia, ad apicem attenuata vel moniliformia. *Pleuropseudocystidia* subclavata vel clavata. *Cheilomacrocystidia* 30-45 × 6-8 µm, clavata vel oblanceolata. *Pileipellis* hyphoepithelium, cellulis inflato-globosis instructa; elementa suprapellis cylindrata decumbentes. INDIA, Uttaranchal, Nainital, Mukteswar, 22 August 2002, K. Das, KD2163 (**holotypus**, BSD).

Pileus 30-50 mm diam., convex to plane with an umbo, disc gradually depressed, papilla conical, persistent; surface smooth, somewhat leathery, azonate, pale reddish-brown, brownish to deep orange or pale brown, often paler towards margin; margin decurved to inrolled, often wavy. *Lamellae* subdecurrent to decurrent, close to rather subdistant (ca. 5-7 per cm at margin), lamellulae of different sizes, orangish-yellow, brownish after bruising. *Stipe* 30-65 × 5-8 mm, cylindric, concolorous to rather darker towards base, smooth. *Context* hollow, pale orange to light brown. *Latex* copious watery to milky white, unchanging. *Odor* not distinct but spicy when dry. *Spore print* whitish. *Basidiospores* 7.5-9 × 5.8-8 µm, (Q = 1.1-1.22), broadly ellipsoid; ornamentation amyloid, up to 0.6-0.8 (-1.2) µm high, reticulate or forming a partial reticulum, isolated warts present, plage not distinct; under SEM the ornamentation is composed of continuous, interconnected ridges, with some free extremes, bands with irregular lobate margin. *Basidia* 38-50 × 8-12 µm, subclavate to clavate, 2- to 4-spored with long sterigma (up to 8 µm long). *Pleuromacrocystidia* 50-80 × 7-12 µm, oblong to oblanceolate, acuminate to moniliform at the apex, somewhat emergent (up to 8 µm); with refractive contents. *Pleuropseudocystidia* subclavate to clavate, up to 8 µm broad, numerous. Lamellar edges fertile, with basidia and few cystidia. *Cheilomacrocystidia* 30-45 × 6-8 µm, clavate to fusiform, infrequent. *Subhymenial layer* up to 14 µm, cellular. *Hymenophoral trama* with sphaerocytes and hyphae, laticifers up to 10 µm broad. *Pileipellis* a hyphoepithelium, up to 70 µm wide, subpellis composed of subglobose to vesiculose cells, arranged in 5-6 layers, cells 12-22 × 8-15 µm; hyphal elements up to 5 µm broad, scarce.

Material examined: INDIA, Uttaranchal, Nainital, Mukteswar, 22 August 2002, K. Das, KD2163 (**holotype**, BSD); Mukteswar, 22 August 2002, K. Das, KD2175 (BSD).

Additional material examined: *Lactarius camphoratus*. BELGIUM, Prov. Oost-Vlaanderen, Zevegem, kasteeldomein Welden, 28 June 1997, R. Walley 1147 (pers. herb.); SPAIN, Cataluña, Monzeni Region, 28 November 1996, Montoya 3373 (XAL).

Ecology: *Lactarius mukteswaricus* grows under *Quercus leucotrichophora* in subtropical to temperate deciduous forests in the Nainital district of Uttaranchal.

Notes: The present species is distinguished by its papillate and applanate pileus, and its rather stocky habit, unchanging watery white latex, basidiomes without any particular odor when fresh, but spicy when dry. Microscopically, the presence of macrocystidia is distinctive. *Lactarius mukteswaricus* is close

to *Lactarius camphoratus* (Bull.: Fr.) Fr., but the latter has a spicy odor in fresh condition, crowded lamellae, and basidiospores having a different ornamentation pattern. The examined Belgian and Spanish specimens of *L. camphoratus* have basidiospores with isolated warts and ridges, at times connected by low bands but not forming a complete reticulum (cf. Heilmann-Clausen *et al.*, 1998; Basso, 1999)

Lactarius verbekena K. Das, J.R. Sharma & Montoya, **sp. nov.** (Figs. 3, 4)

Etymology: In recognition to A. Verbeken for her contributions to the genus *Lactarius*.

Pileus 12-65 mm diam., convexus ad infundibuliformis, brunneus, aurantiacus vel rufobrunneus. *Lamellae* emarginatae vel decurrentes, confertae, luteae. *Stipes* 22-66 × 8-13 mm, cylindricus vel subcylindricus. *Odor* condimento similis. *Latex* luteoalbus, viscidus. *Sporae* in cumulo albae, 6-7.8 × 5.8-7 µm, globosae vel subglobosae, conspicue cretulae vel subalatae. *Pleuromacrocystidia* 50-70 × 8-12 µm, rara, lanceolata vel fusiformia. *Pleuropseudocystidia* cylindrica vel subclavata. *Cheilomacrocystidia* 28-54 × 5-8 µm, oblanceolata. *Pileipellis* hyphoepithelium, elementa subpellis inflato-globosis instructa; elementa suprapellis cylindrata, decumbentes. INDIA, Uttaranchal, Nainital, Mukteswar, August 20, 2002, leg. K. Das, KD2130 (**holotypus**, BSD).

Pileus 12-65 mm diam., convex, gradually plane with depressed centre to funnel shaped, with or without an umbo, surface more or less smooth, azonate, grayish-reddish-orange, dark reddish-orange to pale reddish-brown, paler towards margin, darker towards centre, often with grayish to dark grayish-purple tinge at centre; margin incurved to inrolled when young, gradually expanding, irregularly wavy to folded when mature. *Lamellae* emarginate to decurrent, close to crowded (*ca.* 6-7 per cm at margin), lamellulae of different sizes, light to dark orange-yellow. *Stipe* 22-66 × 8-13 mm, cylindric to subcylindric, mostly concolorous to slightly darker towards base. *Context* hollow, pale orange-yellow. *Latex* yellowish-white, unchanging in colour, sticky after sometime. *Odor* strong, spicy, conserved when dried. *Spore print* yellowish white.

Basidiospores 6-7.8 × 5.8-7 µm (Q = 1-1.1), broadly ellipsoid; ornamentation amyloid, up to 1.5 µm high, composed mostly of ridges and warts, which are arranged more or less parallel and in part giving the appearance of an spiral arrangement or in spiral coils, rarely branched, plage not distinct; under SEM ridges appearing with regular margin, oriented in bands irregularly encircling basidiospore, interrupted warts also present. *Basidia* 27-38 × 7-10 µm, subclavate, mostly 4-spored; sterigma up to 6.4 µm long. *Pleuromacrocystidia* 50-70 × 8-12 µm, infrequent, lanceolate to narrowly fusiform, acuminate to rostrate at apex, emerging up to 25 µm, at times with refringent contents. *Pleuropseudocystidia* cylindric to subclavate with subacute, mucronate or rounded apex, up to 7 µm broad, common. Lamellar edges with basidia and few cystidia. *Cheilomacrocystidia* 28-54 × 5-8 µm,

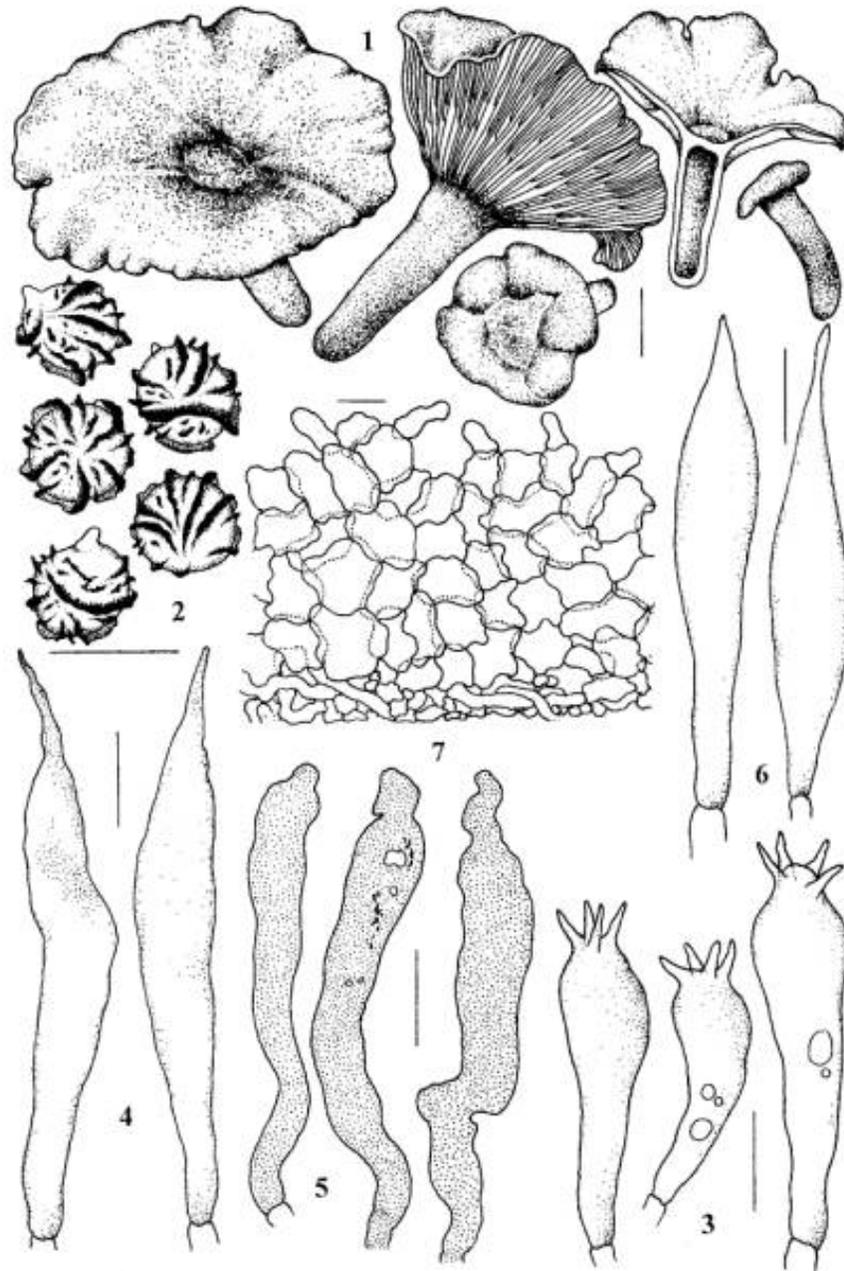


Fig. 3. *Lactarius verbekenaе* (from holotype). **1.** Basidiomes. **2.** Basidiospores. **3.** Basidia. **4.** Pleuromacrocystidia. **5.** Pleuropseudocystidia. **6.** Cheilomacrocystidia. **7.** Cross-section of pileipellis. Bars: 1 = 10 mm; 2-7 = 10 μ m.

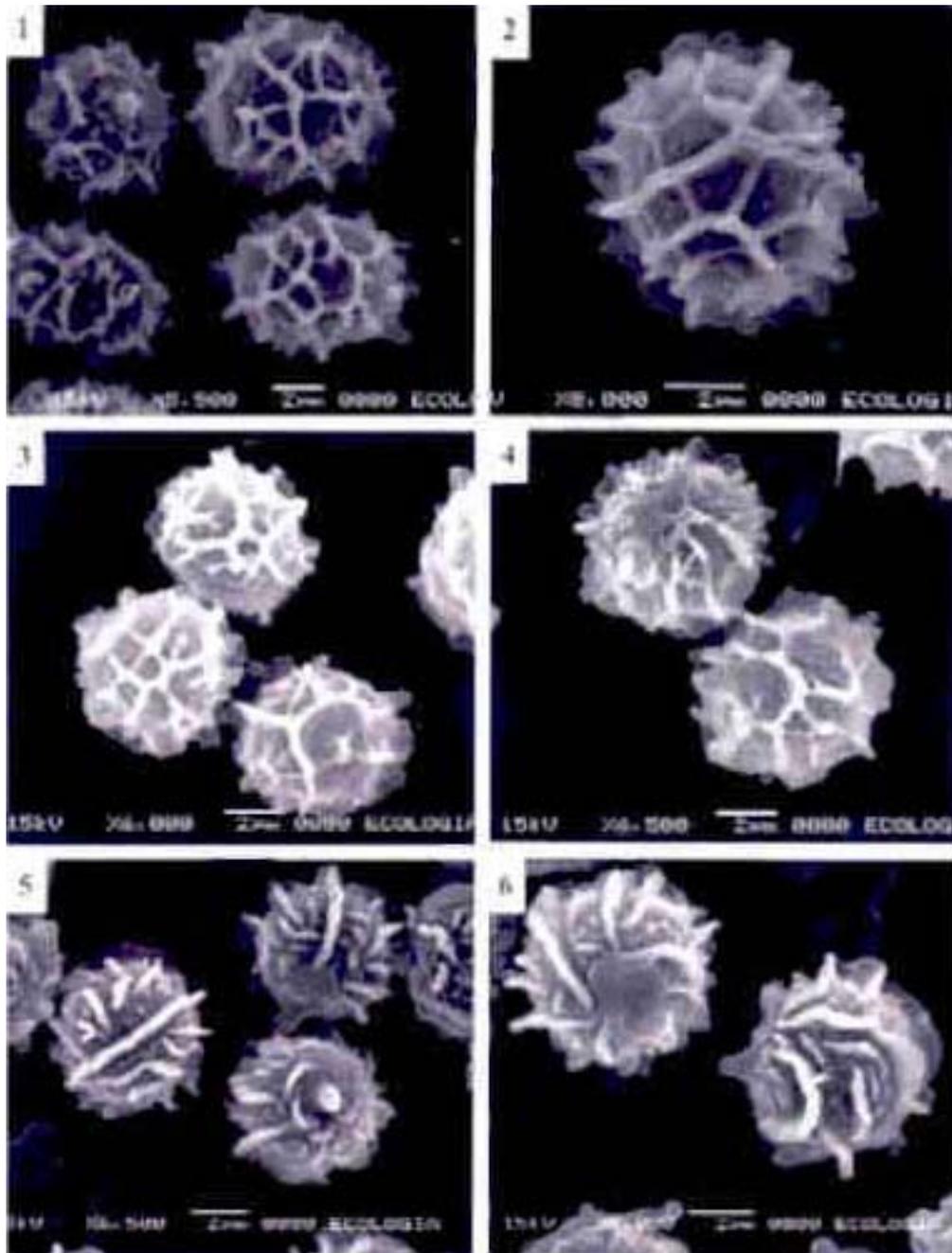


Fig. 4. Scanning Electrón Micrographs of basidiospores. **1, 2.** *Lactarius sanjappae* (from holotype). **3, 4.** *Lactarius mukteswaricus* (from holotype). **5, 6.** *Lactarius verbekenaе* (from holotype).

oblanceolate to fusiform. *Subhymenial layer* up to 20 μm , cellular. *Hymenophoral trama* cellular, composed of sphaerocytes and hyphae, laticifers scarce. *Pileipellis* almost a hyphoepithelium, up to 70 μm wide, subpellis composed of vesiculose to irregularly shaped cells, up to 6 layered; cells 10-28 \times 8-18 μm ; suprapellis elements 10-63 \times 4-9 μm .

Material examined: INDIA, Uttaranchal, Nainital, Mukteswar, 20 August 20 2002, K. Das, KD2130 (**holotype**, BSD); Uttaranchal, Champawat, Lohaghat, 22 September 2002, K. Das & J.R. Sharma, KD4523 (BSD).

Additional material examined: *Lactarius fragilis* (Burl.) Hesler & A.H. Sm. USA, North Carolina, Pink Beds, Burlingham 33 (holotype, NY).

Ecology: *Lactarius verbekena* is found under *Quercus leucotrichophora* in subtropical to temperate deciduous forests in the Champawat and Nainital districts of Uttaranchal. *Lactarius sanjappae* described above was also observed in close association to the present species.

Notes: *Lactarius verbekena* is distinguished by its white to yellowish latex that becomes typically sticky after exposure, its spicy odor, basidiospores with cristulate ornamentation pattern (of the so-called “zebroid type”) and the presence of pleuromacrocystidia. Macroscopically it resembles *Lactarius fragilis* (Burl.) Hesler & A.H. Sm. (var. *fragilis*), but the latter differs from the present Himalayan species by its smaller basidiomes, maize yellow lamellae, watery non-sticky latex and the reticulate ornamentation of the basidiospores.

Discussion

The anatomy of the pileipellis is one of the main taxonomic features that supports the infrageneric classification at the subgeneric level in *Lactarius* (Neuhoff, 1956; Hesler and Smith, 1979; Bon, 1980, 1983; Verbeken, 1998; Basso, 1999). A complete historical account of the taxonomy of the group was published by Basso (1999). Of the 69 taxa of *Lactarius* reported from India, 6 species are considered to belong to subgenus *Russularia* (Atri *et al.*, 1994; Das and Sharma, 2002, 2003; Rawla, 2002). Two of those, *Lactarius rufus* and *L. pallidus*, rather are interpreted in members of subgen. *Piperites* instead of *Russularia* as treated by Hesler and Smith (1979).

Currently, the citations found in the literature of *Lactarius aurantiacus* (Pers.: Fr.) Gray, *L. camphoratus* (Bull.: Fr.) Fr., *L. subdulcis* (Pers.: Fr.) Gray and *L. serifluus* (DC: Fr.) Fr., as well as the three species here proposed are considered to represent the subgenus *Russularia*, sections *Russularia* Fr., *Tabidi* Fr. and *Olentes* Bat. in India. However, further documentation regarding the cited species in the literature is being processed in order to confirm their distribution in this country.

Acknowledgements

The authors are thankful to the Director of the Botanical Survey of India, Kolkata and Joint Director, Northern Circle, Dehradun, India for providing facilities during the exploration and study. Thanks are also given to E. Horak, Geobotanical Institute (Zurich, Switzerland) and V.M. Bandala, Instituto de Ecología (Xalapa, Mexico) for critically reviewing the manuscript. Financial support to one of the authors (KD) was provided by the Botanical Survey of India. Thanks are expressed to B. Thiers (NY), R. Walley and A. Verbeken (GENT) for the loan of specimens.

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(Received 27 October 2003; accepted 1 March 2004)