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New additions to the genus *Agaricus* (*Agaricaceae*, *Agaricales*) from Northwest India

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ABSTRACT

In the present paper 11 taxa of genus *Agaricus* L.: Fr. collected from different tropical, subtropical and temperate areas of Punjab and Jammu and Kashmir (India) are described. These are *A. porphyrocephallus* F.H.Møller, *A. subrutilescens* (Kauffman) Hotson & Stuntz, *A. parvitigrinus* Guinb. & Callac, *A. silvaticus* var. *pallidus* (F.H. Møller) F.H. Møller, *A. mealgaris* var. *obscuratus* (Maire) Heinem, *A. rubribrunnescens* Murrill,W.A, *A. andrewii* Freeman A.E.H, *A. blazei* Murrill W.A, *A. fuscovelatus* Kerrigan R.W, *A. bolorhizus* Berk. & Broome and *A. californicus* Peck. Based on morphotaxonomy all these 11 species are new records for Indian mycobiota and described here for the first time along with their identification key, distribution, ecological and edibility status.

KEYWORDS: Taxonomy, identification key, distribution, ecology, edibility.

INTRODUCTION

Fungal forays were undertaken for the collection of species of genus *Agaricus* L.: Fr. to various localities of Northwest India falling in Punjab, Jammu and Kashmir. The topography and climate of the investigated region favours good growth of mushrooms in general and *Agaricus* in particular during monsoon season in these areas. The genus *Agaricus* is a fleshy lamellate agaricoid mushroom which belongs to family *Agaricaceae* under order *Agaricales.* Recent review on this genus has documented more than 400 species world over (Karunarathna *et al.,* 2016) while from India, about 127 species have been recorded (Biligrami *et al*., 1991; Saini *et al*., 1991; Atri *et al*., 1992, 2001; Natarajan *et al*., 2005; Gupta *et al*., 2008a, b; Farook *et al*., 2013, Kaur *et al*., 2014, 2015; Kaur *et al*. 2016 a, b; Upadhyay *et al*, 2017). It is distinctive and characterized by having white to dull colored fleshy carpophores with scaly or areolately warted cap, pinkish or brown to chocolate brown free gills, annulate stipe, hyphal pileus cuticle and presence or absence of cheilocystidia and pleurocystidia. This genus is known by its nutritionally and nutraceutically important species. Thus the fungal forays were aimed for the collection of the representative taxa belonging to this genus.

Presently, eleven taxa of *Agaricus* were worked out and identified (exclusively with morphology) as new to India. But, phylogenetic confirmation of these species are yet to be established. In all taxonomic details, distribution, ecology and edibility status of the species of this genus have been discussed in this paper. A key to their identification has also been provided.

MATERIALS AND METHODS

Standard protocol was followed for the study of macroscopic and microscopic characters as given by Atri *et al*. (2005). Colors were recorded as per the color terminology given by Kornerup and Wanscher (1978). The examined specimens were preserved as per standard technique given by Smith (1949) and Atri and Saini (2000). Basidiospore quotient (Q) was calculated in profile view by obtaining mean length divided by mean width ratio of a basidiospores. All the examined specimens were deposited in the Herbarium of Botany Department, Punjabi University, Patiala (Punjab), India under PUN.

TAXANOMY

Key to the identification of the 11 species of *Agaricus* namely *A. porphyrocephallus* F.H.Møller, *A. subrutilescens* (Kauffman) Hotson & Stuntz, *A. parvitigrinus* Guinb. & Callac, *A. silvaticus* var. *pallidus* (F.H. Møller) F.H. Møller, *A. mealgaris* var. *obscuratus* (Maire) Heinem, *A. rubribrunnescens* Murrill,W.A, *A. andrewii* Freeman A.E.H, *A. blazei* Murrill W.A, *A. fuscovelatus* Kerrigan R.W, *A. bolorhizus* Berk. & Broome and *A. californicus* Peck is provided. The taxonomic description of individual species has been given as per the sequence of segregation of the individual species in the identification key to the species given below. All the species documented in this manuscript are legitimate on the Mycobank record.

Key to the described species

1. Campestroid.....**2**

1a. Placomycetoid.....**6**

2. Stipe equal in diameter, central; Schaeffer's reaction negative; flesh changing to brown or brownish red.....**3**

2a. Stipe with a bulbous base, central to excentric; Schaeffer's reaction positive or negative; flesh changing to pale orange, pinkish or pale red.....**4**

3. Annulus membranous; flesh taste spicy, changing to brown.....***A. californicus***

3a. Annulus skirt like; flesh taste mild, changing to brownish red.....***A. fuscovelatus***

4. Carpophore dark blond, honey coloured; Veil appendiculate; spores non guttulate; cheilocystidia absent.....***A. blazei***

4a. Carpophore white or cream with orange tinge; veil patchy; spores guttulate; cheilocystidia Present.....**5**

5. Stipe central, distinctly bulbous with mycelial threads at the base; annulus skirt like; flesh taste spicy; pileus cuticle ixocutis; spores with one guttule; cheilocystidia

rarely present, never in chains.....***A. bolorhizus***

5a. Stipe excentric, slightly bulbous without mycelial mat; annulus peronate; flesh taste mild; pileus cuticle non gelatinized; spores with one to three guttules; cheilocystidia abundantly present, mostly in chains.....***A. andrewii***

6. Flesh taste mild or spicy; pileus grayish brown with blackish centre; pileal veil cog wheel; stipe base bright yellow orange or turmeric yellow on injury at the stipe base.....**7**

6a. Flesh taste always mild; pileus white, off white, silvery shinning with brownish orange or light yellow tinge; veil appendiculate or patchy; stipe light yellow or light brown on brusing but never bright yellow or turmeric yellow at the stipe base.....**8**

7. Gill edges smooth; stipe distinctly bulbous with rhizomorphs, turning to turmeric yellow near the base; annulus single to evanescent in mature carpophores.....***A. parvitigrinus***

7a. Gill edges lacerate; stipe slightly bulbous without rhizomorphs, turning to bright orange yellow at the base; annulus double with squamules underside, persistent.....***A. mealgaris* var. *obscuratus***

8. Veil absent; rhizomorphs present.....***A. silvaticus* var. *pallidus***

8a. Veil appendiculate or patchy; rhizomorphs absent.....**9**

9. Veil patchy; gill edges sterile; flesh abruptly changing to reddish then brown to blackish.....***A. rubribrunnescens***

9a. Veil appendiculate; gill edges fertile or heteromorphous; flesh unchanging.....**10**

10. Gill edges smooth; spores non guttulate; cheilocystidia present .....***A. subrutilescens***

10a. Gill edges serrate; spores guttulate; cheilocystidia absent.....***A. porphyrocephallus***

1. ***Agaricus californicus*** Peck, *Bull. Tor. Bot. Club,* **22**: 203, 1895.

Fig. 1(A); 2 (A-G)

Carpophores 2.2 - 4 cm in height, campestroid. Pileus convex when young, applanate at maturity, 2.5 - 4.6 cm broad; umbo absent; surface moist, white when young, reddish white ($9B_2$) at maturity; margin irregular, reflexed; cuticle fully peeling, not extending beyond the gills; flesh pinkish white ($8A_2$), changing to brown on exposure; taste spicy; odour mild. Pileal veil floccose along the margin. Lamellae free, unequal, subdistant, broad up to 0.7 cm broad, pinkish white ($8A_2$) when young, turn to flesh coloured then to greyish brown and finally dark brown at maturity, lamellae edges smooth. Spore deposit dark brown. Stipe central, 1.8 - 3 cm long, 0.5-0.6 cm broad, cylindrical, equal in diameter throughout, concolourous with pileus, hollow, smooth, annulate, annulus single, superior, membranous.

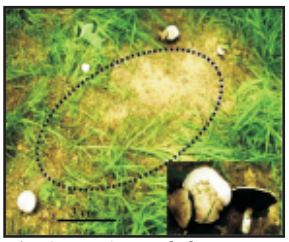

Fig. 1. *A. californicus*: Carpophores growing in fairy rings

Basidiospores 3.4 - 6.8 × 3.4-5.1 µm (excluding apiculus), (Q=1.3), broadly ellipsoid, smooth, double walled, pigmented, apiculate. Basidia 12 - 17 × 5.1 - 6.8 µm, clavate, tetra sterigmate, granular. Pleurocystidia absent. Cheilocystidia 18.0 19 × 6.76 - 12.67 µm, clavate, abundant, rendering the lamellae edges sterile. Carpophore context homoiomerous. Pileus cuticle trichodermal, 4 - 8 µm broad, granular, septate. pileus context hyphal. Hymenophoral trama irregular. Stipe cuticle hyphal, hyphae 3.38 - 6.76 µm broad, longitudinally tangled, septate. Annular ring hyphal, hyphae 2.53 - 4.22 (5.07) µm broad, pigmented. Clamp connections absent throughout.

Chemical colour reaction: Schaeffer's reaction negative. pileus cuticle not yellowing in KOH.

Collections examined: Punjab: Bathinda (211 m), Village Jodhpur, growing in groups on manured grassy soil, forming a fairy ring around *Acacia nilotica,* Harwinder Kaur, PUN 5874, August 01, 2009. Jammu and Kashmir, South Kashmir, Damhal Hanji Pora, village Hallan Manzgam (2700m), 33° 35.627′ N 074°50.798E, growing solitary in ECM association with *Cedrus deodara* in coniferous forest, Nazir Ahmad Malik, PUN 8536, August 5, 2014.

Distribution and ecology: Arora (1986) reported *A. californicus* to be growing solitary to scattered or gregarious in lawns, gardens, parks, under trees like *Acacia, Eucalyptus*, Oaks, etc. The present collection too was found growing in fairy rings among grasses around *Acacia nilotica* or as solitary under *Cedrus deodara* in the month of August.

Edibility: Arora (1986) has mentioned this species as mildly poisonous. The present collection being spicy in taste, is not recommended for eating purpose thus, it should be avoided.

Remarks: The field characters and the internal details of the present collection match with those given for *Agaricus californicus* by Arora (1986) and Kerrigan *et al.* (2005). The flesh colour which changes from pinkish white to brown on exposure exactly matches with the description of Arora (1986). Only the stipe seems to be shorter in our specimens. *A. californicus* is not earlier known from India, thus forms a new fungus record for India.

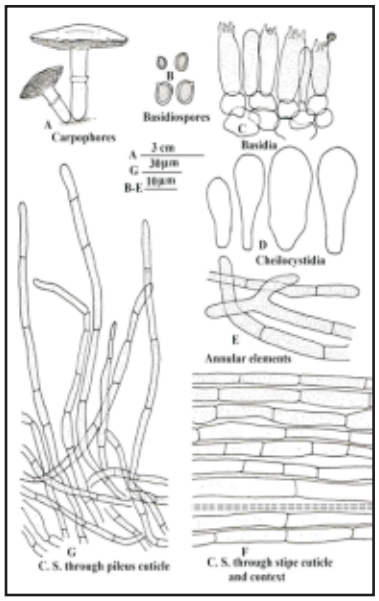

Fig. 2 (A-G) *A. californicus*

2. *Agaricus fuscovelatus* Kerrigan R.W., *Mycotaxon* **22** (2): 424, 1985.

Fig. 3(A); 4 (A-F)

Carpophores 6.5 - 7.3 cm in height, campestroid. Pileus convex, 5.5 - 9 cm broad, broadly umbonate; surface moist, grayish brown ($6D_3$) all over with white grey background; scaly, scales grayish brown ($6D_3$), appressed fibrillose, maximum in the center, arranged concentrically to cover the entire pileus; margin irregular; cuticle fully peeling, extending beyond the gills; flesh up to 1 cm thick, offwhite changing to reddish brown on exposure; taste and odour mild. Pileal veil patchy, brown underside, disappears at maturity. Lamellae free, unequal, crowded, broad (up to 1.3 cm broad), pinkish white ($7A_2$) when young, turning to dark brown ($6F_4$) at maturity, gill edges serrate in young, smooth at maturity, normal. Spore deposit dark brown ($6F_5$). Stipe central, 5.3 - 6.5 cm long, 0.7 - 1.4 cm broad, equal in diameter throughout, cylindrical, white ($1A_1$), somewhat pinkish white ($7A_2$) to brown ($7E_4$) above the annulus, brownish red on handling, hollow, scaly, scales fibrillose, annulate, annulus single, skirt like, superior, thick fleshy, white ($1A_1$), shredding downward, persistent, attached.

Basidiospores 6.76 - 7.6 (8.45) × 5.07 - 5.91 (6.76) µm (excluding apiculus), (Q=1.3), broadly ellipsoid, double walled, smooth, dark brown, granular, guttules absent; apiculate, apiculus, excentric. Basidia 21- 28 × 8.45 - 10.14 µm, clavate, tips granular, bi to usually tetra sterigmate. Pleurocystidia and Cheilocystidia absent; gill edges fertile. Carpophore context homoiomerous. Pileus cuticle trichodermal, 5.91 - 7.88 µm broad, septate; pileus context hyphal. Hymenophoral trama irregular. Stipe cuticle hyphal formed of longitudinally tangled hyphae measuring 3.94 - 5.91 µm in width, septate; stipe context hyphal. Annular hyphae, 3.94 - 7.88 µm broad, closely septate. Clamp connections absent throughout.

Chemical colour reaction: Schaeffer's reaction negative.

Collection examined: Punjab: Faridkot (196 m), Village Dod, growing scattered on humicolous and grassy soil under *Morus alba* tree, Harwinder Kaur, PUN 5892, September 12, 2009.

Distribution and ecology: Kerrigan (1985) reported *A. fuscovelatus* from California, growing gregarious, usually deeply rooted in bare compact soils generally under various planted conifers, during September to January; Arora (1986) found it growing scattered to densely gregarious under trees, in California. Presently found growing scattered on humicolous and grassy soil under *Morus alba*, during mid September.

Fig. 3 *A. fuscovelatus*: Carpophores growing in natural habitat showing pinkish gills in young stage and blackish brown at maturity

Edibility: Edible, although the carpophores are rather tough especially near the stipe (Arora, 1986).

Remarks: The details of presently examined collection matches well with the description given for *A.fuscovelatus* by Kerrigan (1985) and Arora (1986). The distinguishing feature of *A. fuscovelatus* as described by Kerrigan (1985, 1986) are grayish brown broadly umbonate cap covered with appressed fibrillose scales, off white flesh turning reddish on exposure. All these characters are common in the present collection. This species is a first report from India.

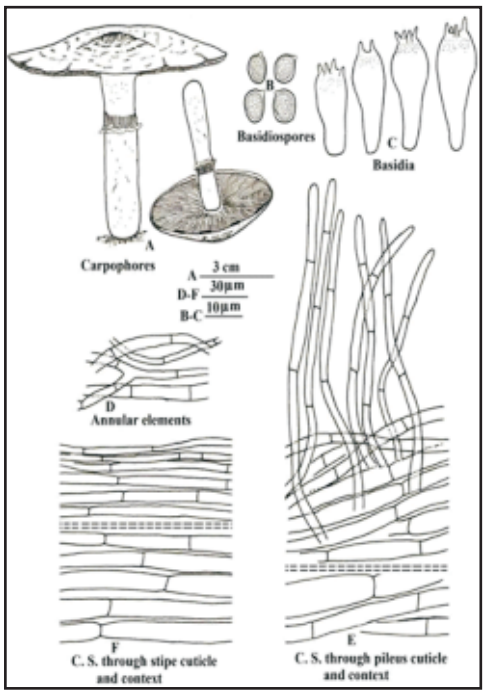

Fig. 4 (A-F) *A. fuscovelatus*

3. *Agaricus blazei* Murrill W.A., *Quart. J. Florida Acad. Sci*. **8** (2): 193, 1945.

Fig. 5(A); 6 (A-F)

Carpophores 1.9 - 9.2 cm in height, campestroid. Pileus dome like when young, convex at maturity, 1.6 - 7.1 cm broad, broadly umbonate; surface moist, glabrous; dark blond honey coloured ($5C_5$) to ($5D_5$) in button stage, off-white, covered with concentrically arranged light brown ($7D_4$) scales in their patches at maturity; scales more concentrated around the centre; margin irregular, extending beyond the gills, splitting at maturity; taste and odour mild; cuticle fully peeling; flesh white changing to light pinkish on exposure when bruised. Pileal veil appendiculate. Lamellae free, unequal, crowded, moderately up to 0.6 cm broad, reddish grey ($8B_2$) when young, maturing to light brown ($7D_4$) to finally dark brown ($7F_4$), gill edges lacerate; normal. Stipe central, 1.1-6.5 cm long, 0.7 - 0.9 cm broad above, up to 1.2 cm broad at the basal portion; base bulbous with small rhizomorphs, white, changing to pale red ($7A_3$) to light pinkish to light brown ($7D_4$) after sometime on handling, annulate, annulus double, superior, short skirt like with recurved margin, brownish to flesh coloured underneath in mature carpophores.

Basidiospores (5.91) 6.76 - 7.6 × 5.07-5.91 µm (excluding apiculus) (Q=1.3), broadly ellipsoid, double walled, granular, apiculate. Basidia 15.21 - 26.19 × 5.91- 9.2 µm, clavate, tetrasterigmate, hyaline; Pleurocystidia and Cheilocystidia absent; gill edges fertile. Carpophore context homoiomerous.

Fig. 5 *A. blazei*: Young carpophores growing in humicolous soil

Pileus cuticle trichodermal measuring 3.94 - 7.88 µm broad, hyphae; pileus context hyphal. Hymenophoral trama irregular. Stipe cuticle hyphal, made up of 3.94-5.91 µm broad hyphae. Annular elements cellular. Clamp connections absent throughout.

Chemical colour reaction: Schaeffer's reaction negative.

Collection examined: Punjab: Mohali (316 m), Village Bhajauli, growing scattered on humicolous soil, Harwinder Kaur, PUN 5890, September 03, 2009. Jammu and Kashmir: South Kashmir, Damhal Hanji Pora, village Hallan Manzgam (2800m), growing solitary on leaf litter of conifers in coniferous forest , Nazir Ahmad Malik, PUN 8535, August 05, 2014.

Distribution and ecology: *A. blazei* is reported from Florida and South Carolina by Freeman (1979). Presently this species was found growing scattered on humicolous soil during early September. But, unfortunately the confirmation of intercontinental conspecificity of this edible species is not yet established through molecular phylogeny.

Edibility: *A. blazei* is an edibile mushroom, considered as functional food and is medicinally important as its extract is reported to be used for prevention and treatment of cancer, diabetes, hepatitis and heart diseases in Brazil, Japan and China (Stijve and Amanonas, 2002; Firenzuoli *et al*.,2007; Wang *et al.,* 2013).

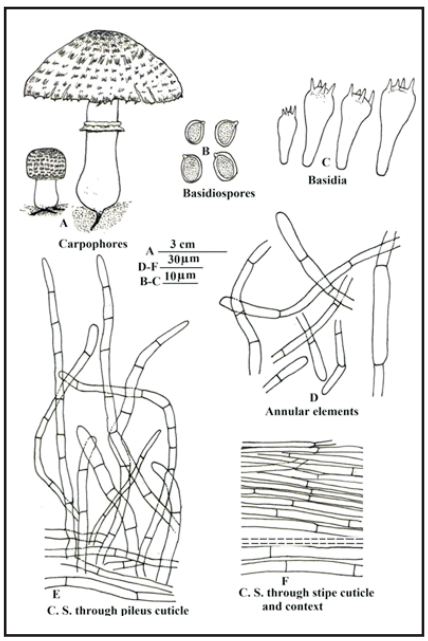

Fig. 6 (A-F) *A. blazei*

Remarks: The macroscopic and microscopic details of presently investigated collection are in agreement with the details given for *A. blazei* Murrill W.A. By Freeman (1979) and Firenzuoli *et al*. (2007). This species is characterized in possessing a campestroid stature, cellular annular tissue and lacking cheilocystidia. When compared with *A. praemagnus* which is an allied species, the presently examined collections are smaller in size and thick fleshed. In comparision to *A. xanthodermoides* the present collections differs in having more robust stature. This species is not earlier reported from India.

4. *Agaricus bolorhizus* Berk. & Broome, *J. Linn. Soc. Bot.* **11**: 549, 1871.

Fig. 7(A); 8 (A-G)

Carpophores 3 - 4 cm in height, campestroid. Pileus convex, 1 - 4.8 cm broad, broadly umbonate; surface moist, pale orange ($5A_3$) all over the surface, light orange ($5A_5$) from periphery, scaly throughout, scales appressed fibrillose, more concentrated in the centre, margin irregular, inrolled in young, exceeding beyond the gills and splitting at maturity; cuticle fully peeling; flesh up to 0.4 cm thick, cream, changing to pale yellowish on exposure; taste spicy; odour mild. Pileal veil patchy, cortinoid in the form of small remnants along the margin. Lamellae free, unequal, lamellulae present, subdistant, moderately broad, up to 0.3-0.4 cm broad, pinkish white ($8A_2$) when young, dark brown ($7F_4$) at maturity, gill edges wavy. Spore deposit greyish brown ($5F_3$). Stipe central, 1-3.6 cm long, 0.2-0.4 cm broad above, up to 0.9 cm broad at the base, equal in diameter throughout with a distinctly bulbous base with mycelial threads, white ($5A_1$) changing to pale orange ($5A_3$) on exposure where bruised, hollow, scaly, scales slightly fibrillose below the annulus, annulus single, superior, skirt like, white to light yellow, evanescent.

Basidiospores 5.07 - 6.76 × 3.38 - 5.07 µm (excluding apiculus), (Q=1.4), ellipsoid, double walled, outer wall thick and dark brown, smooth, guttulate with one guttule per spore, apiculate. Basidia 11.83 - 20.28 × 5.07 - 5.91 µm, narrow, clavate to cylindrical, granular, tetrasterigmate. Pleurocystidia absent. Cheilocystidia 15.21 - 25.35 × 6.76 - 11.83 µm, claviform, rare, granular; gill edges sterile. Carpophore context homoiomerous. Pileus cuticle an ixocutis, few 3.94 - 5.91 µm broad septate, hyphal elements projecting; pileus context hyphal. Hymenophoral trama irregular. Stipe cuticle hyphal, hyphae 7.88 - 13.79 µm broad, giving rise to a few projecting 3.94 - 5.91 µm broad septate hyphae. Annular elements hyphal, 2.53 - 5.9 µm broad, septate, branched. Clamp connections absent throughout.

Chemical colour reaction: Schaeffer's reaction positive, orange residue formed at the crossing point of aniline oil and conc. H_2SO_4.

Collection examined: Punjab: Faridkot (196 m), Village Bajakhana, growing in groups forming a fairy ring, on humicolous soil around the heap of mixed dung, Harwinder Kaur, PUN 5902,

Fig.7. *A. bolorhizus* : Carpophores showing various stages of

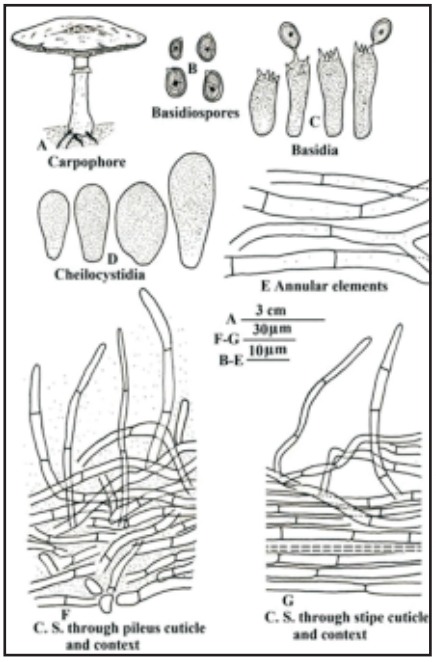

Fig. 8 **(A-G)** *A. bolorhizus*

September 06, 2009.

Distribution and ecology: *A. bolorhizus* was collected as growing solitary on the ground, during September, in District Kandy of Peradeniya, Sri Lanka by Pegler (1986). Present collection was found growing in groups in fairy ring on humicolous soil around the heap of mixed dung during early September.

Edibility: Unknown.

Remarks: The above examined collection belongs to subgenus *Flavoagaricus* Wasser as it shows the similar colour change of carpophore parts to pale orange as described by Pegler (1986). The macroscopic and microscopic details of presently examined collection are in agreement with those of *Agaricus bolorhizus*. The morphological details of present collection with respect to the colour, size of the various carpophore parts, the colour change of the carpophores especially the stipe surface change to pale orange, the distinctly bulbous stipe base with mycelial threads and the microscopic details are in confirmity to those given for *A. bolorhizus* by Pegler (1986). This species is first time report from India.

5. *Agaricus andrewii* Freeman A.E.H., *Mycotaxon*, **8** (1): 60, 1979.

Fig. 9(A-G)

Carpophore up to 8 cm in height, campestroid. Pileus flattened depressed, up to 7.5 cm broad, surface white to creamy white with light orange ($5A_4$) centre, becomes pale yellow ($4A_3$) on drying, dry, smooth, margin irregular, splitting at maturity, cuticle fully peeling, flesh up to 1.7 cm thick, white, changing slowly to orange white ($5A_2$) on exposure while drying; taste and odour mild. Pileal veil patchy. Lamellae free, unequal, crowded, up to 0.7 cm broad, dark brown ($6F_3$), unchanging; gill edges serrate. Spore deposit greyish brown ($5D_3$). Stipe excentric, up to 6 cm long, up to 1.4 cm broad, equal in diameter throughout, with a slightly bulbous base, white turns brown to orange reddish on bruising, solid; annulate, annulus median, peronate, simple ring like, white, attached.

Basidiospores 6.76 - 8.45 × 5.0 - 5.9 µm (excluding apiculus), (Q=1.4) ellipsoid, double walled, dark brown, guttulate with 1-3 guttules per spore, apiculate, apiculus up to 1.69 µm long, prominent. Basidia 20.28 - 32.11 × 8.45 - 10.14 µm, clavate to cylindrical, granular, bi to usually tetra sterigmate; sterigmata 3.38 - 5.07 µm long. Pleurocystidia absent. Cheilocystidia 21.97-33.80 x 7.6-10.98 µm, cylindrical to clavate, abundant, mostly in chains; gill edges heteromorphous. Carpophore context homoiomerous. Pileus cuticle trichodermal of 5.91-7.88 µm broad hyphae. Hymenophoral trama irregular. Stipe cuticle trichodermal. Annular ring present, elements 11.82 - 17.73 µm broad, inflated, thickly granular, cellular elements. Clamp connections absent throughout.

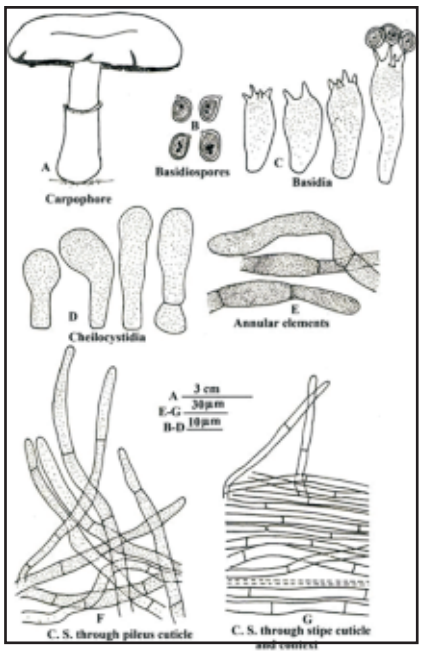

Fig. 9 **(A-G)** *A. andrewii*

Chemical color reaction: Schaeffer's reaction negative.

Collection examined: Punjab: Faridkot (196 m), Village Bajakhana, growing solitary on humicolous soil, Harwinder Kaur, PUN 5886, August 07, 2009.

Distribution and ecology: Freeman (1979) collected *A. andrewii* growing in a meadow and pastures of North Carolina. Presently examined collection was found growing solitary on humicolous soil during early August.

Edibility: According to Freeman (1979), due to the close resemblance of *A. andrewii* with *A. campestris* it has probably been unwittingly eaten and proved edible**.**

Remarks: The external and internal details of above examined collection match with the details given for *A. andrewii* by Freeman (1979). In the field this collection is comparable to *A. campestris* however, internal details of these species are quite variable. In the present collection annular hyphae are inflated which are not so in *A. campestris* (Freeman, 1979), even the size of the spores and cheilocystidia is different in both the species. Present collection has abundant cheilocystidia in comparison to sparse reported by (Freeman, 1979). Even, Dhancholia and Sinha (1988) while describing *A. campestris* have commented upon its close resemblance with *A. andrewii.* Presently, it is first report for India.

6. *Agaricus parvitigrinus* Guinb. & Callac, *Mycologia* **97**, (2): 419, 2005.

Fig. 10(A); 11 (A-G)

Carpophores 3.1 - 8.5 cm in height, placomycetoid. Pileus convex while young, planoconvex to expanded at maturity with a low to a flat umbo, 1.5 - 6 cm broad, surface white ($4A_1$) with greyish brown ($5F_3$) to blackish grey centre, moist,

scaly, scales breaking up into appressed fibrillose squamules, covering the entire pileus, margin irregular, incurved in young, slightly extending beyond the gills and splitting at maturity; cuticle fully peeling; flesh 0.5-0.7 cm thick, white, changing to yellowish white ($4A_2$) on exposure; taste and odour spicy. Pileal veil white, cog-wheel very clear when young. Lamellae free, unequal, not in series, crowded, narrow (0.4 cm broad), pinkish white ($7A_2$) when young, greyish brown ($7D_3$) at maturity, unchanging on exposure where bruised; gill edges smooth. Stipe central, 2.8-8.0 cm long, up to 0.6 cm broad at apex, up to 1 cm broad at the base, distinctly bulbous base with rhizomorphs and a white mycelial mat; stipe off white to yellowish white ($4A_2$) changing to brownish grey ($5C_2$) on handling, base turning turmeric yellow on injury or exposure; annulate, annulus white, single, present as a cog wheel in young fruit bodies, superior to median finally evanescent in mature carpophores, with scaly undersurface, scales grayish brown ($5F_3$).

Basidiospores 5.07 - 5.91 (6.76) × 3.38 - 4.22 µm (excluding apiculus), (Q=1.5) ellipsoid, double walled, smooth, dark brown, granular, guttulate with 1-2 guttules per spore, apiculate. Basidia 17.74 - 25.35 × 6.76 - 9.29 µm, clavate, tetra sterigmate, sterigmata 2.53 - 3.38 µm long, Pleurocystidia absent. Cheilocystidia 10.98 - 21.12 × 5.07 - 10.14 µm, clavate, weakly granular, few hyaline, rare; gill edges heteromorphous. Carpophore context homoiomerous. Pileus cuticle trichodermal with brown pigmentations, hyphae measuring 3.94-7.88 µm broad; pileus context hyphal. Stipe cuticle hyphal. Pileal veil made up of 3.38 - 6.76 µm granular broad hyphae. Clamp connections absent throughout.

Chemical colour reaction: Schaeffer's reaction negative.

Collection examined: Punjab: Patiala (251 m), Baradari garden, growing in scattered caespitose clusters on leaf litter, mixed with manured soil, Harwinder Kaur, PUN 5904, August 24, 2009.

Distribution and ecology: Callac and Guinberteau (2005) and Kerrigan *et al*. (2005) found carpophores of *A. parvitigrinus* growing solitary to gregarious or in caespitose clusters in mixed deciduous wood of *Carpinus, Robinia, Sambucus, Euonymus* or on sandy alluvial soil in Western France. Presently, it was found growing scattered in caespitose clusters on leaf litter, mixed with manured soil from Punjab, India.

Fig.10 *A. parvitigrinus*: Carpophore growing in caespitose clusters on leaflitter

Edibility: Unknown.

Remarks: The macroscopic and microscopic details of present collection match well with the description of *A. parvitigrinus* given by Callac and Guinberteau (2005) and by Kerrigan *et al*. (2005). *A. parvitigrinus* is distinct in possessing a grayish brown, sepia or blackish gray center with a low umbo, white flesh changing to yellow, flesh and odour spicy to strongly phenolic, distinctly bulbous, annulate stipe with rhizomorphs, stipe turning turmeric yellow on injury or on handling especially at the base. This is first record of this species from India.

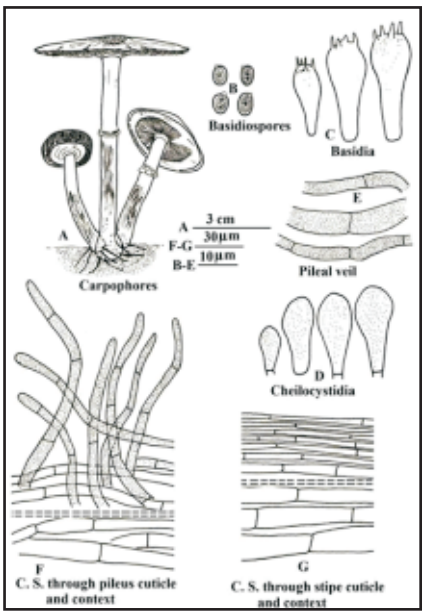

Fig. 11 (A-G) *A. parvitigrinus*

7. *Agaricus meleagris* var. ***obscuratus*** (Maire) Heinem., *Bull. Soc. Mycol. Fr.*, **71** (3): 397, 1965.

Fig. 12(A); 13 (A-G)

Carpophores 8 - 10 cm in height, placomycetoid. Pileus convex, 2.5 - 7 cm broad, with a low umbo, surface white covered with greyish brown ($6F_3$) to blackish grey appressed fibrillose scales in young carpophores which become squamulous at maturity, scales form large patch in center while small broken squamules form scattered concentric rings all over the surface, dry, margin irregular, inrolled in young carpophores, splitting at maturity; cuticle fully peeling, extending beyond the gills, white; flesh, white, changing to yellow on exposure; taste mild to sour, flesh become rubber like after chewing; odour mild. Pileal veil white, cog wheel like become yellowish on handling, shreaded in young fruit bodies. Lamellae free, unequal, not in series, crowded, narrow (0.3 cm broad), brownish orange ($5C_3$) to dark brown ($6F_5$) towards maturity, white along the margin; gill edges lacerate. Spore deposit dark brown ($6F_4$). Stipe central to eccentric, 7.5 - 9.5 cm long, 0.6 - 0.8 cm broad near the pileus, 1 - 1.4 cm towards the base, obclavate to slightly bulbous at the base; stipe brownish grey ($6C_3$) with white base which changes to bright yellow orange to rusty at places in the lower stipe portion on handling, hollow, covered at places with minute fibrillose scales, especially below the annulus; annulus double, superior with brown squamules underneath.

Basidiospores 5.07 - 5.91 (6.76) × 3.38 - 4.22 (5.07) µm (excluding apiculus), (Q=1.4) ellipsoid, double walled, smooth, brown, granular, guttulate with 1-2 guttules per spore; apiculate. Basidia 18.59 - 27.04 × 5.91 - 7.6 µm, clavate, tetra sterigmate, sterigmata 3.38 - 5.07 µm long. Pleurocystidia absent. Cheilocystidia 11.83 - 38.87 × 7.6 -

Fig. 12 *A. mealgaris* var. *obscuratus*: Carpophore growing in their natural habitat showing Carpophores with cog-wheel covering the gills.

11.83 µm, claviform to napiform, few very long, few in chains, abundant; gill edges sterile. Carpophore context homoiomerous. Pileus cuticle trichodermal, made up of 5.91-11.82 µm broad hyphae with dark brown pigments, pileus context hyphal. Hymenophoral trama irregular. Stipe cuticle hyphal made up of 3.94 - 11.82 µm broad, closely septate hyphae, at places with dark brown pigmentations. Annular elements cellular, 3.38 - 10.14 µm broad, granular, inflated, closely septate. Clamp connections absent throughout.

Chemical colour reaction: Schaeffer's reaction negative.

Collection examined: Punjab: Mohali (316 m), Zirakpur, growing gregariously on humicolous soil under hedges, Harwinder Kaur, PUN 5908, July 15, 2010.

Distribution and ecology: Møller (1952) reported *A. meleagaris* var. *obscuratus* growing gregariously in garden under fruit trees on bare soil, during September-October from Holland. Presently found growing gregariously under hedges.

Edibility: The edibility of *A. meleagaris* var. *obscuratus* is unknown.

Remarks: The consolidated external and internal details of the above examined collection agree with the characters given for *A.meleagaris* var. *obscuratus* (Maire) Heinem. by Møller (1952). Atri *et al.* (1992) reported *A. meleagaris* var. *meleagaris* from Punjab plains while Gupta *et al.* (2008a) reported it from Himachal Pradesh and Uttar Pradesh. *A. meleagaris* var. *obscuratus* is a first report from India.

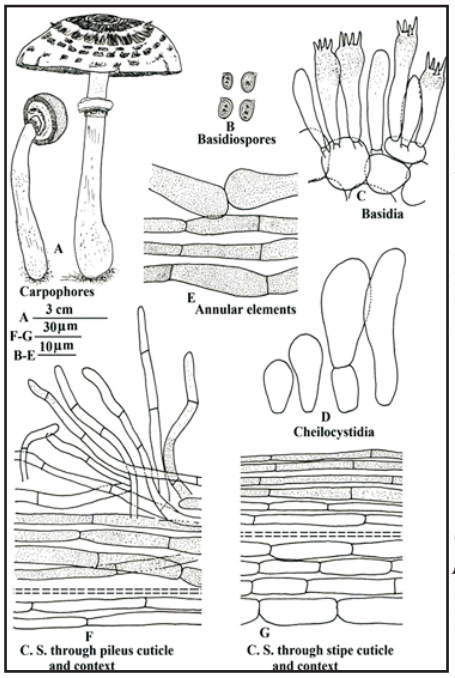

Fig. 13 (A-G) *A. meleagris* var. *obscuratus*

8. *Agaricus silvaticus* var. ***pallidus*** (F.H. Møller) F.H. Møller, *Friesia,* **4** (3): 1952.

Fig. 14 (A); 15 (A-G)

Carpophores 8.5 - 11 cm in height, placomycetoid. Pileus convex to applanate, 6.8 - 7.4 cm broad, surface moist, off-white, silvery with brownish orange ($6C_4$) recurved scales distributed in concentric rings over the entire pileus surface, scales dense in the centre, margin irregular, cuticle fully peeling; flesh white ($5A_2$), changing to brownish on exposure; taste mild to sour; odour mild. Pileal veil absent. Lamellae free, unequal, subdistant, moderately broad (0.6-0.8 cm broad), grayish brown ($6D_3$) to dark brown ($7F_7$); gill edges smooth, white. Spore print brownish grey ($7C_2$). Stipe central, 8-10.5 cm long, 0.7-0.8 cm broad, white changing to brown then to brownish grey ($6C_2$) where bruised, equal in diameter with bulbous base, rhizomorphs at base of stipe covered with white mycelia, scaly above the annulus, scales white floccose to fibrillose, smooth below the annulus; annulate, single, superior, uplifted, white ($1A_1$), without brownish floccules underneath, moveable, evanescent with age.

Basidiospores 5.91 - 8.45 × (4.22) 5.07 - 6.76 µm (excluding apiculus), (Q=1.2), broadly ellipsoid, double walled, smooth, granular with few guttules, apiculate. Basidia (13.52) 15.21-27.04 × (6.76) 7.6 - 10.14 µm, clavate, granular, bi to usually tetra sterigmate. Pleurocystidia absent. Cheilocystidia 13.52 - 35.49 × 6.76 - 18.59 µm, versiform, balloon shaped, claviform to lageniform, sparsely granular, few with thickened apical walls and dense granulations at the apex; gill edges heteromorphous. Carpophore context homoiomerous. Pileus cuticle trichodermal made up of 3.94 - 9.85 µm broad, granular hyphae; pileus context hyphal. Hymenophoral trama irregular. Stipe cuticle composed of longitudinally tangled hyphae giving rise to few 3.94-15.76 µm broad, closely septate, weakly granular projecting hyphae, stipe context hyphal. Annular elements 4.22 - 9.29 µm broad, weakly granular, closely septate. Clamp connections absent throughout.

Chemical colour reaction: Schaeffer's reaction negative.

Collection examined: Punjab: Patiala (251 m), Punjabi University campus, growing solitary along roadside on leaf litter and humicolous mixed soil. Harwinder Kaur, PUN 5896, September 24, 2010; growing solitary on humicolous, soil along roadside, Harwinder Kaur, PUN 5895, July 30, 2011.

Distribution and ecology: *A. silvaticus* var. *pallidus* grows gregarious in *Picea* woods between September to October as described by Møller (1950). From India it was documented growing solitary on leaf litter along roadside between late July to late September.

Fig. 14 *A. silvaticus* var. *pallidus*: Carpophore growing solitary in its habitat and showing gills

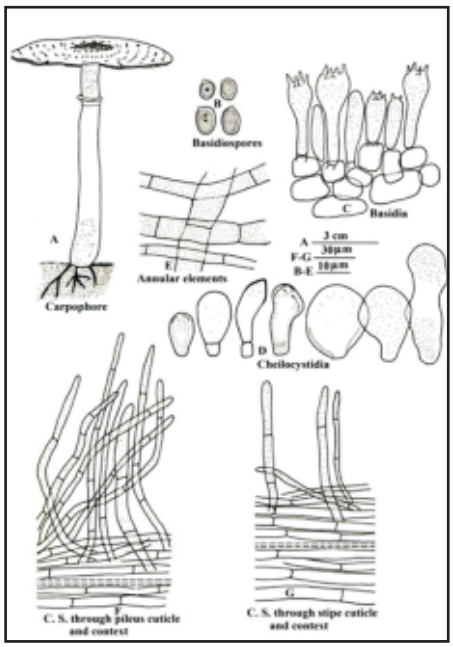

Fig. 15 (A-G) *A. silvaticus* var. *pallidus*

Edibility: Although *A. silvaticus* has been recorded as a good edible fungus by Krieger (1967) and Phillips (1981) however, Purkayastha and Chandra (1985) documented that the edibility of this variety is unknown.

Remarks: The details of above described collections match with the description given for *A. silvaticus* by Murrill (1922), Møller (1950), Pilát (1951), Hotson and Stuntz (1938). Further, in possessing pale white pileus with brownish orange squamules, whitish stipe, white annulus without any brownish squamules on its undersurface these collections are in conformity with the details given for *A. silvaticus* var. *pallidus*by Møller (1950). However, the spore size in the presently investigated collections is larger (5.91-8.45 × 5.07-6.76 µm instead of 5-6 × 3-3.5 µm) than described by Møller (1950). These collections morphologically resemble *A. haemorrhoidarius* but are different in not quickly changing colour to red or otherwise on bruising. In the present collections the carpophores at maturity turn brown on bruising and cutting and never red on bruising, such observation is confirmed by Pilát (1951) for *A. silvaticus* var. *pallidus* where the colour change in mature specimen is described to be brown or not changing at all. *A. silvaticus* var. *pallidus* is not earlier known from India.

9. *Agaricus rubribrunnescens* Murrill,W.A., *Mycologia*, **14** (4): 216, 1922.

Fig.16 (A); 17 (A-G)

Carpophores 2.2 - 5 cm in height, placomycetoid. Pileus dome shaped to convex, 1.2 - 3.2 broad, broadly umbonate; white ($6A_1$) with brownish orange ($6C_3$) center covered with scales; surface moist; scaly, scales appressed fibrillose, brownish orange ($6C_3$), cover the entire pileus with maximum aggregation around the centre, margin irregular, splitting at maturity; cuticle fully peeling; flesh up to 0.4 cm thick, white changing to reddish abruptly on handling later turning brown then blackish; taste and odour mild. Pileal veil patchy, white. Lamellae free, unequal, crowded, moderately broad (0.4-0.5 cm broad), reddish white ($7A_2$) when young, brown ($6E_4$) at maturity, gill edges lacerate, normal. Stipe central, 1.5 - 4.5 cm long, up to 0.5 cm broad near apex, 1 cm broad towards the base, more robust in young carpophores; white ($1A_1$) changing to reddish to light brown on bruising, cylindric, somewhat bulbous base covered with a lot of pure white cottony mycelium, hollow, smooth, shiny, annulate, annulus single, superior, ring like, white ($1A_1$).

Fig.16 *A. rubribrunnescens*: Carpophores showing abrupt color change on brusing

Basidiospores 5.0 - 6.76 × 3.38 - 4.22 µm (excluding apiculus), (Q=1.56) broadly ellipsoid, double walled, granular, smooth, apiculate. Basidia 15.21 - 28.73 × 7.6 - 8.45 µm, clavate, granular, tetra sterigmate. Pleurocystidia absent. Cheilocystidia 15.21-18.59 × 6.76 - 8.45 µm, claviform, granular, thin walled, abundant, few in chains; gill edges sterile. Carpophore context homoiomerous. Pileus cuticle trichodermal made up of 6.9 µm broad hyphae, interspersed with 9.85 - 19.7 µm broad, granular pileocystidioid elements; pileus context hyphal. Hymenophoral trama irregular. Stipe cuticle hyphal, 3.94 - 9.85 µm broad, septate, stipe context hyphal. Pileal veil hyphal, hyphae granular, closely septate. Clamp connections absent throughout.

Chemical colour reaction: Schaeffer's reaction negative.

Collection examined: Punjab: Bathinda (211 m), Village Jeedha, growing in groups on humicolous, grassy soil along roadside, Harwinder Kaur, PUN 5891, August 16, 2010.

Distribution and ecology: Murrill (1922) found *A. rubribrunnescens* growing around exposed roots of a living red maple tree in New York City and Long Island. Freeman (1979) found this species growing in mixed woods, whereas the present Indian collection has been found growing in groups along roadside in mid August.

Edibility: Edibility is unknown Freeman (1979).

Remarks: The above examined collection matches well with the details of *A. rubribrunnescens* as described by Murrill (1922) and Freeman (1979). This species is characterized in having placomycetoid carpophores with somewhat bulbous stipe, with superior ringed annulus, all parts of the carpophores abruptly changing to reddish then brown to finally black on bruising or cutting, further the

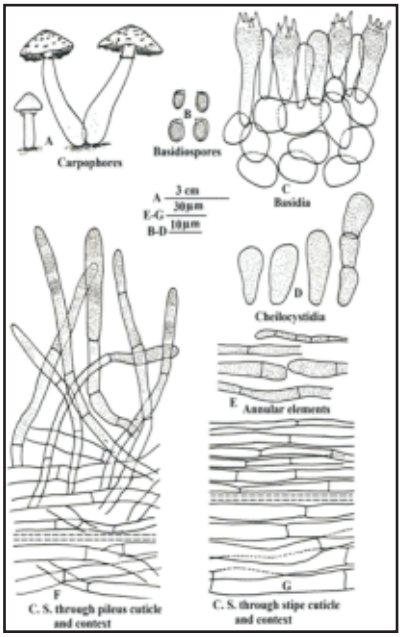

Fig. 17 (A-G) *A. rubribrunnescens*

Schaeffer's reaction is negative. This species is not earlier known from India.

10. *Agaricus subrutilescens* (Kauffman) Hotson & Stuntz, *Mycologia* **30**: 219, 1938.

Fig. 18 (A); 19 (A-F)

Carpophores 2.8 - 6.3 in height, placomycetoid. Pileus convex, 1.9 - 4.8 cm broad, broadly umbonate, white ($9A_1$) to light yellow ($4A_5$) where bruised, surface moist, scaly, scales covering the entire cap, more concentrated in the centre reddish brown ($9E_5$); margin irregular, changing from creamish to somewhat slightly pinkish; cuticle fully peeling; flesh up to 0.4 cm thick, white, unchanging; taste and odour mild. Pileal veil appendiculate, white. Lamellae free, unequal, narrow (0.4 cm broad); dull red ($9B_3$) in immature carpophores, grayish brown ($8F_3$) in mature carpophores; gill edges smooth. Spore print dark brown ($6F_6$). Stipe central, 2.5-5.9 cm long, up to 0.7 cm broad, cylindrical, white ($9A_1$), pale yellow ($4A_3$) on bruising; smooth above the annulus, scaly below, scales fibrillose, velvety, white; annulate, annulus membranous, superior.

Basidiospores 4.98 - 6.64 × 3.32 - 4.98 µm (excluding apiculus), (Q = 1.5) ellipsoid, dark brown, double walled, granular, apiculate. Basidia 9.96 -16.6 × 4.15-6.64 µm, clavate, granular, bi to tera sterigmata. Pleurocystidia absent. Cheilocystidia 11.62-18.26 × 4.98-8.3 µm, claviform, granular throughout, rare; gill edges heteromorphous. Carpophore context homoiomerous. Pileus cuticle trichodermal; pileus context hyphal. Hymenophoral trama irregular. Stipe cuticle made up of longitudinally tangled, up to 8.0 µm broad septate hyphae. Clamp connections absent throughout.

Chemical color reaction: Schaeffer's reaction positive.

Collections examined: Punjab: Ropar (394 m), Village Bhaddal, growing gregariously in groups on humicolous soil, Arpana Lamba, PUN 4286, July 24, 2010; near Shampurd, growing solitary on humicolous soil, Harwinder Kaur, PUN 5915, July 30, 2011.

Distribution and ecology: Smith (1949) collected *A. subrutilescens* growing gregarious to scattered under conifers or in mixed conifer and hardwood forests, while Arora (1986) found this growing solitary to scattered or in small groups in woods, usually under conifers during fall and winter along west coast of California. Wood and Stevens (1997-2013) found this growing solitary, scattered to sometimes in arcs in mixed hardwood-conifer woods, fruiting from early to mid-winter in California while, Phillips (2001-2013) collected it from North America growing in woods. Presently, examined collections were found growing gregariously in groups or solitary on humicolous soil in late July.

Fig.18 *A. subrutilescens*: Carpophores growing in

Edibility: According to Smith (1949), Arora (1986), Wood and Stevens (1997 - 2013), Phillips (2001-2013) this species is documented to be edible.

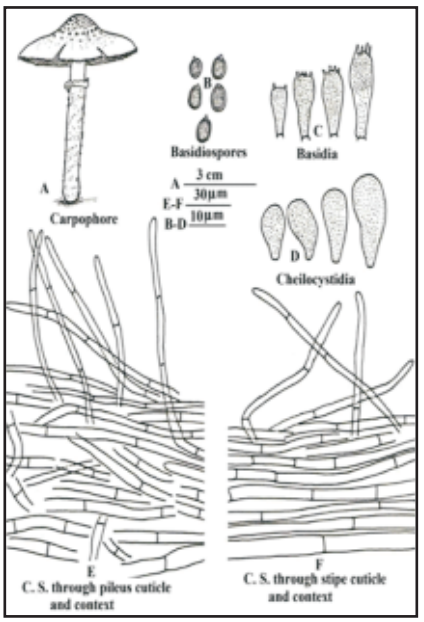

Fig. 19 (A- F) *A. subrutilescens*

Remarks: The diagnostic features of the above examined specimen resemble with the details of *A. subrutilescens* as described by Hotson and Stuntz (1938), Smith (1949), Arora (1986), Kerrigan (1986), Wood and Stevens (1997 - 2013), Phillips (2001 - 2013). The characteristic features of this species are broadly umbonate cap, pileus surface white covered with dark reddish brown scales aggregated in the center which are covering the entire pileus surface, white stipe covered with light velvety and fibrillose scales, stipe turning pale yellow on bruising. This is the first time report from India.

11. ***Agaricus porphyrocephalus*** F.H.Møller, *Freisia* 4 (3): 204, 1952.

Fig. 20 (A); 21 (A-F)

Carpophores 4.4 -10 cm in height, placomycetoid. Pileus dome like in young stage, then convex later becoming flattened with margin uplifted and depressed centre at maturity, 2.5 - 7.2 cm broad, broadly umbonate, surface moist with white ($5A_1$) background; sclay, scales white to pale orange ($5A_3$), concentrically arranged, more aggregated in the center in young carpophores, mature carpophores brown ($7E_5$) with greyish orange ($5B_4$) centre, scales almost washed out, appressed fibrillose, margin irregular; cuticle fully peeling, extending beyond the gills; flesh 0.2-0.4 cm thick, white, unchanging; taste and odour mild. Pileal veil appendiculate, forming a fringed rim along the margins, persistent in mature carpophores. Lamellae free, unequal, crowded, 0.2-0.9 cm broad, pinkish white ($7A_2$) when young, light brown ($7D_4$) to dark brown at maturity, unchanging on bruising, orange red drops oozing out from gills; gill edges serrate, whitish. Stipe central to excentric, 3.9-9.5 cm long, 0.5-1.1 cm broad, cylindric, equal in diameter throughout; white ($1A_1$) above the annulus, light brown ($7D_4$) below with a pale orange ($5A_3$) base changing to yellowish on bruising; hollow, scaly, more fibrillose above the annulus, cover the entire surface, annulate, annulus single, superior, white with light yellowish tinge, membranous, skirt like, patchy in mature carpophores.

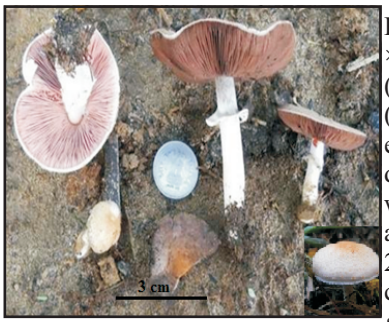

Fig. 20 *A. porphyrocephalus*: Carpophores growing in natural habitat.

Basidiospores 5.0 - 6.76 × 4.22 - 5.07 µm (excluding apiculus), (Q=1.2), broadly ellipsoid, smooth, double walled, guttulate with 1 guttule per spore, apiculate. Basidia 11.83-21.97 × 4.22 - 6.76 µm, clavate, granular, tetra sterigmate, sterigmata 2.53 - 5.91 µm long. Pleurocystidia and Cheilocystidia absent; gill edges fertile. Carpophore context homoiomerous. Pileus cuticle trichodermal, made up of 3.94-7.88 µm broad septate hyphae, pileus context hyphal, gelatinous, appears cellular due to densely packed granular 9.85 - 11.82 µm broad elements. Stipe cuticle hyphal. Annular elements 5.07 - 8.45 µm broad, granular, closely septate. Clamp connections absent throughout.

Chemical colour reaction: Schaeffer's reaction positive.

Collection examined: Punjab: Faridkot (196 m), Village Bajakhana, growing in groups forming fairy ring around manure heap, along roadside, Harwinder Kaur, PUN 5907, August 13, 2011.

Distribution and ecology: Møller (1950) found *A. porphyrocephalus* growing gregariously in meadows during September to October. Phillips (2001 - 2013) found this species growing in field, lawns along roadsides in Europe. The present Indian collection was found in fairy ring around dung heap during August.

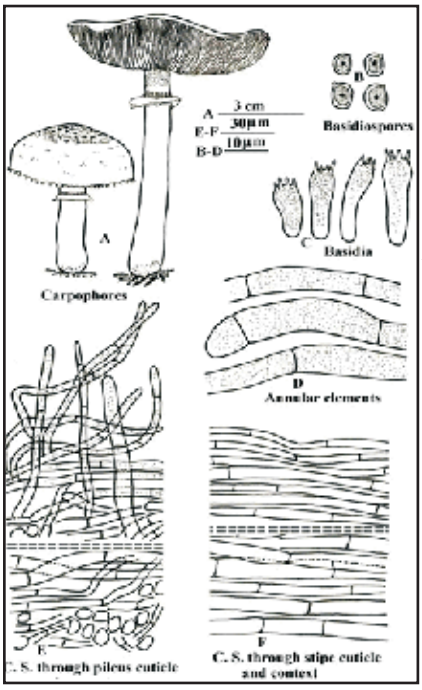

Fig. 21 (A-F) *A. porphyrocephalus*

Edibility: Inedible, to be avoided according to Phillips (2001-2013).

Remarks: The present specimen fits well into the description given for *A. porphyrocephalus* by Møller (1950), Kuo (2007) and Phillips (2001-2013). The basidiospores of the Indian collection are slightly broader (4.22 - 5.07 µm) in comparison to the spore breadth given for this species (3.2 - 4.5 µm). It is recorded for the first time from India.

CONCLUSION

The eleven keyed out species of *Agaricus* in the present paper are first time reports from India. Out of which 05 species viz. *A. fuscovelatus, A. blazei*, *A. andrewii, A. silvaticus* var. *pallidus* and *A. Subrutilescens* are known edible species whereas *A. blazei* is even known for its medicinal importance especially for the treatment of Cancer, Diabetes and Hepatits.

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REFERENCES

Arora, D. 1986. *Mushrooms Demystified. A comprehensive guide to the fleshy fungi*. Ten Speed Press. Berkeley, California. pp. 959.

Atri, N. S., Kaur, A and Saini, S. S. 2001. Mushroom flora of Patiala - The genus *Agaricus* L. ex. Fr. *Indian J. Mush*. **19** (1&2): 1-9.

Atri, N. S. and Saini, S. S. 2000. Collection and study of Agarics- An introduction. *Indian J. Mush.* **18** (1&2): 1-5.

Atri, N. S., Kaur, A. and Kour, H. 2005. Wild mushrooms-collection and identification. In: *Frontiers in Mushroom Biotechnology* (Eds.: Rai, R.D., Upadhyay, R.C. and Sharma, S.R.), National Research Center for Mushroom, Chambaghat, Solan, India, pp. 926.

Atri, N. S., Saini, S.S. and Gupta, A.K. 1992. Fungi of Punjab-VI: Studies on genus *Agaricus* L: Fr. *J. Indian Bot. Soc.* **71**: 119-121.

Bilgrami, K.S., Jamalludin and Rizwi, A.M. 1991. *Fungi of India*. Today and Tomorrow's Printers and Publishers, New Delhi, pp. 798.

Callac, P. and Guinberteau, J. 2005. Morphological and molecular characterization of two novel species of *Agaricus* section *Xanthodermatei*. *Mycologia*, **97** (2), Pp. 416-424.

Dhancholia, S. and Sinha, M. P. 1988. Additional studies on Agarics of Orissa. *Geobios New Reports* **7**: 169-172.

Farook, V. A., Khan, S. S. and Manimohan, P. 2013. A checklist of agarics (gilled mushrooms) of Kerala State, India. *Mycosphere* **4** (1): 97-131.

Firenzuoli, F., Gori, L. and Lombardo, G. 2007. The Medicinal Mushroom *Agaricus blazei* Murrill: Review of Literature and Pharmaco-Toxicological Problems. Advance access Publications *eCAM,* **5** (1): 3-15.

Freeman, A. E. H. 1979. *Agaricus* in South Eastern United States. *Mycotaxon* **8** (1): 50-118.

Gupta, A. K., Atri, N. S. and Kaur, M. 2008a. Studies on the genus *Agaricus* L.: Fr-V. The sub genus *Agaricus*

section *Xanthodermatei* Sing. Indian J. Mush. **26** (1&2): 38-44.

Gupta, A.K., Atri, N. S., Kaur, M. and Saini, S. S. 2008b. Studies on the genus *Agaricus* L.: Fr - IV. The sub genus *Agaricus* section *Arvensis* Konr. et. Maubl. from North West India. *Indian J. Mush*. **26** (1&2): 22-30.

Hotson, J. W. and Stuntz, D. E. 1938. The genus *Agaricus* in Western Washington. *Mycologia* **30**: 204-234.

Karunarathna, S. C., Chen, J., Mortimer, P.E., Xu, J.C., Zhao, R.L., Callac, P and Hyde, K.D. 2016. *Mycosphere* Essay 8: A review of genus *Agaricus* in tropical and humid subtropical regions of Asia. *Mycosphere* **7**(4), 417-439.

Kaur, A., Atri, N.S. and Kaur, M. 2015. Taxonomic study on the coprophilous mushrooms from Punjab, India: new records of family *Agaricaceae*. *Current Research in Environmental & Applied Mycology* **5** (1): 27-45.

Kaur, Amandeep, Atri, N.S. and Kaur, M. 2014. Two New species of *Agaricus* (*Agaricaceae, Agaricales)* collected on dung from Punjab, India. *Kavaka* **42**: 20-24.

Kaur, M., Kaur, H. and Malik, N. A. 2016a. Subgenus *Agaricus*: Three new records to India. *World Journal of Pharmacy and Pharmaceutical Science* **5**(4): 2205-2214.

Kaur, M., Kaur, H. and Malik, N. A. 2016b. Identification and characterization of six new taxa of genus *Agaricus* L.:Fr. (*Agaricaceae* Chevall.) from India. *World Journal of Pharmacy and Pharmaceutical sciences* **5** (7):1518-1533.

Kerrigan, R. W. 1985. Studies in *Agaricus* II. *Agaricus lilaceps* re-evaluated. *Mycologia* **77** (1): 137-141.

Kerrigan, R. W. 1986. *Agaricaceae*. In: *Agaricales of California*, (Ed. Thiers, H. D.) Mad River Press, Eureka CA. pp. 62.

Kerrigan, R.W., Callac, P., Guinberteau, J., Challen, M.P and Parra, L.A. 2005. *Agaricus* section *Xanthodermatei*: a phylogenetic reconstruction with commentary on taxa. *Mycologia* **97** (6): 1292-1315.

Kornerup, A. and Wanscher, J. H. 1978. *Methuen Handbook of Colour*, 3rd ed., Eyre Methuen, London.

Krieger, L.C.C. 1967. *The Mushroom Hand book*. Dover Publications, INC. New York. Pp 1-560.

Kuo, M. 2007. *Agaricus* species 01. Retrieved from the MushroomExpert.Com

Møller, F. H. 1950. Danish *Psalliota* Species. Preliminary Studies for a Monograph on the Danish *Psalliota*. *Freisia* **4**: 1-60.

Møller, F. H. 1952. Danish *Psalliota* Species. Preliminary Studies for a Monograph on the Danish Psalliotae. *Freisia* **4**: 135-217.

Murrill, W.A. 1922. Dark spored agarics-III *Agaricus*. *Mycologia* **14**: 200-221.

Natarajan, K., Kumaresan, V. and Narayanan, K. 2005. A checklist of Indian Agarics and Boletes (1984-2002). *Kavaka* **33**: 61-128.

Pegler, D. N. 1986. *Agaric flora of Sri Lanka*. *Kew Bull. Addi. Ser.* **12**: 1-514.

Phillips, R. 1981. *Mushrooms and other fungi of Great Britain and Europe*. Pan Books Ltd., London. Pp 1-288.

Phillips, R. 2001 - 2013. http://www.rogersmushrooms.com.

Pilát, A. 1951. The Bohemian species of the genus *Agaricus*. *Acta Mus. Nat. Pragae* **7B** (1): 1-142.

Purkayastha, R. P. and Chandra, A. 1985. *Manual of Indian Edible Mushrooms*. Jagmander Book Agency, New Delhi.

Saini, S. S., Atri, N. S. and Gupta, A. K. 1991. Additional studies on North-West Indian Agarics. In: *Indian Mushrooms* 1991, (Ed.: Nair, M.C.), Kerala Agricultural University, Velenikkara, 680654, India, pp. 7-12.

Smith, A.H.1949. *Mushrooms in their Natural Habitat*. Hafner Press, New York, pp. 626. Wood, M. and Stevens, F.1997-2013.

Stijve, T. and Amanonas, M. A. L. 2002. *Agaricus blazei* Murrill. A new gourmet and medicinal mushroom from Brazil. *Australasian Mycologist* **21** (1): 29-33.

Upadhyay, R. C., Verma, B., Sood, S., Atri, N. S., Lakhanpal, T. N. and Sharma, V. P. 2017. *Documentry of Agaricomycetous Mushrooms of India*. Jaya Publishing House, Delhi. pp. 193.

Wang, H., Fu, Z. and Han, C. 2013. The Medicinal Values of Culinary- Medicinal Royal Sun Mushroom (*Agaricus blazei* Murrill). *Evidence based Complementary and Alternative Medicine*. http://dx.doi.org/10.1155/2013/842619.

Wood, M. and Stevens, F. 1997 - 2013. Http://www.mykoweb.Com/CAF/species/*Agaricus_subrutilescens*. html.