

## FAMILY PLUTEACEAE IN NORTH WEST INDIA

MUNRUCHI KAUR\* AND YADWINDER SINGH

Department of Botany, Punjabi University, Patiala 147002, Punjab, India  
munruchi@gmail.com

### ABSTRACT

Family *Pluteaceae* the “pink spored family” falls under order *Agaricales*. It includes 4 genera spread over 346 species [7]. Presently, 30 species falling under 3 genera of this family, *Pluteus*, *Volvariella* and *Volvopluteus*, have been collected from various localities of North West India. Of these 7 species, 4 varieties are presented as new to science and while 11 are recorded for the first time from India. The genus *Pluteus* is defined by the presence of bilateral convergent trama and carpophore stipe lacking both the annulus and volva, while genus *Volvariella* has bilateral convergent trama with the stipe lacking an annulus, the genus *Volvopluteus* is a newly constructed genus on the basis of spore size more than 11 µm and stipe with volva and no annulus. The pluteoid mushrooms occur in abundance in the tropical region, they come up early in the monsoon season, mostly they are terrestrial, few are foliicolous and lignicolous, only genus *Volvariella* was collected from coprophilous habitat. In the study area *Volvariella bombycina*, *V. diplasia* and *Volvopluteus gloiocephalus* are the other commonly hunted mushrooms from the wild for human consumption. These species are also being cultivated commercially. Their wild relatives are of common occurrence in North Western India. From the surveys it has become apparent that there is enough wild germplasm for utilization in strain improvement programme in paddy straw mushroom in study area. Various available wild species of *Volvariella*, namely *V. bakeri*, *V. terastia*, *V. taylorii* and *V. cubensis*, etc. possesses acceptable agronomic features with possibilities of introduction into cultivated commercial strains through breeding experiments.

**Keywords:** systematics, pluteaceae, new species, new varieties, new records, India

### MATERIALS AND METHODS

The material was collected from Punjab plains. The morphological details were recorded from fresh carpophores. The field characters pertaining to gross morphology, shape, color and size of the pileus, stipe and lamellae, presence or absence of annulus, etc were noted down on the ‘Field key’ provided by Atri *et al.* [1] and the colour terminology used is that of Kornerup and Wanscher [8]. The specimens were hot air dried and packed in cellophane paper bags containing 1-4 dichlorobenzene. The microscopic details were studied by cutting free hand sections of revived part of the dried specimen and staining them in 1% Cotton blue or 2% Congo red. The spores were studied from the spore print as well as from the crush mounts of the lamellae, amyloid reaction was checked in Melzer’s Reagent. The dried specimens were deposited in the Herbarium, Department of Botany, Punjabi University, Patiala, (Punjab), India under PUN for further reference.

### RESULTS AND DISCUSSION

*Pluteus transitus* sp. nov. [Figs. 1(A) & 3]

**Etymology:** Epithet name refer to transition phase between two sections of genus *Pluteus*.

Carpophores 4.7-7.2 cm in height. Pileus 2.9-4.6 cm broad, plano-convex to flattened depressed; with acute umbo; surface pastel yellow (3A4) with grayish yellow (4C7) at centre; moist; margin regular, splitting at maturity, striated;; cuticle not peeling flesh white, unchanging, up to 0.3 cm broad; odor mild. Lamellae free, close, broad (up to 0.6 cm), yellowish white (4A2), changing to pinkish white (7A2) or reddish white; lamellulae unequal; gill edges smooth. Stipe central to somewhat excentric, 4.2-6.3 cm long, up to 0.3 cm broad above, up to 0.6 cm broad at the base, almost equal in diameter, with somewhat bulbous base, white above pale yellow (4A3) below, unchanging; smooth; solid; exannulate; volva absent.

Basidiospores [20/2/1] (4.0-) 4.8-7.2 x (4.0-) 4.8-6.4 µm, (**L** = 5.6-6.4 µm; **L'** = 5.9 µm; **W** = 4.8-5.6 µm; **W'** = 5.2 µm; **Q** = 1.0-1.28 (-1.33); **Q'** = 1.15); globose, subglobose to broadly ellipsoid; inamyloid; wall smooth, thick, double;

apiculate, apiculus up to 0.8 µm long, open pore type. Basidia 19.2-32.0 x 5.6-8.0 µm, clavate to sub cylindrical, granular, tetrasterigmate; sterigmata up to 3.2 µm long. Pleurocystidia metuloid, 43.2-69.0 x 11.2-19.2 µm, clavate, fusoid with two to five hooks or prongs at the apex, granular, thin walled. Cheilocystidia 27.2-64.0 x 13.6-25.6 µm, broadly clavate to fusoid, blunt tipped, granular, thin walled. Pileus cuticle subcellular, made up of 16.0-32.0 x 16.0-29.0 µm, globose, subglobose to ellipsoid, thin walled cells, intermixed with thin walled, septate, branched, 1.6-8.0 µm broad hyphae; pileus context made up of loosely arranged, tangled, septate, 1.6-12.8 µm broad hyphae. Hymenophoral trama bilateral convergent. Stipe cuticle made up of longitudinally tangled, septate, 2.0-4.1 µm broad hyphae; stipe context made up of septate, thin walled, 8.2-16.4 µm broad hyphae. Clamp connections absent throughout.

**Collection Examined:** Punjab, Pathankot (600 m), Dhar, growing scattered, on dead wood, in angiospermic forest, Yadwinder Singh, PUN 6448, September 01, 2011.

**Distribution and Ecology:** Present collection has been found growing scattered on dead angiospermic wood from Punjab in late monsoon.

**Remarks:** Under genus *Pluteus* the presence of metuloid pleurocystidia with hooks or prongs is the character of section *Pluteus*, while the cellular pileus cuticle is a distinctive feature in section *Celluloderma*, as described by Fyod [30, 31]. The presently worked out collection has a unique combination of both these characters of different sections of genus *Pluteus* i.e. it has a metalloid pleurocystidia with hooks and prongs as in section of genus *Pluteus* whereas in having a cellular pileus cuticle. It seems to fall under section *Celluloderma*. Although, it is having a yellow cap but it does not match with any of the known yellow capped species of this genus. The present collection was compared with *Pluteus conizitus* which is a synonym with *P. chrysagius* according to Pradeep *et al.* [24] and as in Mycobank. But in *P. conizatus* the pleurocystidia are with simple tips lacking prongs and pileus cuticle is trichodermal. Further the present collection was matched with *P. subcervinus* which possesses pleurocystidia with 3-6 prongs at the tips but the cap color in this species is greyish to fuscous brown rather than pastel yellow of the present collection. From *P. agaeotheles* the present collection differs as in this species the cap is off white although the pileus cuticle is trichodermal, pleurocystidia and cheilocystidia are with 2-5 prongs. In *P. leoninus* the cap color is somewhat similar to the present collection but the cuticle is hyphal and the pleurocystidia are simple. The present collection was further compared with another yellow capped *Pluteus* i.e. *P. castri* but in *P. castri* the pleurocystidia are with very small finger like excrescences and the prongs & hooks are lacking. This species seems to be representing a transition phase between section *Pluteus* and section *Celluloderma*. Thus, a new species *Pluteus transitus* sp. nov. has been proposed to accommodate this collection.

***Pluteus calvitio-stipus* sp. nov. [Fig. 1(B) & 4]**

**Etymology:** epithet name refers to the white stipe of carpophore.

Carpophore up to 10.0 cm in height. Pileus up to 6.0 cm broad, planoconvex with uplifted margins; umbonate; surface greyish brown (5D3), covered with appressed fibrillose scales, white flesh seen through dissociating fibres near margin; dry; margin irregular, splitting at maturity; cuticle fully peeling; flesh white, unchanging, up to 0.4 cm broad; odor disagreeable. Lamellae free, close, broad (up to 0.7 cm); light brown (6D4), changing to dark brown on bruising; gill edges serrate; lamellulae unequal. Stipe central, up to 7.5 cm long, up to 0.8 cm above, up to 1.3 cm at the base; tapering upward; white, changing to yellowish white (4A2); smooth; solid.

Basidiospores [20/1/1] 6.4-8.0 x 5.6-6.4 µm, (**L** = 6.4-8.0 µm; **L'** = 7.1 µm; **W** = 5.6-6.4 µm; **W'** = 6.0 µm; **Q** = 1.12-1.25 (-1.28); **Q'** = 1.18); subglobose to broadly ellipsoid; inamyloid; wall smooth, thick, double; apiculate, apiculus up to 1.6 µm long, open pore type. Basidia 19.2-32.0 x 6.4-8.0 µm, clavate, granular, tetrasterigmate to bisterigmate; sterigmata up to 3.2 µm long. Pleurocystidia 35.2-69.0 x 11.2-24.0 µm, clavate to fusoid-ventricose, blunt tipped or sometimes with finger like projections on the apex. Cheilocystidia 43.2-72.0 x 9.6-27.2 µm, clavate to narrowly clavate to fusoid, blunt tipped, granular, hyaline, thin walled. Pileus cuticle made up of radially arranged, thin walled, septate, 8.0-19.2 µm broad cystidioid hyphae, with acute to subacute or few are broadly rounded tips; pileus context made up of loosely arranged, intermingled, septate, 11.2-22.4 µm broad hyphae. Hymenophoral trama bilateral convergent. Stipe cuticle made up of

longitudinally tangled, septate, 2.4-6.4 µm broad hyphae; stipe context made up of septate, thin walled, 4.8-24.0 µm broad hyphae. Clamp connections absent throughout.

**Collection Examined:** Punjab, Hoshiarpur (295 m), Khadiala Saniyan, growing solitary, on humicolous soil, Yadwinder Singh, PUN 6450, July 16, 2008.

**Distribution and Ecology:** The present collection has been found growing solitary, on humicolous soil in mid July.

**Remarks:** The present collection falls under section *Hispidoderma* as it has hyphal pileus cuticle. It was compared with closely allied species of this section i.e. *Pluteus spilopus* (Berk. & Br.) Sacc. and *P. albobostipitatus* (Dennis) Singer. But, *P. spilopus* differ from the present collection by possessing dark fuscous brown cap with a stipe covered with black fibrillose-squamules and internally the pleurocystidia and cheilocystidia do not exceeded 52.0 µm in length as compared to 72.0 µm long in present collection and habitat on wood rather than terrestrial in the present collection. Further, from *P. albobostipitatus* it differs in *P. albobostipitatus* the habit is lignicolous and the cap is striate at the margin the spores are larger i.e. 7.5-9.0 x 5.5-7.0 µm in comparison to 6.4-8.0 x 5.6-6.4 µm in presently examined collection and the pleurocystidia are with subapical constrictions which is not in the case in the present collection. The present collection is recognized by greyish brown cap, which is covered with appressed fibrillose scales, white flesh seen through dissociating fibres near margin, non striate cap margin and stipe white, changing to yellowish white on handling, non fibrillose, basidiospores subglobose to broadly ellipsoid; pleurocystidia and cheilocystidia clavate, fusoid to fusoid-ventricose in shape. The present collection does not fit into any of the known species of *Pluteus* in section *Hispidoderma*. Therefore, a new species *Pluteus calvitio-stipus* sp. nov. have been proposed to accommodate present collection.

***Pluteus ortonii* sp. nov. [Fig. 1(C) & 5]**

**Etymology:** epithet name dedicated to the P.D. Orton for his monumental work on genus *Volvariella* and *Pluteus*.

Carpophores 7.5-7.8 cm in height. Pileus 5.0- 5.8 cm broad, convex; broadly umbonate; surface pinkish white (10A2), covered with reddish grey (11B2) to brownish grey (7C2) to greyish brown (7D3) appressed fibrillose scales; moist; margin irregular, splitting at maturity, seems to be striated may be formed due to dissociation of fibres along margin; cuticle fully peeling; flesh white, unchanging, up to 0.4 cm broad; taste mild to disagreeable and odor mild to disagreeable. Lamellae free, close, broad (up to 0.7 cm); creamish white to orange brown (5D6), unequal; gill edges serrate; lamellulae present. Stipe central, 6.8-7.3 cm long, up to 0.7 cm broad, tapering upward, with marginate bulb; off white, longitudinally striated, twisted, with greyish white scales, solid.

Basidiospores [61/2/2] (4.0-) 5.6-6.4 x (4.0-) 4.8-5.6 µm, (L = 5.6-6.4 µm; L' = 6.0 µm; W = 4.8-5.6 µm; W' = 5.0 µm; Q = 1.14-1.33; Q' = 1.19); subglobose to broadly ellipsoid; inamyloid; wall smooth, thick, double; apiculate, apiculus up to 0.8 µm long, open pore type. Basidia 22.4-33.6 x 6.4-8.8 µm, clavate, granular, tetrasterigmate; sterigmata up to 2.4 µm long. Pleurocystidia 33.6-70.4 x 8.0-24.0 µm, clavate, lageniform to fusoid to fusoid-ventricose, blunt to tubular tips, densely granular at apex, covered with a very conspicuous mucilaginous deposition at the tips, thin walled. Cheilocystidia 35.2-83.2 x 8.0-38.4 µm, clavate to fusoid, blunt tipped, hyaline, thin walled. Pileus cuticle hyphal, made up of thin walled, horizontally tangled, septate hyphae giving rise to radially arranged, 8.2-16.4 µm broad, granular, septate hyphae; pileus context made up of loosely arranged, intermingled, septate, 12.3-27.0 µm broad hyphae. Hymenophoral trama bilateral convergent. Stipe cuticle made up of longitudinally tangled, septate, 2.0-12.3 µm broad hyphae; stipe context made up of septate, thin walled, 8.2-24.5 µm broad hyphae. Clamp connections absent throughout.

**Collection Examined:** Punjab, Ropar (394 m), water house, growing solitary, on humicolous soil, Yadwinder Singh, PUN 6443, July 18, 2010; growing solitary, on humicolous soil, Yadwinder Singh, PUN 6444, July 19, 2011.

**Distribution and Ecology:** This *Pluteus* species has been collected growing solitary, on humicolous soil from Punjab, India.

**Remarks:** The present collection falls under section *Hispidoderma* as it has a hyphal pileus cuticle. It is recognized by pinkish white cap, having reddish grey to brownish grey to greyish brown appressed fibrillose scales, stipe is with a marginate bulb and its terrestrial habitat. It was compared with a closely allied species *Pluteus pearsonii* Orton but differs from present as in *P. pearsonii* olivaceous black colored cap is present. Further, it differs from *P. depauperatus* Romagnesi as in this species the cap is white with pale clay buff centre, with strongly striated margin and the stipe lacking marginate bulb. Due to the smaller sized carpophore, lacking marginate bulb, presence of cellular pileus cuticle and lignicolous habit of *P. semibulbosus* (Lasch apud Fries) Gillet, the present collection differs from it. *P. boudieri* Orton differs in having white cap with olivaceous-buff or grey-olivaceous at centre, habitat on wood and larger (6-8 x 5-7  $\mu\text{m}$ ) spore size. *P. granulatus* Bresadola possesses a cinnamon or cinnamon-buff cap, scaly at centre, smooth and striate at margin. *P. murinus* Bresadola has a date brown or umber cap but with plane to slightly depressed cap centre and larger (6-8 x 5-7  $\mu\text{m}$ ) spore size. It does not fit into any of the known species of section *Hispidoderma*. Therefore, a new species have been proposed to accommodate this collection.

***Volvariella bumelia* sp. nov. [Fig. 1(D) & 6]**

**Etymology:** Epithet name refers to large size of carpophore.

Carpophore up to 13.5 cm in height. Pileus 9.0 cm broad, convex; broadly umbonate; surface white; covered with white, cottony fibers; margin irregular, splitting at maturity; cuticle fully peeling; flesh up to 1.0 cm thick, white, unchanging; watery latex on cutting; odor mild. Lamellae free, unequal, crowded, broad (up to 1.4 cm), yellowish white (4A2), unchanging; gill edges smooth; lamellulae present. Spore deposit white. Stipe central, up to 11.5 cm long, up to 1.5 cm broad above, up to 2.0 cm broad at the base; cylindrical; surface white unchanging, watery latex on cutting; scaly above and smooth towards base; solid; volva up to 3.5 cm, saccate, 5 lobed, large, fleshy, white, light orange (5A4) at areola.

Basidiospores [37/1/1] (4.0-) 4.8-6.4 x 4.0-5.6 (-6.4)  $\mu\text{m}$ , (**L** = 4.8-6.4  $\mu\text{m}$ ; **L'** = 5.8  $\mu\text{m}$ ; **W** = 4.0-5.6  $\mu\text{m}$ ; **W'** = 4.3  $\mu\text{m}$ ; **Q** = 1.0-1.33 (-1.40); **Q'** = 1.14); globose, subglobose to broadly ellipsoid; inamyloid; wall smooth, thick; apiculate, apiculus up to 0.8  $\mu\text{m}$  long, open pore type. Basidia 30.4-43.2 x 6.4-9.6  $\mu\text{m}$ , clavate, granular, tetrasterigmate occasionally bisterigmate; sterigmata up to 4.0  $\mu\text{m}$  long. Pleurocystidia 35.2-86.4 x 12.8-32.0  $\mu\text{m}$ , claviform to fusoid to fusoid ventricose, with long tubular tips to sometimes blunt tips, densely granular at tips. Cheilocystidia 36.8-88.0 x 11.2-30.4  $\mu\text{m}$ , claviform to fusoid to fusoid-ventricose, with long tubular to sometimes blunt tips, granular. Pileus cuticle hyphal made, up of thin walled, granular, septate, horizontally tangled hyphae, giving rise to turf of radially arranged, septate, granular, 4.1-20.45  $\mu\text{m}$  broad hyphae; pileus context made up of loosely arranged, intermingled, septate, 8.2-31.0  $\mu\text{m}$  broad hyphae. Hymenophoral trama convergent. Stipe cuticle made up of longitudinally tangled, granular, septate, 6.1-12.3  $\mu\text{m}$  broad hyphae, with no projecting elements; stipe context made up of septate, thin walled, smooth, 8.2-20.4  $\mu\text{m}$  broad hyphae. Volva hyphal made up of closely septate, thin walled, granular, gelatinized, 4.1-10.2  $\mu\text{m}$  broad entangled hyphae. Clamp connections absent throughout.

**Collection Examined:** Punjab, Patiala (250 m), growing solitary, on soil, under *Duranta* sp., Yadwinder Singh, PUN 6477, August 25, 2011.

**Distribution and Ecology:** Present collection has been found growing solitary, on soil, under *Duranta* sp. from Punjab.

**Remarks:** The above examined collection is somewhat similar in its appearance to *Volvariella bombycina* (Schaeff. : Fr.) Sing. as it possessing white cap, covered with white cottony, shiny fibrils and the volva is yellowish white as in *V. bombycina*. But, the present collection differs from *V. bombycina* in possessing a robust carpophore, which gives watery latex on cutting of the cap or stipe, there is no yellowish tinge at the cap surface, stipe is cylindrical, lacking bulbous base where as in *V. bombycina* it is not so. Further, the basidiospores are smaller in size (4.0-) 4.8-6.4 x 4.0-5.6 (-6.4)  $\mu\text{m}$  in comparison to 6.6-10.4 x 4.4-6.7  $\mu\text{m}$  basidiospores of *V. bombycina*, even the cystidia are smaller in size in present collection in comparison to the size of cystidia described by Shaffer [28] for *V. bombycina*. Further, *V. bombycina* is always known to be lignicolous in habitat while the present collection is terrestrial in habitat. The present collection was also compared with another white capped *Volvariella* i.e. *V. smithii* Shaffer, as *V. smithii* also has 5-lobed volva and terrestrial in habitat. But,

in *V. smithii* cap has pinkish buff centre, densely pubescent stipe and ochraceous volva with cinnamon touch. Also the spore size given for *V. smithii* by Shaffer [28] is 4.7-7 x 3.1-3.9  $\mu\text{m}$ . Based upon the above discussion a new species *Volvariella bumelia* sp. nov. is proposed. *V. bumelia* sp. nov. is characterized by in possessing a white cap with no pink or yellowish tinge, all parts of carpophores exuding watery latex, a cylindrical stipe without bulbous base and the spore size varying from (4.0-) 4.8-6.4 x 4.0-5.6 (-6.4)  $\mu\text{m}$ .

***Volvariella albida* sp. nov. [Figs 1(E&F) & 7]**

**Etymology:** Epithet name refer to white color of carpophore.

Carpophores 8.0-8.3 cm in height. Pileus 6.5-6.6 cm broad, convex to planoconvex; with or without umbo; surface white (1A1), whitish grey at centre; covered with white, appressed fibrillose scales; margin regular, fimbriate, splitting at maturity; cuticle fully peeling; flesh up to 0.7 cm broad, white, unchanging; odor mild to disagreeable. Lamellae free, crowded, broad (up to 0.6 cm); unequal; white to pinkish white (7A2), unchanging; gill edges serrate; lamellulae truncate. Stipe central, 5.0-7.5 cm long, up to 0.7 cm above, up to 1.3 cm broad at the base; obclavate, with bulbous base; surface white, unchanging; smooth; solid; volva up to 3.4 cm, large, less fleshy, saccate, 3-lobed, white to creamish white, with areolate surface, brown at areola.

Basidiospores [34/2/2] 4.8-5.6 x 4.0-4.8  $\mu\text{m}$ , ( $\text{L} = 4.8-5.6 \mu\text{m}$ ;  $\text{L}' = 5.0 \mu\text{m}$ ;  $\text{W} = 4.0-4.8 \mu\text{m}$ ;  $\text{W}' = 4.5 \mu\text{m}$ ;  $\text{Q} = 1.0-1.20 (-1.40)$ ;  $\text{Q}' = 1.14$ ); ovoid, globose, subglobose to broadly ellipsoid, occasionally ellipsoid; inamyloid; smooth, thick walled; apiculate, apiculus up to 0.8  $\mu\text{m}$  long, open pore type. Basidia 19.2-28.8 x 6.4-8.8  $\mu\text{m}$ , clavate, granular throughout, tetrasterigmate; sterigmata up to 3.2  $\mu\text{m}$  long. Pleurocystidia 40-67.2 x 9.6-32  $\mu\text{m}$ , claviform to fusoid with small tips, Cheilocystidia 29-90 x 11.2-32  $\mu\text{m}$ , claviform to fusoid. Pileus cuticle hyphal, made up of thin walled, granular, septate, radially arranged 8.2-20.4  $\mu\text{m}$  broad projecting hyphae, arising from subhorizontally tangled hyphae; pileus context made up of loosely arranged, intermingled, septate, 8.2-29.0  $\mu\text{m}$  broad hyphae. Hymenophoral trama bilateral convergent. Stipe cuticle hyphal, made up of longitudinally tangled, septate, 4.1-12.3  $\mu\text{m}$  broad hyphae; stipe context made up of loosely interwoven, septate, thin walled, 8.2-37  $\mu\text{m}$  broad hyphae. Volva hyphal, made up of closely septate, thin walled, 4.1-20.4  $\mu\text{m}$  broad tangled hyphae. Clamp connections absent throughout.

**Collection Examined:** Punjab, Patiala, Punjabi University Campus (250 m), growing solitary, on soil, near *Azadirachta indica*, Yadwinder Singh, PUN 6460, July 7, 2008; Punjabi University Campus (250 m), growing solitary, on soil, near *Azadirachta indica*, Yadwinder Singh, PUN 6461, July 22, 2008.

**Distribution and Ecology:** This new species has been found solitary under *Azadirachta indica* during July at an altitude of 250 m from Patiala.

**Remarks:** This collection morphologically looks very similar to *Volvariella bombycina* (Schaeff. : Fr.) Sing. However, it differs from *V. bombycina* in lacking yellow tinge at the umbo of the cap, spores comparatively smaller i.e. 4.8-5.6 x 4.0-4.8  $\mu\text{m}$  instead of 6.6-10.4 x 4.4-6.7  $\mu\text{m}$  of *V. bombycina*. Pleurocystidia 40-67.2 x 9.6-32  $\mu\text{m}$  and cheilocystidia 29-90 x 11.2-32  $\mu\text{m}$  of present collection are smaller in comparison to 26-122 x 8-57  $\mu\text{m}$  pleurocystidia and 26-144 x 8-46  $\mu\text{m}$  cheilocystidia described for *V. bombycina* by Shaffer [28]. Further, even the shape of pleurocystidia and cheilocystidia is mostly clavate to fusoid with small blunt tips in this collection as compared to fusoid to fusoid-ventricose with tubular tips in *Volvariella bombycina*. Present collection has been found growing terrestrially instead of lignicolous habitat which is known for *V. bombycina* [28]. Thus, based on these differences, a new species *V. albida* sp. nov. have been proposed to accommodate this collection.

***Volvopluteus shafferii* sp. nov. [Figs. 2(G) & 8]**

**Etymology:** Epithet name dedicated to R.L. Shaffer for his remarkable work on genus *Volvariella*.

Carpophores 3-18 cm in height. Pileus 1-11.2 cm broad, convex to flattened; broadly umbonate; surface greyish orange (5B3), orange grey (5B2) at centre, with pinkish tinge towards margin; scales appressed fibrillose, greyish brown, more

concentrated near the centre; margin regular to irregular, splitting at maturity; dry to moist; cuticle fully peeling; flesh up to 0.4 cm thick, white, unchanging. Lamellae free, subdistant, broad (up to 1.5 cm); orange grey (6B2) to pinkish brown, unchanging; edges serrate, white, flocculose; lamellulae present. Spore deposit light brown (6D5) to brownish orange (5C<sub>3</sub>). Stipe central, 7.0-16.5 cm long, up to 1.8 cm broad above, up to 2.5 cm broad at the base; yellowish white (4A2); narrowing upward, with slightly bulbous base, fibrillose scaly; hollow; exannulate; volva lobed only in young carpophores then become membranous, tightly packed with stipe base as broken patches, creamish white.

Basidiospores [120/4/4] 11.2-16 x 7.2-12.8  $\mu\text{m}$ , (**L** = 11.2-12.8  $\mu\text{m}$ ; **L'** = 12.3  $\mu\text{m}$ ; **W** = 8.0-10.4  $\mu\text{m}$ ; **W'** = 9.7  $\mu\text{m}$ ; **Q** = 1.14-1.55 (-1.60); **Q'** = 1.28); ovoid, broadly ellipsoid to ellipsoid, occasionally subglobose; inamyloid; smooth, thick walled; guttulate; apiculate, apiculus up to 1.6  $\mu\text{m}$  long, open pore type. Basidia 17.6-34.0 x 8.9-16.0  $\mu\text{m}$ , clavate, granular, tetrasterigmate, occasionally bisterigmate; sterigmata up to 4.8  $\mu\text{m}$  long. Pleurocystidia and cheilocystidia absent. Gill edges sterile. Pileus cuticle hyphal, gelatinized, made up of horizontally tangled septate, granular hyphae, giving rise to turf of radially arranged, septate, granular, 2.4-12.3  $\mu\text{m}$  broad hyphae; pileus context made up of loosely interwoven, septate, thin walled 8.2-20.4  $\mu\text{m}$  broad hyphae. Hymenophoral trama bilateral convergent. Stipe cuticle hyphal, made up of longitudinally tangled, 1.6-6.4  $\mu\text{m}$  broad, septate hyphae interspersed caulocystidia present, caulocystidia elongated, narrowly clavate, granular, 12.8-48.0 x 3.2-11.2  $\mu\text{m}$ ; stipe context made up of thin walled, septate, 3.2-19.2  $\mu\text{m}$  broad hyphae. Volval elements made up of septate, 3.2-11.2  $\mu\text{m}$  broad hyphae. Clamp connections absent throughout.

**Collection Examined:** Punjab, Hoshiarpur (295 m), growing soliatry on leaf litter of *Eucalyptus perriniana* and under *Cannabis sativa*, Yadwinder Singh, PUN 4026, July 19, 2008; Ludhiana, Punjab Agriculture University (254 m), growing scattered, on humicolous soil under *Ficus*, Baljit Kaur, PUN 3934, July 18, 2009; Sangrur, Nadampur village (231m), growing scattered, on humicolous soil. Jagdeep Kaur, PUN 4094, July 25, 2009.

**Distribution and ecology:** Present collection was commonly found growing solitary to scattered in groups, on humicolous soil or on leaf litter of *Eucalyptus* from different localities of Punjab during July-August at an altitude varying from 231-295 m.

**Remarks:** In the presently worked out collections the spores are more than 11  $\mu\text{m}$  and pileus cuticle is gelatinized thus, they fall under genus *Volvopluteus* Vizzini, Contu & Justo. In gross morphological and anatomical characters the present collections are in some features similar to *Vp. speciosa* as described by Justo *et al.* [6]. But, they differ from *Vp. speciosa* in possessing smaller spore size range i.e. 8-16 x 6.8-12.8  $\mu\text{m}$ , instead of 11.7-20.9 x 7.2-12.4  $\mu\text{m}$  reported for *Vp. speciosa* by Justo *et al.* [25], pleurocystidia and cheilocystidia both are present in *Vp. speciosa*, while are absent in the present collections. The present collections also share some characters with *Vp. gloiocephalus* (DC.) Vizzini, Contu & Justo and *Vp. earlei* (Murrill) Vizzini, Contu & Justo [6] in having spores more the 11  $\mu\text{m}$ , gelatinized pileus cuticle, but it differs from these species in possessing larger carpophore size up to 18 cm, lacking lobed volva and lacking pleurocystidia and cheilocystidia. The presently worked out collection is unique in its characters as it possesses a broadly umbonate greyish orange cap with orange grey centre, with a pinkish tinge towards the margin, the volva is lobed only in the young carpophores at maturity it becomes membranous, tightly packed around the stipe base in the form of broken, creamish white patches, basidiospores 8-16 x 6.8- 12.8  $\mu\text{m}$ . The present collection does not completely matched with any known species of genus *Volvopluteus*, thus based upon the above discussion, a new species *Vp. shafferii* sp. nov. is being proposed to accommodate this collection.

***Volvopluteus diversisporus* sp. nov. [Figs. 2(H) & 9]**

**Etymology:** Epithet name refers to different shapes of basidiospores i.e. *diversi* = varied + *sporus* = spores.

Carpophores 3.7-8.7 cm in height. Pileus 4.1-5.9 cm broad, convex; umbonate; surface orange white (6A2); dry; atomate, glabrous; margin irregular, splitting at maturity, striated along margin; cuticle fully peeling; flesh up to 0.3 cm broad, white, unchanging; taste sour or slightly peppery; odor mild. Lamellae free, subdistant, moderately broad (up to 0.3 cm); greyish orange (6B3), unchanging; gill edges smooth; lamellulae attenuate. Stipe central, 3.6-8.5 cm long, up to 0.4 cm broad above, up to 0.6 cm broad at base; tapering upward, with slightly bulbous base; white (2A1), unchanging; smooth; solid; exannulate; volva, up to 1.5 cm wide, small, membranous, tightly packed at base, light grey.

Basidiospores [20/1/1] (8.8-) 11.2-16.0 x 7.2-14.4  $\mu\text{m}$ , (**L** = 9.6-16.0  $\mu\text{m}$ ; **L'** = 12.1  $\mu\text{m}$ ; **W** = 8.0-14.4  $\mu\text{m}$ ; **W'** = 9.1  $\mu\text{m}$ ; **Q** = 1.1-1.78; **Q'** = 1.35); subglobose, ovoid, obovoid, oblong, amygdaliform some with a short blunt snout, broadly ellipsoid, ellipsoid, elongated, or more broader and shorter in length 7.2-14.4 x 9.6-19.2  $\mu\text{m}$ , triangular to typically heart shaped; inamyloid; double walled, smooth; vacuolated; apiculate, apiculus up to 1.6  $\mu\text{m}$  long, open pore type. Basidia 25.6-46.4 x 9.6-17.6  $\mu\text{m}$ , clavate, granular, tetrasterigmate, occasionally bisterigmate, rarely unisterigmate; sterigmata up to 8.0  $\mu\text{m}$  long; lamellae edges heteromorphous. Pleurocystidia 20.8-86.4 x 8.8-34.0  $\mu\text{m}$ , broadly clavate, fusoid to fusoid-ventricose, granular, with blunt to long tubular tips, abundant; cheilocystidia 32.0-80.0 x 9.6-40.0  $\mu\text{m}$ , clavate, fusoid to fusoid-ventricose, granular, densely granular at tips, with blunt, rounded to small knob like to tubular tips, thin walled, abundant. Pileus cuticle hyphal, gelatinized, made up of thin walled, septate, horizontally tangled hyphae, giving rise to radially tangled, gelatinized, 4.1-16.4  $\mu\text{m}$  broad hyphae; pileus context made up of loosely and irregularly interwoven, septate, 8.2-20.4  $\mu\text{m}$  broad hyphae. Hymenophoral trama bilateral convergent. Stipe cuticle hyphal, made up of longitudinally tangled, septate, 4.1-12.3  $\mu\text{m}$  broad hyphae, with no projecting element on the surface; stipe context made up of septate, thin walled, 8.1-29.0  $\mu\text{m}$  broad hyphae. Volva hyphal, composed of septate, granular, 1.6-14.4  $\mu\text{m}$  broad tangled hyphae. Clamp connections absent throughout.

**Collection Examined:** Punjab, Patiala, Bahadurgarh (250 m), growing scattered, among grasses, along road side, Yadwinder Singh, PUN 6480, May 28, 2008.

**Distribution and Ecology:** The above examined collection has been found growing solitary to scattered among grasses in the month of May from Punjab.

**Remarks:** The macroscopic and microscopic details of the presently worked out collection of *Volvo pluteus* are not very convincing when matched with the allied species *Vp. gloiocephalus* (DC.) Vizzini, Contu & Justo and *Vp. earlei* (Murrill) Vizzini, Contu & Justo as both these species are with large sized carpophores, the basidiospores are either ovoid, broadly ellipsoid to ellipsoid and are with comparatively lesser breadth, where as in the present collection the carpophores are smaller, basidiospores are having diverse shapes. On the basis of diverse shapes of the basidiospores this collection was matched with *Volvariella heterospora* Menolli & Capelari as described by Menolli & Capelari [10] and has two different types of basidiospores but, it differs from the present collection in possessing dark grey cap color and lacking angular or heart shaped spores. Thus, based upon the above observations a new species i.e. *Vp. diversisporus* sp. nov. is proposed. *Vp. diversisporus* sp. nov. is characterized in possessing an orange white, glabrous, umbonate cap, without any scales on the surface, basidiospores of diverse shapes i.e. some smaller subglobose, ovoid, obovoid, oblong, amygdaliform with short snout to larger spores which are much broader angular to typically heart shaped, both pleurocystidia and Cheilocystidia present.

*Volvariella bombycina* (Schaeff. : Fr.) Sing. *Lilloa* 22: 401, 1951 var. *parva* var. nov. [Fig. 2(I) & 10]

**Etymology:** Variety name refers to small size of carpophore.

Carpophore up to 5.4 cm in height. Pileus up to 2.8 cm broad, convex; lacking umbo; surface white; decorated with white appressed fibrillose, shiny scales; margin regular, fimbriate or toothed; cuticle fully peeling; flesh white, unchanging; taste and odour mild. Lamellae free, crowded, unequal, white, unchanging; gill edges smooth; lamellulae truncate, spore deposit white (2A1). Stipe central, up to 4.0 cm long, up to 0.8 cm broad; subcylindric; white, unchanging; smooth; exannulate; volva saccate, large, fleshy, 2-lobed, white from inner side and yellowish white (4A2) from outside.

Basidiospores [32/1/1] 4.8-6.4 x 3.2-5.6  $\mu\text{m}$ , (**L** = 4.8-5.6  $\mu\text{m}$ ; **L'** = 5.4  $\mu\text{m}$ ; **W** = 3.2-4.8  $\mu\text{m}$ ; **W'** = 4.3  $\mu\text{m}$ ; **Q** = 1.17-1.50; **Q'** = 1.30); ovoid, broadly ellipsoid to ellipsoid; inamyloid; smooth, thick walled; guttulate; apiculate, apiculus up to 0.8  $\mu\text{m}$  long, open pore type. Basidia 20.8-27.2 x 6.4-8.0  $\mu\text{m}$ , clavate, granular, tetrasterigmate to bisterigmate; sterigmata up to 2.4  $\mu\text{m}$  long. Pleurocystidia 32.0-72.0 x 9.6-19.2  $\mu\text{m}$ , claviform to fusoid. Cheilocystidia 22.4-62.4 x 11.2-27.2  $\mu\text{m}$ , fusoid, clavate, blunt tipped. Gill edges sterile. Pileus cuticle hyphal, made up of thin walled, septate, horizontally tangled hyphae, giving rise a turf of radially tangled, 2.4-9.6  $\mu\text{m}$  broad hyphae; pileus context made up of loosely arranged, intermingled, septate, 3.2-14.4  $\mu\text{m}$  broad hyphae. Hymenophoral trama bilateral convergent. Stipe cuticle made up of

longitudinally tangled, septate, 4.1-12.3 µm broad hyphae; stipe context made up of septate, thin walled, smooth, 8.2-24.5 µm broad hyphae. Volva consists of septate, branched, thin walled, 4.1-20.4 µm broad hyphae. Clamp connections absent throughout.

**Collection Examined:** Punjab, Patiala, Punjabi University, Botanical Garden (251m), growing solitary, on sandy soil, Yadwinder Singh, PUN 6454, August 3, 2007.

**Distribution and Ecology:** The above examined collection has been found growing solitary, on humicolous soil from Punjab.

**Remarks:** The present collection has a white cap, covered with white shiny appressed hair like scales, the stipe is white with yellowish white volva. Thus, in its gross morphology and the microscopic details it falls under *Volvariella bombycina* (Schaeff. : Fr.) Sing. But, the present collection having smaller basidiocarp with small sized cap of up to 2.5 cm as compared to cap 5-20 cm broad cap reported by Shaffer [28] for *V. bombycina*. The cap also lacking yellowish tinge and the spore size, pleurocystidia and cheilocystidia size is also smaller than the size reported for *V. bombycina* by Shaffer [28]. The present collection was then compared with another white colored species i.e. *V. smithii* Shaffer, but, this differs in having white cap with pinkish buff centre, while stipe is densely pubescent having 5-lobed volva, which is fibrillose externally, ochraceous to light cinnamon in color, and spores are much narrower 3.1-3.9 µm rather than 3.2-5.6 µm of present collection. The present collection is similar to *V. bombycina*, but, due to the presence of smaller carpophore somewhat smaller spore range, smaller size of cystidia, it is proposed as a variant of *V. bombycina*. Therefore, a new variety *V. bombycina* var. *parva* var. nov. is proposed to accommodate present collection.

*Volvariella bombycina* (Schaeff. : Fr.) Sing. *Lilloa* 22: 401, 1951 var. *terricola* var. nov. [Figs. 2 (J) & 11]

**Etymology:** Variety name refer to the habitat from which present taxon have been collected.

Carpophores 4.8-13.5 cm in height. Pileus 3.5-8.4 cm broad, companulate to convex to flattened; umbonate; surface white (1A1) to yellowish white (4A2) with pale yellow (4A3) to yellowish brown (5D4) at centre with maturity; covered with white, appressed fibrillose, shiny scales; margin regular, fimbriate; cuticle fully peeling; flesh up to 1.0 cm, white, unchanging; taste mild to spicy; odor agaricoid to disagreeable. Lamellae free, close to crowded, broad (up to 1.4 cm); unequal; yellowish white (4A2), or pinkish white (7A2), or orange white (6A2), or orange grey (6B2), unchanging; gill edges serrate; lamellulae truncate. Stipe central, 4.2- 11.8 cm long, up to 1.1 cm above, up to 1.3 cm broad at middle, up to 2.0 cm at the base, obclavate, with bulbous base; surface white to yellowish white (4A2), to pale yellow (4A3), unchanging; scaly; hollow; volva up to 3.3 cm, saccate, large, fleshy, 3-lobed, yellowish white to creamish white, with areolate surface.

Basidiospores [121/3/3] 6.4-10.4 x 4.8-6.4 µm, (**L** = 6.4-8.0 µm; **L'** = 7.7 µm; **W** = 4.8-6.4 µm; **W'** = 5.6 µm; **Q** = (1.11-1.14-1.67; **Q'** = 1.37); ovoid, obovoid, broadly ellipsoid to ellipsoid, occasionally subglobose, rarely elongate; inamyloid; smooth, thick walled; apiculate, apiculus up to 0.8 µm long, open pore type. Basidia 19.2-43.2 x 6.4-11.2 µm, clavate, granular throughout, tetrasterigmate; sterigmata up to 3.2 µm long. Pleurocystidia 28.8-118.4 x 9.6-54.4 µm, claviform to fusoid-ventricose with long to small tubular tips, granular with crystalline depositions inside. Cheilocystidia 32-118 x 9.6-45 µm, similar with pleurocystidia. Gill edges fertile. Pileus cuticle hyphal, made up of thin walled, granular, septate, radially arranged 1.6-20.4 µm broad hyphae; pileus context made up of loosely arranged, intermingled, septate, 3.2-27.2 µm broad hyphae. Hymenophoral trama bilateral convergent. Stipe cuticle hyphal, made up of longitudinally tangled, septate, 1.6-16.4 µm broad hyphae, granular with yellowish pigment; no projecting elements; stipe context made up of loosely interwoven, septate, thin walled, 3.2- 37.0 µm broad hyphae. Volva hyphal, made up of closely septate, thin walled, granular, 1.6-28.6 µm broad entangled hyphae. Clamp connections absent throughout.

**Collection Examined:** Punjab, Patiala, University Campus (250 m), growing solitary, in open grassy lawn, Yadwinder Singh, PUN 6451, June 27, 2008; Hoshiarpur, Bhagana (295 m), growing solitary, on soil, Yadwinder Singh, PUN 6452, July 20, 2008; Mansa, Gagawal (217 m), growing solitary, on humicolous soil, Harwinder Kaur, PUN 6453, August 6, 2010.

**Distribution and Ecology:** Present collections have been found growing on humicolous soil among grasses from different localities in Punjab in the monsoon season between June to August.

**Remarks:** The diagnostic characters with regard to their morphological and anatomical details are in conformity with *Volvariella bombycina* (Schaeff. : Fr.) Sing. except of its terrestrial habitat. It is characterized by large sized white carpophore pileal surface covered with white shiny hairs, margin exceeding the lamellae. It is interesting to note that *V. bombycina* has always been collected from various countries in lignicolous habitat. It has been collected solitary to scattered or gregarious on decaying trunks or large logs or stumps of maple, beech, elm, etc, by Smith [31], Coker [3] from North Carolina, Shaffer [23] from North America, Orton [14] from England, Monoson *et al.* [11] from Illinois, Seok *et al.* [27] from Korea, and Menolli and Capelari [10] from Brazil. Lakhanpal *et al.* [9] collected it from North West Himalayas on decorticated trunks of *Picea smithiana* while, Pradeep *et al.* [18] found this species on the stumps of dead Mango tree from Kerala. While the present collection has been found growing on humicolous soil among grasses from different localities in Punjab in the monsoon season from June to August. Thus, based on the observation of its terrestrial habit from 3 different localities of Punjab i.e. Mansa, Hoshiarpur & Patiala during monsoon season collected in three different years a new variety is proposed as *Volvariella bombycina* var. *terricola* var. nov.

*Volvariella terastia* (Berk. & Br.) Sing., *Mushr. & Truffl.*: 114, 1961 var. *magnacystidiata* var. nov. [Figs. 2 (K) & 12]

**Etymology:** Variety name refer to the large size of cystidial elements.

Carpophores 10-10.5 cm in height. Pileus 8.6-9.7 cm broad, convex to plano-convex; broadly umbonate; surface white (5A1), with brownish beige (6E3) to brown (5E4) appressed scales, more concentrated in the centre; margin regular, splitting at maturity, fimbriate; cuticle fully peeling; flesh up to 1.0 cm thick, white, unchanging; taste and odor mild. Lamellae free, close, broad (up to 1.1 cm); unequal; orange white (6A2), unchanging; gill edges serrate, white; lamellulae truncate. Spore deposit orange grey (6B2). Stipe central, 8.6-9.3 cm long, 1.3 cm above, 1.5 cm broad in middle and 2.2 cm broad at the base; narrowing upward, with bulbous base; white (5A1), unchanging; scaly; volva up to 5.3 cm, large, fleshy, saccate, 3-5 lobed, aerolate, greyish brown to yellowish brown.

Basidiospores [53/2/2] 4.0-5.6 x 4.0-4.8 (-5.6)  $\mu\text{m}$ , ( $L = 4.8-6.4 \mu\text{m}$ ;  $L' = 5.1 \mu\text{m}$ ;  $W = 4.0-4.8 \mu\text{m}$ ;  $W' = 4.5 \mu\text{m}$ ;  $Q = (1.0-) 1.17-1.20$ ;  $Q' = 1.13$ ); subglobose to broadly ellipsoid, occasionally globose; inamyloid; smooth, double walled; apiculate, apiculus up to 0.8  $\mu\text{m}$  long. Basidia 22.4-30.4 x 6.4-8.0  $\mu\text{m}$ , clavate, granular, tetrasterigmate, occasionally bisterigmate; sterigmata up to 4.0  $\mu\text{m}$  long. Pleurocystidia 38.4-96.0 x 11.2-36.8  $\mu\text{m}$ , clavate to fusoid to fusoid ventricose, blunt tipped to tubular tips, hyaline, thin walled. Cheilocystidia 27.2- 85.0 x 9.6-32.0  $\mu\text{m}$ , clavate, fusoid-ventricose, with blunt to long tubular tips, hyaline, thin walled. Pileus cuticle hyphal, made up of granular, septate, horizontally tangled hyphae, giving rise to turf of radially tangled, thin walled, septate, 1.6-24.5  $\mu\text{m}$  broad hyphae; pileus context made up of loosely intermingled, septate, 8.0-33  $\mu\text{m}$  broad hyphae. Hymenophoral trama bilateral convergent. Stipe cuticle made up of longitudinally tangled, septate, granular, 4.1-14.3  $\mu\text{m}$  broad hyphae; stipe context made up of septate, thin walled, 8.2-33.0  $\mu\text{m}$  broad hyphae. Volva made up of closely septate, intermingled, granular, branched, 4.1-24.5  $\mu\text{m}$  broad hyphae. Clamp connections absent throughout.

**Collection Examined:** Punjab, Patiala, Bahadurgarh (251 m), growing solitary, on humicolous soil, Yadwinder Singh, PUN 6463, September 3, 2008; Punjabi University campus (251 m), growing solitary, under *Azadirachta indica*, Yadwinder Singh, PUN 6464, August 16, 2008.

**Distribution and Ecology:** The above examined collections has been found growing solitary, under *Azadirachta indica* in the months of August and September from Punjab.

**Remarks:** The morphological and anatomical details of these collections are similar with the description given for *Volvariella terastia* (Berk. & Br.) Sing. as described by Pegler [17] except for the larger carpophores size, larger pleurocystidia (38.4- 96 x 11.2-36.8  $\mu\text{m}$ ) and cheilocystidia (27.2-85 x 9.6-32  $\mu\text{m}$ ) as compared to pleurocystidia (35-50 x 15-22  $\mu\text{m}$ ) and cheilocystidia (32-36 x 13  $\mu\text{m}$ ) described by Pegler [17] for *V. terestia*. In present collection the size of the basidia

(22.4-30.4 x 6.4-8.0 µm) is also comparatively larger. On the basis of these differences from *V.terastia*, a new variety *V. terastia* var. *magna-cystidiata* var. nov. have been proposed.

*Volvariella volvacea* (Bull. : Fr.) Sing. *Lilloa* 22: 401, (1949) 1951 var. *lignicola* var. nov.

**[Figs. 2 (L) & 13]**

**Etymology:** Variety name refer to the habitat from which present taxon have been collected i.e. *lignum* = wood, *cola* = habitat.

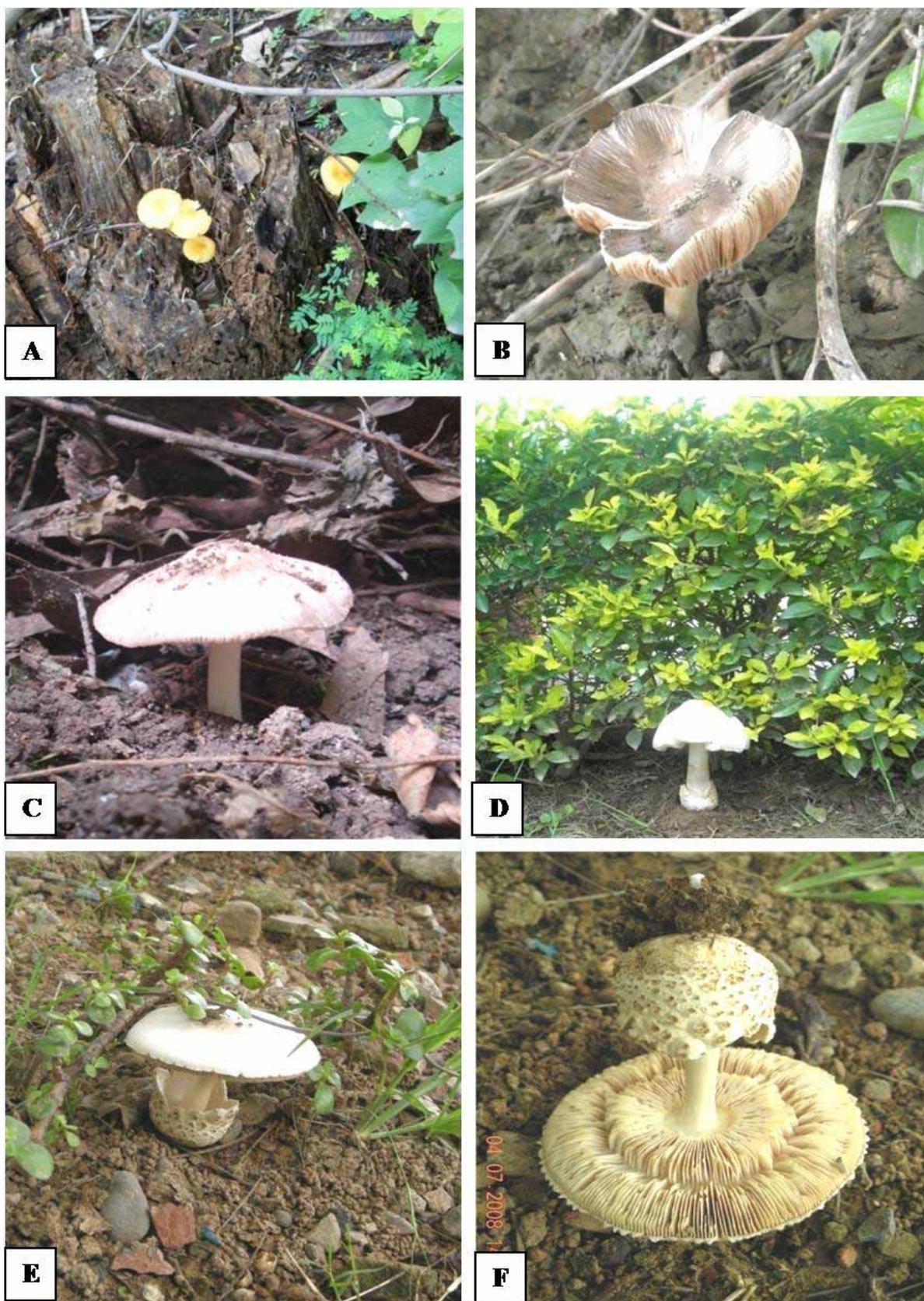
Carpophores 8.5-13.5 cm in height. Pileus 10.5-14.0 cm broad, convex; broadly umbonate; surface brownish grey (5D2), with a paler centre, brownish orange (5C3) at maturity; covered with hairy, greyish black to shiny scales; margin regular, splitting at maturity; cuticle fully peeling; flesh up to 0.6 cm thick, white, unchanging; taste and odour mild. Lamellae free, close, broad (up to 0.8 cm); unequal; pinkish brown in young becomes brownish orange (6C5) at maturity, unchanging on bruising; gill edges serrate; lamellulae attenuate. Spore deposit brownish orange (6C3) to pale red (7A3). Stipe excentric, 9.0-12.5 cm long, up to 0.8 cm above, up to 1.1 cm broad at the base; subcylindric; creamish white, unchanging; smooth; solid; volva up to 2.5 cm, saccate, 2-lobed, large, fleshy, dark greyish.

Basidiospores [34/1/1] 5.6-9.6 x 4.8-6.4 µm, (**L** = 6.4-8.0 µm; **L'** = 7.2 µm; **W** = 4.8-7.2 µm; **W'** = 5.3 µm; **Q** = 1.14–1.50 (-1.57); **Q'** = 1.24); broadly ellipsoid to ellipsoid, occasionally subglobose; inamyloid; smooth, thick walled; apiculate, apiculus up to 0.8 µm long, open pore type. Basidia 19.2-40.0 x 6.4-9.6 µm, clavate, granular, tetrasterigmate, occasionally bisterigmate; sterigmata up to 4.0 µm long. Pleurocystidia 37.0-109.0 x 11.2-33.6 µm, claviform to fusoid with blunt to elongate, tubular tips. Cheilocystidia 29.0-101.0 x 9.6-24.0 µm, fusoid, clavate, blunt to elongate, tubular tipped, densely granular near the tips. Gill edges fertile. Pileus cuticle hyphal, made up of horizontally tangled, septate, thin walled, granular hyphae, giving rise to turf of radially tangled, thin walled, granular, septate, 4.1- 16.4 µm broad hyphae; pileus context made up of loosely interwoven, septate, 4.1- 24.5 µm broad hyphae. Hymenophoral trama bilateral convergent. Stipe cuticle hyphal, made up of longitudinally tangled, granular, septate, 4.1-12.3 µm broad hyphae, with granular, closely septate, projecting hyphae, as if volval elements, 19.2-49.6 x 3.2-9.6 µm; stipe context made up of septate, thin walled, smooth, 8.18- 20.45 µm broad hyphae. Volval elements hyphal, granular, with pointed tips, branched, closely septate, projecting up ward, possessing brownish to olive greenish pigment, 4.1-29.0 µm broad. Clamp connections absent throughout.

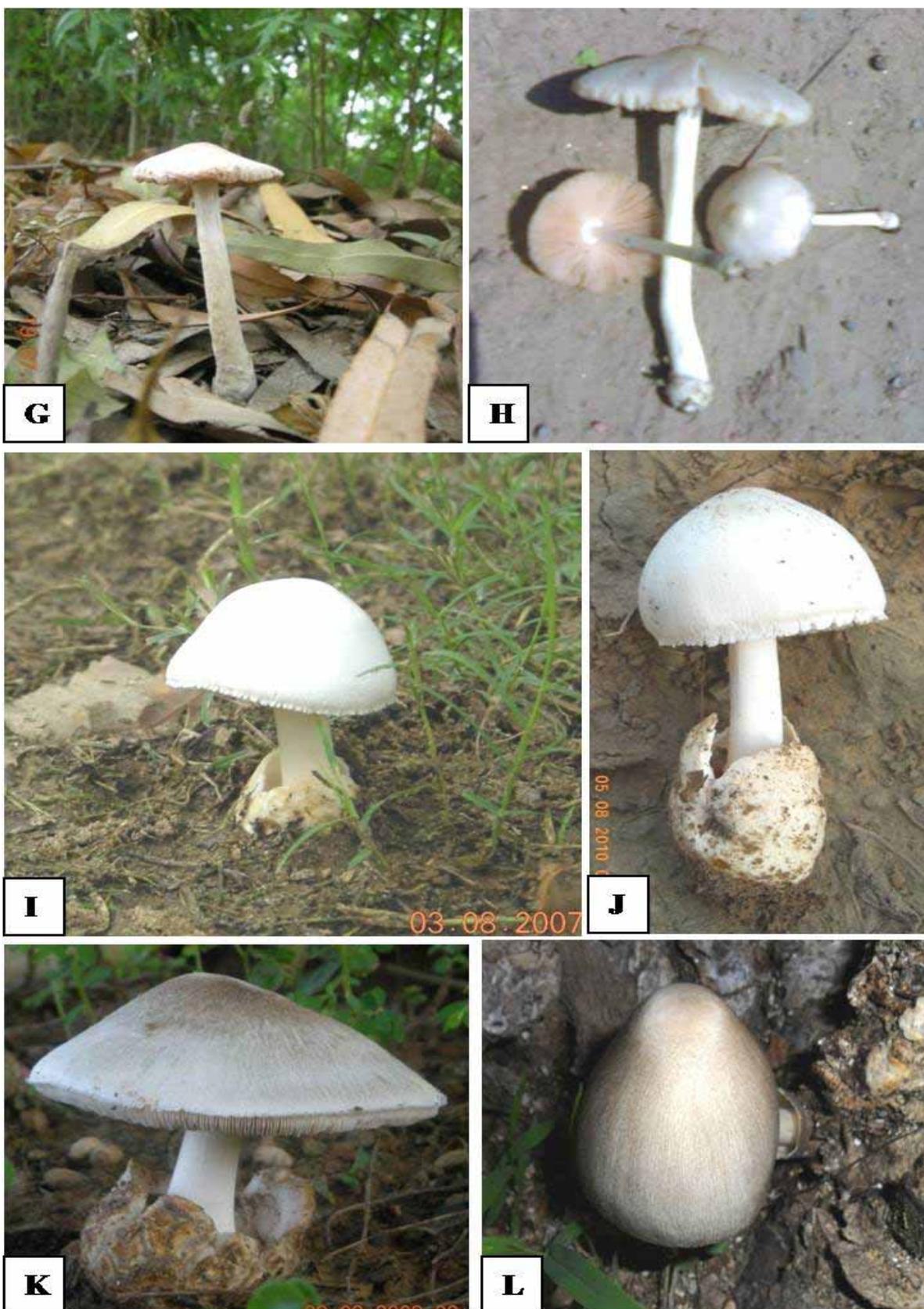
**Collection Examined:** Punjab, Ropar (250 m), growing scattered in small groups, on decaying trunk of *Ficus religiosa*, Yadwinder Singh, PUN 6478, July 18, 2010.

**Distribution and Ecology:** The present collection has been found growing scattered in groups on dead trunk of *Ficus religiosa* in mid July.

**Remarks:** The present collection is similar with the description given by Shaffer [28] and Orton [14] for *Volvariella volvacea* (Bull. : Fr.) Sing. except pileus brownish grey to brownish orange, paler at centre, covered with greyish black, hairy, shiny scales, stipe with dark greyish volva and spores smaller in length (5.6- 9.6 x 4.8-6.4 µm) in comparison to fuliginous to greyish brown cap, blackish brown at centre and brownish volva and larger spores (6.9-10.4 X 4.6-7 µm) in *V. volvacea*. It also differs from *V. volvacea* in its lignicolous habitat. Earlier, *V. volvacea* has been reported on a variety of decaying plant material like paddy straw compost piles, saw dust etc. by Shaffer [28], Orton [14], Coker [3], Monson *et al.* [11], Seok *et al.* [27] and Priest and Conde [25]. From India too it has been collected from similar habitat by Natarajan and Manjula [12], Bhavani Devi [2], Patil *et al.* [16] and Pradeep *et al.* [18] from South India. Pathak *et al.* [15] and Hennings [5] reported it from North West Himalyas and Garcha [4] documented this species from Ludhiana in Punjab. According to Orton [13] the substratum of species in genus *Volvariella* is most important and also stated that *V. volvacea* grows on compost and is not lignicolous, but the present collection has been collected growing on decaying tree trunk. Based upon the lignicolous habitat of present collection and the difference in cap color and comparatively smaller spore size from *V. volvacea*, a new variety of *V. volvacea* i.e. var. *legnicola* var. nov. have been proposed.



**Figure 1.** A. Carpophore of *Pluteus transitus* sp.nov. growing on dead wood. B. Carpophore of *P. calvitio-stipus* sp. nov. growing in soil and cap surface greyish brown, covered with appressed fibrillose scales. C . Carpophore of *P. ortonii* sp. nov.growing in its natural habitat. D. Carpophore of *Volvariella bumelia* sp. nov. growing in its natural habitat. E. Carpophore of *Volvariella albida* sp. nov. in its natural habitat. F. Underside of cap of *V. albida* sp. nov. with free, crowded, yellowish white lamellae and stipe with saccate, white to creamish white volva with areolate surface, brown at areola



**Figure 2.** G. Carpophore of *Volvopluteus shafferi* sp. nov. growing in its natural habitat on leaf litter. H. *Vp. diversi-sporus* sp. nov. Cap surface orange white, atomate, glabrous and underside of cap showing subdistant, greyish orange lamellae. I. *Volvariella bombycina* var. *parva* var. nov. White carpophore growing in its natural habitat. J. Carpophore of *V. bombycina* var. *terricola* var. nov. K. *V. terastia* var. *magna-cystidiata* var. nov. with white cap having brownish beige appressed scales and with fimbriate margins. L. Carpophore of *V. volvacea* var. *lignicola* var. nov. growing on decaying trunk of *Ficus religiosa*

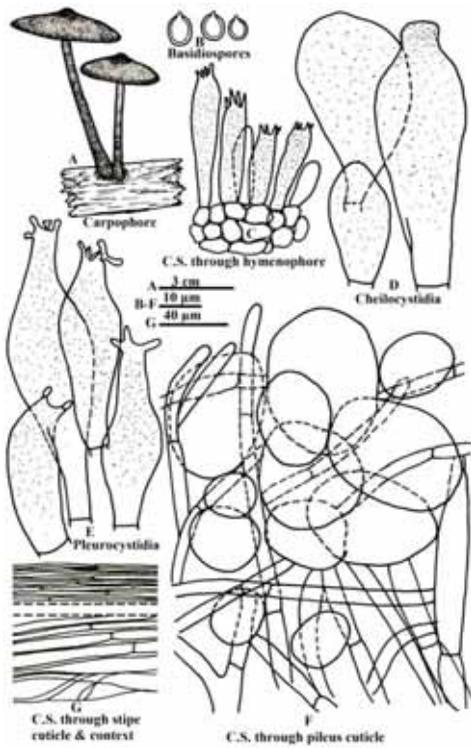


Figure 3. *Pluteus transitus* sp. nov.

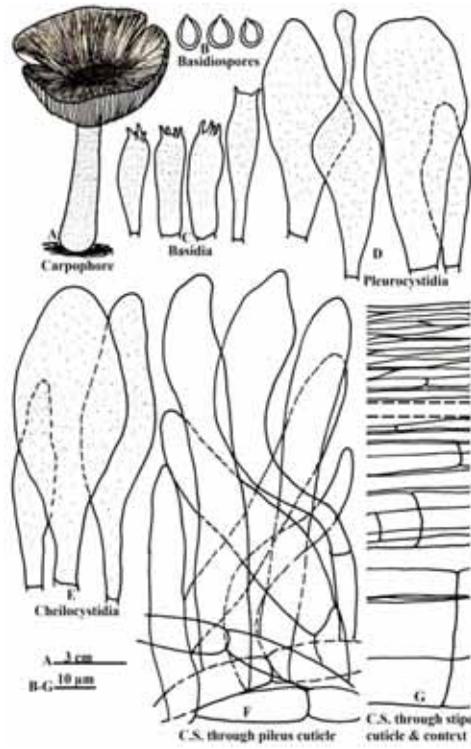


Figure 4. *Pluteus calvitio-stipus* sp. nov.

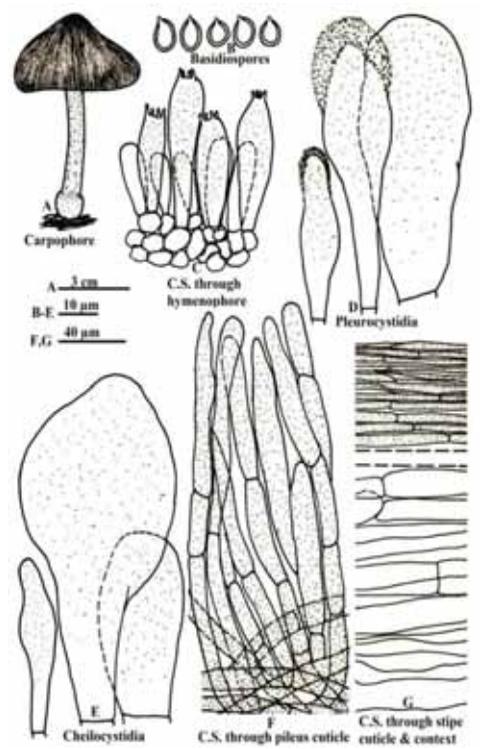


Figure 5. *Pluteus ortonii* sp. nov.

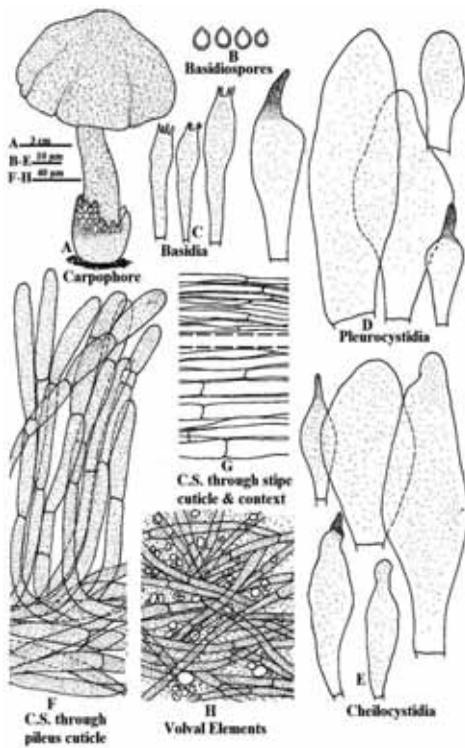


Figure 6. *Volvariella bumelia* sp. nov.

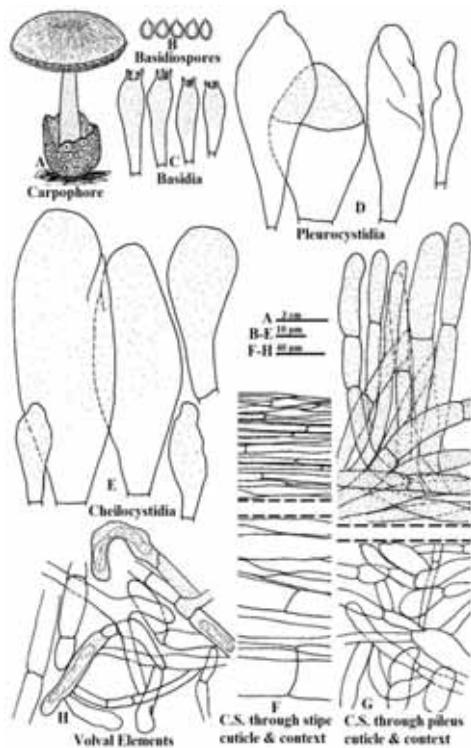


Figure 7. *Volvariella albida* sp. nov.

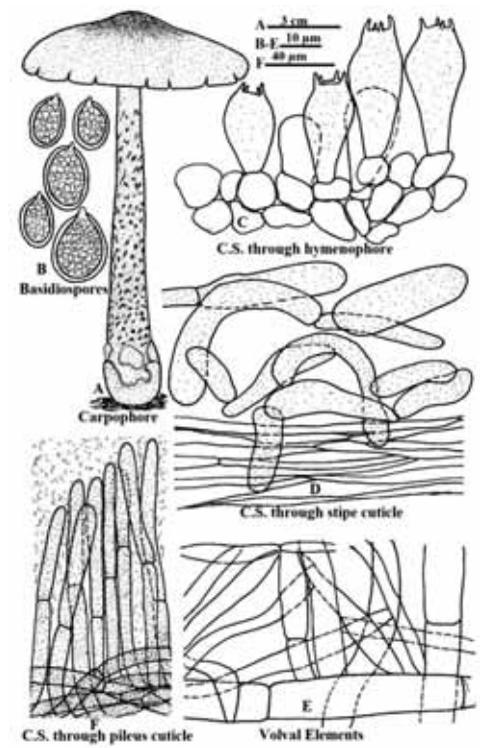
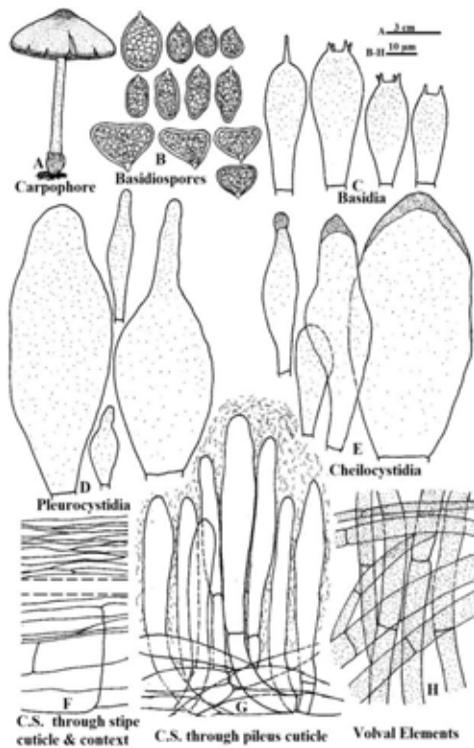
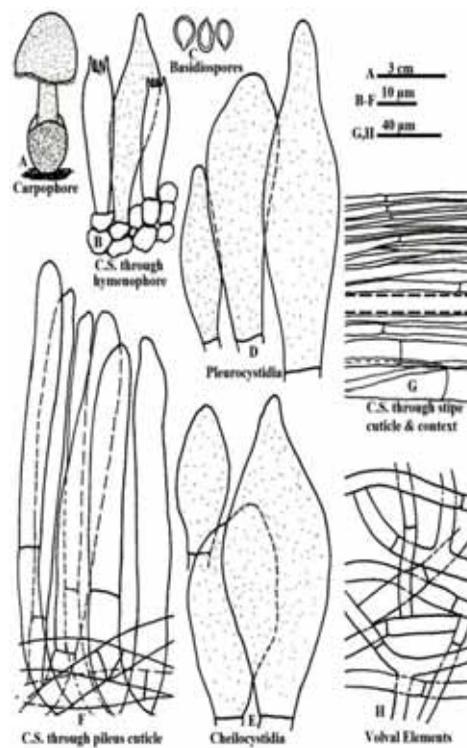


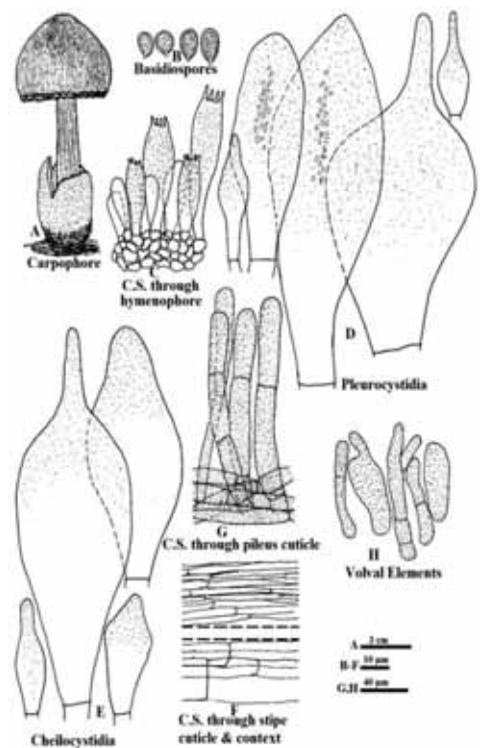
Figure 8. *Volvopluteus shafferii* sp. nov.



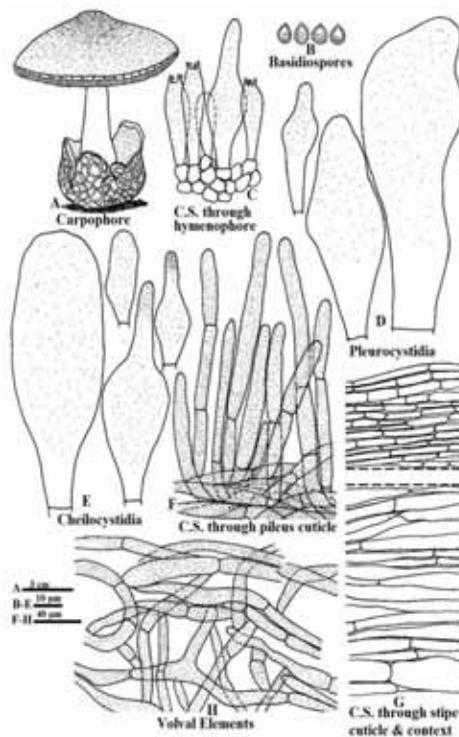
**Figure 9.** *Volvopluteus diversisporus* sp. nov.



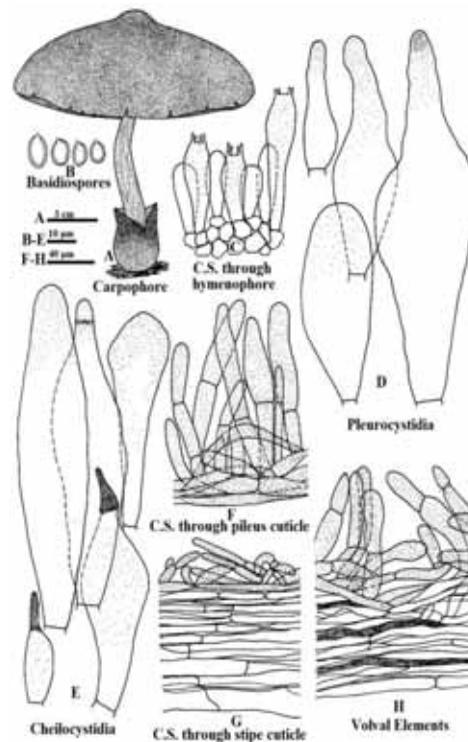
**Figure 10.** *Volvariella bombycina* (Schaeff. : Fr.) Sing. var. *parva* var. nov.



**Figure 11.** *Volvariella bombycina* (Schaeff. : Fr.) Sing. var. *terricola* var. nov.



**Figure 12.** *Volvariella terastia* (Berk. & Br.) Sing. var. *magna-cystidiata* var. nov.



**Figure 13.** *Volvariella volvacea* (Bull.: Fr.) Sing. var. *lignicola* var. nov.

During fungal forays to different localities of North-Western India 10 taxa were recorded for the first time from India viz. *Pluteus dryophiloides* P.D. Orton (PUN 6447), *Pluteus ephesus* (Fr.) Gillet (PUN 6445, PUN 6446), *Volvariella volvacea* var. *nigricans* Kawam. ex Hongo (PUN 6476), *Volvariella volvacea* var. *masseei* Singer & Wasser (PUN 6473), *Volvopluteus earlei* f. *acystidiatus* (N.C. Pathak) Vizzini & Contu. (PUN 6491), *Volvariella jamaicensis* (Murr.) Shaff. (PUN 6465), *Volvariella nullicystidiata* Menolli & Capelari (PUN 6474), *Volvariella lepiotospora* Singer (PUN 6472), *Volvariella peckii* (G.F. Atk.) Shaffer (PUN 6470), *Volvariella bakeri* (Murr.) Shaff. (PUN 4025), *Volvopluteus medius* (Schumach.) comb.nov. (PUN 6490).

## CONCLUSION

Earlier from India 28 taxa of *Volvariella*, 24 taxa of *Pluteus* and 2 taxa of *Volvopluteus* are recorded till date (Pradeep & Vrinda [19-21, 23, 24, 26, 32-34]. As a result of the present work 3 species of *Pluteus*, 2 species each of *Volvariella* and *Volvopluteus* are introduced as new to science, while 4 varieties of *Volvariella* are described as new to science. 6 species of *Volvariella* and 2 species each of *Pluteus* and *Volvopluteus* are recorded for the first time from India. Although there is no clear cut test for determining the edibility of mushrooms however, investigated taxa were screened into edible and inedible types based upon the information gathered from the field and available literature. In the study area *Volvariella bombycina*, *V. diplasia*, *V. volvacea* and *Volvopluteus gloiocephalus* are the commonly hunted mushrooms from the wild for human consumption. These species are also being cultivated commercially and have an established edibility and nutraceutical potential as confirmed from the literature. Sometimes the edible species like *Volvariella volvacea* causes gastrointestinal disorders in some people. Most of *Volvariella* and *Volvopluteus* species were found growing on grasses in the rainy season. *Volvariella bakeri*, *V. bombycina*, *V. diplasia*, *V. terastia*, *V. volvacea* var. *nigricans*, *Volvopluteus gloiocephalus* were edible taxa as reported in literature and of the 15 taxa reported to form putative ectomycorrhizal associations 10 were recorded for the first time in putative ectomycorrhizal association. The wild relatives Pleutoid mushrooms are of common occurrence in North Western India. From the surveys it has become apparent that that there is enough wild germplasm for utilization in strain improvement programme in paddy straw mushroom in study area. Various available wild species of *Volvariella*, namely *V. bakeri*, *V. terastia*, *V. taylorii* and *V. cubensis*, etc. possesses acceptable agronomic features with possibilities of introduction into cultivated commercial strains through breeding experiments.

## ACKNOWLEDGEMENTS

The authors thank Head, Department of Botany, Punjabi University, Patiala, for providing research facilities. We are indebted to UGC & DST, New Delhi for financial assistance.

## REFERENCES

- [1] Atri NS *et al.* (2005). Wild Mushrooms - Collection and Identification. In: Rai RD, Upadhyay RC and Sharma SR eds. *Frontiers in Mushroom Biotechnology*. NRCM Chambaghat, Solan. pp. 9-26.
- [2] Bhavani Devi S. (1995). Mushroom flora of Kerala. In: *Advances in Horticulture Vol. 13 - Mushrooms* (eds. K.C. Chadha and S.R. Sharma), Malhotra Publish House, New Delhi. pp. 277-316.
- [3] Coker WC. (1947). North Carolina species of *Volvaria*. *Jour. Elisha Mitchell Sci. Soc.* 63: 220-230.
- [4] Garcha HS. (1984). *Mushroom Growing*. Punjab Agriculture University Publication, Ludhiana.
- [5] Hennings P. (1901). Fungi Indiae Orientalis II. *Hedwigia*. 40: 323-342.
- [6] Justo A and Castro ML. (2010). An annotated checklist of *Volvariella* in the Iberian Peninsula and Balearic Islands. *Mycotaxon* 112: 271-273.
- [7] Kirk PM *et al.* (2008). Ainsworth Bisby's Dictionary of Fungi. 10<sup>th</sup> edition. CABI, Wallingford Oxon OX10 8DE. UK. pp. 1-771.
- [8] Kornerup A and Wanscher JH. (1978). *Methuen Handbook of Colours* (3rd ed.). Eyre Methuen. London. pp. 252.
- [9] Lakhanpal TN *et al.* (1986). Fleshy Fungi of NW Himalayas-I. A temperate white form of *Volvariella bombycina*. *Indian J. Mushroom* 12: 1-4.
- [10] Menolli Jr NJr and Capelari M. (2008). Records and two new species of *Volvariella* (Pluteaceae, Agaricales) from Brazil. *Mycotaxon* 106: 385-398.

- [11] Monoson HL *et al.* (1993). Illinois species of *Volvariella* (Basidiomycetes, Agaricales, Pluteaceae). *Mycotaxon* XLIX: 269-278.
- [12] Natarajan K and Manjula B. (1978). On the Identity of paddy straw mushroom grown in South India. *Indian J. Mycol. Res.* 16: 279-282.
- [13] Orton PD. (1974). The European species of *Volvariella* Spegazzini. *Bull. Soc. Linn. Lyon.* 43: 313-326.
- [14] Orton PD. (1986). British Fungus Flora Agarics and Boleti 4-Pluteaceae: *Pluteus* & *Volvariella*. Edinburgh: Royal Botanic Garden. pp. 99.
- [15] Pathak NC *et al.* (1978). The genus *Volvariella* in India. *Indian Mush. Sci.* 1: 295-303.
- [16] Patil BD *et al.* (1995). Mushroom flora of Maharashtra. In: *Advances in Horticulture* Vol. 13 - *Mushrooms*, KL. Chadha and SR. Sharma (eds.), Malhotra Publishing House, New Delhi. pp. 317-228.
- [17] Pegler DN. (1986). Agaric Flora of Sri Lanka. *Kew Bull. Addit. Series.* 12: 1-519.
- [18] Pradeep CK *et al.* (1998). The genus *Volvariella* in Kerala State, India. *Mush. Res.* 7(2): 53-62.
- [19] Pradeep CK and Vrinda KB. (2005a). New records of *Pluteus* Fr. from Kerala. *Mush. Res.* 14: 1-4.
- [20] Pradeep CK and Vrinda KB. (2005b). New additions to the genus *Pluteus* Fr. from India. *Mush. Res.* 14: 46-49.
- [21] Pradeep CK and Vrinda KB. (2006). New and noteworthy species of *Pluteus* (Pluteaceae, Agaricales) from Kerala State, India. *Persoonia.* 19(1): 95-99.
- [22] Pradeep CK and Vrinda KB. (2007). Some noteworthy agarics from Western Ghats of Kerala. *Journal of Mycopathological Research.* 1: 1-14.
- [23] Pradeep CK and Vrinda KB. (2008). Two new *Pluteus* (Basidiomycotina, Agaricales) from Kerala, India. *Nova Hedwigia* 87: 231-236.
- [24] Pradeep CK *et al.* (2012). Two new species of *Pluteus* (Pluteaceae, Agaricales) from India and additional observations on *Pluteus chrysaegis*. *Mycol Progress.* 11: 869-878.
- [25] Priest M and Conde B (2006). The occurrence of *Volvariella volvacea* (Bull. : Fr.) Singer in the Northern Territory, Australia. *Australasian Mycologist.* 25(2): 65-67.
- [26] Saini MK *et al.* 2008-2009. The genus *Volvariella* Speg. from North India. *J. Punjab Academy of Sciences* 5-6 (1&2): 52-56.
- [27] Seok SJ *et al.* (2002). Taxonomic study on *Volvariella* in Korea. *Mycobiology* 30(4): 183-192.
- [28] Shaffer R. (1957). *Volvariella* in North America. *Mycologia.* 49: 545-579.
- [29] Singer R. (1958). Monographs of South American basidiomycetes, especially those of the east slope of the Andes and Brazil. *Lloydia.* 21: 195-299.
- [30] Singer R. (1986). *The Agaricales in Modern Taxonomy.* 4th Ed. Sven Koeiltz Scientific Books, Germany. pp. 981.
- [31] Smith HV. (1945). The genus *Limacella* in North America. *Pap. Michigan Acad. Sci.* 30: 125-147.
- [32] Upadhyay RC and Kaur A. (2004). Taxonomic studies on light spored agarics new to India. *Mush. Res.* 13(1): 1-6.
- [33] Upadhyay RC *et al.* (2008a). Three taxa of *Amanita hemibapha* from North-Western Himalaya (India). *Mush. Res.* 17(1): 1-7.
- [34] Upadhyay RC *et al.* (2008b). New Records and Taxonomy of *Agaricales* from North-Western Himalaya. *J. Mycol. Pl. Pathol.* 38(1): 158-163.