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Three new species in genus Cortinarius (Basidiomycota, Agaricales) from mixed broadleaf forests, India

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Abstract

The genus *Cortinarius* (Pers.) Gray is one of the dominating mushroom-forming ectomycorrhizal genera in the Indian Himalaya. In present communication, three novel species, namely *Cortinarius umbrinatus* sp. nov. (under *C.* section *Reideri* (Brandrud & Melot) Brandrud, Dima, Niskanen & Liimat. and *C. subochraceus* sp. nov. and *C. roseolamellosus* sp. nov. (under *C.* section *Anomali* Konrad & Maubl. collected from the state of Uttarakhand are presented here with morphological descriptions, illustrations and nrITS-based molecular phylogenetic inferences.

Introduction

The genus *Cortinarius* (Pers.) Gray, based on *Cortinarius violaceus* (L.) Gray, is the largest group in the order Agaricales and is globally distributed (Clements & Shear 1931; Garnica et al. 2016; Varga et al. 2019). A key identifying feature is a temporary veil, or cortina, that initially covers the gills and later disappears as the fruiting body matures (Stensrud et al., 2014). The genus is highly diverse in appearance, with significant variation in the size, shape, and color of the fruiting bodies, gills, and spores (Peintner et al. 2004; Frøslev et al. 2007; Niskanen et al. 2009, 2013; Liimatainen et al. 2014, 2015; Niskanen et al. 2016). Species of *Cortinarius* are typically found in temperate and subtropical forests and form mycorrhizal associations with ectomycorrhizal trees belonging to families like Cistaceae, Fagaceae, Malvaceae, Nothofagaceae, Pinaceae, and Salicaceae (Singer 1986; Frøslev et al. 2007; Soop et al. 2018). The number of recognized species in the genus has increased with the development of molecular and taxonomic methods.

Due to its high morphological diversity, the internal classification of *Cortinarius* into subgenera and sections has been challenging (Peintner et al. 2004). Different taxonomists have proposed multiple subgroups based on morphological traits, leading to inconsistencies, which suggest that morphology alone is not sufficient for accurate classification (Garnica et al. 2005, 2009). Recent molecular phylogenetic studies have significantly contributed to clarifying the taxonomy of the genus (Peintner et al. 2003; Suarez-Santiago et al. 2009; Dima et al. 2016, 2021).

Section *Riederi* is introduced as a distinct lineage within *Cortinarius*, previously referred to as subsection *Riederi* by Brandrud & Melot. This group exhibits complex and overlapping morphological features, making traditional taxonomy difficult without molecular data. Species in this section show similarities to the *Phlegmacium* group but form a separate phylogenetic branch. The section is newly defined based on species with a fibrillose cap ranging from ochraceous red-brown to whitish, bright violet-blue gills in early stages, and a stipe that is bulbous or slightly marginate. Spores are large and ellipsoid-subamygdaloid, distinct from the more pointed spores typical of phlegmacioid species (Brandrud et al. 2018).

The section *Anomali* (Konrad & Maubl.), based on *Cortinarius anomalus* (Fr.) Fr., includes a large number of species. It is typically characterized by telamonioid or sericeocyboid features, yellowish to brownish veil remnants on the stipe, bluish young gills, and ornamented spores that are subglobose to broadly ellipsoid (Dima et al. 2016, 2021). Initially placed in the subgenus *Telamonia* by Brandrud et al. (1989),

later studies revealed that *Anomali* does not belong to *Telamonia* sensu stricto (Høiland & Holst-Jensen 2000; Peintner et al. 2004; Garnica et al. 2005; Niskanen et al. 2009). The addition and reclassification of species into *Anomali* have led to taxonomic confusion, and a clear consensus on its composition is still lacking (Bidaud et al. 1992, 1994; Consiglio et al. 2006, 2012; Dima et al. 2016). Some phylogenetic studies suggest that *Anomali* represents a monophyletic group within *Cortinarius* that doesn't align with any traditional subgenus (Dima et al. 2016, 2021). While *Anomali* has been extensively studied in Europe and North America, it remains poorly explored in regions like Asia and Africa (Kauffman 1905; Murrill 1945; Dima et al. 2016; Ammirati et al. 2017).

During a macrofungal survey in Chamoli District, Uttarakhand, several *Cortinarius* specimens were collected. Detailed morphological and microscopic examinations identified three potentially new species belonging to sections *Anomali* and *Riederi*. Two of these are proposed as novel species within section *Riederi*, while the third belongs to section *Anomali*. Morphological descriptions and molecular phylogenetic analysis using nrITS sequences support their classification as distinct taxa.

Materials & Methods

Morphological study

A macrofungal exploration was conducted in Chamoli District, Uttarakhand, during the monsoon months of July and August 2024. During this survey, basidiomata at various developmental stages, belonging to the family Cortinariaceae, were collected. Fresh basidiomata were examined for macroscopic features in the field, and photographs were taken both onsite and at the basecamp using Nikon. The coloration of fresh specimens was recorded based on the Methuen Handbook of Colour (Kornerup & Wanscher 1978). Collected samples were dehydrated using an aluminum field dryer. All examined specimens were deposited in the and the Herbarium of Jammu University (HBJU). Microscopic analysis was performed using hand-cut sections from dried samples. Sections were primarily mounted in 5% potassium hydroxide (KOH) and 1% Phloxine, with additional staining done using a mixture of 1% Phloxine and 1% ammoniacal Congo red when required. Basidiospores (sample size: 60/2/3) were examined in Melzer's reagent and measured in side view, excluding surface ornamentation. Spore dimensions and Q-values (length/width ratios) are presented as minimum–mean–maximum values. Sterigmata were not included in basidium measurements. Illustrations of microscopic structures were created using a drawing tube attached to an Olympus BX-43 light microscope at 1000× magnification. Measurements were recorded using CellSens Standard software. Microphotographs were taken with an Olympus DP-22 camera mounted on the same microscope. Additionally, basidiospores were studied using a Scanning Electron Microscope (SEM). For this, dry spores from the gills were mounted on adhesive tape fixed to a metallic stub, gold-coated, and scanned at various magnifications under high vacuum (30 kV) to examine ornamentation patterns. SEM analysis was conducted using JSM 7900F, JEOL model SEM at IIT-Jammu.

DNA extraction, PCR amplification, and sequencing

A fungal genomic DNA Mini Kit was used to isolate nuclear genomic DNA from 100mg of dried fruit bodies. The nuclear ribosomal DNA gene's ITS region was amplified using primer pairs ITS1 and ITS4 (White et al. 1990; Gardes and Bruns 1993). PCR amplification reactions were performed in a 20µl reaction volume containing 1X Phire PCR buffer, 0.2 mMdNTPs, 1 µl DNA, 0.2 µl PhireHotstar II DNA polymerase enzyme, 0.1 mg/ml BSA, and 3% DMSO, 0.5M Betaine, and 5 pM forward and reverse primers. PCR amplification was performed in a PCR thermal cycler (Applied Biosystems, Gene Amp PCR System 9700) programmed for 2 minutes at 96 C, followed by 30 cycles of 30 seconds at 96 C, 40 seconds at 50 C and a final stage of 4 minutes at 60 C. PCR products were purified using the QIAquick Gel Extraction Kit (QIAGEN, Germany) and then Sanger sequenced in an automated DNA sequencer (AB13730xl DNA Analyzer, Applied Biosystems, USA) with the same primers used for amplification. The consensus sequences were generated by using geneious prime and bioedit. All generated ITS sequences were deposited in GenBank and accession numbers were procured.

Phylogenetic analysis

Phylogenetic analyses were performed on an nrITS dataset comprising newly generated sequences together with sequences obtained from nBLAST searches of GenBank (http://www.ncbi.nlm.nih.gov/) and from relevant published studies (Brandrud et al. 2018; Liimatainen et al. 2020; Zhang et al. 2023; Forejt and Vasutova 2025; Jia et al. 2025; Xie et al. 2025; Liu et al. 2026). Two separate trees were constructed: the first, comprising approximately 93 sequences, was rooted with *Hebeloma mesophaeum* (Pers.) Quél. (KT071031) and *Hebeloma sinapizans* (Paulet) Gillet (JQ751191) as outgroups, while the second, comprising 95 sequences, was rooted with *Cortinarius bolaris* (Pers.) Zaw. (KJ705110 & KX302233) as the outgroup. Sequences were aligned using MAFFT v. 7 (Katoh and Standley 2013), and the resulting alignment was manually inspected and trimmed in BioEdit v. 7.0.9 (Hall 1999). Maximum likelihood (ML) analysis was carried out in IQ-TREE v. 2.2.2.6 (Nguyen et al. 2015) under the best-fit model (HKY + F+I+R2), as selected by ModelFinder based on the Bayesian information criterion (BIC) (Kalyaanamoorthy et al. 2017). Nodal support was assessed using ultrafast bootstrapping with 1000 replicates, and bootstrap values (> 70%) are displayed above or below the branches in the resulting trees (Figs. 1 and 2).

Results

Phylogenetic Inferences

Phylogenetic relationships inferred from Maximum Likelihood (ML) analysis of the nuclear ribosomal internal transcribed spacer (nrITS) dataset are presented in Figs. 1 and 2. The analyses resolved our collections into three distinct, strongly supported lineages, two within *Cortinarius* sect. *Anomali* (ML bootstrap support = 100%) and one within *Cortinarius* sect. *Riederi* (ML bootstrap support = 100%).

Within sect. *Anomali*, sequences of *Cortinarius subochraceus* sp. nov. (GenBank accessions PX048673 & PX048672) formed a well-supported monophyletic lineage sister to *C. lepidopus* Cooke (MZ663794, OQ913383 & OQ913382). This clade was further allied with *C. modestus* Peck (MN751565, MZ580446, MZ580447, MN751564 & MN751561), indicating close phylogenetic affinity while remaining genetically distinct from both taxa. *Cortinarius roseolamellosus* sp. nov. (PX048674 & PX048675), also placed within sect. *Anomalli*, was recovered as an independent, well-supported lineage clearly separated from all currently recognized species in the section, including its morphologically similar relative *C. perviolaceus* Murrill (MZ580438 & KU878589). The distinct phylogenetic placement of both taxa, corroborated by their unique morphological characters, supports their recognition as novel species.

The third taxon, *Cortinarius umbrinatus* (PX048662 & PX048663), belonging to sect. *Riederi*, formed a clade distinct from the closely related species *C. infractus* (Pers.) Fr. (NR130225, OM970971, KF732325 & KJ421192), *C. infractipallidus* Bojantchev & Ammirati (NR202412), and *C. infractiflavus* Kytöv, Niskanen, Liimat, Bojantchev & Ammirati (MN751326, KF735327 & FJ039612). Collectively, the molecular phylogenetic results are consistent with, and corroborate, the taxonomic conclusions derived from morphological analysis, supporting the recognition of *C. subochraceus, C. roseolamellosus*, and *C. umbrinatus* as three species new to science.

Taxonomy

Reideri section

Cortinarius umbrinatus Choudhary, Uniyal & Y.P. Sharma sp. nov.

MycoBank No.

MB 860281

GenBank No.

nrITS (PX048662, PX048663)

Diagnosis

Proposed species differs from closely allied species by the characteristics of earthy brown pileus with a prominent dark brown umbo, lamellae deep violaceous blue and showing clear dichotomy at the margins and brittle in nature easily torned, stipe developing glossy brass brown patches and large basidiospores (7.25–9.0 × 5.6–7.0 µm) with verrucose ornamentation of deep grooves.

Etymology

The specific epithet “umbrinatus” refers to earthy brown colouration of the pileus.

Typification

INDIA, Uttarakhand, District Chamoli, Gopeshwar, Mandal 30°27'29.52"N 79°17'36.11"E elev. 2014 m 28 August 2024, *Shikha Choudhary, Priyanka Uniyal* & *Yash Pal Sharma* SC/PU/24/13 Holotype **(HBJU 191).**

Description:

Basidiocarps fleshy and phlegmacioid. Pileus glabrous 22–38 mm and viscid-glutinous, more or less innately fibrillose, earthy brown (5A3–5A4) pileus, slight umbonate, dark brown (5C5), margins striated, pale brown (5B2). Lamellae usually deep violaceous blue when young, brittle, hard, soon fading to violaceous brown (13E5–13F6), decurrent, crowded, anastomised, dichotomous at the margins, slightly dark violet (13E7) at the margin, lamellulae present in regular interval. Stipe 50–105 mm apex 8 – 15 mm in diam., and base 14 – 24 mm in diam.with a clavate-bulbous base, glossy, initially usually deep violet (F136) in upper part, soon fading to pale brown (5B3), often developing glossy brass brown (5D8) patches, presence of white (1A1) cottony basal mycelium. Universal veil very sparse and hardly visible on most species. Context fugacious violet (15D3).

Basidiospores [60/2/3] (6.9–) 7.25–**7.77–**8.29 (–9.0) × (5.6–) 6.09–**6.38**–6.66 (–7.0) µm, Q = 1.07–1.44 µm, av. Q = 1.22 µm, ellipsoid to subamygdaloid, densely verrucose (with discrete warts), where warts are high up to 2 µm leading to deep grooves forming incomplete reticulation type of verrucose, sometimes with an apical 'lense' of confluent warts. Basidia 27.1–38.1 × 7.6–10 µm, abundant, cylindrical to clavate, sterigmata up to 6.3 µm long, Basidioles 25.4–35.5 × 8.2–10.1 µm. Lamellar edge more or less fertile, edge consists of terminal cells 27.1–33.5 × 4.6–5.8 µm. Pileipellis duplex, composed of thin, gelatinised epicutis and subcellular subcutis/ hypodermium with brown parietal-encrusting pigment, hyphae 2.5–7 µm wide.

Habit and Habitat

Terrestrial, scattered under mixed forest of *Quercus leucotrichophora* A. Camus and *Rhododendron arboreum* Sm.

Specimens examined

INDIA, Uttarakhand, District Chamoli, Joshimath 30°33'02.73"N 79°33'23.97"E elev. 2150 m 30 August 2024, *Shikha Choudhary, Priyanka Uniyal* & *Yash Pal Sharma* SC/PU/24/14.

Notes

Morphologically, *C. umbrinatus* resembles to *C. infractus* and *C. infractipallidus* its lamellae colouration and association in broadleaf broad, however, *C. infractus* can be differentiated from *C. umbrinatus* through several distinguishing features, including notably larger basidiomata that may reach up to 100 mm in diameter, involuted margins, an easily detachable cuticle, olive greyish-brown lamellae with serrate edges, and basidiospores measuring 6.05–8.8 × 5–7 µm (Liimatainen et al. 2014). *C. infractiflavus* is set apart by its yellowish pileus, comparatively paler gills, larger spores ranging from

7.5–9.1 × 6.3–7.0 µm, and its habitat preference for boreal and mountainous coniferous forests (Liimatainen et al. 2014). *C. infractipallidus* Bojantchev & Ammirati, on the other hand, is characterized by relatively larger basidiomata reaching up to 100 mm in diameter that become uplifted and undulating with maturity, a beige pileus with orange-brown tints at the disk, the presence of a whitish universal veil, and distinctly verrucose basidiospores measuring 5.6–8.2 × 5–6.1 µm (Index Fungorum no. 571). Among other phyloegentically closely related species, *C. calcofractus* Liimat. & Niskanen is distinguishable by its olivaceous, medium-sized pileus of up to 35 mm in diameter, a medium-length stipe reaching up to 50 mm, comparatively broader basidiospores of 7.5–8.5 × 6.5–7.0 µm, and its preference for calcareous substrates (Index Fungorum no. 528). Finally, *C. mariandrus* Liimat. & Niskanen is identified by a larger pileus measuring up to 60 mm in diameter, moderately spaced lamellae, a dark olivaceous-brown coloration, and subglobose to broadly obovoid basidiospores ranging from 7.5–8.5 × 5.5–6.5 µm (Index Fungorum no. 528).

Anomali section

Cortinarius subochraceus Choudhary, Uniyal & Y.P. Sharma sp. nov.

MycoBank No.

MB 860282

GenBank No.

nrITS (PX048673, PX048672)

Diagnosis

This species is characterized by its small basidiomata, soft ochraceous to more ochraceous at maturity enclosed by proper white cortina, cuticle peeling off, with grayish violet lamellae, broadly ellipsoidal basidiospores, it is clustered and gregarious on ground dominant with *Fagaceae*.

Etymology

The specific epithet “subochraceus” refers to soft ochraceous tones of the pileus.

Typification

INDIA, Uttarakhand, District Chamoli, Gopeshwar, Mandal 30°29'35.52"N 79°19'32.11"E elev. 2200 m 28 August 2024, *Shikha Choudhary, Priyanka Uniyal* & *Yash Pal Sharma* SC/PU/24/15 Holotype **(HBJU 190).**

Description

Larged basidiomata. Pileus 15 – 45 mm in diam., hemispheric when young, then convex to plano-convex, some with a low umbo, margin narrowly when young, surface smooth to finely felty, soft ochraceous (3B3), the disc slightly more orchraceous (3B4), with umbo slight dark pale yellow(3B6), whitish (1A1 –

1B1) toward margin, even to wavy, hygrophanous, proper white to cream (1A2–1B2) coloured cortina present ended at the stipe and on the stipe the cortina is more on pale yellow (3B3), with peeling off cuticle. Lamellae adnate with decurrent tooth to slightly adnexed, upto 3 mm wide, close, violet (16A4 – 16A5) when young, then grayish violet (13D4–13E4), margins wavy, lamellulae present in 2–3 tiers. Stipe 25 – 120 mm long, apex 5 – 10 mm in diam., and base 12 – 18 mm in diam., usually cylindrical, narrow at apex, slightly bulbous at base, fragile, shiny, covered with pale white (1A2–1B2) longitudinal fibrillose, hollow, inner context concolourous with lamellae, basal mycelium white (1A1). Context in pileus solid, firm, sometimes hollow in stipe, silver violet (16B4 – 16C5).

Basidiospores [60/2/3] (5.5–) 6.4–**6.93–**7.47 (–8.0) × (4.3–) 4.98–**5.45**–5.92 (–6.5) µm, Q = 1.14–**1.28**–1.63 µm, av. Q = 1.28 µm, non-dextrinoid, subglobose to broadly ellipsoid, buff to cinnamon-buff, coarsely verrucose. Basidia 4-spored, 29 – 37 × 6.5 – 8.5 µm, cylindrical to clavate, yellowish, tetrasterigmate with sterigmata up to 4 µm long. Lamella trama hyphae thin-walled, smooth, parallel, 3.5–7 µm wide. Lamellae edge fertile, with some small clavate sterile cells, generally considered as marginal cells. Pileipellis of two layers; epicutis thin to well developed, hyphae cylindrical, moderately to strongly interwoven, 5.2–13.2 µm wide, hyaline or yellowish, smooth to encrusted; hypocutis more interwoven hyphae with irregular arrangement, cylindrical to enlarged, hyaline to yellowish, smooth to encrusted, 4–8.5 µm wide. Clamp connections present at the base.

Habit and Habitat

Terrestrial, gregarious under mixed forest of *Quercus leucotrichophora* A. Camus and *Quercus semecarpifolia* Sm.

Specimens examined

INDIA, Uttarakhand, District Chamoli, Joshimath 30°33'26.73"N 79°35'23.84"E elev. 2230 m 30 August 2024, *Shikha Choudhary, Priyanka Uniyal* & *Yash Pal Sharma* SC/PU/24/16 Paratype.

Notes

C. subochraceus is both morphologically and phylogenetically closest to *C. lepidopus* and *C. modestus*. However, *C. lepidopus* differs by its medium-sized (75 mm diam.) basidiomata, surface with white fibrillose to slightly wrinkled, lamellae adnexed to emarginated, crowded and violet when young, stipe with bluish tinges, universal veil of yellow colour forming ring at the middle of the stipe. *C. modestus* is differentiated by its medium sized (70 mm diam.) basidiomata, with minute patches on the pileus, light brown to pale brown in colour with white veil fibrils on outer margins, lamellae adnexed, close, light brown to cinnamon at maturity, edges pale, stipe overall white with pale violaceous tint. Another closely related species *C. deceptivus* Kauffman differs from new proposed species by the suborbicular to hemispherical (70 mm diam.) pileus, grayish blue to fawn coloured with lavender ting, brownish distinct fibrillose patched on the surface, becoming rugulose in age, lamellae thick, crowded to adnate, lavender to turning pale brown, stipe flexuous with a slight enlarge base covered by the yellowish fibrillose veil,

eventually with brownish scales. Another species *C. anomalovelatus* Ammirati, Berbee, E. Harrower, Liimat. & Niskanen segregated by the small-sized basidiomata with rounded conic to hemispheric then obtuse to plane, margins decurved, fibrillose tomentose or scaly from a silvery to whitish buff veil, lamellae adnexed, grayish blue, becoming cinnamon buff at maturity, stipe lilac violet to turning brownish, veil leaving heavy white to creamy buff floccose zones on the surface (Dima et al. 2021).

Cortinarius roseolamellosus Choudhary, Uniyal & Y.P. Sharma sp. nov.

MycoBank No.

MB 860280

GenBank No.

nrITS (PX048674, PX048675)

Diagnosis

This species notably has small to medium-sized basidiomata, with ochraceous pale pileus, buff brown and plano-convex, characteristic pinkish lamellae with fibrillose stipe and larger basidiospores (8.9–12.3 × 6.4–8.7µm), it is solitary on ground under *Rhododendron arboreum* in temperate forest.

Etymology

The specific epithet “roseolamellosus” refers to pinkish gills of the basidiomata.

Typification

INDIA, Uttarakhand, District Chamoli, Dewal, Aaijan Top 30°06'42.60"N 79°37'22.83"E elev. 2369 m 09 September 2024, *Shikha Choudhary, Priyanka Uniyal* & *Yash Pal Sharma* SC/PU/24/55 Holotype **(HBJU 187).**

Description

Larged basidiomata. Pileus 25–45 mm in diam., hemispheric when young, then convex to plano-convex, some slightly umbonate, margin narrowly when young, surface smooth to finely felty, pale buff brown (3B2–3B3), more ochraceous pale pileus (4A3–4A4), pale gray to off white (1A1 – 1B1) toward margin, even, hygrophanous. Lamellae adnate, close, rose pinkish (16A4 – 16A5) when young, then dark violet pink (16B4 – 16C5), Stipe 63–85 mm long, apex 4 – 6 mm in diam., and base 10 – 16 mm in diam., usually cylindrical, slightly bulbous at base, fragile, shiny, covered with white longitudinal fibrillose, apex same as lamellae (16A4 – 16A5)) when young, later light brown (4B3), basal mycelium white (1A1). Context in pileus solid, firm, stuffed in stipe, silver gray [16B4 – 16C5] when fresh, finally light pale (1A3) in age.

Basidiospores [60/2/3] (8.9–) 9.72–**10.5–**11.1 (–12.3) × (6.4–) 7.3–**7.9**–8.3 (–8.7) µm, Q = 1.13–1.56 µm, av. Q = 1.33 µm, subglobose to broadly ellipsoid, brown pigmented, coarsely verrucose, non-dextrinoid. Basidia 4-spored, 35.5–44.5 × 9.1–11.9 µm, clavate, slight yellowish, sterigmata upto 5.8 µm long. Lamella trama hyphae smooth, parallel, 4.9–12.7 µm wide. Lamellae edge fertile, with some small clavate sterile cells. Pileipellis of two types; epicutis thin walled, hyphae cylindrical, moderately to strongly interwoven, 5.3–8.9 µm wide, hyaline or yellowish, smooth to encrusted; hypocutis cellular or hyphae more interwoven and radially arranged, cylindrical to enlarged cells, hyaline to yellowish, smooth to encrusted, 4.5–16.2 µm wide. Clamp connections present throughout the tissue.

Habit and Habitat

Terrestrial, Solitary under *Rhododendron arboreum* Sm. Forest.

Specimens examined

INDIA, Uttarakhand, District Chamoli, Dewal, Konkhora 30°06'56.92"N 79°37'20.85"E elev. 2385 m 11 September 2024, *Shikha Choudhary, Priyanka Uniyal* & *Yash Pal Sharma* SC/PU/24/56 Paratype.

Notes

Morphologically, the present species shows close resemblance with *C. albidipes* Peck and *C. kranabetteri* Niskanen, Liimat., Harrower, Ammirati & Dima. The newly described *Cortinarius roseolamellosus* can be distinguished from *C. albidipes* by its obtuse to subumbonate pileus, pale grey to buff vinaceous-brown in colour, and by lamellae with a decurrent tooth, pale violet to blue, accompanied by a distinct pale orange veil. In contrast, *C. kranabetteri* bears a yellowish-grey to pale brownish-grey pileus, pale to cinnamon-brown lamellae, a bluish stipe apex, and a veil forming girdles and patches on the stipe; it also has smaller basidiospores (6.5–7.5 × 6–6.5 µm) and shorter basidia (24–27 × 8–9 µm) (Dima et al. 2021). Similarly, *C. perrotensis* André Paul, Matheny & Lebeu differs in having a pale greyish-brown pileus, pale brown lamellae, a white veil, smaller basidiospores (6.5–8.5 × 5.5–7.0 µm), and its occurrence in broadleaf–conifer forests (Dima et al. 2021). Another related species, *C. huddartensis* Bojantchev, Liimat., Niskanen, Ammirati & Dima, is recognised by its pale lavender to pale pinkish pileus, lavender to pale tan lamellae, and a white veil (Dima et al., 2021). Another related species *C. ochraceodiscus* D.J. McLaughlin & Ammirati differs by medium-sized basidiomata, pileus transitions from light grayish-yellow brown to yellowish brown upon maturity, lamellae are light yellowish to light yellowish brown, stipe ranges from white to very pale orange-yellow, and the veil exhibits a faint yellowish hue, basidiospores measure an average of 9 × 6 µm, with a predominantly ellipsoid morphology with moderately to coarsely verrucose ornamentation (Dima et al. 2021). One more species *C. perviolaceus* Murrill differs by its small-sized basidiomata, shiny silvery sheen in places, minutely fibrillose scales, lamellae close, gray violet turning brown at maturity, relatively smaller basidiospores (6.6–7.5 × 6.0–6.5 µm) subgloboid (Dima et al. 2021).

Discussion

Today the Cortinariaceae count ten genera, of which the genus *Cortinarius* is the largest among all the Agaricales. Until now most discoveries have been made in Europe and North America, very little work is done in Asian countries, including India. During our recent macrofungal survey to Uttarakhand (one of the Himalayan states in India), several specimens were collected from Himalaya, and it is now evident by our study through combined (morphology and molecular phylogeny) approach that India treasures numerous undiscovered species of Cortinariaceae. It is anticipated that the mushroom wealth of Cortinariaceae will be uncovered in the near future as we undertake more macrofungal explorations to all the climatic zones of this vast country including Indian Himalaya.

Declarations

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Author contribution Each author has made substantial contributions to the conception or design of the work. Specimen collection: PU & SC; writing and original draft preparation: SC, PU, YPS; writing, review and editing: SC, PU, YPS. All authors have read and agreed to the published version of the manuscript.

Ethics approval and consent to participate Not applicable.

Consent for publication Not applicable.

Competing interests The authors declare no competing interests.

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Figures

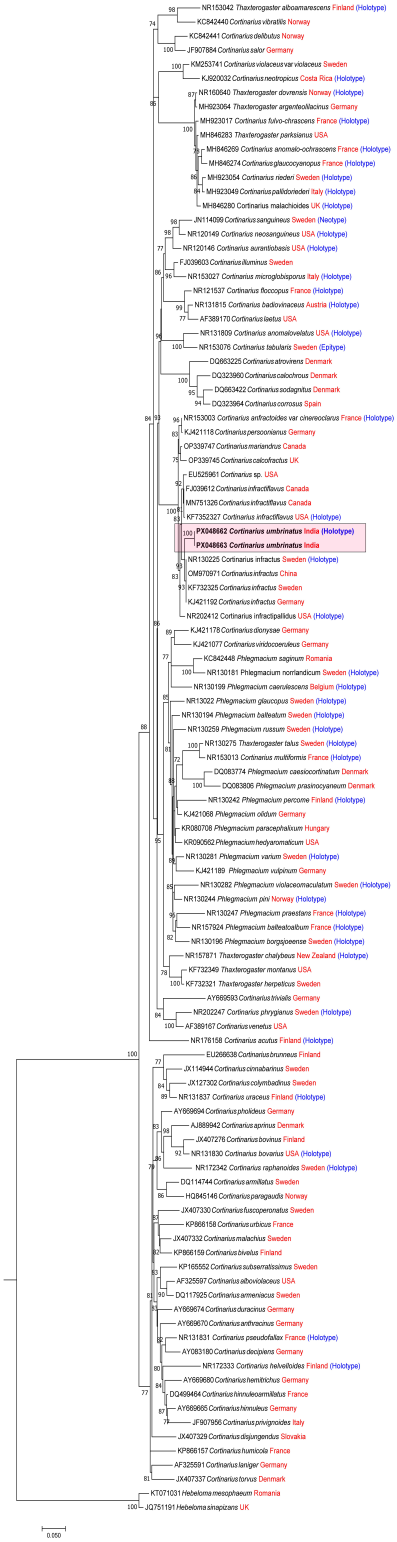


Figure 1

Maximum Likelihood phylogenetic tree inferred from ITS-rDNA sequence data using GTR+GAMMA model of nucleotide evolution constructed in RAxML v.2.0.10. Branches are labelled with ML bootstrap support values (≥70 %). Sequence derived from ***Cortinarius umbrinatus*** sp. nov. is shown as bold in the tree.

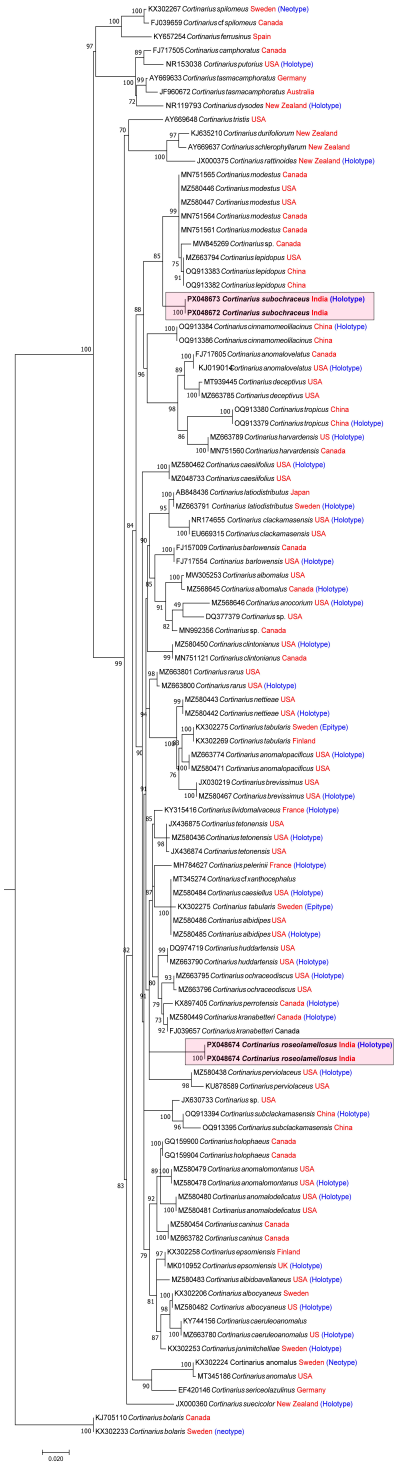


Figure 2

Maximum Likelihood phylogenetic tree inferred from ITS-rDNA sequence data using GTR+GAMMA model of nucleotide evolution constructed in RAxML v.2.0.10. Branches are labelled with ML bootstrap support values (≥70 %). Sequence derived from ***Cortinarius subochraceus*** sp. nov. and ***Cortinarius roseolamellosus***sp.nov. are shown as bold in the tree.



Figure 3

Macro and micro-morphological characteristics of *Cortinarius umbrinatus*.: (A–D) Fresh basidiomata in the field and basecamp; (E) Basidiospores under light microscope in Phloxine; (F–G) Basidia; (H) Transverse section through pileipellis. Scale bars: (A–D) = 10 mm, (E–H) = 10 µm.

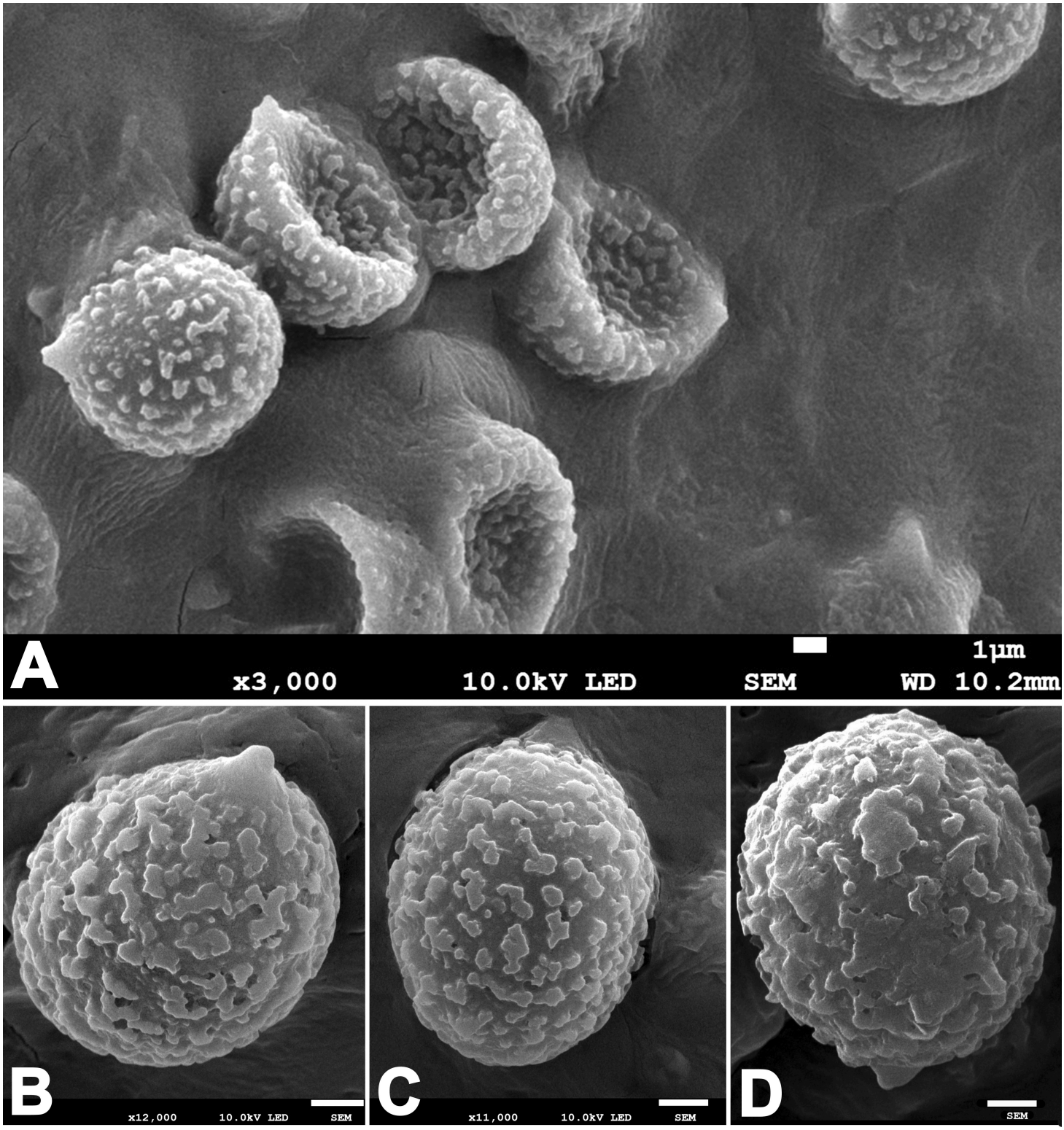


Figure 4

Scanning electron microscopic images of basidiospores of *Cortinarius umbrinatus*. Scale bars: (A–D) = 1 µm.

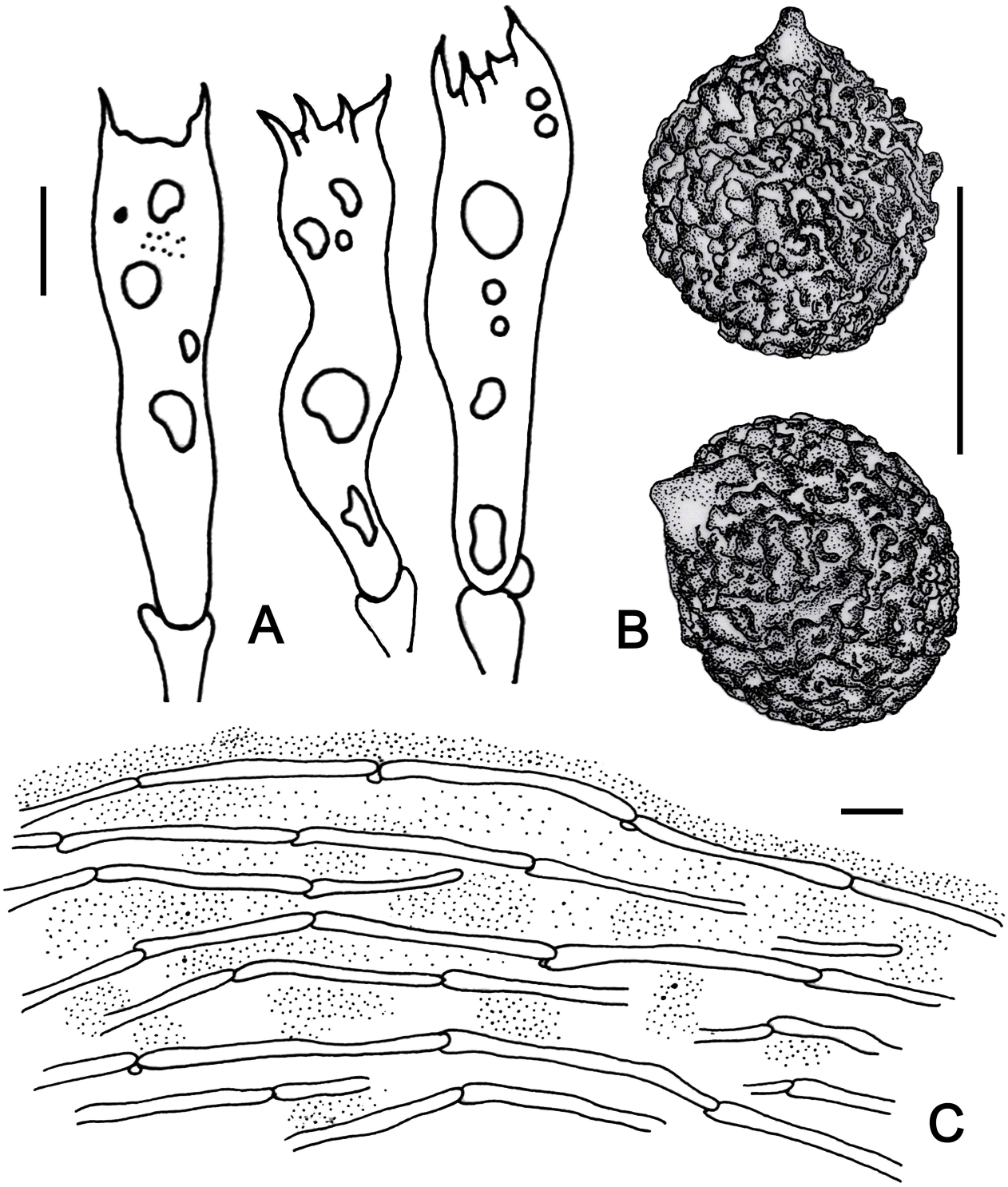


Figure 5

Line drawings of *Cortinarius umbrinatus*.: (A) Basidia; (B) Basidiospores; (C) Transverse section through pileipellis. Scale bars: (A–C) = 10µm.



Figure 6

Macro and micro-morphological characteristics of *Cortinarius subochraceus*.: (A–F) Fresh basidiomata in the field and basecamp; (G) Basidiospores under light microscope in Phloxine; (H) Basidia; (I) Terminal marginal cells; (J) Transverse section through pileipellis. Scale bars: (A) = 10 mm, (G–J) = 10 µm.

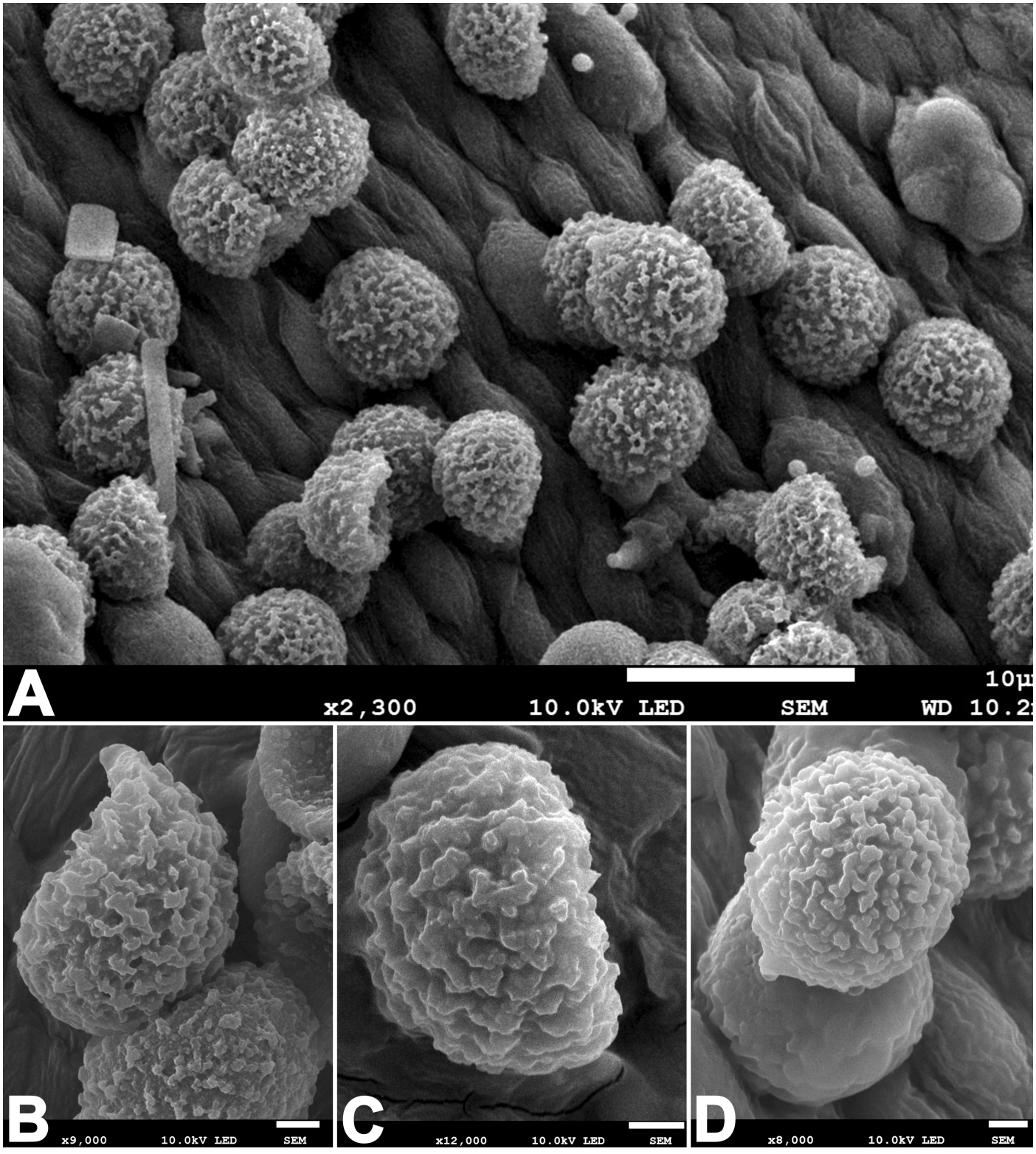


Figure 7

Scanning electron microscopic images of basidiospores of *Cortinarius subochraceus*. Scale bars: (A) = 10 μm; (B–D) = 1 μm.

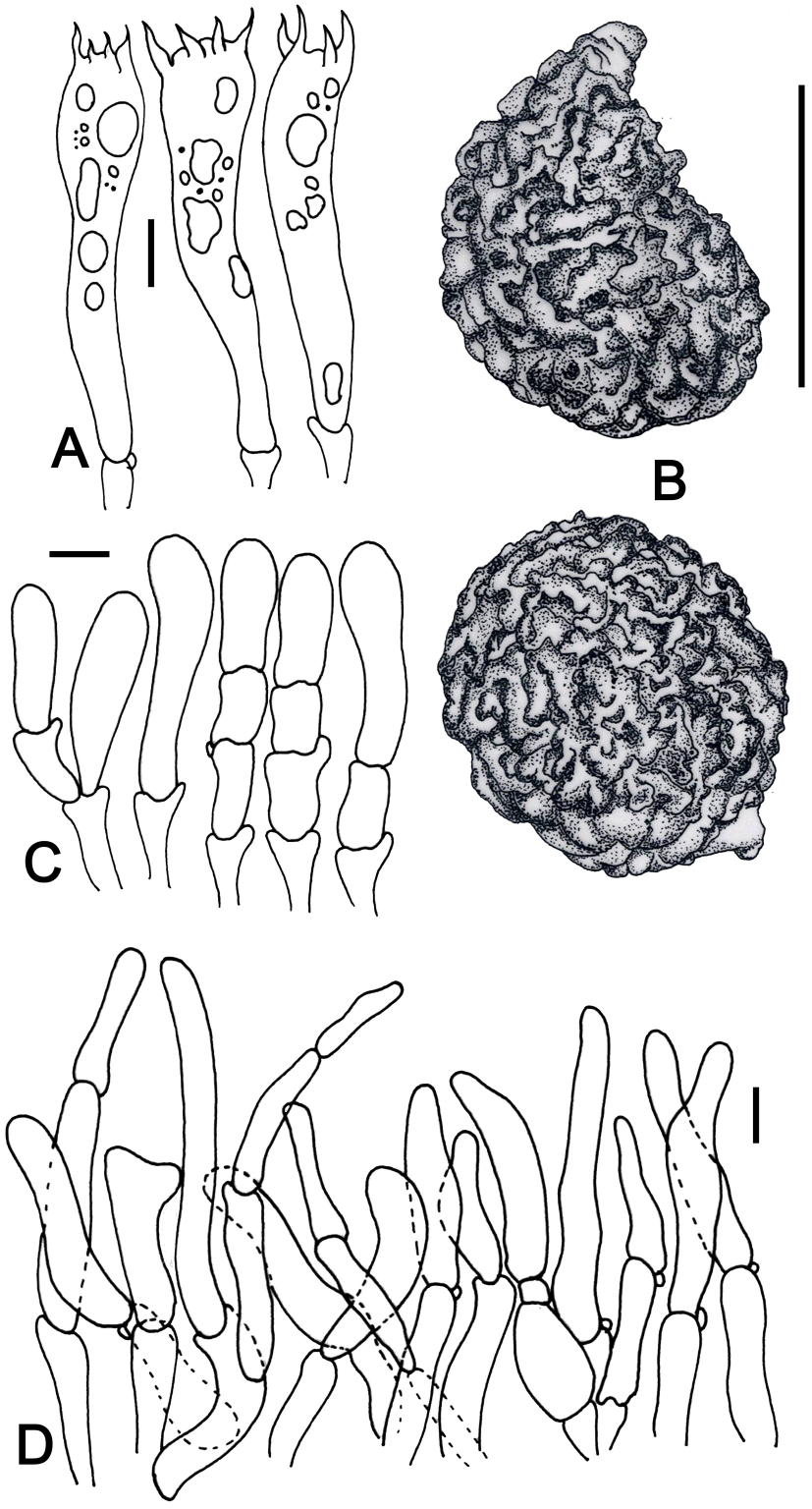


Figure 8

Line drawings of *Cortinarius subochraceus*.: (A) Basidia; (B) Basidiospores; (C) Terminal cells; (D) Transverse section through pileipellis. Scale bars: (A–D) = 10µm.

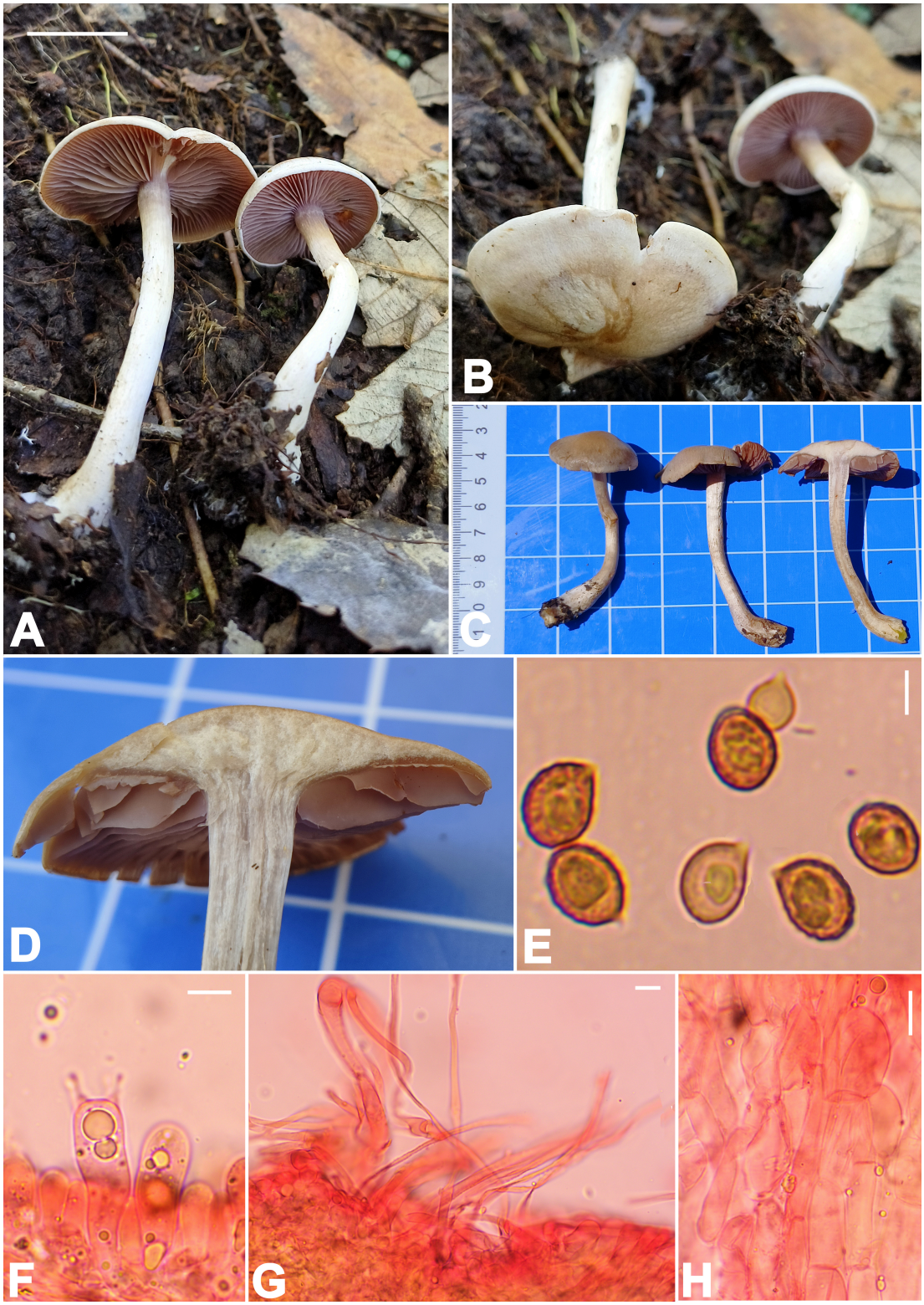


Figure 9

Macro and micro-morphological characteristics of *Cortinarius roseolamellosus*.: (A–D) Fresh basidiomata in the field and basecamp; (E) Basidiospores under light microscope in Phloxine; (F) Basidia; (G) Transverse section through pileipellis (H) Cells of pileipellis. Scale bars: (A) = 10 mm, (E–H) = 10 µm.

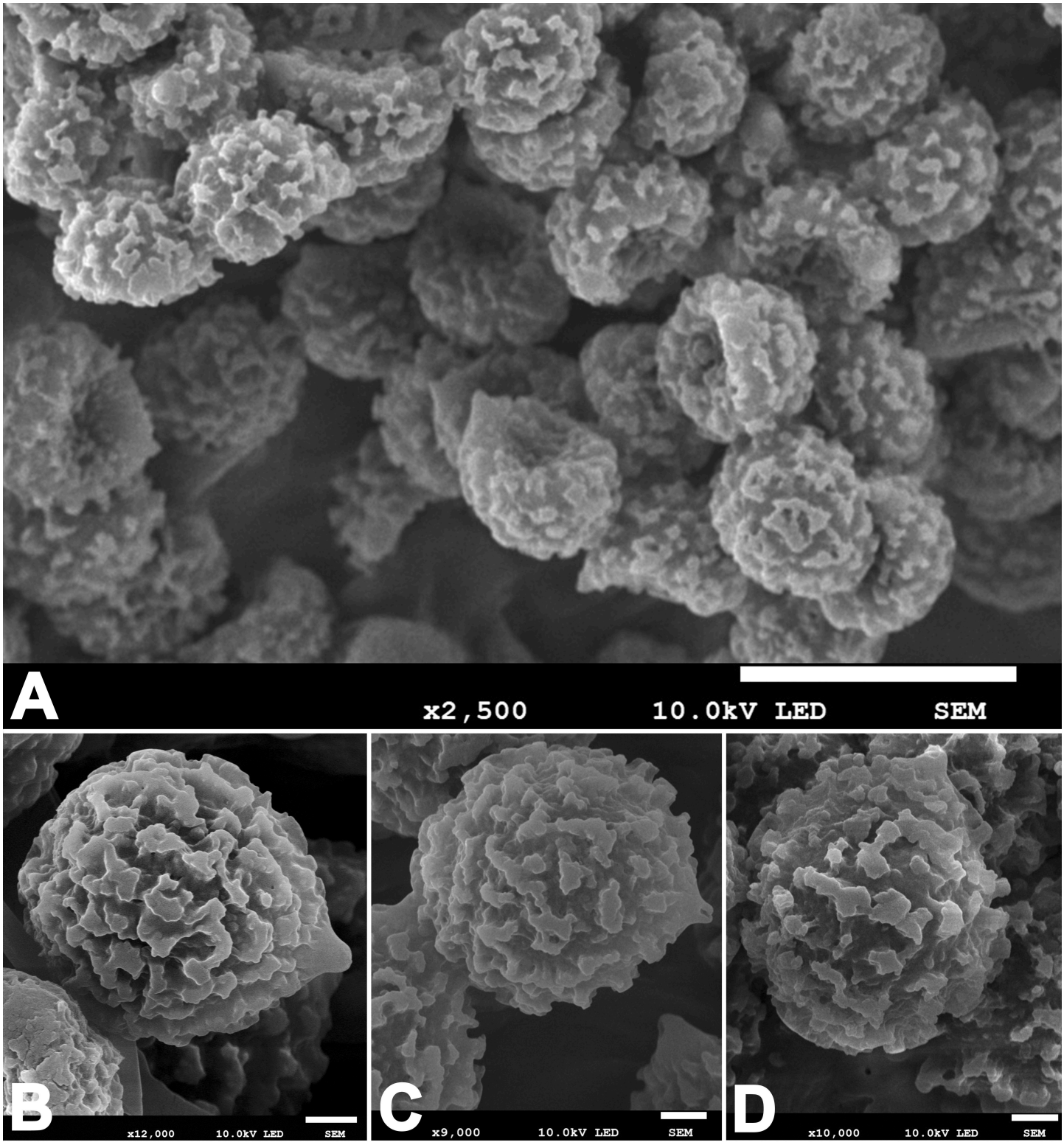


Figure 10

Scanning electron microscopic images of basidiospores of *Cortinarius roseolamellosus*. Scale bars: (A) = 10 μm; (B–D) = 1 μm.

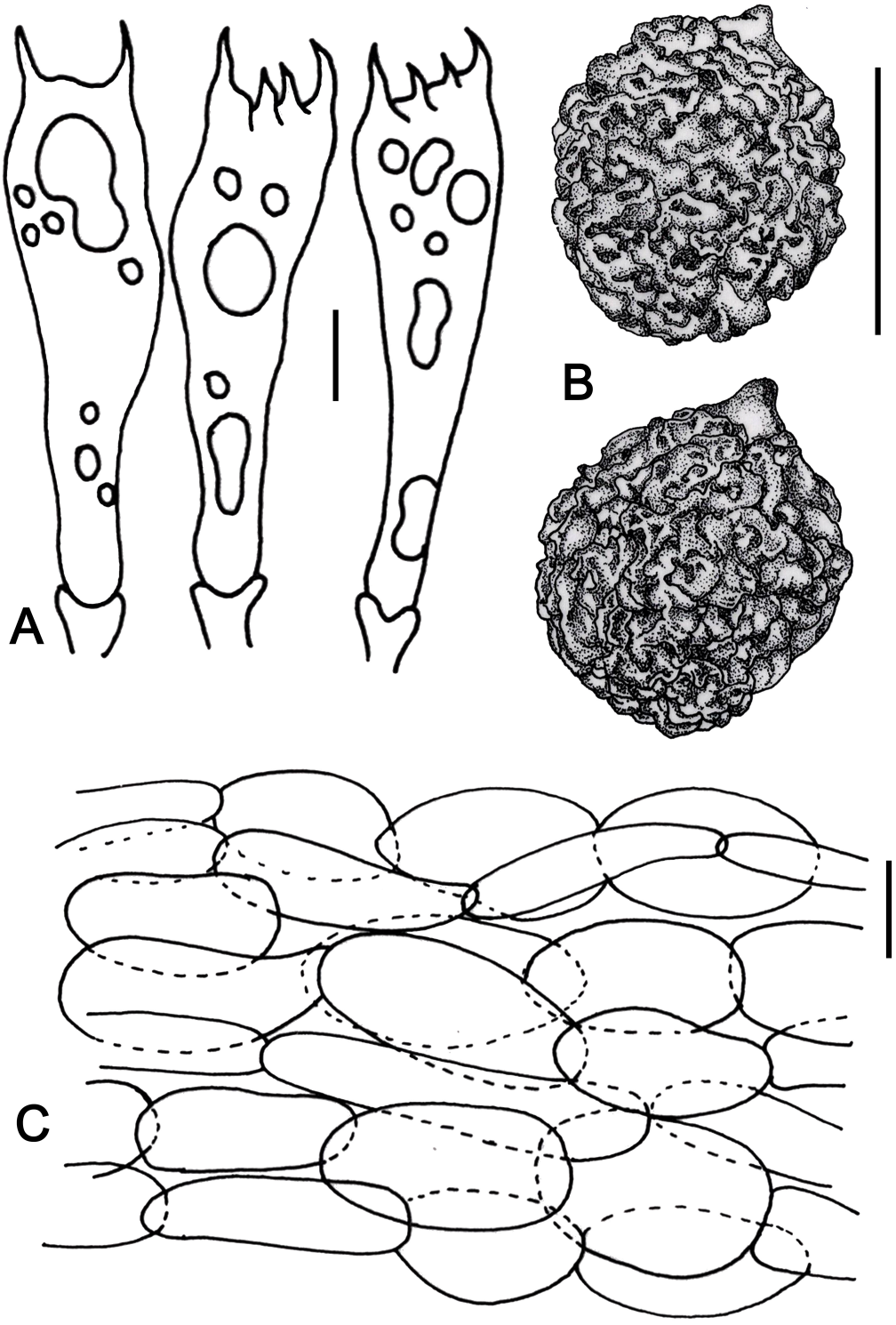


Figure 11

Line drawings of *Cortinarius roseolamellosus*.: (A) Basidia; (B) Basidiospores; (C) Transverse section of pileipellis elemets. Scale bars: (A–C) = 10µm.