New records of *Cantharellus* species from the northwestern Himalayas of India

Kumari Deepika, M. Sudhakara Reddy* and Ramesh C. Upadhyay

*Department of Biotechnology, Thapar University, Patiala 147004, India; ‡Directorate of Mushroom Research, Solan 173213, Himachal Pradesh, India

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This study investigated several collections of the genus *Cantharellus* (Cantharellaceae) from the northwestern Himalayas, India, on the basis of morphology and molecular data. Phylogenetic relationships and species limits were investigated by using nuclear ribosomal large subunit sequences (LSU). We recognized 13 species: *Cantharellus appalachiensis* Petersen, *C. cibarius* Fries, *C. lateritius* (Berk) Singer, *C. miniatescens* Heinem., *C. minor* Peck, *C. pseudoformosus* and seven species, *C. applanatus* sp. nov., *C. elongatipes* sp. nov., *C. fibrillosus* sp. nov., *C. himalayensis* sp. nov., *C. indicus* sp. nov., *C. natarajanii* sp. nov., and *C. umbonatus* sp. nov., as new to science. All these species are described and their taxonomy and ecology are discussed. In addition, a key is provided to all the recognized species. The phylogenetic analysis recovered 10 major supported clades of *Cantharellus* species.

Keywords: *Cantharellus*; molecular systematic; phylogeny; taxonomy; large subunit (LSU) of rDNA

Introduction

*Cantharellus* is one of the important genera of wild edible mushrooms, collected from Europe, Africa, Asia and North America. The economic importance of the Cantharellaceae has resulted in considerable research on their ecology, physiology and phylogenetics (Danell 1994; Dunham et al. 2003; Eyssartier et al. 2009; Buyck and Hofstetter 2011; Tian et al. 2012; Buyck et al., 2013). The significant levels of proteins, lipids, minerals, vitamins and some nutraceuticals in their basidiocarps are of considerable value (Pilz et al. 2003; Kumari et al. 2011a). Noteworthy taxonomic works on Cantharellaceae include those of Fries (1821–1832), Persoon (1825), Smith and Morse (1947), Corner (1966, 1969), Bigelow (1978), Petersen (1979), Feibelman et al. (1994, 1996), Dahlman et al. (2000), Moncalvo et al. (2006), Eyssartier et al. (2009), Buyck and Hofstetter (2011) and Buyck et al. (2013) who have made it possible to deal quite effectively with cantharelloid mycoflora.

Although the taxonomy of Cantharellaceae has been well studied in other parts of the world, only preliminary work has been done in India. The species reported from India to date include: *C. appalachiensis* Peterson, *Cantharellus cibarius* Fries, *C. cinnabarinus* Schw., *C. friesii* Quel., *C. lateritius* (Berk) Singer, Liloa, *C. luteocomus* Bigelow and *C. minor* Peck (Bhatt and Lakanpal 1988; Dhancholia et al. 1991; Abraham et al. 1995). The diversity of *Cantharellus* in particular and the fungal diversity in general are understudied in the northwestern Himalayan region. Hence, repeated collection efforts have been made to investigate the diversity of Cantharellales occurring in this region. Earlier, we reported *C. miniatescens* and *C. pseudoformosus* from the Himalayan region (Kumari et al. 2009, 2011b). In the present study, we describe seven species of *Cantharellus* new to science.

Materials and methods

Fungal collections

Basidiomes were collected from the forests of northwestern Himalayas, India, which includes Himachal Pradesh (30° 22′–33° 12′ N and 70° 47′–74° 04′ E) and Uttarakhand (29° 37′–30° 15′ N and 77° 53′–79° 15′ E) (Figure 1, Table 1). Both these states have arctic, alpine, sub-alpine and temperate biomes. These regions have diverse floras because of their varied climate zones and wide range of altitudes (Kumar et al. 1990). The distribution of rainfall is uneven and varies from 600 to 3200 mm annually. Of the total annual rainfall, 75% of the rainfall is during the rainy season (June to September) and the rest in the winter season (December to March). The majority of our collections were located in temperate forests, at elevations between 1600 and 2400 m amsl, associated with *Quercus* and *Rhododendron* in hardwood and *Pinus, Cedrus, Picea* and *Abies* in coniferous forests.

Morphological analysis

In the forest forays of Himachal Pradesh, during the rainy seasons of 2005–2009, several taxa of *Cantharellus* were
collected. The macroscopic and microscopic characteristics of all the collections were studied and documented by using standard techniques (Singer 1986). Colour terminology was noted from Mearz and Paul (1930). Micromorphological features of dried specimens were examined with a Leica DM LS2 microscope with light and phase contrast optics. For basidiospores, basidia and other anatomical structures (at least 45 individuals per collection) were measured. Rehydrated fungal tissue was mounted in water and 3% KOH, 2% Congo red, 2% phloxine and Melzer’s reagent. The basidiospores were studied from the spore deposits and from fresh material. Voucher specimens have been deposited in the Punjabi University Herbarium (PUN), India (Table 1).

**DNA extraction, PCR and DNA sequencing**

For molecular characterization, genomic DNA was extracted from basidiomes by the method of Van Kan et al. (1991). Primer pairs ITS4R (5’-GCATATCAATAAGCGGAG GA-3’) (White et al. 1990) and LR5 (5’-ATCCTGAGGGAAACTTC-3’) (Vilgalys and Hester 1990) were used to amplify a portion of the LSU gene. The ITS region of nrDNA was amplified by PCR with ITS1 (5’-TCCGTAGGTGAACCTGCGG-3’) and ITS4 (5’-TCCTCCGCTTATTGATATGC-3’) primers (White et al. 1990). The 50 µL reaction mixture for PCR amplification contained: 10 ng DNA, 1× PCR buffer, 1.5 mM MgCl2, 0.2 mM of each dNTPs, 0.5 µM of each primer and 2.5 units of Taq polymerase (Fermentas, USA). Amplifications were performed in a thermal cycler (Perkin Elmer, USA) with an initial denaturation step of 94°C for 3 min followed by 35 cycles of 94°C for 1 min, 50°C for 1 min and 72°C for 1.5 min and a final extension of 72°C for 8 min. PCR products were purified and cloned in Ins TA clone PCR cloning kit (Fermentas, USA) as per the manufacturer’s instructions and transformed into *E. coli* DH5α cells. Screening of clones was done using promoter specific (M13F and M13R) primers. Primers used for sequencing were ITS4R and LR5 for the LSU region and ITS1 and ITS4 for the ITS region.

**Phylogenetic analysis**

Sequences were aligned by using the MAFFT software (Katoh et al. 2002) and adjusted manually using the data.
Table 1. Data of *Cantharellus* species examined from the northwestern Himalayas of India.

| S. no. | Species                     | Locality                          | Host species                        | Collection no | Voucher no. | GenBank accession no |
|--------|-----------------------------|-----------------------------------|-------------------------------------|---------------|-------------|----------------------|
| 1      | *C. applanatus* sp. nov.    | Karshog forest, Jageshwar forest  | *Pinus roxburghii*                 | 43-07, 121-08 | PUN 3964    | ITS HQ270118         |
| 2      | *C. appalachiensis*         | Chail, Jageshwar forest           | *Cedrus deodara, Quercus dilatata*  | 39-07, 84-08, 95-08 | PUN 3959    | LSU HM750918, ITS HQ386220, LSU HQ342887 |
| 3      | *C. cibarius*               | Karol, Bageshwar, Devidhura forest | *Q. incana, Q. dilatata*           | MSR1-08, 90-09 | PUN 3973    | LSU HQ270123         |
| 4      | *C. elongatipes* sp. nov.   | Bhasar forest                     | *P. wallchiana, Abies pindrow, Picea smithiana, C. deodara* | 184-08, 295-09 | PUN 3966    | LSU HM750927, ITS HQ270115 |
| 5      | *C. fibrillosus* sp. nov.   | Khada Pathar, Dhalli forest       | *C. deodara*                       | 113-07, 17-08, 236-06 | PUN 3957    | LSU HM750929, ITS HQ270125, LSU HM750917 |
| 6      | *C. himalayensis* sp. nov.  | Khada Pathar, Kufari, Jageshwar forest | *C. deodara*                     | 43-06, 169-07, 32-09 | PUN 3972    | LSU HM750919, ITS HQ270129 |
| 7      | *C. indicus* sp. nov.       | Kufri forest, Karol forest        | *Q. lewotrichophora*              | MSR2-07, MSR4-08, 45-09 | PUN 3962    | LSU HM750928, ITS HQ270122 |
| 8      | *C. lateritius*             | Kadha Pathar, Shilly forest       | *C. deodara, P. roxburghii*        | 333-05, 161-07, 119-05 | PUN 3958    | LSU HM750924, ITS HQ270121, LSU HM750919 |
| 9      | *C. minor*                  | Khada Pathar                      | *C. deodara, Q. dilatata*          | 354-06, 251-09 | PUN 3971    | LSU HM750919, ITS HQ270123 |
| 10     | *C. natarajanii* sp. nov.   | Chail forest, Jageshwar forest    | *C. deodara, Q. dilatata*          | 106-08, 35-09, 93-09 | PUN 3963    | LSU HM750923, ITS HQ270120 |
| 11     | *C. umbonatus* sp. nov.     | Khada Pathar                      | *C. deodara*                       | 348-05, 316-06, 217-07 | PUN 3968    | LSU HM750926, ITS HQ270116, LSU HM750916 |
The phylogenetic tree was reconstructed using 26 ITS sequences of *Cantharellus* spp., *Craterellus* species were used as an outgroup taxon for rooting purposes.

Maximum parsimony (MP), maximum likelihood (ML) and Bayesian analysis (BA) were performed with the following parameters. (i) MP: equally weighed parsimony analysis was performed using PAUP (Swofford 2002) with 1000 heuristic search replicates performed with starting trees generated by stepwise addition with random addition sequences followed by Tree Bisection Reconnection (TBR) branch swapping. Gaps were treated as missing data. To assess the relative support for each clade, bootstrap (BS) values were calculated from 1000 replicates. Optimal models of DNA substitution was inferred using the Akaike information criterion (AIC) (Akaike 1981) as implemented in the MrModelTest ver. 2.3 (Nylander 2008). (ii) ML: The analysis was performed in PAUP* with a GTR+I+G model of nucleotide substitution, starting trees obtained via stepwise addition, random sequence addition, TBR branch swapping and MaxTrees set to one million generations. (iii) BA: Bayesian analysis utilized the Metropolis-coupled Markov Chains Monte Carlo search algorithm as implemented in the program MrBayes v 3.1.2 (Ronquist and Huelsenbeck 2003). Two simultaneous independent replicates of six were run for 5 million generations with sampling at every 100th generation, and the convergence of the runs visualized using Tracer ver. 1.4 (Rambaut et al. 2013). Those tree sampled prior to searches reaching a split deviation frequency value of 0.01 were discarded as the burn-in, and the remaining trees were used to calculate Bayesian posterior probabilities (PP) of the individual clades. Only Bayesian posterior probabilities (PP) greater than or equal to 95% are considered significant. To compare topologies resulting from the different search criteria, unconstrained trees (MP, ML) were compared in PAUP* using the Kishino–Hasegawa test (Kishino and Hasegawa 1989) in order to determine whether trees were significantly different. Trees were figured in Treeview (Page 1996).

**Results**

**Analysis of the LSU data set**

The final data set consisted of 40 sequences of 792 characters, of which 224 were parsimony informative, 487 and 81 were constant and parsimony-uninformative, respectively. Maximum parsimony analysis resulted in nine equally parsimonious trees with the branch-and-bound search (TL = 229, CI = 0.84, RI = 0.94). Maximum likelihood analysis recovered a single topology (−ln L = 3564.5978). The resulting MP and ML topologies did not differ significantly. The Kishino–Hasegawa tests among the topologies obtained from ML and MP indicated that the ML tree was significantly better and one of the maximum likelihood trees is shown in Figure 2. Most single species clades received moderate to strong support (65–100% BS, 56–100% PP).

The phylogenetic tree, based on LSU sequences was clustered into 10 clades. *Cantharellus appalachiensis*, *C. fibrillosus*, *C. himalayensis* and *C. umbonatus* are clustered together as clade 1. *Cantharellus cinnabarinus* and *C. minor* are grouped in clade 2, while *Cantharellus lateritius* formed as a distinct monophyletic clade (clade 3). Clade 4 consisted of *Cantharellus indicus*, *C. persicinus* and *C. formosus*, formed as a separate clade (clade 5). *C. pseudoformosus* and *C. cascadenensis* are clustered as clade 6 and clade 7, respectively. Sequences of *C. appalanatus*, *C. natarajanii* and *C. elongatipes*, which are new to science are grouped as clade 8 and *C. subalbidus* sequences formed into clade 9. *Canthareullus cibarius* sequences are clustered into clade 10.

**Analysis of the ITS data set**

Sequences generated from ITS contained 406 bp from the 5′ end of the ITS 1 and 560 from the 3′ end of the ITS 2 including the 5.8S nrDNA gene. The aligned data set contained 1105 characters, of which 521, 226 and 358 were constant, parsimony-uninformative and parsimony-informative, respectively. In MP analysis, five equally parsimonious trees resulted with the branch-and-bound search (TL = 314, CI = 0.70, RI = 0.80). Maximum likelihood analysis recovered a single topology (−ln L = 8812.2). The resulting MP and ML topologies did not differ significantly (Figure 3).

**Taxonomy**

*Cantharellus appalachiensis* Petersen, Svensk Bot, Tidskr. 65:402. 1971. Figures 4A, 5A–B

**Pileus** 3–7 cm wide, plano convex to shallow depressed, pinkish yellow (10I-4) to yellowish (10G-2), appressed, faintly squarose, surface glutinous, non-hygrophanous, covered with indistinct scales; margin irregular, non-striate, lobed, split, uplifted with age. **Context** up to 1-cm thick, yellowish. **Lamellae** decurrent, folded, interveined, hymeniform folded up to 2-mm broad, Apricot yellow (9K-5). **Stipe** 3.5–7 × 0.5–1.1 cm, terete with slightly expanded apex, lacunose, stipe surface fibrous pinkish yellow to citron yellow (10J-2); taste very pleasant (like other chanterelles). Spore deposit creamish white. **Basidiospores** [45/2/2], 7.5–9.5 × 4.5–6 μm, L = 8.4 μm, W = 5.2, Q = 1.62, ellipsoid to elongate, inamyloid,
Figure 2. Phylogeny of *Cantharellus* generated from maximum likelihood of LSU sequences, rooted with *Craterellus* species. Parsimony bootstrap support (BS) and Bayesian posterior probability (PP) values >50% are given at the internodes (BS/PP). The bold species represent the Indian collections.
smooth, faintly yellowish in 3% KOH, contents monoguttate to granulated. Basidia ±52–77 × 7.5–9 µm, cylindrical to narrowly clavate, sterigmata 4.5–7 µm long, cornuted 4–6 per basidium, developing basidia with evenly granulose, light yellow contents, basal septa with clamps. Basidioles numerous with opaque light yellow contents in 3% KOH.

Pileipellis epicutis made up of subclavate to clavate cells with projecting cystidiod end, ±70–100 µm long, made up of radially to sub-radially arranged hyphae, 4–12 µm diam, granulated wall thin to slightly thick and pale yellowish in 3% KOH, context hyphae cylindric ±3–17 µm diam, slightly thick walled. Hymenophoral trama interwoven with cylindric hyphae ±2.5–7 µm wide. Pleurocystidia and Cheilocystidia absent. Stipe cuticle made up of subclavate to clavate hyphae, thin to slightly thick walled, ±3–11-µm wide, contents similar to suprapellis, septa frequently clamped.

**Habitat.** Gregarious to caespitose; on soil under Cedrus deodora.

**Specimens examined.** India, Himachal Pradesh, Shimla, Chail forest, N31°06’ E77°.10’ 1800 m, 30 July 2007, 39-07; same location, 12 August 2008, 84-08; Uttarakhand, Jageshwar forest N29°00’ E79°.17’ 1646 m, 24 August 2008, 95-08. Accession No.: PUN 3959 (95-08).

**Commentary.** Based on the taxonomic characters of the present specimen with a previously described type specimen (Bigelow 1978), it was identified as Cantharellus appalachiensis. The morphological features such as matted cap with appressed fibrils, non-hygrophanous, similar colour tones, folded lamellae, intervenose, subacute edges, similar spore size, and pileipellis hyphae non-encrusted with cystidiod end cells indicated similarity with C. appalachiensis. Further, phylogenetic analysis of LSU sequences supported its identity with C. appalachiensis.
**Cantharellus applanatus**

Deepika, Upadhyay & Reddy, sp. nov. 

**Figures 4B, 5C–D, 6A**

MycoBank MB519516

**Pileus**

Upto 3–6.5 cm, applanate to shallow depressed; golden yellow (9L-6), smooth; margin regular, split. 

**Context**

3–7-mm thick, yellowish, confluent, unchanging on exposure to air, surface smooth, glabrous. 

**Lamellae**

Decurrent, folded, anastomosing, forked up to 2 mm broad, golden yellow (9L-6). 

**Stipe**

Central, 2.5–5 × 0.4–0.7 cm, cream (9D-2), equal in the diameter throughout, surface glabrous to thin hairy. Spore deposit white. 

**Basidiospores** [55/2/2], 7–8.5 (–9) × 4.5–5.5 µm, L = 7.6 µm, W = 4.5, Q = 1.54, ellipsoid, inamyloid, smooth, contents monoguttulate to granulated. 

**Basidia** ±55–78 × 6.0–7.5 µm, clavate, sterigmata 2.5–4 µm diam, cornuted 4–5 per basidium, developing basidium with evenly granulose, light yellow contents, basal septa with clamps. 

**Basidioles**

Numerous with opaque light yellow contents in 3% KOH. 

**Hymenophoral trama**

Irregular to interwoven, branched, hyaline to faint yellowish, slightly constricted at septa which are frequently clamped, 3–7.5 µm wide. 

**Pileipellis**

Consisting of compactly arranged projecting end hyphae, cylindric to filamentous, yellow to yellowish brown, branched, thin to thick walled, frequently clamped, non-amyloid hyphae, 3–8 µm-wide, contents granulose. 

**Pleurocystidia** and **cheilocystidia** absent. 

**Stipe cuticle**

Made up of yellowish brown, cylindric to filamentous, 2.5–7 µm wide, branched, hyphae frequently clamped. 

**Habitat.** Caespitose to gregarious, on soil among green grass with *P. roxburghii*. 

**Specimens examined.** India, Himachal Pradesh, Shimla, Karsog forest, N31°24′ E77°12′ 1900 m, 5 August 2007, 43-07; same location, 21 August 2008, 121-08. 

**Holotype:** PUN 3964 (121-08). 

**Commentary.** *C. applanatus* formed same clade as *C. elongatipes* and *C. natarajanii*, however was differentiated by its pileus and stipe features. Some of the morphological characters, such as colour, spore range and Q values of *C. applanatus* match well with the characters described for *C. viscosus* Berk (Corner 1966). However, the present specimen can be distinguished from *C. viscosus* by its applanate pileus, compared to the prominent infundibuliform in *C. viscosus*. It can be further distinguished from *C. cascadensis* and *C. subalbidus* (white *Cantharellus*) by pileus and stipe colour, hymenium surface and basidiospores, basidia and the width of hymenium. 

**Etymology:** from the Latin word **applanatus**–**applanate**, referring to the shape of the cap. 

**Cantharellus cibarius** Fries, Syst. Mycol. I: 318. Sohi et al. (1964). Figure 4C

**Commentary.** This is a common species of *Cantharellus*, frequently found in the Indian Himalayas and easily recognized by field characters, especially the fruit-like smell. Fries described the type specimen in detail from the Kashmir region, India. Colour of pilei and stipe is ochraceous brown to yellowish brown; the decurrent hymenium forms blunt ridges or veins; basidia is frequently six spored, slender clavate with basal clamp-connections. The basidiospores are 8.5–10.5 (–11) × 4.5–6 µm, L = 8.5 µm, W = 5.5 µm, Q = 1.54, ellipsoid, smooth, non-amyloid, wall hyaline, contents monoguttulate to multi-guttulate, that coincide with previously described *C. cibarius*. The distinctness of *C. cibarius* was also supported by phylogenetic analysis of LSU sequences, which formed same clade with other similar species.
Habitat. On soil, gregarious to caespitose; under Quercus incana. Specimens examined. India, Uttarakhand – Bageshwar forest, N29°45′ 1696 m, 15 July 2008, MSR1-08; Devidhura forest N29°05′ E78°.00′ 1615 m, 12 August 2009, MSR3-09; Himachal Pradesh – Karol forest N30°92′ E77°.15′ 2100 m, 22 September 2009, 90-09. Accession No. PUN 3973 (90-09).

Cantharellus elongatipes Deepika, Upadhyay & Reddy, sp. nov. Figures 4D, 5E–F, 6B

MycoBank MB519521

Pileus upto 1.5 cm, convex to plano convex with slightly depressed in the centre; Mirabelle (10J-7), orangish yellow, smooth; margin regular to irregular, split. Context thin. Lamellae strongly decurrent, anastomosing to subdistant, hymeniform folded up to 1-mm high, orange. Stipe 3–3.5 × 0.4–0.7 cm, equal in diameter, lacunose, stipe surface glabrous, Mirabella (10J-7) to dirty orange. Spores deposit white. Basidiospores [55/2/2] 6–7.5 × 4.5–5.5 µm, L = 6.6 µm, W = 4.9 µm, Q = 1.35, broadly ellipsoid to ellipsoid, non-amyloid, smooth, wall hyaline, contents monoguttulate. Basidia ±52–70 × 7–10 µm, narrowely clavate to clavate, sterigmata 2.5–4.5 µm long, cornuted 4–5 per basidium, developing basidia with evenly granulose, light yellow contents, basal septa with clamps. Basidioles numerous with opaque light yellow contents in 3% KOH. Subhymenium made up of non-inflated hyphal segments, branched, septate with frequently clamped. Hymenophoral trama interwoven with cylindric hyphae ±2.5–6-µm wide. Pileipellis made up of sub parallel arranged filamentous hyphae, septate, clamped, hyaline to pale yellowish, 2–3.5-µm wide, followed by clavate to subclavate or irregularly arranged cylindrical elements, 9–18-µm wide, granulated.
Pleurocystidia and Cheilocystidia absent. Stipe cuticle made up of hyaline to pale yellow, filamentous to cylindrical, followed by cystoid end cells, branched, frequently clamped hyphae, 2.5–8-µm wide. Habitat. gregarious to caespitose; on soil under Cedrus deodara. Specimens examined. India, Uttarakhand, Pauri Garhwal, Bharsar forest, N29°45′ E78°55′ 2350 m, 29 September 2008, 184-08; same location, 8 September 2009, 295-09. Holotype: PUN 3966 (184-08).

Commentary. Presence of clamp connections throughout the basidiomes, cantharelloid sterigmata and the almost cylindrical basidia placed the present specimen in the genus Cantharellus. When young, C. elongatipes can be mistaken with basidiomes of C. minor but can be differentiated by its less fleshy stipe and decurrent hymenium. The name C. elongatipes has been assigned due to the presence of small pileus as compared to stipe length (pileus diam 1–1.5 cm, stipe length 2–4.5 cm). This new species forms a distinct lineage in phylogenetic tree generated from LSU sequences (Figure 2).

Etymology: elongatipes – refers to the long stipe.

Cantharellus fibrillosus Deepika, Upadhyay and Reddy, sp. nov. Figures 4E, 5G–H, 6C
Mycobank MB519517

**Pileus** up to 5–8.20-cm wide, infundibuliform, Mustard brown (14D-10) in the centre, golden wheat (11D-7) outwards, fibrillosate, dense in the centre, surface dry, hygrophanous; margin irregular, non-striate, decurved. **Context** 2–3-mm thick, creamish, confluent, unchanging on exposure to air, surface smooth but not glabrous. Lamellae abundantly decurrent to sub-decurrent, anastomosing, separable easily from the flesh. Stipe 6–8 × 0.7–1.0-cm thick, yellowish orange (10C-4), terete with slightly swollen at base, surface smooth to hairy. Spore deposit white. **Basidiospores** [45/2/2] (8–9–12 (12.5) × 5–6 (–6.5) μm, L = 9.7 μm, W = 5.9 μm, Q = 1.64, ellipsoid to cylindrical, non-amyloid, non-cyanophilic, wall hyaline, contents monoguttulate to multiguttulate with greenish referective oil droplets; spores deposit white. **Basidia** ±60–90 × 9–11.5 μm, clavate, sterigmata 3.5–6.5 × 1–2-μm diam., cornuted 2–6 per basidium, developing basidia with evenly granulose, light yellow contents, basal septa with clamps. **Basidioles** numerous with opaque light yellow contents in 3% KOH. **Hymenophoral trama** irregular to interwoven, branched, hyaline to faint yellowish, constricted slightly at septa, septate frequently clamped. **Pileipellis** consisting of filamentous and interwovenly arranged hyphae, hyaline, branched, thin- to thick-walled, frequently clamped, non-amyloid hyphae, 3–12-μm wide, contents granulose. **Pleurocystidia** and **Cheilocystidia** absent. **Stipe cuticle** made up of hyaline to yellowish, branched, frequently clamped hyphae, 1.5–5-μm wide. **Habitat.** Caespitose to gregarious, on soil under Cedrus deodara and *P. wallichiana*.

**Specimens examined.** India, Himachal Pradesh, Shimla, Khada Pathar forest, N30°72′ E78°63.2′ 1950 m, 30 September 2006, 236-06; Dhalli forest N 30°17′ E78°64.5′ 1700 m, 18 August 2007, 113-07; same location, 23 September 2006, 43-06; Kufri forest, N30°00′ E77°15′ 1700 m, 6 September 2007, 169-07; same location, 23 August 2009, 32-09. Holotype: PUN 3972 (169-07).

**Commentary.** *C. fibrillosus* clustered with *C. umberatus* in LSU, however their morphology was distinct. Also, this species can be differentiated from *C. ianthinoxanthus* Kuhner (Corner 1966) by its stipe colour and smaller basidia. The stipe colour of *C. ianthinoxanthus* is clear yellow, while that of *C. fibrillosus* is light orange, the stipe becoming brown towards the apex and lighter near the base; *C. fibrillosus* also has smaller basidia with 4–6-steregmuta.

**Etymology:** from the Latin word *fibrillosus* – fibrillose, referring to the pellis surface.

**Cantharellus himalayensis** Deepika, Upadhyay & Reddy, sp. nov. Figures 4F, 5I–J, 6D

Mycobank MB519518

**Pileus** up to 3–7-cm wide, infundibuliform, margin wavy, irregular, faintly striate to non-striate, conceolour yellowish, Pecan brown (14A-9) in the centre due to scales, Champagne (11B-3) to Beige (11B-4) outwards, surface dry, non-hygrophanous. **Context** fleshy up to 1.3-cm wide, yellowish. Lamellae folded, hymeniform, inter veneed to bifurcate. Sugarcane (10B-6) to Cornhusk (10E-6) or Capuccine buff (9E-5), edges subacute. **Stipe** up to 4–7.5 × 0.8–1.1 cm, tapering downwards, stipe surface glabrous to thin hairy at bottom. Beige (11B-4) to Pecan brown (14A-9), darker at the base as leather brown. Smell of apricot; taste indistinct. Spore deposit creamish white. **Basidiospores** [45/1/1] 6–8 × 4.5–6 μm; L = 5.91 μm, W = 5.16 μm; Q = 1.34, ellipsoid to broadly ellipsoid, inamyloid, smooth, hyaline, apiculus up to 0.5-μm long, contents monoguttulate to multiguttulate and frequently granulated. **Basidia** 60–85 × 8–11-μm long, narrow clavate to subcylindric, sterigmatata 4 per basidium, 6–9.5-μm long, contents granulated with multi oil droplets, basal septa with clamps. **Basidioles** numerous with opaque light yellow contents in 3% KOH. **Pileipellis** made up of parallel to repent filamentous hyphae, 3–9-μm wide, followed by cylindric hyphae, thin to thick walled yellowish, septate, branched, context hyphae compactly arranged. **Hymenophoral trama** irregular to interwoven, made up of thin walled, clamped, branched hyphae, 3–6-μm wide. **Subhymenium** made up of non-inflated hyphal segments, septate, branched, clamped. **Pleurocystidia** and **Cheilocystidia** absent. **Stipe cuticle** made up of longitudinally arranged thin walled septate, branched, clamped hyphae, 3–12-μm wide, contents similar to pileipellis hyphae.

**Habitat.** Caespitose to gregarious; among mosses on soil in mixed forest dominated by Cedrus deodara.

**Specimens examined.** India, Himachal Pradesh, Shimla, Kaso Pathar forest, N30°72′ E78°63.2′ 1950 m, 30 September 2006, 43-06; Kufri forest, N30°00′ E77°15′ 1700 m, 6 September 2007, 169-07; same location, 23 August 2009, 32-09. Holotype: PUN 3972 (169-07).

**Commentary.** This species can be distinguished from *C. cibarius* by the presence of basidia with four spores, long sterigmatata (up to 9.5 μm), smaller spores (6–8 × 4.5–6 μm) and partially gelatinized pileipellis. *C. himalayensis* was grouped with *C. appalachiensis* in LSU, however greatly distinguished from *C. appalachiensis*, which has larger ellipsoid to elonagte spores (7.5–9 × 4.5–6 μm), and basidia bearing 4–6 curved sterigmatata (4.5–7 μm long). The larger basidiomes of this species differentiates it from *C. minor*.

**Etymology:** from the Latin word Himalayensis – Himalaya, referring to locality.

**Cantharellus indicus** Deepika, Upadhyay & Reddy, sp. nov. Figures 4G, 5K–L, 6E

Mycobank MB519519

**Pileus** 3–7 cm broad, shallow depressed, infundibuliform to applanate; egg yellow to pale ochraceous yellow; margin involute, split, irregular, lobed. **Context** 3–7-mm thick, pale yellow to creamish, confluent, unchanging on exposure to air, surface smooth but not glabrous. Lamellae decurrent,
folded to anastomosing, crowded, separable easily from the flesh. **Stipe** 4–9 × 0.5–1 cm, Sunset (10C-4), slightly swollen at the base, surface smooth to hairy. Spores deposit white. **Basidiospores** [35/2/2] 7–10 × 4.5–5.5 µm, L = 7.9 µm, W = 5.2 µm, Q = 1.5, ellipsoid, smooth, non-amyloid, non-cyanophillic, wall hyaline, contents monoguttulate to multiguttulate with greenish referective oil droplets; spore deposit white. **Basidia** ±65–90 × 9.5–11 µm, clavate, sterigma 3.5–4.5 × 1.2–2–µm diam., cornuted 4–6 per basidium, developing basidia with evenly granulose, light yellow contents, basal septa with clamps. **Hymenophoral trama** irregular to interwoven, branched, hyaline to faint yellowish, constricted slightly at septa, septa frequently clamped. **Pileipellis** consisting of filamentous and interwovenly arranged hyphae, hyaline, branched, thin to thick walled, frequently clamped, non-amyloid hyphae, 3–8-µm wide, contents granulose. **Pleurocystidia** and **Cheilocystidia** absent. **Stipe cuticle** made up of hyaline to yellowish, cylindrical, branched, frequently clamped hyphae, 1.8–3.5-µm wide. **Habitat.** caespitose to gregarious, on soil under *Quercus leucotrichophora*. **Specimens examined.** India, Himachal Pradesh, Shimla, Kufri forest, N30°00′15′′ 1700 m, 3 July 2007, MSR2-07; same location, 25 July 2008, MSR4-08; same location, 14 August 2009, 45-09. Holotype: PUN 3962 (MSR2-07).

**Commentary.** This species shares some common morphological features (long stem compared to the width of the pileus) with *C. cibarius* var. *longipes* Peck as described by Corner (1966). It can be distinguished from *C. cibarius* var. *longipes* which has a smooth pileus, more or less yellow hymenium, and yellowish-white branched stem and from *C. persicinus* which has a peach or pink colour pileus 2–4.5-cm wide; convex, becoming broadly convex or nearly flat, and spores 10.5–11.5 × 6–7 µm and basidia with four sterigmata. The distinctness of *C. indicus* from other species was supported by phylogenetic analysis of LSU sequences.

**Etymology:** from the latin word *Indicus* – India, referring to the region.

**Cantharellus lateritius** (Berk) Singer, Lilloa 22: 729. 1951. Figures 4H, 5M, 5N–6F

**Pileus** upto 3–8-cm broad depressed in the middle to sub-infundibuliform, surface hygrophanous, moist, light yellow (10G-5) to golden yellow (91-6), sometimae appressed to fibrillosae; margin inrolled, irregular, split, sometime lobed. **Hymenium** smooth, without ridges or folds, Golden corn (91-5). **Stipe** 3–7 × 0.4–1 cm, central to eccentric, tapering downwards, Raffia (11E-5), lacunose, glabrous, consistency cartilaginous, stuffed then hollow, context yellowish; taste mild pleasant when fresh. Spore deposits white. **Basidiospores** (45/2/2) 7–9 × 4.5–5.5 (–6) µm, L = 7.9 µm, W = 5.02 µm, Q = 1.57, broadly ellipsoid to ellipsoid, smooth, non-amyloid, non-cyanophillic, wall hyaline, contents monoguttulate to multiguttulate. **Basidia** ±29–60 × 4.5–6 µm, cylindro-clavate to clavate, sterigma 2–4 per basidium, developing basidia with evenly granulose, basal septa with clamps. **Basidioles** numerous with opaque light yellow contents in 3% KOH. **Pileipellis** made up of repent to interwovenly arranged, 2–6–µm wide, embedded in partially gelatinized matrix, branched, septa, clamped, contents granulated, context hyphae comparatively broader. **Hymenophoral trama** subparallel to interwovenly arranged, partially gelatinized at top, pale yellowish in 3% KOH, branched, clamped, 2–6–µm wide. **Pleurocystidia** and **Cheilocystidia** absent. **Stipe cuticle** made up of hyaline, branched, thin to thick walled, granulated contents, 1.5–3.5–µm wide, clamp connections present. **Habitat.** caespitose to gregarious, on soil under *Cedrus deodara.*

**Specimens examined.** India, Himachal Pradesh, Shimla, Kadha Pathar forest, N30°72′ E78°.632′ 1950 m, 13 September 2005, 119-05; same location, 28 September 2006, 333-06; same location, 11 August 2007, 161-07. Accession No.: PUN 3958 (161-07).

**Commentary.** The specimen showed similarities with *C. lateritius* as described by Bigelow (1978), with completely smooth hymenophore, sweet smell and clamped hyphae, except that the Q values are slightly smaller. This species was reported from Jageshwar forest, Uttarakhand by Dhancholia et al. (1991), but they did not mention any taxonomic details to support their identification. This species can be distinguished from other reported *Cantharellus* by its smooth hymenium, lacking ridges or folds. Phylogenetic analysis of LSU sequences also supported identity of the specimen as *C. lateritius*, which formed a separate clade (Figure 2).

**Cantharellus minor** Peck, Annual Rep. New York State Cab 23: 122. 1872. Figure 41

**Commentary.** *Cantharellus minor* is easily recognized by its field characters: small basidiomata, yellow to orange-yellow pileus with decurrent hymenophore. Sohi et al. (1964) described the type specimen in detail from Kashmir region, India. In the present study, this specimen was also collected from forests of Chail and Khada Pathar. After documentation and microscopic examination this specimen easily agrees with the description of *C. minor* described by Sohi et al. (1964). *C. minor* clustered with *C. cinnabarinus* in LSU, however differed mainly based on pileus size and colour. Colour of pilei and stipe is yellow to yellow-orange, gills are crowded, not distant, basidiospores are 6.5–9.5 × 4.5–5.5 µm, L = 8.2 µm, W = 5.5 µm, Q = 1.49, ellipsoid, smooth, non-amyloid, wall hyaline, contents monoguttulate to multiguttulate.

**Habitat.** On soil, gregarious to caespitose; under *Cedrus deodara* and *Quercus dilatata.*

**Specimens examined.** India, Himachal Pradesh, Shimla, Kadha Pathar forest, N30°72′ E78°.632′ 1950 m, 15
July 2005, 354-05; same location, 22 July 2008, 251-09. Accession No.: PUN 3971 (354-05).

**Cantharellus miniatescens** Heinem., BULL. Jard. Bot. Etat Brux. 28, 393, Heinemann 1958, f.36; Fl. Ic. Champ.

**Commentary.** *Cantharellus miniatescens* is recognized in the field by its campanulate pileus, folded decurrent lamellae, stipe surface smooth but not glabrous, slightly swollen at base, colour dull ochre to dull ochraceous orange. Distinctive microscopic characters are ellipsoid spores, frequently clamped pileipellis hyphae and subcylavate to subventricose terminal cells. However, the spore Q value is comparatively smaller in the present described specimen (Q = 1.74) which suggests that the spores are more cylindrical than the type specimen (Q = 1.66), described by Heinemann (1958). The overall macroscopic and microscopic details of the present specimen are in conformity with *C. miniatescens* Heinem except for the slight variation in spore shape.

This species was described by authors in detail from the northwestern Himalayas, India (Kumari et al. 2009). This specimen was collected from Dhalli Reserve forest, Shimla. After documentation and microscopic examination this specimen agrees with the description of type specimen of *C. miniatescens* (Heinemann 1958).

**Habitat.** Solitary to gregarious; on soil under the mixed forest dominated by Cedrus deodara.

**Specimens examined.** India, Himachal Pradesh, Shimla, Dhalli Reserve forest. N31°20' E76°.11' 1700 m, 25 July 2007, Accession No. RCU 65/07.

**Cantharellus natarajani** Deepika, Upadhyay & Reddy, sp. nov. Figures 4I, 5O–P, 6G

**MycoBank MB519522**

**Pileus** 5–10-cm wide, hemispherical, plano-convex to finally depressed, Golden yellow (9K-4) to Chinese yellow (10K-6), smooth, margin irregular, wavy, lobed, non-striate. **Context** 3–5-mm thick, lemon yellow to yellow, confluent, unchanging on exposure to air, surface smooth, glabrous. **Lamellae** distinctly hymeniform, decurrent, anastomosing to distinctly interveined, golden yellow (9L-6).

**Stipe** central, 3.5–6 x 0.4–1 cm, Sunset, slightly expanded at apex, surface glabrous to appressed fibrils. Spore deposit white. **Basidia** 52/2, 6.5–9 x 5–6.5 µm, L = 7.6 µm, W = 5.67, Q = 1.34, broadly ellipsoid to ellipsoidoid, thin walled, smooth, faintly yellowish in 3% KOH, contents monoguttulate to multi oil refractive gutulate, inamyloid. **Basidiospores** ±57–85 x 6.5–10.5 µm, clavate, sterigmata 4.5–8 x 1.2–2.5 µm diam., cornuted 4–5 per basidium, developing basidia with evenly granulose, light yellow contents, basal septa with clamps. **Basidioles** numerous with opaque light yellow contents in 3% KOH. **Hymenophoral trama** irregular to interwoven, branched, hyaline to faint yellowish, slightly constricted at septa, septa frequently clamped. **Pileipellis** consisting of cylindrical to filamentous and interwovenly arranged hyphae, end-cells are distinctly subclavate to subventricose, yellowish to yellowish brown, branched, thin to thick walled, frequently clamped, non-amyloid hyphae, 3–10-µm wide, followed by cystoids end hyphae, contents granulose. **Pleurocystidia** and **Cheilocystidia** absent.

**Stipe cuticle** made up of yellowish brown, cylindric to filamentous, branched, frequently clamped hyphae, 2.5–10-µm wide.

**Habitat.** caespitose to gregarious, on soil among moss under Cedrus deodara and Quercus dilatata.

**Specimens examined.** India, Himachal Pradesh, Shimla, Chail forest, N31°06' E77°.10' 1700 m, 30 July 2008, 106-08; same location, 22 August 2009, 35-09; same collection, Uttarakhand – Jageshwar forest N29°00' E79°.17', 29 August 2009, 93-09. Holotype: PUN 3963 (106-08).

**Commentary.** This species can be distinguished from *C. cibarius* which is much larger (pileus 15 cm broad, spores range 8.5–11.5 x 4.5–5.5 µm), moreover the colour morphology is dissimilar, Important character of *C. natarajanii* is “pileus hypal end-cells which is distinctly subclavate to subventricose” which clearly differentiates from *C. cibarius*. Phylogenetic analysis of LSU sequences also confirmed its distinction with other species of *Cantharellus* (Figure 2).

**Etymology.** Is named in honour of Professor K. Natarajan on the account of his contribution towards Indian mycology.

**Cantharellus pseudoformosus** Deepika, Upadhyay & Reddy, Mycoscience 52: 147–151. 2011

**Commentary.** This species was described from the northwestern Himalayas, India (Kumari et al. 2011b), who reported that this collection is morphologically similar to *C. formosus* Corner, as described by Pilz et al. (2003). However, the molecular analyses of LSU and ITS sequences showed *C. pseudoformosus* is distinct from *C. formosus*.

**Habitat.** Gregarious to caespitose; on soil under trees of Cedrus deodara.

**Specimens examined.** India, Himachal Pradesh, District-Chamba, Khajjiyar, N32°10' E75°.45' 6400 m, 28 September 2007, 281-07; Suala (25 km away from the Khajjiyar guest house); same collection, 28 September 2007, 272-07; Bharour (5 km away from the Bharour bus stand), same collection, 12 September 2009, 282-09. Holotype: PUN 3883 (281-07).

**Cantharellus umbonatus** Deepika, Upadhyay & Reddy, sp. nov. Figures 4K, 5Q–R, 6H

**MycoBank MB519523**

**Pileus** 4–5 cm, applanate then umbilicate, Capuccine orange to yellow, smooth; margin irregular, hygrophanous, non-striate, lobed. **Context** 2–3 mm thick, straw (10F-2), confluent, unchanging on exposure to air, surface smooth but not glabrous. **Lamellae** abundantly decurrent, interveined to anastomosing, white reaching up to the half of
the stipe. **Stipe** 9–11.5 × 1–1.5 cm thick, central, Margurite yellow (10C-1), terete with slightly swollen apex, radicate, surface fibrous, stipe trama colonial buff (10G-2). Spore deposit white. **Basidiospores** [55/2/2] (8–) 8.5–10 (–10) × 5–5.5 (–6) μm, L = 8.99 μm, W = 5.08 μm, Q = 1.76, ellipsoid to cylindrical, non-amyloid, non-cyanophilic, wall hyaline, contents granulated to multiguttulate with greenish referective oil droplets. **Basidia** ±67–99 × 7–9.7 μm, clubed shaped to sub clavate, sterigmata 3.5–6.5 × 1.2–2 μm diam., conuted 4–6 per basidium, developing basidia with evenly granulose, light yellow contents, basal septa with clamps. **Basidioles** numerous with opaque light yellow contents in 3% KOH. **Subhymenium** made up of narrow to non-inflated hyphal end cells. **Hymenophoral trama** irregular to interwoven, branched, hyaline to faint yellowish, constricted slightly at septa, septa frequently clamped. **Pileipellis** consisting of filamentous and interwoven arranged, hyaline, branched, thin to thick walled, frequently clamped, non-amyloid hyphae, 3–12 μm wide, followed by protruding end cells, contents granulose. **Pleurocystidia** and **Cheilocystidia** absent. **Stipe cuticle** made up of hyaline to yellowish, branched, frequently clamped hyphae, 2.5–6 μm wide. **Habitat.** caespitose to gregarious, on soil under the trees of Cedrus deodara.

**Specimens examined.** India, Himachal Pradesh, Shimla, Katha Pathar forest, N30°72’ E78°63.2’ 1950 m, 25 July 2006, 316-06; same location, 29 July 2007, 348-07; same location, 28 August 2009, 217-09. Holotype: PUN 3968 (316-06).

**Commentary.** *C. umbonatus* clustered with *C. fibrillosus* sequence of LSU whereas clustered with *P. pseudoformosus* with ITS sequences. However, morphologically distinct characters separated this species as new to the world from *C. fibrillosus* and *P. pseudoformosus*. *C. umbonatus* is readily distinguished by its slightly umbo-nate pileus and umber hymenium that reaches up to half of the stipe. The species is closely related to *C. cyanoxanthus* Heim, Corner (1966), but differs in pileus, stem and hymenium colour. Morphologically, it was also found that *C. umbonatus* differs from *C. appalachiensis* by its dark orange to yellow, with smooth pileus surface, and ellipsoid to elongate basidiospores (Q = 1.62). On the other hand *C. cinnabarinus* is smaller with pileus up to 1.5 cm broad and with distinctive flamingo-pink colours. **Etymology:** From the Latin word umbonatus—umbilicate, referring to the shape of the cap.

**Key to the Indian species of Cantharellus**

1. Hymenophore smooth ......................... *C. lateritius*  
2.* Hymenophore with prominent folds ...................... 2  
2. Lamellae yellow, yellow orange or reddish orange when mature .................................................. 3  
2.* Lamellae whitish to off-white ..........................  
3. ........................................................................ 4  
3. Fruit-bodies infundibuliform, ocharaceous brown to yellowish brown .......................... 4  
3.* Fruit-bodies planoconvex to convex, hemispherical to planate, egg yellow to yellowish range ........ 7  
4. Pileus up to 7-cm broad, surface with prominent fibris, squamules at the center, usually surface uneven and rugose .................. *C. fibrillosus* sp. nov.  
4.* Pileus <7 cm broad, surface with matted fibris or glabrous ........................................................ 5  
5. Pileus ocharaceous yellow with gelatinizes pileipellis hyphae, four basidiospores per basidium ..........................................................................................................................  
5.* Pileus ocharaceous yellow without gelatinized hyphae, 4–6 basidiospores per basidium .......... 6  
6. Pileipellis epicutis with projecting cystidiod end sub-clavate to clavate cells, spore 7–9 × 5–6 μm ..........  
6.* Pileipellis with elongate to broad clavate end cells, spores 8.5–11.5 × 4.5–5.8 μm .... *C. cibarius*  
7. Stipe more than the width of pileus .................. 8  
7.* Stipe equal to width of pileus or smaller .......... 9  
8. Fruit bodies plum yellow to organgish, pileus 1.5 cm broad, stipe up to 4.5 cm .... *C. elongatipes* sp. nov.  
8.* Fruit bodies egg yellow to pale ocharaceous yellow, pileus 7-cm broad, stipe up to 12 cm ...........  
9. Pileus <3 cm broad ............................................. 10  
9.* Pileus >3 cm broad ........................................ 11  
10. Pileus yellowish orange to orange; context concolorous with pileus; spores 7–11.5 μm long ... *C. minor*  
10.* Pileus deep yellow, context pale yellow to yellow; spore 5–6 (–7) μm long ....................... *C. friessi*  
11. Lamellae decurrent, folded, interveined, hymeniform folded, yellowish, stipe surface fibrous, pinkish yellow to citron yellow .................................................. 12  
11.* Stipe surface glabrous to thin hairy, yellowish ... 13  
12. Pileus and stipe dull brown, becoming dingy yellowish to dingy orangish yellow with brownish tones remaining on the pileus disc and stipe base .............................  
12.* Pileus and stipes colour not as in *C. appalachiensis* 14  
13. Pileus appellenate to shallow depressed; spore 7–8.5 × 4.5–5.5 μm .................. *C. appalachiensis* sp. nov.  
13.* Pileus convex to shallow depressed; spore 10–13 × 6–8.5 μm ................................. *C. luteocomus*  
14. Pileus cuticle made up of repent hyphae, context cells are distinctly subelavate to subventricose ..........  
14.* Pileus cuticle made up of parallel to suberectly arranged hyphae ................................. *C. miniatescens*
Table 2. Comparison of morphological characters of *Cantharellus* species found in the northwestern Himalayas region of India.

| Name of species          | Pileus diameter (cm) | Pileus surface              | Stipe diameter (cm) | Basidia (µm) | Basidiospores (µm) | Pileipellis hyphae                                                                 |
|-------------------------|----------------------|-----------------------------|---------------------|---------------|--------------------|-----------------------------------------------------------------------------------|
| *C. applanatus*         | 3–6.5                | Golden yellow               | 2.5–5 × 0.4–0.7     | 55–78 × 6.0–7.5 | 7–8.5 × 4.5–5.5    | Projecting end hyphae                                                             |
| *C. appalachiensis*     | 3–7                  | Pinkish yellow to yellowish | 3.5–7 × 0.4–1.1     | 52–77 × 7.5–9  | 7.5–9.5 × 4.5–5.8  | Subclavate to clavate cells with projecting cystidiod end hyphae                  |
| *C. cibarius*           | 3–15                 | Egg yellow to pale ochraceous| 3–8 × 0.4–0.8       | 50–110 × 7.5–10| 8.5–10.5 × 4.5–5.8 | Cylindric hyphae end hyphae                                                        |
| *C. elongatipes*        | 1.5                  | Orangish yellow             | 3–3.5 × 0.4–0.7     | 52–70 × 7–10   | 5.9–7.2 × 4.5–5.4  | Sub parallel arranged filamentous hyphae                                          |
| *C. fibrillosus*        | 5–8.2                | Mustard brown               | 6–8 × 0.7–1.0       | 60–90 × 9–11.5 | 8.5–12 × 5–6.2     | Filamentous and interwovenly arranged hyphae                                     |
| *C. himalayensis*       | 3–7                  | Yellowish                   | 4–7.5 × 0.8–1.1     | 60–85 × 8–11   | 6–8 × 4.5–6        | Parallel to repent filamentous hyphae                                             |
| *C. indicus*            | 3–7                  | Egg yellow to pale ochraceous| 4–9 × 0.5–1.0       | 65–90 × 9.5–11 | 7.2–10 × 4.5–5.4   | Filamentous and interwovenly arranged hyphae                                     |
| *C. lateritius*         | 3–8                  | Light yellow to golden yellow| 3–7 × 0.4–1.0      | 29–60 × 4.5–6 | 7–9 × 4.5–5.5      | Repent to interwovenly arranged hyphae                                             |
| *C. miniatescens*       | 3–5                  | Orange grey to greyish orange| 3.5–6.0 × 0.4–0.8   | 50–75 × 7.2–9  | 7.2–9 × 4.5–5.4    | Parallel to suberectly arranged hyphae                                            |
| *C. minor*              | 0.5–3                | Dull yellow to orange       | 1.5–2.5 × 0.3–0.5   | 40–70 × 7.6–10.5| 7.5–10 × 4.5–6.0   | None inflated hyphal cells                                                        |
| *C. natarajanii*        | 5–10                 | Golden yellow               | 3.5–6.0 × 0.4–1.0   | 57–85 × 6.5–10.5| 6.5–9 × 5.2–6.3    | Subclavate to subventricose hyphal cells                                          |
| *C. pseudoformosus*     | 1–3                  | Light yellow to brownish orange| 2–4.5 × 0.3–0.6     | 40–65 × 5.3–9 | 7–9 × 5.0–6.0     | Projecting cystidiod end subclavate to clavate cells                              |
| *C. umbonatus*          | 4–5                  | Capuccine orange yellow     | 9–11.5 × 1–1.5      | 67–99 × 7–9.7 | 8.5–9.8 × 5.5–5.8 | Filamentous and interwovenly arranged hyphae                                     |
| *C. luteocomus*         | 1–2.5                | Yellowish orange            | 1.5–3.5 × 0.4–0.8   | 60–95 × 6–8.5 | 7.0–10.0 × 5–7     | Cylindric to slightly inflated hyphae                                             |
| *C. friessi*            | 0.6–1.5              | Deep yellow to orange yellow| 1.5–2.2 × 0.1–0.3   | 48–72 × 7–9.5 | 6.5–10 × 4–6.5     | Interverovely arranged hyphae                                                     |
Discussion

All the species described above are morphologically well delimited. The majority of the species can be unambiguously recognized based on their spores, although the size and colour of the basidiome, the nature of the pileus, pileipellis hyphae and ecology are also useful characteristics in species identification. Most of the species are common and widespread in northwestern Himalayan coniferous forests; however, *Cantharellus miniatasem* seems to be very rare and found only Dhatti Reserve forest, Shimla, under Cedrus deodara. Although, *C. friessi* and *C. luteocomus* were reported from western Himalayan region by Bhatt and Lakhanpal (1988), we did not find either in our collections. All the collected specimens were critically examined and also compared with previously reported *C. friessi* and *C. luteocomus* and found to differ from these two species based on various uncommon characters. We have summarized the morphological characters of all the species collected from the northwestern Himalayas of India in Table 2. Although *Cantharellus* species are reported from all over the world, only few species have either complete ITS sequences or LSU sequences in public databases, indicating poor coverage of these species. We could not achieve congruence in the LSU and ITS phylogenies because of the limited number of ITS sequences in the databases. The species having LSU sequences in the databases are higher, hence; in the present study we have reconstructed the phylogenetic trees using these sequences for further analysis.

Phylogenetic analysis of LSU sequences yielded consistent topologies in different taxa of Cantharellaceae. The phylogenetic tree, based on limited species of *Cantharellus*, indicated that the present infrageneric classification is composed of non-monophyletic taxa. A revised infrageneric classification of *Cantharellus* is an issue for future studies with more species included and data from additional genes added. Our results are consistent with the monophyletic character of the species of *Cantharellus*, providing support to some taxonomic questions. Nevertheless, delimitation of some of those species requires further studies. In addition to its contribution to the study of the taxonomy of *Cantharellus*, this work would be useful to design the probes in the identification of new species, or as a database for comparing sequences of unidentified species.

In conclusion, phylogenetic analysis of LSU sequences revealed clades with statistical support corresponding to circumscribed morphological characters and identified seven new species within *Cantharellus*. This study suggests that the Indian subcontinent and the Himalayas are likely to harbour a considerable part of the still undiscovered fungal diversity, and possibly many endemic species. We analysed two loci and tried to avoid erroneous identification but it cannot be ruled out that multiloci analysis comparing type sequences would further corroborate this identification.

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