6. Order Agaricales Underw. - A Diagnosis


The order Agaricales was first proposed in *North American Flora* in parenthesis and without a diagnosis, but its meaning was equivalent to the Hymenomycetes of Clements classification (1909). However, in their old delimitation, neither Hymenomycetes nor Agaricales were accepted to modern taxonomists because of the inclusion of widely separated families under this order. The order Agaricales as used by Singer (1986) in his monograph entitled, *The Agaricales in Modern Taxonomy* was amended to contain all of Clements Agaricales minus Gastromycetales and Aphyllorales of Rea’s classification (1922). The order Agaricales with its type family Agaricaceae and the type genus *Agaricus* was accepted by modern taxonomist in their treatment in all subsequent publications. Under this order Singer (1986) retained Polyporaceae, sensu stricto as one of the family. Instead of erecting smaller orders, Singer (1986) divided the order Agaricales into 3 suborders namely, Agaricineae, Boletineae and Russulineae. Hawksworth *et al.*, (1995) in the *Dictionary of Fungi* accepted almost all the families recognized by Singer (1986) except Boletaceae, Bondarzewiaceae, Cortinariaceae, Russulaceae and Polyporaceae, which have been elevated as orders and stands as Boletales, Bondarzewiales, Cortinariales, Russulales and Polyporales, respectively which were subsequently accepted in the latest version of *Dictionary of Fungi* by Kirk *et al.*, (2008).

Carpophores annual, 0.3 mm to 500 mm in height, not concentrically zonate, never effuse resupinate but either stipitate, pileate or with reduced stipe whereby the free pileus assumes an ostreate or cup shaped appearence and sometimes develops a pseudostipe on its sterile sides. Pileus 0.2 mm to 500 mm in diameter, membranous,
soft, fleshy to fleshy tough, leathery, occasionally partly or entirely gelatinous, never woody or carbonaceous. Hymenophore inferior, generally distinct, mostly lamellate, also tubular, rarely venose or absent. Stipe typically present and central, sometimes excentric, lateral or absent, sometimes replaced by a pseudostipe; sometimes sclerotia, pseudosclerotia or rhizomorphs present. Species with pseudostipe are always thin, sub-membranous to flexible tough or fleshy fragile or partly gelatinous, never thick and corky tough, but often cyphelloid or pleurotoid, also spathulate. Veilar structures at times present and persisting into maturity as a volva, annulus, cortina or pileal and stipe squamules or absent.

Basidiospores small to gigantic, 2 - 48.5 µm long, very variable in form, hyaline or pigmented, with evenly rounded outside or nodulose, nodulose stellate, cruciform, angular, smooth or irregularly-rough, spinose, echinate, finely echinulate, warty, punctate, longitudinally veined or ridged or with a fragmentary or complete network, reticulate, isodiametric to strongly elongate, most frequently ellipsoid to slightly ovoid, also often subglobose or cylindric with rounded ends, or subfusoid to fusoid with or without suprahilar depression or applanation, spore wall thin to somewhat thickened (0.5 - 1.0 µm) or thick, simple or compound, having germ pore or germ pore absent, amyloid, pseudoamyloid or inamyloid, formed continuously during the life time of the carpophore or especially in reviving (light spored) carpophores, formed only during a short fertile period or several such periods. Aside from basidiospores, chlamydospores are sometimes formed in the hymenophore or in the surface layer of the pileus or the stipe or on special synnematoid carpophores; arthrospores and conidia are occasionally formed, endospores none.

Basidia holobasidious, clavate to cylindric, typically tetrasporic, also mono, bisporic or trisporic, always chiastic; sterigmata mostly half sickle shaped which are
not strongly elongate, with or without a clamp between the last tramal or subhymenial cell and the basidium, with or more often without siderophilous granulosity, normally unicellular, in the immature stage either narrowly clavate or fusoid, thin walled, rarely thick walled, generally not sporulating while the hymenium is enclosed, sometimes regularly interrupted by pseudoparaphyses or with interspersed cystidia of various types or with pseudocystidia; edges of the lamellae often heteromorphous with cheilocystidia, fertile or sterile. Cystidia frequently present, leptocystidioid, metuloidal, gloeocystidioid or pseudocystidioid. Trama regular, bilateral, irregular or intermixed, mostly consisting of both fundamental and connective hyphal systems either di- or amphimitic or monomitic, more or less with laticiferous hyphae; subhymenium present or more rarely absent, either ramose (filamentous), cellular or intermixed, fundamental tissue often consisting of sphaerocysts (Russulaceae) or of large elements especially in the stipe, the hyphae sometimes gelatinized with thick walls or embedded in a gelatinous mass and then usually thin walled, amyloid, pseudoamyloid or inamyloid; hyphae with or without clamp connections.

Pileal and stipe surface either little differentiated, or dense, or forming a cutis, or a trichodermium or a hymeniform layer, an epithelium or Rameales structure or often divided into two or more rarely three layers and sometimes covered by remainders of the veilar layer, the outermost layer often containing dermatocystidia or dermatopseudocystidia or hair like bodies, the walls of other epicuticular hyphae often gelatinized or embedded in a gelatinous mass.

Mycelial tomentum present (non institious) or virtually absent (institious) at the base of the stipe. Mycelium filamentous, rarely forming sclerotia or pseudosclerotia or rhizomorphs, hyphal cells dikaryotic, generally haploid, rarely developing a diploid phase.
Taxonomic observations

Distribution: The members of Agaricales are cosmopolitan in distribution. They grow on wide variety of habitats from an open grassy lawn to deep forests. The members of Agaricales may be parasitic on the roots of trees, herbaceous plants, shrubs, etc., also on trunks of trees on stems of herbaceous plants and shrubs, even on twigs and leaves of living plants or their fruits; saprophytic on all kinds of plant debris, even on animal debris (hides, bones, hairs), often very specialized as to species and organ of the host, on dung, on scattered organic matter, on sand, rocks, on living trees, pavement, etc., on naked earth in pastures, meadows, steppes, tundras, deserts, gardens, roadsides, greenhouses; on various artificial matter such as some plastics, sawdust, wooden structures, charcoal heaps, ropes, clothing, etc., in close connection with stands of mosses such as Sphagnum, Polytrichum, etc., in symbiosis with conifers, oaks, rhododendron, etc. In all zones and continents, altitudes and plant communities, but very rarely truly aquatic.

Development: The development is mostly hemiagiocarpic, very rarely gymnocarpic.

Delimitation: The members of the order Agaricales can be delimited from other orders of Holobasidiomycetidae on the basis of fleshy carpophore texture, lamellate or tubular hymenophore, chiastic basidia, mostly angio, or hemiagiocarpic development and presence of veil.


During the present study lepiotoid and termitophilous mushrooms belonging to two families namely, Agaricaceae and Lyophyllaceae of order Agaricales has been worked out. A key to their delimitation is given below:-
1. Basidiocarps not associated with termites, with characteristic squamules on the pileus; gill trama regular to irregular but never bilateral; spores with or without germ pore; basidia without siderophilous granulation; clamp connections, may be present or absent................................................................. **Agaricaceae**

1.’ Basidiocarp mostly associated with termites; gill trama bilateral in primordial stages; basidia often with siderophilous granulation, germ pore in basidiospores and clamp connections typically absent .............................................................................. **Lyophyllaceae** (**Termitomycetaceae**)

### 6.1 Family: Agaricaceae Chevall. – A Diagnosis


**Type genus:** *Agaricus* L.: Chevall.

**Characters:** Carpophores very small, delicate to very large and robust. Pileus convex, expanding, often umbonate, vividly coloured, usually soft and fleshy; surface moist to dry, silky, tomentose, glabrous with characteristic squamules. Lamellae free, occasionally adnexed or adnate, thin, variable in colour, often very crowded with numerous lamellulae. Stipe mostly central, cylindric, often with a bulbous base, fibrous to fibrillose. Veil forming a cortiniform to membranous annulus. Volva present or remnants of volval elements may be present or absent. Caulocystidia present or absent. Context firm to soft, often whitish, often showing colour changes on bruising on exposure to air, consisting of inflated hyphae with or without clamp connection. Spore print extremely variable varying from white to cream, green, ochraceous, purplish or dark sepia. Spores very small to very large, ovoid, ellipsoid, subcylindrical or amygdaliform with or without a germ pore, hyaline to sepia, inamyloid, dextrinoid or rarely amyloid; congophilous, cyanophilous, wall composition simple or compound, smooth or rarely with any ornamentation. Basidia clavate, mostly tetraspore rarely bisporic. Lamellae edges sterile to heteromorphic or
rarely fertile, sometimes covered with remnants of the partial veil. Cheilocystidia frequently present, crowded, variously shaped, occasionally septate, Pleurocystidia occasionally present. Hymenophoral trama regular to subregular, never bilateral divergent, inamyloid, or more rarely dextrinoid. Pileal surface variable, varying from undifferentiated repent cutis to a trichodermal palisade or an epithelium, or in the form of chains of loose sphaerocysts. Clamp connections present or absent.

**Habit and habitat:** Habit pluteoid, tricholomatoid collyboid or even lepiotoid. Mostly terrestrial, humicolous or lignicolous.

Kirk *et al.*, (2008) recognized 85 genera in this family. From India 11 genera are known so far. During the present study, species belonging to 8 genera of this family have been collected and worked out. These are *Chlorophyllum*, *Macrolepiota*, *Leucoagaricus*, *Leucocoprinus*, *Lepiota*, *Cystolepiota*, *Clarkienda* and *Chlorolepiota*.

**Key to the genera investigated**

1. Lamellae white to cream or pale; spore print white, pale pink or cream, never green .................................................................................................................2  
1.’ Lamellae green; spore print greenish .........................................................................................................................6  
2. Spore wall thick and compound, spores always with germ pore, endosporium metachromatic with cresyl blue .................................................................................................................................3  
2.’ Spore wall simple, thin, lacking an apical germ pore, endosporium not metachromatic with cresyl blue .................................................................................................................................4  
3. Lamellae, collariate; apical pore prominent ...............................................................................................................5  
3.’ Lamellae, non-collariate; apical pore indistinct .............. *Leucoagaricus*  
4. Lamellae free, lamellae edges always sterile; spores dextrinoid, rarely amyloid; pileipellis varying from repent cutis to a trichodermal palisade or hymeniform .............................................................................................................. *Lepiota*  
4.’ Lamellae free to adnexed, lamellae edges fertile to heteromorphous, spores dextrinoid or inamyloid; pileus cutis often with detesile elements ............................................................................................................. *Cystolepiota*  
5. Carpophore robust, pileal margin non striate; annulus complex, pileus cuticle a disrupted trichodermal palisade .................................................................................................................. *Macrolepiota*  
5.’ Carpophore fragile, striate; pileus cuticle neither hymenodermic nor palisadic ........................................ *Leucocoprinus*  

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6. Pileus covered with central stellate patch in the centre, volva present or rudimentary………………………………………Clarkiendra

6.’ Pileus neither with central stellate patch, nor with volva at the base of the stipe……………………………………………………………...7

7. Pileus covered with concentrically arranged scales; basidiospores without apical pore………………………………………………………Chlorolepiota

7.’ Pileus without concentrically arranged scales; basidiospores wall thick and compound, apical pore present……………………………………Chlorophyllum

The taxonomic details of different investigated species has been given under their respective genus. In the thesis various worked out genera have been arranged in order of their segregation in the key above. The first genus segregated in the key is Leucoagaricus. The diagnosis of this genus along with the key to the species of Leucoagaricus investigated is given below.

6.1.1 Leucoagaricus (Locquin) Sing. - A Diagnosis


Synonym

Leucocoprinus Pat. subg. Leucoagaricus Locq. in Bull. Soc. Linn. Lyon 12: 91(1943)

Type species: Leucoagaricus macrorhizus (Locquin) Sing.

Characters: Carpophores small to medium, fragile, slender to sturdy. Pileus thick, fleshy, fibrillose, floccose, squamulose to scaly, rarely granulose, with entire or very short striate margin. Lamellae free, rarely collariate, white, sometimes becoming pinkish, thin, crowded to subdistant, ventricose. Spore print pure white to pinkish. Stipe central, comparatively short, equal or with bulbous base. Veil annulate, persistent, fixed. Spores ovoid, ellipsoid or amygdaliform, with rudimentary or rarely distinctive germpore, moderately thick walled, dextrinoid, endosporium metachromatic with cresyl blue, smooth or rarely ornamented; gill edges sterile. Pseudoparaphyses absent around basidia. Pileal surface either trichodermium or a
Taxonomic observations

cutis of repent and radially arranged hyphae lacking sphaerocysts. Cheilocystidia abundant, pleurocystidia occasionally present, clamp connections absent.

**Habit and habitat:** Habit lepiotoid or pluteoid to agaricoid. Habitat terrestrial, on rotten debris, decayed wood or coprophilous.

**Development of the carpophore:** Hemiangiocarpous.

**Distribution:** Cosmopolitan.

**Limits:** The genus *Leucoagaricus* (Locquin) Sing. belongs to family Agaricaceae Chevall. of the tribus Leucocoprineae and differs from closely related *Leucocoprinus* in having very shortly pectinate pileus margin instead of long pectinate margin. Initially it was treated as a subgenus of *Leucocoprinus* by Locquin (1943). It was Singer (1948) who elevated *Leucoagaricus* from subgenus level to generic level.

**Statistics:** The world over 90 species of the genus *Leucoagaricus* are known so far (Kirk et al., 2008). From India only 4 species of the genus namely, *L. excoriatus* (Schaff.: Fr.) Sing., *L. holosericeus* (Fr.) Moses, *L. rubrotinctus* (Peck.) Sing. and *L. fuligineus* Peg. are reported (Bilgrami et al., 1979; Sarbhoy et al., 1992; Jamalludin et al., 2001 and Natarajan et al., 2005). Presently fifteen collections falling under 8 species of *Leucoagaricus* viz. *L. albidus* sp. nov., *L. rhodocephalus* (Berk.) Peg., *L. crystallifer* Vellinga, *L. sublittoralis* (Kühner : Hora) Sing., *L. barsii* (Zellar) Vellinga var. *bulbobasilarus* var. nov., *L. tener* (Orton) Bon var. *brevispora* var. nov., *L. melanotrichus* var. *melanotrichus* (Malenc. & Bert.) Trimb. and *L. rubrotinctus* (Peck.) Sing. have been worked out for their external and internal details. Out of which one new species *Leucoagaricus albidus* sp. nov. and two new varieties namely *L. barsii* (Zellar) Vellinga var. *bulbobasilarus* var. nov. and *L. tener* (Orton) Bon var. *brevispora* var. nov. have been proposed.
Key to the species of Leucoagaricus investigated

1. Both cheilocystidia and pleurocystidia present ..............................................2

1.’ Cheilocystidia present but, pleurocystidia absent ......................................3

2. Basidiocarps shining white to yellowish white, when fresh, stipe annulate, appendiculate velar fragments present, basidiospores 5 - 6.7 (7.6) x 3.4 - 4.8 (5) µm .......................................................... L. albidus sp. nov.

2.’ Basidiocarps pale yellow with greyish brown scales, appendiculate velar fragments absent, basidiospores 8 - 10 x 6.4 - 7.25 µm ........................................ L. barsii var. bulbobasilarus var. nov.

3. Stipe yellowish white, changes to yellowish brown on bruising ..................4

3.’ Stipe whitish not changing colour on bruising ........................................5

4. Carpophores 7.5 - 8 cm, pileus greyish orange to ochraceous towards the margin with greyish orange appressed fibrillose scales on yellow background, disc brown in colour ......................................... L. tener var. brevispora var. nov.

4.’ Carpophores up to 3.6 cm in height, pileus covered with brownish grey scales with blakish tinge on yellowish white background, apex purplish with greenish hue ................................................................ L. melanotrichus var. melanotrichus

5. Gill edges smooth; cheilocystidia without any incrustations ..................................L. rhodocephalus

5.’ Gill edges serrate; cheilocystidia with encrustations and granular ..................6

6. Annulus yellowish white with no different colour edge; evanescent ......................... L. crystallifer

6.’ Annulus yellowish white with purplish or orange edge; persistent ..................7

7. Umbo purplish pink; stipe yellowish white with pinkish to olivaceous hue; cheilocystidia up to 55 µm long ................................................................. L. sublittoralis

7.’ Umbo reddish brown; stipe yellowish white without any hue; cheilocystidia up to 40 µm long ................................................................. L. rubrotinctus

i. Leucoagaricus albidus sp. nov. Figs. 5 (A-B) & 6 (A-F)

Fructifications 3 - 7 cm in height. Pileus 2 - 3 cm in diameter, convex to hemispherical, surface shining, white to yellowish white (4A2), brownish orange on drying; margin regular, incurved, not splitting at maturity; cuticle fully peeling; flesh 0.5 cm thick, white, changing to yellowish white to pinkish on bruising; taste and odour mild. Pileal veil in the form of appendiculate veil fragments. Lamellae free, unequal, of 2 lengths, subdistant to crowded, 0.5 cm broad, yellowish white in young specimens, reddish white (8A2) to brown at maturity; gill edges lacerate. Stipe
Taxonomic observations

central, 2 - 6.3 cm long, 0.6 - 1.1 cm broad, pale yellow (4A3), obclavate, concolorous with the pileus, hollow, scaly, glabrous; annulate, annulus single, superior, ring like.

Spores 5 - 6.7 (7.6) x 3.4 - 4.8 (5) µm (Q = 1.4), broadly ellipsoid to amygdaliform with rounded apex, thick walled, congophilous, cyanophilous, dextrinoid, weakly metachromatic in cresyl blue, apical pore absent. Basidia 19.3 - 29 x 6.4 - 9.6 µm, clavate, tetrasporic; sterigmata 1.6 - 2.4 µm long. Pleurocystidia 22.5 - 32.2 x 8.8 - 12.8 µm, scattered, clavate to pyriform; gill edges heteromorphous. Cheilocystidia 19.3 - 30.6 x 7.2 - 16 µm, crowded, broadly clavate to pyriform, granular, scattered, hyaline.

Pileus cuticle a trichoderm, consisting of regular turf of branched, septate cylindrical to tubular tipped elements measuring 4 - 8 µm in width, some of these with interacellular pigmentation; context homoiomerous; hymenophoral trama regular, tramal hyphae up to 10 µm in width; subhymenium pseudoparenchymatous, well developed. Pileal veil elements septate, granular, up to 9.8 µm in width. Stipe surface hyphae parallel 4 - 26 µm in width. All hyphae lack clamp connections.

Figs. 5: (A – B) Carphophores in their natural habitat.
Figs. 6 (A-F) *Leucoagaricus albidus* sp. nov.: A. Carpophores, B. Basidiospores, C. Hymenophore with Basidia, D. Pleurocystidia, E. Cheilocystidia, F. Pileus trichodermial elements.
**Collection examined**: Himachal Pradesh, Mandi, Sarkaghat, Bakarta, (850 m), growing scattered or in caespitose clusters in rice field, Babita Kumari, PUN 4309, July 12, 2009.

**Remarks**: - It is an interesting whitish coloured lepiotoid mushroom, in which flesh turns light yellowish to pinkish when bruised. In its outward morphology it appears quite similar to *L. leucothites* of which Vellinga (2001 b) has recognized one more variant, namely var. *carneifolinus* beside var. *typica*. The presently examined variant is quite close to *L. leucothites* var. *typica* from which it differs in possessing small sized aporus basidiospores measuring 5 - 6.7 (7.6) x 3.4 - 4.8 (5) µm in size instead of 7.5 - 11 x 5 - 7 µm as reported by Vellinga (2001 b). In view of the presence of shining whitish carpophores whose flesh discolour yellow to pinkish on bruising, annulate stipe, smaller spores and presence of pleurocystidia, a new species *Leucoagaricus albidus* sp. nov. has been proposed to accommodate this collection.


Fructifications 3.4 - 6.5 cm in height. Pileus 2.5 - 5.6 cm in diameter, plano-convex; surface pale yellow (3A2) covered with greyish brown (5C2) scales, squamules more concentrated towards the center; margin irregular, splitting at maturity; cuticle fully peeling; flesh up to 0.4 cm thick, off white, unchanging; taste mild, odour fruity. Lamellae free, collariate, unequal, of 3 - 4 lengths, subdistant, pale yellow (3A3), 0.6 cm broad; gill edges fimbriate; spore deposit pale yellow (4A3). Stipe central, 5.8 cm long, 1.1 cm broad, yellowish white (4A2), brownish on bruising, obclavate with bulbous base, hollow; annulus single, thick, attached.

Spores 8 - 10 x 6.4 - 7.3 µm (Q = 1.2), broadly ellipsoid with rounded apex, inamyloid, congophilous, cyanophilous, dextrinoid, weakly metachromatic in cresyl blue, apical pore absent. Basidia 22.5 - 48.3 x 9.6 - 12 µm, broadly clavate, tetrasporic; sterigmata 3.2 - 4.8 µm long; gill edges heteromorphous, largely sterile
Figs. 7 (A-F) *Leucoagaricus barsii var. bulbobasilarus var. nov.*: A. Carpophore, B. Basidiospores, C. Basidia, D. Cheilocystidia, E. Pleurocystidia, F. Pileus cuticle elements.
with occasional basidial elements. Cheilocystidia 25.8 - 42 x 9.6 - 16 µm, crowded, broadly clavate to pyriform, thick walled, hyaline. Pleurocystidia 23.6 - 41.5 x 9 – 15.5 µm, present near the gill edges which are similar to cheilocystidia.

Pileus cuticle a disrupted epicutis of radial hyphae measuring 4 - 8 µm in width; context homoiomerous, well developed; gill trama subregular, tramal hyphae 3.2 - 4.8 µm in width; subhymenium pseudoparenchymatous. Stipe surface hyphae parallel running, 4 - 8 µm in width. Clamp connections present in the basal mycelium.

**Collection examined:** Patiala, Girls Hostel road, Punjabi University Patiala (250 m), growing scattered on sandy soil, Babita Kumari, PUN 4311, June 18, 2008.

**Remarks:** This is an interesting mushroom growing solitary on sandy soil. The species is easily recognized by greyish fibrillose brown squamules on the pileus surface, presence of both cheilocystidia and pleurocystidia. In many of its features it is closely related to *L. macrorhizus*, which mainly differs from it in having big carpophore with brownish pileus and large spores with germ pore. (Vellinga 2001 b). Because of the presence of pleurocystidia, it can also be compared with *L. americanus*. On the basis of large spore size and bulbous base *L. barsii* var. *bulbobasilarus* var. nov. has been proposed. *L. barsii* is not documented earlier from India.


Fructifications 7.5 - 8 cm high. Pileus 2.2 - 5 cm wide, convex to campanulate, disc brown (6D7), greyish orange (5B5) to ochraceous towards the margin with greyish orange (5B5) appressed fibrillose scales on a pale yellow (4A3) background; scales more dense towards the center in young sporophores; margin irregular, splitting at maturity; cuticle fully peeling; flesh 0.3 - 0.4 cm thick, off white, unchanging; taste mild and odour sour (like lemon). Lamellae free, close to crowded, unequal, of 3 - 4
lengths, yellowish white (4A2), unchanging; gill edges smooth; spore deposit yellowish white (4A2). Stipe 7 - 7.6 cm long, 0.5 - 0.6 cm broad, yellowish white (4A2); yellowish brown on bruising, concolorous with the pileus, expanding slightly at the base, hollow, pruinose fibrillose; annulus single, funnel shaped with brown dots on the lower side, presence of water drops on the upper portion of stipe surface.

Spores 4.8 - 6.5 x 3.2 - 4.0 µm (Q = 1.56), ellipsoid to slightly amygdaliform, pseudoamyloid, guttulate with single guttule, metachromatic in cresyl blue, apical pore absent. Basidia 12.9 - 20.9 x 5.6 - 7.24 µm, thin walled, hyaline, tetrasporic; sterigmata 2.4 - 3.2 µm long; gill edges sterile. Cheilocystidia 19.3 – 40.3 x 5.6 - 12.8 µm, crowded, versiform, varying from clavate to lageniform or even irregular with lateral apical prolongations. Pleurocystidia absent.

Pileus cuticle formed of more or less irregular trichoderm consisting of short cylindrical, thin walled segments measuring 20 - 78 µm in length and 4 - 8 µm in width, devoid of clamp connections at slightly constricted septa and readily dissociating towards the terminal portion, terminal elements clavate to cylindrical with obtuse tips; context homoiomerous; gill trama subregular; subhymenium pseudoparenchymatous well developed, formed of more or less isodiametric elements. Stipe cuticle hyphae parallel 4 - 12 µm in width with some projecting branched elements measuring 6 - 8 µm in width. Clamp connections absent throughout.

**Collection examined:** Himachal Pradesh, Mandi, Sarkaghat, Bakarata (850 m), growing scattered in association with roots of Bamboo, Babita Kumari, PUN 3939, August 5, 2009.
Figs. 8 (A-E) *Leucoagaricus tener var. brevispora var. nov.*: A. Carpophore, B. Basidiospores, C. Basidia, D. Cheilocystidia, E. Pileus trichodermal elements.
Remarks:- It can be easily identified in the field by its brownish disc with greyish orange fibrillose flecks on a pale yellow background and presence of water drops on the fresh carpophores especially on the upper portion of stipe. The macroscopic and microscopic features of this mushroom are in close agreement with L. tener. It is a small spored variant of Leptota tener with spores measuring from 4.8 - 6.5 x 3.2 - 4 µm instead of 6.0 - 8.0 x 3.2 - 4 µm as reported by Reid (1995) for the type variety. A new variety L. tener var. brevispora var. nov. has been proposed to accommodate this collection, otherwise L. tener is a new fungus record for India.


Synonym

Leucoagaricus melanotrichus var. septentrinalis D Reid in Mycotaxon 53: 331.1995.

Fructification up to 3.6 cm in height. Pileus up to 0.9 cm in diameter, convex, apex coloured purplish with a greenish tinge, covered with brownish grey to blakish tinge (9F2) scales over yellowish white (4A2) background; surface moist, margin irregular, splitting at maturity; cuticle fully peeling; flesh up to 0.4 cm thick, off white, unchanging; taste and odour mild. Lamellae free, close, unequal, of 2 lengths, ventricose, yellowish white, unchanging; gill edges smooth to serrated; spore deposit pale yellow (4A3). Stipe central, 3.2 cm long, 0.1 cm broad, yellowish white (4A2), yellowish brown on bruising, cylindrical with broad basal region, obclavate, hollow; annulus single, peronate, with blackish layer on the upper side.
Figs. 9 (A-E) *Leucoagaricus melanotrichus var. melanotrichus*: A. Carpophore, B. Basidiospores, C. Hymenophore with basidia, D. Cheilocystidia, E. Pileus trichodermial elements.
Spores 4.8 - 6.4 x 3.2 - 4 µm (Q = 1.6), amygdaliform, dextrinoid, not metachromatic in cresyl blue, congophilous, cyanophilous, apical pore absent. Basidia 16 - 20.9 x 4.8 - 6.4 µm, broadly clavate, tetrasporic; sterigmata 1.6 µm long; gill edges sterile. Cheilocystidia 24.2 - 48.3 x 8 - 17.7 µm, crowded, versiform, irregular, clavate to heart shaped or even pyriform, septate, crowded, hyaline. Pleurocystidia absent.

Pileus cuticle formed of elements incrusted with golden brown to dark brown interacellular pigments. These elements are invariably thick walled branched, irregularly arranged, anastomising with cylindrical to tubular tips, measuring (4) 6 - 10 µm in width; context homoiomerous; gill trama subregular, tramal hyphae measuring 4 - 12 µm in width; subhymenium pseudoparenchymatous, well developed. Stipe cuticle hyphae parallel, 6 - 18 µm in width, septate. All hyphae lacking clamp connections.

**Collection examined:** Uttrakhand, Chakrata Road, Korba (2200 m), growing solitary on humicolous soil under Quercus leuco trichophora, Babita Kumari, PUN 4310, July 21, 2010.

**Remarks:** The above examined collection is typical of *Leucoagaricus melanotrichus* var. *melanotrichus* (Vellinga, 2001 b). It is represented by small sized carpophore with thin delicate flesh having purplish colour with greenish hue covered by brownish grey to black scales over yellowish white background, presence of annulus on thin cylindrical stipe and cheilocystidia with irregular outgrowths. It shows close resemblance with *Leucoagaricus melanotrichus* var. *fuligineobrunneus* except having variable colour pigment in the pileus covering. It is a new fungus record for India.


**Figs. 10 (A-E)**

Carpophores 5 - 7 cm in height. Pileus 2.2 - 4.7 cm in diameter, convex; surface reddish brown at the disc covered by radially arranged scales over a white background, fading towards the periphery; margin silky, feebly striate, often splitting; cuticle fully peeling; flesh up to 0.2 cm thick, white, unchanging. Lamellae free, sub
Taxonomic observations

remote, unequal, subdistant, 0.5 cm broad, yellowish white (4A2), unchanging; gill edges smooth. Stipe central, 4.0 - 6.5 cm long and 0.5 - 0.7 cm broad, almost equal in diameter, whitish, hollow, annulus membranous, peronate, single, attached to the upper half of the stipe.

Spores 6.4 - 9 x 4 – 5 µm (Q = 1.7), ellipsoid, hyaline, strongly dextrinoid amygdaliform, wall moderately thick, stratified, apical pore absent, large oil guttules present in the spore matrix, metachromatic in cresyl blue. Basidia 10 – 17.7 x 4 - 6.4 µm, broadly clavate, tetrasporic; sterigmata 1.6 - 3.2 µm long; gill edges sterile. Cheilocystidia 16.1 - 27.37 x 8 - 12.8 µm, crowded, hyaline thin walled, arranged in clusters, varying from cylindrical, fusiform, pyriform to even ventricose with a rounded to slightly pointed apex. Pleurocystidia absent.

Pileus cuticle a disrupted trichoderm of upright hyphae measuring 4 - 12 µm in diameter with tubular ends; context homoiomerous; gill trama regular, narrow; subhymenium well developed, pseudoparenchymatous. Stipe cuticle consisting of parallel running hyphae measuring 8 - 12 µm in width. Clamp connections absent.

Collection examined: Punjab, Hoshiarpur (300 m), growing scattered on soil, Munruchi Kaur, PUN 3944, July 17, 2008.

Remarks:- It is an interesting mushroom, which comes up early during the start of the monsoon season in Punjab. Its macroscopic and microscopic features are in agreement with the details given for Leucoagaricus rhodocephalus by Pegler (1977). It is characterized by silky striate reddish orange pileus, annulate stipe and presence of versiform cheilocystidia. It is a new fungus record for India.

**Figs. 11 (A-E)**

**Synonyms**


Fructifications 4.2 - 6.5 cm in height. Pileus 1.6 - 3.5 cm in diameter, convex to hemispherical, surface yellowish white (4A2) to orange white (5A2) with orange white umbo covered with recurved white silky fibrillose scales which are more dense towards the center over yellowish white (4A2) background, carpophore remain light coloured on drying; margin feebly striate, irregular, splitting at maturity; cuticle fully peeling; flesh up to 0.2 cm thick, off white, unchanging; taste and odour mild. Lamellae free, close to crowded, unequal, of 3 - 4 lengths, 0.3 - 0.4 cm broad, yellowish white (4A2), unchanging; gill edges dusty, serrate, fragile; spore deposit creamish white. Stipe central, 4 - 6.1 cm long, 0.3 - 0.4 cm broad, yellowish white (4A2), equal with a slightly broad base, hollow, scaly; annulate, annulus single, peronate, shredded.

Spores 5.6 - 8 x (2.4) 3.2 - 4 µm (Q = 2.1), ellipsoid to slightly amygdaliform, metachromatic in cresyl blue, dextrinoid, congophilous, cyanophilous, apical pore absent. Basidia 16 - 25.8 x 5.63 - 8 µm, clavate, thin walled, hyaline, granular in the upper region, tetrasporic; sterigmata 3.2 - 4.8 µm long; gill edges sterile. Cheilocystidia in tufts, 24.2 - 64.4 (80.5) x 4.8 - 6.4 (10.5) µm, thin walled, crowded, versiform varying from clavate cylindric to lageniform or even ventricose with some variable sized crystals towards the apical region. Pleurocystidia absent.

Pileus cuticle formed of disrupted trichoderm consisting of septate cylindrical elements measuring 4 – 8 µm in width; context homoiomerous, well developed; hymenophoral trama subregular, tramal hyphae up to 10 µm in width; subhymenium
Taxonomic observations

Taxonomic observations


Collection examined: Himachal Pradesh, Palampur, Luhna, (1300 m), growing scattered on huminolous soil, Babita Kumari, PUN 4313, July 30, 2009.

Remarks: The above examined collection belongs to Leucoagaricus crystallifer (Vellinga, 2001b). The chief characters include the yellowish to orange white, carpophores covered with silky fibrillose scales over yellowish white background, versiform cheilocystidia with variable sized crystals in the apical region and absence of pleurocystidia. L. crystallifer is quite close to L. meirii which primarily differs from it in having relatively thick fleshy bigger carpophores with abruptly bulbous stipe base. It is a new fungus record for India.


Fructifications 3.5 - 4.5 cm in height. Pileus 2.6 - 3.2 cm in diameter, convex; surface yellowish white covered with light brown (7D5) hair like appressed scales and reddish brown (8E5) disc having purplish pink center, pileus radially fibrillose with fine cracks along the periphery; margin irregular, splitting at maturity; cuticle fully peeling; flesh up to 0.2 cm thick, yellowish white (4A2), unchanging; taste and odour mild. Lamellae free crowded, unequal, of 3 - 4 lengths, 0.3 - 0.5 cm broad, yellowish white (4A2); gill edges serrated. Stipe central, 3.2 - 4.1 cm long, 0.3 - 0.5 cm broad, yellowish white (4A2), with faint pinkish to olivaceous hue, cylindrical with bulbous base, hollow, scaly; annulate, annulus peronate, single, attached to the mid of the stipe, with pinkish orange to pinkish brown edge, soon evanescent.

Spores 5.6 - 8 (9) x 4 - 4.8 µm (Q = 1.6), dextrinoid, ellipsoid to oblong to subamygdaliform with rounded apex, guttulate with a single guttule; metachromatic in cresyl blue, congophilous, cyanophilous, apical pore absent. Basidia 12.8 - 22.5 x 5.6 - 8.8 µm, thin walled, clavate, tetrasporic; sterigmata 3.2 - 4 µm long; gill edges sterile. Cheilocystidia 20.9 - 54.7 x 6.4 - 13.7 µm, crowded, septate, versiform, varying from clavate, cylindrical fusiform to even utriform with some crystal like incrustations towards the apex. Pleurocystidia absent.
Taxonomic observations

Pileus cuticle formed of loose trichodermal elements with broad to rounded apical ends measuring 5.6 - 11.3 µm in width; context homoiomerous; gill trama regular, tramal hyphae measuring up to 8 µm in width; subhymenium pseudoparenchymatous. Stipe cuticle hyphae parallel running throughout, 3.2 - 9.6 µm in width. All hyphae lacking clamp connections.

**Collection examined**: Punjab, Chandigarh, Rose Garden (321 m), growing scattered among grasses, Babita Kumari, PUN 4312, September 3, 2009.

**Remarks**: The above examined collection is typical of *L. sublittoralis* (Vellinga, 2001 b). It is characterized by pileus having yellowish white surface covered by light brown to reddish brown pigmentation having purplish pink centre, radially fibrillose scales over yellowish white background which are more prominent along the cracked margin, yellowish white annulate stipe with annulus having pinkish orange to pinkish brown margin, presence of cheilocystidia having crystal like incrustations towards the apical region and absence of pleurocystidia. It is a new fungus record for India.

Figs. 14 (A-E)

**Synonym**

*Lepiota rubrotincta* Peck. *Sydowia* 2: 36.1948

Fructifications 3.5 - 10 cm in height. Pileus 2.3 – 5 cm in diameter, surface convex, yellowish white (4A2), convex, vary in colour from brown, reddish brown, greyish brown to dark brown (7E8, 8D5 - 7F8) in the central region, with light brown (6D5) to reddish brown (8D5) recurved scales, dry, margin irregular, splitting at maturity, cuticle fully peeling; flesh up to 0.2 cm thick, white, unchanging; taste and odour mild. Lamellae free, crowded, unequal, of up to 3 lengths, yellowish white, 0.4 - 0.6 cm broad; gill edges serrate, fragile. Stipe central, 3 - 6.1 cm long, 0.3 - 0.5 cm broad, yellowish white (4A2), obclavate; hollow, annulus single, reddish orange in outline on upper surface of annulus, attached.
Taxonomic observations

Spores 4.8 (5.6) – (7.3) 8 x (3.2) 4 – 5.0 µm (Q = 1.2) ellipsoid, pseudoamyloid to dextrinoid, strongly congophilous, cyanophilous, not metachromatic in cresyl blue, apical pore absent. Basidia 12.8 (16) - 22.5 (25.8) x (4.8) 5.6 - 8 µm, clavate, with well developed pseudoparenchymatous cells, tetrasporic; sterigmata 2.4 - 3.2 µm long; gill edges sterile. Cheilocystidia 24.2 - 40.3 x 6.4 - 11.3 µm, crowded, appear in bunches, clavate to lageniform, granular. Pleurocystidia absent.

Pileus cuticle composed of cylindrical to obtuse upright tangled elements measuring 4 - 12 µm in width; context homoiomerous; gill trama regular; subhymenium pseudoparenchymatous, well developed. Stipe cuticle hyphae running parallel, measuring 4 – 28.9 um in width. Clamp connections absent throughout.

Collections examined: Himachal Pradesh, Mandi, Bakarta (850 m), growing on Buffalow dung, Babita Kumari, PUN 4660, July 12, 2009.
   Punjab, Patiala, Shambhu Road, growing scattered under Thespesia trees, Munruchi Kaur, PUN 4655, September 17, 2010.

   Uttrakhand, Chakarta, Korba (2200 m), growing scattered on soil under mosses, Babita Kumari, PUN 4653, July 18, 2010; Dhanaulti (2000 m), growing scattered on soil, Babita Kumari PUN 4654, July 20, 2010; Dhanaulti (2000 m), growing scattered on soil in a mixed forest, Babita Kumari, PUN 4656, July 20, 2010; Dhanaulti (2000 m), growing scattered on soil in a mixed forest, Babita Kumari, PUN 4659 July 20, 2010; Dhanaulti Road (2000 m), growing scattered on soil in mixed forest, Babita Kumari, PUN 4661, July 20, 2010; Chakrata, Korba (2200 m), growing scattered on soil among mosses, Babita Kumari, PUN 4657, July 18, 2010.

Remarks:- The above examined collections are typical of Leucoagaricus rubrotinctus. The external and internal details are in agreement with the details given by Arora (1986) for this species. It is one of the beautiful mushroom, which can be easily identified in the field by its greyish brown to reddish brown tone of the pileus. It is characterized by variable coloured cap surface from pinkish brown, brown to pinkish orange with dark centre, usually breaking into radially arranged scales or fibrils. In the mycobank Leptota rubrotincta has been shifted to Leucoagaricus
rubrotinctus. In India Lepiota rubrotincta was reported by Trivedi (1972) from Nagpur. Here it has been recorded for the first time from North India.

6.1.2 Lepiota (Pers.: Fr.) S. F. Gray – A Diagnosis


Type species: Lepiota colubrina (Pers.: Fr.) S.F. Gray.

Characters: Carpophores very tiny to large robust, pileus convex to applanate, often umbonate or campanulate; pileus vividly coloured, surface mostly squamulose, rarely powdery. Spore print typically white to pale cream, rarely pinkish or green. Lamellae usually free, occasionally sub-adnate, thin, mostly light coloured. Stipe central, well developed, cylindrical to obclavate; surface smooth to fibrillose typically with annulus either membranous or cortinoid, or remnants of velum particle. Pileus surface an epicutis ranging from repent hyphae to palisadic, hymeniderm or a trichoderm occasionally with detersile elements (sphaerocysts). Clamp connections present or absent. Spores dextrinoid, pseudoamyloid, inamyloid or rarely amyloid, congophilous, cyanophilous, rarely shows metachromatic reaction with cresyl blue, always smooth, sometimes with apical germ pore, small to large, varying in shape, usually longish, subfusiform, elliptical, ovate to spurred. Gill edges sterile, rarely heteromorphous. Cheilocystidia present, mostly in fascicles or scattered. Pleurocystidia absent or occasionally present. Hymenophoral trama regular.

Habit and habitat: Habit pluteoid to lepiotoid, terrestrial to saprobic, often in nutrient rich areas, in woods and in grasslands.

Development of the carpophore: Hemiangiocarpic or bivelangiocarpic.

Distribution: Almost cosmopolitan, absent from arctic and high alpine regions but majority of the species are tropical and subtropical.
**Limits:** The genus *Lepiota* belongs to the family Agaricaceae Chevall. of tribus Lepioteae Fayod. The genus *Lepiota* differs from *Cystolepiota* Sing. in the structure of universal veil. In *Cystolepiota* Sing. the univerasal veil consists of loosely arranged globose to inflated elements and from the members of tribus Agaricaceae Chevall. by presence of light coloured spore prints. From the genus *Macrolepiota* Sing. it differs because of fundamental differences between the two genera in hymenophoral trama, spore wall composition and structure of universal veil. The genus *Lepiota* differs from the other members of tribus Lepioteae in having epicutis which is never epithelium and posseses a smooth homogenous spore wall. Mostly species of *Lepiota* are characterized by pileus with presence of characteristic squamules which makes it fibrillose, presence of free gills, simple annulus, light coloured spore deposition and sterile gill edges. Initially Persoon (1801) treated the genus *Lepiota* under genus *Agaricus*. Fries (1821) in *Systema Mycologicum* treated it as a tribe of the genus *Agaricus*. Gray (1821) elevated *Lepiota* Pers. from tribe to generic level.

**Statistics:** The world over as many as 400 species of *Lepiota* are recorded so far (Kirk et al., 2008). Out of these, 92 species are known from India (Bilgrami et al., 1991; Jamalludin et al., 2001; Kaur, 2000; Kour, 2005; Kumar and Manimohan, 2009 a). In the present study 47 collections spread over 13 species collected from different localities of North West India have been worked out for their external and internal details. Out of the presently worked out taxa one new speices viz. *L. attenuispora* sp. nov. and eight species namely, *L. boudieri* Bres., *L. humei* Murrill, *L. castaneidisca* Murrill, *L. truncatispora* Murrill, *L. atrodisca* Zeller, *L. roseifolia* Murrill, *L. floralis* (Berk. et Rav.) Sacc. and *L. plumbicolor* (Berk. & Br.) Sacc. are new fungus records for India. Earlier reports of *L. clypeolaria* (Fr.) P. Kumm. was by Sathe and Rahalkar (1976) from Poona and *L. erythrogramma* (Berk. & Br.) Sacc. by Roy and Samajpati.
(1980) from West Bengal, *L. metulaespora* (Berk. & Br.) Sacc. and *L. cristata* (Bolt.: Fr.) Kumm. which have been re-recorded by Atri et al., (1996) from Punjab plains. Key to the investigated species is given below. In the text individual species is taxonomically described in the sequence of segregation in the key given below:

**Key to the species of *Lepiota* investigated**

1. Spores stenosporic
   
2. Spores ellipsoid
   
1.' Spores ellipsoid

2. Pileus cuticle a trichoderm made up of cylindric to clavate, erect to semierect elements; flesh unchanging

2.' Pileus cuticle a hymeniderm, made up of short clavate to pyriform elements; flesh changing

3. Basidiocarps up to 4.5 cm in height; cap diameter up to 2.5 cm; pileus cuticle a disrupted trichoderm made up of articulated disarticulated golden brown walled elements; spores (5.5) 6 – 8.5 (9) x 4.5 – 6.4 μm 
   
3.' Basidiocarps up to 7 cm in height; cap diameter up to 5.7 cm; pileus cuticle a trichoderm of non-articulated, erect, cylindrical elements; spores (6.5) 7.2 – 9.6 x 3.2 – 4 μm
   
4. Cap diameter up to 5 cm; flesh off white changing to yellowish brown, cheilocystidia non-sphaeropedunculate

4.' Cap diameter up to 2 cm; flesh white changing to light pinkish; cheilocystidia sphaeropedunculate

5. Basidiocarps large sized, more than 11 cm in height

5.' Basidiocarps small sized, less than 11 cm in height

6. Cap diameter up to 1.8 cm; cheilocystidia 1 - 2 times septate near the base; flesh taste and odour mild

6.' Cap diameter 6 – 7.5 cm; cheilocystidia nonseptate; flesh taste and odour sour

7. Basidiocarps much elongated, up to 20 μm long; trichoderm made up of narrow elongated elements

7.' Basidiospores ellipsoid, up to 15 μm long; trichoderm made up of clavate to ventricose elements
8. Carpophores colour yellowish white with orange white to brownish grey scales; appendiculate veil along the margin; spores attenuated. 

8.' Carpophores colour white with red, purplish or blakish scales; non appendiculate margin; spores not attenuated.

9. Carpophores flesh, stipe, gills unchanging on bruising or cutting. 

9.' Carpophores flesh, stipe, gills changing to reddish or yellowish brown on bruising.

10. Mature carpophores smaller, up to 4.8 cm in height; annulus white and with reddish orange line on the margin/rim.

10.' Mature carpophores larger, up to 15 cm in height; annulus white to yellowish white and without a distinct coloured rim/margin.

11. Pileus umbo brown; gill edges serrate; stipe scaly below the annulus; cheilocystidia up to 27 µm long, pyriform.

11.' Pileus umbo pale yellow to brownish grey, gill edges smooth; stipe scaly throughout; cheilocystidia up to 58 µm long, lageniform to claviform, with subcapitate apices.

12. Pileus margin striate; all parts of the carpophores quickly bruising red; basidiocarps 5.8 – 10.8 x 4.9 – 7.5 µm; cheilocystidia up to 58 µm long.

12.' Pileus margin nonstriate; stipe bruising yellowish with time; basidiospores smaller 5.6 x 3.2 4.8 µm; cheilocystidia up to 37 µm long.

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**Figs. 15 (A - E)**

Carpophores 4.2 - 4.5 cm in height. Pileus 2 - 2.5 cm in diameter, convex, with brown (6D8) to reddish brown scales over yellowish white (4A2) background, scales arranged concentrically around the umbo; margin irregular, splitting at maturity; cuticle fully peeling; flesh off white, unchanging, up to 0.2 cm thick; taste and odour mild. Lamellae free to slightly adnexed, close, unequal, up to 7 mm broad, yellowish white (4A2) when young, orange grey (5B2) at maturity; gill edges fimbriate, often dusted brown (6D8) in appearance; spore deposit white. Stipe central, 4.1 cm long 0.3 cm broad, greyish (5B3), covered with brown (6D8) scales which are more dense.
towards base, hollow, brownish on handling; white mycelial cords attached to the base of the stipe; annulus single, patchy, soon evanescent.

Spores (5.5) 6 - 8.5 (9) - 9 x 4.5 - 6.3 (6.4) µm (Q = 2.4), stenosporic, triangular, often with basal apiculation, large guttule present inside, weakly dextrinoid, pseudoamyloid, congophilous, cyanophilous. Basidia 12 - 20 x 4.5 - 7 µm, clavate, tetrasporic; sterigmata up to 2 µm long; gill edges sterile. Cheilocystidia, very crowded, pyriform, few of them with septation, 20 - 42 x 5 - 11 µm. Pleurocystidia absent.

Pileus cuticle a disrupted trichoderm formed of long cylindrical, clavate, erect to semierect, articulated to dis-articulated clamped hyphae with thick golden brown walls measuring 30 - 180 (195) x 5 - 27 µm; context homoiomerous with few laticiferous elements; subhymenium pseudoparenchymatous, well developed; hymenophoral trama regular, up to 11µm in width. Stipe surface hyphae septate, parallel, running throughout with some projecting elements similar to those of pileal cuticle. Clamp connections present.

**Collection examined:** Himachal Pradesh, Cheog (2200 m), scattered on soil in association with *Cedrus deodara* in pure *Cedrus deodara* forest, R. C. Upadhyay, PUN 4414, September 4, 2011.

**Remarks:** The above examined collection is in conformity with the description of *Lepiota truncatispora* as given by Akers & Sundberg (2001). It is easily recognized in the field by its reddish brown carpophores, presence of fibrillose scales on the stipe surface, and white mycelial cords. In many of its characters, it is close to *L. ignicolor* and *L. castanea*. This species is described for the first time from India.

_Figs. 16 (A-D) & 17 (A-E)_

**Synonyms**


Carpophores 5 - 7.1 cm in height. Pileus 2.5 - 5.7 cm in diameter, convex to broadly umbonate with inflexed margin, planate at maturity, dark brown (6F5), surface covered by brown (6E4) appressed scales over yellowish white (4A2) background, scales more dense towards the centre; cuticle fully peeling; flesh up to 0.3 cm thick, yellowish white, unchanging; taste and odour mild. Lamellae free, close to crowded, yellowish white, unchanging, forking near the margin, some lamellae branched. Stipe central, 4.7 - 6.3 cm long, 0.3 - 0.7 cm broad, orange white (5A2), reddish brown on bruising, obclavate, hollow, pruinose, scaly, covered with brown (6E4) scales below the annulus; annulus single, patchy, cottony, soon shredded.

Spores (6.5) 7.2 - 9.6 x 3.2 - 4.0 μm (Q = 2.3), cylindrical to subcylindrical with rounded to tapering apex and protracted stenosporic spur like projection at the base of the spore, dextrinoid, not metachromatic in cresyl blue. Basidia 16.9 - 24.2 x 6.5 - 8 μm, clavate, tetrasporic with basal clamp connections; sterigmata 3.2 - 4.8 μm long; gill edges sterile. Cheilocystidia 24.2 - 40.3 x 8 - 16 μm, septate, versiform, narrowly clavate to clavate, some utriform, or even pyriform, to slightly ventricose in shape. Pleurocystidia absent.

Pileus cuticle formed of a trichoderm, consisting of erect cylindrical pigmented elements measuring 8 - 10 μm in width with narrowly clavate to tubular ends, clamp connections present at the septa, sphaerocysts absent. Context homoiomerous; gill trama regular; subhymenium pseudoparenchymatous. Stipe
cuticle hyphae running parallel, 4 - 24 μm broad. Clamp connections present in the basal mycelium, stipe surface hyphae, pileus tramal hyphae and at the base of basidia.

**Collection examined**: Himachal Pradesh, Shimla, Chadwick fall (1800 m), growing scattered under *Cedrus deodara* trees, Babita Kumari, PUN 3941, August 13, 2009.

**Figs. 16 (A-D) Lepiota boudieri**: A. Basidiospores, B. Basidia with hymenephore, C. Cheilocystidia, D. Stipe surface hyphae with clamp connections.

**Remarks**: The above examined collection falls in the overall taxonomic limits of *Lepiota boudieri* as described by Vellinga *et al.*, (2001 b). It is characterized by the presence of stenosporic spores having a protracted spur like projection at the base of spore and a trichodermal palisade covering the pileus surface. *Lepiota boudieri* constitutes a new fungus record for India.
**Figs. 18 (A-E) & 19 (A-C)**

**Synonyms**

*Agaricus cristatus* Scop., 1774; *Agaricus cristatus* Bolt.: Fr., *Syst. Mycol.* 1: 22, 1821  

Carpophores 2.5 - 8 cm in broad. Pileus 1.2 – 4.5 cm broad, surface convex with brownish orange (6C4) to dark brown (6E5) disc, brownish orange, brown to dark brown (6C4, 7E6, 6F8, 6E8, 7F6), appressed fibrillose scales concentrically arranged over yellowish white (4A2) background; margin striate, irregular, splitting at maturity; cuticle fully peeling; flesh up to 5 mm thick, white, changing, slightly pinkish to brownish on bruising; taste mild, odour spicy or sour. Lamellae free, unequal, of 2 - 3 lengths, subdistant, 2 - 4 mm broad, narrow, yellowish white to pinkish white, slightly ventricose; gill edges smooth to serrated, fragile, colour changes pink to brownish after some time on bruising; spore deposit creamish to yellowish white (4A2). Stipe central, up to 6.8 cm long, 0.2 - 0.6 cm broad, cylindrical, yellowish white (4A2) to orange white (5A2), colour changes to brownish on bruising, hollow, scaly; annulate, annulus single, patchy evanescent.

Spores (4) 5.6 – 8 x 2.4 - 3.2 (4) µm (Q = 2.4), stenosphor, truncate, triangular, apical pore absent, pseudoamyloid or weakly dextrinoid, not metachromatic in cresyl blue. Basidia 12.8 – (24) 26.5 x 3.5 - 8.0 (9.6) µm, clavate, tetrasporic; sterigmata up to 4 µm long; gill edges sterile. Cheilocystidia 20.9 - 32.2 (40.2) x (6.4) 8 - 14.5 (16) µm, crowded, clavate, pyriform to lageniform. Pleurocystidia absent.
Taxonomic observations

Figs. 19 (A-C) *Lepiota cristata*: A. Basidiospores B. Pileus hymeniderm layer, C. Cheilocystidia.

Pileus cuticle formed of compact hymeniform layer, made up of erect clavate closely packed elements measuring 14.5 - 42 x 7.2 – 14.5 µm in size with basal clamp connection; context homoiomerous; gill trama regular; subhymenium pseudoparenchymatous. Stipe cuticle hyphae parallel, measuring 3.2 - 14.5 µm in width. Clamp connections present throughout.

Collections examined: Himachal Pradesh, Dharmsala, McLeodganj, (2000 m), growing scattered in *Cedrus* forest, Babita Kumari, PUN 4641, July 29, 2009; Andretta (1100 m), growing solitary, Babita Kumari, PUN 4649, July 29, 2009; Glen (2000 m), growing solitary in *Quercus* forest, Babita Kumari, PUN 4642, August 13, 2009; Dalhousie, Jatingari (2085 m), growing in groups among *Pinus* Forest on humicolous soil, Samidha Sharma, PUN 4652, September 15, 2009; Barot, (2500 m), growing caespitose on soil, Babita Kumari, PUN 4645, August 9, 2010; Barot, (2500 m), growing scattered on soil, Babita Kumari, PUN 4651, August 9, 2010.
Taxonomic observations

Uttrakhand, Dhanolti Road (2000 m), growing scattered on humicolous soil in mixed forest, Munruchi Kaur and Babita Kumari, PUN 4647, July 20, 2010; Mussoorie (2000 m), growing scattered on humicolous soil in mixed forest, Munruchi Kaur and Babita Kumari, PUN 4646, July 19, 2010; Dhanaulti road (2000 m), growing scattered on humicolous soil, Babita Kumari, PUN 4643 & 4642, July 20, 2010; Chakarata Road, Korba (2200 m), growing scattered on humicolous soil in mixed forest, Munruchi Kaur and Babita Kumari, PUN 4650, July 21, 2010; Jamnipur (420 m), growing scattered on humicolous soil, Babita Kumari, PUN 4648, July 22, 2010.

Remarks:— The above examined collections are typical of *Lepiota cristata* (Vellinga, 2001 a). These are characterized in possessing concentrically scaled, reddish brown to dark brown caps which soon breaks into small scales, cylindrical stipe staining brownish on bruising, free subdistant yellowish white gills which become pinkish to brown when bruised; fragile patchy annulus, presence of stenosporic spores and clavate to pyriform cheilocystidia. It is quite close to *L. castaneidia* in its overall morphology, however, it can be distinguished from it in lacking clumps of soil particles at the base of stipe, flocculose gill edges and wedge shaped bicornate spores. The species is already been reported by Hennings (1901) from Uttar Pradesh, Sharma *et al.*, (1978) from Himachal Pradesh and Atri *et al.*, (1996) from Punjab.


Figs. 20, 21 (A-E)

Carpophores 2.9 - 5.5 cm high. Pileus 1.2 - 5.7 cm broad, rounded convex to paraboloid with small brown to ochraceous umbo, brownish orange (5C4), appressed fibrillose scales concentrically arranged over yellowish white (4A2) background; margin striate, irregular, splitting at maturity; cuticle fully peeling; flesh 1 mm thick, white, changing to slightly pinkish on bruising; taste mild and odour spicy. Lamellae free, unequal, of 2 - 3 lengths, subdistant, 2 - 3 mm broad, narrow, slightly ventricose; gill edges smooth to serrated, flocculose, fragile, yellowish white colour changing pink to brownish after some time on bruising; spore deposit creamish. Stipe central,
2.7 - 5.3 cm long, 0.2 - 0.3 cm broad, yellowish white (4A2) to orange white (5A2), colour changes to brownish on bruising, equal in diameter, hollow, scaly, clumps of soil particles attached at the stipe base; annulus present, single, patchy, evanescent.

Spores 4.8 - 7.2 (8) x 2.4 (2.8) - 3.2 (4) µm (Q = 1.9) cylindrical to subcylindrical with rounded apex or tapering towards the apex, stenosporic, pseudoamyloid or weakly dextrinoid, not metachromatic in cresyl blue. Basidia 14.5 - 27.4 x 5.55 - 9.6 µm, clavate, granular, tetrasporic with basal clamp connection; sterigmata 3.2 - 4.8 µm long; gill edges sterile. Cheilocystidia 16.6 - 33.8 x 7.2 - 10.5 µm, crowded, septate, clavate, pyriform to lageniform. Pleurocystidia absent.

Pileus cuticle formed of tightly arranged hymeniform, septate clavate to pyriform elements measuring 28 - 53.8 x 8 - 12 µm in size with basal clamp connections; context homoiomerous; gill trama regular; subhymenium pseudoparenchymatous. Stipe surface hyphae parallel running throughout, measuring 3.2 - 14.5 µm in width. Clamp connections present throughout.


Study of Putative Mycorrhizal Association Fig. 22 (A-F)

The investigations for understanding the putative mycorrhizal association of L. castaneidisa with roots of Grevillea robusta was done by examination of both external and internal details of colonized roots of the plant with which the mushroom mycelium was associated in the field.

Morphology of mycorrhizal roots:- Ramification was absent in the mycorrhizal roots and unramified ends were smooth, shiny and granular due to adhering soil particles. The apical tips of unramified ends were straight, brownish red to dark brown in colour. Rhizomorphs were frequent and white in colour. The overall surface
of the colonized roots appeared wooly with entrapped soil particles. Sclerotia were not observed at all.

**Anatomical details of mycorrhizal roots:**- The mycelial mantle was thin, smooth and not completely differentiated when examined in root sections. The intercellular hartig net was found penetrating both epidermis and cortical cells of root. Hartig net extended up to 2 - 3 layers deep into the cortex. Hyphae with clamp connections were observed colonizing the roots of the plant in the intercellular locations.

![Fig. 20: Carpophores in their natural habitat.](image)
**A. Normal root**

**B. Mycorrhizal root with swollen morphology**

**C. Wooly rhizomorphs**

**D. T. S of root with mantle**

**E. Hartig net**

**F. Clamp connection in hypha of mantle surface**

**Figs. 22 (A-F):** Microphotography of root of *Grevillea robusta* showing mycorrhizal association with *Lepiota castaneidisca.*
Remarks:- The above examined collection is typical of *Lepiota castaneidisca* (Vellinga, 2001 a). It is characterized by its concentrically scaled rounded to paraboloid brownish orange cap, cylindrical stipe staining brownish on bruising, free subdistant yellowish white gills which became pinkish to brown when bruised, evanescent patchy annulus, presence of triangular spurred spores and cheilocystidia, some of which are sphaeropedunculate. It is quite close to *L. cristata* in its overall morphology, however, it can be distinguished from *L. cristata* on the basis of small brown to ochraceous umbo, presence of clumps of soil particles at base of stipe, flocculose gill edges and congophilous dextrinoid wedge shaped steno spores. The species forms putative mycorrhizal association with roots of *Grevillea robusta*. *Lepiota castaneidisca* constitutes a new fungus record for India.


**Figs. 23 (A-B) & 24 (A-E)**

Fructifications up to 3.8 cm in height. Pileus 1.2 - 1.8 cm in diameter; surface campanulate then expanding, pale orange with brownish yellow (5C7) umbo, covered with brownish yellow fibrills on yellowish background, dry; margin not splitting at maturity; cuticle fully peeling, flesh about 1 mm thick, unchanging; taste and odour nil. Lamellae free, unequal, of 4 lengths, subdistant, up to 3 mm broad, light yellow (4A4), fragile; gill edges smooth; spore deposit white. Stipe central, up to 3.4 cm in length, 0.5 cm broad, light yellow (4A4), fleshy, cylindrical, hollow; surface scaly; annulus shredded, patchy, finally evanescent.

Spores 10 - 13.3 (15) x 4 - 5 µm (Q = 2.6), double walled, smooth, ellipsoid with curved basal apiculus, dextrinoid. Basidia 19.3 – 33.2 x 6.6 – 12.5 µm, clavate, hyaline, tetrasporic; sterigmata up to 5.8 µm long; gill edges sterile. Cheilocystidia 18.3 – 33.2 x 8.6 – 16.6 µm, clavate to pyriform, lageniform, inamyloid, some with septation. Pleurocystidia absent.
Pileus cuticle composed of radially arranged repent hyphae measuring 8 – 12 µm in width; context homoiomerous; hymenophoral trama subregular to intermixed; subhymenium pseudoparenchymatous. Stipe cuticle composed of parallel running hyaline 6.6 - 10 µm broad hyphae. Clamp connections present.

Collection examined: Himachal Pradesh, Solan, Chambaghat (1300 m), growing scattered on humicolous soil, Munruchi Kaur and Babita Kumari, PUN 3956, August 17, 2008.

Figs. 23 (A-B) Lepiota floralis: A. Basidiospores, B. Cheilocystidia.

Remarks: The above examined collection is in complete conformity with Lepiota floralis as described by Dennis (1952). It is a short statured, thin fleshed fungus with pale orange pileus and dextrinoid spores having long and curved basal apiculus. It is a new fungus record for India.
Taxonomic observations


Synonyms

Agaricus clypeolarius Bull., *Herb. France*; pl. 405, 1789
Agaricus clypeolarius Bull.: Fr., *Syst. Mycol.* 1: 21, 1821
Agaricus colubrinus Pers., *Syn. Meth. Fung.*: 258, 1801

Carpophores 6.0 - 15 cm in height. Pileus 2 - 7.5 cm in diameter, campanulate then expanding; broadly umbонate, surface yellowish white (4A2) with orange grey (5B2) umbo, covered with appressed fibrillose light brown to reddish brown (5C4) scales arranged concentrically; margin regular, feebly striate, splitting at maturity; cuticle fully peeling; flesh 0.1 - 0.3 cm thick, white, unchanging; taste mild, odour sour. Lamellae free, subdistant, unequal, of 4 lengths, up to 0.8 cm broad in the centre, whitish, unchanging; gill edges smooth to serrate; spore deposit yellowish white (4A2). Stipe central, 3 - 14.5 cm long, 0.5 - 1.4 cm broad, light yellow (4A4), surface whitish, powdery to scaly, yellowish; veil floccose, shreds distributed along the stipe length; annulus patchy to finally evanescent.

Spores 10.5 – 15 (16) x 4 - 5.8 (6.4) µm (Q = 2.8), ellipsoid to fusiform with curved apiculus, dextrinoid (Orange brown in Melzer’s reagent), germ pore none, hyaline in KOH, not metachromatic, double walled. Basidia 20 - 33 x 6 - 12 µm, clavate, granular throughout, four spored; sterigmata 1.6 - 5.8 µm long, pointed; gill edges sterile. Cheilocystidia 15 - 33.2 x 6.5 - 16.6 µm, crowded, versiform, clavate to balloon shaped, lageniform to subcylindric, sometimes with pedicel, apices rounded, walls smooth, hyaline in KOH. Pleurocystidia none.
Figs. 25 (A-D) *Lepiota clypeolaria*: A. Basidiospores, B. Cheilocystidia, C. Stipe cuticle showing clamp connection, D. Pileus cuticle surface.

Pileus cuticle composed of turf of hyphoid elements forming loose trichodermal palisade, of hyphae which are more or less straight and erect narrowly subcylindric and some times with a subapical constriction. Trichodermal elements measuring 6 - 14 µm in diameter arise from short pedicels and are often branched and mixed with short clavate to ventricose elements having rounded apices. Elongated cylindrical pilocystidial and subcuticular elements stain reddish brown in KOH and Melzer's reagent. Context homoiomerous; hymenophoral trama subregular to intermixed; tramal hyphae measuring 10 - 16 µm in width. Stipe cuticle composed of parallel running hyphae measuring 6.5 - 11.6 µm in width. Clamp connections present in basal mycelium, pileus tramal hyphae, stipe cuticle hyphae and occasionally at the bases of basidia, cheilocystidia and pileocystidia.
**Collections examined:** Himachal Pradesh, Narkanda, Hattu peak, (3300 m), growing solitary on humicolous soil, Munruchi Kaur and Yadwinder Singh, PUN 3903, July 13, 2007; Narkanda, Hattu Peak, (3300 m), growing in caespitose to gregarious clusters on humicolous soil, Munruchi Kaur and Yadwinder Singh, PUN 3902, July 14, 2007.

Uttarakhand, Dhanaulti (2200 m), growing scattered on soil in mixed forest, Babita Kumari, PUN 4636, July 20, 2010.

**Remarks:**- The above examined collections falls in the overall taxonomic limits of *L. clypeolaria* as described by Akers and Sundberg (2000). The fungus is characterized by its fusiform spores and floccose partial veil which spread in the form of sheds along the stipe length. It was earlier reported by Sathe and Rahalkar (1976) from Poona.


**Synonym**

*Agaricus metulaesporus* Berk. & Br. in *Journ. Linn. Soc., Bot.* II: 512 (1871)

Fructifications 4.8 - 8.6 cm in height. Pileus 3.4 - 6 cm in diameter, campanulate then expanding, broadly umbonate; surface yellowish white (2A2) with orangish brown umbo; cuticle on the disc breaking up into abundant scales; pileus white underneath; scales light yellow (4A4), recurved fibrillose; margin irregular, splitting at maturity, notched; flesh white, unchanging; pileal veil appendiculate; taste and odour mild. Lamellae free, unequal, close, ventricose, up to 8 mm in the centre, fragile; gill edges smooth; spore deposit yellowish white (4A2). Stipe central, 3.5 - 8 cm long, 3 - 5 mm broad, white, tending to become yellow to pale yellow or even brown upon handling, cylindrical, covered with cottony fibrillose elements below the annulus; annulus single, movable, shredded, patchy to finally evanescent.

Spores 13.3 - 19.9 x 4.2 - 4.9 µm (Q = 3.64), elongate ellipsoid with a suprahilar depression, hyaline, without an apical pore, dextrinoid. Basidia 19.9 - 36.5 x 7.5 – 10 µm, inamylloid; clavate, tetrasporic; sterigmata 2.3 - 4.6 µm long; gill edges
Taxonomic observations

Fig. 27: Carpophores of *Lepiota metulaespora* in natural habitat

Figs. 28 *Lepiota metulaespora* (A-B): A. Basidiospores, B. Basidia

heteromorphic. Cheilocystidia crowded, clavate to lageniform, 16.6 - 28.2 x 7.5 - 12.5 µm in size. Pleurocystidia absent.

Pileus cuticle a disrupted trichodermal palisade of elongated apical elements with pointed or broad ends measuring 4 - 8 µm in diameter; context homoiomerous, inamyloid, context hyphae 4.5 - 15.3 µm in diameter; hymenophoral trama parallel, inamyloid, hyphal elements regularly intericated to thin broad hyphae measuring 3.3 -
Figs. 29 (A-F) *Lepiota metulaespora*: A. Carpophore, B. Basidiospores, C. Basidia, D. Cheilocystidia, E. Pileus cuticle elements.
Taxonomic observations

6.6 µm in diameter. Stipe cuticle hyphae thick walled, septate, some of them inflated, up to 5.8 µm in width. Clamp connections present.

**Collections examined:** Himachal Pradesh, Solan (1350 m), growing in caespitose clusters on humicolous soil under the *Duranta* plant, Babita Kumari, PUN 3945, August 21, 2008; Shimla, Tara Devi (2000 m), growing solitary under bushes, Babita Kumari, PUN 4629, August 14, 2009; Shimla, Tara Devi (2000 m), growing solitary under *Quercus* tree, Babita Kumari, PUN 4630, August 14, 2009.

**Remarks:** The above examined collections belong to *L. metulaespora* (Pegler, 1986). They are characterized by long, elongated spores, trichodermial cuticular elements with clamps and heteromorphic type of gill edges. The species was recorded by Natarajan and Manjula (1983) from Madras and Atri *et al.* (1996) from North India (Punjab).

**viii. Lepiota attenuispora sp. nov.**

Fructifications 2.2 – 4.2 cm in height. Pileus 1.5 – 5 cm in diameter, convex, surface composed of appressed fibrillose brownish grey (6C2) to orange white (6B2) scales over yellowish white (4A2) background; margin irregular, shaggy, splitting at maturity; feebly striate at maturity; cuticle fully peeling; flesh 4 – 7 mm thick, white, unchanging; taste mild and odour sour; pileal veil appendiculate. Lamellae free, unequal, with lamellulae of 3 lengths; crowded, up to 0.6 cm broad, white to yellowish white (4A2); changes yellowish pink to brownish on bruising; gill edges lacerate to wavy; spore deposit yellowish white (2A2). Stipe central, 1.8 – 3.9 cm long, 3 - 5 mm broad, yellowish white (4A2), concolorous with the pileus, unchanging, cartilaginous, slightly tapering downwards, hollow, pruinose fibrillose sheathed with soft cottony scales below the annulus; annulate, annulus single, persistent, attached on the lower half of the stipe.

Spores 4 – 6.4 x 2.4 – 3.8 µm (Q = 1.67), subamygdaliform with a slight apical attenuation, apical pore absent, dextrinoid. Basidia 11.3 – 19.3 x 3.2 – 4.8 µm,
clavate, thin walled, inamyloid, 4 spored; sterigmata up to 1.6 µm long; gill edges sterile. Cheilocystidia clavate, septate, hyaline 17.7 – 27.4 x 4 – 6.4 µm in size. Pleurocystidia absent.

Pileus cuticle formed of radially arranged repent hyphae measuring 2.4 – 4.2 µm in diameter. Pileus context homoiomerous; gill trama parallel. Stipe cuticle hyphae parallel, 3.2 - 11.3 µm broad. Clamp connections present.

**Fig. 30:** Carpophores of *Lepiota attenuispora* in natural habitat.

**Collections examined:** Punjab, Patiala, Punjabi University Campus near Botany Department (250 m), growing scattered on soil, Babita Kumari, PUN 4626, September 3, 2009; growing scattered on soil, Babita Kumari, PUN 4627, August 26, 2010; growing scattered on soil, Babita Kumari, PUN 4628, August 26, 2010.

**Remarks:** It is an interesting mushrooms with shaggy appearance of the pileus margin and stipe sheathed with soft cottony scales below the veil, absence of distinct annulus and free whitish lamellae. In these features, it clearly resembles *L. clypeolaria*. However, basidiospores are smaller (4 - 6.4 x 2.4 - 3.8) µm instead of 11-
Figs. 31 (A-E) *Lepiota attenuispora* sp. nov.: A. Carpophore, B. Basidia, C. Basidiospores, D. Cheilocystidia, E. Pileus hymeniform elements.
18.5 x 4.5 – 6 µm as documented by Vellinga (2001 b) and with slight apical attenuation, which makes the presently examined collection interesting and unique. Based upon these unique features a new species L. attenuispora has been proposed.

ix. Lepiota plumbicolor (Berk. & Br.) Sacc., Syll. Fung. 5: 63 (1887)

Synonym


Fructifications 2.2 - 3.2 cm in height. Pileus 1.2 - 2 cm in diameter, convex, surface orange white (5A2) with greyish to purplish umbo over the yellowish white background; scaly, scales light brown, appressed fibrillose to warty squamulose; margin irregular, splitting at maturity; cuticle fully peeling; flesh yellowish white, unchanging, up to 2 mm thick; taste and odour mild. Lamellae free, collariate, unequal, with lamellulæ of 0.2 – 0.3 cm in length, subdistant, 4 - 6 mm broad, yellowish white (4A2), unchanging; gill edges serrate; spore deposit white (1A1). Stipe central, 2 - 3 cm long, 0.2 - 0.3 cm broad, yellowish white (4A2) to orange white (6A2), brownish on bruising, fleshy, equal in diameter throughout with a slightly bulbous base, hollow, pruinose fibrillose, fibrills soon disappear upon handling; annulus fibrillose, soon evanescent.

Spores 8 - 9.6 x 4.83 - 6.44 µm (Q = 1.6), broadly ellipsoid, double walled, outer wall thick without apical pore, dextrinoid, congophilous, non metachromatic in cresyl blue. Basidia 12.5 – 37 x 7.2 - 8.8 (9.6) µm, broadly clavate, granular, tetrasporic; sterigmata up to 3 µm long; gill edges sterile. Cheilocystidia crowded, 25.76 - 40.3 x 8 - 11.3 µm, thin walled, broadly clavate, pyriform, utriform with pedicellate cells and clamp connections, inamyloid. Pleurocystidia absent.

Pileus surface a hymeniform trichoderm formed of broadly clavate globose to elongated cylindrical septate elements measuring 24.2 - 92.6 x 8.8 - 16 µm in size,
Figs. 32 (A-F) *Lepiota plumbicolor*: A. Carpophores, B. Basidiospores, C. Basidia, D. Cheilocystidia, E. Pileus cuticle elements, F. Caulocystidia.
often with clamp connections; context homoiomerous; gill trama parallel, inamyloid.

Stipe hyphae thick walled, septate, consisting of caulocystidia 40 – 62 x 8 - 16 µm in size, clavate to pyriform septate elements, scattered. Clamp connections present.

**Collection examined:** Patiala, GTB Hall, Punjabi University campus (250 m), growing scattered on soil, Babita Kumari, PUN 4635, September 9, 2009.

**Remarks:** The above examined collection belong to Section Ovisporae J. Lange of genus *Lepiota* given by Pegler (1986). It has miniature stature with orange white to greyish orange pileus with purplish tinge on the disc having trichodermial hymeniform pileipellis formed of long clavate elements and presence of caulocystidia. It is a new fungus record for India.

**x. Lepiota erythrogramma** (Berk. & Br.) Sacc., *Syll. Fung.* **5**: 54 (1887)  
**Figs. 33 (A-E)**

**Synonyms**

*Agaricus erythrogramus* Berk. & Br. in *Journ. Linn. Soc., Bot.* **11**: 498 (1871)

Carpophore up to 4.8 cm in height. Pileus up to 1.3 cm in diameter, convex, carrot red coloured, scaly, scales concolourous, appressed fibrillose on a yellowish white (4A2) background; cracking and more dense towards the centre; margin irregular, splitting at maturity; cuticle fully peeling; flesh up to 0.1 cm thick, white, unchanging; taste and odour mild. Lamellae free, crowded, 0.3 cm broad, unequal, of 2 - 3 lengths, yellowish white (4A2), unchanging; gill edges smooth, fragile. Stipe central, 4.6 cm long, 0.3 - 0.4 cm broad towards the base, 0.2 cm broad near the attachment of stipe to the pileus, yellowish white (4A2), colour changes to yellowish on bruising, obclavate, hollow; annulate, single, peronate, superior, reddish orange line present on the underside of the annulus.

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**Figs. 33 (A-F)** *Lepiota erythrogramma*: A. Carpophore, B. Basidiospores, C. Basidia, D. Cheilocystidia, E. Pileus cuticle elements.
Spores 5.63 - 8.8 x 3.2 - 4.8 µm (Q = 1.67) ellipsoid to sub-amygdaliform, hyaline, thick walled, pseudoamyloid to dextrinoid, congophilous, cyanophilous, apical pore absent, not metachromatic in cresyl blue. Basidia 17.7 - 24.2 x 6.4 - 8 µm, broadly clavate, tetrasporic; sterigmata 3.3 - 4.9 µm long; gill edges sterile to heteromorphous. Cheilocystidia 19.3 - 48.3 x 4.8 - 9.6 µm, crowded, hyaline, thin walled, clavate to cylindric, slightly lageniform, often granular inside, some with subcapitate to elongated tips. Pleurocystidia absent.

Pileus cuticle composed of radially arranged septate, 3.5 - 8 µm wide hyphae with apical cylindrical to obtuse apices; context homoiomerous; gill trama regular, tramal hyphae up to 6.2 µm in width; subhymenium pseudoparenchymatous. Stipe cuticle consisting of parallel running hyphae measuring 8 - 28 µm in width. Clamp connections present in the stipe surface hyphae.

**Collection examined:** Chandigarh, Golf ground, near Sukhna Lake (321 m), growing solitary on humicolous soil under Mulberry trees, Babita Kumari, PUN 4637, August 23, 2009.

**Remarks:** The morphological and anatomical details of the above examined collection are in conformity with *L. erythrogramma* as given by Pegler (1986). It is characterized by small sized carrot red carpophores covered with reddish coloured appressed fibrillose scales and annulate thin obclavate stipe. Roy and Samajpati (1980) recorded it from West Bengal.

**Lepiota roseifolia** Murrill *Mycologia* 4: 235.1912. *Figs. 34 & 35 (A-E)*

Fructifications 6 - 9 cm in height. Pileus 2.5 - 4 cm broad, convex with brown (6E4) umbo, surface covered by concentrically arranged brownish appressed fibrillose scales over whitish background; margin irregular, splitting at maturity; cuticle fully peeling; flesh up to 2 mm thick, white (4A2), immediately changing to pinkish red to orangish on bruising; taste and odour mild. Lamellae free, subdistant to crowded,
unequal, with lamellulae of 2 - 3 lengths, up to 5 mm broad, yellowish white (4A2), reddish on bruising; gill edges serrate; spore deposit cream. Stipe central, 5.3 - 8.3 cm long, 3 - 4 mm broad, orange white (5A2), scaly, scales brownish, more towards the base, reddish on bruising; hollow, obclavate; annulate, annulus single, attached.

Spores 5.63 - 8 x 3.2 - 4.8 µm (Q = 1.7), thin walled, smooth pseudoamyloid to dextrinoid, ellipsoid to amygdaliform, not metachromatic in cresyl blue, apical pore inconspicous. Basidia 15.2 - 24.2 x 6.4 - 8 µm, inamyloid, thin walled, clavate, tetrasporic; sterigmata 3.2 - 4.8 µm long; gill edges sterile. Cheilocystidia 19.3 - 27.3 x 8 - 14.5 µm, inamyloid, clavate to pyriform. Pleurocystidia absent.

Pileus cuticle composed of trichoderm consisting of septate elongated hyphae with rounded or tubular tips; context homoiomerous; subhymenium pseudoparenchymatous, well developed, composed of loosely arranged elements. Stipe cuticle hyphae parallel running, 4 – 20 µm broad. Clamp connections absent.

Collection examined: Himachal Pradesh, Palampur, IHBT road (1200 m), growing scattered under Pinus tree, Babita Kumari, PUN 4634, July 27, 2009.
Remarks: The above examined collection is typical of *L. roseifolia* which closely resembles with the details given by Murrill (1912). It can be easily recognized in the field by its carpophore parts changing to pinkish red to orangish on bruising. Overall the pileus is covered by brownish appressed fibrillose scales over yellowish white background, trichodermal palisade consisting of septate upright hyphae with rounded to tubular tips. It is often confused with *L. flammeatincta* in outward morphology from which it mainly differs in bruising in all parts of the carpophore instead of stipe and cap surface only. It is a new fungus record for India.


Carpophores 3.7 – 15 cm in height. Pileus 1.1 - 10 cm in diameter, convex; surface whitish (4A2) with pale yellow (4A3) to brown umbo, covered with light brown coloured recurved fibrillose scales; margin striate, irregular, often splitting; cuticle fully peeling; flesh 0.2 - 0.5 cm thick, white, immediately changing to pinkish red on exposure; taste and odour mild. Lamellae free, subdistant to crowded, up to 0.3 - 1.3 cm broad, unequal, of 3 - 4 lengths, yellowish white (4A2), changing to reddish on bruising; gill edges smooth; spore deposit yellowish white (4A2). Stipe central, 3.4 - 14.2 cm long and 0.3 - 1.8 cm broad, yellowish white (4A2), reddish on bruising, cylindrical with a bulbous base, hollow; annulus peronate, single, ring like, superior.

Spores 5.8 - 10.8 x 4.9 - 7.5 µm (Q = 1.3), ellipsoid to amygdaliform, hyaline, thick walled, strongly dextrinoid, congophilous, cyanophilous, apical pore absent with large oil guttules in the spore matrix, metachromatic in cresyl blue. Basidia 15 - 36.5 x 6.6 -11.6 µm, broadly clavate, tetrasporic; sterigmata 3.3 - 4.9 µm long; gill edges sterile. Cheilocystidia 12.3 – 58 x 4.9 - 11.6 µm, crowded, hyaline, thin walled, arranged in clusters with shapes varying from cylindrical to clavate and even lageniform with subcapitate tips in some specimens. Pleurocystidia absent.
Figs. 37 (A-F) *Lepiota humblei*: A. Carpophores in natural habitat, B. Mycelium growth in petriplate, C. Basidiospores in congo red, D. Basidiospores showing metachromatic reaction with cresyl blue; E. Basidia, F. Clamp connection.
Pileus cuticle a disrupted trichoderm of cylindrical to elongated claviform elements measuring 3.3 - 12 µm in diameter; context homoiomerous; gill trama regular, tramal hyphae 3.3 - 6.6 µm in width; subhymenial pseudoparenchymatous.

Stipe cuticle consisting of parallel running hyphae 8.9 – 15.6 µm in width, some of the surface hyphae measuring up to 4.5 µm in width projecting. Veil tissue hyphal, hyphae 4.9 - 11.62 µm broad, septate. Clamp connections present in the basal mycelium, stipe cuticle hyphae and context hyphae.

Collections examined: Himachal Pradesh, Solan, Kather, (1200 m), growing scattered among grasses in Pinus Forest, Babita Kumari, PUN 4098, August 17, 2008; Chailchock (Mandi) (2000 m), growing scattered on dung, Babita Kumari, PUN 4107 & 4099, July 15, 2009; Mandi, Bakarata (850 m), growing scattered on soil, Babita Kumari, PUN 4420, June 25, 2010.

Punjab, Patiala, Thaper university campus (250 m), growing gregarious on soil, Munruchi Kaur and Babita Kumari, PUN 4114, June 28, 2008; growing gregarious to scattered on humicolous soil, Munruchi Kaur and Babita Kumari, PUN 4631, June 28, 2008; Patiala, Punjabi University campus (250 m), growing gregarious on dung, Babita Kumari, PUN 4115, August 12, 2008; growing scattered or gregarious on dung, Babita Kumari, PUN 4113, July 16, 2008; Patiala, Shekhpura growing scattered on soil, Babita Kumari, PUN 4100, July 19, 2008; growing gregariously on dung, Babita Kumari, PUN 4112, May 23, 2008; Hoshiarpur, Simbli (300 m), growing gregarious to scattered on humicolous soil, Babita Kumari, PUN 4110, July19, 2008; Khadiala (300 m), growing scattered on humicolous soil, Babita Kumari, PUN 4116, July 16, 2008; Hoshiarpur, Dasudka (300 m), scattered on soil, Babita Kumari, PUN 4109, July 19, 2008; Patiala Punjabi University campus (250 m), growing scattered on dung, Babita Kumari, PUN 4102, August 12, 2008; growing gregariously on dung, Babita Kumari, PUN 4110, May 27, 2008; Patiala, Rajpura (250 m), growing on dung, Babita Kumari, PUN 4103, August 19, 2009; Rajpura Road, Bahadurgarh (250 m), growing scattered on dung, Babita Kumari, PUN 4097, August 18, 2009; growing scattered on soil, Babita Kumari, PUN 4632, August 21, 2010.

Uttarakhand, Dehra Dun Road, Jamnipur (420 m), growing scattered on soil, Babita Kumari, PUN 4633, July 22, 2010.

Remarks:– It is an interesting mushroom which comes up early during the start of the monsoon season and remains up to September and often found on dung. The above examined collection belongs to *Lepiota humei*. It is characterized by medium sized carpophores often with a pale yellow to brown umbo, striate margin and characterstic pinkish red coloration on bruising. The diagnostic features including key characters
are in conformity with the details provided by Akers and Sundberg (1997) for this species except spores which are smaller measuring 5.8 - 10.8 x 4.8 - 7.5 µm instead of 8 - 13.5 x 6 - 8.5 µm documented in the literature (Akers and Sundberg, 1997). The presence of both 2 spored and 4 spored basidia is yet another noteworthy feature of this mushroom. It is a new fungus record for India. This species is often confused with *Macrolepiota* species with similar characters from which it differs from in having smaller carpophores and absence of germpore in the basidiospores.

**Culture characteristics:** The culture of this mushroom was raised on PDA medium. In the culture obtained the mycelium appeared white, cottony, thin, fluffy with irregular growth. Over all the mat obtained was dense and raised at some places with biscuity odour. It has been deposited in the GenBank of Directorate of Mushroom Research Chambaghat, Solan against GenBank accession no. DMRX1128.

**Lepiota atrodisca** Zeller *Mycologia* 30: 473. 1938.  

Figs. 38 (A-E)

Carpophores 7.8 - 8.9 cm in height. Pileus 2.5 - 3.1 cm in diameter, convex, umbonate, brownish grey (7D2) to dark blakish on the disc, surface covered by patches of light brownish grey scales over yellowish white (4A2) background, moist; margin regular, splitting at maturity, inrolled; cuticle fully peeling; flesh up to 0.1 cm thick, off white, unchanging; taste and odour mild. Lamellae free, crowded, unequal, of 3 - 4 lengths, yellowish white (4A2), unchanging, 0.2 cm broad; gill edges smooth, fragile. Stipe central, 7.8 - 8.6 cm long, 0.2 - 0.3 cm broad, yellowish white (4A2), concolourous with the pileus, turns yellowish brown on handling, obclavate, hollow, scaly; annulate, annulus single, membranous, often with a greyish black margin, attached, superior.

Spores 5.6 - 8 x 3.2 - 4.8 µm (Q = 1.6), ellipsoid with single guttule, dextrinoid, strongly congophilous, not metachromatic in cresyl blue, apical pore absent. Basidia 12.8 - 24.9 x 6.4 - 8 µm, clavate, tetrasporic; sterigmata 3.2 - 4.8 µm
long; gill edges sterile. Cheilocystidia 22.5 - 37 x 4.8 - 11.3 µm, clavate, lageniform, subcapitate, crowded, often in clusters. Pleurocystidia absent.

Pileus cuticle composed of a disrupted trichoderm made up of branched, apical clavate to cylindrical elements with obtuse ends measuring 4.8 - 11.3 um in size; context homoiomerous; gill trama regular; subhymenium pseudoparenchymatous. Stipe surface hyphae running parallel throughout measuring 4.8 - 11.2 um in width, clamp connections absent throughout.

**Collection examined:** Himachal Pradesh, Mandi, Sarkaghat, Bakarta (850 m), growing scattered on leaf litter of Syzigium cumini, Babita Kumari, PUN 4418, July 14, 2009.

**Remarks:** The above examined collection is typical of *L. atrodisca* as described by Zeller (1938). It is characterized by medium sized carpophores having a cap with fine, greyish-black scales, annulate stipe often with a greyish brown annular margin. It is a new fungus record for India.

**6.1.3 Cystolepiota Sing. – A Diagnosis**


**Type species:** *Cystolepiota constricta*

**Synonyms**


**Characters:** Carpophores very tiny to medium sized. Pileus convex; pileus surface floccose, granular to pulverulent with conical, verrucose to spinose squamules, powdery. Spore print whitish. Lamellae free, to adnexo-adnate thin, mostly pale coloured. Stipe central, well developed, cylindrical to obclavate; surface smooth to fibrillose, typically with annulus either membranous or cortinoid, or remnants in the form of velum particle. Pileus surface a disrupted epithelium forming globose, detersile sphaerocysts, never hymeniform. Clamp connections present or absent.
Spores dextrinoid, inamyloid or rarely amyloid, congophilous, cyanophilous, rarely shows metachromatic reaction with cresyl blue, always smooth, usually small, lacking germ pore. Gill edges heteromorphous. Cheilocystidia mostly inflated. Pleurocystidia absent. Hymenophoral trama regular.

**Habit and habitat:** Habit pluteoid to lepiotoid, terrestrial to saprobic, often in nutrient rich areas, in woods and in grasslands.

**Development of the carpophore:** Hemiangiocarpic or bivelangiocarpic.

**Distribution:** Almost cosmopolitan, absent from arctic and high alpine regions but majority of the species are tropical and subtropical.

**Limits:** The genus *Cystolepiota* belongs to the family Agaricaceae Chevall. of tribus Lepioteae Fayod. In *Cystolepiota* the univerasal veil consists of loosely arranged globose to inflated elements.

**Statistics:** The world over as many as 8 species of *Cystolepiota* are recorded so far (Kirk *et al.*, 2008). Out of these, only one species *Cystolepiota hemisclera* (Berk. & M.A. Curtis) Peg. is known from India (Narayanan and Natarajan, 2004). In the present study 3 collections collected from different localities of North West India have been worked out for their external and internal details. Out of the presently worked out taxa one new species, namely *C. indica* sp. nov. and one new record for India, namely *C. icterina* have been documented. Key to their identification is given below:-

**Key to the species of Cystolepiota**

1. Pileus yellowish white with brown umbo and surface covered by dark brown spiny scales; gill edges lacerate................................. *C. indica* sp. nov.

1’. Pileus off white to greyish brown with yellowish tinge covered by powdery scales, gill edges smooth.............................. *C. icterina*
Taxonomic observations

**i. Cystolepiota indica sp. nov.**

Carpophores 1.6 - 7 cm in height. Pileus 0.2 - 3.5 cm in diameter, subumobnate, yellowish white (4A2) with brown umbo (6E4), surface covered by dark brown (6F5) spiny scales which are more prominent in young specimens; margin incurved with pileal remnants, nonstriate, irregular, splitting at maturity; cuticle fully peeling; flesh whitish to creamish, unchanging, up to 0.2 cm thick; taste mild, odour heavily aromatic. Lamellae free, close, unequal, of 3 lengths, 0.2 cm broad, yellowish white (4A2); gill edges lacerate. Stipe central, 1.2 - 6.2 cm long, 0.2 - 0.5 cm broad, yellowish white (4A2), to orange white (5A2), covered by brown (6E4) to dark brown (6F5) scales, aggregated more prominently towards the base, brownish on bruising; annulus pruinose fibrillose, evanescent, attached to the upper half of the stipe.

Spores 4 - 5.6 x 2.4 - 3.2 µm (Q = 1.69), ellipsoid, pseudoamyloid, cyanophilous, congophilous, not metachromatic in cresyl blue. Basidia 12.8 - 19.3 x 3.2 - 6.4 µm, clavate, tetrasporic; with well developed sterigmata measuring 3.2 - 5.6 µm in length; gill edges sterile. Cheilocystidia 27.5 - 34 x 6.6 - 7.7 µm, septate, clavate to pyriform, scattered. Pleurocystidia absent.

Pileus surface a trichoderm consisting of cylindrical to claviform closely septate golden brown clamped elements with blunt to ampullaceous tips; context homoiomerous; hymenophoral trama regular, trimal hyphae measuring 4 - 20 µm in width; subhymenium pseudoprenchymatous. Stipe cuticle formed of septate parallel running hyphae measuring 10 - 16 µm in width with some projecting cylindrical to clavate elements measuring 10 - 12 µm in width. Clamp connections present throughout.
**Figs. 39 (A-D) Cystolepiota indica sp. nov.** A. Basidiospores, B. Pileus cutis elements, C. Stipe cutis elements, D. Cheilocystidia.

**Collections examined:** Uttrakhand, Chakrata Road, Korba (2200 m), growing scattered under Cedrus deodara among mosses, Munruchi Kaur and Babita Kumari, PUN 4329, July 21, 2010.

Himachal Pradesh, Barot (2500 m), growing scattered under Eucalyptus tree, Babita Kumari, PUN 4335, August 11, 2010.

**Remarks:** This species is easily recognized by its brownish carpophores covered by small spiny scales, minute spores and chains of golden brown walled pileal elements. In its outward morphology it appears quite close to Cystolepiota ompenera as given by Pegler (1986) which mainly differs from it in having lamellulae of three lengths, larger spore size and appearance and size of squamules on the pileus surface. Based upon these unique features of the presently examined mushroom, a new species *Cystolepiota indica* sp. nov. has been proposed.

Figs. 41 (A-E)

**Synonym**

*Lepiota icterina* F. Moller *Friensia* 7: 453(1965)

Carpophores 3.2 - 4.9 cm in height. Pileus 2.3 - 3.2 cm in diameter, convex, surface off white to light greyish brown with yellowish tinge and powdery granules over the entire pileus surface which are more dense towards the center; margin irregular, splitting at maturity, inrolled; cuticle fully peeling; flesh 0.2 cm thick, white, unchanging; taste and odour mild. Lamellae free, subdistant, unequal, of 2 lengths, yellowish white (4A2), unchanging, 0.3 cm broad. Stipe central, 2.9 - 4.2 cm long, 0.2 - 0.3 cm broad, yellowish white to brown towards the base, unchanging, equal in diameter; annulate, annulus single, patchy, soon shredded.

Spores 4 - 6.4 x 2.4 - 3.2 µm (Q = 1.63), pseudoamyloid, ellipsoid, congophilous, cyanophilous, single walled, smooth, non-metachromatic in cresyl blue. Basidia 16 – 25.8 x 4.8 – 8 µm, clavate, tetrasporic; sterigmata 2.4 - 3.2 µm long; gill edges heteromorphous. Cheilocystidia 19.3 - 61.2 x 6.4 - 11.3 µm, scattered, septate, versiform, lanceolate, narrowly clavate to clavate, some utriform, or even pyriform, to slightly ventricose in shape. Pleurocystidia absent.

Pileus cuticle a trichoderm consisting of loosely interwoon 6 - 12 um broad hyphae with apical globose or clavate to elongated cylindrical elements measuring 10 - 24.5 x 6 -18 um; context homoiomerous; gill trama of parallel running hyphae measuring 4 - 12 um in width with some projecting clavate to cylindrical elements measuring 8 - 12 um in width; subhymenium pseudoparenchymatous, clamp connections present in the stipe cuticle hyphae.

**Collection examined**: Punjab, Rajpura, Shambhu road (250 m), growing scattered on sandy soil under *Thespesia* trees, Munruchi Kaur and Babita Kumari, PUN 4334, September 17, 2010.
Remarks: The above collection is in conformity with the details of *Cystolepiota icterina* as given by Vellinga (2001 b). It is characterized by powdery whitish carpophores with tough stipe, presence of trichoderm consisting of globose to cylindrical elongated elements and presence of septate versiform cystidia. It is a new fungus record for India.

6.1.4 *Macrolepiota* Sing. – A Diagnosis


**Type species:** *M. procera* (Scop.: Fr.) Sing.

**Characters:** Basidicarps large, lepiotoid. Pileus fleshy, campanulate-convex, soon expanding; surface dry, smooth at the disc, squamulose with fine granulose squamules. Gills free, collariate, white to pale, broad, close. Spore deposit white cream to pale pink. Stipe central, elongated, often with a bulbous base, fleshy; annulus movable, complex, persistent. Spores large, broadly ellipsoid to amygdaliform, apically truncated by a germ pore, with or without hyaline cap over the germ pore, hyaline to stramineous, dextrinoid, congophilous, cyanophilous, wall smooth, thick, strongly metachromatic in cresyl blue. Lamellae edges sterile. Cheilocystidia always present. Pleurocystidia absent. Pileus cuticle a disrupted trichoderm or hymeniderm or palisade. Hymenophoral trama regular. Clamp connections present.

**Habit and habitat:** Habit of the carpophore is lepiotoid. Terrestrial, grow solitary to scattered or in fairy rings, mostly on nutrient rich soil, among grasses or under trees or hedges.

**Development:** Bivelangiocarpous.

**Distribution:** Almost cosmopolitan, but majority of the species are tropical to subtropical, absent from arctic and high alpine habitats.
**Limits:** The genus *Macrolepiota* Sing. belongs to the tribus Leucocoprineae Sing. of family Agaricaceae Chevall. This genus can be delimited from the other genera of the tribus Leucocoprineae on the basis of large sized, strongly metachromatic spores, pure white to creamish spore print and presence of double, movable annulus. Singer (1948) established the genus *Macrolepiota.*

**Statistics:** The world over 30 species of the genus *Macrolepiota* are known so far (Kirk *et al.*, 2008). Out of these only five species are known from India (Bilgrami *et al.*, 1991). Presently 28 collections belonging to seven species have been worked out for their macroscopic and microscopic details. These seven species are *M. rhacodes* (Vitt.) Sing., *M. procera* (Scop.: Fr.) Sing., *M. fuliginosa* (Barla) M. Bon., *M. dolichaula* (Berk. & Br.) Pegler & Rayner, *M. excoriata* (Schaeff.: Fr) Wasser, *M. heimii* Locq.: Bon. and *M. puellaris* (Fr.) M. M. Moser. Key to their identification is given below:

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**Key to the species of *Macrolepiota* investigated**

1. Spores ellipsoid with a rounded apex, broadly truncated by a germpore without hyaline cap, 7.2 - 11.62 x 5.6 - 8.3 µm in size……………………………………..………….*M. rhacodes*

1.’ Spores ellipsoid to amygdaliform with a small germpore covered by a hyaline cap, 7.5 – 18.2 x 7.2 – 12 µm in size……………………………………..…………..2

2. Stipe yellowish white covered by greyish brown scales which breakup and appear in the form of bands throughout the length of the stipe, bands more prominent towards the base, no change where bruised……………………………………..…………..*M. procera*

2.’ Stipe white to yellowish white, with or without patchy scales on the stipe which do not give banded appearance. Lamellae and stipe surface flesh turn pinkish to brownish where bruised……………………………………..…………..3

3. Carpophores 10 - 17 cm in height……………………………………..…………..4

3.’ Carpophores 17 – 33.5 cm in height……………………………………..…………..*M. dolichaula*
4. Carpophores up to 17 cm in height; pileus 5.5 cm in diameter with star shaped pale patch over umbo………………………...M. excoriat 

4.’ Carpophores 10 – 14.5 cm in height; pileus 4 – 9.2 cm in diameter without any star shaped patch over the umbo……………….5

5. Basidiospores large sized, 11.5 – 17.6 x 7 – 10 µm……………………………6

5.’ Basidiospores small, 7.5 – 11 x 5 – 6.5 µm……………………. M. puellaris

6. Pileus yellowish white with brown to brownish orange umbo covered by brownish recurved fibrillose scales; stipe yellowish white with brown scales; annulus movable, double, purplish pink underneath……………M. fuliginosa

6.’ Pileus greyish orange with concolorous fibrillose scales; stipe silky shining white with tiny thin scales, annulus persistent, simple, not purplish pink underneath ………………………………………..M. heimii

Figs. 42 (A-B) & 43 (A-E)

**Synonyms**

*Agaricus rhacodes* Vitt., *Descr. Funghi Mangerecci* 158, t. XX (1835)  
*Lepiota rhacodes* (Vitt.) Quel., Champ. Jura Vosges I 32 (1872)  
*Leucocoprinus rhacodes* (Vitt.) Locq. in *Bull. Soc. Linn. Lyon* II: 40, t IA (1942)  
*Lepiotophyllum rhacodes* (Vitt.) Locq. in *Bull. Soc. Linn. Lyon* II: 40, t. IA (1942)

Carpophores 4.5 – 25.0 cm in height. Pileus 1.6 – 9.5 cm in diameter, convex; surface yellowish white (4A2) with velar fragments in the centre, dry; surface entire at the disc, elsewhere breaking up in to brownish, greyish orange to greyish brown patchy squamules on a whitish to orange white background; scaly, scales light brown to brownish orange, more aggregated towards the centre, sparse towards the periphery; pileal margin non striate, sulcate, irregular, splitting at maturity; cuticle fully peeling; flesh 0.3 – 1 cm thick, white, unchanging; taste mild and odour mild to heavily aromatic. Lamellae free, collariate, unequal, of 4 lengths, close, ventricose, up to 1.2 cm broad, yellowish white (4A2), slightly pinkish red on bruising; gill edges serrate, brown layered; spore deposit light yellow (4A4) to yellowish white (4A2). Stipe central, 3.5 – 19 cm long, 0.4 – 1.2 cm broad, yellowish white (4A2), pinkish to
reddish brown on bruising, obclavate, hollow, scaly; annulate, annulus double, persistent.

Spores (7.2) 8.0 - (10.5) 11.62 x (4.8) 5.6 - (7.2) 8.3 µm (Q = 1.3 - 1.38), dextrinoid, congophilous, cyanophilous, thick walled, smooth apically truncated by a germ pore without a hyaline cap, apiculate, ellipsoid to amygdaliform, metachromatic with cresyl blue. Basidia (24.2) 26.3 - 46.58 (63.08) x 8.3 - 13.3 µm, broadly clavate, tetrasporic; sterigmata 3.2 - 4.9 µm long; lamellae edges sterile. Cheilocystidia (19.3) 21.3 - 43.5 x 9.6 (12.8) – 24.9 µm, crowded, globose to pyriform, inamyloid. Pleurocystidia absent.


Pileus surface composed of a trichodermal palisade of short cylindrical, clavate, shortly lageniform, lanceolate elements 40.3 - 96.6 x 3.2 – 17.8 µm; context homoiomerous; gill trama regular; subhymenium pseudoparenchymatous. Stipe cuticle hyphae comprising of septate hyphae measuring 6.7 - 15.6 µm in width. Clamp connections present throughout.
**Collections examined:** Punjab, Patiala, Bahadurgarh (250 m), growing scattered on humicolous soil. Babita Kumari, PUN 4415, May 28, 2008; Patiala, Nabha Sahib, (250 m), growing scattered on humicolous soil, Munruchi Kaur, PUN 4664, June, 24, 2008; Patiala, Punjabi University (250 m), growing scattered on humicolous soil, Babita Kumari, PUN 3942 & 3943 July 4, 2008; Hoshiarpur, Pandori (300 m), growing scattered on humicolous soil, Munruchi Kaur and Yadwinder Singh, PUN 4417, July 17, 2008; Mirzapur (300 m), growing scattered on humicolous soil, Munruchi Kaur and Yadwinder Singh, PUN 4416, July 17, 2008; Chandigarh (321 m), growing scattered on humicolous soil, Babita Kumari, PUN 4646, August 23, 2009; (321 m), growing scattered on soil, Babita Kumari, PUN September 3, 2009; Patiala, Baradandari garden, (250 m), growing solitary on humicolous soil, Babita Kumari, PUN 4665, August 2, 2010.

Himachal Pradesh, Barog (1650 m), growing caespitose in association with roots of *Pinus roxburghii*, Munruchi Kaur and Babita Kumari, PUN 4425, August 22, 2008.

Utrakhand, Dehra Dun, Jamnipur, Herbertpur, (425 m), growing caespitose to scattered on humicolius soil under *Eucalyptus* tree, Babita Kumari, PUN 4326, July 22, 2010.

**Remarks:**- It is one of the most common species found in gardens, lawns and can be easily recognized by large plate like brown squamules over the pileus surface, brown layered gill edges, reddening on exposure, presence of broadly truncated ellipsoid spores with rounded apex and clavate to cylindrical trichodermal elements. The diagnostic features of this mushroom are in agreement with the details given by Pegler (1977). It was earlier reported by Ghosh and Pathak (1965) from Lucknow (U.P.), Sohi *et al.* (1964) from Himachal Pradesh and Kour (2005) from Punjab. It is an established edible mushroom (Purkayastha and Chandra, 1985).

**Cultural characteristics:**- The mushroom culture was raised on Malt extract medium. To begin with the mycelial colony was thin and the individual hyphae were thread like filamentous. The overall pattern of growth was regular. Towards maturity the mycelium appeared light brown with mild odour. The raised pure culture has been deposited in the GenBank of Directorate of Mushroom Research at Chambaghat, Solan under accession no. DMRX 1130.
**ii. Macrolepiota procera** (Scop.: Fr.) Sing. in Papers Mich. Acad. Sci., Arts letters 32: 141.1948 (‘1946’).

Figs. 44 (A-F) & 45 (A-E)

**Synonyms**


*Agaricus procerus* Scop.: Fr., *Syst. Mycol.* I: 20 (1821)


*Leucocoprinus procerus* (Scop.: Fr.) Pat., *Essai Taxon. Hymen.*: 171(1900)


Carpophores 6.5 - 19 cm in height. Pileus 4.6 - 9.5 cm in diameter, surface convex, brown to greyish brown (5D3) with olive brown umbo (4E4) covered with greyish brown (5D3) to brownish orange (5C3) appressed fibrillose scales scales over yellowish white background; margin inflexed, irregular, splitting at maturity; cuticle fully peeling; flesh creamish white, unchanging, 0.4 – 1.0 cm thick; taste and odour mild. Lamellae free, collariate, close to crowded, unequal, of 3 - 4 lengths, 0.5 - 0.8 cm broad, yellowish white (4A2), ventricose; gill edges smooth. Stipe central, 6.2 - 16 cm long, 0.5 - 0.7 cm broad, 2 cm near the base, yellowish white (4A2), often covered with greyish brown (5D3) scales which breaks up into irregular patches, at some places stipe surface cracked resulting in to banded appearance, more dense towards the base, obclavate; annulate, annulus double, brown layered on the lower side, annulus fibrous, funnel shaped, initially attached, finally movable.

Spores 11.3 (12.8) - 16 (17.7) x (7.2) 8 - 9.6 (12) µm (Q = 1.5), broadly ellipsoid with rounded narrow germpore covered by hyaline cap, dextrinoid, metachromatic in cresyl blue, congophilous, cyanophilous. Basidia 26.6 - 53.2 x 11.2 - 16.6 µm, clavate, granular, thin walled, tetrasporic; sterigmata 2.4 - 3.2 µm long; gill edges sterile. Cheilocystidia crowded, 23.0 - 59.8 x 7.2 - 12.9 µm, versiform, claviform to pyriform or even cylindrical, few with septation. Pleurocystidia absent.
Pileus cuticle composed of a trichoderm consisting of branched, septate, cylindrical to tubular elements measuring 55 - 110 x 4.5 - 16 µm in size; context homoiomerous; trama subregular; tramal hyphae measuring 6 - 12 µm in width; subhymenium pseudoparenchymatous. Stipe cuticle hyphae parallel running throughout, measuring 6 - 16 µm in width. Clamp connections present in stipe surface hyphae and basal mycelium.

**Collections examined:** Himachal Pradesh, Bakarta, Mandi (850 m), growing solitary on Buffalo dung, Babita Kumari, PUN 3946, July 14, 2009; Mandi (850 m), growing solitary on open fields, Babita Kumari, PUN 4324, June 20, 2010; Mandi (850 m), growing in caespitose clusters in open fields, Babita Kumari, PUN 4327, June 27, 2010; Nahan, Kolar (900 m), growing solitary on sandy soil in Shorea robusta forest, Munruchi Kaur and Babita Kumari, PUN 4422, July 17, 2010.

**Remarks:** These collections are morphologically and microscopically well within the circumscriptions of *M. procera* as documented by Pegler (1977). This species is easily recognized by large sized basidiocarps, banded squamulose or granulose stipe with movable annulus, a hyaline cap over the germpore and a trichodermal pileal covering made up of cylindrical elements. It is already reported from India (Bhavani Devi, 1995; Patil *et al.*, 1995; Doshi and Sharma 1997). It is often abundant in the early monsoon period and is one of the well known edible mushroom.


**Figs. 46 (A-E) & 47 (A-B)**

**Synonyms**


*A. beckleri* Br. in *Journ. Linn. Soc.*, *Bot.* 13: 156 (1872)

*A. stenophyllus* Cooke & Masse in *Grevillea* 15: 98. 1887.

*Lepiota dolichaula* (Berk. & Br.) Sacc., *Syll. Fung.* 5: 32 (1887)


**Taxonomic observations**

*Leucocoprinus dolichaulus* var. *cryptocylus* Pat. in *Bull. Trimmest. Soc. mycol. Fr.* **29**: 215(1913)

Fructifications 17 – 33.5 cm in height. Pileus 4.5 - 15 cm in diameter, subglobose to convex, finally planate at maturity, brownish orange (5B3) to, greyish orange (5B3) with prominent light brown (5D5) umbo, scaly, scales greyish orange (5B3) to brownish orange (5C4) over yellowish white background, pileus scales give granular or powdery appearance in young specimens; margin irregular, splitting at maturity; cuticle fully peeling; fleshy, flesh 0.7 - 1.0 cm thick, white to off white, unchanging; taste and odour mild. Lamellae free, collariate, unequal, of 2 - 4 lengths, close to crowded, up to 1.5 cm broad, yellowish white (4A2), unchanging; gill edges smooth; spore deposit yellowish white (4A2). Stipe central, 17 - 30 cm long, 0.4 - 1.5 cm broad, 2.2 cm near the base, yellowish white (4A2), changes from orangish to brownish, pruinose fibrillose, obclavate with distinctly bulbous base, fleshy, with hollow centre; annulate, annulus double, persistent, fibrous, attached, movable, whitish, pinkish to brownish on bruising.

Spores (8.8) 9.6 - (14.5) 16 x (6.4) 7.2 – (8.8) 9.6 µm (Q = 1.2), broadly ellipsoid with rounded apex, having a small inconspicuous germ pore covered by a hyaline cap, dextrinoid, congophilous, metachromatic in cresyl blue, apiculate. Basidia 25.8 - 35.4 x (8) 9.6 – (12.8) 13.7 µm, clavate, hyaline, granular, tetrasporic, thin walled; sterigmata 2.4 - 4.8 µm in length; gill edges sterile. Cheilocystidia few, 24.2 - 32.2 x 4 - 9.6 (14.5) µm in size, pyriform to clavate; basidioles numerous, 27.5 - 36.7 x 9 - 10.7 µm in size, clavate, septate, thin walled. Pleurocystidia absent.

Pileus cuticle composed of a trichodermal palisade consisting of septate, cylindrical to tubular elements measuring 4 - 10 µm in width; context homoiomerous; gill trama regular, tramal hyphae measuring 6 - 10 µm in width; subhymenium pseudoparenchymatous. Stipe cuticle hyphae hyaline, thin walled, parallel running.

throughout, measuring 6 - 16 µm in width. Clamp connections present in stipe surface hyphae and basal mycelium.

Collections examined: Himachal Pradesh, Tanda (970 m), growing scattered on soil, Babita Kumari, PUN 4428, July 17, 2009; Palampur, Holta (1300 m), growing scattered in open field, Babita Kumari, PUN 4319, July 30, 2009; Palampur, Langha (1300 m), growing on hemicolous soil in *Pinus* forest, Babita Kumari, PUN 4427, July 27, 2009; Mandi, Sain (850 m), growing caespitose clusters on humicolous soil among grasses, Babita Kumari, PUN 4325, August 2, 2009; Mandi, Sarkaghat, Sain, (850 m), growing scattered among grasses, Babita Kumari, PUN 4419 & 4424, August 2, 2009; Mandi, Sarkaghat (850 m), growing scattered on soil under *Mulberry* tree, Babita Kumari, PUN 4321, June 26, 2010.

Uttrakhand, Chakrata, Korba (2200 m), growing scattered among grasses in mixed forest, Babita Kumari, PUN 4336, July 21, 2010; Chakrata (2200 m), growing scattered among grasses in mixed forest, Babita Kumari, PUN 4669, July 18, 2010.

Remarks: The overall features of the above examined collections are in conformity with *M. dolichaula* (Pegler, 1977). It is a common species found mainly in temperate areas. It can be easily identified in the field by its relatively large sized carpophores having raised umbo and long stipe turning pinkish to brownish on bruising near the base. It is normally confused with *M. mastoidea* and *M. procera* which largely differs from it in having relatively smaller size, irregular patchy brown squamules on the
pileus and stipe surface. Earlier record of this species is from Tamil Nadu by Natarajan and Manjula (1981) and Kour (2005) from Punjab.

**Cultural characteristics:** It is an edible mushroom and was cultured on PDA medium. In the culture the overall growth was irregular, mat formed was white, cottony and dense at places emitting sweet odour. The culture has been deposited in GenBank under accession no. DMRX 1129 at the Directorate of Mushroom Research, Chambaghat, Solan.

*Figs. 48 (A-E)*

**Synonyms**

*Agaricus excoriatus* Schaeff Fr. *Syst. mycol.* 1: 21, 1821  
*Lepiota excoriata* (Schaeff.: Fr.) Kumm., *Fuhr. Pilzk.* 135, 1871  
*Lepiotophyllum excoriatus* (Schaeff.: Fr.) Locq. in *Bull. Mens, Soc. linn. Lyon* 11: 40, 1942  
*Leucoagaricus excoriatus* (Schaeff,: Fr.) Sing. in *Sydowia* 2: 35, 1948  

Carpophore up to 17 cm in height. Pileus up to 5.5 cm in diameter, surface dry, convex with prominent star shaped pale patch over the umbo; scaly, scales light brown and appressed over the yellowish white (4A2) background, scales more dense towards the center; margin irregular, splitting at maturity; cuticle half peeling; flesh white, unchanging on exposure, up to 0.5 cm thick; taste and odour mild. Lamellae free, collariate, subdistant to crowded, slightly ventricose, unequal, of 3 lengths, 0.4 cm broad, yellowish white (4A2); gill edges serrate. Stipe central, 15 cm long, 0.7 cm broad, yellowish white (4A2), slightly brownish on bruising, cylindrical with slightly expanded base, then finally tapering, first solid then hollow; annulus simple, tomentose, creamish with brownish edge, persistent, attached.
Taxonomic observations

Spores 10.8 - 16.6 (18.2) x 7.5 - 9.96 (11.6) µm (Q = 1.47 - 1.6), ellipsoid to amygdaliform, truncated by a narrow germ pore, covered by hyaline cap, dextrinoid, strongly metachromatic in cresyl blue, congophilous, cyanophilous. Basidia 16.6 (19.9) - 41.5 (46.5) µm, clavate, thin walled, few with clamp connections, tetrasporic; sterigmata 1.6 - 6.6 µm long; gill edges sterile. Cheilocystidia abundant, 18.3 - 29.8 (38.2) x 7.5 - 11.6 µm, clavate to pyriform. Pleurocystidia absent.

Pileus cuticle composed of a trichoderm of upright hyphae with tubular or obtuse ends measuring 4.5 - 8 µm in width; context homoiomerous; trama regular, narrow, tramal hyphae 3.3 - 6.6 µm in width; subhymenium pseudoparenchymatous. Stipe cuticle hyphae parallel running throughout measuring 4.5 - 8.9 µm in width. Clamp connections present in stipe surface hyphae and at the base of few basidia. Veil tissue septate, measuring 2.5 - 5 µm in width.

Collection examined: Himachal Pradesh, Mandi, Sarkaghat (850 m), growing on humicolous soil under grasses, Babita Kumari, PUN 4668, August 14, 2008.

Remarks:- It is one of the most distinctive, edible, safest and tastiest species of Macrolepiota. It is characterized by pileus surface with pale star shaped pattern on yellowish white background, presence of thin annulur ring on the upper part of stipe and presence of clamp connections at the base of basidia. The above examined collection is morphologically and microscopically well within the circumscription of M. excoriata as described by Vellinga (2001 b). This is a new fungus record for India.

Figs. 49 (A-E)

Carpophore up to 10 cm in height. Pileus up to 6.5 cm in diameter, applanate with a broad umbo; surface whitish to orange white (5A2) with brownish orange (5C4) centre, moist; covered with thick long brownish orange (5C4) appressed fibrillose to recurved scales which are concentrically arranged around the umbo region; cuticle fully peeling; margin striate, irregular, splitting at maturity; flesh off white, changing to pinkish red on bruising, up to 0.5 cm thick; taste mild and odour sweet. Lamellae free, collariate, fragile, crowded, ventricose, unequal, of 3 lengths, 0.5 - 0.7 cm broad, whitish, becomes orange grey (5B2) on maturity; gill edges serrate, finely brown layered. Stipe central, 9.2 cm long white, hollow; annulate, annulus white and brownish underneath, double, persistent; covered by thick squamules of veilar remains in annulate fashion down the stipe; or with patchy scales on the lower portion of the stipe.

Spores 7.5 - 11 x 5 - 6.5 µm (Q = 1.6), broadly ellipsoid, double walled, dextrinoid, congophilous, cyanophilous, with small pore covered by a hyaline cap. Basidia 23 - 35 x 9.5 - 14.5 µm, clavate, tetrasporic, sterigmata up to 2.5 µm long; gill edges sterile. Cheilocystidia 26 – 57 (80) x 8 - 17 µm, versiform, lageniform to pyriform or even subcapitate cylindrical with broad apex. Pleurocystidia absent.

Pileus cuticle a loose trichoderm of long multisepate, unbranched to branched thick walled, cylindrical elements measuring up to 12 µm in width which are without clamp connections, tips of the trichodermal elements broad obtuse to tapered; context homoiomerous; gill trama almost regular, composed of up to 24 µm broad hyphae. Stipe cuticle hyphae running parallel throughout, with some dark stained cylindrical.
septate elements, thick walled, measuring 4 - 25 µm in width. Clamp connections present.

**COLLECTION EXAMINED:** Himachal Pradesh, Kinnaur, Nichar (2499 m), growing solitary on needles of *Cedrus deodara* forest, R.C.Upadhyay and Babita Kumari, PUN 4673, September 24, 2011.

**Remarks:** The above examined collection resembles with *M. puellaris* in its macroscopic and microscopic details as given by Breitenbach and Kranzlin (1995). The chief characters include the whitish to orange white carpophores covered with thick, long fibrous scales on pileus surface and presence of versiform cheilocystidia. It is found in cold region of coniferous forests of Himachal Pradesh. Earlier it has been reported by Ghosh and Pathak (1965) from Lucknow (U.P.).


**Synonyms**

*Lepiota procera* var. *fuliginosa* Barla *Champ Alpes- Martense* **21**.1888

*Leucocoprinus fuliginosus* (Barla) Locq. in *Bull. Mens Soc. Inr Lyon* **14**: 92, 1945


Carpophores 10 - 14 cm in height. Pileus 4 - 7.2 cm in diameter, surface convex, yellowish white (4A2) with brown (6E4) to brownish orange (5C3) umbo covered by greyish brown to brown orange (5C3) recurved fibrillose scales over yellowish white background; margin irregular, splitting at maturity; sheath fringed, cuticle fully peeling; flesh white, unchanging, up to 0.5 cm thick; taste and odour mild. Lamellae free, collariate, crowded, unequal, of 4 lengths, 0.4 - 0.7 cm broad, yellowish white (4A2), to pinkish cream, ventricose; gill edges white, floccose; spore print white. Stipe central, 10 - 13.2 cm long, 0.7 - 0.9 cm broad, yellowish white
Taxonomic observations

(4A2) covered by light brown scales, pinkish red to brownish on bruising, obclavate; annulate, annulus fixed on the upper half of the stipe, finally movable, double, purplish pink underneath, fibrous.

Spores 12 - 16 (17.6) x 7 - 9 µm (Q = 1.7), broadly ellipsoid to amygdaliform, truncated by a narrow germpore covered by hyaline cap, dextrinoid, metachromatic in cresyl blue, congophilous, cyanophilous. Basidia 33.8 - 48.3 x 9.6 - 13.7 µm, clavate, granular, thin walled, 2 to 4 spored; sterigmata 2.4 - 3.2 µm long, basidia with clamp connections; gill edges sterile. Cheilocystidia numerous, 22.5 - 48.3 x 7.2 - 12.8 µm, versiform, utriform to claviform or even pyriform, some of them cylindrical to subcapitate with basal clamp connection. Pleurocystidia absent.

Fig. 50: Carpophores of *Macrolepiota fuliginosa* in their natural habitat.
Figs. 51 (A-D) *Macrolepiota fuliginosa*: A. Basidiospores, B. Basidia, C. Pileus cuticle surface, D. Cheilocystidia.

Pileus cuticle composed of a trichoderm consisting of branched, septate cylindrical to obtuse elements measuring 6 - 12 µm in width, often with clamp connections; context homoiomerous; trama regular; tramal hyphae measuring 8 - 12 µm in width; subhymenium pseudoparenchymatous. Stipe cuticle hyphae parallel running throughout, 8 - 12 µm in width, some projecting cylindrical to clavate elements 6 - 12 µm in width. Clamp connections present throughout.

**Collections examined:** Uttrakhand, Deoban (2200 m), growing scattered in *Cedrus deodara* forest, Babita Kumari, PUN 4323, July 18, 2010; Deoban (2200 m), growing scattered in *Quercus* and *Cedrus deodara* forest, Babita Kumari, PUN 4331, July 18, 2010.
Remarks:- It is characterized by brownish carpophores covered with recurved greyish brown fibrillese scales, with loose grey brown patches of universal veil on the pileus surface, white floccose gill edges and gills turning pinkish red to brownish on bruising. The details of this mushroom are in agreement with description given by Vellinga (2001 b). It is a new fungus record for India.


Figs. 53 (A-E)

Fructification up to 14.5 cm in height. Pileus up to 9.2 cm in diameter, surface dry, convex to hemispherical, surface dry, applanate with short umbo, greyish orange (5B4) near the center, covered by greyish orange (5B4) appressed fibrillese scales soon cracking into small pieces, dense towards the center and scattered towards the margin over orange white (4A2) background; margin feebly striate, reflexed, splitting at maturity; cuticle fully peeling; flesh up to 0.6 cm thick, off white, unchanging; taste and odour honey like. Lamellae free, collariate, crowded, unequal, of 2 lengths, subdistant to crowded, ventricose, 0.5 cm broad, yellowish white (4A2) in young specimens, brownish on bruising; gill edges minutely serrate. Stipe central, up to 12 cm long, 0.8 cm broad in the centre and 2 cm broad near the base, obclavate with distinctly bulbous base, silky shining white with very tiny scales; annulus persistent, simple, attached.

Spores 11.5 - 16 x 7 - 10 μm (Q = 1.63), broadly ellipsoid to amygdaliform, dextrinoid, congophilous, cyanophilous, weakly metachromatic in cresyl blue, with apical germ pore covered by a hyaline cap, roughned inside. Basidia 25 - 36 x 10 – 15 μm, clavate, tetrasporic; sterigmata up to 2.5 μm long; gill edges sterile. Cheilocystidia versiform, varying from pyriform to clavate or even lageniform to shortly subcapitate in shape, 22 – 48 x 7 – 18 μm in size, crowded. Pleurocystidia absent.
Pileus cuticle composed of a trichoderm of loosely arranged thin long cylindrical septate up to 4 µm broad hyphae arising from the context, context homoiomerous; hymenophoral trama regular; tramal hyphae up to 15 µm in width; subhymenium pseudoparenchymatous, well developed. Stipe cuticle hyphae running parallel throughout measuring up to 20 µm in width with some projecting cylindrical elements measuring up to 4 µm in width. Clamp connections present.

**Collection examined:** Himachal Pradesh, Kinnaur Nichar, (2499 m), growing scattered on soil, R.C.Upadhyay and Babita Kumari, PUN 4674, September 24, 2011.

**Remarks:** The above examined collection resembles with *M. heimii* in its macroscopic and microscopic details as given by Breitenbach and Kranzlin (1995). It is an interesting white coloured mushroom with simple annulus and presence of versiform cheilocystidia. It is a new fungus record for India.

### 6.1.5 Leucocoprinus Pat. – A Diagnosis


**Synonyms**

*Hiatula* sensu Heim & Raman. in *Bull. Soc. Mycol. Fr.* **50:** 186(1934)


*Lepiota* sect. *Striatae* Murr., in *N. Amer. Fl.* **10:** 42(1914)


**Type species:** *L. cepaestipes* (Sow.: Fr.) Kummer

**Characters:** Carpophores lepiotoid, pluteoid to coprinoid, often fragile, readily decaying, small to very large. Pileus membranous, striate with sulcate marginal zone, often plicate, floccose squamulose, context very thin. Lamellae, free, collariate, soft, sometimes deliquescent, crowded. Spore deposit white to creamish, pale pink. Stipe central, elongate, cylindric, obclavate or with bulbous base, hollow, smooth or covered by large fragile scales. Veil annulate, annulus single or double, membranous, movable at maturity. Spores medium to large, hyaline to yellowish, ovoid-ellipsoid or
Taxonomic observations

Amygdaliform with protracted apex, apically truncated with more or less distinct germ pore, binucleate, dextrinoid, congophilous, endosporium strongly metachromatic with cresyl blue, smooth walled. Lamellae edges sterile. Cheilocystidia abundant, smooth, variously shaped, often long necked. Pleurocystidia absent. Pileus surface an epicutis of radially arranged hyphae, often forming loose floccular elements, rarely sphaerocysts. Pileus context homoiomerous; hymenophoral trama regular. Clamp connections absent.

**Habit and habitat:** Carpophores lepiotoid to coprinoid. Habitat terrestrial, lignicolous, or on forest debris.

**Distribution:** Pantropical to subtropical.

**Development:** Hemiangiocarpic

**Limits:** The genus *Leucocoprinus* Pat. belongs to tribus Leucocoprineae Sing. of family Agaricaceae Chevall. It is quite different from other genera of the tribe. The genera *Clarkeinda* and *Chlorophyllum* have green or olive spore print, *Macrolepiota* has large sized carpophore with scaly pileus and apically truncated spores, *Sericeomyces* have spores without or a rudimentary germ pore and context not discolouring when bruised while genus *Leucoagaricus* has fleshy carpophores with non-striate pileus margin. Patouillard (1888) established the genus *Leucocoprinus* so as to include lepiotoid fragile, squamulose radially decaying mushrooms.

fragillissimus (Rav.) Pat. and L. lacrymans T.K.A. Kumar & Manim. already are reported from India (Bilgrami et al., 1991, Jamalludin et al., 2001 and Vrinda et al., 2003, Kumar and Manimohan 2004). From Punjab Rawla et al., (1982) recorded L. cretatus. Presently 20 collections spread over 6 species of the genus Leucocoprinus has been worked out for their external and internal details. These include L. cepaestipes (Sow.: Fr.) Pat., L. fragillissimus (Rav.) Pat., L. meleagris (Sow.) Locq., L. birnbaumii (Corda) Sing., L. bresadolae (Schulzer) Moser, L. squamulosus (Mont.) Peg. Out of these, four species viz. L. meleagris (Sow.) Locq., L. birnbaumii (Corda) Sing., L. bresadolae (Schulzer) Moser and L. squamulosus (Mont.) Peg. are new records for North India. Key to the identification of the investigated species is given below. The description of the individual taxa has been given in the sequence of their segregation in the key to the species.

**Key to the species of Leucocoprinus investigated**

1. Carpophores whitish to creamish.................................................................2

1.’ Carpophores yellowish white to pale yellow or even with greyish orange to reddish brown scales over yellowish white background on the pileus.................................................................3

2. Carpophores 7.5 - 19.5 cm in height, growing in caespitose clusters; fruit body uniformly white, entirely covered by powdery to floccose soft cottony fibrills; stipe swollen at base covered with floccose fibrils, unchanging on bruising..............................................L. cepaestipes

2.’ Carpophores 4.5 - 9 cm in height, growing gregariously on soil; pileus surface whitish to creamish with greyish brown to brown umbo; stipe flesh pinkish red towards the base otherwise yellowish white overall, becoming brownish on bruising..............................................L. squamulosus

3. Pileus radially striate with prominent ridges and grooves; stipe surface pastel yellow, turn greenish where bruised.................................................................4

3.’ Pileus radially striate but striations not as prominent; stipe surface yellowish white, turns orange brown to reddish brown on bruising.................................................................5

4. Carpophores 7.5 – 18.5 cm in height; carpophores partially deliquesing to partially decaying in due course; basidiospores 8 - 13.7 x 6.4 - 9.6 µm.................................................................L. fragilissimus
4. Carpophores smaller 7 - 7.6 cm in height; stipe with bulbous base; carpophores not deliquescing at all; basidiospores smaller 8 - 10.5 (11.3) x 5.63 - 7.2 (8) μm .......................... L. birnbaumii

5. Carpophores robust, 6.5 – 15 cm in height; pileus background yellowish white with dot like reddish brown scales; flesh yellowish orange, brown on exposure........................................ L. bresadolae

5.’ Carpophores smaller, 4.2 – 4.9 cm in height; pileus background yellowish white with greyish orange recurved fibrillose scales; flesh white, unchanging on exposure. ........................................ L. meleagris

i. Leucocoprinus cepaestipes (Sow.: Fr.) Pat., Analyt. Fung. Fasc. 7: 45, 1889.
Figs. 54 (A-E) & 55 (A-E)

Synonyms

Agaricus cepaestipes Sow.: Fr., Syst. Mycol. 1: 280 (1821)
A. rorulentus Panizzi, comm. Soc. Critt. Ital. 172 (1861)
A. oncopus Berk. & Br. in Journ. Linn. Soc., Bot. 11: 496 (1871)
A. adoreus Berk.& Br. in Journ. Linn. Soc., Bot: 499 (1871)
Lepiota cepaestipes (Sow.: Fr.) Kummer, Fuhr. Pilz.: 136 (1871)
L. rorulenta (Panizzi) Barla in Bull. Soc. Mycol. Fr. 9: 117 (1886)
L. continua (Berk.& Br.) Sacc., Syll. Fung. 5: 44 (1887)
L. oncopus (Berk.& Br.) Sacc., Syll. Fung. : (1887)
Loneopus (Berk. & Br.) Sacc., Syll. Fung.: 57 (1887)
L. adorea (Berk.& Br. ) Sacc., Syll. Fung. : (1887)
Mastocephalus cepaestipes (Sow.: Fr.) Kuntze, Rev. Gen.Pl. 2: 859 (1891)
Histula cepaestipes (Sow.: Fr.) Heim & Romagn. in Bull. Soc. Mycol. Fr. 50: 184 (1934)

Fructifications 7.5 - 19.5 cm in height. Pileus 3 - 10 cm in diameter. Pileus surface snow white throughout with slight off white centre, convex to campanulate or in some mature fructifications pileus plano-convex or reflexed, covered with white fibrillose floccose scales throughout including the lower half of the stipe; apex feebly depressed to broadly umbonate; margins irregular, striate, splitting at maturity, with attached membranous cortina; cuticle fully peeling; flesh white, unchanging on exposure, 1 - 4 mm thick at the disc; taste and odour mild; pileal veil warty throughout; gills free, unequal, subdistant, 2 - 5 mm broad in the centre, ventricose, fragile; gill edges smooth; spore deposit white. Stipe central, 6.9 - 16 cm long, 0.3 -
Figs. 54 (A-E) *Leucocoprinus cepaestipes*: A. Carpophores in their natural habitat, B. Mycelium growth in petriplates, C & D. Basidiospores in congo red and cresyl blue, E. Cheilocystidia.
0.8 cm broad in the centre, 1.8 cm broad at the base, obclavate with a bulbous base, hollow above, solid at the base, lower half covered with floccose cottony scales, upper half covered with finely powdered scales; annulate, annulus in the form of movable, double ring, persistent, superior.

Spores 8.3 - 13.3 x 5.8 (6.6) - 8.3 µm, amygdaliform to broadly ellipsoid, apically truncated by a germ pore, double walled, dextrinoid, strongly metachromatic with cresyl blue. Basidia 10.8 - 28.2 x 6.4 - 10.8 µm, clavate to narrowly clavate, four spored, pigmented, hyaline, thick walled, inamyloïd; sterigmata 1.6 - 4.2 µm in length; gill edges sterile. Cheilocystidia abundant, variously shaped, clavate to cylindrical lageniform or even moniliform, with mucronate to subcapitate tip measuring 23.24 - 66.4 x 4.9 - 16.6 µm in size. Pleurocystidia absent.

Pileus cuticle of loose aggregates of cylindrical elements measuring 7 - 9 µm in width with occasional dermatocystidia measuring 8.3 - 13.28 µm in size; context homoiomerous; gill trama interwoven, tramal hyphae 3 - 15 µm in width. Stipe cuticle hyphae inamyloïd, 4.9 - 11.6 µm wide. Clamp connections absent in all types of hyphae.

**Collections examined:** Punjab, Chattbir (316 m), in association with Acacia tree. Babita Kumari, PUN 4330, June 23, 2008; Patiala, Punjabi University Campus (250 m), Plant Conservatory, growing in dense caespitose clusters on and around the dead stump of Cassia fistula tree, Babita Kumari, PUN 3937, July 16, 2008; Plant Conservatory (250 m), growing scattered on soil, Babita Kumari, PUN 4638, September 16, 2009; Patiala PUP campus, Conservatory (250 m), growing solitary on dry wooden log. Babita Kumari, PUN 4100, July 13, 2009; Chandigarh (250 m), growing scattered on soil, Babita Kumari, PUN 4640, September 9, 2009.

Himachal Pradesh, Mandi, Bakarta (850 m), growing scattered on Buffalo dung, Babita Kumari, PUN 4108, July 16, 2009; Palampur, Langha (1300 m), growing scattered to gregarious on Cow and Goat dung. Babita Kumari, PUN 4308, July 27, 2009; Palampur (1300 m), scattered to gregarious on dung, Babita Kumari, PUN 4104, September 22, 2009; Mandi, Bakarta (850 m), growing in caespitose on dung. Babita Kumari, PUN 4108, September 19, 2009; Palampur, Bhadrol (1300 m), growing scattered on soil, Babita Kumari, PUN 4104, September 16, 2009. Pradesh, Mandi, Bakarta (850), growing in association with roots of Bamboo, Babita Kumari, PUN 4639, August 19, 2010.
Remarks: All the above examined collections are typical of *L. cepaestipes* which is characterized by white pruinose to fibrillose carpophores with swollen stipe base, often found in caespitose manner on richly manured soil. The species was recorded by Natarajan (1977 b) from South India, Roy and Samajpati (1980) from West Bengal. Kour (2005) reported this species from Punjab plains.

Culture characteristics: This mushroom was cultured on malt extract medium. In the culture raised the mycelium was white fluffy and dense showing irregular growth emitting spicy odour. The culture has been deposited in GenBank under accession no. DMRX 1127 at Directorate of Mushroom Research, Chambaghat, Solan.

Figs. 56 (A-B) & 57 (A-E)

Synonym


Fructifications 4 - 9 cm high. Pileus 1.5 - 5.5 cm in diameter, conico-campanulate with well developed greyish brown (6D3) to brown (4D2) umbo covered with brown (6D3 - 4D2) scales over whitish to creamish background; margin plicate, striate, irregular, splitting at maturity, cuticle fully peeling; flesh up to 1 cm thick; cream coloured, unchanging; taste and odour mild. Lamellae free, collariate, unequal, of 2 - 3 lengths, subdistant, up to 0.3 cm broad, yellowish white (4A2); gill edges smooth. Stipe central, 3.5 - 7.5 cm long, 0.2 - 0.5 cm broad, yellowish white (4A2), cylindrical, white in the upper region of stipe, pinkish red on the lower region, brownish on bruising, annulus single, funnel shaped, thin, soon evanescent.

Spores (7.2) 8 - 11.3 (12) x 5.6 - 7.2 (6.4) µm (Q = 1.5), ellipsoid to amygdaliform, wall thickened, stratified, apically truncated by a broad central germ pore, dextrinoid, congophilous, cyanophilous, metachromatic in cresyl blue.
Taxonomic observations

Basidia 12.8 - 19.3 x 5.6 - 11.3 µm, broadly clavate, granular, tetrasporic; sterigmata 1.6 - 3.2 µm in length; gill edges sterile. Cheilocystidia 23 - 66 (82) x 6.5 - 12.8 µm in size, clavate, lageniform to fusoid ventricose, sometimes with obtuse apex, mucronate. Pleurocystidia absent.

Figs. 56 (A - B): Carpophores in their natural habitat

Pileus cuticle formed of trichoderm of loosely arranged disrupted cylindrical hyphae measuring 2.8 - 6 µm in width; context homoiomerous; gill trama subregular, up to 10 µm in width; subhymenium pseudoparenchymatous, well developed. Stipe cuticle hyphae 8 - 16 µm broad, parallel running throughout with some projecting cylindrical elements measuring up to 8 µm in width. Clamp connections absent throughout.

Collections examined: Himachal Pradesh, Palampur, Chandpur (1300 m), growing gregariously in caespitose clusters in association with roots of Bamboo, Babita Kumari, PUN 4306, July 27, 2009; Mandi, Sain (850 m), growing gregariously on fine Clay soil, Babita Kumari, PUN 4322, September 21, 2010.

Remarks:- The above examined collections are typical of *L. squamulosus*. These closely resembles to *L. cepaestipes* except that *L. squamulosus* lack swollen stipe base and persistent annulus. This species is characterized by whitish conical to campanulate carpophores having thin annulate stipe, plicate striate pileus margin and
presence of versiform cheilocystidia. In India it has been documented from Kerala by Vrinda et al., (2003). It is reported for the first time from North India.

iii. *Leucocoprinus fragilissimus* (Rav.) Pat., Essai *Taxon.*: 171(1900).

Figs. 58 (A-D) & 59 (A-E)

**Synonyms**

*Agaricus licmophorus* Berk. & Br. in *Journ. Linn. Soc., Bot.* 11: 500 (1871)
*Lepiota licmophora* (Berk. & Br.) Sacc., *Syll. Fung.* 5: 44 (1871)
*Agaricus fragilissimus* (Rav.) P. Henn. in *Engl, & Prantl, Nat. Pfl.-Fam.1,1*: 263 (1900)
*Leucocoprinus fragilissima* (Rav.) Morgan in *Journ. Mycol.* 13: 5 (1907)
*Leucocoprinus licmophorus* (Berk. & Br.) Pat. in *Bull Soc. Mycol. Fr.* 29: 216 (1913)

Fructifications 7.5 – 18.5 cm high. Pileus 3 - 5 cm broad, initially conical, then campanulate and finally expanded, fragile, pastel yellow (2A4), powdery to scaly, scales bright to pale yellow (4A3) over a yellowish white (4A2) background, cap centre often yellowish brown (5D4); margin radially striate, ridged; cuticle fully peeling; flesh thin, membranous, 0.1 cm thick, yellowish white (4A2), unchanging; taste and odour mild; carpophores partially deliquescent to readily decaying in due course. Lamellae free, unequal, of 2 - 3 lengths, subdistant, ventricose, 0.2 - 0.3 cm broad, yellowish white (4A2); changes to lemon colour on bruising; gill edges smooth. Stipe central, 7.2 - 11 cm long, 0.2 - 0.3 cm broad, concolorous with the pileus, light greenish on bruising, tubular with slightly broad base; annulate, annulus bright yellow, pruinose, movable.
Taxonomic observations


Spores 8 - 13.7 x 6.4 - 9.6 µm (Q = 1.3), ellipsoid to amygdaliform with thickened stratified wall, apically truncated by a germpore, dextrinoid, metachromatic in cresyl blue. Basidia 20.9 - 38.6 x 8.8 - 9.6 µm, granular, clavate, tetrasporic; sterigmata 3.2 - 4.8 µm in length; gill edges sterile. Cheilocystidia 20.7 - 48.3 x 8 - 15.3 µm, versiform, fusoid ventricose with extended tips to pyriform. Pleurocystidia absent.

Pileus cuticle composed of irregular trichodermal layer, which become disrupted to form loose floccular elements, cuticular elements 6 - 10 µm broad; context homoiomerous. Stipe cuticle hyphae thin walled, 8 - 28 µm broad, some
Taxonomic observations

Hyphae parallel running throughout and some projecting hyphae measuring 4 - 8 µm in width. Clamp connections absent throughout.

**Collection examined:** Himachal Pradesh, Palampur, IHBT road (1300 m), growing scattered on humicolous soil under *Pinus roxburghii*, Babita Kumari, PUN 1680, July 27, 2009.

**Remarks:** It is an interesting mushroom with pastel yellow to yellowish white carpophores turning light greenish to lemon colour on bruising. This species is extremely delicate and tends to collapse as soon as it is gathered. In its gross morphological and anatomical details it falls within the overall taxonomic limit of *L. fragillissimus* as described by Pegler (1986). This species has been reported from Kerala by Vrinda *et al.*, (2003). It is first time reported from North India.


*Figs. 60 & 61 (A-E)*

**Synonyms**

*A. cepaestipes* Sow.: Fr. var. *lutea* Bolt.: Secr., *Mycogr. Suisse* 1: 56 (1833)
*A. flos-sulphuris* Schnizlein in *Sturm, Deut. Fl.* 3 (31): 1,1 (1851)
*A. luteus* (Bolt : Fr.) Secr. *Intell. Observer* : 7 (1865)
*A. aureus* (Massee) F. M. Bailey (1913)
*Lepiota flammula* (Alb.& Schw.) Gillet, *Champ. Fr.*: 63 (1874)
*L. coprinoides* Beeli in *Fl. Icon. Champ. Cong.* 2: 42, pl.8/11 (1936)
*L. flos-sulphuris* (Schnizlein) Cejp in *Ceska. Mycol. 2*: 78 (1948)

Fructifications 7 - 7.6 cm high, slender, fragile. Pileus 2.2 - 3.6 cm broad, thin, membranous, dome shaped, conical, radially striate, floccose; surface pastel yellow (1A4) with greyish yellow (4B4) center, covered with greyish brown (5D3) scales; margin irregular, finely striate, membranous, splitting at maturity, cuticle fully peeling; flesh thin, membranous, 0.2 cm thick, yellowish, changing to greenish blue on handling, taste and odour spicy. Lamellae free, collariate, unequal, of 2 - 3 lengths,
subdistant, ventricose, pruinose, 0.2 - 0.3 cm broad, pale yellow (1A3); gill edges serrate. Stipe central, up to 6.5 cm long, 0.2 - 0.6 cm broad, concolorous with the pileus, tubular with slightly broad base, pastel yellow (1A4), greenish blue on bruising, pruinose; annulate, annulus single, attached in the middle of the stipe, membranous, patchy, soon evanescent.

Spores 8 - 10.5 (11.3) x 5.63 - 7.2 (8) µm (Q = 1.53), ellipsoid to amygdaliform with compound thickened stratified wall, apically truncated by broad germpore, dextrinoid, congophilous, metachromatic in cresyl blue. Basidia 24.2 - 32.2 x 7.2 - 8.8 µm, clavate, tetrasporic; sterigmata 2.4 - 3.2 µm in length; gill edges sterile. Cheilocystidia dimorphic, some inflated pyriform measuring 25.3 - 29.2 x 9.9 - 12 µm and some elongate pyriform to lageniform irregular measuring 27.4 - 67.6 x 6.4 - 14.5 (16) µm in size, scattered. Pleurocystidia absent.

**Fig. 60:** Carpophore in its natural habitat.
Taxonomic observations

Pileus cuticle formed of loosely arranged floccose disrupting elements which are cylindrical, branched to unbranched measuring 6 - 12 µm in width; context homoiomerous, formed of 6 - 12 µm broad hyphae; gill trama regular, tramal hyphae 6 - 12 µm in width; subhymenium pseudoparenchymatous. Stipe cuticle hyphae thin walled, 6 - 16 µm broad, parallel. Clamp connections absent throughout.

**Collections examined:** Himachal Pradesh, Palampur, Gopalpur, (1300 m), growing solitary on huminolic soil under *Pinus roxburghii*, Babita Kumari, PUN 4307, July 29, 2009; Solan, Sakodi (1900 m), growing solitary on *Pinus roxburghii* log, Munruchi Kaur and Babita Kumari, PUN 4305, August 19, 2008.

**Remarks:** The above examined collections are typical of *L. birnbaumii* with diagnostic features resembling with the details given for this species by Pegler (1977). It can be easily recognized in the field by bright yellow coloured carpophores with floccose squamules over pileus surface and plicate striate margin. It is quite close to *L. fragillissimus* which have delicate, plicate, striate and grooved pileal margin and long thin cylindrical stipe. In India it has been documented from Kerala by Vrinda et al., (2003) and Orissa by Dhancholia and Sinha (1990). Kaur (2000) reported this species from Punjab plains.


**Figs. 62 (A-E) & 63 (A-B)**

**Synonyms**


Fructifications 6.5 - 15 cm in height, pileus 2.5 - 8.3 cm in diameter; conico-convex in the young stage, then convex with brown (7F4) umbo; surface with small dot like reddish brown (7A2) scales scattered towards the periphery over yellowish
white background; margin irregular, striate, splitting at maturity; cuticle fully peeling; flesh 0.3 - 0.5 cm thick, changing, first yellowish orange then reddish brown after 5 - 10 minutes on exposure; taste and odour mild. Lamellae free, collariate, unequal, close to crowded, 0.3 - 0.6 cm broad, yellowish white (4A2) with brown layered fimbriate edges; spore print yellowish white (4A2). Stipe central, 5.4 - 13 cm long, 0.5 - 1.0 cm broad, 0.8 - 1.0 cm broad near the base then slightly tapering, yellowish white (4A2), first orange and then reddish brown on bruising, hollow, covered with brown (7E4) scales which are more dense towards the base; annulate, annulus single, thin, superior, (Just above mid of the stipe), membranous, fugacious with a dark brown fringed rim.

Spores 8 - 12.8 x 5.6 - 7.3 µm (Q = 1.61), ellipsoid to elliptical with a narrow germ pore, strongly dextrinoid, metachromatic in cresyl blue. Basidia 17.7 - 33.8 x 7.2 - 11.3 µm, clavate, tetrasporic; sterigmata 3.2 - 4.8 µm long; gill edges sterile. Cheilocystidia 28.9 - 67.6 x 10.5 - 16 µm, crowded, hyaline, lanceolate, pyriform to lageniform with pointed to mucronate apices. Pleurocystidia absent.

**Figs. 63 (A – B):** Carpophores in their natural habitat
Pileus cuticle formed of a disrupted trichoderm with clavate to fusiform uplifted elements measuring 8 - 20 µm in width; context homoiomerous; gill trama regular. Stipe cuticle hyphae parallel running throughout measuring 4 - 24 µm in width with scattered 8 x 12 µm broad caulocystidia. Clamp connections absent throughout.

**Collection examined:** Patiala, Bahadurgarh, (250 m), growing scattered or in gregarious clusters among grasses, Babita Kumari, PUN 3946, August 18, 2009.

**Remarks:** The presently examined collection is characterized by its large carpophores with reddish brown squamules over entire surface, large ellipsoid, dextrinoid thick walled spores with a narrow germ pore and colour changes on bruising in all parts of fruit body, from yellowish white to orange and finally reddish brown. In its gross morphological and anatomical details it falls within overall taxonomic limits of *Leucocoprinus bresadolae*, except for the spores which are larger and measure from 8 - 12.8 x 5.6 - 7.3 µm in PUN 3946 as compared to 7.0 - 10 x 5.2 - 7.2 µm in size documented by Reid (1990). Vrinda et al., 2003 recorded this species from Kerala. Here it is reported for the first time from North India.

Figs. 64 (A-E)

**Synonyms**

*Gymnopus meleagris* (Sow.) S. F. Gray, *Natural Arrangement of British Plants* 1: 609 (1821)  
*Lepiota meleagris* (Sow.) Ouel., *Champignons du Jura et des Vosges* 2: 326 (1873)  
*Leucoagaricus meleagris* (Sow.) Singer, *Lilloa* 22: 422(1951)  

Fructifications 4.2 - 4.9 cm high. Pileus 2.2 - 2.5 cm broad, thin, convex with short umbo; surface covered by greyish orange (5B3) recurved fibrillose scales over a yellowish white background (4A2); margin plicate, striate, irregular, splitting at maturity, cuticle fully peeling; flesh thin, membranous, up to 0.2 cm thick, whitish,
unchanging; taste and odour mild. Lamellae free, collariate, unequal, of 2 - 3 lengths, subdistant, up to 0.3 cm broad, yellowish white (4A2), reddish brown on bruising; gill edges smooth. Stipe central, 3.6 - 4.2 cm long, 0.2 - 0.4 cm broad, expanding near the base then slightly tapering with mycelial threads at the base of the stipe, yellowish white (4A2), reddish brown on bruising; annulate, annulus single, attached in the middle of the stipe, thin, membranous.

Spores 9 - 11.6 x 5.8 - 6.6 µm (Q = 1.54), broadly ellipsoid to amygdaliform with compound thickened stratified wall, apically truncated by a central broad germ pore, dextrinoid, congophilous, metachromatic in cresyl blue. Basidia 25 - 39.8 x 8.3 - 13.3 µm, clavate, tetrasporic; sterigmata 3.32 - 4.98 µm in length; gill edges sterile. Cheilocystidia 26.6 - 56.5 x 9.96 - 13.3 µm in size, clavate or even, lageniform to fusoid ventricose, sometimes with obtuse to mucronate apex, crowded. Pleurocystidia absent.

Pileus cuticle formed of radially arranged hyphae with obtuse or tubular ends measuring 5 - 6.7 µm in width; context homoiomerous; gill trama regular, up to 10 µm in width; subhymenium pseudoparenchymatous. Stipe cuticle hyphae thin walled, 6.7 - 9 µm broad, parallel running throughout with some projecting cylindrical elements measuring up to 5 µm in width. Clamp connections absent throughout.

**Collection examined:** Himachal Pradesh, Solan (1650 m), growing in caespitose clusters or even scattered under *Grevellia robusta*, Babita Kumari, PUN 4337, September 21, 2008.

**Remarks:** The above examined collection is typical of *L. meleagris*. It resembles in diagnostic features with the details given for this species by Reid (1990). It can be easily recognized in the field by carpophores with plicate striate margin, presence of mycelial threads arising from the stipe base, thin membranous annulus and stipe
Figs. 64 (A-E) *Leucocoprinus meleagris*: A. Carpophore, B. Basidiospores, C. Basidia, D. Cheilocystidia, E. Pileus trichodermal elements.
reddish brown on bruising. In India it has been documented from Kerala by Vrinda et al., (2003). It is recorded for the first time from North India.

**6.1.6 Clarkeinda Kuntze – A Diagnosis**

*Rev. Gen. Pl. 2: 848 (1891)*

**Type species:** *Clarkeinda trachodes* (Berk.) Sing.

**Characters:** Basidicarp large, lepiotoid. Pileus fleshy, hemispherical to applanate; surface dry, often hygrophanous. Gills free, collariate, white to greenish, close to crowded. Spore deposit yellowish green. Stipe central, often with a bulbous base, fibrillose; annulate, annulus attached, complex, squamose, persistent; volvate, volva persistent, membranous, lobed, rudimentary. Hyphal system monomitic. Context turn immediately orange red on exposure. Spores always small to medium, ovo-ellipsoid, apically truncated by a germ pore, yellowish green, dextrinoid, wall smooth, thick, not metachromatic in cresyl blue. Lamellae edges heteromorphous to sterile. Cheilocystidia crowded. Pleurocystidia absent. Pileus cuticle trichodermal, formed by chains of doliform elements. Hymenophoral trama regular.

**Habit and habitat:** Habit of the carpophore lepiotoid. Terrestrial, grows solitary to scattered mostly on soil, among grasses or under trees or hedges.

**Development:** Bivelangiocarpous.

**Distribution:** Almost cosmopolitan, but majority of the species are tropical to subtropical.

**Limits:** The genus *Clarkeinda* belongs to the tribus Leucocoprinae Sing. of family Agaricaceae Chevall. This genus is generally considered to be closely related to *Chlorophyllum* on the basis of green truncated spores, presence of complex, persistent annulus and trichodermal structure of pellicle surface.
Statistics: The world over 5 species of the genus *Clarkiendra* are known so far (Kirk *et al.*, 2008). Out of these only one *Clarkiendra trachodes* is known from India (Bilgrami *et al.*, 1991). Presently one collection of *Clarkiendra trachodes* gathered from Himachal Pradesh have been worked out for its macroscopic and microscopic details.


Figs. 65 & 66 (A-E)

Synonyms

*Agaricus pedilium* Berk. & Br. in *Journal of the Linnean Society (Botany)*, 14: 32 (1873).


Carpophores 8 - 11.5 cm in height. Pileus 4.5 - 11.5 cm in diameter, convex; surface covered with yellowish brown (5D4) to greyish brown concentrically arranged warty granules over a whitish background; greyish brown (8F3) stellate to irregular patch of cuticular remnant present at the centre of the pileus; margin finely striate, incurved with hanging cortina, at places feebly splitting; cuticle fully peeling; flesh 0.5 - 0.7 cm thick, white, first changes to pinkish and then brownish after 10 - 15 minutes; taste mild and odour heavily aromatic (like chlorine). Gills free, collariate, close to crowded, not in series, 2 - 4 lengths, 4 - 5 mm broad, yellowish white (4A2), changes to greenish, dark brown on drying, normal; gill edge fimbriate; spore print
orange grey (5B3). Stipe central, 3.5 - 10.3 cm long, 1 - 2 cm broad 2.5 cm near the base, orange white (5A2), fleshy, obclavate, solid, surface pruinose fibrillose; annular veil present, annulus single, pendulus from apex of the stem, very broad, white, powdery veil extending from the pileus margin to the stipe surface; volvate, volva grey, usually closely appressed to the stipe and often inconspicuous.

Spores (4.8) 5.6 - 7.2 (6.4) x 4 - 4.8 µm (Q = 1.45), subamygdaliform with truncate apex, spore wall dark brown at the point of attachment with apiculus, metachromatic in cresyl blue. Basidia 16.1 - 24 x 6.4 - 8 µm, hyaline, thin walled, tetrasporic; sterigmata 2. 4 - 3.2 µm long; gill edges sterile. Cheilocystidia 24.2 - 56.4 (64) x 2.8 - 25.8 µm, crowded, arranged in clusters, pyriform to broadly clavate, inamyloid. Pleurocystidia absent.

Fig. 65: Carpophores in their natural habitat.

**Collection examined:** Himachal Pradesh, Kangra, Baijnath (1700 m), growing on humicolous soil, Babita Kumari, PUN 3938, July 30, 2009.

**Remarks:** This collection is typical of *Clarkeinda trachodes*. It is characterized by hemispherical applanate pileus with furfuraceous squamules and cartilaginous pellicle, white to greenish collariate lamellae, annulate and volvate stipe. These features are in agreement with the details given for *C. trachodes* by Pegler (1986). The genus is closely related to *Chlorophyllum* by virtue of the green truncated spores, trichodermal structure of the pileal pellicle. The trichodermal chains in *Clarkeinda* are formed by shortened, subsisodiametric, doliform elements. This feature is unique to this genus. In India it has been documented from Kerala by Leelavathy *et al.*, (1981). It is reported for the first time from North India.

**6.1.7 Chlorolepiota Sathe & Deshpande – A Diagnosis**


**Type species:** *C. mahabaleshwarensis* Sathe & Deshpande

**Characters:** Carpophores large, lepiotoid. Pileus fleshy, convex; surface scaly; flesh reddening on bruising. Lamellae free, collariate, crowded, first white, becomes green on maturity, broad, deep; spore deposit greenish. Stipe central, obclavate with distinctly bulbous base, reddening on bruising; annulate, annulus double, complex, movable. Spores smooth, large, thick-complex walled, dextrinoid, congophilous, cyanophilous, strongly metachromatic with cresyl blue. Gill edges sterile. Cheilocystidia abundant, crowded. Pleurocystidia absent. Hymenophoral trama
regular. Pileus surface a trichodermal palisade of upright hyphae. Clamp connections present.

**Habitat:** Found growing on rich soils, also often in fairy rings.

**Development:** Hemiangiocarpous.

**Limits:** Sathe and Deshpande established the genus *Chlorolepiota* in 1979. It belongs to family Agaricaceae Chevall. and shows resemblance with *Chlorophyllum* in having greenish lamellae and green spore print. It is quite close to *Macrolepiota* in having similar external and internal morphology but for the absence of germpore in basidiospores and having green spore print in case of *Chlorolepiota*.

**Statistics:** The world over only single species, namely *C. mahabaleshwarensis* is known which was established by Sathe & Deshpande (1979) on the basis of collections from Mahabaleshwar in India. Presently, based upon the collections two species are described as new to science.

**Key to the species of Chlorolepiota investigated**

1. Lamellae yellowish white to yellowish grey, gill edges dentate, brown layered, thin annulus present near the mid of the stipe, pileus surface a disrupted trichoderm of cylindrical elements; spores 8 - 12.8 x 6.4 - 8 µm in size ........................................................................................................... *C. indica* sp. nov.

1.’ Lamellae greenish white, gill edges smooth, prominent annulus present, pileus surface a disrupted trichoderm of cylindrical to narrowly clavate elements measuring up to 10 – 16 µm in width; spores 7 - 9 x 5.5 - 7 µm in size........................................................................................................... *C. brunneotincta* sp. nov.

i. *Chlorolepiota indica* sp. Nov

Figs. 67 (A- B) & 68 (A-E)

Carpophores 5 - 7.6 cm in height. Pileus 5.3 - 8 cm in diameter, convex, surface dry with brown broad umbo (6E4), covered with concentrically arranged brown (6E4) scales with yellowish tinge over creamish background, scales more dense towards the center and sparsely aggregated along the periphery; margin
irregular, splitting at maturity; cuticle fully peeling; flesh yellowish white (4A2), changing from pale yellow (4A3) to finally pink on exposure, 0.3 - 0.5 cm thick; taste and odour spicy. Lamellae free, collariate, subdistant, yellowish white, unequal, of 3 - 4 lengths, 0.9 cm broad, ventricose, yellowish white to yellowish grey (2A2 - 2B2), finally greenish when mature and brown on drying; gill edges dentate, brown layered. Stipe central, 4.5 - 7 cm long, 0.6 - 0.9 cm broad, 1.4 cm broad near the bulbous base cream to pale yellow (4A3), pinkish to reddish brown on bruising near stipe attachment and yellowing to dark grey brown on bruising elsewhere, obclavate, hollow, scaly; annulate, annulus single, present near the mid of the stipe, some specimens with band like marking near the base.

Spores 8 - 12.8 x 6.4 - 8 µm (Q = 1.37), broadly ellipsoid, apical pore indistinct to almost none, dextrinoid, metachromatic in cresyl blue, congophilous, cyanophilous. Basidia 30.6 - 46.7 x 9.6 - 12.8 µm, clavate, tetrasporic; sterigmata 3.2 - 6.4 µm long; gill edges sterile. Cheilocystidia very crowded, 37 - 66 x 9.6 - 17.7 µm, versiform, lageniform to cylindrical or even heart shaped, appear in clusters, some with brownish content or some hyaline. Pleurocystidia absent.

Figs. 67 A- B: Carpophores of Chlorolepiota indica sp. nov.
Pileus cuticle a trichoderm consisting of thin walled cylindrical elements measuring 4 - 8 µm in width; context homoiomerous; hymenophoral trama regular, trama hyphae 4 - 10 µm broad; subhymenium pseudoparenchymatous. Stipe cuticle hyphae parallel running throughout measuring 4 - 12 µm in width. Clamp connections present throughout.

Collection examined: Punjab, Patiala, Punjabi University campus (250 m), scattered on sandy soil under *Eucalyptus* tree, Harwinder Kaur, PUN 4423, September 17, 2010.

Remarks: The presently examined collection falls in the overall limit of genus *Chlorolepiota* in view of its intermediate features between *Chlorophyllum* and *Macrolepiota*. It differs from *Chlorophyllum* in having non-truncate spores which show strong metachromatic reaction with cresyl blue. From *Macrolepiota* the major difference is its lamellae colour which becomes greenish brown at maturity. There is only one species, namely *C. mahabaleshwarensis* Sathe & deshpande under *Chlorolepiota* (Kirk et al., 2008), which was described by Sathe & Deshpande (1979) from India. The present collection is quite different from the earlier described species in having convex brown pileus with concentrically arranged brown scales with yellow tinge around the centre, cream to pale yellow stipe which becomes pinkish to reddish brown on bruising, whitish flesh changing to yellowish white and then pinkish on exposure, smaller spores measuring 8 - 12.8 x 6.44 - 8 µm (Q = 1.37) and larger cheilocystidia measuring 37 - 66 x 6.44 - 8 µm in comparison to buffish yellow to straw coloured pileus, primrose yellow gills, buffish yellow stipe which don’t change colour on bruising, large spores (11.44 - ) 14.30 - ( - 15.73) x (5.72 - ) 8.58 ( - 9.3) µm (Q = 1.67) and smaller cheilocystidia measuring 17.16 - 20.0 x 5.72 - 14.30 µm in
Figs. 68 (A-E) Chlorolepiota indica sp. nov.: A. Carpophore, B. Basidiospores, C. Hymenophore with basidia, D. Cheilocystidia, E. Pileus trichodermial elements.
**Taxonomic observations**

*C. mahabaleshwarensis*. In view of the above difference in the presently examined collection from *C. mahabaleshwarensis* a new species *C. indica* has been proposed.

ii. *Chlorolepiota brunneotincta* sp. nov.  
Figs. 69, 70 (A-D) & 71 (A-E)

Carpophores 2.5 – 6.5 cm in height. Pileus 2.5 – 5.5 cm wide; surface, moist, white, convex to campanulate with a prominent broad tawny or brown umbo covered with brown fibrillose scales over yellowish white (4A2) background; margin striate, regular, splitting at maturity; cuticle fully peeling; flesh up to 3 mm thick, white, changing to brownish on bruising; taste and odour mild; spore deposit yellowish white (4A2) with greenish shade. Lamellae free, collariate, unequal, of 3 – 4 lengths, crowded, 2 - 4 mm broad, white to greenish white, becomes brownish green on drying; gill edges smooth. Stipe central, up to 6.3 cm long, 0.2 - 0.6 cm broad, white, colour changes to brownish on bruising, equal in diameter, hollow, scaly; annulate, annulus single, peronate.

Spores 7 - 9 x 5.5 - 7 μm (Q = 1.28) ellipsoid, thick walled, non-truncate, appears aporous, with rounded apex studded with a poral plug, dextrinoid, cyanophilous, congophilous, metachromatic in cresyl blue. Basidia 18 - 30 x 7 - 10 μm, clavate, tetrasporic; sterigmata up to 4 μm long; gill edges sterile. Cheilocystidia 25.5 – 44.5 x 6.5 - 9 μm, crowded, clavate to cylindric, subcapitate or even slightly lageniform. Pleurocystidia absent.

Pileus cuticle a disrupted trichoderm of cylindrical to narrowly clavate elements measuring 10 – 16 μm in width; context homoiomerous; gill trama regular; tramal hyphae measuring 8 - 20 μm; subhymenium pseudoparenchymatous, well developed. Stipe cuticle hyphae parallel running throughout, measuring 3.2 - 14.5 μm in width. Clamp connections present in the basal mycelium and stipe surface hyphae. Hyphal construction monomitic.
Collection examined: Solan, Kather (1350 m) growing scattered on soil in Pinus roxburghii forest, Babita Kumari, PUN 4711, August 17, 2008.

Remarks:- The present collection is characterized by medium statured whitish carpophores with convex to campanulate pileus having prominent brown umbo enriched by brown fibrillose scales over yellowish white (4A2) background, collariate greenish white lamellae, white coloured flesh and stipe changing brownish on brusing, ellipsoid non truncate dextrinoid metachromatic spores with rounded apex studded with poral plug, crowded versiform cheilocystidia rendering gill edges sterile, absence of pleurocystidia and presence of clamp connections in the stipe surface hyphae and basal mycelium.

The details of this collection closely resembles with Chlorophyllum molybdites in outward morphology, scaly pileus and unique green coloration of lamellae and spores except for shape of cheilocystidia, nontruncate spores, presence of clamp connection in the basal mycelium and stipe hyphae and brown colouration of flesh and stipe surface on bruising. In its gross morphology and presence of clamp connection the present collection resemble Macrolepiota. However, comparatively short stature of the carpophores, green colour of lamellae and absence of apical truncation in the spores makes the present collection quite distinct from Macrolepiota. Most of the features of this collection comes quite close to the taxonomic details of Chlorolepiota, a genus described by Sathe and Deshpande (1979) from Poona, which is characterized by macrolepiotoid habit, yellowish green spore deposit and absence of clamp connections. Chlorolepiota is a monotypic genus with only one species C. mahabaleshwarensis. In comparison to C. mahabaleshwarensis the presently examined collection has smaller spores (7 - 9 x 5.5 - 7 µm instead of 11.4 – 15.7 x 5.7
Taxonomic observations

9.3 µm) browning flesh and stipe surface on bruising, versiform cheilocystidia and clamp connection in the basal mycelium and stipe surface hyphae. Since in the allied two genera (*Macrolepiota* and *Chlorophyllum*) the presence of clamp connection is a prominent character, the feature which the present variant also possesses but the same is reported to be absent in the genus *Chlorolepiota* (Sathe and Deshpande, 1979) which seems to be an aberration the description is based on limited observation since the genus is monotypic and the description is single collection based, hence no importance has been given to this features in the present case.

![Fig. 69: Carpophores of Chlorolepiota brunneotincta in natural habitat.](image)
Figs. 70 (A-D): A. Basidiospores in cresyl blue showing metachromatic reaction, B. Basidiospores in Congo red, C. Clamp connection in stipe surface hyphae, D. Cheilocystidia.

The distinguishing characters of the presently examined collection provides a sufficient ground for the erection of a new species. Its molecular sequencing was also done so as to arrive at the final conclusion. The sample exhibited 84% homology with *Chlorophyllum molybdites* and Lepiotaecae in the parsimony analysis, which clearly takes it away from *Chlorophyllum*. Along with other features, taking browning of flesh and stipe surface on bruising into consideration as a unique character of this variant of *Chlorolepiota*, a new species *C. brunneotincta* has been proposed to accommodate this collection.
Figs.71 (A-E) *Chlorolepiota brunneotincta* sp. nov.: A. Carpophore, B. Basidiospores, C. Basidia, D. Cheilocystidia, E. Pileus trichodermal elements.
6.1.8 *Chlorophyllum* Massee – A Diagnosis


**Type species:** *C. esculentum* Mass. [C. *molybdites* (Mayer : Fr.) Mass].

**Characters:** Carpophores large, lepiotoid. Pileus fleshy, convex; surface scaly, entire at the disk, elsewhere disrupting to form large plate like or coarse squamules; flesh reddening on bruising. Lamellae free, collariate, crowded, first white then becomes green on maturity, broad, deep; spore deposit greenish to greyish buff. Stipe central, obclavate with distinctly bulbous base, reddening on bruising; annulate, annulus double, complex, movable. Spores smooth, large, thick-complex walled, dextrinoid, congophilous, cyanophilous, strongly metachromatic with cresyl blue. Gill edges sterile. Cheilocystidia abundant, crowded. Pleurocystidia absent. Hymenophoral trama regular. Pileus surface a trichoderm palisade of upright hyphae. Clamp connections present.

**Habitat:** Found growing on rich soils, mostly under trees, gardens and plantations also often in fairy rings, probably in woods in the tropics.

**Development:** Hemiangiocarpous.

**Limits:** Massee (1898) established this genus. It belongs to tribus Leucocoprineae Sing. of family Agaricaceae Chevall. and differs from the other members of the tribus Leucocoprineae in having greenish lamellae and green spore print. *Chlorophyllum* is distinguished from its closely related genus *Clarkeinda* in having large spores and absence of volva, which is present in the genus *Clarkeinda*. It closely resembles *Macrolepiota* in having largely similar morphology.

**Statistics:** The world over 8 species of the genus *Chlorophyllum* Massee are known (Hawksworth *et al.*, 1995). From India *C. molybdites* (Mayer : Fr.) Massee was documented by Ghosh *et al.*, 1976; Sathe and Deshpande, 1980; Natarajan and Manjula, 1981 and Bhavani Devi, 1995. Besides this, three more species have also
been described from India namely, *C. cochinense* Sathe and Sasangan (1977), *C. bharatense* Sathe and Kulkarni (1980) and *C. shimogaense* Sathe and Kulkari (1980).

In the present study five collections of this genus have been worked out for their macroscopic and microscopic details. Key to the invesigated species of *Chlorophyllum* is given below:

**Key to the species of Chlorophyllum investigated**

1. Fruit bodies up to 25.5 cm in height; flesh changing colour when bruised or cut; lamellae becoming greenish when mature; spore print green; spores 7.5 (9.1) - 9.9 (12.5) x 5.8 (7.2) - 7.4 (8.3) µm, germpore present .................................................. *C. molybdites*

1'. Fruit bodies up to 8.7 cm in height; flesh unchanging colour when bruised or cut; spore print whitish; basidiospores 8 - 9 x 6.4 - 7.2 µm subglobose to ellipsoid, without a germ pore...*C. sphaerosporum var. macrospora var. nov.*

Figs. 72 (A-B) & 73 (A-E)

**Synonyms**

*Agaricus molybdites* Meyer : Fr., *Syst. Mycol.* 1: 308 (1821)  
*A. morganii* Peck in *Bot. Gaz.* 4: 137 (1879)  
*A. glaziovii* Berk. in *Vidensk. Meddel.* 1879-80: 32(1880)  
*Lepiota molybdites* (Meyer : Fr.) Sacc., *Syll. Fung.* 5: 30 (1887)  
*Pholiota glaziovii* (Berk.) Sacc., *Syll. Fung.* 5: 30 (1887)  
*Lepiota ochrospora* Cooke & Massee in *Grevillea* 21: 73 (1893)  
*C. esculentum* Massee in *Bull. Misc. Inf. Kew* (1898)  
*Agaricus guadelupensis* Pat. in *Bull. Soc. Mycol. Fr.* 15: 197 (1899)  
*Lepiota esculenta* (Massee) Sacc. & Syd., *Fung.* 16: 2(1901)  
*Agaricus congoensis* Beeli in *Bull Soc. Roy. Bot. Belg.* 61: 92, fig. 46 (1928)  

Fructifications 7.5 - 25.5 cm in height. Pileus 5 - 14.0 cm in diameter, convex with broad umbo; surface yellowish white (4A2) to orange white (5A2), covered with radiating brown fibrillose scales and squamules around umbo region, margin
irregular, splitting at maturity; cuticle fully peeling; fleshy, flesh 1 - 1.2 cm thick, white, unchanging; taste and odour mild. Lamellae free, unequal, of 3 lengths, subdistant, up to 1.2 cm broad, yellowish white (4A2) to orange white (5A2), changes from greyish yellow to olive, or even greyish green, ventricose, normal; gill edges smooth to slightly wavy; spore print oliv to greyish green (30B6) to olive brown (4D3). Stipe central, 6.7 - 21 cm long, 1.8 cm broad near the base, concolorous with the pileus, slightly tapering upward with distinctly bulbous base, fleshy, with hollow centre; surface hairy, stipe colour changes to brownish on bruising; annulus double, persistent, movable, scaly, peronate.

Spores 7.5 (9.1) - 9.9 (12.5) x 5.8 (7.2) - 7.4 (8.3) µm (Q = 1.26 - 1.32), broadly ellipsoid, thick walled, dextrinoid, congoophilous, cyanophilous, metachromatic in cresyl blue, apiculate, apically truncated by a germ pore. Basidia 24.9 - 36.5 x 8.3 - 13.3 µm, tetrasporic, clavate, hyaline, thin walled sterigmata 3.3 – 5.0 µm in length; gill edges sterile. Cheilocystidia abundant, 21.6 - 38.2 (46.3) x 11.6 - 24.9 µm in size, globose, pyriform to broadly clavate, thin walled.

Pileus cuticle a trichoderm, consisting of thin walled hyphae with long septate tubular or rounded apex hyphae measuring from 3.3 - 15.6 µm in width; context homoiomerous, made up of septate hyphae measuring from 3.3 - 6.6 µm in diameter; gill trama regular. Stipe surface consists of parallel running septate hyaline hyphae measuring 6.6 - 17.8 µm in width. Veil tissue of septate hyphae measuring 4.2 - 10.8 µm in width. Clamp connections present.
Taxonomic observations

Figs. 72 (A-B) *Chlorophyllum molybdites*: A. Basidiospores, B. Clamp connection.

**Collections examined**: Punjab, Hoshirapur, Nawanshahar, Jahal Kalan (300 m), growing in caespitose clusters under *Cannabis* on sandy soil, Babita Kumari, PUN 4429, July 18, 2008; Patiala, Bahadurgarh (250 m), growing scattered among *Cynodon dactylon*, Babita Kumari, PUN 4431, May 23, 2008; near Punjabi University gate (250 m), growing scattered on humicolous soil, Babita Kumari, PUN 4432, July 4, 2008; Faridkot (196 m), growing in caespitose clusters on wheat straw, Babita Kumari, PUN 4433, August 28, 2008; Patiala, Baradari garden (250 m), growing scattered on humicolous soil, Babita Kumari, PUN 4462, August 24, 2009; Patiala, Shekhupura (250 m), growing scattered on humicolous soil, Babita Kumari, PUN 4421, July 13, 2010.

Himachal Pradesh, Solan, Kather (1650 m), growing scattered on humicolous soil in Pine forest, Babita Kumari, PUN 4430 August 7, 2008.


*var. macrospora* var. nov.

Figs. 74 (A-F)

Carpophores 2.4 - 8.7 cm in height. Pileus 2 - 2.3 cm in diameter, convex, surface covered with appressed fibrilllose greyish brown (6D3) to brown (7E4) scales over a yellowish white background; margin regular, splitting at maturity; cuticle fully peeling; flesh yellowish white, unchanging, 0.5 - 0.7 cm thick; taste and odour mild. Lamellae free, crowded, collariate, yellowish white (4A2), unequal, of 3 - 4 lengths, 0.5 - 0.7 cm broad, ventricose; gill edges smooth; spore print whitish. Stipe central, up to 6.4 cm long, 0.8 - 0.9 cm broad, yellowish white, (4A2), concolourus with the pileus, obclavate with distant bulbous base with white mycelial strands, hollow, brownish on bruising; annulate, annulus double, ascending, attached.

Spores 8 - 9 x 6.4 - 7.2 µm (Q = 1.2), subglobose to ellipsoid, apical pore absent, dextrinoid, metachromatic in cresyl blue, congophilous, cyanophilous. Basidia 28.9 - 45 x 8.8 - 11.3 µm, clavate, clamp connection absent at the base of basidia, tetrasporic; sterigmata 3.2 - 4.8 µm long; gill edges sterile. Cheilocystidia crowded, 16 - 37 x 10.5 - 20.9 µm in size, pyriform, clavate, globose with pedicellate cells, clamps absent at the base. Pleurocystidia absent.

Pileus cuticle composed of a disrupted trichoderm consisting of thin elongated elements with basal clamp connection measuring 32 - 80 (95) x 15 - 23 µm; context homoiomerous with numerous laticiferous elements; gill trama regular, tramal hyphae measuring 4 - 10 µm in width; subhymenium pseudoparenchymatous. Stipe cuticle hyphae parallel running throughout measuring 4 - 20 µm in width. Clamp connections present throughout.

**Collection examined:** Punjab, Patiala Sukhna Lake (321 m), growing scattered in humicolous soil, Babita Kumari, PUN 4663, September 3, 2009.
Figs. 74 (A-F) *Chlorophyllum sphaerosporum* var. *macrospora* var. nov.: A. Carpophore, B. Basidiospores, C. Basidia, D. Pileus squamules, E. Pileus cuticle elements, F. Cheilocystidia.
**Remarks:-** It is characterized by greyish brown scales over yellowish white background, annulate stipe having mycelial strands at the base, presence of pyriform cheilocystidia and pileus cuticle formed of distributed trichodermal elements. It is quite close to *Chlorophyllum sphaerosporum* and *C. bharatense* in having similar external and internal morphology except in lacking discoumation of stipe on exposure and slightly larger spores which measures (8.0) 9.0 – 10.0 (11) x 7.0 – 9.0 (9.5) µm in *C. sphaerosporum* and 9.5 – 11 x 6.5 – 8.5 µm in *C. bharatense* as compared to 8- 9 x 6.4 – 7.2 µm sized spores in the presently examined collections. In *C. bharatense* the trichodermal elements are broader measuring 32 - 80 (95) x 15 – 23 µm in size as compared to 43 – 108 x 11 – 13.5 µm sized elements in the present collection. In view of the prevailing differences from both these species, a new variety *C. sphaerosporum* var. *macropora* has been proposed based upon the presence of larger spores. This species is described for the first time from India.

### 6.2. Family *Lyophyllaceae* Jülich – A Diagnosis

**Type genus:** *Termitomyces* Heim

Carpophores very small to large robust. Pileus hemispherical, then expanded to convex, with or without umbo, viscid or not. Lamellae free, adnato-decurrent to decurrent, thin, often crowded with lamellulae. Stipe central, lateral or sometimes prolonging downwards into soil forming pseudorrhiza. Veil present either as velar squamules or persistent but may be consistent or absent at maturity. Context soft, fleshy. Hyphal system monomitic with or without clamp connections. Spore print white, cream, pinkish, pale or buff but never dark. Chlamydospores may be present or absent. Spores inamyloid or amyloid and even dextrinoid lacking a germ pore, oval to ellipsoid or cylindrical, smooth or ornamented. Basidia with or without siderophilous granules. Cystidia present or absent. Lamella edges with or without sterile cells.
Taxonomic observations

Hymenophoral trama subparallel, bilateral to irregular. Pileus surface either trichodermial or undifferentiated, glutinous or not. Clamp connections present or absent.

**Development:** Gymnocarpic or hemiangiocarpic.

**Habitat:** Terrestrial, lignicolous, parasitic, foliicolous, on humus, and debris.

**Statistics:** This family includes 8 genera namely, Asterophora, Blastosporella, Calocybe, Hypsizygus, Lyophyllopsis, Lyophyllum, Ossicaulis, Tephrocybe, and Termitomyces spread over 157 species (Kirk et al. 2008). During the present work only termitophilous genus Termitomyces belonging to this family has been investigated.

### 6.2.1 Termitomyces Heim – A Diagnosis

*Arch. Mus. Nat. Ser.* (6) 18: 147, 1942

**Type species:** *Termitomyces striatus* (Beeli) Heim

**Characters:** Basidiocarp pleurotoid or mycenoid to collybioid. Pileus very small (*T. microcarpus*) to very large (*T. titanicus*, which is the largest mushroom in the world, according to Guinees Book of records which has a cap having diameter up to 1 m whereas in *T. microcarpus* diameter rarely exceeds 2 cm), usually with a prominent perforatorium. Pileus colour varies from snow white to orange or even blakish brown, radially striate along the margin, with or without velar remains, dry or with a glutinous surface. Lamellae free to adnexed, rarely with decurrent tooth, pale to pinkish, crowded. Spore deposit yellowish white to pinkish. Stipe central, solid, usually with a long pseudorrhiza. Veil annulate, appendiculate, cortinoid or even absent. Context soft, fleshy, white, formed of hyaline inamyloid hyphae. Hyphal system monomitic, usually without clamp connections. Spores thin walled, inamyloid, hyaline, cyanophilous, ovoid to ellipsoid. Basidia inamyloid, hyaline, with
Taxonomic observations

siderophilous granules, clavate, tetrasporic. Lamellae edges heteromorphous to sterile. Cystidia smooth, often present, numerous and large. Gill trama subregular to bilateral divergent. Subhymenium well developed, pseudoparenchymatous. Pileus surface a cutis of undifferentiated to differentiated, repent hyphae which often get gelatinized. Clamp connection absent.

Habitat: - Often growing on termite nests or underground termitaria and its neighbouring soil because of which these are referred as termitophilous mushrooms.

Development: - Largely hemiangiocarpic to angiocarpic.

Distribution: - *Termitomyces* is a Paleotropical genus distributed throughout and Southern Africa and South East Asia.

Limits: - Genus *Termitomyces* was established by Heim (1942 a, b, c) and was classified under family Amanitaceae. Jülich (1981) erected a seperate monotypic family Termitomycetaceae to accommodate *Termitomyces*. Later Pegler (1986) shifted the genus to family Pluteaceae along with *Volvariella* and *Pluteus*. Singer (1986), due to presence of cyanophilous spores, bilateral lamellar trama, siderophilous staining of basidia and spore hilum of the open pore type shifted this genus to family Tricholomataceae next to Lyophyllaceae under tribus, Termitomyceae, due to complete absence of clamp connections. Molecular analysis (Moncalvo *et al*., 2000) supports its classification under Tricholomataceae within or near Lyophyllaceae (Kirk *et al*., 2008). However, Kirk *et al*., (2008) group it under family Lyophyllaceae.

Statistics: - The world over 30 species of genus *Termitomyces* Heim are documented so far (Kirk *et al*., 2008) out of which 21 species are known from India (Bilgrami *et al*., 1991, Atri *et al*., 2005 b). In the present study 29 collections, spread over 14 species collected from different localities of North West India have been worked out for their macroscopic and microscopic details. These species are, namely *T.*
microcarpus (Berk. & Br.) Heim, T. badius Otieno, T. medius Heim and Gasse, T. clypeatus Heim, T. radicatus Natarajan, T. schimperi (Pat.) Heim, T. mammiformis forma albus Heim, T. heimii Natarajan, T. sagittiformis (Kalchbr. & Cooke) D.A. Reid, T. reticulatus Van der Westhuizen & Eicker, T. striatus (Beeli) Heim, T. umkowaani (Cooke & Mass.) Reid, T. eurhizus (Berk.) Heim and T. robustus (Bl.) Heim. Out of these T. reticulatus Westhuizen and Eicker is new fungus record for India. T. sagittiformis, T. schimperi (Pat.) Heim and T. robustus are recorded for first time from North India. The other worked out species are already documented by (Atri et al., 2005 b). In the ongoing account a key to the identification of the presently investigated species of Termitomyces has been given. In the text the description of individual species is given in the sequence of its segregation in the key below:

**Key to the species of Termitomyces investigated**

1. Annular veil present.................................................................2
   1.’ Annular veil absent......................................................................7
2. Annular veil double, persistent.........................................................3
   2.’ Annular veil double ridged to membranous, but never double.........................................................4
3. Carpophores 11- 31 cm in height including pseudorrhiza which is longitudinally twisted and scabrous below the annulus and with brown squamules above ground; spores 5.6 - 7.2 (8) x 4 - 4.8 (5.6) µm ..................................................................................................................T. heimii
   3.’ Carpophores up to 11 cm in height including pseudorrhiza with patchy white scales on the lower portion of the stipe; spores 6.4 - 9 x 4 - 5.6 (6.4) µm in size...........................................................................................................T. schimperi
4. Pileus with scrobiculate mammiform perforatorium; stipe with long creamish to pale coloured pseudorrhiza.........................................................................................T. mammiformis
   4.’ Pileus with conical to obtusely rounded perforatorium, stipe with long creamish to brownish pseudorrhiza.................................................................5
Taxonomic observations

5. Carpophores 34.4 - 38.6 cm in height including pseudorrhiza which is creamish but appear brownish due to adhering soil particles ................................................................. *T. reticulatus*

5.’ Carpophores 15 - 17 cm in height including pseudorrhiza which possess pale to brownish surface ................................................................. 6

6. Pileus up to 6 cm broad, planate with obtusely rounded umbo, feebly striate and splitting along the margin but without veil ...................................... *T. eurhizus*

6.’ Pileus 3 - 5.6 cm in diameter; conico-convex with conical perforatorium, margin radially striate and splitting and with prominently hanging veil ................................................................. *T. striatus* var. *annulatus*

7. Carpophores 2.5 - 8 cm in height including pseudorrhiza ........................................ 8

7.’ Carpophores 9.5 - 21 cm in height including pseudorrhiza ........................................ 11

8. Carpophores scattered on wet termitophilous soil; pileus cuticle with subcellular elements giving rise to a turf of projecting hyphae; Cheilocystidia present, pleurocystidia sometimes lacking ........................................ 9

8.’ Carpophores gregarious on termitaria; pileus cuticle hyphal with subcellular elements giving rise to a turf of projecting hyphae; pleurocystidia and cheilocystidia present ................................................................. 10

9. Pileus 2 - 4 cm in diameter, surface yellowish white with brownish grey spiniform perforatorium; pleurocystidia lacking; gill edges serrate ................................................................. *T. radicatus*

9.’ Pileus 1.3 - 2.5 cm in diameter, surface yellowish white with orange grey spiniform perforatorium; both pleurocystidia and cheilocystidia present; gill edges smooth ................................................................. *T. medius*

10. Carpophores shining white with an occasional orange white umbo; cheilocystidia versiform without basal cells ................................................................. *T. microcarpus*

10.’ Carpophores greyish brown with brownish umbo; cheilocystidia pyriform with 2 - 3 basal cells ................................................................. *T. badius*

11. Carpophores up to 13.5 cm including pseudorrhiza; pseudorrhiza dark brown ................................................................. 12

11.’ Carpophores more than 17 cm including pseudorrhiza, pseudorrhiza white to yellowish white ................................................................. 13

12. Perforatorium obtusely nipped; surface not scrobiculate, splitting radially almost to the disc; cheilocystidia hyaline without any transverse septa ................................................................. *T. sagittiformis*
12.’ Perforatorium acute; surface scrobiculate, not splitting as above; cheilocystidia thick walled with transverse septa……………………………………T. robustus

13. Spores 6.4 - 9.6 (10.5) x 4.8 - 5(6.5) µm; doliform cells present in pileus context; caulocystidia present…………………………………………….T. umkowaani

13.’ Spores 5.6 - 8 x 4 - 5.7 µm; doliform cells lacking in pileus context; caulocystidia absent……………………………………………..T. clypeatus


Figs. 75 (A-B) & 76 (A-F)

Synonyms


Carpophores 11 - 31 cm in height including pseudorrhiza. Pileus 3.9 - 7 cm in diameter, convex then expanding to planate with a broad perforatorium; surface dry, silky white with yellowish white (4A2) to pale yellow (4A3), appressed fibrilloose scales; margin irregular, incurved, non striate, splitting at maturity; cuticle fully peeling; flesh white, unchanging, 0.4 cm thick; taste and odour mild. Lamellae free, white, (1A1) to whitish pink, unequal, of 3 - 4 lengths, subdistant to crowded, 0.7 cm broad; gill edges serrate; spore deposit pale yellow (4A2). Stipe central, 4.5 - 6.8 cm long with 26 cm long pseudorrhiza, 0.6 - 1.0 cm broad, 1.6 cm broad near the annulus, solid above the ground, subterranean part hollow, light brown squamules present on the above ground portion, pseudorrhiza longitudinally twisted, scabrous below the annulus; veil in the form of persistent double annulus which is attached to upper quarter of the stipe.

Spores 5.6 - 7.2 (8) x 4 - 4.83 µm (Q = 1.36), ovoid to ellipsoid, thin walled, with suprahilar depression containing oil droplets, siderophilous granules present, inamyloid, hyaline. Basidia 14.5 - 27.3 x 4.8 - 11.3 µm, clavate, inamyloid, tetrasporic; sterigmata 1.6 - 3.3 µm long; lamellae edges heteromorphous. Cheilocystidia abundant, 18.9 - 43.5 x 12 - 19.3 µm, broadly clavate to pyriform with
1-2 basal cells, hyaline. Pleurocystidia 20.9 - 53.9 x 6.4 - 22.5 µm, occasionally present, clavate to pyriform with 1-2 basal cells, inamyloid.

Pileus cuticle formed of radially arranged gelatinized, inamyloid 1.6 - 4 µm broad hyphae, some hyphae inflated up to 22.5 µm in width; context homoiomerous; gill trama almost regular with numerous laticiferous elements; tramal hyphae 2.4 - 6.5 µm broad; subhymenium pseudoparenchymatous. Stipe cuticle hyphae thin walled, measuring 1.6 - 3.2 µm in width; context hyphae 4.8 - 9.9 µm wide. Clamp connections absent.

**Figs. 75 (A-B) **T. heimii**: A. Carpophores of *T. heimii* in their natural habitat, B. Mycelium in petriplate.

**Collections examined:** Punjab, Hoshiarpur (300 m), growing scattered on termite hills, Munruchi Kaur and Yadwinder Singh, PUN 4243, July 16, 2008; Patiala, Punjabi University Campus, near Art gallery (250 m), growing scattered on termite hills, Babita Kumari, PUN 4244, August 19, 2009.

**Remarks:** The macroscopic and microscopic details of the above described specimens are typical of *T. heimii* as described by Natarajan (1979). The main characteristics of this species are medium sized carpophores having pileus with broad perforatorium, incurved and nonstriate pileus margin, well developed annulus and stipe surface with light brown squamules. It is a well documented edible mushroom of
South East Asia including India, Malaysia and Pakistan (Pegler & Vanhaecke, 1994). Atri et al., (2005 b) reported it from different localities of Punjab Plains.

**Culture characteristics:** - The culture was raised on PDA medium. In culture the mycelium was white which became fluffy, dense with slightly blakish pigmentation at maturity. Over all, the colony appeared regular and emitted fungoid odour. Culture has been deposited in the GenBank of Directorate of Mushroom Research, Chambaghat, Solan, under accession no. DMRX 1084.

Figs. 77 (A-E) & 78 (A-F)

**Synonym**

*Lepiota schimperi* Pat; Rev. Mycol. 13: 135(1891)

Carpophores up to 31 cm in height including pseudorrhiza. Pileus 2.5 - 7.2 cm in diameter, convex with a broad perforatorium; surface white with brownish orange (5C4) centre, moist; scales appressed fibrillose; cuticle alveolately shredded along the periphery with central unbroken plate, shreds equal and parallel; margin irregular, giving petal like appearance to pileus surface due to deep splitting at maturity; cuticle half peeling; flesh white, unchanging, up to 1 cm thick; taste and odour mild. Lamellae free, crowded, unequal, up to 7 mm broad, white unchanging; gill edges serrate. Stipe central, up to 4.3 cm long excluding pseudorrhiza which is up to 20.6 cm long and attenuating upward, broadening up to 0.8 - 1.5 cm in the middle then tapering downwards with a discoidal base, white, hollow, covered by thick squamules of veilar remains scattered in annulate fashion down the stipe; or patchy type scales remaining on lower portion of stipe, persistent.

Spores 6.4 - 9 x 4.5 - 6.4 µm (Q = 1.5), broadly ellipsoid, thin walled, inamylloid, cyanophilous, smooth with guttulate contents. Basidia 17.7 - 30.6 x 6.64 - 11.3 µm, double walled, siderophilous granules present, tetrasporic; sterigmata up to 3
µm long; gill edges sterile. Cheilocystidia 20.9 - 32.2 x 8 - 14.5 µm, crowded, inflated, clavate to pyriform, thin walled, inamyloid. Pleurocystidia 22.5 - 44.2 x 6.44 - 12.8 µm, inamyloid, double walled, versiform with bifurcate to mucronate tip, some cystidia lanceolate to capitate-fusoid or even lageniform to flame shaped with tubular tip, some of them even pyriform, with or without transverse septa.

Pileus cuticle made up of radially arranged septate, inamyloid, thick walled, 4 - 6 µm broad hyphae, some of which are with inflated apical cells measuring up to 10 - 12 µm in width; context homoiomerous with numerous laticiferous elements; gill trama almost regular, composed of 3.23 µm broad hyphae. Stipe cuticle septate with lateral branches measuring 8 - 20 µm in width with numerous laticiferous elements. Clamp connections absent throughout. Veil tissue formed of an aggregation of inflated to cylindrical elements some of which are darkly stained measuring 6.4 - 12.8 µm in width.

Collections examined: Himachal Pradesh, Sirmour, Kotla Barog, (900 m), growing solitary on moist soil of termites, N.S. Atri, PUN 4238, August 16, 2009. Punjab, Patiala PUP, GTBH Road (250 m), growing scattered on termitaria, Babita Kumari, PUN 4332, September 5, 2009; Chandigarh, near Bus Stand (250 m), growing scattered on moist soil of termite hills, Babita Kumari, PUN 4301, September 05, 2009; Punjabi University Campus (250 m), gregarious to scattered on sandy soil, Babita Kumari, PUN 4302, August 16, 2009.

Remarks:-The above examined collections resemble with T. schimperi in their macroscopic and microscopic details as given by Van der Westhuizen and Eicker (1990). The chief characters include the presence of thick alveolately cracked velar squamules over the pileus surface, absence of prominent perforatorium and presence of versiform cystidia, some of which are septate. Recently, Mohanan (2011) also reported T. schimperi from Kerela (South India) which shows the wide distribution of this species from North to South India. Present collection is different from species as reported by Mohanan (2011) in having small spore size varying from 6.4 - 9 x 4.5 -
Taxonomic observations

Figs. 78 (A-F) *Termitomyces schimperi*: A. Carpophore, B. Basidiospores, C. Basidia, D. Cheilocystidia, E. Pleurocystidia, F. Pileus cuticle elements
6.3 (6.4) µm, presence of inflated cells and septation in cystidia as compared to 7 - 11 x 5 - 8 µm spores, absence of inflated cells and septation in cystidia in the collection from Kerala, creation of new variety has been avoided pending examination of more collections.


Figs. 79 & 80 (A-F)

Carpophores 10 – 41 cm long including pseudorrhiza. Pileus 3.4 - 7.0 cm in diameter, young pilei convex with obtuse scrobiculate perforatorium, surface whitish to creamish with pale yellow to light brown mammiform perforatorium; whitish, becoming coffee brown at maturity; surface with appressed fibrillose scales; margin striate, reflexed, irregular, splitting at maturity; cuticle alveolately shredded along the periphery with central unbroken plate; cuticle fully peeling; flesh 0.3 - 0.5 cm thick, white to creamish, unchanging; taste and odour mild. Lamellae free to adnexed, subdistant to crowded, unequal, lamellulae of 3 - 4 lengths, 4 - 8 mm broad, white (4A1) to creamish; gill edges serrate; spore deposit white. Stipe central, 2 - 4.5 cm in length with 28 - 35 cm long pseudorrhiza, 0.5 - 1.4 cm broad, attenuating upward, broad in the middle and tapering downwards in to a long pseudorrhiza, solid above ground, hollow below the soil; scaly, scales persistent, light brown, more dense below the annulus, pseudorrhiza creamish to pale coloured; annulate, annulus persistent, membranous to thick, uplifted, attached to the upper quarter of the stipe.

Spores 5.8 – 8 (8.8) x (3.3) 4.8 - 5.63 (6.4) µm (Q = 1.4), ovoid to ellipsoid with suprahilar depression, inamyloid, cyanophilous, thin walled, containing a single guttule. Basidia 15 - 30.6 x 4.9 - 9.6 µm, clavate, thin walled, inamyloid, tetrasporic; sterigmata 2.5 - 3.32 µm long; gill edges sterile to heteromorphous. Cheilocystidia
crowded, 16 - 38.2 x 8 - 18.3 µm, thin walled, inamyloid, clavate to pyriform without basal cells. Pleurocystidia scattered, 20.9 - 31.5 (33.2) x (4.8) 5.8 - 11.6 µm, thin walled, inamyloid, clavate, vesicolose to pyriform, similar to cheilocystidia.

Fig. 79: Termitomyces mammiformis: Mycelium in petriplate.

Pileus cuticle made up of radially arranged, gelatinized inamyloid 2.4 - 4.8 µm broad hyphae, some inflated 14.5 - 20.2 µm broad; context homoiomerous with scattered lacitiferous elements; gill trama bilateral to almost regular; tramal hyphae 3.3 - 8.3 µm wide. Stipe cuticle hyphae thin walled, projecting 2.5 - 5 µm broad; stipe context hyphae 4.9 - 20 µm broad. Clamp connections absent.

Collections examined: Punjab, Patiala, Punjabi University Campus (250 m), growing scattered on termitaria, Babita Kumari, PUN 4250, September 11, 2007; Goal market, (250 m), growing scattered on grassy soil, Babita Kumari, PUN 3947, July 5, 2008; Hoshiarpur, Pandori (300 m), growing scattered or in groups on termite hills, Munruchi Kaur and Yadwinder Singh, PUN 4251, July 17, 2008.

Remarks: The above examined collections belong to T. mammiformis forma albus. The macroscopic and microscopic details of this fungus are in full conformity with the description of T. mammiformis as given by Pegler (1977). It is a commonly occurring species of tropical Africa (Pegler, 1977) and is characterized by medium sized white coloured carpophores having pileus with scrobiculate mammiform
Taxonomic observations

perforatorium, striate margin, membranous annulus on upper part of the stipe and pale long pseudorhiza. Earlier report of this species is by Thite et al., (1976) from Maharashtra, Patil et al., (1979) described this species from Poona (Maharashtra) and Atri et al., (1995) reported it from Punjab.

Culture characteristics: - The culture of this species was raised on PDA medium. In the culture white mycelium appeared in concentric rings which emitted sweet alcoholic odour at maturity. The culture has been deposited in GenBank at Directorate of Mushroom Research, Chambaghat, Solan under accession no. DMRX 1087.


Figs. 81 & 82 (A-F)

Fructifications 34.5 - 38.6 cm long including pseudorhiza. Pileus 2.4 - 5.1 cm in diameter, convex to broadly conical with rounded broad umbo, surface white with greyish tinge in the centre, brown patches of soil particles adhering on the pileus surface around the umbo; margin smooth, without radial striations, splitting at maturity, white veilar elements prominently hanging from the margin; cuticle fully peeling; fleshy, flesh white, firm, unchanging, up to 0.6 mm thick near the umbo; taste and odour fruity. Lamellae free, crowded, ventricose, unequal, lamellulae of 3 lengths, 0.4 cm broad in centre, white; gill edges smooth to finely crenate. Stipe central, 5 - 6 cm in epigeal portion, solid, slightly expanding downward before tapering into white to creamish 29.5 - 33 cm long pseudorhiza which appear brownish due to adhering soil particles and closely appressed fibrils forming a ridged annular veil. Fibrils prominent in young carpophores mostly attached to the pileal margin and stipe leaving a torn area midway on the stipe, which appear stretched across the lamellae exposing white surface underneath, stipe surface of partially
Taxonomic observations

mature carpophores appears patchy due to shredding of the cuticular surface in a circular fashion.

Spores 6.4 - 8 x 4.8 - 5.7 μm (Q = 1.4), inamyloid, cyanophilous, thin walled, lacking suprahilar depression, ovoid to ellipsoid, containing single oil droplet. Basidia 17.7 - 25.8 x 6.4 - 8 μm, inamyloid, thin walled, clavate, siderophilous granules present, tetrasporic; sterigmata 1.6 - 2.4 μm long; gill edges sterile to heteromorphous. Cheilocystidia crowded, 19.3 - 64.4 x 8 - 29 μm in size, inamyloid, thin walled, clavate to pyriform with one basal cell, hyaline. Pleurocystidia occasional, inflated clavate to pyriform, inamyloid 23 – 32 (34.7) x 7 - 16 μm, several laticiferous ducts present on the gill edges and in pileus context.

Fig. 81: Carpophores of *Termitomyces reticulatus* in their natural habitat.
Pileus cuticle made up of gelatinized hyphae measuring 4 - 5 µm in width, subcutis 2 - 3 layered; context homoiomerous, made up of 2 - 4 µm broad hyphae; hymenophoral trama bilateral with numerous laticiferous ducts measuring 4.8 - 13 µm; subhymenium pseudoparenchymatous, made up of hyaline thin walled hyphae measuring 1.6 - 3.2 µm in width. Stipe cuticle hyphae thin walled hyaline 4.8 - 13 µm in diameter with some projecting hyphae measuring 1.6 - 3.2 µm in width. Clamp connections absent.

**Collections examined:** Patiala, Punjabi University Campus, Girls hostel road (250 m), growing scattered on sandy soil of termites, Arpana Lamba, PUN 4249, July 17, 2010; Punjabi University Campus (250 m), along the roadside, growing scattered on termitaria under *Lagerstroemia indica*, Harvinder Kour, PUN 3349, August 23, 2004.

**Remarks:**- The above examined collections belong to *T. reticulatus*. The macroscopic and microscopic details of this fungus are in conformity with the details of *T. reticulatus* given by Westhuizen and Eicker (1990). The mushroom is characterized by whitish pileus with patches of adhering soil particles over the surface, reticulate cuticle on the stipe surface, presence of thick laticiferous ducts and pedicellate cheilocystidia which are typical of *T. reticulatus*. This fungus is recorded for the first time from India.

**v. Termitomyces eurhizus** (Berk.) Heim in *Arch. Mus. Nat, Hist. Serr.* 6, **18**: 140 (1942).  
*Figs. 83* (A-F)

**Synonyms**

*Lentinus cartilaginous* Berk; *Lond. J. Bot.*: 496 bis (1847)  
*Agaricus sparsiباربیس* Berk. & Broome in *Trans. Linn. Soc.* 27: 151(1870)  
*Rajapa eurrhiza* (B.) Sing; *Lloydia* 8: 143, 1945.
Taxonomic observations

Fructification up to 16 cm long including pseudorrhiza. Pileus up to 6 cm in diameter, applanate with obtusely rounded umbo, surface yellowish white (4A2) to light brown with brownish centre, moist; perforatorium concolorous with hair like lines running along the surface; margin irregular, reflexed at maturity, feebly striate and splitting along the margin, striations extending radially towards the pileus surface; splitting at maturity; cuticle fully peeling; flesh off white, unchanging, up to 0.3 cm in thickness; taste mild and odour farinaceous. Lamellae free, crowded, unequal, lamellulae of 3 - 4 lengths, 0.4 cm broad in the middle, whitish to light yellowish pink; gill edges smooth, normal; spore deposit light yellow. Stipe central, up to 6.5 x 0.8 cm in size above the soil level, yellowish white (4A2) broadening near the base before tapering in to 7.8 cm long brown pseudorrhiza, surface smooth; annulus membranous, persistent.

Spores 5.8 - 8.3 x 3.3 - 5 µm (Q = 1.7), ovoid to ellipsoid having suprahilar depression, thin walled, apiculate, cyanophilous, hyaline, inamyloid. Basidia 14.9 - 23.24 x 6.6 - 8.3 µm, narrowly clavate, siderophilous, inamyloid, tetrasporic; sterigmata 1.6 - 3.3 µm long; gill edges sterile. Cheilocystidia 19.9 - 33.2 x 8.8 - 19.9 µm, scattered, abundant, inflated clavate to pyriform, thin walled, hyaline. Pleurocystidia 21.6 - 33.2 x 8 - 10.5 µm, abundant, inamyloid, thin walled, broadly clavate to ventricose.

Pileus cuticle made up of radially arranged repent granular hyphae measuring 3.3 - 6.6 µm in width; context homoiomerous, context hyphae 5.0 - 7.0 µm broad; hymenophoral trama bilateral measuring 5.0 - 7.0 µm in width; subhymenium pseudoparenchymatous. Stipe cuticle hyphae parallel running throughout, measuring 5 - 10 µm in diameter with numerous laticiferous elements. Clamp connections absent.
Collection examined: Punjab, Nawanshahar, Hakimpur (300 m), growing solitary on sandy soil, Munruchi Kaur, PUN 4240, July 18, 2008.

Remarks:- The above examined collection is typical of *T. eurhizus*. It is characterized by medium to large sized carpophores with brownish obtusely rounded umbo, cortinoid annulus and long dark brown pseudorrhiza. This species is quite close to *T. umkowaani* in having similar morphology including shape, size and dark coloured pseudorrhiza (Westhuizen and Eicker, 1990). However, it differs in having comparatively large sized spores and annulate stipe. It is a well known species from various parts of India including West Bengal (Purkayastha & Chandra, 1975), and Punjab (Atri et al., 2005 b).


**Figs. 84 & 85 (A-F)**

**Synonyms**


Carpophores 15 - 17 cm in height including pseudorrhiza. Pileus 3 - 5.6 cm in diameter, conico-convex, finally expanded with a prominent broad greyish brown (4D3) conical perforatorium; surface moist, viscid, whitish, radially fibrillose with patchy appearance below the perforatorium; margin striate; radially splitting at maturity; veil prominently hanging from the margin; veilar elements white; cuticle fully peeling; flesh white, unchanging, 0.3 - 0.4 cm thick near the perforatorium; taste and odour mild. Lamellae free, crowded, unequal, of 2 lengths, shining white in young carpophores, off white when mature, 0.3 - 0.5 cm broad; gill edges serrate; spore deposit pale white. Stipe central, 3 - 5.2 cm long in epigeal portion, 0.5 - 1.3 cm broad, solid, cylindric, fleshy, white, expanding downward before tapering into more than 12.5 cm long pale to light brown pseudorrhiza which is covered by fibrillose
scales throughout; surface white, fibrillose below the annulus, which is membranous and attached on the upper quarter of the stipe.

Spores 5.6 - 7.2 x 4 - 4.8 \( \mu \text{m} \) (Q = 1.5), ovoid to ellipsoid, inamyloid, cyanophilous, hyaline, thin walled, lacking a suprahilar depression. Basidia 16 - 27.4 x 5.6 - 8 \( \mu \text{m} \), clavate, thin walled, inamyloid, siderophilous granules present, tetrasporic, sterigmata 1.6 - 2.4 \( \mu \text{m} \) long; gill edges sterile. Cheilocystidia abundant, 25.76 - 45 x 10.7 - 20.9 \( \mu \text{m} \), thin walled, inamyloid, hyaline, clavate to pyriform, inflated. Pleurocystidia scattered, 20.9 - 32.2 x 8 - 10 \( \mu \text{m} \), thin walled, inamyloid, clavate inflated to pyriform.

Pileus cuticle formed of radially arranged upright hyphae measuring 2 - 4 \( \mu \text{m} \) in width. Context homoiomerous, made up of 2 - 4 \( \mu \text{m} \) broad hyaline hyphae; hymenophoral trama bilateral divergent to sub-regular to almost regular; tramal hyphae 3 - 9 \( \mu \text{m} \) wide; subhymenium interwoven, made up of hyaline thin walled hyphae measuring 2 - 4 \( \mu \text{m} \) in diameter. Stipe surface hyphae thin walled, hyaline, measuring 8 - 20 \( \mu \text{m} \) in width with some projecting hyphae measuring 2 - 4 \( \mu \text{m} \) in width. Clamp connections absent.

![Fig. 84: Carpophore of *Termitomyces reticulatus* in natural habitat](image)
**Collection examined:** Punjab, Patiala, Punjabi University campus (IAS Training centre) (250 m), growing scattered on termitaria, Babita Kumari, PUN 4283, September 6, 2009.

**Remarks:** The above examined collection is characterized by medium sized carpophores having conical perforatorium, striate margin, well developed annulus and prominent veil in the form of squamules over the entire pileus margin, elongated stipe forming pseudorrhiza. It seems quite close to *T. heimii* in its characteristic features (Pegler, 1977). From North India it was documented from Chandigarh by Rawla et al., (1983), from Kolkata by Roy and Samajpati (1981) and Punjab by Atri et al., (2005 b).


Figs. 86 (A-B) & 87 (A-E)

Carpophores 2.5 - 8 cm in height. Pileus 2 - 4 cm broad, convex with spiniform perforatorium; surface yellowish white (4A2) with brownish grey (4D2) centre, moist; scaly, scales appressed fibrillose, hairy; margin irregular, incurved, reflexed and splitting at maturity; cuticle fully peeling; flesh up to 2 mm in thickness, brittle, off white, unchanging; taste and odour mild. Lamellae free to adnexed, subdistant, unequal, of 3 - 4 lengths, not in series white to yellowish white (4A2), unchanging, 0.3 - 0.4 cm broad in the centre; gill edges serrate; spore deposit orange white (5A2). Stipe central, 2 - 4 cm long with 3 cm long and 0.2 - 0.4 cm broad pseudorrhiza, yellowish white (4A2), unchanging, smooth, hollow; annulus absent.

Spores 4.8 - 8.3 x 4 - 6.7 µm (Q = 1.45), ovoid to ellipsoid with 1 - 2 oil droplets lacking suprahilar depression, thin walled, hyaline, smooth, inamyloid. Basidia 18.3 - 28.2 x 6.6 - 10 µm, clavate, siderophilous, 4 spored; sterigmata up to 3 µm long; gill edges heteromorphous. Cheilocystidia 16 - 46.5 x 6.4 - 21.6 µm, few,
scattered, numerous, broadly clavate to pyriform, without basal cells. Pleurocystidia absent.

Pileus cuticle a trichoderm arising from the basal subcellular to hyphoid elements measuring 6 - 9 µm in width; context homoiomerous, made up of 4.5 - 7.5 µm broad hyaline hyphae; gill trama almost regular; subhymenium pseudoparenchymatous. Stipe cuticle formed of running parallel hyphae measuring 4 - 16 µm in width. Clamp connections absent.

Collections examined: Himachal Pradesh, Sarkaghat, Bakarta (850 m), growing scattered on moist soil of termitaria, Babita Kumari, PUN 4232, July 14, 2009.
Punjab, Mohali, Silvi Park (316 m), growing on termitaria, Munruchi Kaur and Babita Kumari, PUN 4670, July 22, 2009; Punjabi University campus, Guest House road (250 m), growing scattered on moist soil of termites, Babita Kumari, PUN 4671, July 25, 2010; Patiala, PUP (250 m), growing scattered on soil, Babita Kumari, PUN 4672, September 16, 2010.

Remarks: The above examined collections are typical of *T. radicatus*. Its morphological and internal details are in full conformity with those given for this species by Pegler (1977), Pegler and Vanhaecke (1994). The diagnostic characters

Figs. 86 (A-B) *Termitomyces radicatus*: A. Carpophores in their natural habitat, B. Mycelium growth in petriplate.
Figs. 87 (A-E) *Termitomyces radicatus*: A. Carpophore, B. Basidiospores, C. Basidia, D. Cheilocystidia, E. Pileus cuticle elements.
include presence of brownish grey spiniform perforatorium, short pseudorrhiza at the base of stipe, presence of cheilocystidia and absence of pleurocystidia. This species is very close to *T. microcarpus* and differs from it in having short pseudorrhiza. Natarajan (1977 a) described this species from Jammu as a new species. Atri *et al.*, (2005 b) recorded this species for the first time from Punjab plains. It is being collected in bulk by local people of Himachal Pradesh for consumption.

**Culture characteristics:** - *T. radicatus*, being edible species, was cultured on PDA medium. In the medium whitish fluffy feathery mycelium was obtained which became yellowish white at maturity. The overall growth of the mycelium was radial and it emitted sweet agreeable odour at maturity. The culture has been deposited in the GenBank of Directorate of Mushroom Research at Chambaghat, Solan under GenBank accession no. DMRX 1131.


**Figs. 88 (A-F) & 89**

Carpophores 3 - 5.5 cm in height. Pileus 1.3 - 2.5 cm in diameter, convex with spiniform perforatorium; surface dry, glabrous, yellowish white (4A2) with orange grey (5B2) centre; margin incurved, irregular, splitting at maturity; cuticle fully peeling; flesh up to 5 mm thick, white, unchanging; taste and odour mild. Lamellae free to adnexed, unequal, of 3 lengths, subdistant, not in series, 3 mm broad, yellowish white (4A2); gill edges smooth, fragile; spore deposit yellowish white (4A2). Stipe central, 2.8 - 3.3 cm and 1 - 3 mm in width, cylindrical, solid, with with a small 2 cm long pseudorrhiza; surface smooth, yellowish white (4A2), annulus absent.

Spores 6.6 - 8.3 x 4 - 5.8 µm (Q = 1.38), ovoid to ellipsoid, containing single guttule, smooth, thin walled, hyaline, inamyloid. Basidia 19 - 26.7 x 6.6 - 8.3 µm, clavate, 4 spored; sterigmata 1.6 - 3.3 µm long; gill edges heteromorphous.
Cheilocystidia 23.2 - 31.5 x 11.6 - 14.9 µm in size, clavate to pyriform, numerous, thin walled, hyaline. Pleurocystidia scattered, numerous, 33.2 - 49.8 x 16.6 - 21.58 µm.

Pileus cuticle composed of upright projecting hyphae measuring 0.8 - 2.5 µm in diameter, cuticular elements arises from the basal subcellular layer; context homoiomerous; gill trama regular, made up of hyaline thin walled hyphae measuring 7.5 - 13.5 µm in diameter; subhymenium pseudoparenchymatous. Stipe cuticle hyphae hyaline, thin walled, parallel running throughout measuring 4.5 - 22.3 µm in diameter with some projecting elements measuring 4.5 - 8.9 µm. Laticiferous elements present. All hyphae lacking clamp connections.

Collections examined: Patiala, Punjabi University campus (250 m), growing in caespitose clusters and scattered on termite hills, Babita Kumari, PUN 4239, July 13, 2008; Chattbir (316 m), in group on grassy soil, under Adhatoda vasica, Harvinder Kour, PUN 3175, August 24, 2002.

Remarks:-The above collections is typical of T. medius. The diagnostic characters include small sized carpophores having small orange grey perforatorium, 2 cm long pseudorrhiza and presence of both cheilocystidia and pleurocystidia. Natarajan and Purushothama (1986) recorded this species from Karnataka while Atri et al., (2005 b) documented it from Punjab.

**Synonyms**

*Agaricus microcarpus* Berk. & Broome in *Journ. Linn. Soc. Bot.* 11: 537 (1871)


*Podobrella microcarpus* (Berk & Broome) Singer in *Lloydia* 8: 144 (1945).


Fructifications small sized, 0.5 - 3.8 cm in height. Pileus 1 - 1.2 cm in diameter, first convex finally planate to depressed at maturity; surface silky white to yellowish white (442), with occasional acute papillate orange white (5A2) umbo in the centre; scaly, scales appressed fibrillose; margin irregular, first incurved, finally reflexed at maturity, splitting, finely striate; cuticle fully peeling; at places shredded; flesh unchanging, white (1A1), 0.1 - 0.2 cm thick; taste and odour mild. Lamellae free to adnexed, subdistant to crowded, unequal, of 2 - 3 lengths, 0.2 - 0.3 cm broad in the centre, white (1A1); gill edges smooth. Stipe central, 0.4 - 2.8 cm long, 0.1 - 0.2 cm broad, white to creamish without pseudorrhiza, cylindrical, fibrous, smooth, glabrous, hollow, annulus absent.

Spores 4.2 (5.6) - 6.6 (7.5) x 3.3 (4.2) - 4.8 (5) µm (Q = 1.2 - 1.5), inamyloid, thin walled, ovoid to ellipsoid with oil droplets, thin walled, lacking a suprahilar depression, hyaline, cyanophilous, inamyloid. Basidia 16 - 30 x 5 – 8 (11.6) µm, clavate, thin walled, inamyloid, siderophilous granules present; gill edges sterile to heteromorphous. Cheilocystidia scattered 16 - 35.5 x 6.6 (8) - 22 µm, broadly clavate to pyriform, cylindrical or even ventricose with extended tip, thin walled, inamyloid, without basal cells.
Pleurocystidia 18 - 38 x 8.3 - 23.3 µm, thin walled, similar to cheilocystidia in shape. Pileus cuticle composed of radially arranged thin walled, inamyloid hyphae measuring 3.3 - 12 µm in width; context homoiomerous; gill trama regular to bilateral, measuring 4.9 - 8.9 µm in width; subhymenium pseudoparenchymatous. Stipe surface formed of parallel running hyphae throughout measuring 2.5 - 13.3 µm in width. Clamp connections absent.

Collections examined: Punjab, Punjabi University Campus, Goal market (250 m), growing gregarious or scattered on termitaria, Babita Kumari, PUN 4237, October 20, 2007; Punjabi University Campus, Botany Department (250 m), growing gregarious on termite mounds, Babita Kumari, PUN 4252, June 28, 2008; Patiala Punjabi University Campus, Girls hostel road (250 m), growing scattered to gregarious or even in caespitose manner on termite hills, Babita Kumari, PUN 4235, July 13, 2008; Punjabi University Campus, Plant conservatory (250 m), growing caespitose even to scattered or even gregarious on termitaria, Babita Kumari, PUN 4241, July 4, 2008; Shekhupura (250 m), growing scattered on termitaria, Babita Kumari, PUN 4304, July 13, 2010.

Remarks: - The above examined collections are typical of T. microcarpus (Pegler, 1977) in their macroscopic and microscopic details. The diagnostic characters include the small sized white fruit bodies turning termite mounds snow white and absence of the pseudorrhiza. This species was first recorded from India by Natarajan (1977 b) from Tamil Nadu, Rawla et al., (1983) from Chandigarh and Atri et al., (1995) from Punjab plains. It is an excellent mild tasting whitish mushrooms with typical mushroom flavor and soft texture. Being miniature sized morphologically, mycophagists gather it in bulk from the termite mounds during rainy season. Normally it is mixed with rice to prepare rice pulao. Besides, being available in sufficient quantity it can be cooked as normal vegetable or mixed vegetable and even as mushroom soup.


Fructifications 2.8 - 5.5 cm in height. Pileus 1 - 1.7 cm in diameter, applanate with prominent conical brownish umbo; surface greyish brown (5C2) with whitish
background, almost creamish along the margin, scales appressed fibrillose; margin irregular, striate, splitting at maturity; cuticle fully peeling; flesh white (4A1), unchanging, up to 2 mm in thickness; taste and odour mild. Lamellae free, crowded, unequal, lamellulae of 2 lengths, up to 2 mm broad in the middle, white (4A1); gill edges smooth to serrate. Stipe central, 2 - 5 cm long, 2 - 8 mm broad, solid, equal in diameter throughout; surface smooth, white, pseudorrhiza and annulus absent.

Spores 5.8 - 7.5 x 4.2 - 5 µm (Q = 1.4), ovoid to ellipsoid with a single guttule, without a suprahilar depression, thin walled, smooth, hyaline, inamyloid. Basidia 14.5 - 25 x 6.6 - 8.3 µm, clavate, inamyloid, tetrasporic; sterigmata up to 2 µm long; gill edges heteromorphous. Cheilocystidia 26.5 - 43.2 x 11.6 - 20 µm, scattered, numerous, pyriform with 2 - 3 basal cells, thin walled, hyaline to slightly granulur. Pleurocystidia 16.6 - 26.6 x 8.3 - 10 µm, broadly clavate to pyriform, inamyloid, few, basal cells absent.

Pileus cuticle formed of radially arranged septate 2.4 - 6.4 µm broad hyphae, many of which are projecting with rounded to tapered tip, context homoiomerous with scattered laticiferous elements, context hyphae 4 - 5.6 µm in width; gill trama regular, tramal hyphae 3.3 - 9.6 µm in diameter, hyaline. Stipe surface hyphae parallel running throughout measuring 8.9 - 22.3 µm in diameter. Clamp connections absent throughout.

**Collections examined:** Patiala, near Bus stand (250 m), growing on termite mounds, Babita Kumari, PUN 4248, June 28, 2008; Punjabi University (250 m), Botanical Gardens, growing in groups on sandy soil, under *Thuja* sp. and *Polyalthia* sp., Harvinder Kour, PUN 3333, September 24, 2003.

**Remarks:** The above examined collections are characterized by small sized carpophores, whitish pileus with greyish brown centre having prominent pointed greyish brown perforatorium, absence of veil and pseudorrhiza and presence of both
cheilocystidia and pleurocystidia. These features are in conformity with *T. badius* as described by Natarajan (1975) from Madras University campus. Atri et al., (2005b) described it from Punjab plains. This species is very close *T. microcarpus* from which it differs on the basis of brown colour of the pileus, sharply pointed greyish brown umbo and presence of clavate to pyriform cystidia instead of broadly inflated to ventricose or even cylindrical cystidia in *T. microcarpus*.

*Fig. 93 & 94 (A-F)*

**Synonym**


Fructifications 9.5 - 13 cm in height including pseudorrhiza. Pileus 7.3 - 7.6 cm in diameter, convex with a prominent acute perforatorium; surface yellowish white to orange grey (5B2) with greyish brown (5B3) to greyish orange (5B3) umbo; scaly, scales brown, recurved to appressed fibrillose; margin irregular, incurved, splitting radially almost to the disk; cuticle fully peeling; flesh white, unchanging, 3 - 5 mm in thickness; taste and odour mild. Lamellae free, crowded, unequal, lamellulae of 4 - 5 lengths, up to 4 mm broad in the middle, light yellow (4A4); gill edges serrate; spore deposit pale orange (5B3). Stipe central, 4 - 5.5 cm long above the soil level, 6 - 9 mm broad, yellowish white (4A2), pseudorrhiza 4.5 - 6 cm long, 1.6 cm broad, expanded before entering in to soil, brown, solid, annulus absent.

Spores 6.64 (7.2) - 8.8 (9.6) x 4.2 - 4.8 µm (Q = 1.46), ovoid to ellipsoid with a single oil droplet and suprahilar depression, thin walled, apiculate, cyanophilous, hyaline, inamyloid. Basidia 19.9 - 25 (33) x 6.6 - 10 µm, clavate, inamyloid, tetrasporic; sterigmata 2.5 - 4.9 µm long; gill edges heteromorphous. Cheilocystidia 24.9 - 38 x 8.3 - 26.7 µm, scattered, numerous, broadly clavate to pyriform, thin
Taxonomic observations

Walled with 1-2 basal cells, hyaline. Pleurocystidia 21.6 - 40.3 x 6.6 - 21 µm, inflated clavate to inflated pyriform with basal cells, few, inamyloid.

Pileus surface covered by an epicutis formed of radially arranged repent hyphae measuring 1.6 - 3.2 µm in width, subcutis made up of erect, parallel running hyphae measuring 5.6 - 10.5 µm in diameter; context homoiomerous with numerous laticiferous elements made up of 4 - 6.5 µm broad hyphae; gill trama bilateral convergent, tramal hyphae 3.2 - 6.5 µm in width. Stipe surface hyphae parallel running throughout, measuring 4.8 - 14.5 µm in diameter with numerous laticiferous elements. Clamp connections absent.

![Fig. 93: Carpophore of *T. sagittiformis* in natural habitat.](image)

**Collections examined**: Punjab, Patiala, NIS, (250 m), growing solitary on soil, Yadwinder Singh, 4231, July 1, 2008; Chattbir (316 m) growing scattered on soil, Babita Kumari, PUN 4247, August 29, 2008.

**Remarks**: The above examined collections belong to *T. sagittiformis*. It is characterized by its medium sized carpophores having pileus with prominent acute greyish brown perforatorium, radially cracking pileus surface with brownish recurved scales, incurved margin and dark blakish brown pseudorrhiza. These features are in
agreement with the details given by Westhuizen and Eicker (1990). It is quite close to T. rabourii, T. clypeatus and T. umkowaani. From T. rouburii it differs in having prominent acute greyish brown perforatorium and dark blackish pseudorrhiza in T. rabourii. In T. clypeatus the perforatorium is less acute and stipe has dark surface with black pseudorrhiza as compared to sharply pointed perforatorium and yellowish white stipe in T. sagittiformis. T. umkowaani is a unique species with inflated septate hyphae and doliform cells in its pileus surface, which are altogether absent in T. sagittiformis. Vrinda and Pradeep (2009) documented this species from Kerala. It is first time reported from North India.

Figs. 95 (A-D) & 96 (A-F)

Synonyms


Carpophores 13.5 cm in height including pseudorrhiza. Pileus 4.7 cm in diameter, surface whitish with greyish brown centre, applanate with scrobiculate dark coloured obtusely nippled perforatorium, which is concolourous with hair like lines running along the surface, margin irregular, slightly incurved; splitting at maturity; cuticle fully peeling; flesh off white, unchanging, up to 3 mm in thickness; taste and odour mild. Lamellae free, crowded, unequal, lamellulae of 2 - 3 lengths, 0.3 cm broad in the middle, yellowish white (4A2); gill edges serrate, normal; spore deposit light yellow. Stipe central, 6 cm long, 0.8 cm broad, expanded to 1.7 cm in width near the soil level, solid, yellowish white, with 6.4 cm long dark brown pseudorrhiza, annulus absent.

Spores 6.4 – 8 (8.8) x 4 - 4.8 (5.6) µm (Q = 1.6 - 1.7), ovoid to ellipsoid lacking suprahilar depression, thin walled, apiculate, cyanophilous, hyaline,
Figs. 95 (A-D) *Termomyces robustus*: A. Basidiospores, B. Basidia, C. Cheilocystidia, D. Pileus cuticle elements.

inamyloid. Basidia 20 - 26.6 x 6.6 - 8.3 µm, narrowly clavate, siderophilous, inamyloid, tetrasporic; sterigmata 2.5 - 3.3 µm long; gill edges sterile. Cheilocystidia 16 - 35.6 x 11.6 - 18.26 µm, scattered, crowded, versiform, lageniform to cylindric or even clavate with inflated apex, thick walled with 1 - 2 transverse septa, hyaline. Pleurocystidia 26.6 - 36.5 x 11.6 - 16.6 µm, abundant, inamyloid, thin walled, broadly clavate to inflated, thick walled with 1- 2 transverse septa.

Pileus surface an epicutis formed of gelatinized tangled hyphae measuring 2 - 8 µm in width; context homoiomerous, context hyphae measuring 4 - 8 µm in width;
hymenophoral trama bilateral composed of hyphen measuring 2.4 - 7.2 µm in width; subhymenium pseudoparenchymatous. Stipe cuticle hyphae parallel running throughout measuring 8.9 - 13.3 µm in diameter. Clamp connections absent.

**Collection examined:** Punjab, Ropar Maharaja Ranjeet Singh Park (394 m), growing solitary on sandy soil, Babita Kumari, PUN 4236, September I, 2008.

**Remarks:**- The above examined collection is typical of *T. robustus* (Pegler, 1977). The diagnostic characters include medium sized carpophores having mammiiform scrobiculate greyish brown perforatorium and presence of thick walled cystidia. Patil and Thite, (1978) reported this species from Poona for the first time in India. Here it is being reported for the first time from North India.


**Figs. 97 (A-G)**

**Synonyms**

*Agaricus umkowaani* Cooke & Mass; *Grevillea* **17**: 70 (1889)  

Fructification up to 17.5 cm long including pseudorrhiza. Pileus up to 6.2 cm in diameter, surface orange greyish to brownish grey (5B2 - 5C2), ridged, convex with dark spiniform perforatorium, silky, moist, slightly viscid at umbo, orange greyish (5B2), scaly, scales appressed fibrillose; margin irregular, incurved, feebly striate; splitting at maturity; cuticle fully peeling; flesh up to 0.5 cm thick, off white, changing to light yellowish brown on bruising; taste and odour mild. Lamellae free, crowded, unequal, lamellulae of 3 - 4 lengths, up to 0.5 cm broad in the middle, yellowish white (4A2); gill edges serrate, light yellowish brown on exposure. Stipe slightly excentric, 4.5 cm long, 1.3 cm broad, yellowish white (4A2), extending in to 13.2 cm long pseudorrhiza below, exannulate, smooth, yellowish white (4A2), solid, light brownish on exposure.
Spores 6.6 - 9.6 (10.5) x 4.8 - 5.6 (6.5) µm (Q = 1.5), ovoid to ellipsoid containing a single large oil droplet with a suprahilar depression, thin walled, apiculate, cyanophilous, hyaline, inamyloid. Basidia 19.3 - 32.2 x 6.4 - 8 µm, clavate, siderophilous, inamyloid, tetrasporic, sterigmata 3.2 - 4 µm long; gill edges sterile. Cheilocystidia 12.6 - 59.6 (72.5) x 6 - 37 µm, scattered, crowded, broadly clavate to pyriform, thin walled with 2 - 3 pedicellate cells, hyaline. Pleurocystidia 20.9 - 54.7 x 9.6 - 29 µm, abundant, inamyloid, thin walled, broadly clavate to inflated pyriform with 1 - 2 basal cells, similar to cheilocystidia.

Pileus surface a cutis of radially arranged septate cylindrical to tubular hyphae measuring 4 - 6 µm in width; context homoiomeres, made up of inflated hyphae with short hyaline brownish inflated doliform cells measuring up to 22 µm in width; hymenophoral trama regular to bilateral measuring 3.2 - 11.3 µm in width; subhymenium pseudoparenchymatous, very narrow. Stipe cuticle hyphae parallel running throughout measuring 8 - 28 µm in diameter with numerous laticiferous elements. Caulocystidia measuring 8 - 19.3 x 4 - 6.4 µm in size. Clamp connections absent.

**Collection examined:** Himachal Pradesh, Hamirpur, Dalli Khad (850 m), growing solitary among grasses on moist soil of termitaria, Babita Kumari, PUN 4234, August 8, 2008.

**Remarks:** The above examined collection belongs to *T. unkowaani*. It is characterized by its medium sized carpophores having convex to campanulate umbonate greyish brown pileus surface, presence of doliform cells in the context, pedicellate caulocystidia and hymenial cystidia. Its morphological and internal details are in full conformity with description given for this species by Westhuizen and Eicker (1990). Vrinda *et al.*, (2002) reported this species from Kerala. Here it being reported for the first time from North India.
Figs. 98 & 99 (A-F)

**Synonyms**


Carpophores 17 - 21 cm in height including pseudorrhiza. Pileus 7 - 9 cm in diameter, plano-convex to broadly campanulate with pointed prominent perforatorium, surface brownish grey (5C2) to greyish brown (5D3) with well developed greyish brown (5E3) pointed perforatorium, veil absent; margin yellowish white (4A2), moist, irregular, radially arranged; non inflexed, non striate; cuticle fully peeling, flesh white, unchanging, up to 9 mm thick along pointed umbo and 0.2 cm thick away from the umbo; taste and odour mild. Lamellae free to adnexed, remote, crowded, bifurcate, unequal, with lamellulae of 3 - 4 lengths, up to 4 mm broad in the centre, white, normal; gill edges smooth. Stipe excentric, 7 - 7.5 cm long with 12 - 13.5 cm long pseudorrhiza, white to yellowish white (4A2), 0.8 - 0.9 cm thick, slightly broad before entering in to soil; annulus absent.

Spores 5.6 - 8 x 4 - 5.7 µm (Q = 1.45), ovoid to ellipsoid containing a single oil droplet, thin walled, inamyloid, cyanophilous, non metachromatic in cresyl blue, apiculate. Basidia 16.9 - 25.8 x 6.4 - 8 µm, clavate, thin walled, siderophilous granules present, inamyloid, four spored; sterigmata 1.6 - 4 µm; gill edges heteromorphous. Cheilocystidia 24.2 - 40.3 x 8 - 17.7 µm, numerous, thick walled, pyriform, more thickened towards the apex, inamyloid. Pleurocystidia 28 - 42 x 8 - 26 µm, thick walled with 2 - 3 basal cells, pyriform, scattered, inamyloid.
**Fig. 98:** *Termitomyces clypeatus* in natural habitat.

Pileus surface composed of radially arranged septate cylindrical to obtuse septate elements with vacolular pigment measuring 6 - 8 µm in width; context homoiomerous, context hyphae measuring 6 - 12 µm in width; gill trama regular, tramal hyphae measures 2.4 - 6.4 µm in width; subhymenium pseudoparenchymatous, 4 - 8 µm in width. Stipe cuticle composed of parallel running hyphae throughout measuring 4 - 20 µm width. Clamp connections absent.

**Collections examined:** Himachal Pradesh, Nahan, Kolar (900 m), growing scattered on moist soil excavated by termites, Munruchi Kaur and Babita Kumari, PUN 4246, July 17, 2010. Punjab, Ropar, Maharaja Ranjeet Singh Bagh (300 m), Harvinder Kour, PUN 3331, September 20, 2003.

**Remarks:** It is chiefly characterized by strongly pointed perforatorium on the pileus surface, greyish brown pileus, stipe with long tapering pseudorrhiza and absence of any veilar fragments. The macroscopic and microscopic details of above examined collections are in agreement with the *T. clypeatus* (Pegler, 1977). *T. clypeatus* is very close to *T. spiniformis* which have scrobiculate perforatorium, rather than smooth as in *T. clypeatus*. This species seems to be close to *T. sagittiformis* in having a conical pointed pileus but later being more robust and also bear dark brown crust on
Figs. 99 (A-F) *Termomyces clypeatus*: A. Carpophore, B. Basidiospores, C. Basidia, D. Cheilocystidia, E. Pleurocystidia, F. Pileus cuticle elements
pseudorrhiza (Pegler & Vanhaecke, 1994). It is a well documented species from various part of India including Kerala (Leelavathy et al., 1983), Tamil Nadu (Natarajan, 1975) and Punjab (Atri et al., 2005 b).