



Taxonomic study on the coprophilous mushrooms from Punjab, India: new records of family Agaricaceae

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Abstract

This paper deals with the taxonomy of nine species, namely *Agaricus cupreobrunneus*, *A. halophilus*, *Coprinus comatus* var. *caprimammillatus*, *C. cordisporus*, *Lepiota epicharis* var. *occidentalis*, *L. thrombophora*, *L. subincarnata*, *L. xanthophylla* and *Leucocoprinus straminellus*, belonging to the family Agaricaceae of the order Agaricales. The collections were made from various dung localities of Punjab state in India. All these taxa are described along with their dung sources, illustrated with line drawings of morphological and anatomical features and compared with similar taxa. Out of these, *Agaricus halophilus*, *Coprinus comatus* var. *caprimammillatus* and *C. cordisporus* are the first time records from India. *Agaricus cupreobrunneus*, *Lepiota epicharis* var. *occidentalis*, *L. thrombophora*, *L. subincarnata*, *L. xanthophylla* and *Leucocoprinus straminellus* are new records for North India. Habitat photographs of all the taxa are given. A key to aid in determining their genus is also presented.

Keywords – *Agaricus* – *Coprinus* – herbivorous dung – *Lepiota* – *Leucocoprinus* – taxonomy

Introduction

The family Agaricaceae Chevall is characterized by small, delicate to large, non-deliquescent to deliquescent carpophores, with convex, expanding, often umbonate, vividly colored pileus, mostly free gills, hyaline to greenish, ochraceous, pink, sepia or dark reddish brown spores, monomorphic to polymorphic basidia, and pileus cuticle ranging from undifferentiated repent cutis to a trichodermial palisade, but also often hymeniform or forming an epithelium, or in the form of chains of loose sphaerocysts (Pegler 1986, Readhead *et al.* 2001).

Kirk *et al.* (2008) recognized 85 genera in the family Agaricaceae. Myco Bank (www.mycobank.org) documents 170 associated records till August 10, 2014. The genera *Agaricus* L.: Fr., *Chlorolepiota* Sathe & S.D. Deshp., *Chlorophyllum* Masee, *Clarkianda* (Berk.) Sing., *Coprinus* Pers., *Crucispora* E. Horak, *Cystoderma* Fayod, *Cystolepiota* Sing., *Echinoderma* (Locq. ex Bon) Bon, *Hymenagaricus* Heinem., *Lepiota* (Pers.: Fr.) S.F. Gray, *Leucoagaricus* (Locquin) Sing., *Leucocoprinus* Pat., *Macrolepiota* Sing., *Melanophyllum* Velen., *Microsalliota* Höhn., *Volvolepiota* Sing. and *Xanthagaricus* (Heinem.) Little Flower, Hosag. & T.K. Abraham are already known from India (Saini & Atri 1995, Natarajan *et al.* 2005, Farook *et al.* 2013).

During the course of fungal survey of coprophilous mushrooms undertaken in Punjab, some mushrooms belonging to *Agaricus*, *Coprinus*, *Lepiota* and *Leucocoprinus* of the family Agaricaceae have been collected and worked out for their macroscopic and microscopic details. Out of these, nine taxa viz. *Agaricus cupreobrunneus* (Schäffer & Steer: Møller) Pilát, *A. halophilus* Peck, *Coprinus comatus* var. *caprimammillatus* Bogart, *C. cordisporus* T.Gibbs, *Lepiota epicharis* var. *occidentalis* Dennis, *L. thrombophora* (Berk. & Br.) Sacc., *L. subincarnata* J.E. Lange, *L. xanthophylla* P. D. Orton and *Leucocoprinus straminellus* (Bagl.) Narducci & Caroti, are described in this paper.

Material & Methods

The materials were collected from various dung localities in Punjab. The macroscopic characters pertaining to gross morphology, shape, color and size of pileus, stipe, etc. were noted down from the fresh material on the field key especially designed for the purpose (Atri *et al.* 2005). The colour terminology used is that of Kornerup & Wanscher (1978). The specimens were hot air dried in a wooden drier. During drying 40-45°C temperature was maintained inside the chamber. After drying, the mushrooms were finally packed in the moisture proof cellophane paper bags containing 1-4 dichlorobenzene. The microscopic structures were observed by cutting free hand sections after reviving a part of the dried specimens in 10% KOH solution and staining the sections in 1% Cotton blue or 2% Congo red. Line drawings of microscopic details were drawn with the aid of Camera lucida under oil lens. All the collections have been deposited under PUN in the Herbarium of Punjabi University Patiala, India. During the present investigation, authentic names, basionym and synonyms of the investigated taxa are as per the latest version of Dictionary of Fungi (Kirk *et al.* 2008) and the information available on MycoBank (www.mycobank.org). The field photographs, macroscopic and microscopic details of the described mushrooms have been provided in this paper.

Taxonomy

In the text, the investigated species are described according to the sequence of segregation of their genera in the key given below:

- 1 Lamellae deliquescent; spore print black; basidia polymorphic; pseudoparaphyses present between the basidia; pileus cuticle a cutis of repent hyphae..... ***Coprinus***
- 1' Lamellae non-deliquescent or subdeliquescent; spore print never black; basidia monomorphic; pseudoparaphyses absent; pileus cuticle varying from an undifferentiated cutis to trichoderm, hymeniform to an epithelium.....**2**
- 2 Basidiospores with a hyaline covering on the germ pore, endosporium metachromatic in cresyl blue; spore print white, creamish yellow to pinkish; lamellae collariate; pileus cuticle formed by a mixture of different types of cells and hyphae, not by a homogenous palisade, also not by a hymenidermal layer***Leucocoprinus***
- 2' Basidiospores always without germ pore, endosporium not metachromatic in cresyl blue.....**3**
- 3 Spore print white to pale cream; basidiospores light colored, dextrinoid, pseudoamyloid, rarely inamyloid or amyloid; pileus cuticle varying from cutis to trichoderm or hymeniform; clamp connections present.....***Lepiota***
- 3' Spore print grayish brown, brown to dark brown; basidiospores dark colored; pileus cuticle consisting of appressed elongate hyphae, or of fragments of a palisade, never cellular; clamp connections absent.....***Agaricus***

Coprinus comatus* var. *caprimammillatus Bogart in *Mycotaxon* 4(1): 274, 1976. Figs. 1-2

Carpophores 5.7-12 cm in height. Pileus 4.5-7.5 cm long before expansion, 2.5-5.5 cm broad at maturity; shape ovate-oblong when young campanulate at maturity, finally revolute; surface moist, white (6A₁), with brown (6E₄) apex; pileal veil scaly, scales thick, hairy, brown,

recurved fibrillose, covering complete pileus surface; margin irregular, splitting at maturity, radially plicate; cuticle not peeling; flesh thin, white, deliquescent, changing to black colored liquid at maturity; taste and odor mild. Lamellae free, unequal, crowded, narrow, white, deliquescent, becoming grayish black to black; gill edges smooth. Spore print black. Stipe central, 5.5–12 cm long, 0.9–1.4 cm broad, cylindrical, with distinct bulbous base, hollow, surface white (6A₁), pubescent; stipe lumen with a mass of loose hyphae; annulate, annulus single, small, membranous, white, movable, evanescent at maturity.

Basidiospores 11.4–18.5 × 7–10 μm (Q = 1.75), ellipsoidal, with a broad germ pore that is central to eccentric in location, thick-walled, smooth, blackish brown; apiculate, apiculus 0.7–1.4 μm long. Basidia abundant, trimorphic, short basidia 14.2–20 × 11.4–14.2 μm, clavate with sterigmata 2–3.6 μm long, medium sized basidia 31–42.6 × 10–14.2 μm in size, clavate with sterigmata 3.6–5.7 μm long, larger basidia elongated 45.4–55.4 × 11.4–17 μm in size, cylindrico-clavate with sterigmata 2.8–4.3 μm long, all 4-spored, thin-walled; sterigmata with conspicuous dark plug occupying the tip. Gill edges heteromerous. Cheilocystidia dimorphic, globose and clavate, globose cystidia measuring 15.6–35.5 × 8.5–24.2 μm while clavate cystidia measuring 34–51 × 11.4–17 μm in size, thin-walled, smooth, granular. Pleurocystidia absent. Pileus cuticle hyphoid with projecting veil remnants; pileus context homoiomerous, made up of radially oriented, cylindrical, thin-walled 5.7–18.7 μm broad hyphae; veil elements filamentous, unbranched, septate, thin-walled, hyaline, 4.3–15.3 μm in width. Hymenophoral trama regular, composed of thin-walled 7–15.6 μm broad hyphae. Subhymenium pseudoparenchymatous. Stipe cuticle hyphal with projecting veil remnants; stipe context made up of longitudinally tangled, septate, thin-walled 6.8–25.5 μm broad hyphae; projecting velar turf irregular, made up of septate, thin walled, narrow 3.6–5.7 μm broad hyphae. Clamp connections present in the stipe hyphae and universal veil remnant hyphae.



Fig. 1 – *Coprinus comatus* var. *caprimammillatus*. A Ovate-oblong carpophores when young. B Carpophores deliquescing at maturity.

Collections studied – India, Punjab, Sangrur, Qila Rehmatgarh, 231 m asl., densely grouped on mixed cattle dung in a pasture, 03 June 2008, Amandeep Kaur, PUN 4061. Bathinda, Naruaana, 211 m asl., growing in groups on mixed cattle dung, 01 August 2009, Amandeep Kaur, PUN 4782.

Discussion – The presently examined collections are typical of *C. comatus* var. *caprimammillatus* (Van de Bogart 1976). In the literature this species is commonly known as ‘Lawyer’s wig’ or ‘Shaggy Mane’ because its pileus remains cylindrical and is covered with very thick scales giving it shaggy appearance (Arora 1986). *Coprinus comatus* var. *caprimammillatus* is quite close to *C. comatus* var. *comatus* and *C. comatus* var. *excentricus*. But in *C. comatus* var. *comatus* the basidiospores possess truly central germ pore while in *C. comatus* var. *excentricus* the location of germ pore in the basidiospores is extremely eccentric as compared to central to eccentric position of germ pore in *C. comatus* var. *caprimammillatus*.

Coprinus comatus is one of the most popular edible species of mushroom in India (Bose & Bose 1940, Purkayastha & Chandra 1985, Atri *et al.* 2009). Arora (1986) described it as one of the safest and the best known edible species of all wild mushrooms which has delicate flavor and

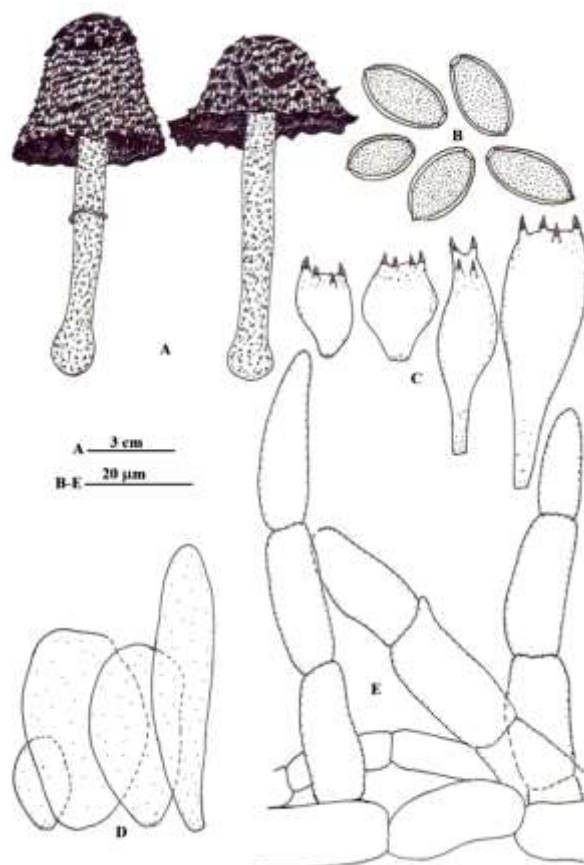


Fig. 2 – *Coprinus comatus* var. *caprimammillatus*. A Carpophores. B Basidiospores. C Basidia. D Cheilocystidia. E Pileal elements.

marvelous texture. The species is being collected from the wild during rainy season for local consumption and is also sold in Patiala and Hoshiarpur districts of Punjab state in India (Atri *et al.* 2009). It is also reported to possess antidiabetic, antifungal and antibacterial properties (Chopra & Chopra 1955, Efremenkova *et al.* 2001, 2003).

Van de Bogart (1976) recorded *C. comatus* var. *caprimammillatus* during the month of September from Washington and Montana in United States of America. Presently the collections have been made from cattle dung during the months of June and August. It is a new fungus record from India.

Coprinus cordisporus T.Gibbs in *Yorkshire Naturalist* p. 100, 1898.

Figs. 3 – 4

Synonyms:

Coprinus volvaceominimus Crossland in *The Naturalist London* p. 372, 1892.

Coprinus patouillardii ssp. *isabellinus* Locq. in *Bull. Oc. Mycol. Fr.* 63: 83, 1947.

Carpophores 4.3–8 cm in height. Pileus 0.7–1.3 cm broad, convex to applanate, with minute depression at the apex; surface dry, greenish gray (27D₂); pileal veil granular, white; margin irregular, not splitting, striated, ridges and grooves extending up to the pileus apex; cuticle thin, not peeling; flesh very thin, shriveling; no taste and odor. Lamellae free, equal, crowded, narrow, fragile, grayish black; gill edges smooth. Spore print grayish black. Stipe central, 4.2–7.9 cm long, 0.2 cm broad, equal in diameter with somewhat broadened base, hollow, surface pale yellow (4A₃), unchanging, pruinose; annulus absent.

Basidiospores 6.8–10 × 6–8.5 μm (Q=1.15), triangular to rectangular, limoniform in face view, ellipsoidal in side view, with a short germ pore, thick-walled, smooth, dark brown; apiculate, with imperceptible apiculus. Basidia 12–29 × 6–8.5 μm, short clavate to elongate clavate, 2- and 4-spored, thin walled, hyaline; sterigmata 2.5–4.3 μm long, without golden contents; pseudoparaphyses present between the basidia. Gill edges heteromerous. Cheilocystidia scattered, 30.6–57.6 × 18.6–37.4 μm, inflated clavate, thin-walled, hyaline. Pleurocystidia 32.3–37.3 × 17–22

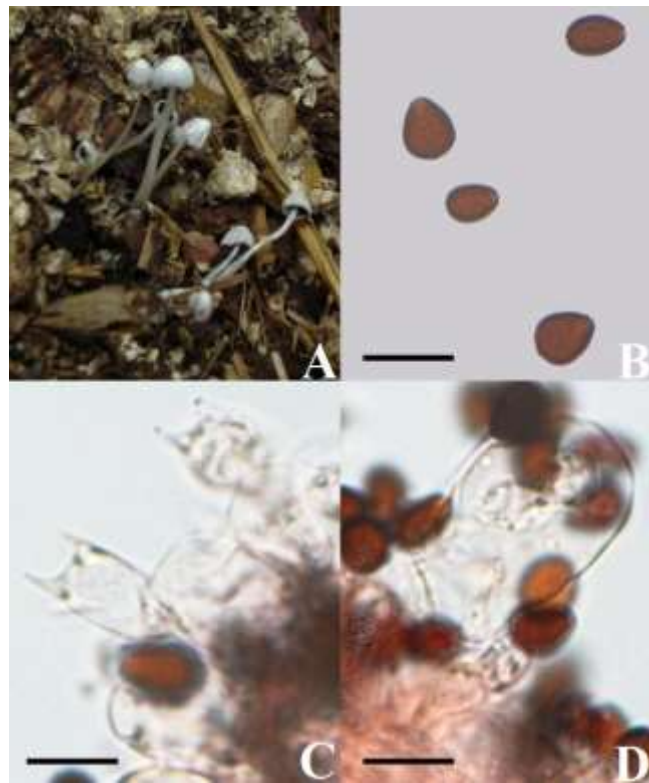


Fig. 3 – *Coprinus cordisporus*. A Carpophores growing in natural habitat. B Basidiospores. C Basidia and pseudoparaphyses. D Pleurocystidium. Bars B–D 20 μ m.

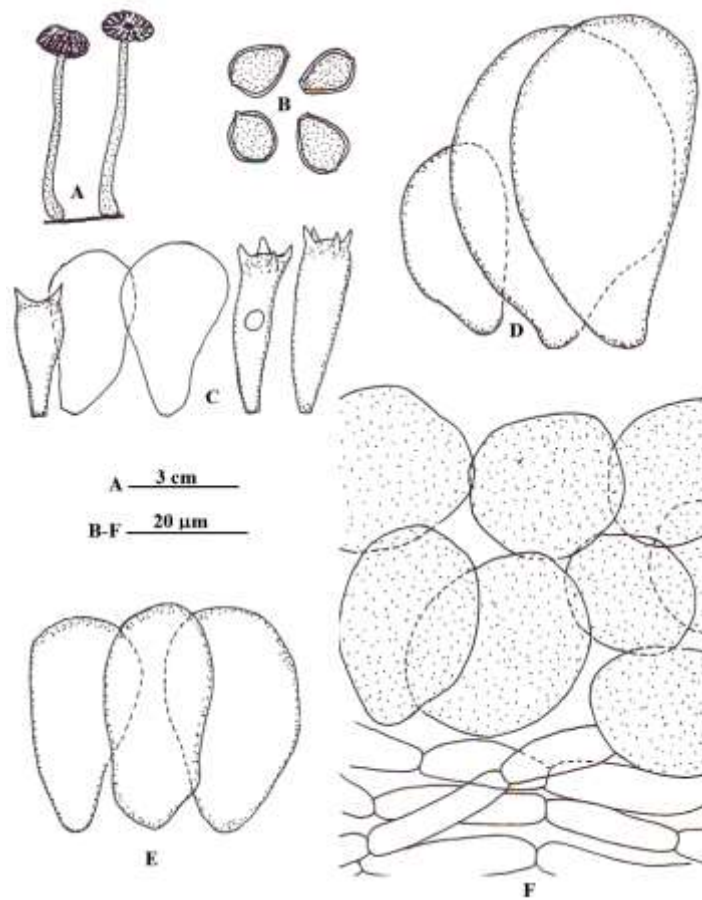


Fig. 4 – *Coprinus cordisporus*. A Carpophores. B Basidiospores. C Basidia and pseudoparaphyses. D Cheilocystidia. E Pleurocystidia. F Hyphal pileus cuticle with overlying cellular veil elements.

µm, few, inflated clavate, thin-walled, hyaline. Pileus cuticle hyphal with cellular veil remnants; pileus context homoioimerous, made up of interwoven 5–13.5 µm broad hyphae, velar elements 18.7–34 × 8.5–29 µm, subglobose, clavate or ellipsoidal, thin walled, having granular contents that dissolve in dilute HCl. Hymenophoral trama regular to subregular, composed of thin-walled 5–17 µm broad hyphae. Subhymenium pseudoparenchymatous. Stipe cuticle hyphal, smooth; context hyphae longitudinally tangled, thin-walled, hyaline, 6.8–27 µm broad. Clamp connections absent throughout.

Collection studied – India, Punjab, Hoshiarpur, Satiana, 295m asl., growing in groups on mixed cattle and horse dung heap, 14 July 2010, Amandeep Kaur, PUN 4784.

Discussion – Recent work using molecular and morphological data suggest that *Coprinus cordisporus* and its allies may represent a distinct coprinoid lineage worthy of generic recognition (Redhead *et al.* 2001, Keirle *et al.* 2004, Padamsee *et al.* 2008). *Coprinus cordisporus*, *C. cardiasporus* and *C. patouillardii* are very similar species. *Coprinus cordisporus* forms relatively large carpophores and possesses relatively large and darkly pigmented lemon-shaped basidiospores, lageniform cheilocystidia, and growth only on dung (Uljé & Noordeloos 1993). In comparison, *C. cardiasporus* is distinguished by smaller carpophores, smaller and more flask-shaped basidiospores and a habitat on dung mixed with woodchips or grow strictly on wood (Uljé & Noordeloos 1993). Orton & Watling (1979) differentiated *C. cordisporus* from *C. patouillardii* on the bases of growth on pure and relatively fresh dung, smaller sized carpophores, smaller spores and presence of pleurocystidia in *C. cordisporus*. Watling & Richardson (2010) reported *C. cordisporus* to be a coprophilous species and *C. patouillardii* non-coprophilous in habitat. The presently examined collection was found growing on mixed cattle and horse dung heap and it possesses inflated clavate pleurocystidia because of which it has been placed in *C. cordisporus* complex.

Coprinus cordisporus has been traditionally classified in *Coprinus* section *Vestiti* based on the presence of globose veil cells and hyphal pileus cuticle. Based on molecular studies, a number of workers reclassified other coprinoid mushrooms of this section in the genus *Coprinopsis* (Hopple & Vilgalys 1999, Readhead *et al.* 2001, Moncalvo *et al.* 2002, Keirle *et al.* 2004). However, there was a lot of confusion regarding the taxonomic position of *Coprinus cordisporus* at the generic level. Morphologically it is more similar to *Coprinopsis* than to *Coprinellus*; however, the molecular studies reported it to be close to the genus *Coprinellus* (Moncalvo *et al.* 2002, Keirle *et al.* 2004). But the members belonging to *Coprinellus* have a cellular pileus cuticle, whereas *Coprinus cordisporus* has hyphal pileus cuticle. These studies chose to not formally transfer *Coprinus cordisporus* to the genus *Coprinopsis* or to *Coprinellus* because of the discrepancy between morphological and molecular data. For the time being this mushroom has been placed under *Coprinus cordisporus*.

Keirle *et al.* (2004) documented *C. cordisporus* growing on horse and cow dung and associated with woodchips from the Hawaiian Islands. Watling & Richardson (2010) recorded the species growing on cattle and horse dung from Stanley and on rabbit pellets from West and East Falkland. Here it has been recorded for the first time on mixed cattle and horse dung from India.

Leucocoprinus straminellus (Bagl.) Narducci & Caroti in *Mem. Soc. Tosc. Sci. Nat.* p. 49, 1995.

Figs. 5 – 6

Basionym: *Agaricus straminellus* Baglietto in *Comment. Soc. Crittog. Ital.* 2(2): 263, 1865.

Synonyms: *Agaricus denudatus* Rabenhorst in *Hedwigia* 6: 45, 1867.

Lepiota straminella (Baglietto) Saccardo 1887.

Lepiota guegueni Saccardo & Traverso in *Syll. Fung.* 19: 1081, 1910.

Lepiota cepistipes var. *straminella* (Baglietto) Konrad & Maublanc in *Icones Selectae Fungorum Fasc.* 1: 41, 1924.

Carpophores 3.7–5.1 cm in height. Pileus 1.5–2.7 cm broad, 1–1.3 cm high, conical to campanulate; umbonate, umbo broad, yellowish brown; surface dry, yellowish white, withered; pileal veil scaly, scales appressed flocculose and powdery, white, covering the entire pileus surface; margin regular, plicate–striate, not splitting at maturity; cuticle not peeling; flesh thin, up to 0.2 cm



Fig. 5 – *Leucocoprinus straminellus*. A Carpophores growing in natural habitat. B Carpophore showing lamellae arrangement.

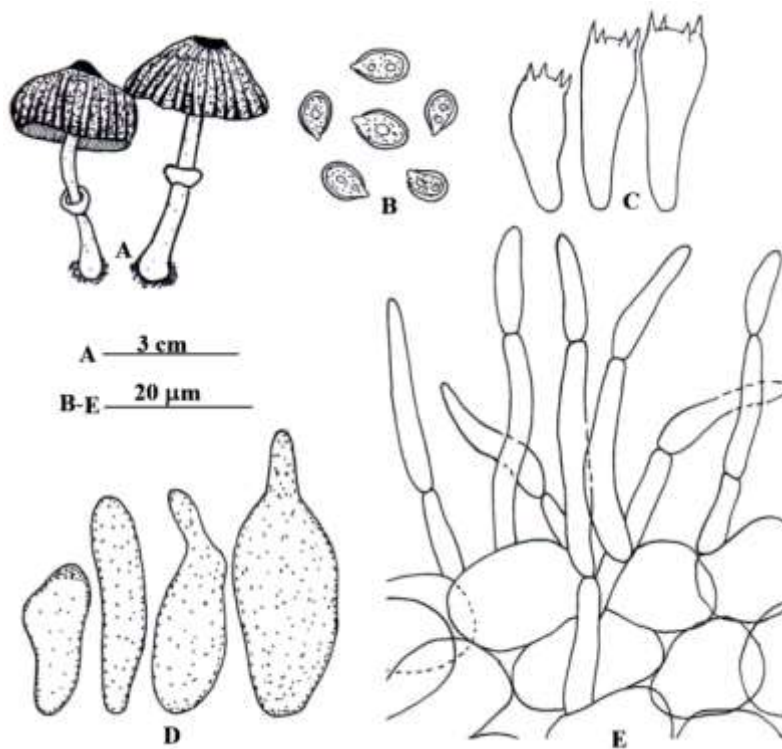


Fig. 6 – *Leucocoprinus straminellus*. A Carpophores. B Basidiospores. C Basidia. D Cheilocystidia. E Pileal elements.

thick, white, unchanging; taste and odor not distinctive. Lamellae free, collariate, equal, crowded, narrow, up to 0.2 cm broad, white, unchanging; gill edges smooth. Spore print white. Stipe central, 3.5–4.8 cm long, 0.2 cm broad, cylindrical, bulbous at the base, solid, surface yellowish white, smooth to pruinose, with white basal mycelium; annulate, annulus single, thin, attached on the middle part of the stipe.

Basidiospores $5\text{--}6.8 \times (3.4) 4.3\text{--}5 \mu\text{m}$, ($Q=1.26$), ellipsoid to ovoid, thick walled, smooth, germ pore absent, colorless, dextrinoid, metachromatic in cresyl blue. Basidia $17\text{--}25.5 \times 6.8\text{--}9.3 \mu\text{m}$, clavate, 4-spored, thin walled, hyaline; sterigmata $1.7\text{--}3.4 \mu\text{m}$ long. Gill edges sterile. Cheilocystidia $18.7\text{--}39 \times 6.8\text{--}15.3 \mu\text{m}$, polymorphic, cylindrical, clavate to ventricose, thin walled, granular. Pleurocystidia absent. Pileus cuticle made up of $8.5\text{--}18.7 \times 8.5\text{--}22 \mu\text{m}$, subglobose to ellipsoidal cellular elements; pileal veil made up of loosely arranged, cylindrical, $2.5\text{--}4.3 \mu\text{m}$ broad hyphal elements. Hymenophoral trama regular, composed of thin-walled hyphae measuring $5\text{--}15.3 \mu\text{m}$ in width. Subhymenium pseudoparenchymatous. Stipe cuticle hyphal, context composed of parallel, thin-walled, hyaline $5\text{--}18.7 \mu\text{m}$ broad hyphae. Clamp connections absent throughout.

Collection studied – India, Punjab, Patiala, Harpalpur, 251 m asl., growing in groups on buffalo dung heap, 19 July 2011, Amandeep Kaur, PUN 4792.

Discussion – This specimen has been identified as *L. straminellus*. The species is recognized by yellowish white pileus with a darker yellowish brown umbo, median annulus and ovoid to ellipsoidal basidiospores without germ pore. *Leucocoprinus birnbaumii* is a closely related species but has sulphur yellow pileus and thicker stipe in comparison to this species (Vellinga 2001, Assfour *et al.* 2009).

Assfour *et al.* (2009) recorded the species growing in flower pots from Morocco. It has also been reported growing in fasciculate manner on compost heaps (http://naturamalta.com/Leucocoprinus_straminellus.html). Kumar & Manimohan (2009b) reported this species from South India. It is a new record from North India.

Lepiota epicharis var. *occidentalis* Dennis in *Kew Bull.* 15: 111, 1962.

Figs. 7 – 8

Carpophores 4.7–6.3 cm in height. Pileus 3.3–4.2 cm broad, 2.7–3.2 cm high, convex; surface dry, scaly, scales reddish brown (8E₅) on pale (2A₂) background, appressed fibrillose, radially arranged in concentric rings, covering the entire surface, more aggregated along the apex; margin regular, not splitting, non striate; cuticle half peeling; flesh thin, up to 0.25 cm thick, pale, unchanging; taste acrid; odor farinaceous. Lamellae free, unequal, 4–sized, subdistant, moderately broad, up to 0.3 cm broad in the center, pale (2A₂); gill edges smooth. Spore print white. Stipe 4.4–5 cm long, 0.3–0.5 cm broad, cylindrical, with slightly bulbous base, solid, surface pale (2A₂), bruising brown, pruinose with white mycelium at the base; annulate, annulus pale (2A₂), fleshy, superior, attached, persistent.

Basidiospores 6–8.5 × 4.3–6 μm (Q = 1.4), ovoid to ellipsoidal, germ pore absent, thick-walled, smooth, colorless, dextrinoid, not metachromatic in cresyl blue. Basidia 17–25.5 × 6–8.5 μm, cylindrico-clavate, 2-, 4-spored, mostly 4-spored, thin walled, hyaline; sterigmata 2.5–4.3 μm long. Gill edges sterile. Cheilocystidia 25.5–35.7 × 7.6–15.3 μm, cylindrical to clavate, thin-walled, weakly granular. Pleurocystidia absent. Pileus cuticle hymeniform, made up of cylindrical, clavate to piriform, thin-walled, weakly granular subcellular elements measuring 20.4–63 × 6.8–12 μm; pileus context homoiomerous, composed of interwoven, thin walled, hyaline 5–15.3 μm broad hyphae. Hymenophoral trama regular, made up of thin-walled 3.4–10 μm broad hyphae. Subhymenium pseudoparenchymatous. Stipe cuticle smooth, context hyphae longitudinally tangled, cylindrical, thin-walled, hyaline, 5–13.6 μm broad. Clamp connections present in pileus and stipe context hyphae.



Fig. 7 – *Lepiota epicharis* var. *occidentalis*. A Carpophores growing in a natural habitat. B Carpophores showing pileal scales and fleshy annulus.

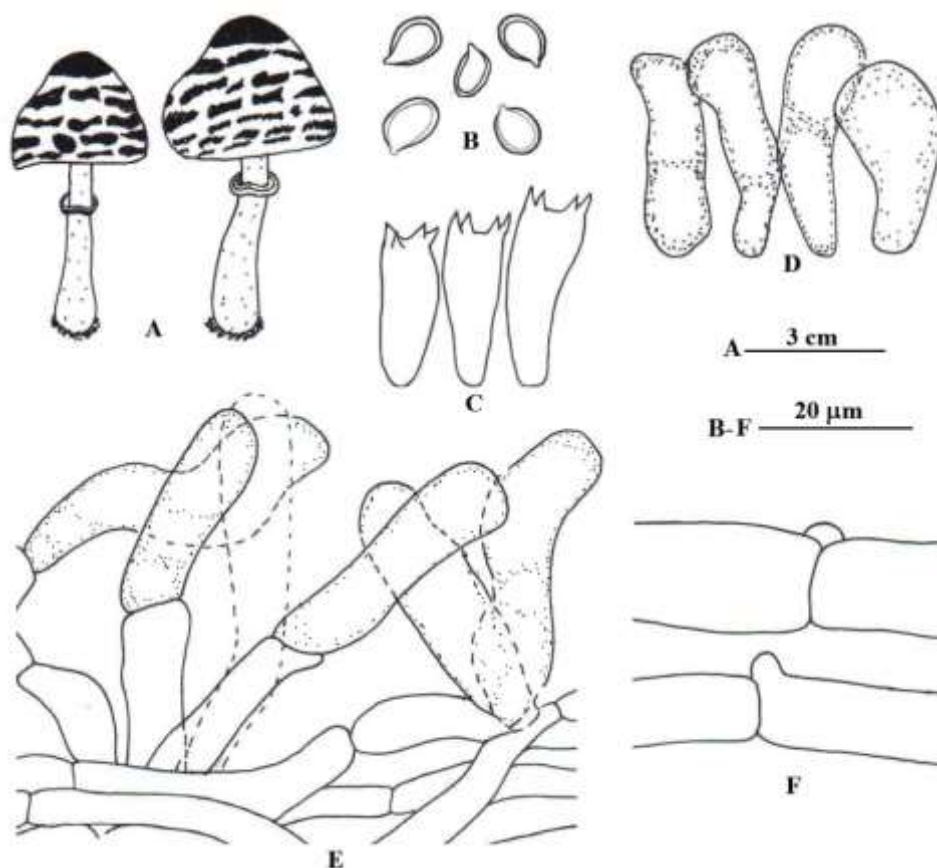


Fig. 8 – *Lepiota epicharis* var. *occidentalis*. A Carpophores. B Basidiospores. C Basidia. D Cheilocystidia. E Pileus cuticle elements. F Clamp connections in stipe context hyphae.

Collection studied – India, Punjab, Hoshiarpur, Shehbazpur Tanda, 295 m asl., growing in a group on mixed buffalo dung and leaf litter heap, 03 September 2011, Munruchi Kaur and Amandeep Kaur, PUN 4787.

Discussion – In the presently examined collection, the morphological and microscopic characters are similar to those given for *L. epicharis* var. *occidentalis* by Pegler (1983). This variety possesses convex pileus with non-striate margin, pale colored lamellae and reddish brown scales (Pegler 1983). *Lepiota epicharis* var. *epicharis* differs from it in having campanulate outline of the pileus with striate margin, yellowish lamellae and the slightly paler squamules (Pegler 1972). *Lepiota epicharis* var. *indica* is yet another close variant which differs from it in the pileus shape which is ovate with a flat disc when young, becoming conic to convex with an umbo at maturity, grayish orange lamellae and slightly smaller spores measuring $4.4\text{--}7.7 \times 2.2\text{--}3.3 \mu\text{m}$ in size (Natarajan & Manjula 1982).

Pegler (1983) described *L. epicharis* var. *occidentalis* growing solitary on forest soil during the month of July from Martinique and Venezuela in Lesser Antilles. Manjula (1983) reported the species from Tamil Nadu state in South India. Presently it has been recorded for the first time from North India.

Lepiota subincarnata J.E. Lange in *Flora Agaricina Danica* 5: 5, 1940.

Figs. 9 – 10

Synonyms: *Lepiota josserandii* Bon & Boiffard in *Bull. Soc. Mycol. France* 90(4): 289, 1975.

Lepiota josserandii var. *rosabrunnea* Raithelhuber in *Metrodiana* 16(1–3): 42, 1988.

Carpophore 2.5 cm in height. Pileus 1.7 cm broad, convex, ex-umbonate; surface dry, pale yellow, scaly; scales reddish purple, erect, pointed, arranged in concentric rings, more aggregated along the apex; margin regular, splitting, non-striate, involute; cuticle fully peeling; flesh thin, 0.25 cm thick, pale, unchanging; taste acrid; odor mild. Lamellae free, unequal, 3-sized, subdistant,



Fig. 9 – *Lepiota subincarnata*. A Carpophore growing in natural habitat. B Carpophore showing involute pileal margin and discoloring of stipe surface when bruised.

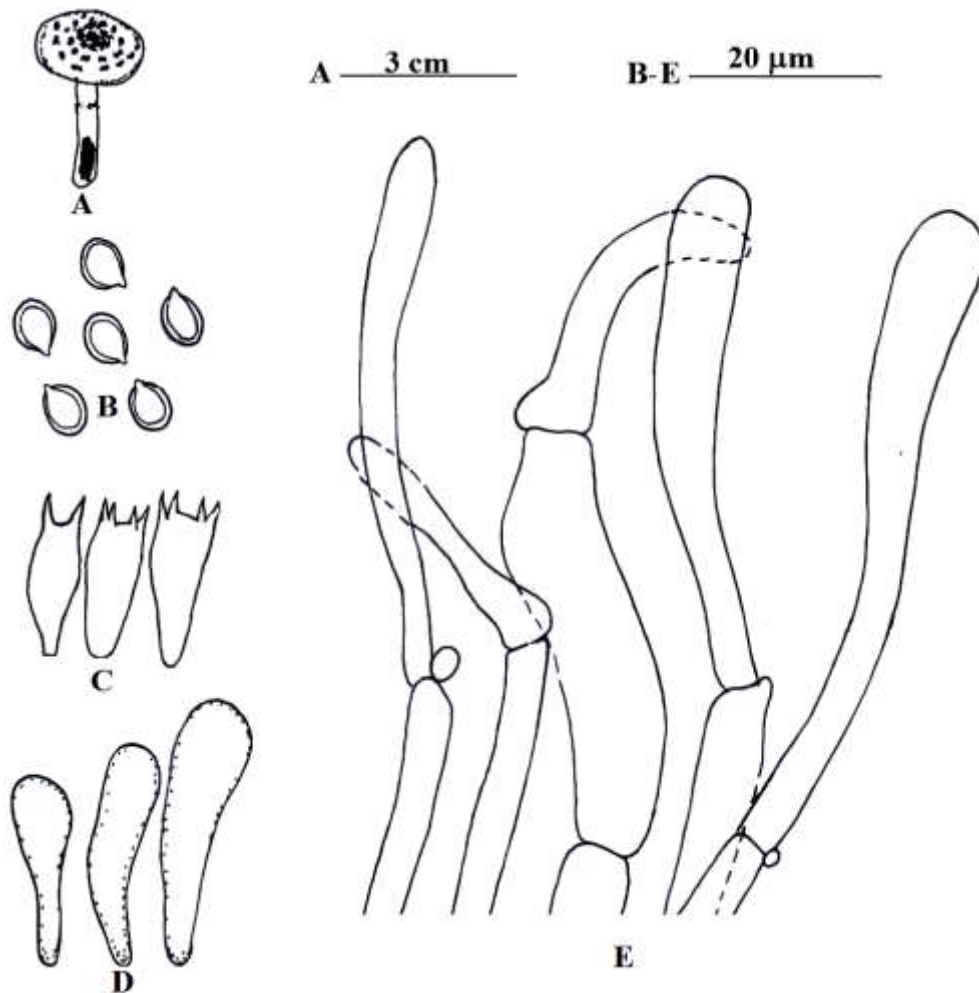


Fig. 10 – *Lepiota subincarnata*. A Carpophore. B Basidiospores. C Basidia. D Cheilocystidia. E Pileus cuticle elements.

moderately broad, up to 0.3 cm broad, white; gill edges smooth. Stipe central, 2.3 cm long, 0.3 cm broad, cylindrical, equal in diameter throughout, solid, surface pale yellow, changing to reddish brown when handled, pruinose; annulate, annulus superior, membranous, patchy.

Basidiospores $5-7 \times 3.4-4.3 \mu\text{m}$ ($Q = 1.55$), ovoid to ellipsoidal, thick-walled, smooth, germ pore absent, colorless, dextrinoid, not metachromatic in cresyl blue. Basidia $13.6-17 \times 5-6.8 \mu\text{m}$, cylindrical to clavate, 2- and 4-spored, thin walled, hyaline; sterigmata $2.5-4.3 \mu\text{m}$ long. Gill edges sterile. Cheilocystidia $18.7-27.2 \times 5-7.6 \mu\text{m}$, elongated cylindrical to clavate, thin-walled, hyaline. Pleurocystidia absent. Pileus cuticle a trichodermial palisade, made up of elongated, erect, cylindrical to clavate, thin-walled, $5-12 \mu\text{m}$ broad hyaline hyphal elements, sometimes with clamp connections at the basal septa; pileus context homoiomerous, made up of interwoven, thin-walled, hyaline $5-15.3 \mu\text{m}$ hyphae. Hymenophoral trama regular composed of parallel, thin-walled, hyaline hyphae. Subhymenium pseudoparenchymatous. Stipe cuticle smooth, context made up of parallel, thin-walled, hyaline $5-12 \mu\text{m}$ broad hyphae. Clamp connections present throughout.

Collection studied – India, Punjab, Sangrur, Qila Rehmatgarh, 231 m asl., growing solitary on camel dung mixed with plant debris, 19 September 2011, Amandeep Kaur, PUN 4788.

Discussion – The morphological and anatomical details of the above examined collection are in conformity with *L. subincarnata* (Vellinga 2001). The characteristic features of the species include the small sized carpophore, reddish purple erect scales, involute pileal margin, stipe bruising brownish and unpleasant taste (Vellinga 2001).

It is reported to be very toxic and lethal because of the presence of amanitins and amatoxins (Vellinga 2001, Hall 2003). The species is reported to be widespread in Europe on humus or nutrient-rich sandy to clayey soils, in parks and gardens and also on mine waste heaps (Vellinga 2001). From India, Kumar & Manimohan (2009a) recorded the species for the first time from Kerala state. Presently, it was found for the first time from North India.

Lepiota thrombophora (Berk. & Br.) Sacc. in *Syll. Fung.* 5: 53, 1887.

Figs. 11 –12

Basionym: *Agaricus thrombophorus* Berk. & Broome in *J. Linn. Soc. Bot.* 11: 500, 1871.

Carpophores up to 6 cm in height. Pileus up to 4.5 cm broad, 2.3 cm high, conical to convex when young, applanate at maturity; umbonate, umbo broad, depressed, golden brown; surface dry, scaly, scales brownish on whitish background, powdery and recurved fibrillose, fibrils arranged in concentric rings, covering the entire surface; margin regular, not splitting, non-striate, sometimes reflexed at maturity, appendiculate in some carpophores; cuticle not peeling; flesh thin, whitish, unchanging; taste and odor mild. Lamellae free, unequal, 3- sized, close, broad, up to 0.4 cm in width, cream; gill edges smooth, fragile. Stipe central, up to 5 cm long, 0.7 cm broad, cylindrical, with bulbous base, hollow, surface cream, changing to brownish yellow on bruising, fibrillose, with white mycelium at the base; annulate, annulus single, superior, membranous.

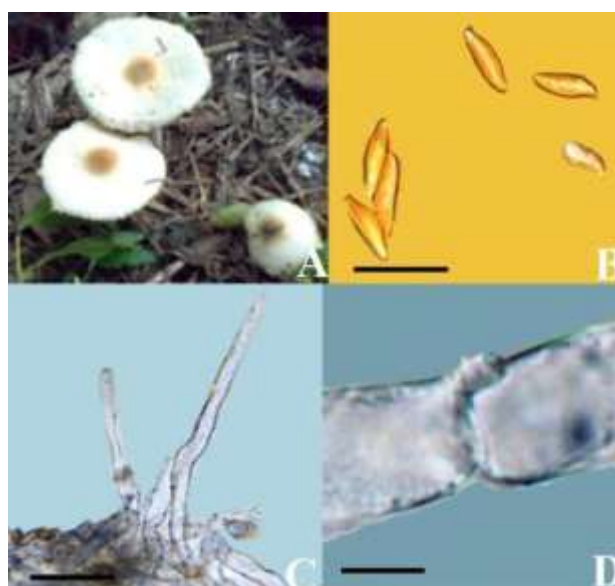


Fig. 11 – *Lepiota thrombophora*. A Carpophores. B Basidiospores. C Pileal elements. D Clamp connection in pileus context. Bars B–D 20 μm .

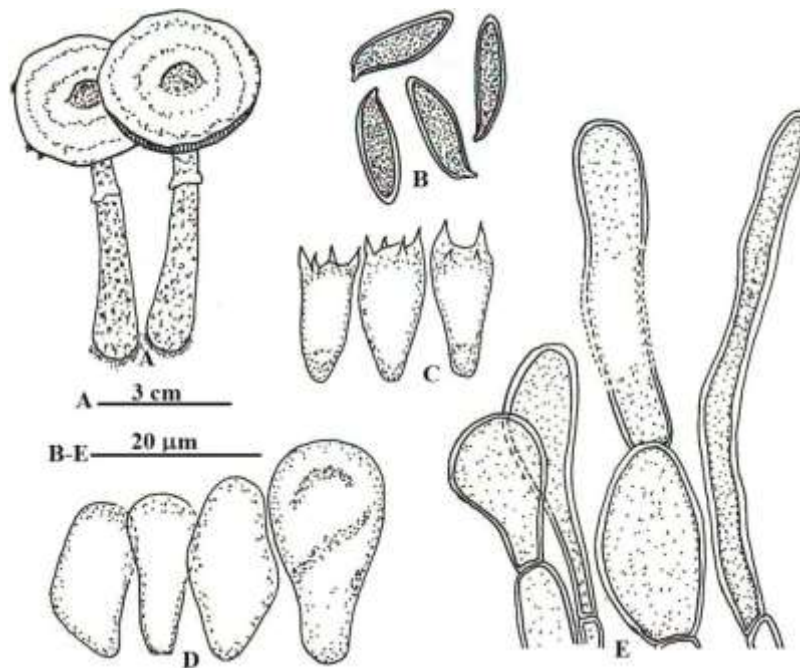


Fig. 12 – *Lepiota thrombophora*. A Carpophores. B Basidiospores. C Basidia. D Cheilocystidia. E Pileus cuticle elements.

Basidiospores $11.4\text{--}15.6 \times 2.8\text{--}5 \mu\text{m}$ ($Q = 3.46$), oblong, cylindrical to elongated fusiform, with an attenuated apex and suprahilar depression, thick-walled, smooth, dextrinoid, not metachromatic in cresyl blue. Basidia $11.4\text{--}14 \times 5.4\text{--}8.4 \mu\text{m}$, clavate, 4-spored, thin walled, hyaline; sterigmata $2.8\text{--}4.3 \mu\text{m}$ long. Gill edges sterile. Cheilocystidia $18.5\text{--}27 \times 7\text{--}14 \mu\text{m}$, clavate, lageniform, thin-walled. Pleurocystidia absent. Pileus cuticle a trichodermial palisade, made up of $40\text{--}102 \times 4\text{--}32.5 \mu\text{m}$, cylindrical to clavate, thick-walled hyphal elements; pileus context homoiomerous, made up of intermingled, hyaline hyphae. Hymenophoral trama regular composed of parallel, thin-walled hyphae measuring $6\text{--}20 \mu\text{m}$ in width. Subhymenium pseudoparenchymatous. Stipe context made up of thin-walled, hyaline $4\text{--}17 \mu\text{m}$ broad hyphae. Annulus composed of intermingled, septate, $3\text{--}8.5 \mu\text{m}$ broad hyphae. Clamp connections present in pileus and stipe context hyphae.

Collection studied – India, Punjab, Ropar, Mugal Majri, 394 m asl., growing in groups on mixed cattle dung and leaf litter, 21 August 2009, Amandeep Kaur, PUN 4071.

Discussion – The gross morphology and internal details of the presently worked out collection are in conformity with *L. thrombophora* (Pegler 1972, 1986). The species is recognized by elongate and fusoid basidiospores, brownish scales on the pileus, non-striate pileal margin, inflated cylindrical to clavate pileus cuticle hyphae and whitish fibrillose stipe. *Lepiota metulaespora* closely resembles this species but differs in having light ochraceous buff pileal scales, radially sulcate striate pileal margin, obtuse apices of pileus cuticle hyphae and lemon yellow stipe surface (Pegler 1972).

Pegler (1986) reported this species growing on ground in the month of January from Sri Lanka. Manjula (1983) reported the species growing on soil for the first time from Tamil Nadu in India. In the present investigation, it has been recorded from the coprophilous habitat for the first time from North India.

Lepiota xanthophylla P.D. Orton in *Trans. Brit. Mycol. Soc.* 43(2): 289, 1960. Figs. 13 – 14

Carpophores $3.7\text{--}5.7 \text{ cm}$ in height. Pileus $2.3\text{--}2.9 \text{ cm}$ broad, applanate; umbonate, umbo broad, reddish brown; surface dry, yellowish white, scaly; scales reddish brown, appressed, wooly squamose, arranged in concentric rings, entire at the umbo, sparse towards the periphery; margin irregular, splitting, non-striate, reflexed at maturity, appendiculate in some carpophores; cuticle



Fig. 13 – *Lepiota xanthophylla*. A Carpophore growing in natural habitat. B Carpophore showing lamellae arrangement.

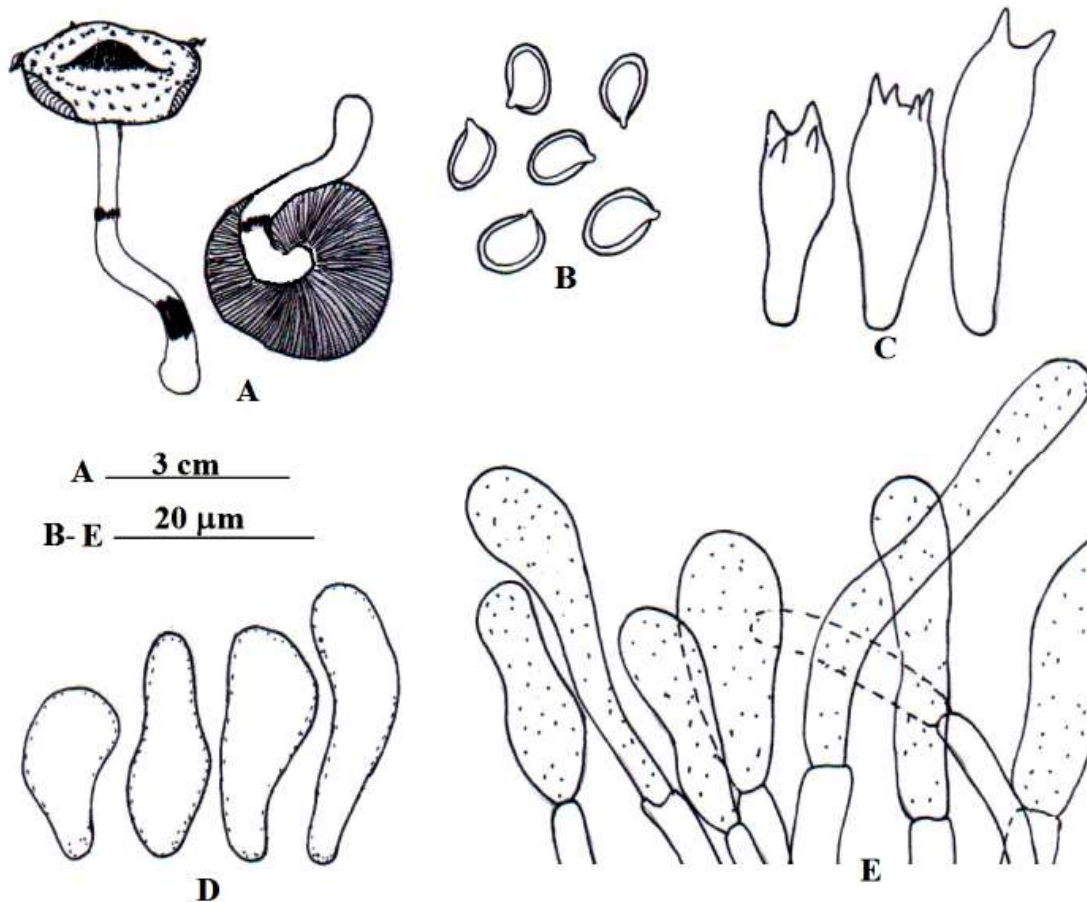


Fig. 14 – *Lepiota xanthophylla*. A Carpophores. B Basidiospores. C Basidia. D Cheilocystidia. E Pileus cuticle elements.

fully peeling; flesh thin, 0.2 cm thick, whitish, unchanging; taste mild; odor disagreeable. Lamellae free, unequal, 4– sized, subdistant, moderately broad, 0.3– 0.4 cm broad, fragile, yellowish white; gill edges serrate. Stipe central, 3.5–5.5 cm long, 0.2–0.3 cm broad, cylindrical, obclavate, longitudinally striated, curled, solid, surface yellowish white, changing to yellowish brown where handled, smooth; annulate, annulus single, median, membranous, patchy, attached.

Basidiospores $6.8\text{--}8.5 \times 3.4\text{--}4.3(5) \mu\text{m}$ ($Q = 1.98$), oblong, ellipsoidal to oblong, thick-walled, smooth, germ pore absent, colorless, dextrinoid, not metachromatic in cresyl blue; apiculate, apiculus eccentric, $0.85 \mu\text{m}$ long. Basidia $18.7\text{--}32.3 \times 6.8\text{--}9.3 \mu\text{m}$, cylindrico-clavate to clavate, 2- and 4-spored, thin walled, hyaline; sterigmata $1.7\text{--}3.4 \mu\text{m}$ long. Gill edges sterile. Cheilocystidia $17\text{--}25.5 \times 8.5\text{--}11 \mu\text{m}$, polymorphic, cylindrical, clavate to lageniform, thin-walled, hyaline. Pleurocystidia absent. Pileus cuticle a trichodermial palisade, made up of cylindrical, piriform, lageniform to clavate, thin-walled, granular, $6.7\text{--}12.7 \mu\text{m}$ broad hyphal elements; pileus context homoiomerous, made up of ellipsoidal to cylindrical hyphae. Hymenophoral trama regular, composed of parallel, thin-walled, hyaline hyphae measuring $5\text{--}16 \mu\text{m}$ in width. Subhymenium pseudoparenchymatous. Stipe cuticle smooth, context made up of parallel, thin-walled, hyaline $3.4\text{--}18.7 \mu\text{m}$ broad hyphae. Clamp connections present throughout.

Collection studied – India, Punjab, Faridkot, Deena Kangar, 196 m asl., growing scattered on buffalo dung, August 19 August 2011, Amandeep Kaur, PUN 4789.

Discussion – The presently worked out collection is identified as *L. xanthophylla*. Another species *L. citrophylla* is quite close but differs in having citrine colored pileus with more olivaceous scales, basidiospores strongly truncate at the base and the trichodermial elements mostly lageniform in shape (Pegler 1977, Vellinga 2001).

Pegler (1977) reported this species growing solitary on forest floor in the month of March from Kenya and on leaf litter in June from Uganda. Vellinga (2001) reported it growing gregariously on nutrient-rich humicolous soils in the months of September and October from the Netherlands. Chou (2010) recorded it growing on rotten wood in the month of May from Taiwan. Kumar & Manimohan (2009a) and Mohanan (2011) recorded *L. xanthophylla* from South India. Presently, it was found growing scattered on buffalo dung for the first time from North India.

Agaricus cupreobrunneus (Schäffer & Steer: Møller) Pilát in *Acta Mus. Nat. Pragae* 7B(1):14, 1951. Figs. 15 – 16

Basionym: *Psalliota cupreobrunnea* Jul. Schäff. & Steer: F.H. Møller in *Friesia* 4(1–2): 54, 1950.

Synonym: *Psalliota campestris* var. *cupreobrunnea* Jul. Schäff. & Steer ex F.H. Møller in *Friesia* 4(1–2): 54, 1950.

Carpophores up to 8.3 cm in height, placomycetoid. Pileus up to 6.3 cm broad, convex when young, applanate at maturity; surface dry, shiny, white, scaly, scales appressed fibrillose throughout the pileus surface when young, with scattered squamules arranged in concentric rings at maturity, squamules more aggregated along the centre, reddish brown; margin irregular, radially splitting at maturity, non-striate, appendiculate; cuticle fully peeling; flesh up to 0.4 cm thick, white, reddish brown when handled or with age; taste mild, odor fragrant. Lamellae free, unequal, 2-sized, subdistant, broad, up to 0.6 cm broad, brown then dark chocolate brown; gill edges smooth. Spore print grayish brown. Stipe central, up to 8.1 cm long, 1.1 cm broad, cylindrical, obclavate, solid, surface white, bruising brownish, shiny, minutely scaly; annulate, annulus superior, thin, membranous, patchy, evanescent.



Fig. 15 – *Agaricus cupreobrunneus*. A Carpophores growing in natural habitat. B Mature carpophores showing radially splitting margin.

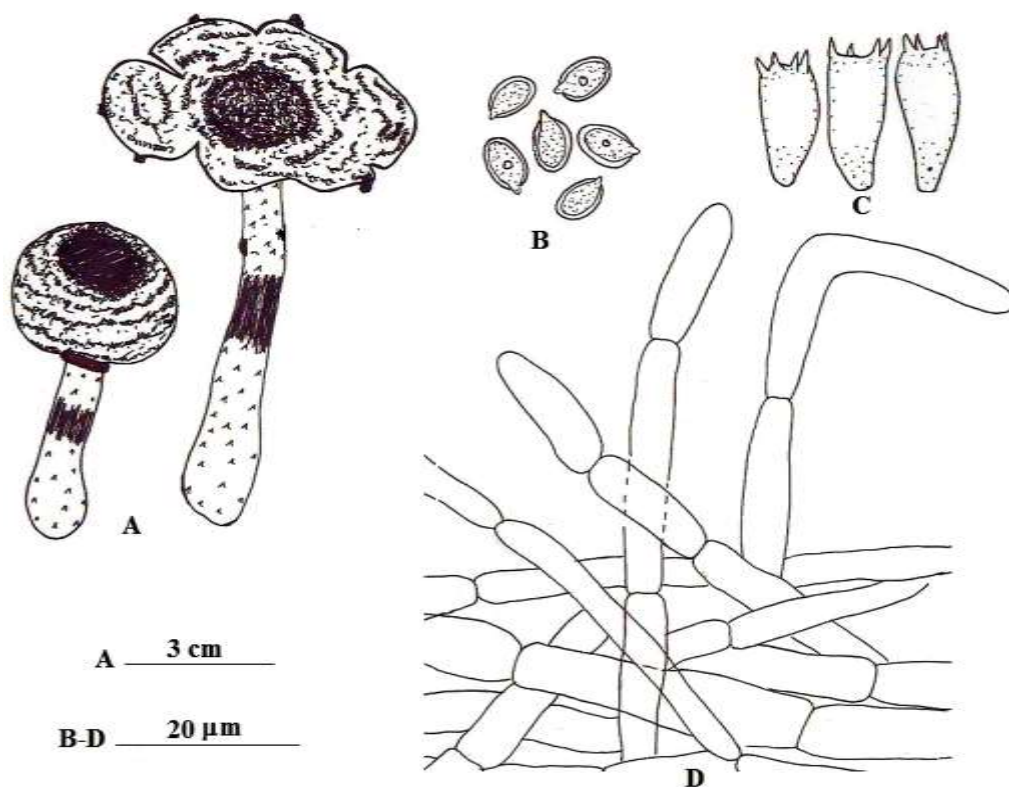


Fig. 16 – *Agaricus cupreobrunneus*. A Carpophores. B Basidiospores. C Basidia. D Pileus cuticle elements.

Basidiospores $6.8\text{--}8.5 \times 3.4\text{--}5 \mu\text{m}$ ($Q=1.82$), ovoid, germ pore absent, thick-walled, smooth, 1-guttulate, grayish brown. Basidia $15.3\text{--}18.7 \times 6\text{--}7.6 \mu\text{m}$, clavate, 4-spored, thin walled, weakly granular towards the base; sterigmata $1.7\text{--}2.5 \mu\text{m}$ long. Gill edges fertile. Both cheilocystidia and pleurocystidia absent. Pileus cuticle with scattered, projecting, septate, thin-walled, $3.4\text{--}6.8 \mu\text{m}$ broad hyphae; pileus context made up of interwoven $6.8\text{--}15.3 \mu\text{m}$ broad hyphae. Hymenophoral trama regular, composed of parallel, $5\text{--}13.6 \mu\text{m}$ broad hyphae. Stipe made up of longitudinally arranged, thin-walled $5\text{--}15.3 \mu\text{m}$ broad hyphae. Universal veil tissue made up of subglobose to ellipsoidal elements measuring $5\text{--}12 \mu\text{m}$ in width. Clamp connections absent throughout.

Chemical color reactions – Schaeffer's reaction negative; pileus flesh turns dark brown in concentrated H_2SO_4 .

Collection studied – India, Punjab, Sangrur, Fatehgarh Channa, 231 m asl., growing scattered in a fairy ring on mixed cattle dung along with earthworm excreta, 25 July 2010, Amandeep Kaur, PUN 4213.

Discussion – The above examined collection has been identified as *A. cupreobrunneus*. Its morphological and anatomical details match well with the description given for this species by Arora (1986), Kerrigan (1986) and Kuo & Zordani (2004). The species is commonly known as "Brown Field Mushroom" (Arora, 1986). It is recognized by medium sized carpophores, brown appressed shaggy tomentum forming fibrillose-squamulose pileus surface, inconspicuous membranous annulus, and blunt stipe base. *Agaricus rutescens* is a similar species but has reddish scales on the pileus. *Agaricus subrutescens* is also similar but has stipe conspicuously floccose to cottony below the annulus and gills becoming rufescent when cut or bruised (Arora 1986, http://www.mycoweb.com/CAF/keys/Agaricus_key.pdf).

Agaricus cupreobrunneus has been documented to be edible, having good flavor (Arora, 1986; Kerrigan, 1986). However, from India there is no report about its edibility.

It grows solitary, scattered to gregariously in disturbed areas and grassy places, such as lawns, pastures, and roadsides etc. (http://en.wikipedia.org/wiki/Agaricus_cupreobrunneus). Arora (1986) reported the species growing solitary to scattered or gregarious in pastures, lawns and other grassy places from California. Kuo & Zordani (2004) reported it growing in grassy areas throughout North America. The species was documented earlier from Maharashtra state in India by Patil *et al.* (1995). The fungus is a new record from North India.

Agaricus halophilus Peck in *Bull. New York State Mus.* 94: 36, 1905.

Figs. 17 – 18

Synonyms: *Agaricus maritimus* Peck in *Bull. Torrey Bot. Club* 26: 66, 1899.

Inocybe maritima (Peck) Saccardo in *Syll. Fung.* 21: 208, 1912.

Carpophores 3.5–10 cm in height, placomycetoid; Pileus 2.7–7 cm broad, 1.7–2.5 cm high, convex to applanate; umbonate, umbo broad, brown; surface dry, dingy, pinkish gray to brownish gray, scaly, scales dark brown, appressed fibrillose to recurved fibrillose, arranged in concentric rings, more aggregated around the apex; margin regular, involute, splitting at maturity, non-striate; cuticle fully peeling; flesh thin, pale, becoming reddish brown to dark brown when cut; taste mild; odor farinaceous. Lamellae free, unequal, 3-sized, crowded, moderately broad to broad, 0.3–0.6 cm broad, dingy, pinkish brown when young, dark brown to blackish brown at maturity. Spore print brown. Stipe central, 3.3–9.8 x 0.7–0.95 cm, cylindrical, with sub-bulbous base, solid, surface creamish, bruising pinkish brown then dark brown, fibrillose, with white mycelium at the base; annulate, annulus superior, large, thick, with brownish floccose scales on the under surface, pendant, persistent.

Basidiospores 5–7.6 x 3.4–5 (6) μm (Q=1.5), ovoid to broadly ellipsoidal, germ pore absent, thick-walled, smooth, brown. Basidia 16–20.4 x 6.8–9.4 μm , clavate, 4-spored, thin-walled, hyaline. Gill edges fertile. Cheilocystidia and pleurocystidia absent. Pileus cuticle with projecting, sometimes branched, septate, thin walled, 5–8.5 μm broad hyphae, uppermost cell sometimes capitate; pileus trama below the cuticle homoiomerous, made up of interwoven hyphae measuring 3.4–12 μm in width. Hymenophoral trama regular, composed of parallel, thin walled, 3.4–13.4 μm broad hyphae. Subhymenium pseudoparenchymatous. Stipe context made up of cylindrical, thin-walled, 3.4–13.4 μm broad hyphae. Clamp connections absent throughout.

Chemical colour reaction – Schaeffer's reaction negative.

Collections studied – India, Punjab, Mohali, Dau Majra, 316 m asl., growing scattered on mixed cattle dung heap, 10 July 2010, Amandeep Kaur, PUN 4211; Sangrur, Daulatpur Channa, 231 m asl., growing in groups on buffalo dung, 25 July 2010, Amandeep Kaur, PUN 4212.



Fig. 17 – *Agaricus halophilus*. A Carpophores growing in natural habitat. B Underside of the carpophore showing thick, pendant annulus and discolored stipe surface after bruising.

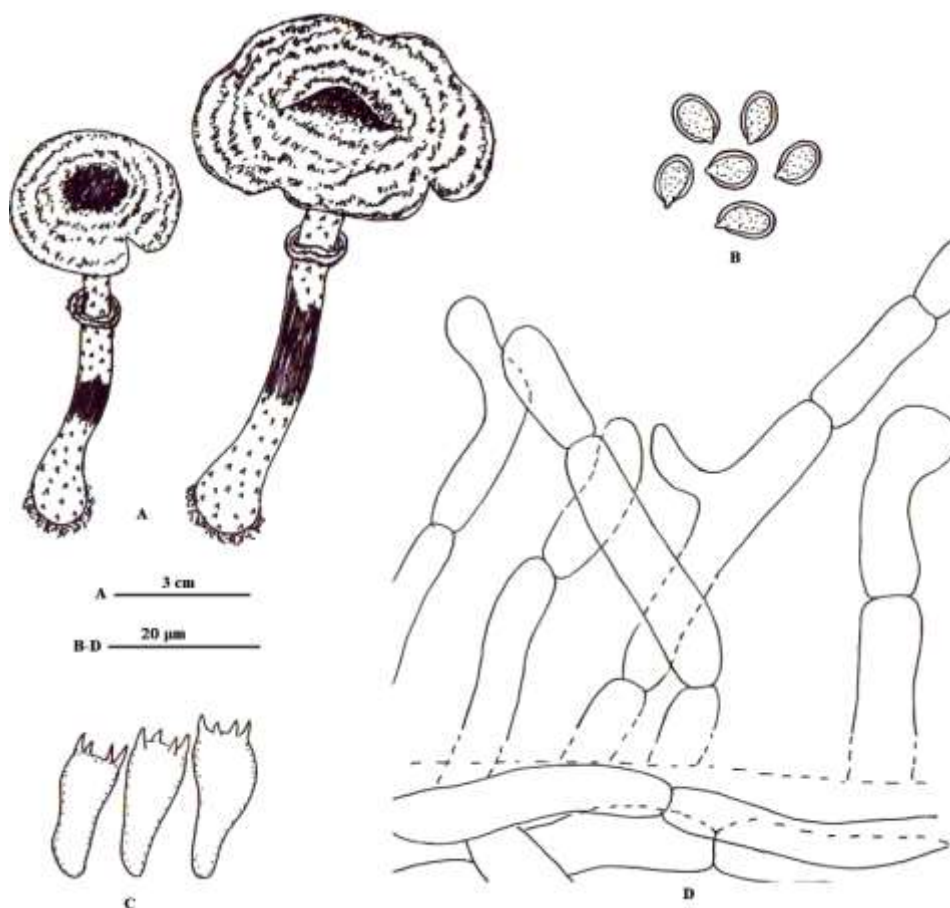


Fig. 18 – *Agaricus halophilus*. A Carpophores. B Basidiospores. C Basidia. D Pileus cuticle elements.

Discussion – The morphological and anatomical characters of the presently examined collections are in conformity with those given for *A. halophilus* by Murrill (1922) and Hotson & Stuntz (1938). The species is recognized by its dingy pinkish gray to grayish brown pileus with inrolled margin, dark brown to blackish brown crowded gills, solid stipe with large thick persistent annulus and context staining reddish brown when cut. *Agaricus haemorrhoidarius* is quite close to this species but differs by having hollow stipe, flesh becoming blood-red where broken, rosy to purplish umber gills and membranous annulus (Hotson & Stuntz 1938).

Agaricus halophilus is reported to be an edible mushroom with a slightly salty taste (Murrill 1922).

The species has been reported to be growing solitary or scattered to densely gregarious in sandy soil, disturbed areas, lawns and various other habitats throughout Europe (Murrill 1922). Hotson & Stuntz (1938) recorded it from Washington. Presently it is recorded for the first time from India.

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