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ARTICLE

# Diversity and Distribution of Boletoid Fleshy Pored Fungi in Uttarakhand Himalaya, India (2007–2023): A Comprehensive Study

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**ABSTRACT** This study provides a comprehensive analysis of boletoid fleshy pored fungi across the elevational zones of Uttarakhand Himalaya, India, from 2007 to 2023. The study encompasses 167 collections representing 24 genera and 46 species, including lamellate members. Key genera include Aureoboletus, Austroboletus, Boletellus, Boletus, Borofutus, Cyanoboletus, Gyrodon, Gyroporus, Hemileccinum, Hortiboletus, Indoporus, Lanmaoa, lamellate boletoid members, Leccinellum, Leccinum, Phylloporus, Porphyrellus, Pulveroboletus, Rugiboletus, Strobilomyces, Suillus, Sutorius, Tylopilus, Xerocomellus, and Xerocomus. The paper includes field photographs, staining reactions on bruising of pores and sliced context, spore prints, microscopic images, and commentary on species determination, aiding readers in understanding the rich species diversity of boletoid mushrooms in Uttarakhand Himalaya. The compiled information serves as a baseline for aspiring researchers, guiding them to explore new localities for novel species of boletoid fleshy pored fungi. Recommendations for future research include extensive fungal forays, classical taxonomy, and advanced molecular studies, given the widespread occurrence of these mushrooms across before the Uttarakhand Himalaya's forest types.

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## INTRODUCTION

Boletoid fungi are a distinctive group within the class Agaricomycetes and order Boletales, characterized by their unique tubular-poroid hymenophores. Interestingly, despite this defining feature, some lamellate members, such as those belonging to the genera *Phylloporus*, *Phylloporopsis*, and *Phylloboletellus*, are also classified as boletoid fungi. These fungi typically display pileate-stipitate growth form, which may sometimes be sequestrate. The basidiomes range in size from small to very large or stout, and their texture transitions from firm in the early stages to fleshy or spongy upon maturation. The fruiting body of these mushrooms closely resembles a bun with a stalk and is locally known as "Ladodhia Cheun." This name originates from the Garhwali dialect, where "Ladodhia" translates to "lung," aptly reflecting the mushroom's appearance, which is reminiscent of a goat's lungs.

The pileus of boletoid fungi may exhibit a variety of surface characteristics, including smooth, fibrillose-scaly, tomentose, dry, or viscid textures. Upon bruising or exposure to air, the context and pores often exhibit characteristic staining reactions, turning greenish-blue, bluish, reddish, or blackish. Hymenophore colors vary widely, whitish, yellowish, pinkish, reddish, orangish, or brownish, with pores that are round or angular, broad, or narrow. The stipe morphology is equally diverse, presenting as terete, cylindrical, clavate, or with a broadened base, and its surface may be glabrous, reticulated, or adorned with dots or scabrous squamules. Basal mycelium typically appears white, cream, or yellow.

Basidiospores of boletoid fungi display considerable morphological diversity, ranging from fusiform to ellipsoid-fusoid or broadly ellipsoid to ovoid, with varying wall thickness. These spores may have obtuse proximal ends near the apiculus or truncate distal ends. They can be hyaline or pigmented and exhibit smooth or ornamented surfaces, displaying patterns such as pitted, bacillate, longitudinally ridged, or reticulated with network-like or winged structures. The pileipellis, i.e., outermost layer of the pileus, shows varied hyphal

**Table 1.** The twenty-nine collection localities, tree components, and elevational ranges.

| Region | Locations abbreviation | Locations | Tree composition | Altitudinal range |
|---|---|---|---|---|
| Garhwal Region | AD | Adwani (Pauri) | *Q. leucotrichophora, M. esculenta, R. arboreum* mixed with *P. roxburghii* | 1900-2000 m |
| | BG | Bageecha (Rudraprayag) | *Q. leucotrichophora, M. esculenta, R. arboreum* | 1800-2000 m |
| | BR | Barsudi (Pauri) | *Q. leucotrichophora, M. esculenta, R. arboreum, P. roxburghii* | 1800-1850 m |
| | BS | Bharsar (Thelisain) | *Q. leucotrichophora, M. esculenta, R. arboretum, Corylus jacquemontii, Acer* sp., *Alnus nepalensis, Cedrus deodara, P. roxburghii, Cupressus torulosa.* | 2000-2200 m |
| | CR | Chakrauta (Dehradun) | *Cedrus deodara, Cupressus torulosa, P. roxburghii, Q. leucotrichophora, R. arboreum* | 2000-2200 m |
| | CH | Chaurikhal (Pauri) | *Q. leucotrichophora, M. esculenta, R. arboreum, Corylus jacquemontii, Acer* sp., *Alnus nepalensis, Cedrus deodara, P. roxburghii, Cupressus torulosa.* | 2150-2300 m |
| | CK | Chobattakhal (Pauri) | *Q. leucotrichophora, M. esculenta, R. arboreum* | 1900-2000 m |
| | DP | Dandapani (Pauri) | *Q. leucotrichophora, M. esculenta, R. arboreum* | 1900-2100 m |
| | GK | Gudkhiyakhal (Pauri) | *Q. leucotrichophora, M. esculenta, R. arboreum* | 1900-2000 m |
| | HM | Hanuman Mandir (Pauri) | *Q. leucotrichophora, M. esculenta, R. arboreum, P. roxburghii, Cedrus deodara* | 1800-2150 m |
| | KN | Kanda (Satpuli) | *S. robusta, P. roxburghii* | 700–800 m |
| | KT | Kathuli (Pauri) | *Q. leucotrichophora, M. esculenta, R. arboreum* | 1750– 1900 m |
| | KH | Khanduisen (Pauri) | *Q. leucotrichophora, M. esculenta, R. arboreum* | 1750– 1850 m |
| | KS | Khirsu (Pauri) | *Q. leucotrichophora, M. esculenta, R. arboreum, P. roxburghii* | 1950-2150 m |
| | KL | Kulhad (Satpuli) | *S. robusta* | 600-750 m |
| | KD | Kund (Rudraprayag) | *Q. leucotrichophora, Cinnamomum tamala* | 1000– 1160 m |
| | LP | Ladpur (Dehradun) | *S. robusta, T. grandis* | 600-650 m |
| | LD | Lansdown (Pauri) | *Q. leucotrichophora, M. esculenta, R. arboreum* | 1900-2100 m |
| | MN | Manpur (Guptkashi) | *Q. leucotrichophora, Symplocos recemosa, M. esculenta* | 1900-2100 m |
| | MD | Mundneshwar (Kaljikhal) | *Q. leucotrichophora, M. esculenta, R. arboreum* | 1800-2050 m |
| | NH | Nahsain (Pauri) | *Q. leucotrichophora, M. esculenta, R. arboreum* | 1850-2000 m |
| | PH | Phedhkhal (Pauri) | *Q. leucotrichophora, M. esculenta, R. arboreum* | 1900-2000 m |
| | SM | Saat Mode (Rishikesh) | *S. robusta, T. grandis* | 550-650 m |
| | SK | Sikukhal (Pauri) | *Castanopsis* sp., *P. roxburghii* | 1650-1700 m |
| | TP | Tapovan (Dehradun) | *S. robusta, T. grandis* | 550-600 m |
| | TK | Teka (Pauri) | *Q. leucotrichophora, M. esculenta, R. arboreum, P. roxburghii* | 1850-2000 m |
| Kumaon Region | CW | Champawat | *Q. leucotrichophora, M. esculenta, R. arboreum* | 1900-1950 m |
| | MW | Mayawati | *Q. leucotrichophora, M. esculenta, R. arboreum* | 1900-2000 m |
| | DR | Devidhura | *Q. leucotrichophora, M. esculenta, R. arboreum* | 1900-2000 m |

arrangements, including trichodermium, cutis, epithelium, and palisadoderm. This layer may be embedded in a gelatinized matrix, leading to classifications such as ixocutis, ixotrichodermium, and ixohypoepithelium. Notably, hyphae lack clamp connections except in certain genera, such as *Gyrodon*, *Gyroporus* and *Boletinellus*, and may or may not have incrustations, which contributes to the group's remarkable morphological diversity.

In recent years, advances in DNA fingerprinting and molecular phylogenetics have greatly enhanced our ability to identify and differentiate boletoid species. As a result, 109 genera have been delineated within this group (Li et al. 2011; Nuhn et al. 2013; Gelardi et al. 2014; Wu et al. 2014, 2015; Farid et al. 2017; Das et al. 2023; Halling et al. 2023). Furthermore, researchers in India have contributed to the understanding of boletoid fungi, with a total of 102 species and 27 genera documented (Verma and Reddy 2015; Patil et al. 2021; Chakraborty et al. 2022; Semwal et al. 2022; Das et al. 2023a). Notably, recent studies have identified 24 distinct taxa of boletoid fungi including 1 new genus *Singeroboletus* in Uttarakhand Himalaya, including *Aureoboletus miniatoaurantiacus*, *Austroboletus appendiculatus*, *Boletus bainiugan, Boletus dhakuricus*, *Cyanoboletus paurianus*, *Cyanoboletus macroporus*, *Harrya olivaceobrunnea, Leccinellum binderi*, *Leccinellum bothii*, *Phylloporus himalayanus*, *Phylloporus smithii*, *Phylloporus yunnanensis*, *Porphyrellus uttarakhandae*, *Retiboletus pseudoater, Rugiboletus extremiorientalis, Singeroboletus himalayanus, Strobilomyces mirandus*, *Sutorius apleurocystidiatus*, *Tylopilus himalayanus*, *Tylopilus pseudoballoui*, *Xerocomus rugosellus*, *Xerocomus*

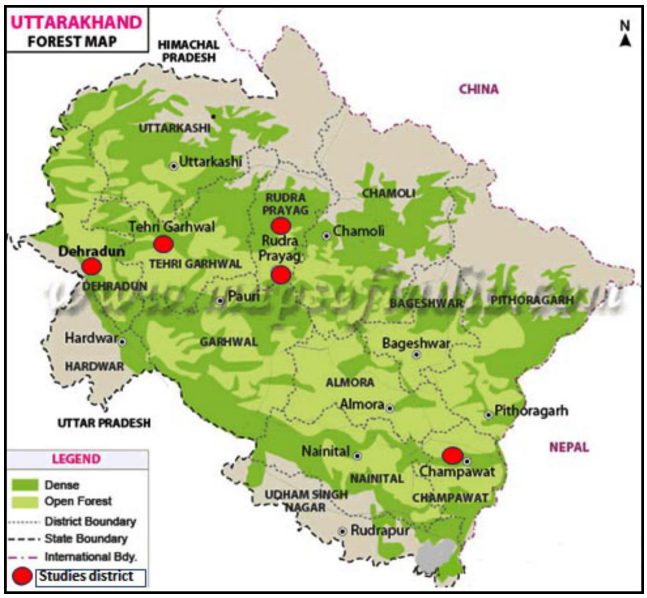


**Figure 1.** Locations of some of the studied localities depicted as red spots.The map of forest density is a modified version of the source map available from–https://www.mapsofindia.com/maps/uttarakhand/Uttaranchal–forest–map.htm

*uttarakhandae*, *Xerocomellus himalayanus*, and *Xerocomus fraternus* (Tibpromma et al. 2017; Chakraborty et al. 2017b; Das et al. 2023a,b, 2024, 2025, Datta et al. 2024).

The data presented in this study results from an extensive 16-year investigation (2007-2023) comprising repeated expeditions to document the diversity of wild mushrooms across different elevational zones and forest ecosystems of the Uttarakhand Himalaya. This prolonged exploration revealed a remarkable abundance of boletoid fleshy pored fungi, prompting the meticulous documentation of their occurrence, distribution, and diversity.

The total collections for boletoid fleshy pored fungi ranked as the second highest, surpassed only by the family *Russulaceae* and followed by *Amanitaceae* and *Cortinariaceae* families. These mushrooms, a significant subgroup within the Boletales of the phylum Basidiomycota, form essential ectomycorrhizal associations with a variety of tree species across a wide altitudinal range, spanning from 500 to 2300 meters above sea level, and encompassing lower-altitude subtropical forests.

The Uttarakhand Himalaya is characterized by diverse forest types, ranging from subtropical forests dominated by *Shorea*, *Dalbergia*, and *Tectona* to middle Himalayan temperate forests with *Quercus*, *Rhododendron*, *Myrica*, *Cinnamomum*, and *Pinus*. The higher Himalayan ranges feature *Cedrus*, *Betula*, and *Abies* alongside various *Quercus* and *Rhododendron* species.

The biodiversity of the Uttarakhand Himalaya, encompassing broadleaf, mixed, and coniferous forests across sub-temperate, subtropical and alpine zones, supports an exceptional diversity of wild mushrooms (Joshi et al. 2012; Vishwakarma and Bhatt 2013; Semwal et al. 2018; Semwal and Bhatt 2019). This includes a significant representation of boletoid fungi, which plays a crucial ecological role in this rich and varied landscape.

This paper provides a foundational dataset that highlights the diversity and distribution of boletoid fleshy pored fungi in Uttarakhand, contributing valuable insights to the broader understanding of fungal biodiversity.

## Materials and methods

### *Study area*

Between 2007 and 2023, a comprehensive survey was conducted across 29 distinct locations spanning various elevational zones during the monsoon season. The primary objective was the systematic collection of boletoid fleshy pored fungi, complemented by the collection and identification of other wild macrofungi groups. Geographically, the study area lies between latitudes 28°43'N and 31°28'N and longitudes 77°34'E and 81°03'E.

The surveyed locations are distributed across two politico-cultural regions: Garhwal and Kumaon (Table 1). Notably, most collection sites were in the Garhwal region, with only three localities visited in Kumaon during the study (Fig. 1). This extensive geographical coverage ensured a comprehensive representation of boletoid fleshy pored fungi across the region, forming a robust basis for the analysis and findings presented in this paper.

### *In-field and laboratory investigations*

Each specimen underwent a meticulous identification process involving both macro- and micro-morphological observations. The following criteria were considered for identification:

- Color and texture of the fruit body
- Color and pattern of the hymenophore (pores)
- Reactions to bruising or sectioning on both pores and context
- Coloration of basal mycelium
- Taste and smell of the pileus context
- Stipe structure and spore print color
- Microscopic features, including spore shape, size, and ornamentation; shape of hymenial cystidia; and pileipellis tissue characteristics

To ensure taxonomic accuracy, relevant research papers, taxonomic keys, and field guides were consulted, including seminal works by Singer (1986), Binder and Hibbett (2007), Šutara (2008), Nuhn et al. (2013), Wu et al. (2015, 2016), Li et al. (2016), Chakraborty et al. (2017a, b; 2018a, b), Chai et al. (2019), Li and Yang (2021), Vadthanarat

**Table 2.** List of unidentified samples, collection numbers, habitat, ecology, locality, elevation, and collection dates.

| S. No. | Collection No. | Habitat, ecology, locality, elevation, and collection date |
|---|---|---|
| 1. | KCS 1119 | In soil, under *S. robusta*, KN (Satpuli), 700 m; Aug 15, 2007 |
| 2. | KCS 1127 | In soil, under *S. robusta*, KN (Satpuli), 700 m; Aug 15, 2007 |
| 3. | KCS 1341 | In soil, under *S. robusta*, LP (Dehradun), 600 m; Sept 9, 2009 |
| 4. | KCS 1719 | In soil, under *S. robusta*, TP (Dehradun), 650 m; Sept 2, 2013 |
| 5. | KCS 1726 | In soil, under *S. robusta*, TP (Dehradun), 650 m; Sept 2, 2013 |
| 6. | KCS 1831 | In soil, under the canopy of *Q. leucotrichophora*, MD (Kaljikhal), 2050 m; July 31, 2014 |
| 7. | KCS 1833 | In soil, under the canopy of *Q. leucotrichophora*, MD (Kaljikhal), 2050 m; July 31, 2014 |
| 8. | KCS 1835 | In soil, under the canopy of *Q. leucotrichophora*, MD (Kaljikhal), 2050 m; July 31, 2014 |
| 9. | KCS 1846 | In soil, under the canopy of *Q. leucotrichophora*, MD (Kaljikhal), 2050 m; July 31, 2014 |
| 10. | KCS 1858 | In soil, under the canopy of *Q. leucotrichophora*, MD (Kaljikhal), 2050 m; July 31, 2014 |
| 11. | KCS 1860 | In soil, under the canopy of *Q. leucotrichophora*, MD (Kaljikhal), 2050 m; July 31, 2014 |
| 12. | KCS 5032 | In soil, under the canopy of *Q. leucotrichophora*, MD (Kaljikhal), 2050 m; Aug 12, 2022 |
| 13. | KCS 2524 | Under *Q. leucotrichophora*, among leaf litter, KT (Pauri), 1900 m; July 21, 2016 |
| 14. | KCS 2526 | Under *Q. leucotrichophora*, among leaf litter, KT (Pauri), 1900 m; July 21, 2016 |
| 15. | KCS 5041 | In soil, under *Q. leucotrichophora*; PH (Pauri), 2100 m; Sept 3, 2022 |
| 16. | KCS 5051 | On wall, among mosses, under the canopy of *Q. leucotrichophora* and *M. esculenta*; DP (Pauri), 2000 m; Sept 9, 2022 |

et al. (2021), and Das et al. (2023). Current nomenclature was verified using the online database *Index Fungorum*.

Specimens were identified to the genus or species level whenever possible. However, some older or degraded samples lacked discernible microscopic features, and their identification relied on field notes, spore print characteristics, spore morphology, and archival photographs in the authors' digital library. Ecological data, including habitat conditions and associated vegetation, were documented during fieldwork, and high-resolution images of the basidiomes were captured using Nikon Coolpix P510 and Sony DSC–W35 cameras.

Fresh specimens were examined in water to observe the original pigmentation of tissues and spore colors. For dried specimens, tissues were revived using a 3% aqueous KOH solution and microscopic structures were stained with reagents such as 2% Congo Red, 2% Phloxine, Lactophenol-Cotton Blue, and Melzer's reagent. Microscopic analysis was performed using an EcostarPrimia (Quasmo) light microscope. Spore measurements were obtained from 25 spores from a profile view to ensure consistency. The Q value was calculated by dividing the total length by the total width of the spores. Specimens were meticulously air-dried at 40 °C using a commercial dryer (Ezidri, HydraflowInds. Ltd, New Zealand) to preserve their integrity for future DNA molecular studies.

Four specimens (KCS 4004, KCS 4006, KCS 4033, KCS 4037) sent for DNA analysis to the Rajiv Gandhi Centre for Biotechnology (RGCB), Thiruvananthapuram, India. The sequence data were analysed online in NCBI BLAST. However, details of the DNA analysis are not given in the present communication.

### *Specimen archiving and documentation*

All collected specimens are currently housed in the personal herbarium of the first author (KCS), along with collection numbers. However, they will eventually be transferred to the Hemwati Nandan Bahuguna Garhwal University Herbarium (GUH) in Srinagar Garhwal, Uttarakhand, India, to receive official herbarium accession numbers. Detailed records, including collection dates, locations, elevations, and associated tree species, are summarized in Tables 3–14. Field photographs illustrating the morphological features of fruit bodies, as well as microscopic images of basidiospores and pileipellis tissues, are included for reference (Figs. 2–13).

## Results and Discussion

A comprehensive analysis of boletoid fleshy pored fungi was conducted based on 167 collections from 29 distinct locations in the Uttarakhand Himalaya. Rigorous investigations identified 24 genera and 46 species, although some collections remained unidentified or were only tentatively categorized at the genus level (Table 2). The primary reasons for these limitations included aged or contaminated specimens, as well as decomposition during transport to the base camp or laboratory. The identified genera encompassed a broad diversity, including *Aureoboletus*, *Austroboletus*, *Boletellus*, *Boletus*, *Borofutus*, *Cyanoboletus*, *Gyrodon, Gyroporus*, *Hemileccinum*, *Hortiboletus, Indoporus*, *Lanmaoa, Leccinellum*, *Leccinum*, *Phylloporus*, *Porphyrellus*, *Pulveroboletus*, *Rugiboletus*, *Strobilomyces*, *Suillus*, *Sutorius*, *Tylopilus*, *Xerocomellus*, and *Xerocomus*.


**Figure 2.** Photographic details of representative species. **A.** *Aureoboletus miniatoaurantiacus* (KCS 2422); **B.** T.S. through pileus with pores; **C.** Trichoderm pileipellis with cystidoid terminal cells filled with lemon-yellow content; **D.** Basidiospores. **E.** *Austroboletus* aff. *dictyotus* (KCS 6024); **F.** Pores; **G.** Ixocutis pileipellis; **H.** Basidiospores. **I.** *Boletellus emodensis* (KCS 4002); **J.** T.S. through pileus showing blue discoloration upon exposure to air; **K.** Trichoderm pileipellis; **L.** Basidiospores. **M.** *Boletus* aff. *bainiugan* showing dark brown spore deposits on the cap (KCS 5007); **N.** T.S. through pileus and pores; **O.** Ixotrichoderm pileipellis; **P.** Basidiospores. **Q-R.** The fruit body of *Boletus violaceo-fuscus* with pores (KCS 4006); **S.** Ixoepithelium pileipellis elements; **T.** Basidiospores.

**Table 3.** List of identified species, habitat, ecology, locality, elevation, collection numbers, collection dates, and key notes.

| Species name & Fig. No. | Specimen examined | Basidiospores micromorphology | Pileipellis elements | Commentary |
|---|---|---|---|---|
| *Aureoboletus miniatoaurantiacus* (Bi & Loh) Ming Zhang, N.K. Zeng & T.H. Li<br><br>Fig. 2 A-D | In soil, among mosses, under the canopy of *Q. leucotrichophora*; CW (Kumaun), 1950 m, KCS 1267, Aug 26, 2009; MD (Kaljikhal), 2050 m, KCS 1837, July 31, 2014; DP (Pauri), 2000 m, KCS 2422 m, Aug 1, 2015; MD (Pauri), 2050 m, KCS 2454, Aug 12, 2015. | 9.4-12 × 4.6-5.8 µm, Q= 2.09, elliptic to oblong, slightly thick-walled | A trichoderm with erect cylindrical hyphae and cystidoid terminal cells obtuse apex or rounded ends with prominent lemon-yellow content. | Key features: bright yellow fruit body and the pileus surface covered with yolk yellow to dark yellow cottony fibrils. This species was published earlier under the name *Pulveroboletus auriflammeus* (Berk. & M.A. Curtis) Singer, from Uttarakhand Himalaya (Das et al. 2016a). |
| *Austroboletus appendiculatus* Semwal, D. Chakr., K. Das, Indoliya, D. Chakrabarty, S. Adhikari & Karunarathna | In soil, under *Sal* tree in the subtropical forest; TP (Dehradun), 650 m, KCS 1401, July 29, 2023. | 14.2-16.5 x 7.3-9.1 µm, Q = 1.83, broadly fusoid to amygdaliform, surface appears warted by disruption of the outer wall. | A trichoderm, composed of erect, septate hyphae, terminal cylindrical cells with rounded apex | Key features: stipe covered with pale orange to light orange appendages forming flaring to wing-like network and warted or deeply pitted amygdaliform spores. |
| *Austroboletus* aff. *dictyotus* (Boedijn) Wolfe<br><br>Fig. 2 E-H | In soil, under *Shorea robusta,* in the subtropical forest; TP (Dehradun), 650 m, KCS 6024, July 17, 2010. | 12.2-17.6 (-21.2) x (6.7-) 7.5-9 µm, Q= 1.8, subamygdaliform to ovoid, surface warted and forming reticulum, yellowish brown. Spore print vineceous brown. | Ixocutis, made up of cylindrical to subcylindrical terminal cells, raised from interwoven hyphae which is embedded in gelatinized matrix. | The key features of this species include yellowish brown to brown pileus, appendiculate margin, ivory whitish broad pores, stipe covered with short appendages forming network, ixocutis pielipellis and warted or deeply pitted, amygdaliform spores, presence of 2- celled pleurocystidia, upper cylindrical cells, and lower broadly clavate cells which take this taxon close to *A. dictyotus* but the spores sizes of latter larger [(16-) 18–23 (-25) x (7-) 8–10 (-12) µm, Q= 2.28, Wu et al., 2016]. However, the spore size takes this taxon near to *A. albidus* (13–18 x 7.5–9 µm, Q= 1.89), but can be distinguished by its whitish to cream pileus which is covered with light orange to brownish nubby squamules, the greyish white to purplish grey or greyish purple to dark purple hymenophore (Li and Yang 2021). |
| *Boletellus emodensis* (Berk.) Singer<br><br>Fig. 2 I-L | On wall, among moss under the canopy of *Shorea robusta;* KN (Satpuli, 700 m, KCS 1120, Aug 15, 2007; TP and LP (Dehradun), 650 m, KCS 1335, Sept 13, 2009, KCS 1717, Sept 2, 2013; KCS 4002, July 21, 2021; KCS 5020, July 29, 2022. | 16.4-19.5 x 6.3-8.9 µm, Q= 2.4, elongate– ellipsoid with longitudinal ridges. | A trichoderm, made up of interwoven, thin- walled, yellowish-brown hyphae, terminal cells with round to obtuse apex. | This species distribution is restricted to the lower altitude Himalayan range forest in Dipterocarpaceae forest dominated by *S. robusta* species. Key features include red- pink squamose pileus, appendiculate margin, the yellow pores and the context staining blue very rapidly on bruising or cut and large spores with long striation on the surface. |
| *Boletus* aff. *bainiugan* Dentinger<br><br>Fig. 2 M-P | Growing among leaf litter, under the canopy of *Castanopsis* sp., *Q. leucotrichophora* and *P. roxburghii,* SK (Pauri), 1650 m, KCS 5007, July 17, 2022, KCS 5022, Aug 4, 2022; TK (Pauri), 1950 m; Sept 9, 2022, KCS 5056; BR (Pauri), 1800 m, KCS 6001, July 7, 2023; SK (Pauri), 1650 m, KCS 6008, July 14, 2023; KS (Khirsu), 1950 m, KCS 6015, July, 17, 2023. | (10.5-) 11-13.8 (-15.2) × 3.5-5 µm, Q= 2.91, elliptic long-fusiform, yellowish in 3% KOH. | An ixotrichoderm, made up of narrow -cylindrical terminal cells with obtuse apices. | Prominently reticulated stipe, ocraceous brownish pileus with yellowish hymenophore, unchanged context and hyemenophore, pleasant smell, white basal mycelium, elliptic, long-fusiform spores and a trichoderm pileipelliis meet well with the data of *B. bainiugan.* This species was previously reported in China (Cui et al., 2015) and also in Uttarakhand by Das et al. (2023). The specimen bears a striking resemblance to the European species *B. reticulatus* Schaeff, as evidenced by its morphological features and spore data (10-13 x 3-4 µm, Kuo & Methven, 2014). |
| *Boletus violaceofuscus* Chiu<br><br>Fig. 2 Q-T | In soil, under the canopy of *Q. leucotrichophora;* TK (Pauri), 1950 m, July 31, 2021, KCS 4006; MD (Kaljikhal), 2050 m, Aug 12, 2022. | (9.5-) 11– 15.5 (16.6-) x (4.2-) 5.0 – 6.0 (-6.8) µm, Q= 2.40, elliptico- subfusiform, smooth, brownish in 3% KOH, smooth. | An ixoepithelium, made up of inflated, broad clavate, subglobose cells, gelatinized, the elements are olive yellow in 3% KOH. | This specimen matches 100% with *B. violaceo-fuscus* in the NCBI Blast result. However, there are no yellowish spots or patches on pileus as reported in the original description and the larger basidiospores (14.0) 15.5 (±0.8 (17.8) x (5.0-) 5.6 ± 0.3 (6.2) µm, Simonini et al. 2001; and (14.2-) 14.9-16.5 (-17.5) x (5.0-) 5.3-6.0 (-6.1) µm, Floriani et al, 2000). |

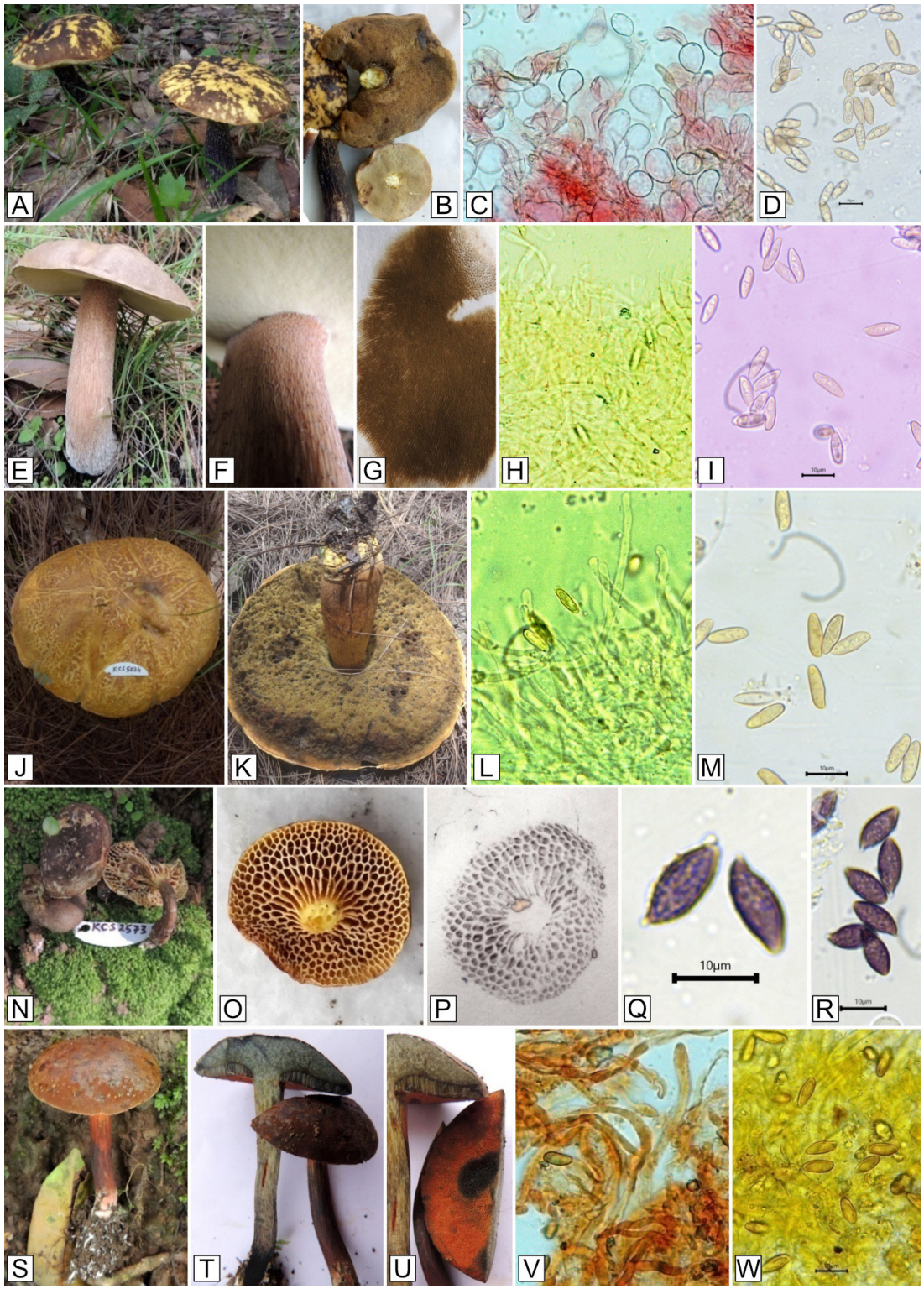


**Figure 3.** Photographic details of representative species. **A**. The fruit body of *Boletus* aff. *violaceo-fuscus* (KCS 6010); **B.** Pores of young and mature fruit bodies; **C.** Ixoepithelium pileipellis elements; **D.** Basidiospores. **E-F.** Fruit body, pores, and reticulation on the stipe of *Boletus* Sp.1 (KCS 2412); **G.** Brown spore print; **H.** Trichoderm pileipellis; **I.** Basidiospores. **J.** The fruit body of *Boletus* Sp. 2 (KCS 5024); **K.** Pores; **L.** Pileipellis elements; **M.** Basidiospores. **N-O.** The fruit body and pores of *Borofutus dhakanus* (KCS 2573); **P.** Spore print; **Q-R.** Basidiospores with fine ornamentations. **S-U.** Fruit body of *Cyanoboletus* cf. *brunneoruber* showing blue staining of pores and context upon exposure to air (KCS 2528); V. Ixotrichoderm pileipellis; **W.** Basidiospores.

**Table 4.** List of identified species, habitat, ecology, locality, elevation, collection numbers, collection dates, and key notes.

| Species name & Fig. No. | Specimen examined | Basidiospores micromorphology | Pileipellis elements | Commentary |
|---|---|---|---|---|
| *Boletus* aff. *violaceo-fuscus* Chiu<br><br>Fig. 3 A-D | Growing under the canopy of *Q. leucotrichophora* and *Cedrus deodara,* KS (Pauri), 1950 m, KCS 6010, July 16, 2023. | (10.5-) 11.3-14.4 x (4.2-) 4.5-5.2(-6.3) µm, Q= 2.64, elliptico-subfusiform, yellowish-brown in 3% KOH, spore print dark brown to brown. | An ixoepithelium, made up of inflated, broadly clavate, subglobose cells, gelatinized | This species matches well with *B. violaceo– fuscus* based on yellow and brown spotted or patchy pileus with other colour combination of fruitbody (Simonini et al. 2001) but the spore size is smaller in this specimen. |
| *Boletus* Sp. 1<br><br>Fig. 3 E-I | In soil, under *Q. leucotrichophora* and *P. roxburghii*; LD (Pauri), 2100 m, KCS 2412 July 18, 2015 | 9.2-13.4 x 3.5-4.4 µm, Q= 2.84, fusiform to elongate-fusiform, inequilateral in side view, spore print golden- brown (5D7). | A trichoderm, made up of thin-walled hyphae with slightly clavate terminal cells. | A large fruitbody (pileus 11 cm diam., stipe 11 x 3 cm), small, creamish yellow pores, strongly reticulated stipe with pale reticulation up to the base, stipe context comparatively solid, white basal mycelium, and brown spore print are the key features of this specimen. This takes it close to genus *Boletus*. The taste could not be recorded so placement into the genus *Tylopilus*is limited. |
| *Boletus* Sp. 2<br><br>Fig. 3 J-M | In soil, under *P. roxburghii* in mixed woodland. CH (Thelisain), 2250 m, KCS 5024, July 8, 2022 | 10.6-14.7 x 3.7-4.5 µm, Q= 3.07, fusiform to elongate-fusiform, yellowish in 3% KOH. | A trichoderm, made up of thin-walled hyphae with terminal cylindrical cells, often with round apices. | A stout fruitbody (pileus 18-19 cm diam., stipe 10-11 x 3.4-3.8 cm), small, dark yellow, unchanged pores, with dark spots due to insect wounds, smooth, clavate stipe, whitish stipe context, yellowish basal mycelium, indistinct taste, mushroomy smell and light brown spore print are the key features; these take it close to genus *Boletus*. However, the genus *Boletus* featured white to cream-coloured hymenophore, stipe always covered with distinctly white reticulations and white basal mycelium. |
| *Borofutus dhakanus* Hosen & Zhu L.Yang<br><br>Fig. 3 N-R | On the wall, among moss, in *S. robusta* dominated forest; TP (Dehradun), 650 m, KCS 1721, Sept 2, 2013, and KCS 2573, Aug 28, 2016. | 11-15(-16) x (5.0-) 5.2-5.9(-6.4) µm, Q= 2.32, sub-amygdaliform to fusoid, surface finely verrucose, purplish violet in 3% KOH. | A trichoderm with terminal inflated cell. | This specimen description matches well with the *B. dhakanus* as described by (Hosen et al. 2013, Thongkantha et al. 2017, Parihar et al. 2014). It includes, subdecurrent hymenophore which appear tubular near junction to stipe, broad pores, curved stipe, whitish basal mycelium, somewhat similar coloured, shaped and sized basidiospores -[(10-)11–13(-14) × (4.5-)5–6(-6.5) µm, Q = 2.29±0.16, Hosen et al., 2013]. |
| *Cyanoboletus* cf. *brunneoruber* G. Wu & Zhu L. Yang<br><br>Fig. 3 S-W | On wall, among moss, under the canopy of *Q. leucotrichophora*and *M. esculenta;* DP (Pauri), 2000 m, KCS 2528, July 28, 2016.. | 9.0-11.5 x 3.3-4.5 µm, Q= 2.3, subfusiform and inequilateral in side view, yellowish brown, smooth. | Ixotrichoderm, made up of cylindrical, clavate terminal cells | The spores of this specimen are slightly smaller than the original description of *C. brunneoruber* from China [(9-)10-13(-14) x 4.5-5.5(-6) µm, Q= 2.35; Wu et al. 2016]. However, other macro- and micromorphological features align closely with the original description. Notably, the specimen exhibits a rapid bluing of the context and hymenophore when cut or bruised, a characteristic feature of this species. Additionally, it possesses ixotrichoderm pileipellis and smooth spores. The tomentose to velvety, rusty brown pileus and the reddish-brown hymenophore further evoke similarities to the genus *Neoboletus*. |

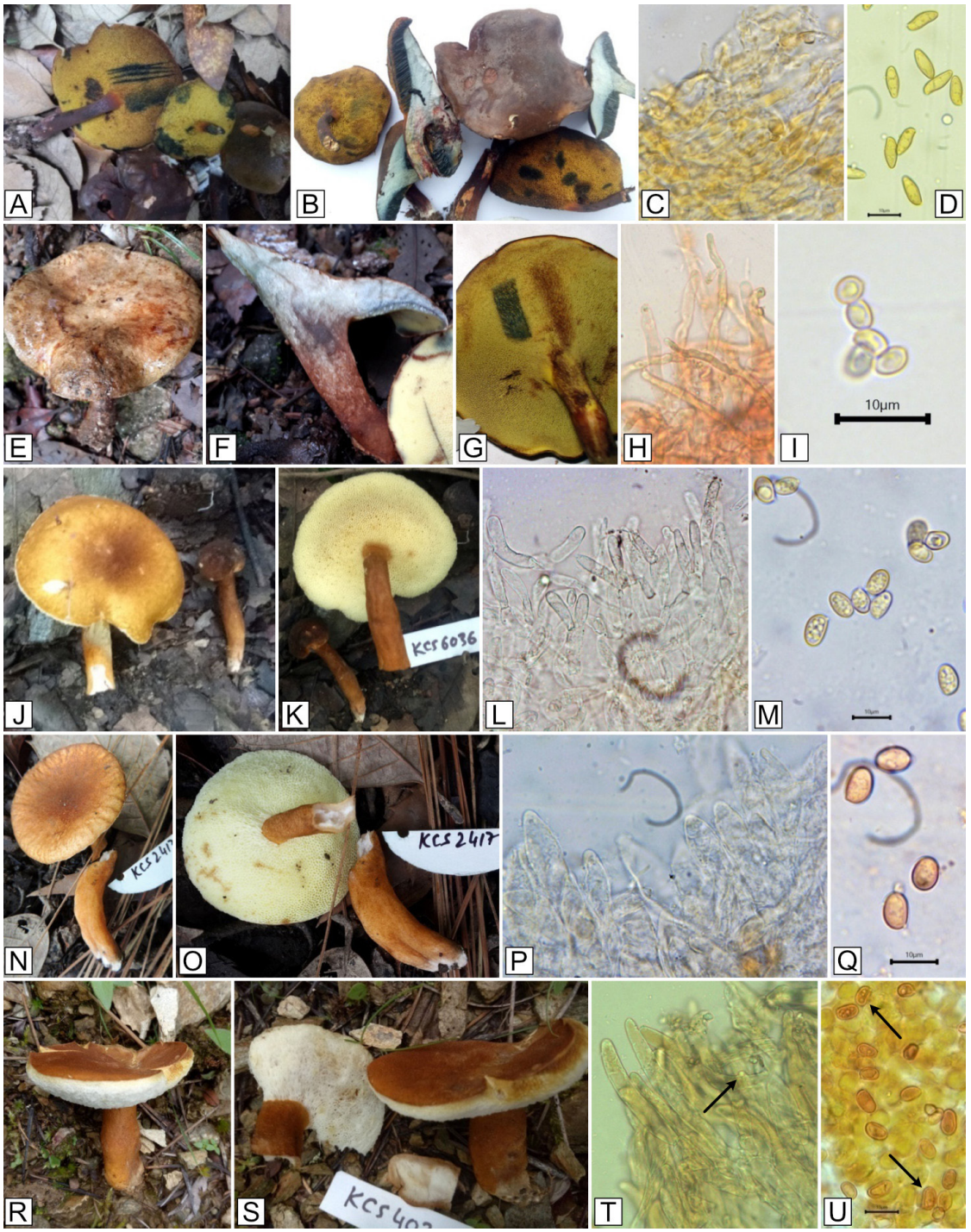


**Figure 4.** Photographic details of representative species. **A-B.** Fruit body of *Cyanoboletus* cf. *macroporus* (KCS 5008) with pore discoloration upon bruising; **C.** Ixocutis pileipellis with yellow content in 3% KOH; **D.** Basidiospores. **E.** *Gyrodon* cf. *lividus* (KCS 2535); **F.** T.S. through pileus showing blue discoloration upon exposure to air; **G.** Pores extending to stipe apex, showing discoloration (initially bluish-green, later yellowish-brown upon bruising); **H.** trichoderm pileipellis; **I.** Basidiospores. **J-K.** Fruit body with hymenophore of *Gyroporus* cf. *malesicus* (KCS 6036); **L.**Trichoderm with frequently septate, inflated, subfusiform to cylindric cells; **M.** Basidiospores. **N-O.** Fruit body of *Gyroporus pallidus* with pores (KCS 2417); **P.** Palisado-trichoderm with long-clavate, subfusiform to fusiform inflated cells; **Q.** Basidiospores. **R-S.** Fruit body of *Gyroporus* aff. *paramjitii* showing pores and fistulate stipe (KCS 4039); **T.** Pileipellis elements with clamps on septa (indicated by arrow); **U.** Ellipsoid basidiospores with a reniform shape in profile view (indicated by arrow).

**Table 5.** List of identified species, habitat, ecology, locality, elevation, collection numbers, collection dates, and key notes.

| Species name & Fig. No. | Specimen examined | Basidiospores micromorphology | Pileipellis elements | Commentary |
|---|---|---|---|---|
| *Cyanoboletus* cf. *macroporus* Sarwar, Naseer & Khalid<br><br>Fig. 4 A-D | On soil, under the canopy of *C. deodara;* CR (Dehradun), 2200 m; July 19, 2009. On wall, among mosses, under the canopy of *Q. leucotrichophora* and *M. esculenta.* DP (Pauri), 2000 m, KCS 3032, Aug 4, 2018 and KCS 5008, July 19, 2022. | 10.13-14.5 x 3.93-4.87 µm, Q= 2.77, subfusiform to elongate, inequilateral in side view, yellowish in water mount. | An ixocutis, made up repent to suberect hyphae with cylindrical terminal cells often with round and subventricose apices, yellowish pigmented in 3% KOH. | This species matches well with the description of *C. macroporus*, however, the spores are broader in the original description (12-14 × 4-7 µm, Sarwar et al. 2021, Das et al. 2023) and the pileipellis somewhat an ixocutis in the present specimen. |
| *Gyrodon* cf. *lividus* (Bull.) Sacc.<br><br>Fig. 4 E-I | In soil, under *Q. leucotrichophora* and *Aesculus indica,* in temperate forest; CW (Kumaun), 1900 m, KCS 1268, Aug 26, 2009; MN (Guptkashi), 1900 m, KCS 2429, Aug 11, 2016; BS (Thelisain), 2050 m, KCS 2535, Aug 2, 2015. | (3.6-)4.1-5.0 x 2.8-3.5 µm, Q= 1.44, ellipsoid, small. | A trichoderm, made up of thin walled, elongate cylindrical hyphae, septa with clamp connection, filled with yellow contents in 3% KOH. | The rough, areolated pileus surface, viscid when wet, yellow pores with a series of discoloration, first bluish green and later yellowish brown on bruising, staining blue context, septa with clamp connection, ellipsoid spores and brownish spore print are the key features of this specimen. |
| *Gyroporus* cf. *malesicus* Corner<br><br>Fig. 4 J-M | On the wall, among mosses, under the canopy of *Q. leucotrichophora.* BR (Pauri), 1800 m, KCS 6036, Aug 9, 2023; BS (Thelisain), 2050 m, KCS 4083, Sep 12, 2021. | 7.2-10.0(-12.5) x 5.0-6.0(-6.22) µm, Q= 1.49, ellipsoidal, sometimes reniform, light yellowish in water mount. | A trichoderm with erect cells, made up of thin walled frequently septate, branched cylindrical cells, light yellow in 3% KOH. | This species looks like *G. malesicus,* based on the absence of clamp connection in the septa of the hyphae. Although, the spores are slightly larger and less broad, 9–10× 5–5.5 µm (Xie et al. 2022, Horak 2011). Furthermore, according to Davoodian (2018), the clamps connections are present in the *G. malesicus.* Due to the ambiguous status of the presence of clamp connections, this species was kept as *Gyroporus* cf. *malesicus* in this text. |
| *Gyroporus pallidus* Ming Zhang & T.H. Li<br><br>Fig. 4 N-Q | Uunder the canopy of *Cinnamomum tamala*; KD (Rudraprayag), 1000 m, KCS 1097, Aug 13, 2007; among leaf litter of *Q. leucotrichophora,* on the roadside; LD (Pauri), 2100 m, KCS 2417, July 18, 2015; On the wall, among mosses; DP (Pauri), 2000 m, KCS 3030, Aug 4, 2018 | 7.6 – 9.8 x 5.0 – 6.0 (-6.3) µm, Q= 1.54, ellipsoid. | A palisado-trichoderm with cystidoid erect cells, made up of thin to slightly thick walled long-clavate to subfusiform, fusifrom cells with obtuse apex, light yellow in 3% KOH. | Based on the morphological and microscopic features including subtomentose pileus, roughened stipe and somewhat similar spores shape and size (8–10 × 5-6 µm, Q= 1.61, Ming et al. 2022) this specimen resembles *G. pallidus.* However, *G. punctatus* is another species that resembles to present specimen which was originally described from far east Russia (Ming et al. 2022) and Japan (Nagasawa 2001), but differs in its rugulose pileus, rugulose stipe, and larger basidiospores (up to 12 µm long, Nagasawa 2001). |
| *Gyroporus* aff. *paramjitii* K. Das, D. Chakr. & Vizzini<br><br>Fig. 4 R-U | On wall, among mosses, under *C. deodara*, HM (Pauri), 1950 m, KCS 4039, Aug 26, 2021. | 6.4-9.5 x 4.0-5.0 µm, Q= 1.62, ellipsoidal to reniform, light yellowish in water mount. | A trichoderm, made up of erect, long– cylindrical cells, with yellowish pigmentation and incrustations. | The characteristics of the current specimen closely resemble those of *G. paramjitii*, except for smaller spores [(7.5)–8.0–9.8–11.6– (13.0) × (4.8)–5.0–5.8–6.6–(7.0) µm, Das et al. 2017]. Additionally, this specimen was found in a habitat within a *Cedrus* stand while *G. paramjitii* occurred under the *Castanopsis* sp. |

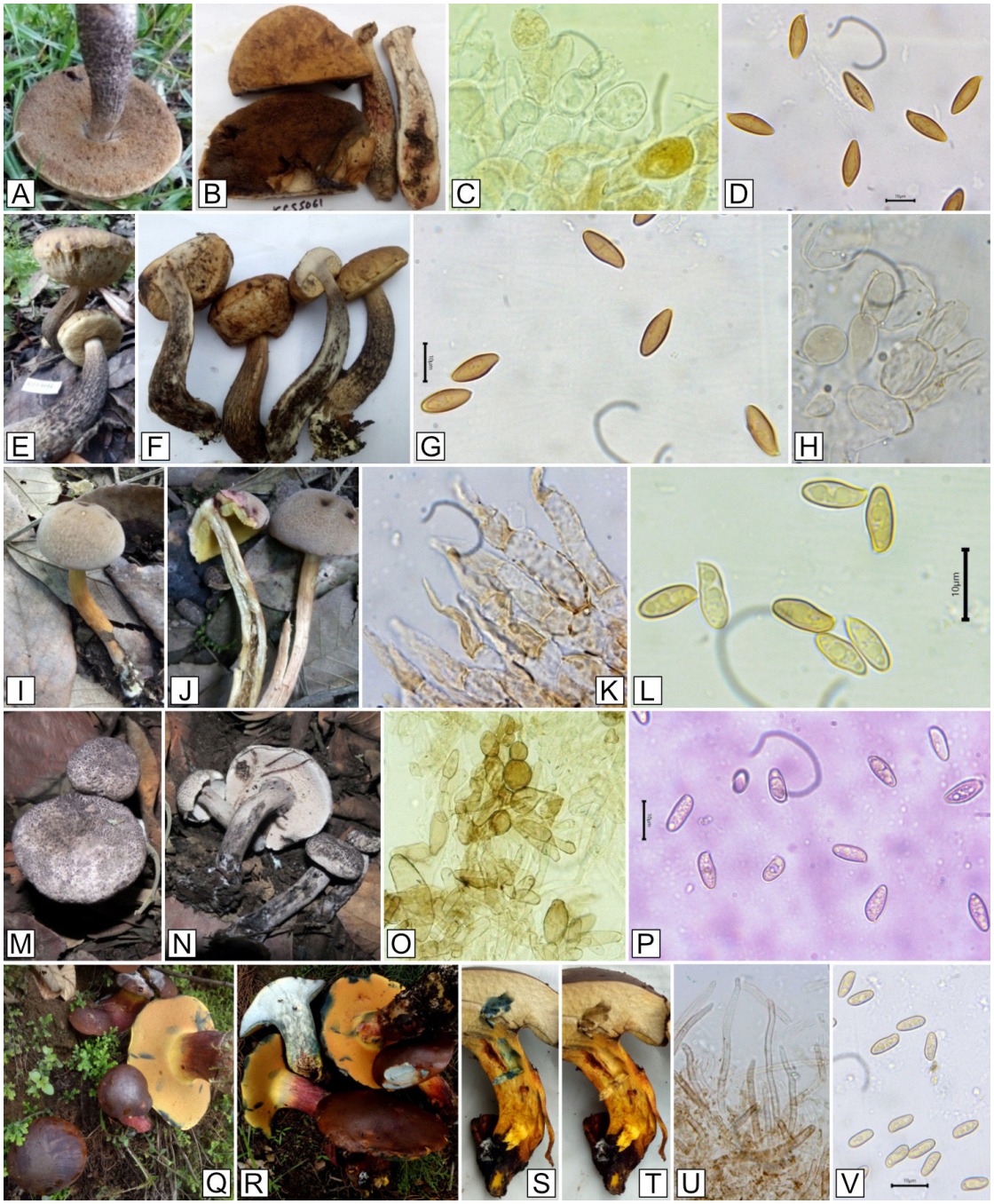


**Figure 5.** Photographic details of representative species. **A-B.** Fruit body of *Hemileccinum* Sp. 1 showing longitudinal dots on the stipe and reddening stipe context upon exposure to air (KCS 5061); **C.** Pileipellis consisting of an epithelium with concatenated, inflated cells; **D.** Basidiospores. **E-F.** Fruit body of *Hemileccinum* Sp. 2 showing longitudinal dots on the stipe and context reddening upon exposure to air, later blackening over time (KCS 4096); **G.** Pileipellis consisting of an epithelium with concatenated, inflated cells; **H.** Basidiospores. **I-J.** Fruit body of *Hortiboletus indorubellus* showing reddening on insect wounds on pileus and yellowish pores (KCS 5058); **K.** a palisadoderm pileipellis made up of vertically arranged, broadened, tapering terminal cells with golden-yellow incrusted hyphal elements; **L.** Basidiospores. **M-N.** Fruit body of *Indoporus shoreae* with pores (KCS 4000); **O.** Palisadoderm pileipellis with concatenated, inflated cells; **P.** Basidiospores. **Q-R.** Fruit body of ***Lanmaoa aff. macrocarpa*** (KCS 6009), showing blue staining of pores on bruising; **S-T.** Context staining greenish blue on exposure to air, later reverting to an earlier colour stage; **U.**Trichodermium pileipellis elements; **V.** Basidiospores.

**Table 6.** List of identified species, habitat, ecology, locality, elevation, collection numbers, collection dates, and key notes.

| Species name & Fig. No. | Specimen examined | Basidiospores micromorphology | Pileipellis elements | Commentary |
|---|---|---|---|---|
| *Hemileccinum* Sp. 1<br><br>Fig. 5 A-D | In soil, under the tress of *Q. leucotrichophora;* DP (Pauri) 2000 m, KCS 5061, Sept 9, 2022; TK (Pauri), 1890 m, KCS 5065, Sept 19, 2022; PH (Pauri), KCS 1782, Sept 2, 2013; TK (Pauri), 1900 m KCS 6031, Aug 5, 2023. | (14.5-)15.1-20.5(-24.0) x 5.0-6.8(-7.3) µm, Q= 3.00, elongate-fusiform to subfusiform, thick walled, light brownish in water mount. | An epithelium, made up of repeatedly septate hyphae with terminal broadly inflated, ellipsoid or subglobose, clavate-fusoid chained element. | The presence of broadly inflated, ellipsoid to subglobose cells, which form a distinct epithelial layer in the pileipellis, aligns this specimen with the genus *Hemileccinum* and distinguishes it from the closely related genus *Leccinum*. In *Hemileccinum*, the pileipellis is characterized by two distinct modifications of a trichoderm, consisting of cylindrical, filamentous hyphae and a limited number of terminal cells that are slightly broadened at the apex. Notably, the pileipellis undergoes significant changes during development, with the hyphae gradually expanding and becoming more inflated. As a result, the pileipellis often resembles a subepithelium composed predominantly of ellipsoid to subglobose cells (Sutara, 2008). This recorded specimen is mature and probably represents the modified pileipellis structure. While this specimen bears a resemblance to KCS 4051 and KCS 4096 (see next description), it can be differentiated by its larger and broader basidiospores. |
| *Hemileccinum* Sp. 2<br><br>Fig. 5 E-H | On the wall, among mosses and under the tress of *Q. leucotrichophora*; TK (Pauri), 1890 m, KCS 4051 and KCS 4096, Aug 29, 2021, and Aug 5, 2023; CH (Thelisain), 2050 m, KCS 6032, Sept 11, 2021. | (11.6-)12.3-16.6 x 4.7- 6.1 µm, Q= 2.68, fusiform to elongate, slightly thick walled, light brownish in water mount. | An epithelium, made up of repeatedly septate hyphae with terminal broadly inflated, ellipsoid or subglobose or clavate-fusoid chained elements. | The presence of broadly inflated, clavate-fusoid, chained elements in the pileipellis, yellow hymenophore and unchanging context are the key features of *Hemileccinum* to distinguish it from the closest genus *Leccinum.* This specimen looks like KCS 5061 and KCS 5065 but differs in having smaller basidiospores. |
| *Hortiboletus indorubellus* D. Chakr., K. Das, A. Baghela, S.K. Singh & Dentinger<br><br>Fig. 5 I-L | On the wall, among mosses, under the canopy of *Q. leucotrichophora*, GK (Pauri), 1900 m, KCS 4063, Sept 10, 2021; DP (Pauri), 2000 m, KCS 5058, Sept 9, 2022, and KCS 6049, Sept 17, 2023. | 10.1-12.6 x 3.5-4.3 µm, Q= 2.60, fusoid to subfusiform. | A palisadoderm, made up of elongate, vertically arranged, cylindrical cells with tapering or obtuse terminal ends, often yellowish brown and incrusted in lowers elements, light brown to hyaline in terminal cells. | The micro-morphological features of this specimen are consistent with those observed in *Hortiboletus indorubellus* which include the pileipellis arrangement and spore shape and measurements. |
| *Indoporus shoreae* A. Parihar, K. Das, Hembrom & Vizzini<br><br>Fig. 5 M-P | On soil, under *Shorea robusta*, *Tactona grandis* and *P. roxburghii*; KN (Satpuli), 780 m, KCS 1117, Aug 15, 2007; SM (Rishikesh), 650 m, KCS 4000, July 12, 2021; TP (Dehradun), 650 m, KCS 5019, July 29, 2022. | 9.3-11.6 x 3.7-4.6 µm, Q= 2.5, cylindrical, subfusiform, inequilateral, thin–walled, smooth. | An epithelium with concatenated, inflated cells, dark brown to blackish pigmented. | The occurrence in subtropical climate, *S. robusta* dominated forest in low altitude, the colour combination of the fruitbody and the elements of the pileipellis are the key features to take this specimen close to the *I. shoreae*. However, the spores are slightly larger in the original description 8.72-12.3-12.5- (18.4) -20 × 3.6-4.5-4.7-5.4 µm; Parihar et al. 2018). |
| *Lanmaoa* aff. *macrocarpa* N.K. Zeng, H. Chai & S. Jiang<br><br>Fig. 5 Q-V | Growing under the canopy of *Cupressus torulosa* D. Don, and *P. roxburghii*, on the wall, among moss. SK (Pauri), 1650 m, KCS 6009, July 16, 2023. | 8.6-10.4 x 3.0- 3.8 µm, Q= 2.76, ellipsoidal to subfusiform, brownish yellow in 3% KOH. | A trichodermium to subcutis, made up of thin walled hyaphe, terminal cells either round or obtuse with slightly clavate, and hyphae incrusted towards trama. | The unique combination of a dark reddish-brown, pileus, large fruit body (9-16 cm wide pileus; stipe 9.5-13.5 x 2.5-3.7 cm), yellowish pore surface, and a turmeric-yellow stipe apex with reddish streaks suggests resemblance to *Baorangia bicolor* (Kuntze) G. Wu, Halling & Zhu L. Yang, particularly due to the stipe coloration. However, this specimen was identified as *Lanmaoa macrocarpa* based on key features: the fruitbody stains blue immediately on handling or bruising, has a trichodermium pileipellis, and smooth spores. However, the spores are larger in original description [(9–)10–12(–13) × 4.5–5 µm, Q=2.39, Chai et al., 2019). Additional distinguishing characteristics include a creamish-yellow context staining blue, adnate hymenophore, pores staining blue on bruising, angular pores, yellowish tubes staining blue, finely pruinose-furfuraceous stipe, and white basal mycelium. Furthermore, while morphologically similar to *Suillellus* Murrill, it lacks amyloid hyphae at the stipe base. |

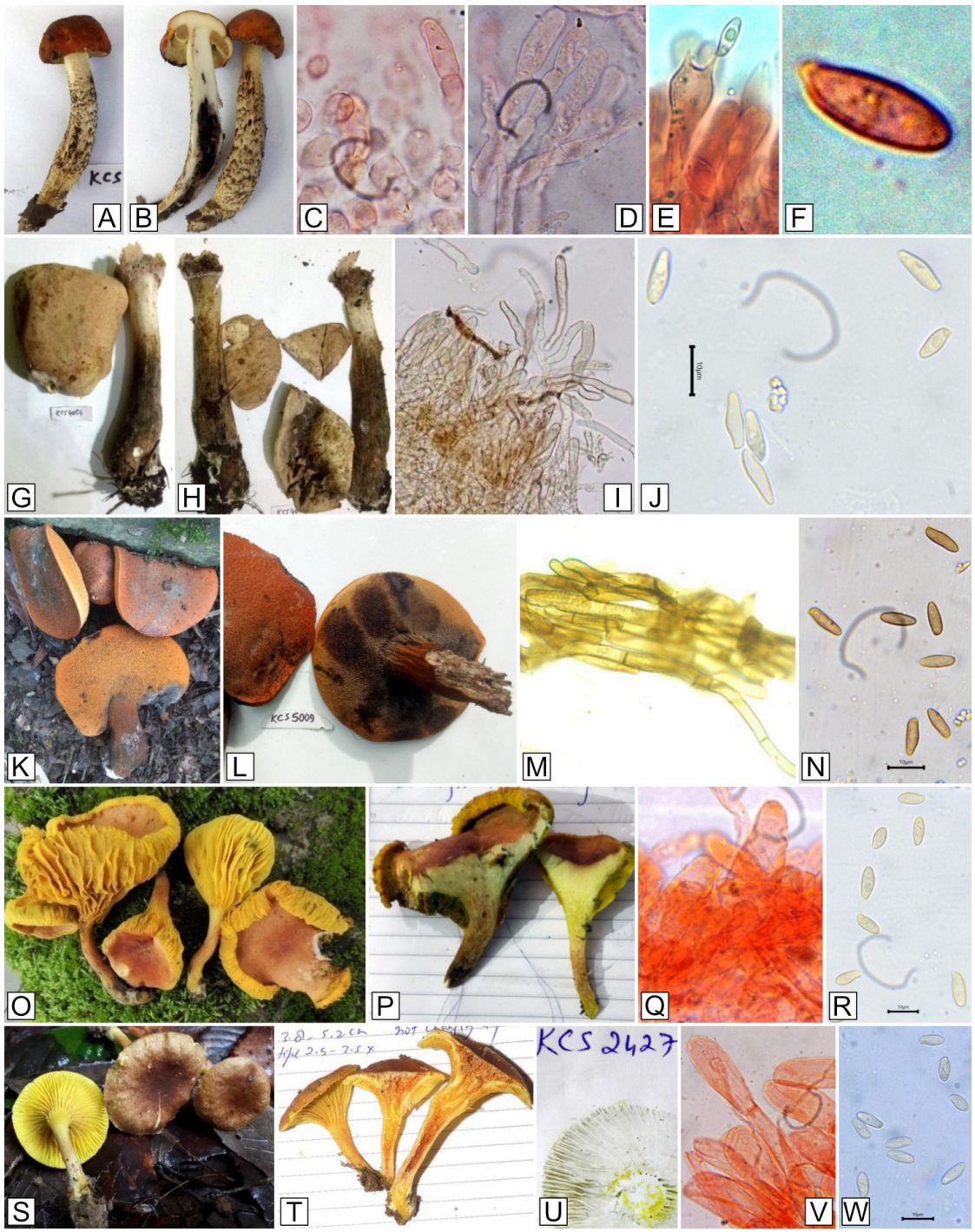


**Figure 6.** Photographic details of representative species. **A-B.** Fruit body of *Leccinellum* cf. *indoaurantiacum* (KCS 5045), showing dark dots on the stipe and blackening stipe context upon exposure to air; **C-D.** Ixotrichoderm pileipellis with inflated, short-cylindric to clavate terminal cells; **E.** Basidia showing immature spores; **F.** Basidiospores. **G-H.** Fruit body of *Leccinum* aff. *scabrum* with pores (KCS 4054); **I.** Trichoderm pileipellis with cylindrical to subcylindrical terminal cells; **J.** Basidiospores. **K-L.** Fruit body of cf. *Leccinum* Sp. (KCS 5009) with pores staining first greyish and then blackish upon bruising; **M.** Pileipellis showing a cutis; **N.** Basidiospores. **O-P.** Fruit body of *Phylloporus* cf. *attenuatus* showing greenish-blue staining on lamellae and partially on the context (KCS 2415); **Q.**Trichoderm pileipellis with inflated cylindrical cells; **R.** Basidiospores. **S-T.** Fruit body of *Phylloporus* aff. *luxiensis* showing no color change or staining on bruising on either lamellae or context (KCS 2427); **U.** Olive-brown spore print; **V.** Pileipellis elements; **W.** Basidiospores.

**Table 7.** List of identified species, habitat, ecology, locality, elevation, collection numbers, collection dates, and key notes.

| Species name & Fig. No. | Specimen examined | Basidiospores micromorphology | Pileipellis elements | Commentary |
|---|---|---|---|---|
| *Leccinellum* cf. *indoaurantiacum* D. Chakr., K. Das, A. Baghela, S.K. Singh & Dentinger<br><br>Fig. 6 A-F | In soil, under *Q. leucotrichophora,* PH (Pauri), 2100 m, KCS 5045, Sept 3, 2022. | 10.5-15.5 x 5.5- 4.6 µm, smooth. | An ixotrichoderm, made up broadly–inflated, broadly- ellipsoid, clavate-fusoid to short cylindrical terminal elements, frequently septate, embedded in getalinized matrix. | The present collection featured a small fruitbody with a small reddish-orange pileus (2.5 cm diam., stipe- 6.5 x 0.8 cm), yellowish hymenophore, staining brownish when hurt, greyish beige tubes, black to blackish brown small squamules or dots, mostly near the middle to downwards on the stipe surface, and ixotrichodermium type pileipellis. *Leccinellum indoaurantiacum* reported from India (Li et al. 2016) bears a resemblance to this specimen but can be distinguished by its unchanging pore surface and tube, yellowish stipe surface, fusoid-ventricose to clavate pleurocystidia, and its habitat at high altitudes under *Betula* sp. However, our specimen was not fully matured, and only a few spores were observed, making spore measurement changeable (See Fig. 5. Q-R). Further confirmation of the species requires a mature specimen. |
| *Leccinum* aff. *scabrum* (Bull.) Gray<br><br>Fig. 6 G-J | In soil, under *Q. leucotrichophora;* MD (Kaljikhal), 2050 m, KCS 2445, Aug 12, 2015; CK (Pauri), 1950 m, KCS 4054, Aug 31, 2021; GK (Pauri), 1950 m, KCS 4062, Sept 10, 2021; CH (Theilisain), 2290 m, KCS 4092, Sept 13, 2021. | (9.8-)10.2-13.5(-14.5) x 3.1-4.3 µm, Q= 3.20, fusiform, inequilateral, slightly thick walled, brownish yellow in 3% KOH. | A trichoderm pileipellis with cystidoid to subcylindrical terminal elements, with round ended apices. | A trichoderm with cystidoid, subcylindrical cells is the key feature of Leccinum and this characteristic feature distinguishes it from *Hemileccinum* in which the broadly– inflated, concatenated cells occur in pileipellis. However, the spores are smaller in the present specimens as compared to the reports from India and China (15.2-18.1-22 × 4-5.3-6.2 µm, Q = 3.44, Das and Chakraborty 2014; (16-)17-20(-21) x 6-7(-7.5) µm, Q = 2.79, Wu et al. 2016). |
| Cf. *Leccinum* Gray<br><br>Fig. 6 K-N | Below stone, on a wall, among mosses, under the canopy of *Q. leucotrichophor;* DP (Pauri), 2000 m, KCS 5009, July 19, 2022, and KCS 5038, Aug 31, 2022. | (8.5-)9.1-11.8(-15.3) x 3.1-3.9 µm, Q= 3.01, 3.01, long-fusiform to elongate, slightly thick walled, light yellowish-brown in 3% KOH. | A subcutis composed of erect, thin-walled hyphae with brown-pigmented, cylindrical terminal cells, often with rounded ends and golden-brown incrustations. | This specimen appears distinctive due to its orangish-red pileus with appressed, darker squamules; chrome-orange pores that stain greyish and then blackish upon bruising; longitudinally rugulose stipe covered with blackish dots; and context that stains blackish on wounds and exposure to air. Additional features include a subcutis pileipellis with yellowish-brown incrustated hyphae, a brownish spore print in mass, long fusiform to elongate, thick-walled spores, and a pleasant smell. These characteristics align the specimen closely with *Leccinum*, particularly based on traits such as hymenophore staining blackish, blackish dots, longitudinal ridges on the stipe surface, and longer basidiospores. However, it differs by exhibiting chrome-orange hymenophore, whereas *Leccinum* species typically display greyish, brownish, or yellowish hymenophores, but never pink or pinkish tones (Wu et al. 2016). Further confirmation requires molecular studies. |
| *Phylloporus* cf. *attenuatus* Iqbal Hosen<br><br>Fig. 6 O-R | On soil and wall among mosses, under *Q. leucotrichophora, S. recemosa, C. deodara* and *C. tamala*; MW (Kumaoun), KCS 1280, Aug 26, 2009; LD (Pauri), 2100 m, KCS 2415, July 18, 2015; MN (Guptkashi), 1900 m KCS 3079, Aug 22, 2018; KH (Pauri), 1850 m, KCS 4012, Aug 10, 2021. | 9.3-11.8 (-12.3) x (3.84-) 4.10- 4.98 µm, Q= 2.32, subfusiform to fusiform, inequilateral. | A trichoderm, composed of thin-walled hyphae with terminal cylindrical to clavate cells featuring obtuse apices. | Based on certain features including the pileus colour, context and lamellae staining bluish green, stipe tapering towards base, white basal mycelium, cylindrical terminal cells in pileipellis, fusoid to narrowly fusoid pleurocystidia without encrustations take this specimen closer to *P. attenuatus* reported from Bangladesh. However, it differs based on the following features: habitat in *Shorea robusta* tree dominated forest, smaller spores, with Q value (7-8 (-9) × 4-5 µm, 1.84 and bacillate spores (Hosen and Li 2017), However, for the bacillate ornamentation of the spores statement the SEM study of spores needed for this collection. |
| *Phylloporus* aff. *luxiensis* M. Zang<br><br>Fig. 6 S-W | On the soil and wall among mosses, under *Q. leucotrichophora.* DR (Champawat), 1950 m, KCS 1322, Aug 28, 2009; HM (Pauri), 1950 m, KCS 1431, Aug 6, 2010; DP, (Pauri), 2000 m, KCS 2427, Aug 1, 2015. | (7.5-)8.2–10.3 x 3.1-4.2 µm, Q= 2.53, ellipsoid to fusiform. | A trichoderm, made up of thin-walled hyphae with cylindrical terminal cells often with round and narrowing apex. | This species is characterized by small fruitbody (pileus 3.8-5.2 diam., brownish to yellowish brown; stipe 2.5-3.5 x 0.4-0.7 cm), unchanging lamellae and context on bruising or exposure to air while other species of the genus *Phylloporus* staining blue. Furthermore, yellow basal mycelium, olive-yellow spore print, and depressed pileus are other features which take it close to *P. luxiensis*. However, the spores are slightly larger in it (10)-12 × (4-)4.5-5 µm, Q= 2.26, Zeng et al. 2011) and the pileipellis is not much with uninflated cells, which is somewhat a distinguished feature of this taxon (Zeng et al. 2013). |

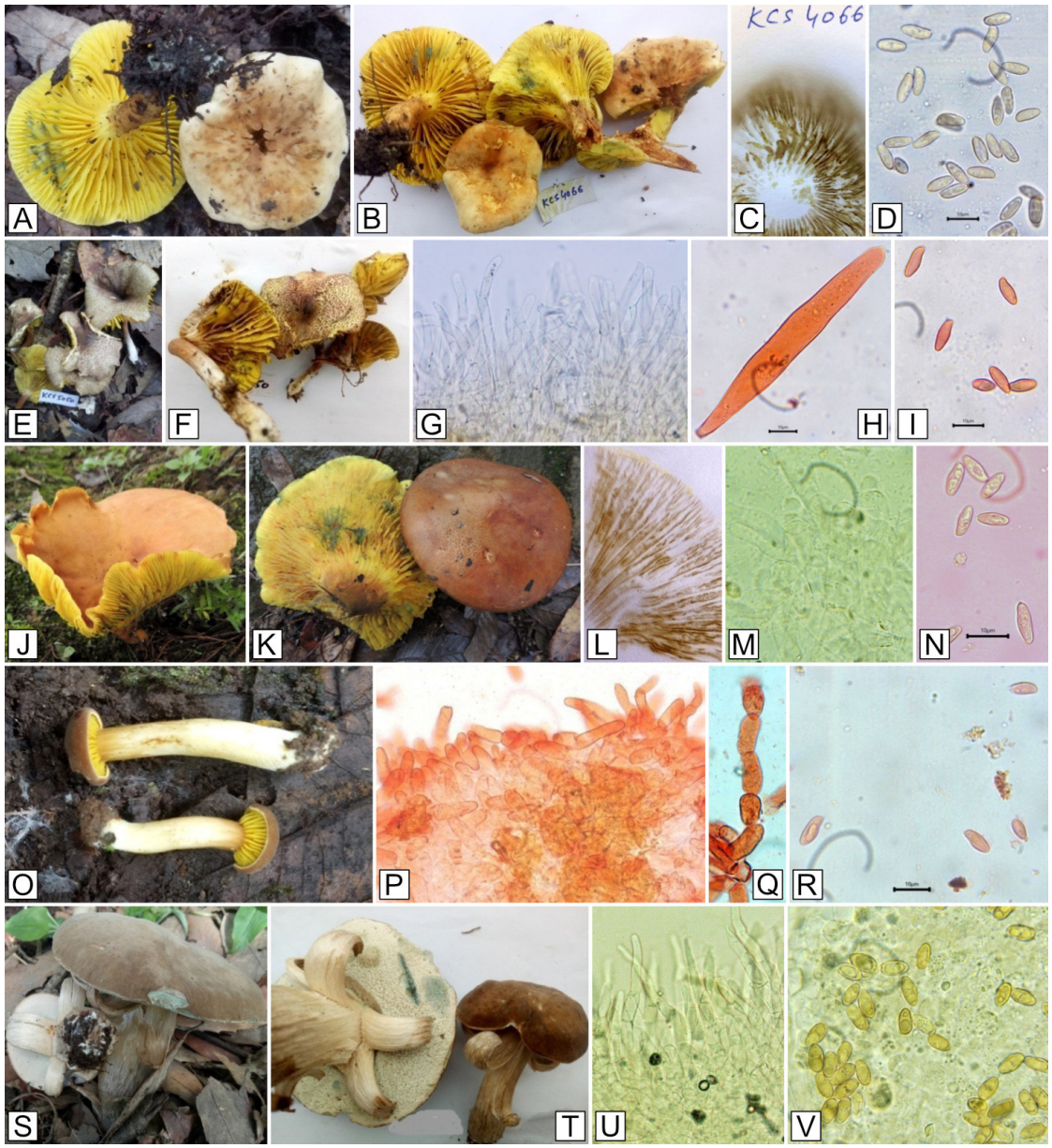


**Figure 7.** Photographic details of representative species. **A-B.** Fruit body of *Phylloporus maculatus* with lamellae staining greenish-blue on bruising (KCS 4066); **C.** Olive-brown spore print; **D.** Basidiospores. **E.** Fruit body of *Phylloporus* aff. *megacystidiatus* (KCS 5050); **F.** Lamellae showing a blue tinge on bruising, with the cap having a slight purplish tinge; **G.** Trichoderm pileipellis with inflated cylindrical cells; **H.** Long pleurocystidia; **I.** Basidiospores. **J-K.** Fruit body of *Phylloporus* sp. 1 showing greenish-blue staining on lamellae (KCS 2531); **L.**Trichoderm pileipellis with inflated cylindrical terminal cells; **M.** Orangish-brown spore print; **N.** Basidiospores. **O.** Fruit body of *Phylloporus* sp. 2 (KCS 4060); **P-Q.** Trichoderm pileipellis with inflated cylindrical, frequently septate cells, with round apices; **R.** Basidiospores. **S-T.** Fruit body of *Porphyrellus* aff. *griseus* with pores staining olive-bluish on bruising (KCS 5006); **U.**Trichoderm pileipellis with sub-cylindrical cells having obtuse ends; **V.** Basidiospores.

**Table 8.** List of identified species, habitat, ecology, locality, elevation, collection numbers, collection dates, and key notes.

| Species name & Fig. No. | Specimen examined | Basidiospores micromorphology | Pileipellis elements | Commentary |
|---|---|---|---|---|
| *Phylloporus maculatus* N.K. Zeng, Zhu L. Yang<br><br>Fig. 7 A-D | Among mosses, under the canopy of *Q. leucotrichophora;* KD (Guptkashi), 1000 m, KCS 1094, Aug 13, 2007; GK (Pauri), 1950 m, KCS 4066, Sept 10, 2021. | 8.7-11.5 x 3.8- 4.4 µm, Q= 2.46, ellipsoid to oblong, subfusoid, spore print olive brown. | A trichoderm, made up of cylindrical terminal cells with round apices. | The description of this specimen closely matches that of *P. maculatus* as reported by Chakraborty et al. (2018b). However, the spores in the present collection are slightly larger (10–11.6–12.5 × 3.6–4.0–4.5 µm, with a Q value of 2.38–2.6–3.1). |
| *Phylloporus* aff. *megacystidiatus* L. Ye, P.E. Mortimer, J.C. Xu & K.D. Hyde<br><br>Fig. 7 E-I | On the wall, among moss, under the canopy of *Q. leucotrichophora*; DP (Pauri) 2000 m, KCS 5050, Sept 9, 2022. | (8.9-)10.0-12.4(-16.5) x 3.7-4.7 µm, Q= 2.64, subfusiform. | A trichoderm, made up of thin-walled hyphae with subcylindrical cells often with round and narrowing apex. | The presence of large pleurocystidia and cheilocystidia are key features of this species, as reported by Ye et al. (2014). The overall characteristics of this specimen closely align with the description of *P. megacystidiatus*, including larger pleurocystidia dimensions (84-110 × 11-14 µm in Ye et al. 2014, compared to 78-106 × 9-17 µm in the present collection). However, the habitat of the present specimen is oak-dominated forests, whereas *P. megacystidiatus* is typically associated with tea plantations (Ye et al. 2014) |
| *Phylloporus* Sp. 1<br><br>Fig. 7 J-M | On the wall, among the green grasses, under the canopy of *C. deodara;* KT (Pauri), 1900 m, KCS 2531, July 30, 2016, and KCS 3042, Aug 15, 2018. | (6.8-) 7.6 – 11.0 x 3– 4.3 µm, Q= 2.31, subfusiform to ellipsoid or subfusoid. | A trichoderm, with inflated cylindrical terminal cells, mostly with round apices | Medium to large sized pileus (10-11.5 cm diam.; comparatively small stipe, 3-4.5 x 1.0-1.3 cm), cinnabar or red-orangish brown pileus with slightly rimose surface outwards, olive green staining lamellae and context on bruising or cut, yellowish to reddish, brownish red stipe, yellowish context, whitish basal mycelium, a trichodermium pileipellis, subfusiform to ellipsoid or subfusoid spores and orangish brown spore print are the key features of the present *Phylloporus* sp. 1. |
| *Phylloporus* Sp. 2<br><br>Fig. 7 O-R | Growing on wall, among moss; AD (Pauri), 1950 m, KCS 4060, Sept 5, 2021. | 7.62-9.48 x 3.6- 4.1 µm, Q= 2.22, subfusiform to ellipsoid. | A trichoderm pileipellis with inflated cylindrical, frequently septate cells with round apices. | The key features of this *Phylloporus* sp.2 include velvet, light brown to greyish brown, tiny pileus (1.8 cm), small but thick, cylindrical stipe (3.6-4.7 x 0.8-1.0 cm), recurved margin, thick yellowish lamellae, white stipe and small spores. |
| *Phylloporus* Sp. 3 | On the wall, among moss, under the canopy of *Q. leucotrichophora;* DP (Pauri) 2000 m, KCS 5052, Sept 9, 2022**.** | 7.8-10.1 x 3.3- 4.2 µm, Q= 2.42, subfusiform to ellipsoid or subfusoid. | A trichoderm, made up of thin-walled hyphae with terminal cylindrical cells, mostly with round apices. | Medium-sized fruit body, brownish, cracked or rimose, slightly depressed pileus, unchanged lamellae and context, creamish white, peeled of stipe with whitish basal mycelium, a trichodermium pileipellis, ventricose pleurocystidia, subfusiform to ellipsoid-fusiform spores are the key features of the present *Phylloporus* sp. 3 |
| *Porphyrellus* aff. *griseus* Yan C. Li & Zhu L. Yang.<br><br>Fig. 7 S-V | Growing among green grasses, under the canopy of *Q. leucotrichophora*; CK (Khirsu), 1950 m, KCS 5006, July 15, 2022. | (7.5-) 8 – 10 (– 11.5) x 4.2 – 5.3 µm, Q= 1.89, ellipsoid to subovate, yellowish in 3% KOH. | A trichoderm pileipellis, made up of thin walled, cylindrical to sub-cylindrical cells with obtuse terminal ends. | This taxon is characterized by a medium to large fruit body (pileus 7-11 cm diameter, stipe 8.2-12 × 1.4-2.9 cm), a greyish-brown to pale-brown velvety pileus when young, rimose and dry texture, and a light wheatish hymenophore with roundish, marginate pores. The pores stain olive green initially, turning pinkish-brown upon bruising. The context is solid, pinkish-white, and stains light olive green above the hymenophore. Key features include ellipsoid to subovate spores and a trichodermium pileipellis with cylindrical to sub-cylindrical terminal cells. The stipe surface peels off in a recurved manner, even in younger specimens. These features place the taxon near *P. griseus*, though its spores (9.5-11.5 × 4.5-5 µm, Q = 2.18) are slightly larger (Li and Yang 2021). Molecular and phylogenetic studies are needed for confirmation. |

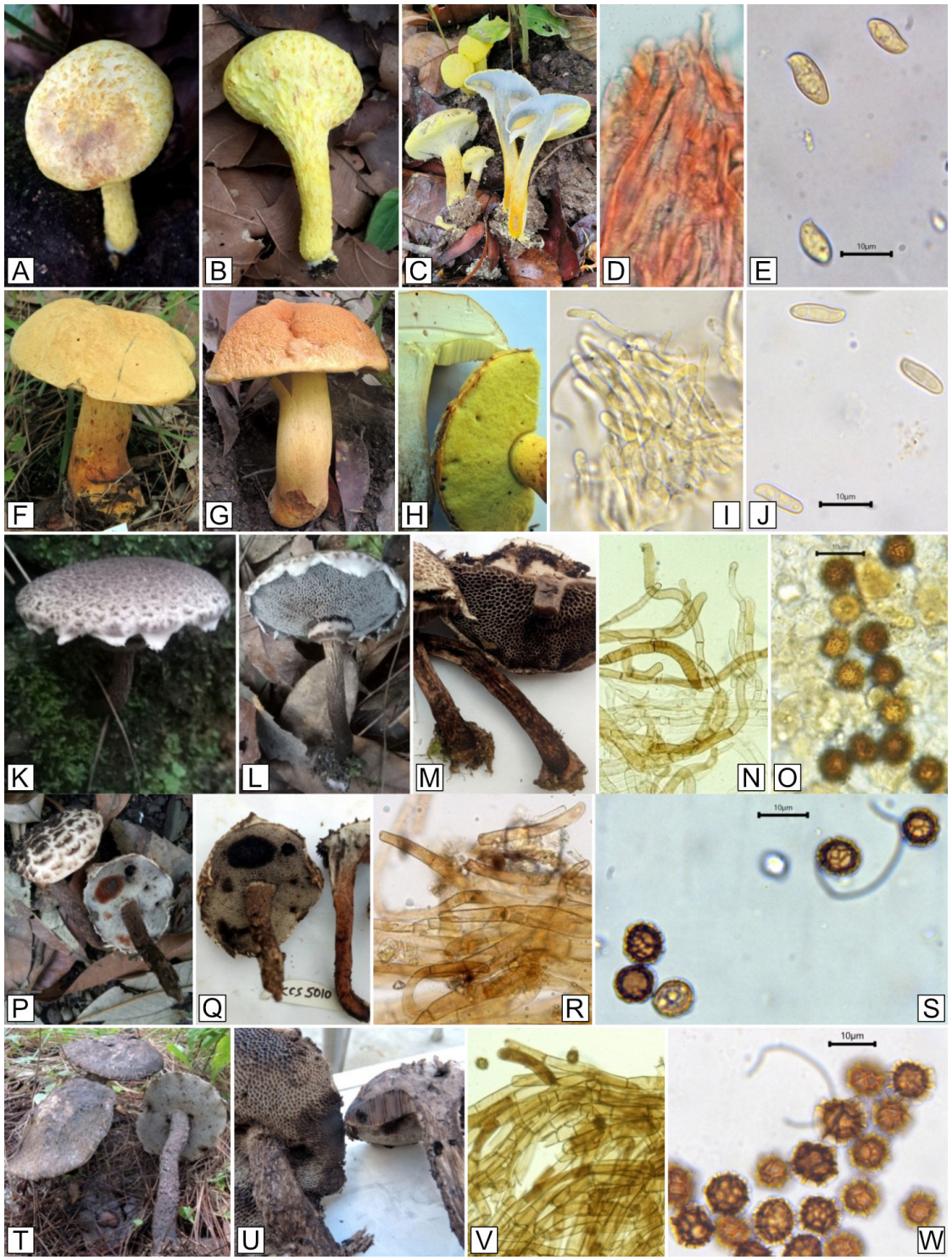


**Figure 8.** Photographic details of representative species. **A.** Fruit body of *Pulveroboletus* aff. *flaviscabrosus* (KCS 1711); **B.** Veil covering the entire fruit body in young specimens; **C.** context staining bluish on exposure to air; **D.** Trichoderm pileipellis with inflated cylindrical cells; **E.** Basidiospores. **F-G.** Fruit body of *Rugiboletus extremiorientalis* (KCS 4004); **H.** Solid context and pores; **I.** Pileipellis elements; **J.** Basidiospores. **K-L.** Fruit body of *Strobilomyces* aff. *confusus*, showing a prominent annulus at the stipe apex (KCS 5057); **M.** T.S. through pileipellis staining pinkish; **N.** Pileipellis elements; **O.** Basidiospores. **P-Q.** Fruit body of *Strobilomyces* aff. *echinocephalus* with pores staining rusty brown and then blackish (KCS 5010); **R.** Pileipellis elements; **S.** Basidiospores. **T-U.** Fruit body of *Strobilomyces* cf. *glabriceps* showing pores and context (KCS 4010); **V.** Pileipellis elements; **W.** Basidiospores.

**Table 9.** List of identified species, habitat, ecology, locality, elevation, collection numbers, collection dates, and key notes.

| Species name & Fig. No. | Specimen examined | Basidiospores micromorphology | Pileipellis elements | Commentary |
|---|---|---|---|---|
| *Pulveroboletus* aff. *flaviscabrosus* N.K. Zeng & Zhu L. Yang,<br><br>Fig. 8 A-E | In soil, under *S. robusta.* TP, (Dehradun), 600 m; KCS 1711, Sept 2, 2013; under unidentified broadleaved tree species, KL (Satpuli), 750 m, KCS 2481, Aug 28, 2015. | 9.2-12.8 x 5.0- 6.0 µm, Q= 1.94, subfusoid to ellipsoid, smooth, yellowish in water and 3% KOH. | A trichoderm pileipellis with clavate, subcylindrical terminal hyphal ends. | This specimen aligns well with the genus *Pulveroboletus* and matches *P. flaviscabrosus* based on basidiospore shape and size (9–12(-13) × (4.5-) 5–6(-6.5) µm; Q = 2.01; Zeng et al. 2017), as well as the pileus color and floccose, densely arranged yellowish squamules. However, it differs by having a completely lemon-yellow stipe without a reddish tinge and its occurrence at lower altitudes in *Shorea robusta* dominated Dipterocarpous forests. |
| *Rugiboletus extremmiorientalis* (Lj. N. Vassiljeva) G.Wu & Zhu L. Yang<br><br>Fig. 8 F-J | In soil, under the canopy of *Q. leucotrichophora, P. roxburghii,* and in the under pure stand of *Cedrus deodara*; TK (Pauri), 1950 m, KCS 4004, July 31, 2021; HM (Pauri), 2000 m, KCS 4014, Aug 10, 2021; BR (Pauri), 1800 m, KCS 4016, Aug 13, 2021; CH (Pauri), 2250 m, grows under the canopy of *Q. leucotrichophora, Corylus jacquemontii* and *Alnus nepalensis,* KCS 5026, Aug 8, 2022. | (9.5-)10.5-12.0 x 3.0-4.0 µm, Q= 3.21, long ellipsoid to fusiform, smooth, light yellowish brown in 3% KOH. | A trichoderm, with cylindrical terminal hyphal cells with round ends, yellow in 3% KOH. | This specimen shows a 99.47% match with *R. extremiorientalis* in the NCBI Blast result, though the spores are smaller (11-13 × 4-5(-5.5) µm; Q = 2.81; Wu et al. 2016) compared to the original description. |
| *Strobilomyces* aff. *confusus* Singer<br><br>Fig. 8 K-O | In soil, under *Q. leucotrichophora, S. robusta*; MD (Kaljikhal), 1950 m, KCS 5034, Aug 12, 2022; DP (Pauri), 2000 m, KCS 5057, Sept 9, 2022; KN (Satpuli), 700 m, KCS 1113, Aug 15, 2007. | 6.7-8.5 x 5.2-6.7 µm, Q= 1.27, broaly ellipsoid to subglobose, incomplete and low reticulation, brownish in 3% KOH. | A trichodermium pileipellis, made up of inflated cells with terminal cylindrical cells with rounded ends, thin to slightly thick walled, often brown in 3% KOH. | This specimen aligns somewhat with the description of *S. confusus*, which includes a pileus covered with medium-sized, appressed, spiny scales (Singer 1986), a context that quickly turns reddish-orange and fades to black on exposure, and the presence of an annulus on the stipe apex. However, the spores in the original description are larger [(8. 8-)10.5-12.5 × (8.2-)9.5-10.5(-11.2) µm; Gelardi et al. 2013]. While *S. confusus* is widely distributed across North and Central America and East and Southeast Asia (Gelardi et al. 2013), its presence in the northern Indian Himalaya is plausible. *Strobilomyces annualatus* Corner is another close species due to its annulated stipe but differs significantly with larger spores (9.5-11.5 × 7-10 µm, Q = 1.3; Han et al. 2020, Corner 1972). |
| *Strobilomyces* aff. *echinocephalus* Gelardi & Vizzini<br><br>Fig. 8 P-S | In soil, among moss, under the canopy of *Q. leucotrichophora*; CW ( Kumaoun), 1950 m, KCS 1265, Aug 26, 2009; DP (Pauri) 2000 m, KCS 5010, July 19, 2022. | 7.4 – 9.15 × (-10.8) x (6.3-) 6.8 – 7.8 (-9.08) µm, Q= 1.13, broadly ellipsoid to subglobose, sometimes globose, complete reticulation with low ridges (up to 1.15 µm high), brownish in 3% KOH. | A trichodermium pilepellis, made up of suberect to repent hyphae with cylindrical to subcylindrical terminal cells often with round apices, brownish in 3% KOH and water mount. | The small to medium-sized fruitbody (pileus 4.5–5.5 cm diam., stipe 6.5–8 × 0.5–0.8 cm) features a whitish pileal surface covered with blackish-brown scattered scales, pointed in the middle and patchy-fibrillose outward. The hymenophore stains rusty brown, later turning blackish on bruising or exposure. The spore dimensions [(6.2-)8.5 ± 1.03(-10.8) × (5.6-)7.1 ± 0.79(-9.5) µm, Q = 1.18] are broadly ellipsoid to subglobose and ornamented with complete reticulation, taking this specimen close to *S. echinocephalus*. However, it differs in lacking the context's rapid greyish-black staining within minutes, bypassing reddish or rusty hues (as noted by Gelardi et al., 2013). Instead, the context transitions slowly from rusty brown to blackish upon cutting. Its occurrence in *Quercus leucotrichophora*-dominated forests also sets it apart from *S. echinocephalus*. |
| *Strobilomyces* cf. *glabriceps* W.F. Chiu<br><br>Fig. 8 T-W | In soil, among the leaf litter of *P. roxburghii*; TK (Pauri), 1950 m; KCS 4010, July 31, 2021. | (7.25-)8.0-10(-10.5) × (6.7-)7.3-9.5 µm, Q= 1.07, globose or subglobose, with complete reticulation and ridges very high up to 2.25 µm, brownish in 3% KOH; spore print black. | A trichodermium pilepellis, made up of suberect to repent erect to suberect hyphae with cylindrical to subcylindrical terminal cells. | This specimen is distinguished by its large fruitbody (pileus 9.2-11.5 cm wide, stipe 12.5-17 × 1.1-1.6 cm), slender, long stipe, minute appressed fibrillose-scaly pileus covering, and basidiospores with complete reticulation and high ridges. Micromorphologically, it resembles *S. glabriceps* W.F. Chiu in terms of basidiome shape and size, spore dimensions, ornamentation height, and staining context (9.0-15.0 cm diam.; spores 9-11 × 7.5-9.5 µm, Q = 1.21; 2-4 µm ornamentation). However, the large Q values of spores and the presence of an annulus differ from the current collection. *S. verruculosus* Hirot. Sato is somewhat similar but has a shorter and thicker stipe (5-12 × 1-3.5 cm), incomplete reticulation, and smaller basidiospores with lower ridge ornamentation (7.8-9.5 × 7.4-8.6 µm, Q = 1.06; ornamentation 1-1.5 µm high; Sato and Murakami 2009). Alternatively, *S. longistipitatus* D. Chakr., K. Das & S. Adhikari shares a similar stipe size (11.0-20.0 × 1.7-2.8 cm) and high spore ornamentation but differs in its smaller pileus (3.7-5.0 cm diam.) and broadly ellipsoid spores (10-11.1-12.7 × 8-9.1-9.9 µm; Tibpromma et al. 2017). |

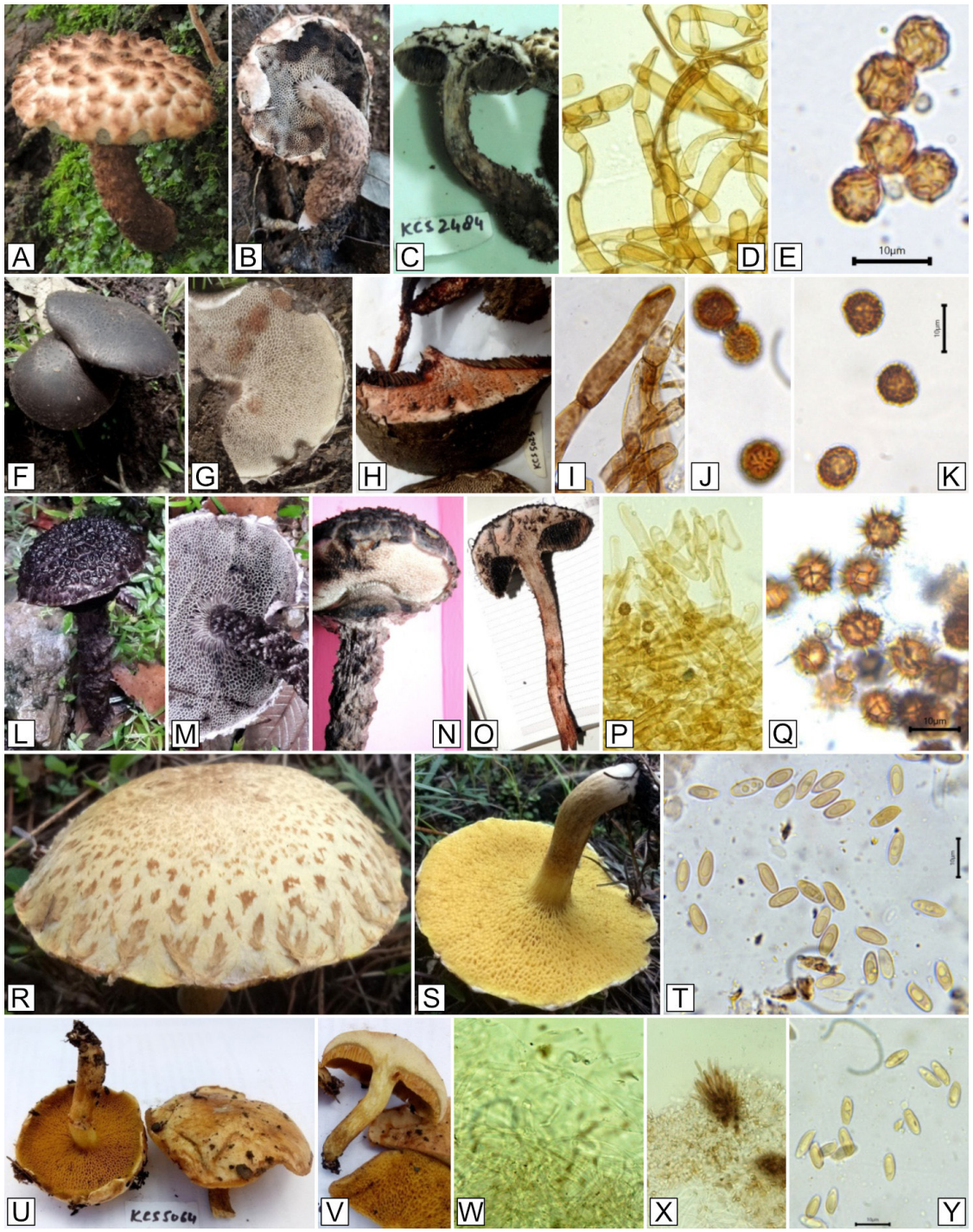


**Figure 9.** Photographic details of representative species. **A-B.** Fruit body of *Strobilomyces rubrobrunneus* with pores and reticulated stipe apex due to the decurrence of tubes (KCS 2484); **C.** Pileus and stipe context staining greyish black upon exposure to air; **D.** Pileipellis elements; **E.** Basidiospores. **F-G.** Fruit body and pores of *Strobilomyces* aff. *seminudus* (KCS 5025); **H.** Context staining pinkish red; **I.** Pileipellis elements; **J-K.** Basidiospores showing low ornamentation. **L-M.** Fruit body of *Strobilomyces* aff. *strobilaceus* with pores (KCS 2426); **N.** Presence of annulus in younger fruit body; **O.** Context turning pinkish on exposure to air; **P.** Pileipellis elements; **Q.** Basidiospores with complete reticulation and high ridges. **R.** Fruit body of *Suillus* cf. *americanus* with brownish scales on the pileus (KCS 5055); **S.** Yellow, broad pores; **T.** Basidiospores. **U-V.** Fruit body of *Suillus* aff. *indicus* and T.S. through pileus showing no colour change in context (KCS 5064); **W.** Ixotrichoderm pileipellis; **X.** 'Suillus-type' fasciculate oleocystidia with dark wine-brown content in hymenium; **Y.** Basidiospores.

**Table 10.** List of identified species, habitat, ecology, locality, elevation, collection numbers, collection dates, and key notes.

| Species name & Fig. No. | Specimen examined | Basidiospores micromorphology | Pileipellis elements | Commentary |
|---|---|---|---|---|
| *Strobilomyces mirandus* Corner | On soil under *Q. leucotrichophora* and *C. tamala;* KD (Guptkashi), 1160 m, KCS 1102, Aug 13, 2007; and KCS 2556, Aug12, 2016. | 7.2-8.8(-10.5) × 6-6.9(-7.7) µm, Q= 1.17, subglobose or broadly ellipsoid, with complete reticulation, brownish in 3%KOH. | A trichodermium pilepellis, made up of erect to suberect hyphae with cylindrical to subcylindrical terminal cells. | Morphological features of the present specimen conform to *S. mirandus,* reported from different Asian countries like Malaysia, Japan and China (Corner 1972, Sato et al. 2005, Ge and Yang 2005) and India (Chakraborty et al. 2017b). |
| *Strobilomyces rubrobrunneus* L.H. Han & Y.J. Hao<br><br>Fig. 9 A-E | In soil, under *Q. leucotrichophora* and *C. tamala*; KD (Guptkashi), 1160 m, KCS 1090, Aug 13, 2007; PH (Pauri), 1945 m, KCS 2484, Aug 31, 2015; BG (Jakholi), 1910 m, KCS 3048, Aug 17, 2018; On the wall, among mosses, TK (Pauri), 1950 m, KCS 4032, Aug 23, 2021; GK (Pauri), 1900 m, KCS 4067, Sept 10, 2021; MD (Kaljikhal), 1950 m, KCS 5033, Aug 12, 2022; DP (Pauri), 2000 m, KCS 5049, Sept 9, 2022. | (6.0-)7-8(-8.8) x 5.5-6.7(-7.8) µm, Q= 1.22, subglobose to globose, complete reticulation, brownish in 3% KOH. | A trichodermium pileipellis, made up of repeatedly septate inflated cells with short cylindrical to short tapering terminal cells, cells are often brown in 3% KOH. | This specimen matches well with the description for the *S. rubrobrunneus* which includes the pileus covering, reddish brown erect pyramidal scales, tiny basidiomes (3.5-5.5 cm in diam.), reticulated stipe apex due to the decurrence of tubes, stipe context staining greyish black on exposure to air except the spores are larger in original description from China (8-10 × 7-8(-8.5) µm, Q- 1.15, Han et al. 2018). |
| *Strobilomyces* aff. *seminudus* Hongo<br><br>Fig. 9 F-K | On soil, in burned forest, under *Q. leucotrichophora.* CH (Thelisain), 2290 m; KCS 5025, Aug 8, 2022 | (7.36-)8.4-10.5 × 6.5-8.5 µm, Q= 1.26, broadly ellipsoid to subglobose, sometimes globose, incomplete reticulation with low ridges, brownish in 3% KOH; spore print black. | A trichodermium pilepellis, made up of suberect to repent hyphae with cylindrical to subcylindrical terminal cells, brownish in 3% KOH and water mount. | The thin, appressed, radially arranged, flat fibrillose-scaly covering on the pileus, incomplete reticulation with low ridges on basidiospore surfaces, and strongly staining pinkish or rusty reddish context on exposure are the key features of this collection. It closely resembles *S. seminudus* based on these characteristics, including spore shape and size (8-10(-11) × 7-8.5(-9.5) µm, Q = 1.28; Wu et al., 2016; 7-10 × 6-9 µm; Sato et al. 2011). However, it can be differentiated by its adnate to subdecurrent pores. |
| *Strobilomyces* aff. *strobilaceus* (Scop.) Berk<br><br>Fig. 9 L-Q | In soil, under *Q. leucotrichophora,* and among the leaf litter of *P. roxburghii*; PH (Pauri), 2000 m, KCS 1785, Sept 1, 2013; LD (Pauri), 2100 m, KCS 2418, July 18, 2015; DP (Pauri), 2000 m, KCS 2426, Aug 1, 2015; KT (Pauri), 1900 m, KCS 4059, Aug 31, 2021; TK (Pauri), 1950 m, KCS 5053, Sept 9, 2022. | 7.4–10.7 × 6.7–8.7 µm, Q = 1.17; globose to subglobose with complete reticulation and high meshes, 1.5-2.5 µm high, brownish in 3% KOH. | A trichodermium pileipellis, made up of inflated cells with terminal cylindrical cells with rounded ends, thin to slightly thick walled, often brown in 3% KOH. | This specimen align with the description for the *S. strobilaceus* except the spores are larger and lower meshes (0.5–1 µm high) in the original description from China [(9-)10-11(-12) x (7-)7.5-9.5 µm, Wu et al. 2016)]. Although, the spores reported from India are much larger [(8.5-)9.5-14.0(-15) × (7.5-) 8.5-12.0 (-13) µm; Kour et al. 2013)] as compared to this specimen. |
| *Suillus* cf. *americanus* (Peck) Snell<br><br>Fig. 9 R-T | Among moss, under *P. roxburghii,* in mixed forest with *Q. leucotrichophora;* TK (Pauri), 1965 m, KCS 2502&KCS 2508, Sept 4, 2015; and KCS 5055, Sept, 9, 2022. | 8.5-10.8 x 3.4- 4.4 µm, Q= 2.46, ellipsoid to subfusiform. | An ixotrichoderm, made up of thin hyphae, embedded in gelatinized matrix. | The description of *S. americanus* (Smith and Thiers 1964) aligns well with the present specimens, except the spores are broader (8-11(-12) × 3-4 µm). Similarly, *S. himalayensis* B. Verma and M.S. Reddy, previously reported from India, is now considered a synonym of *S. americanus* (Nguyen et al. 2016). Due to the inability to record context staining in the current specimen, it is reported as "cf." for this taxon. |
| *Suillus* aff. *indicus* B. Verma and M.S. Reddy<br><br>Fig. 9 U-Y | In soil, among the leaf litter of *P. roxburghii* and *Q. leucotrichophora.* TK (Pauri), 1965 m; KCS 5064, Sept 19, 2022. | (7.62-)8.5-10.7(-11.5) x 3.0-4.0(4.64) µm, Q= 2.74, subfusiform to ellipsoid. | An ixotrichoderm pileipellis, made up of thin hyphae, embedded in gelatinized matrix. | The presence of fascicles of oleocystidia in the hymenium with a somewhat similar spore size confirms this specimen as *S.* aff. *indicus* (Verma and Reddy 2015). |


**Figure 10.** Photographic details of representative species. **A.** Fruit body of *Suillus* aff. *placidus* with vinaceous brown granules on the stipe surface (KCS 6025); **B.** Lemon-yellow context at stipe base in younger specimens; **C.** Ixotrichoderm pileipellis; **D.** Fasciculate oleocystidia with dark wine-brown content; **E.** Basidiospores.**F-H.** Fruit body of *Sutorius* aff. *pseudotylopilus* with pore surface and stipe context staining slightly reddish (KCS 5017); **I.** Trichoderm pileipellis elements; **J.** Reddish-brown spore print; **K.** Basidiospores. **L-N.** Fruit body of *Sutorius* aff. *rubriporus* (KCS 6004), showing blue staining of pores on bruising, later turning greenish and then lighter; O**-P.** Context staining bluish on exposure to air, subsequently reverting to an earlier colour stage; **Q.**Trichodermium pileipellis elements; **R.** Basidiospores. **S-T.** Fruit body of *Sutorius* aff. *ubonensis* with pores (KCS 4033); **U.** T.S. through pileus showing slightly pinkish staining on exposure to air; **V.** Trichoderm pileipellis elements; **W.** Basidiospores. **X.** Fruit body of *Tylopilus himalayanus* (KCS 4037); **Y.** Pores and stipe; **Z.** White solid context; **Z1.** Pores attachment to stipe and reticulation at stipe apex; **Z2.**Trichoderm pileipellis with terminal inflated cylindrical cells containing yellow pigments; **Z3.** Basidiospores.

**Table 11.** List of identified species, habitat, ecology, locality, elevation, collection numbers, collection dates, and key notes.

| Species name & Fig. No. | Specimen examined | Basidiospores micromorphology | Pileipellis elements | Commentary |
|---|---|---|---|---|
| *Suillus* aff. *placidus* (Bonord.) Singer<br><br>Fig. 10 A-E | On soil, among grasses, under *P. roxburghii,* in mixed forest with *Q. leucotrichophora*; TK (Pauri), 1965 m; KCS 6025, Aug 5, 2023. | (8.4-)9-10.7(-11.8) x 3.6-4.3(4.9) µm, Q= 2.5, elliptical-fusiform to subfusiform. | An ixotrichoderm, made up of thin hyphae, embedded in gelatinized matrix. | This creamish white *Suillus* is distinguished by vinaceous brown granules on the stipe surface, small pores, a viscid pileus surface, tough consistency when young, and a pleasant fruity smell. However, its spores are smaller compared to those of *S. placidus* (Verma and Reddy 2014; Smith and Thiers, 1964; Palamarchuk et al., 2021). While like *S. triacicularis* reported from India, it differs in having larger spores and a yellowish to reddish or orange-yellow pileus color (Verma and Reddy 2014). |
| *Sutorius* aff. *pseudotylopilus* Vadthanarat, Raspé & Lumyong<br><br>Fig. 10 F-K | In soil, on the wall, among moss, under *Q. leucotrichophora, P. roxburghii* and *Castanopsis* sp.; GK (Pauri), 1900 m, KCS 2581, Sept 1, 2016; SK (Pauri), 1650 m, KCS 5017, July 24, 2022, and KCS 5030, Aug 20, 2023; MD (Kaljikhal), 1950 m KCS 6043, Aug 12, 2022. | (9.5-)10.5-12.5(-13.4) x 3.9-4.8 µm, Q= 2.62, fusoid to ellipsoid, yellowish in 3% KOH. | A trichodermium, made up of cylindrical cells, with inflated terminal cells, light yellowish in 3% KOH. | Medium to large fruitbody (pileus 10–15.5 cm diam.; stipe 7.2-10 × 1.8-2.5 cm), with a pale reddish-brown to violet-brown pileus, pale greyish to dull whitish context, and a brownish hymenophore showing a purplish hue near the margin. The pores remain unchanged, while the tubes stain slightly pinkish to reddish-brown when cut. The solid stipe stains faintly reddish on cutting, with white basal mycelium. Additional characteristics include a trichodermium pileipellis, indistinct taste, fruity smell, reddish-brown spore print, and spore measurements [(10.5)11-13 × 4-4.5 µm; Li and Yang 2021]. These features align this specimen closely with *S. pseudotylopilus*. While *S. eximius* also appears similar, it notably lacks the reddish staining of the context upon injury (Chai et al. 2019; Li and Yang 2021). |
| *Sutorius* aff. *rubriporus* G. Wu & Zhu L. Yang<br><br>Fig. 10 L-R | Growing among leaf litter and moss on the wall, under the canopy of *Castanopsis* sp., *P. roxburghii* and *Q. leucotrichophora*; SK (Pauri), 1650 m, KCS 5002, July 12, 2022; PH (Pauri), 1900 m, KCS 5003, July 15, 2022; CH (Pauri), 2250 m, KCS 5023, Aug 8, 2022; SK (Pauri), 1650 m, KCS 6004, July 14 2023. | 8.4-12.1(-12.9) x 3.0-4.3 µm, Q= 2.79, ellipsoidal, brownish yellow in 3% KOH. | An interwoven trichodermium to subcutis pilepellis, made up of thin walled hyaphe with slightly clavate terminal cells, often rounded ends and filled with yellowish contents. | This specimen was identified as *Sutorius* aff. *rubriporus* based on key features: the fruitbody stains blue immediately upon handling or bruising, exhibits a trichodermiumpileipellis, and has smooth spores. Notable characteristics include creamish-yellow context staining blue, adnate hymenophore, reddish-brown pore surface staining blue on bruising, angular pores, yellowish tubes staining blue, finely pruinose-furfuraceous stipe staining blue on contact, and white basal mycelium. However, the yellowish hymenophore in younger specimens and ellipsoidal spores with a central depression deviate from the typical features of *Sutorius*. While it shares similarities with *Suillellus* Murrill, it differs by lacking amyloid hyphae at the stipe base. However, in the current taxonomic treatment S. rubriporus is recombined as Neoboletus rubriporus (Chai et al., 2019). |
| *Sutorius* aff. *ubonensis* Vadthanarat, Raspé and Lumyong<br><br>Fig. 10 S-W | In soil, under *Q. leucotrichophora* and *Castanopsis* sp.; TK (Pauri), 1950 m, KCS 4033, Aug 23, 2021, and KCS 5016, July 24, 2022. | (8.8-)9.1-14.5(-15.0) x 3.0-4.4 µm, Q= 3.19, cylindrical to long– fusiform, yellowish in 3% KOH. | A trichodermium, made up of cylindrical cells, often with clavate terminal cells, light yellowish in 3% KOH. | The small to medium-sized fruitbody (pileus 5–6 cm diam., stipe 5.5–7 × 1.0–2 cm) features a purplish pileal surface, fruity smell, unchanged context, trichodermium pileipellis and the somewhat similar spore measurement taking this specimen close to *Sutorius* ***ubonensis*** [(8.7–) 9.8–12–14.7 (–16.8) × (3.1–) 3.4–4–4.4 (–4.7) µm], reported from Thailand (Vadthanarat et al. 2021). However, this specimen shows a 91.20% match with *S. eximius* in the NCBI Blast result. |
| *Tylopilus himalayanus* D. Chakr., K. Das & Vizzini<br><br>Fig. 10 X-Z3 | In soil, under *C. deodara,* in *Cedrus* stands, HM (Pauri), 1800 m; KCS 4037, Aug 26, 2021. | 8.2-11.0(-11.5) x 3.2-4.0 µm, Q= 2.66, fusiform, inequilateral, light yellowish brown in 3% KOH. | A trichodermium pileipellis made up of erect, terminal inflated-cylindrical cells with obtuse apices, incrusted hyphae also present, yellowish brown in 3% KOH. | This specimen shows a 99.77% match with *Tylopilus himalayanus* reported from India (Chakraborty et al. 2018a) in the NCBI BLAST search. However, macro-, and micromorphological differences are evident, including the absence of pale yellow or greyish-yellow pileus coloration in the present collection. Additionally, *T. himalayanus* has larger spores (10.9-12.5-14.4 × 3.9-4.5-4.9 µm, Q = 2.75; Chakraborty et al. 2018a). The present collection features a stout and large fruit body (pileus up to 20 cm; stipe 12.5 × 7 cm) with a larger cap-to-stipe ratio, a flaring margin, and unchanged pores—traits that do not align with *T. himalayanus* descriptions. In contrast, KCS 5011 aligns well with the original description of *T. himalayanus* (Chakraborty et al. 2018a), including its spore measurements (10.4-13.9(-15.4) × 3.8-4.8 µm, Q= 2.83). |

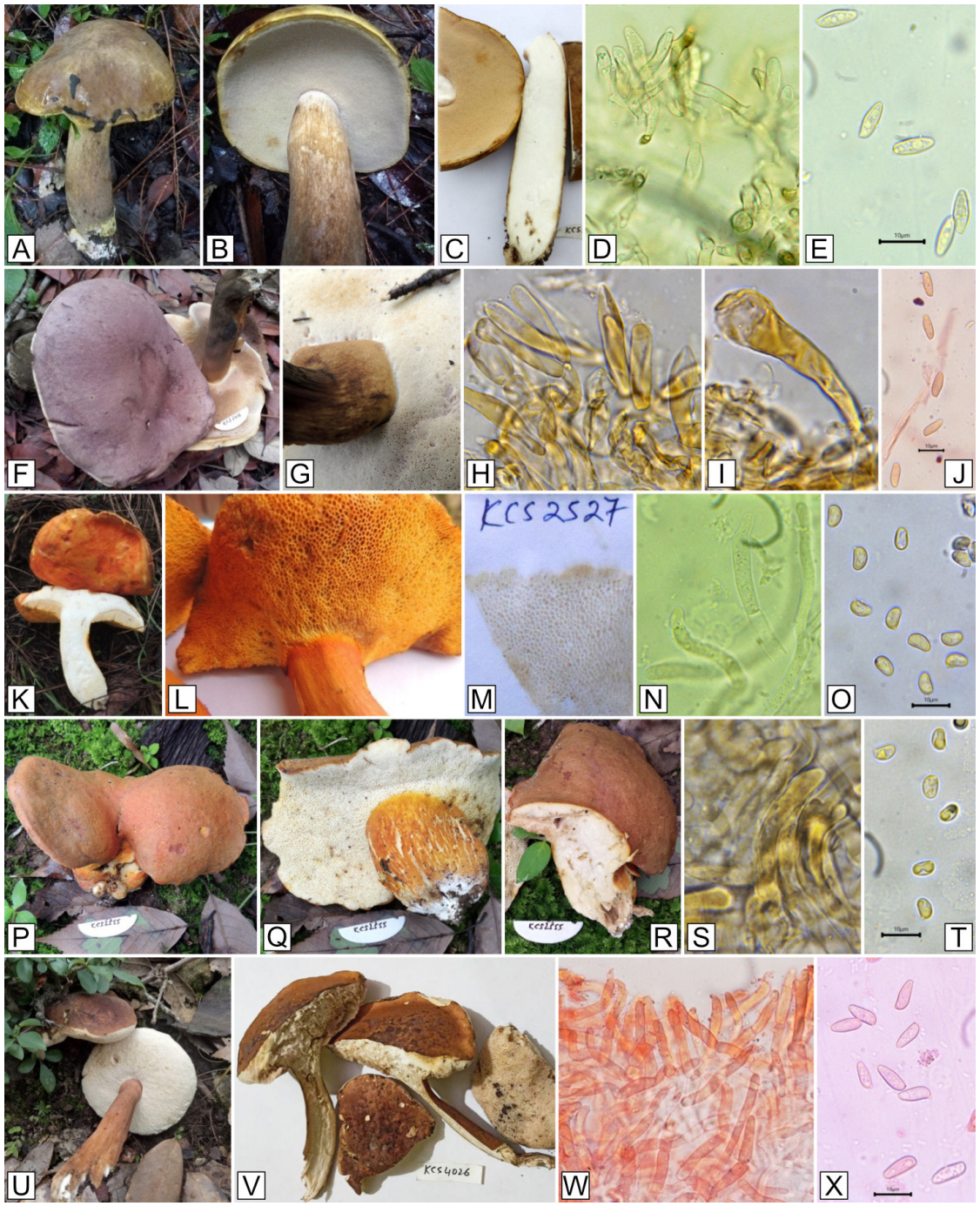


**Figure 11.** Photographic details of representative species. **A-C.** Fruit body of *Tylopilus* aff. *himalayanus* (KCS 5011) with pores and solid stipe; **D.** Trichoderm pileipellis with erect, terminal cylindrical cells; **E.** Basidiospores. **F.** Fruit body of *Tylopilus* aff. *plumbeoviolaceus* (KCS 2416); **G.** Pores and faintly reticulated stipe apex; **H-I.** Trichodermium pileipellis with cylindrical to clavate, club-shaped terminal cells filled with yellow pigments in 3% KOH; **J.** Basidiospores. **K-L.** Fruit body of *Tylopilus pseudoballoui* with pores and stipe showing unchanged context (KCS 2527); **M.** Trichoderm pileipellis; **N.** Pinkish-red spore print; **O.** Basidiospores. **P-Q.** Fruit body of *Tylopilus* aff. *rubrotinctus* with pores and stipe (KCS 2555); **R.** T.S. through pileus; **S.** Trichodermium pileipellis showing dark yellowish contents in hyphae; **T.** Basidiospores. **U.** Fruit body of *Tylopilus* Sp. 1 with pores (KCS 4026); **V.** T.S. through pileus; **W.** Trichodermium pileipellis with cylindrical cells; **X.** Basidiospores.

**Table 12.** List of identified species, habitat, ecology, locality, elevation, collection numbers, collection dates, and key notes.

| Species name & Fig. No. | Specimen examined | Basidiospores micromorphology | Pileipellis elements | Commentary |
|---|---|---|---|---|
| *Tylopilus* aff. *himalayanus* D. Chakr., K. Das & Vizzini<br><br>Fig. 11 A-E | In soil, among leaf litter, under *Q. leucotrichophora*; NH (Pauri), 1960 m, KCS 5011, KCS 5012, and KCS 5013, July, 22, 2022. | 10.4-13.9(15.4) x 3.8-4.8 µm, Q= 2.83, ellipsoid– elongate to fusoid, inequilateral, thin walled. | A trichoderm with erect, cylindrical cells, with yellow content, hyphae encrusted below. | The overall morphological and microscopic features match well with the *T. himalayanus* (Chakraborty et al. 2018a). See comments in KCS 4037 (*Tylopilus himalayanus*). |
| *Tylopilus* aff. *plumbeoviolaceus* Snell & Dick<br><br>Fig. 11 F-J | In soil, under *Q. leucotrichophora*; LD (Pauri), 2000 m; KCS 2416, July 18, 2015 | (9.3-)10-12.8(-13.8) x 3.5-4.5 µm, Q= 2.82, ellipsoid– elongate to fusiform, inequilateral, thin walled, light yellowish in 3% KOH. | A trichoderm with suberect, broad-cylindrical to clavate cells, with yellow content, hyphae encrusted in pileus context. | This large fruit body (pileus 16.5-18.5 cm in diameter, stipe 9-11 × 2.5-3.5 cm with a broadly clavate base up to 5.6 cm thick) features a purplish-brown, dry pileus; whitish to greyish pink, adnate pores that darken slightly on bruising; and a stipe faintly reticulated only near the apex. The trichodermium pileipellis, ellipsoid-elongate to fusiform spores, and peppery taste closely align this specimen with *Tylopilus plumbeoviolaceus*. This identification is supported by the unchanging pileus color on bruising and the somewhat similar spore shape and size: 9-14 × 3-4-5.5) µm (Snell and Dick 1970) and 10-13(-14) × 3-4 µm (Smith and Thiers 1971). *Tylopilus violatinctus* Baroni & Both is another species with some similarity to this collection. However, it differs by exhibiting a bright rusty violet to deep dark violet staining of the pileus when bruised, a feature absents in the present collection. Additionally, the spore sizes of *T. violatinctus* [(6.8-)7.6-9.7 × 2.9-4.1 µm, Q = 2.0-2.8; Baroni and Both 1998] are smaller than those of the current specimen. |
| *Tylopilus pseudoballoui* K. Das, D. Chakr & Vizzini<br><br>Fig. 11 K-O | In soil, under *P. roxburghii* and Q. *leucotrichophora* trees in mixed forest; MN (Guptkashi), 1900 m, KCS 2540, Aug 11, 2016; on wall, among moss, under and *C. tamala*; KD (Guptkashi), 1150 m KCS 3080, Aug 23 2018; AD (Pauri), 1950 m KCS 5073, Sept 27, 2022; TK (Pauri), 1950 m KCS 6029, Aug 5, 2023. | 6.1-7.8 x 3.6-4.4 µm, Q= 1.73, ellipsoidal, some spores seem reniform. | A trichodermium, made up of thin walled hyaphe, cylindrical, terminal cells either round or obtuse. | This taxon matches well macro-micromorphologically with *T. pseudoballoui*. However, the spore size reported was larger in the original description (6.4-7.4-9.9 × 3.8-4.5-5.7 µm, Q= 1.73, Chakraborty et al. 2018a). |
| *Tylopilus* aff. *rubrotinctus* Yan C. Li & Zhu L. Yang<br><br>Fig. 11 P-T | On soil and wall among moss, under and *C. tamala*. KD (Guptkashi), 1150 m; KCS 2555, Aug 12, 2016 | 5.5-7.0 x 3.5-4.3 µm, Q= 1.63, ellipsoidal. | A trichodermium pileipellis made up of suberect, terminal inflated- cylindrico-clavate cells with generally round apices, often yellowish in 3% KOH. | This medium to large specimen (pileus up to 13.5 cm in diameter) with a greyish-red to reddish-orange pileus, small but stout yellowish stipe (up to 6 × 2.6 cm), whitish, adnate, broad (up to 0.3 cm), subangular pores, unchanged context, and non-peppery taste exhibits features close to *Tylopilus rubrotinctus* (Li and Yang 2021). Key characteristics include a trichodermium to palisadoderm pileipellis composed of suberect cylindrical-clavate cells with generally rounded apices, often yellowish in 3% KOH, abundant fusiform to fusoid-ventricose pleurocystidia (hyaline or filled with yellowish pigments), and ellipsoidal spores (5-6.5 × 3.5-4.5 µm, Q =1.54). However, the smaller fruit body, thinner stipe, and tropical habitat distinguish this specimen from *T. rubrotinctus*. |
| *Tylopilus* Sp. 1<br><br>Fig. 11 U-X | In soil, among moss, under *Q. leucotrichophora, C. deodara*; CK (Pauri), 1950 m; KCS 4026, Aug 15, 2021. | (8.3-)9.1-12.7(-14.2) x 3.1-4.2(-5.2) µm, Q= 2.97, fusiform to fusoid, light yellowish in 3% KOH. | A trichodermium pileipellis with terminal cylindrical cells with round apices. | Morphologically, this species resembles *Gyroporus* but can be distinguished by the absence of clamp connections, fusoid spores, and the presence of longitudinally arranged pileipellis cells. These features suggest it belongs to *Tylopilus* P. Karst (based on personal communication with Dr. Olivier Raspé, Mae Fah Luang University). However, it notably lacks the characteristic peppery taste. |


**Figure 12.** Photographic details of representative species. **A.** Fruit body of *Tylopilus* sp. 2 (KCS 4015); **B.** Pores; **C.** T.S. through pileus showing no colour change of solid context; **D.** Trichodermium pileipellis with terminal cylindrical cells having rounded and obtuse apices; **E.** Basidiospores. **F-G.** Fruit body of *Tylopilus* sp. 3 with pores (KCS 6027); **H.** T.S. through pileus; **I.** Trichodermium pileipellis showing dark yellowish contents in hyphae; **J.** Basidiospores. **K-N.** Fruit body of *Tylopilus* sp. 4 with pores and solid white stipe with unchanging context (KCS 6014); **O.** Trichodermium pileipellis with long cylindrical cells containing yellow pigments; **P.** Basidiospores. **Q-R.** Fruit body of *Tylopilus* sp. 5 (KCS 6033); **S.** Pores and reticulation on stipe apex; **T.** Trichodermium pileipellis with terminal cylindrical cells having rounded and obtuse apices; **U.** Basidiospores. **V-W.** Fruit body of *Tylopilus* sp. 6 (KCS 4005); **X.** Ruby-colored spore print; **Y.** Ixotrichoderm pileipellis; **Z.** Basidiospores.

**Table 13.** List of identified species, habitat, ecology, locality, elevation, collection numbers, collection dates, and key notes.

| Species name & Fig. No. | Specimen examined | Basidiospores micromorphology | Pileipellis elements | Commentary |
|---|---|---|---|---|
| *Tylopilus* Sp. 2<br>Fig. 12 A-E | In soil, under *C. deodara;* Near HM in *Cedrus* stand (Pauri), 1800 m, KCS 4015, Aug 10, 2021, and KCS 6039, Aug 9, 2023. | (9.1- 9.8-13.8(-15.4) x 3.4-4.8 µm, Q= 2.90, fusiform to fusoid, with inequilateral, light yellowish in 3% KOH. | A trichodermium pileipellis with terminal short cylindrical with obtuse apex. | This species has been identified *Tylopilus* P. Karst, based on its peppery taste (key character of *Tylopilus*, Li and Yang 2021; Wu et al. 2016), small pores, unchanging context, white basal mycelium, longitudinal arrangement of pellis cells with a trichodermiumpileipellis and fusiform spores. |
| *Tylopilus* Sp. 3<br>Fig. 12 F-J | Under the tree trunk of *Q. leucotrichophora*, in soil; TK (Pauri), 1950 m; KCS 6027, Aug 5, 2023. | (10.8-)11.5-14.8 x 4.2-5.2 µm, Q= 2.79, elongate fusiform, inequilateral, thin walled, yellowish in 3% KOH. | A trichodermium pileipellis, made up of cylindrical terminal cells, often with round apices, lemon yellowish pigmented cells. | The olivaceous pileus colour, lacking marginal flap, pale pinkish tube, bitter taste of context, the color of the pores and unchanging hymenophore take this collection close to the genus *Tylopilus* P. Karst. The colour combination of the pileus resembles with european *Amanita phalloides.* Other key fetures includes the large fruitbody (pileus 14 cm in diameter; stipe 17 x 1.6 cm with slightly clavate base, 2.8 cm thick), lemon yellowish to whitish basal mycelium, fruity and pleasant odor, a trichodermium pileipellis composed of cylindro-clavate, yellowish pigmented terminal cells, and elongate fusiform spores. Further molecular and phylogenetic studies are necessary to confirm the classification of this species under genus *Tylopilus*. |
| *Tylopilus* Sp. 4<br>Fig. 12 K-P | In soil under the canopy of *Q. leucotrichophora,* on roadside; KH (Pauri), 1800 m; KCS 6014, July 17, 2023. | (9.5-) 10.5-12.5 (-14.0) x (3.1-) 3.8-4.8 µm, Q= 2.69, fusiform to elongate, inequilateral in side view, light yellowish in 3% KOH. | A trichodermium pileipellis, made up of cylindrical terminal cells, often with obtuse, tapering apices, yellowish pigmented cells. | A large and stout fruit body (pileus 19 cm diam.; stipe 10 × 3.6 cm), with an applanate, dry, brown pileus, unchanging white context, greyish pink to whitish adnate pores, acrid-tasting context, faintly reticulate stipe apex, a trichodermium pileipellis, and fusiform spores are the key features of this specimen. These characteristics suggest it belongs to *Tylopilus* P. Karst. |
| *Tylopilus* Sp. 5<br>Fig. 12 Q-U | Growing on the tree stem where soil is deposited; PH (Pauri, 1950 m, KCS 5004, July 5, 2022; TK (Pauri), 1950 m, KCS 6033, Aug 8, 2023. | 10.5-12.5 x 3.3-3.8 µm, Q= 3.2, fusiform to elongate, inequilateral in side view, light yellowish in 3% KOH. | A trichodermium pileipellis with terminal subcylindrical cells with obtuse and round apices, light yellowish in 3% KOH. | The large fruitbody (pileus 9.3-11 cm diam.; stipe 18-20 x 2.5-3.2 cm with longer stipe ratio to pileus), ivy green to dark greyish green pileus, greyish pink, unchanged hymenophore with greenish hue, acrid taste, spindle stipe, finely reticulated at stipe apex, and growing on the tree stem where soil is deposited are the key features of the present taxon. Due to the taste and other features, this taxon is identified as a *Tylopilus* P. Karst. |
| *Tylopilus* Sp. 6<br>Fig. 12 V-Z | On soil, under the canopy of *M. esculenta* and *P. roxburghi*; MN (Guptkashi), 2100 m, KCS 3066, Aug 22, 2018; TK (Pauri), 1950 m, KCS 4005, July 31, 2021. | 9.10-12.0 x 3.1- 4.1 µm, Q= 2.90, elongate to fusiform, inequilateral in side view. | An ixotrichoderm pileipellis, the elements embedded in gelatinized matrix. | This specimen was identified as *Tylopilus* P. Karst, based on the peppery taste, unchanging context, greyish brown pileus, and angular pores. However, based on the ruby spore print colour it may be a member of the genus *Rubinosporus (*Vadthanarat et al. 2022). Molecular and phylogenetic studies are needed for confirmation. |

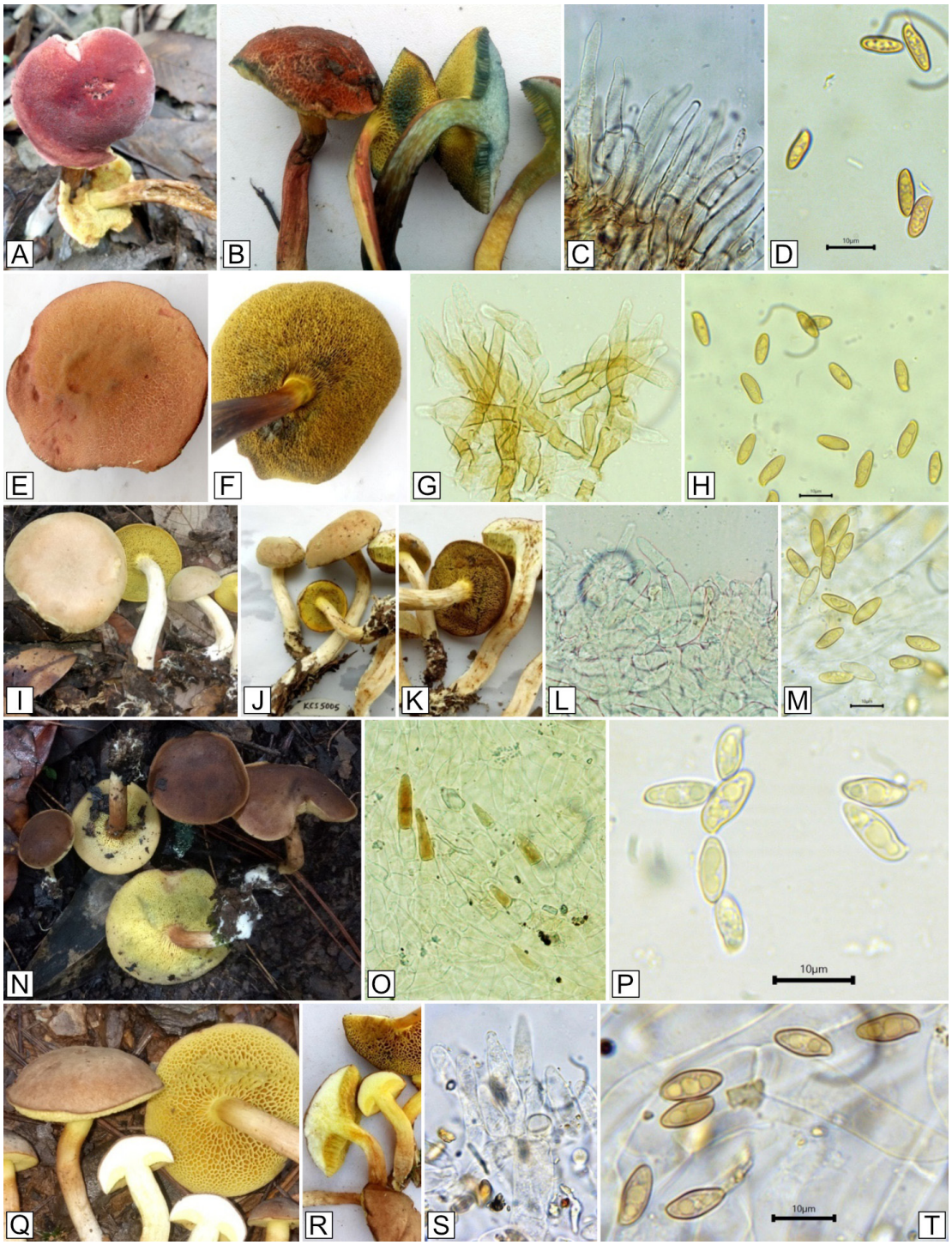


**Figure 13.** Photographic details of representative species. **A.** Fruit body of *Xerocomellus corneri* (KCS 6003); **B.** Context and pores bluing on bruising and sectioning; **C.** a palisadoderm pileipellis with cylindrical cells having obtuse ends; **D.** Basidiospores. **E-F.** Fruit body of *Xerocomellus* Sp. 1 with blue-staining pores on bruising (KCS 5036); **G.** Trichoderm pileipellis made up of vertically arranged, broadened, tapering terminal hyphal elements, often with golden-yellow incrusted cells; **H.** Basidiospores. **I-K.** Fruit body of *Xerocomus doodhcha* (KCS 5005), showing no immediate color change of pores on bruising, but later turning greenish blue on bruising or cutting, very slowly; **L.** Trichodermium pileipellis made up of inflated sub-cylindric terminal cells; **M.** Basidiospores. **N.** Fruit body of *Xerocomus microcarpoides* (KCS 5015) with pores showing greenish blue staining; **O.**Trichoderm pileipellis made up of frequently septate sub-cylindric elements, with tapering terminal cells, hyaline to filled with yellow pigments; **P.** Basidiospores. **Q-R.** Fruit body of *Xerocomus uttarakhandae* (KCS 6040), with pores showing very slow bluish-green staining on bruising, context yellowish; **S.** Trichoderm pileipellis made up of thin-walled, cylindric to sub-cylindric terminal cells with obtuse apices; **T.** Basidiospores.

**Table 14.** List of identified species, habitat, ecology, locality, elevation, collection numbers, collection dates, and key notes.

| Species name & Fig. No. | Specimen examined | Basidiospores micromorphology | Pileipellis elements | Commentary |
|---|---|---|---|---|
| *Xerocomellus corneri* Xue T. Zhu & Zhu L. Yang<br><br>Fig. 13 A-D | On soil, under the canopy of *Q. leucotrichophora,* sometimes on wall, among moss. LD (Pauri), 2100 m, KCS 2413, July 18, 2015; BR, (Pauri), 1800 m, KCS 6003, July 7, and KCS 6037, Aug 9, 2023; TK (Pauri), 1950 m, KCS 6047, Sept 4, 2023. | 9.5-11(-12) x 3.5- 4.2 µm, Q= 2.66, narrow amygdaliform to subfusoid, brownish yellow in water. | A palisadoderm, consisting of elongate, vertically arranged, , cylindrical cells with tapering terminal ends, often yellowish brown pigmented and incrusted in lowers elements, light brown to hyaline in terminal cells. | This specimen aligns well with the characteristics of *X. corneri*, including the overall fruit body size, velvety pileus surface with red to reddish-brown coloration, yellowish context that stains blue, adnate hymenophore depressed around the stipe, yellow pores that turn blue immediately upon bruising, angular pores, longitudinally fibrillose stipe surface, and palisadoderm pileipellis. However, the spores are slightly larger than those reported from China [(10-)11–13(-14) × 4.5–5 µm, Q = 2.46; Wu et al. 2016]. |
| *Xerocomellus* Sp. 1<br><br>Fig. 13 E-H | On soil, among leaf litter, under the tress of *Q. leucotrichophora*; GK (Pauri), 1900 m, KCS 4065, Sept 10, 2021; DP (Pauri) 2000 m, KCS 5036, Aug 18, 2022, and KCS 5059 Sept, 12, 2022. | 10.3-12.5(-13) x 3.9-4.9 µm, Q= 2.60, fusoid to subfusiform. | A trichoderm, made up of elongate, vertically arranged short cylindrical cells with obtuse or tapering terminal ends, often yellowish brown and incrusted in lowers elements, light brown to hyaline in terminal cells. | The overall micro-morphological features are conformity with the genus *Xerocomellus* which include the reddish to purplish, red-tinged pileus and stipe, dry subtomentose pileal surface, the angular and relatively large pores and the trichoderm pileipellis. |
| *Xerocomus doodhcha* K. Das, D. Chakr., A. Baghela, S.K. Singh & Dentinger<br><br>Fig. 13 I-M | In soil, under *Q. leucotrichophora*; PH (Pauri), 2000 m, KCS 5005, July 15, 2022; MD (Kaljikhal), 1950 m, KCS 5035, Aug12, 2022. | 10-12.8(-14.1) x 4.0-5.2 µm, Q= 2.48, subfusoid to fusiform, inequilateral. | A trichodermium, made up of thin walled, erect, cylindrical to subcylindrical cells, with round apices. | This collection matches well with the earlier reported *X. doodhcha* which includes the pileipellis arrangement and the spore shape and measurements (10.0-11.03-13.0 × 3.8-4.4-5.0 µm, Q= 2.69, Das et al. 2016b). However, the stripe colour is brighter in the present specimen. |
| *Xerocomus microcarpoides* (Corner) E. Horak<br><br>Fig. 13 N-P | In soil, under the trees of *Q. leucotrichophora,* and *M. esculenta*; TK (Pauri), 1950 m, KCS 5015, July 22, 2022. | (7.7)9.8-12.0 x 3.5-4.9 µm, Q= 2.59, subfusoid, inequilateral. | A trichoderm pileipellis, made up of frequently septate sub-cylindrical elements, with tapering terminal cells, hyaline or filled with yellow pigments. | The traits of this specimen match well with the description provided for the *X. microcarpoides* from China (Wu et al. 2016) which include the pileipellis arrangement and spore shape and measurements. |
| *Xerocomus uttarakhandae* K. Das, Sudeshna Datta, and A. Ghosh<br><br>Fig. 13 Q-T | In soil, under the trees of *Q. leucotrichophora,* and *M. esculenta*; MN (Guptkashi), 2100 m, KCS 2545 and KCS 3065, Aug 11, 2016, and Aug 22, 2018; TK (Pauri), 1950 m, KCS 6028 and KCS 6040, Aug 5 and 15, 2023. | (8.8-)10.2-12.7 x 4.3-5.3 µm, Q= 2.39, fusoid to ellipsoid, inequilateral in side view. | A trichodermium, made up of thin walled, erect, cylindrical to sub– cylindrical cells with obtuse apices. | This collection matches well with the earlier reported *X. uttarakhandae* from the same state of India which include the pileipellis arrangement and the spore shape and measurements (9-10.6-12.6 × 3.8-4.5-5.1 µm, Q= 2.36, Das et al. 2023). |

The study highlights the diversity of boletoid fleshy pored fungi in the Uttarakhand Himalaya, underscoring the region's ecological richness. These findings emphasize the need for comprehensive DNA molecular studies and phylogenetic analyses to confirm species identification and resolve ambiguities. Such research requires significant funding and collaborations with molecular laboratories capable of sequencing all identified boletoid species.

During the study, varying species frequencies were observed, with some species being relatively common and others exceptionally rare. While the local population including Tibetan refugees, consumed a few species like *Boletellus emodensis* (Fig. 2I), and only seven species have been documented as edible in Uttarakhand (Kukreti et al. 2020). Globally, the Boletaceae family includes cherished edible species such as *Boletus edulis* (commonly referred to as the "King Bolete"), with a recently described edible species, *Boletus indoedulis* D. Chakr., K. Das, A. Baghela, S. Adhikari & Halling, also reported in India (Chakraborty et al. 2017a).

Managing and identifying boletoid fungi present notable challenges due to their robust, fleshy fruit bodies, which are prone to rapid decay and mite infestation. Furthermore, drying these specimens is time-intensive, and morphological similarities between species complicate differentiation. Even under microscopic examination, features like basidiospores and hymenial cystidia often appear strikingly similar. Accurate identification frequently relies on advanced tools, such as scanning electron microscopy (SEM), which can reveal surface ornamentation not visible under light microscopy. For instance, the spores of *Xerocomus*, which appear smooth under a light microscope, exhibit bacillate ornamentation under SEM, a critical feature for distinguishing it from related genera like *Hortiboletus* and *Xerocomellus*.

The immense diversity of wild fungi in the Uttarakhand Himalaya highlights an urgent need to explore fungal diversity using classical and molecular techniques. Unfortunately, many fungal groups in Uttarakhand remain unexplored and at risk of local extinction due to socioeconomic pressures and developmental activities. Factors such as forest fires, road construction, expanding settlements, intensive tourism, and shifting rainfall patterns are significantly eroding the state's fungal diversity.

The lack of comprehensive taxonomic data for various families within the Agaricomycetes and other fungal groups in the Basidiomycota and Ascomycota phyla in the Uttarakhand Himalaya is a major limitation in mycological research. However, new species have been described from fungal families like *Amanitaceae*, *Cortinariaceae* and *Russulaceae* but detailed taxonomic descriptions for other families, such as *Agaricaceae*, *Cantharellaceae, Entolomataceae*, *Strophariaceae*, *Tricholomataceae*, *Pluteaceae*, *Inocybaceae*, *Lyophyllaceae*, *Marasmiaceae*, *Mycenaceae*, and *Pleurotaceae*, are still lacking. Advances in DNA molecular methods have enabled the segregation of morphologically similar taxa and facilitated the discovery of numerous new boletoid fungi species. However, these molecular techniques have also led to reclassifications, with many species placed into new genera and families (Gelardi 2021; Halling et al. 2023; Wang et al. 2023; Wu et al. 2015, 2016, 2023).

The findings presented in this study, including data on collection numbers, representative taxa, and visited localities, provide valuable insights into the species diversity and distribution of boletoid fleshy pored fungi in the Uttarakhand Himalaya. As highlighted in Tables 3-14, many species exhibit overlapping morphological and microscopic traits, complicating their differentiation. Delimiting species or genera based solely on morphology is challenging and it is important to note that the species identified in this study are considered provisional until validated through future molecular studies. This compilation of data aims to inspire further research and draw global attention to the mycological diversity of Uttarakhand, encouraging advanced studies and conservation efforts in this ecologically significant region.

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