

## Diversity of coprophilous species of *Panaeolus* (Psathyrellaceae, Agaricales) from Punjab, India

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### ABSTRACT

Kaur A, Atri NS, Kaur M. 2014. Diversity of coprophilous species of *Panaeolus* (Psathyrellaceae, Agaricales) from Punjab, India. *Biodiversitas* 15: 115-130. An account of 16 *Panaeolus* species collected from a variety of coprophilous habitats of Punjab state in India is described and discussed. Out of these, *P. alcidis*, *P. castaneifolius*, *P. papilionaceus* var. *parvisporus*, *P. tropicalis* and *P. venezolanus* are new records for India while *P. acuminatus*, *P. antillarum*, *P. ater*, *P. solidipes*, and *P. sphinctrinus* are new reports for north India. *Panaeolus subbalteatus* and *P. cyanescens* are new records for Punjab state. A key to the taxa explored is also provided.

**Key words:** Dung, epithelial pileus cuticle, systematics, taxonomy.

### INTRODUCTION

The genus *Panaeolus* (Fr.) Quél., belonging to the family Psathyrellaceae Readhead, Vilgalys & Hopple, is characterized by its usually coprophilous habitat, bluing context, epithelial pileipellis, metalloid chrysocystidia and spores which do not fade in concentrated sulphuric acid. The members of the closely related genus *Psathyrella* are usually found growing on wood or lignin-enriched soils, have brittle white stipe and their basidiospores loose color in concentrated sulphuric acid. The gills of *Panaeolus* do not deliquesce as do those of the related genera *Coprinopsis* P. Karst., *Coprinellus* P. Karst. and *Parasola* Redhead, Vilgalys & Hopple. The genus *Panaeolina* Maire is distinguished by having ornamented spores and dark brown gills, in comparison to smooth basidiospores and mottled grayish-black gills in *Panaeolus*.

Kirk et al. (2008) recognized 15 species under this genus. However, MycoBank ([www.mycobank.org](http://www.mycobank.org)) documents 134 associated records of the genus till July 31, 2014. *Panaeolus* species are saprotrophic in habitat and most of the species grow solitary, scattered or in groups on dung and on soil (Singer 1986; Pegler 1986). From India, so far 27 species are reported by various workers (Bose 1920; Pathak and Ghosh 1962; Ghosh et al. 1967; Sathe and Sasangan 1977; Sarbhoy and Daniel 1981; Natarajan and Raaman 1983; Bhide et al. 1987; Abraham 1991; Dhancholia et al. 1991; Lakhanpal 1993, 1995; Bhavani Devi 1995; Patil et al. 1995; Vrinda et al. 1999; Manimohan et al. 2007; Kaur et al. 2013, 2014). Here we present the results of a preliminary study of coprophilous *Panaeolus* as it occurs in the state of Punjab.

### MATERIALS AND METHODS

#### Study area

The state of Punjab is located in the north-western part of India covering an area of 50,362 sq. km. which constitutes 1.57% of the total geographical area of the country. It lies between 29°32' to 32°32'N latitude and 73°55' to 76°70'E longitude. Its average elevation is about 300 m from the sea level. Climatically, Punjab has four major seasons—summers, monsoon, winter and autumn season. The amount of rainfall ranges between 250 mm to 1000 mm. Most of the annual rainfall is experienced during the arrival of southwest monsoon in the region. About 70-80% of the total rainfall is received during July, August and September and the rest during the winter months. The mean monthly temperature is more than 20°C. It is primarily an agrarian state having diverse flora and fauna. Various domesticated and wild herbivorous animals are found on the grazing lands of the state. Of the total livestock, about 90% are cattle and buffaloes and the rest are sheep, goats, camels and other animals which are domesticated for agriculture, dairy, transportation and other purposes.

#### Collection, preservation and observation

Conventional morphology based mycological techniques were used in the study (Singer 1986; Pegler 1977, 1986; Atri et al. 2005). The color terminology used for macroscopic description is that of Kornerup and Wanscher (1978). The specimens were preserved according to the techniques given by Smith (1949) and Atri and Saini (2000). The drawings of microscopic details were made with the aid of camera lucida under an oil immersion lens. All the collections examined have been deposited in the

Herbarium of Botany Department, Punjabi University, Patiala (Punjab), India (PUN). 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).

## RESULTS AND DISCUSSION

### Taxonomy

*Panaeolus* (Fr.) Quél. in Mém. Soc. Émul. Montbéliard 5: 151, 1872.

**Basionym.** *Agaricus* subgen. *Panaeolus* Fr. in Summa Veg. Scand. 2: 297, 1849.

**Synonyms.** *Campanularius* Roussel, 1806. *Coprinarius* Fr. in Syst. Mycol. 1: 11, 300, 1821. *Anellaria* P. Karst. in Bidr. Känn. Finl. Nat. Folk 32: 517, 1879. *Chalymmota* P. Karst. in Bidr. Känn. Finl. Nat. Folk 32: 518, 1879. *Copelandia* Bres. in Hedwigia 53: 51, 1912.

**Type species.** *Panaeolus papilionaceus* (Bull.) Quél. (1872).

### Key to the investigated coprophilous taxa of *Panaeolus*

- |   |  |   |
|---|--|---|
| 1 | Chrysocystidia present; caulocystidia present or absent .....  | 2   |
| 1 | Chrysocystidia absent; caulocystidia present .....   | 9   |
| 2 | Caulocystidia present .....  | 3   |
| 2 | Caulocystidia absent; pileocystidia present; clamp connections present .....   | 8   |
| 3 | Clamp connections present; pileocystidia absent .....  | 4   |
| 3 | Clamp connections absent; pileocystidia present or absent .....  | 7   |
| 4 | Stipe solid at maturity, stout .....   | 5   |
| 4 | Stipe hollow at maturity, thin .....   | 6   |
| 5 | Pileus plano-convex, umbonate, surface smooth; stipe white, unchanging; chrysocystidia with constricted apex; basidiospores 12–15.6×10–11 µm..... <i>P. solidipes</i>                              |   |
| 5 | Pileus convex, exumbonate, surface aerolate, having angular scales; stipe pale, bruising brown; chryso-cystidia with tapered pedicellate base; basidiospores 13.6–20.4×10–13.6 µm .....            | <i>P. antillarum</i>                          |
| 6 | Pileus 1.4–1.5 cm broad, umbonate; basidia 4-spored; basidiospores 10–14×7–9.8 (11) µm, germ pore oblique to straight..... <i>P. ater</i>  |   |
| 6 | Pileus 2.5–4 cm broad, exumbonate; basidia mostly 2-spored, very rarely 4-spored; basidiospores 9–12×7–10 µm .....   | <i>P. tropicalis</i>                          |
| 7 | Pileus convex, exumbonate, pileal margin appendiculate, with brownish gray marginal band; pileo-cystidia present; basidia 4-spored; basidiospores 12–14.5×8.5–10.2 µm, stipe diverse colored ..... | <i>P. africanus</i> var. <i>diversistipus</i> |
| 7 | Pileus campanulate, umbonate, margin non-appendiculate; pileocystidia absent; basidia mostly 2-spored, very rarely 4-spored; basidiospores 13.6–17×10–12 µm .....                                  | <i>P. lepus-stercus</i>                       |
| 8 | Pileus surface with irregular angular cracks, greenish white; basidiospores 12–14.4 (15.3)×7.6–10 µm, verrucose .....  | <i>P. castaneifolius</i>                      |

- |    |  |   |
|----|--|---|
| 8  | Pileus surface with horizontal cracks, pale colored with ashy gray, brownish gray or bluish gray shades; basidiospores 11.4–16.4×8.5–12 µm, smooth..... <i>P. cyanescens</i>   |   |
| 9  | Stipe annulate; pileus umbonate ..   | 10  |
| 9  | Stipe without annulus; pileus umbonate or not .....  | 11  |
| 10 | Carpophores yellowish brown; pileus and stipe flesh staining bluish when bruised; stipe equal in diameter throughout, hollow; annulus median in position... <i>P. cyanoannulatus</i>   |   |
| 10 | Carpophores orange white to orange gray; stipe staining reddish when bruised, obclavate, solid; annulus superior .....   | <i>P. venezolanus</i>                           |
| 11 | Pileus umbonate .....  | 12  |
| 11 | Pileus exumbonate .....  | 14  |
| 12 | Pileus and stipe surface creamish buff; pileal margin splitting at maturity; cuticle fully peeling; basidio-spores large, (14.3) 15.7–18.5×9.2–11.4 µm..... <i>P. alcidis</i>  |   |
| 12 | Pileus and stipe surface with reddish shades; pileal margin not splitting at maturity.....   | 13  |
| 13 | Pileus 1.8–3.2 cm broad, conico-convex to convex, with prominent marginal band; stipe 0.2–0.4 cm broad, pruinose; basidiospores 11.8–14.4 (15.3)×7–9.3 (10) µm .....   | <i>P. subbalteatus</i>                          |
| 13 | Pileus 1.7–2 cm broad, campanulate to broadly conical, marginal band absent; stipe 0.2 cm broad, pruinose near the apex, smooth below; basidiospores 11.4–15×7.8–11 µm..... <i>P. acuminatus</i>   |   |
| 14 | Pileal margin appendiculate; basidiospores 13–17×8.5–11.5 µm, limoniform-hexagonal; pileocystidia present .....  | <i>P. sphinctrinus</i>                          |
| 14 | Pileal margin non-appendiculate.....   | 15  |
| 15 | Pileus surface yellowish white to grayish white, smooth; margin splitting at maturity; taste and odor not distinctive; stipe surface yellowish white, bruising pinkish brown; clamp connections present; basidiospores 13.6–17×8.5–12 (12.7) µm..... <i>P. papilionaceus</i> var. <i>parvisporus</i> |   |
| 15 | Pileus surface yellowish, with orange scales; margin not splitting at maturity; taste mild; odor farinaceous; stipe surface yellowish, bruising blackish gray; clamp connections absent; basidiospores 12.8–15.5×8.5–10 µm .....   | <i>P. speciosus</i> var. <i>pilocystidiosus</i> |

*Panaeolus solidipes* (Peck) Sacc. in Syll. Fung. 5: 1123, 1887. Figure 1.

**Basionym.** *Agaricus solidipes* Peck in Ann. Rep. New York St. Mus. Nat. Hist. 2: 101, 1872.

**Synonym.** *Campanularius solidipes* (Peck) Murrill in Mycologia 10 (1): 31, 1918.

Carpophores 12 cm in height. Pileus 5.5 cm broad, plano-convex; broadly umbonate; surface white (2A<sub>1</sub>), yellowish white (2A<sub>2</sub>) at umbo, dry, delicate, white (2A<sub>1</sub>), smooth; pileal veil absent; margin regular, splitting at maturity, non-striate, non-appendiculate; cuticle fully peeling; flesh thin, white, unchanging; taste and odor mild. Lamellae adnate, unequal, 4-sized, subdistant, broad, up to 0.6 cm broad, fragile, grayish black, unchanging; gill edges smooth. Stipe central, 11.6 cm long, 0.7 cm broad, cylindrical, equal, longitudinally twisted, solid, surface white (2A<sub>1</sub>), unchanging, smooth, exannulate.

Basidiospores 12–15.6×10–11 µm (Q = 1.3), lenticular, limoniform in face view, ellipsoidal in side view, apically truncated by a broad, central germ pore, thick-walled,

smooth, rusty brown, not bleaching in concentrated  $H_2SO_4$ . Basidia  $17\text{--}23 \times 8.5\text{--}13 \mu\text{m}$ , clavato-cylindrical, 2-, 4-spored, thin-walled, hyaline; sterigmata  $2.8\text{--}3.6 \mu\text{m}$  long. Gill edges sterile. Cheilocystidia  $14\text{--}27 \times 4\text{--}9 \mu\text{m}$ , abundant, polymorphic, clavate to sublageniform, thin-walled, hyaline, densely granular at the apices. Pleurocystidia chrysocystidioid,  $21\text{--}47 \times 11.4\text{--}17 \mu\text{m}$ , abundant, metulloid, ventricose-fusoid, constricted at the apex, thin-walled, granular throughout. Pileus cuticle cellular epithelium, cellular elements  $20\text{--}34 \times 24\text{--}45.5 \mu\text{m}$ , globose, subglobose to piriform, thin-walled, hyaline; pileocystidia absent; pileus context homoiomerous, made up of interwoven  $7\text{--}15.6 \mu\text{m}$  broad hyphae. Hymenophoral trama regular, composed of parallel, thin-walled, hyaline  $3\text{--}14 \mu\text{m}$  broad hyphae. Subhymenium pseudoparenchymatous. Stipe cuticle hyphal with scattered groups of caulocystidia; stipe context made up of thin-walled, hyaline,  $8.5\text{--}30 \mu\text{m}$  broad hyphae; caulocystidia  $17\text{--}31 \times 5\text{--}8.5 \mu\text{m}$ , cylindrical to clavate, thin-walled, hyaline. Clamp connections present in stipe context hyphae.

**Material examined.** India, Punjab, Sangrur, Upoki, 231 m asl., solitary on horse dung, 4 September 2009, Amandeep Kaur, PUN 4034.

**Discussion.** The above examined collection matches well with the description of *P. solidipes* (Arora 1986). It is characterized by medium sized basidioma, white to yellowish white pileus, solid stipe, absence of veil and lenticular spores. *P. semiovatus* which is closely related can be separated by its hollow annulate stipe and elongate-elliptic basidiospores. Arora (1986) reported this species

from California and Arizona where it fruit on horse dung and on manure. Arora considers it as the only non-hallucinogenic *Panaeolus* worth eating while Hard (1908) opined it as one of the best of mushrooms to eat. Miller (1968) reported it from Alaska, Yukon and Canada where it is found growing solitary on horse dung. The only previous record of this species from India is that of Bhavani Devi (1995) from Trivandrum, Kerala state. Our collection therefore represents the first record of the species from north India.

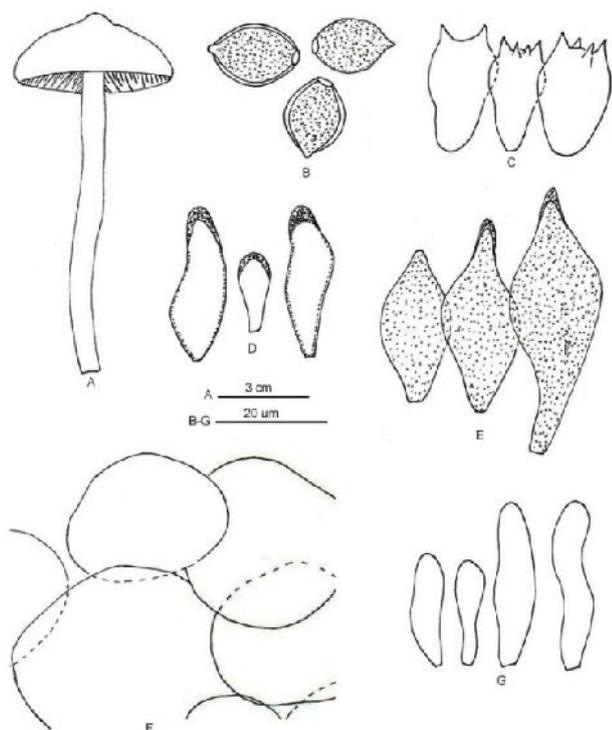
***Panaeolus antillarum*** (Fr.) Dennis in Kew Bull. 15 (1): 124, 1961. Figures 2 and 3.

**Basionym.** *Agaricus antillarum* Fr. in Elench. Fung. 1: 42, 1828.

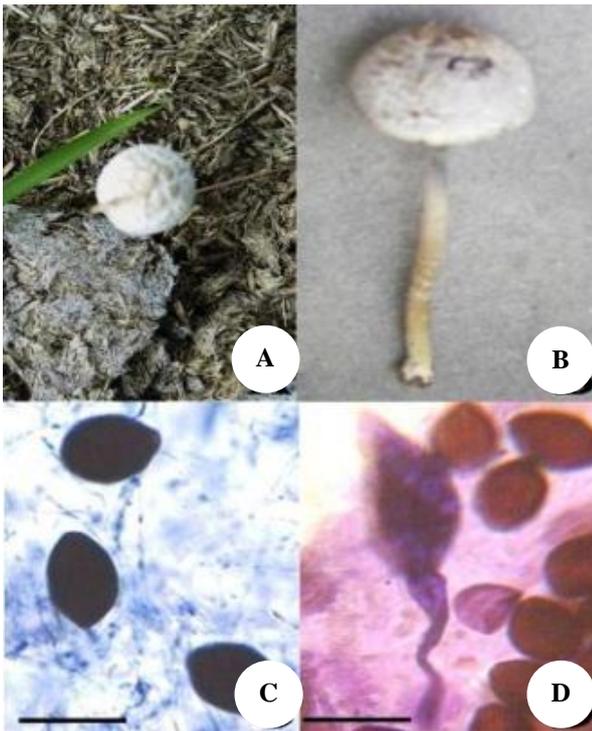
**Synonyms.** *Psilocybe antillarum* (Fr.) Sacc. in Syll. Fung. 5: 1052, 1887. *Anellaria antillarum* (Fr.) Hlaváček, 1997.

Carpophore 9.2 cm in height. Pileus 2.8 cm broad, 1.7 cm high, convex; surface pale ( $2A_2$ ) to buff with light brown ( $6D_8$ ) shades, dry, cracked, aerolate, squamose, non-striate; pileal veil scaly, scales large, angular, appressed fibrillose, covering the entire pileus surface; apex plane, dark brown ( $6F_7$ ), margin regular, splitting, non-striate, non-appendiculate; cuticle fully peeling; flesh thin, 0.1 cm thick, pale, unchanging; taste and odor mild. Lamellae adnate, unequal, 2-sized, crowded, moderately broad, up to 0.6 cm broad, fragile, grayish-black. Spore print grayish black. Stipe 9 cm long, 0.45 cm broad, cylindrical, with subbulbous base, solid, dusted with grayish-black basidiospores on the upper half, surface pale ( $2A_2$ ), changing brownish towards the base when handled, fibrillose, exannulate.

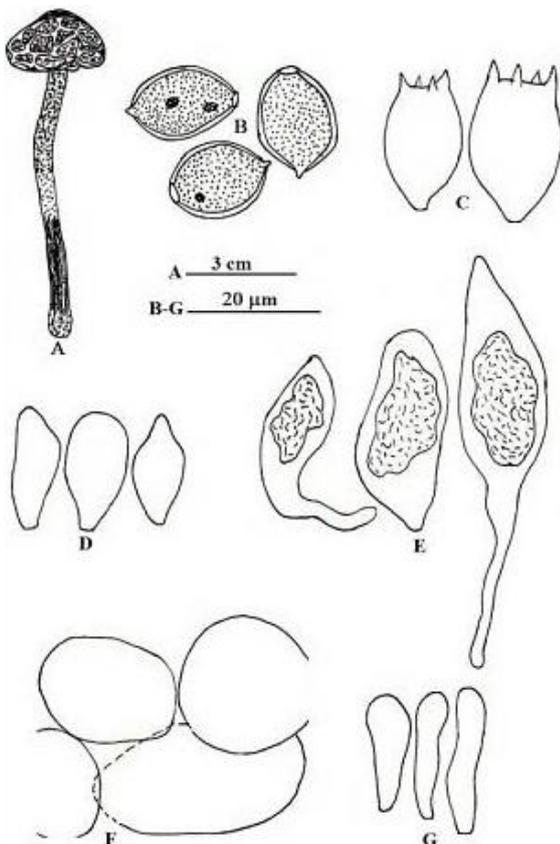
Basidiospores  $13.6\text{--}20.4 \times 10\text{--}13.6 \mu\text{m}$  ( $Q = 1.44$ ), limoniform-subhexagonal in face view, ovoid to ellipsoidal in side view, with broader base, acute apex, truncated with a central germ pore, thick-walled, smooth, blackish brown, not bleaching in concentrated  $H_2SO_4$ . Basidia  $10\text{--}20 \times 7\text{--}13.5 \mu\text{m}$ , inflated clavate, 4-spored, thin-walled, hyaline; sterigmata up to  $3.6 \mu\text{m}$  long. Gill edges sterile. Cheilocystidia  $14\text{--}18.5 \times 8.5\text{--}10 \mu\text{m}$ , abundant, polymorphic, clavate, cylindrical or lageniform, with round apex, thin-walled, hyaline. Pleurocystidia chrysocystidioid,  $25\text{--}57 \times 7\text{--}13 \mu\text{m}$ , abundant, polymorphic, inflated clavate, elongate ovoid, lageniform or ventricose-fusoid, with long tapering base, thin-walled, hyaline but having a single irregular amorphous refractive body which becomes pale golden in 10% KOH. Pileus cuticle a cellular epithelium; cells  $15.6\text{--}37 \times 11.4\text{--}18.5 \mu\text{m}$  in size, subglobose or piriform, thin-walled, hyaline; pileocystidia absent; pileus context homoiomerous, made up of thin-walled,  $3\text{--}11.4 \mu\text{m}$  broad hyphae. Hymenophoral trama regular, composed of parallel, thin-walled  $3\text{--}7 \mu\text{m}$  broad hyphae. Subhymenium pseudoparenchymatous. Stipe cuticle hyphal, with caulocystidia scattered in tufts; stipe context made up of longitudinally running cylindrical thin-walled  $2.8\text{--}18.5 \mu\text{m}$  broad hyphae; caulocystidia  $18.7\text{--}30.6 \times 5\text{--}8.5 \mu\text{m}$ , cylindrical to clavate, with round apex, thin-walled, hyaline. Clamp connections present throughout.



**Figure 1.** *Panaeolus solidipes*. A. Carpophore; B. Basidiospores; C. Basidia; D. Cheilocystidia; E. Chrysocystidia; F. Pileal elements; G. Caulocystidia.



**Figure 2.** *Panaeolus antillarum*. A. Carpophore growing in natural habitat; B. Aerolatepileal surface and stipe changing brownish towards the base when handled; C. Basidiospores; D. Chrysocystidium. Bars C-D = 20  $\mu$ m.



**Figure 3.** *Panaeolus antillarum*. A. Carpophore; B. Basidiospores; C. Basidia; D. Cheilocystidia; E. Chrysocystidia; F. Pileus cuticle elements; G. Caulocystidia.

**Material examined.** India, Punjab, Sangrur, Ratolan, 231 m asl., growing solitary on cattle dung, 28 September 2008, Amandeep Kaur, PUN 4225.

**Discussion.** *Panaeolus antillarum* is recognized by medium sized basidiomata, whitish pileus with angular scales, solid exannulate stipe, subhexagonal spores with central germ pore and prominent pedicellate chrysocystidia with an irregular amorphous refractive body (Pegler 1977; Watling and Gregory 1987; Stamets 1996; Reid and Eicker 1999). Pegler (1977) reported this species growing on cow dung in Kenya; on elephant and buffalo dung in Uganda and amongst grasses in open pasture in Tanzania. Watling and Gregory (1987) reported it growing in grassy places or on freshly manured soil from British Isles. Zhishu et al. (1993) reported it growing gregariously on cow dung from China's Guangdong Province. Stamets (1996) reported it growing gregariously in subcespitosous groups during rainy season in north and south America. According to Reid and Eicker (1999), this species is able to grow on a wide range of dung of herbivorous mammals including cattle, horses, buffaloes, elephants and rhinoceros. They also observed it growing on pile of stable manure and in open pasture in South Africa. Hausknecht and Krisai (2003) reported it growing on horse manure heaps from Australia. Doveri (2010) collected the species growing on cattle dung from Italy. Watling and Richardson (2010) recorded it growing on cattle and horse dung from East Falkland. They documented it as a widespread tropical to subtropical coprophilous species. From India, the species was earlier reported growing on elephant dung from Tamil Nadu (Natarajan and Raaman 1983) and Kerala (Manimohan et al. 2007). The present collection from Punjab represents the first report of this species from north India.

*Panaeolus ater* (J.E. Lange) Kühner & Romagn. in Doc. Mycol. 16 (61): 46, 1985. Figures 4 and 5.

**Basionym.** *Panaeolus fimicola* var. *ater* J.E. Lange in Fl. Agaric. Danic. 4: 6, 1940.

Carpophores 5.7–8.8 cm in height. Pileus 1.4–1.5 cm broad, 0.6–0.8 cm high, convex to applanate; umbonate, umbo short, yellowish; surface whitish (2A<sub>1</sub>) to pale (2A<sub>2</sub>) with grayish brown (6E<sub>3</sub>) shades, hygrophanous, changing to pale color, smooth; margin regular, not splitting at maturity, non-striate, non-appendiculate, sometimes reflexed at maturity; cuticle not peeling; flesh thin, whitish, unchanging, non-deliquestent; taste and odor mild. Lamellae adnate, unequal, 3-sized, subdistant, narrow, 0.15–0.2 cm broad, fragile, grayish-black; gill edges smooth. Spore print black. Stipe 5.5–8.7 cm long, 0.15–0.2 cm broad, cylindrical, equal in diameter throughout, solid when young, hollow at maturity, surface whitish (2A<sub>1</sub>), changing to grayish brown on bruising, pruinose, shiny; annulus absent.

Basidiospores 10–14×7–9.8 (11)  $\mu$ m (Q = 1.42), lenticular, limoniform-subhexagonal in face view, ellipsoidal in side view, with oblique to straight, yellowish germ pore, thick-walled, smooth, reddish brown to blackish brown, not bleaching in concentrated H<sub>2</sub>SO<sub>4</sub>. Basidia 17–22.7×8.5–11.5  $\mu$ m, clavate, 4-spored, thin-walled, granular; sterigmata 2.8–4.3  $\mu$ m long. Gill edges sterile.

Cheilocystidia 22.7–27×5.7–10 μm, abundant, polymorphic, cylindrical, clavate, sublageniform to fusoid, thin-walled, densely granular at apex. Pleurocystidia chrysocystidioid, 24–53×11.4–14 μm, abundant, metulloid, ventricose-fusoid, with blunt, tubular to mucronate tips, thick-walled, granular, golden brown, some with apical encrustations. Pileus cuticle a cellular epithelium; cells 14–36×14–26 μm, subglobose, ellipsoidal, clavate to piriform, thin-walled, hyaline; pileocystidia absent; pileus context homoiomerous, made up of horizontally tangled, septate, thin walled 11.4–21.4 μm broad hyphae. Hymenophoral trama regular, composed of thin-walled, 8.5–14 μm broad hyaline hyphae. Subhymenium pseudoparenchymatous. Stipe cuticle hyphal, with caulocystidia scattered in tufts on the surface and in between the context tissue; context made up of cylindrical, thin-walled 8.5–24 μm broad hyphae; caulocystidia 25–50×4.4–11.4 μm, abundant, polymorphic like cheilocystidia, cylindrical, clavate, lageniform or fusoid, thin-walled, with rounded to distinctly capitate granular tips. Clamp connections present throughout.

**Materials examined.** India, Punjab, Fatehgarh Sahib, Nogwaan, 228 m asl., scattered on cattle dung, 21 August 2009, Amandeep Kaur, PUN 4032; Hoshiarpur, Chak Sadhu, 295 m asl., in groups on buffalo dung, 22 July 2011, Narinderjit Kaur, PUN 4704.

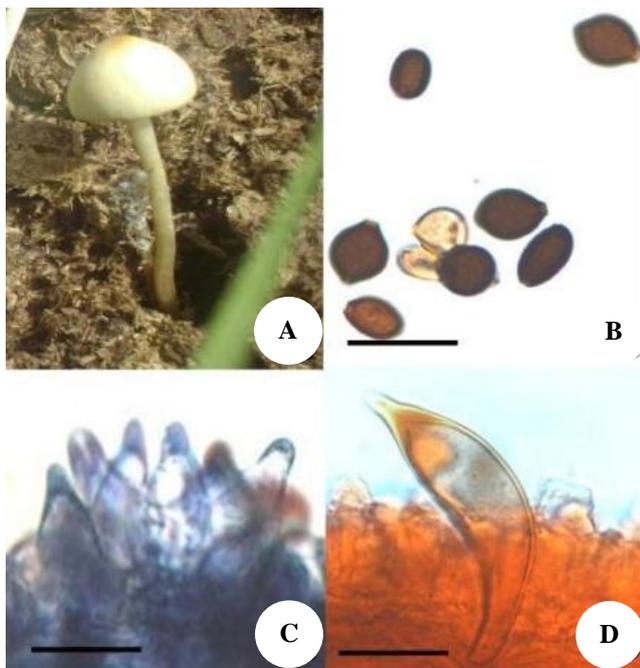
**Discussion.** The above description matches closely with *P. ater* (Watling and Gregory 1987; Stamets 1996). The species is characterized by convex, pale to grayish brown, slightly umbonate pileus, pruinose stipe, presence of chrysocystidia and limoniform spores. *Panaeolus fimicola* Fr. mainly differs by the lack of chrysocystidia (Watling

and Gregory 1987). This species is reported to grow in grassy places in British Isles (Watling and Gregory 1987) and in well fertilized lawns or on dung in America, Africa and Europe (Stamets 1996). Except for the record by Bhavani Devi (1995) from Kerala, no other reports exist for this species in India. The present collection therefore seems significant and forms the first record for north India.

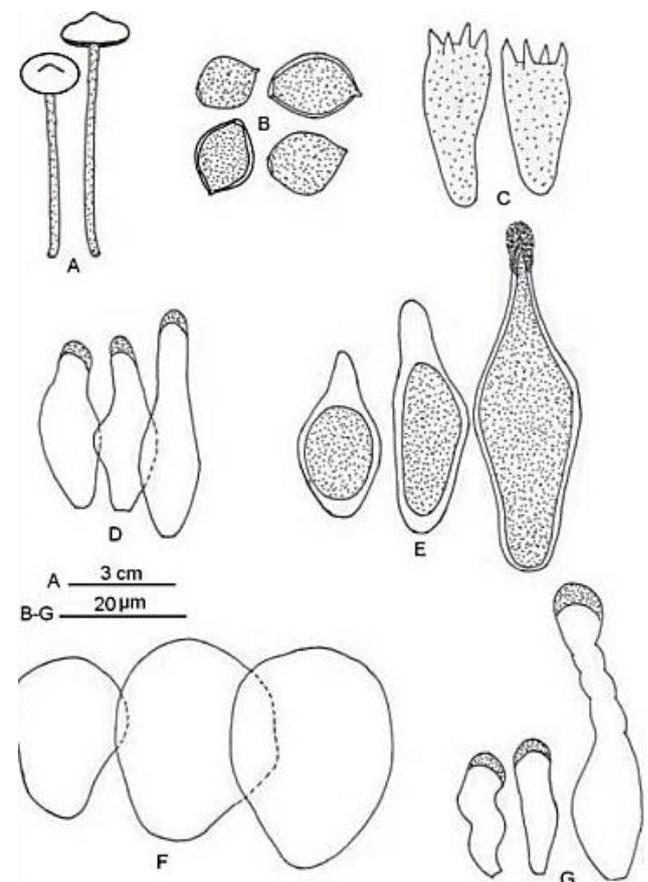
*Panaeolus tropicalis* Oláh in Rev. Mycol. 4: 289, 1969. Figures 6 and 7.

**Basionym.** *Copelandia tropicalis* (Oláh) Singer & R.A. Weeks in Lloydia 42 (5): 472, 1979.

Carpophores 6.5–12.5 cm in height. Pileus 2.5–4 cm broad, 1.5–1.8 cm high, convex to applanate; surface pale cream with bluish gray tinge, dry, smooth; pileal veil absent; margin regular, not splitting at maturity, non-striate; cuticle fully peeling; flesh thin, bluing when handled, non-deliquestent; taste and odor not distinctive. Lamellae adnate to recurrent, unequal, 3-sized, subdistant, moderately broad, up to 0.25 cm broad, fragile, bluish gray; gill edges smooth. Stipe central to slightly eccentric, 6.4–12.4 cm long, 0.2–0.4 cm broad, tubular, equal in diameter throughout, solid, surface pale cream, changing to bluish gray on bruising, pruinose, exannulate.

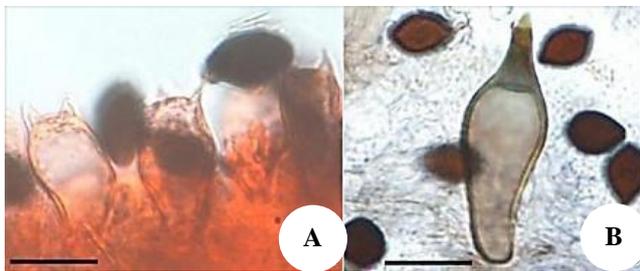


**Figure 4.** *Panaeolus ater*. A. Carpophore growing in a natural habitat; B. Basidiospores; C. Cheilocystidia; D. Chrysocystidium. Bars B-D = 20 μm.

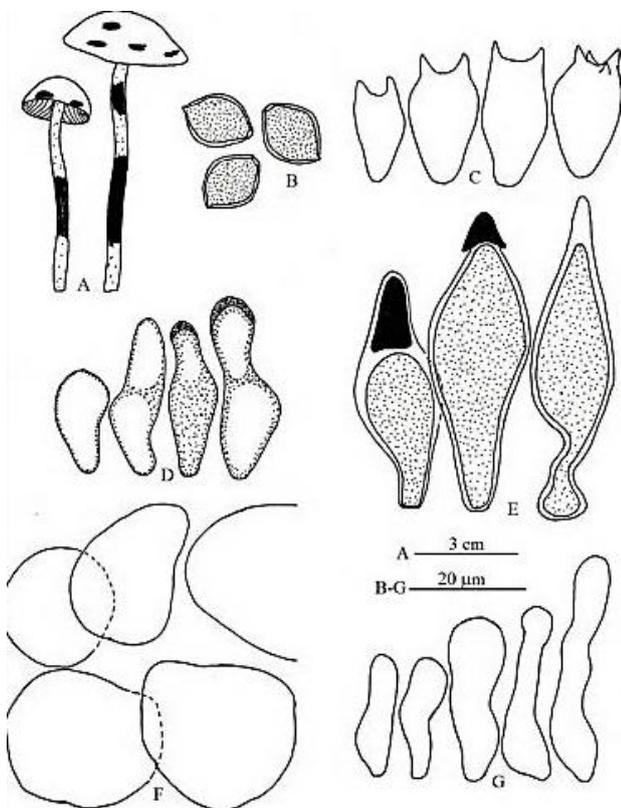


**Figure 5.** *Panaeolus ater*. A. Carpophore; B. Basidiospores; C. Basidia; D. Cheilocystidia; E. Chrysocystidia; F. Pileal elements; G. Caulocystidia.

Basidiospores  $9\text{--}12 \times 7\text{--}10 \mu\text{m}$  ( $Q = 1.23$ ), lenticular, limoniform in face view, broadly ellipsoidal in side view, slightly angular at the centre, with acute base and a truncate germ pore at the apex, thick-walled, smooth, blackish brown, not bleaching in concentrated  $\text{H}_2\text{SO}_4$ . Basidia  $12.8\text{--}21 \times 7\text{--}11.4 \mu\text{m}$ , clavate, 2-, 4-spored, mostly 2-spored, thin-walled, hyaline; sterigmata  $2\text{--}3.6 \mu\text{m}$  long. Gill edges sterile. Cheilocystidia  $15.5\text{--}25.5 \times 5.5\text{--}8.5 \mu\text{m}$ , abundant, polymorphic, cylindrical, clavate or lageniform, thin-walled, hyaline to granular, some with subcapitate densely granular tips. Pleurocystidia chrysocystidioid,  $31\text{--}54 \times 8\text{--}17 \mu\text{m}$ , metulloid, ventricose-fusoid, thick walled, granular, golden brown, reddish brown in  $\text{NH}_4\text{OH}$ , some with apical encrustations. Pileus cuticle a cellular epithelium, cells  $21\text{--}30 \times 11\text{--}35.5 \mu\text{m}$ , globose, subglobose or piriform, thin-walled, hyaline; pileocystidia absent; pileus context made



**Figure 6.** *Panaeolus tropicalis*. A. Basidia; B. Chrysocystidium and spores. Bars A-B =  $20 \mu\text{m}$ .



**Figure 7.** *Panaeolus tropicalis*. A. Carpophores; B. Basidiospores; C. Basidia; D. Cheilocystidia; E. Chrysocystidia; F. Pileal elements; G. Caulocystidia.

up of interwoven  $5.7\text{--}20 \mu\text{m}$  broad hyphae. Hymenophoral trama regular, composed of thin-walled  $5.7\text{--}18.5 \mu\text{m}$  broad hyphae. Subhymenium pseudoparenchymatous. Stipe cuticle hyphal, with caulocystidia present in groups; context hyphae interwoven, thin-walled, hyaline  $2.8\text{--}25.6 \mu\text{m}$  broad; caulocystidia  $17\text{--}37 \times 5.7\text{--}7.7 \mu\text{m}$ , cylindrical, clavate or lageniform, thin-walled, hyaline. Clamp connections present in the stipe context hyphae.

**Materials examined.** India, Punjab, Patiala, Nainakut, 251 m asl., in groups on mixed cattle dung, 16 June 2008, Amandeep Kaur, PUN 4076; Patiala, Bhunerheri, 251 m asl., in groups on mixed cattle dung, 16 June 2008, Amandeep Kaur, PUN 4346; Hoshiarpur, Kot Fatuhi, 295 m asl., solitary on mixed cattle dung among grassy litter, 18 August 2011, Narinderjit Kaur, PUN 4341.

**Discussion.** The characteristic features of the present collections are in agreement with *Panaeolus tropicalis* (Stamets 1996). *Panaeolus cyanescens* is a closely matching species but unique in having mostly 4-spored basidia, larger spores ( $12\text{--}16 \times 9\text{--}10.5 \mu\text{m}$ ) and presence of pileocystidia (Watling and Gregory 1987). *Panaeolus tropicalis* is typically dung inhabiting and reported from Hawaii, Central Africa, Cambodia (Stamets 1996) and also in Mexico, Tanzania, Florida, Japan and the Philippines ([http://en.wikipedia.org/wiki/Panaeolus\\_tropicalis](http://en.wikipedia.org/wiki/Panaeolus_tropicalis)). No previous report of this species exists in India prior to this study.

***Panaeolus africanus* var. *diversistipus*** Amandeep Kaur, NS Atri & Munruchi Kaur in *Mycosphere* 4 (3): 620, 2013.

**Material examined.** India, Punjab, Hoshiarpur, 295 m asl., Jejon Duaba, solitary on mixed cattle dung heap, 5 July 2011, Amandeep Kaur, PUN 4342.

**Discussion.** *Panaeolus africanus* var. *diversistipus* differs from the type variety mainly in the stipe characteristics. *P. africanus* has a white stipe with pinkish shades and a pruinose apex (Stamets 1996). However, *P. africanus* var. *diversistipus* has pure white surface towards the stipe apex, grayish brown in the middle and light brown towards the base, moreover the whole surface is covered with white scales and also with cottony basal mycelium. Stamets (1996) reported *P. africanus* from Central and South Africa where it found growing on hippopotamus and elephant dung in the spring and rainy seasons. The variety is so far known only from the type locality (Amandeep et al. 2013).

***Panaeolus lepus-stercus*** Atri, M. Kaur & A. Kaur in *J. New. Biol. Rep.* 3 (2): 129, 2014.

**Material examined.** India, Punjab, Pathankot, Sheep and Rabbit Breeding Farm, Dalla Dhar, 309 m asl., growing scattered on rabbit pellets, 01 September 2011, Amandeep Kaur, PUN 4340.

**Discussion.** *Panaeolus lepus-stercus* is characterized by yellowish gray umbonate pileus, bisporic as well as tetrasporic basidia, large limoniform-hexagonal spores, polymorphic chrysocystidia, absence of pileocystidia, absence of clamp connections and habitat on rabbit pellets.

Among the species of *Panaeolus* having chrysocystidia, *P. tropicalis* Oláh, *P. ater* (J.E. Lange) Kühner & Romagn.,

*P. rubricaulis* Petch, *P. antillarum* (Fr.) Dennis, *P. cyanescens* (Berk. & Br.) Sacc., *P. solidipes* (Peck) Sacc. and *P. tirunelveliense* Natarajan and Raman are some of the superficially related ones. *Panaeolus tropicalis* and *P. ater* differs by their smaller spores while *P. antillarum* by its much larger spores. *Panaeolus rubricaulis* is distinct by the dark brown pileus with white marginal band and appendiculate margin (Pegler 1986). *Panaeolus cyanescens* differs in having larger carpophores, presence of pileocystidia and clamp connections, and in the absence of caulocystidia (Pegler 1986; Wartchow et al. 2010). *Panaeolus solidipes* differs in having large sized pure white carpophores, plano-convex pileus, longitudinally twisted stipe and in the presence of clamp connections (Arora 1986). *Panaeolus tirunelveliense* can easily be separated by its exclusive 2-spored basidia, smaller spores (12.6–14×8.4–11.2 µm) and by the terrestrial habitat. The species is so far known only from the type (Kaur et al. 2014).

***Panaeolus castaneifolius*** (Murrill) A.H. Sm. in *Mycologia* 40 (6): 685, 1948. Figures 8 and 9.

**Basionym.** *Psilocybe castaneifolia* Murrill in *Mycologia* 15 (1): 17, 1923.

**Synonyms.** *Psathyrella castaneifolia* (Murrill) A.H. Sm. in *Mem. New York Bot. Gard.* 24: 33, 1972. *Panaeolina castaneifolia* (Murrill) Bon. in *Doc. Mycol.* 9 (35): 39, 1979. *Panaeolina castaneifolia* (Murrill) Ew. Gerhardt in *Biblioth. Bot.* 147: 111, 1996.

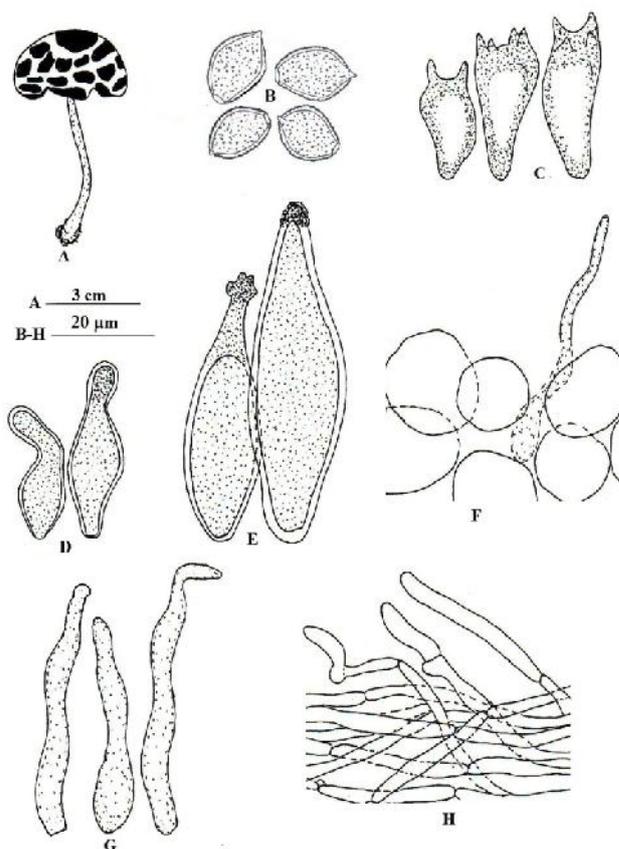
Carpophores 5.7–6.5 cm in height. Pileus 3.3–3.8 cm broad, 1.5–2 cm high, hemispherical to convex; surface greenish white (27A<sub>2</sub>) with brown (6E<sub>8</sub>) apex, dry, wrinkled, with irregularly angular cracks; pileal veil absent; margin irregular, splitting at maturity, non-striate; cuticle fully-peeling; flesh thin, pale, bluing when handled; taste and odor not distinctive. Lamellae adnate, unequal, 3-sized, subdistant, moderately broad, up to 0.4 cm broad, smooth, fragile, grayish-black; gill edges white. Spore print black. Stipe central, 5.5–6.3 cm long, 0.2–0.25 cm broad, cylindrical, slightly bulbous at the base, twisted, hollow, surface greenish white (27A<sub>2</sub>), changing to grayish brown on handling, pruinose, exannulate.



**Figure 8.** *Panaeolus castaneifolius*. Carpophores showing cracked pileus surface and stipe bruising grayish brown.

Basidiospores 12–14.4 (15.3)×7.6–10 µm (Q=1.5), limoniform in face view, ellipsoidal in side view, with a truncate germ pore, thick-walled, finely verrucose, blackish brown, not bleaching in concentrated H<sub>2</sub>SO<sub>4</sub>. Basidia 15.3–29×6.8–13.6 µm, clavate, 2-, 4-spored, thin-walled, granular; sterigmata 3.4–5 µm long. Gill edges sterile. Cheilocystidia 18.7–27.2×8.5–12 µm, abundant, lageniform to ventricose-fusoid, thick-walled, granular, densely granular at the tips. Pleurocystidia chrysocystidioid, 35.7–52.7×15.3–22 µm, metulloid, ventricose-fusoid, thick-walled, granular, with golden yellow apical incrustations. Pileus cuticle cellular with scattered pileocystidia; cellular elements 12–20.4×10–23.8 µm, globose to subglobose, thin-walled, hyaline; pileocystidia 35.7–54.4×3.4–8.5 µm, cylindrical, lageniform or filiform, thin-walled, granular; context made up of interwoven 6.8–18.7 µm broad hyphae. Hymenophoral trama regular composed of thin-walled, 5–15.3 µm broad hyphae. Subhymenium pseudo-parenchymatous. Stipe cuticle hyphal with projecting hyphal elements all over the surface; projecting hyphae septate, thin-walled, hyaline, 3.4–5 µm broad; context composed of 6.8–20.4 µm broad, intermingled, cylindrical, thin-walled hyaline hyphae. Clamp connections present throughout.

**Materials examined.** India, Punjab, Sangrur, Sikanderpura, 231 m asl., in groups on mixed cattle dung, 29 June 2011, Amandeep Kaur, PUN 4358; Patiala, Ghanaur, 251 m asl., solitary on buffalo dung, 19 July 2011, Amandeep Kaur, PUN 4357.



**Figure 9.** *Panaeolus castaneifolius*. A. Carpophore; B. Basidiospores; C. Basidia; D. Cheilocystidia; E. Chrysocystidia; F. Pileus cuticle elements; G. Pileocystidia; H. Stipe cuticle.

**Discussion.** The above examined collections have been identified as *P. castaneifolius*. Their macroscopic and microscopic characters are in conformity with the details given by Stamets (1996) for this species. However, pleurocystidia of the Indian collections are extending well beyond the basidial layer and not so in Stamets (1996) collections. It is reported as growing scattered to gregariously in grassy areas from North and South America (Stamets 1996). The species is recorded for the first time from India.

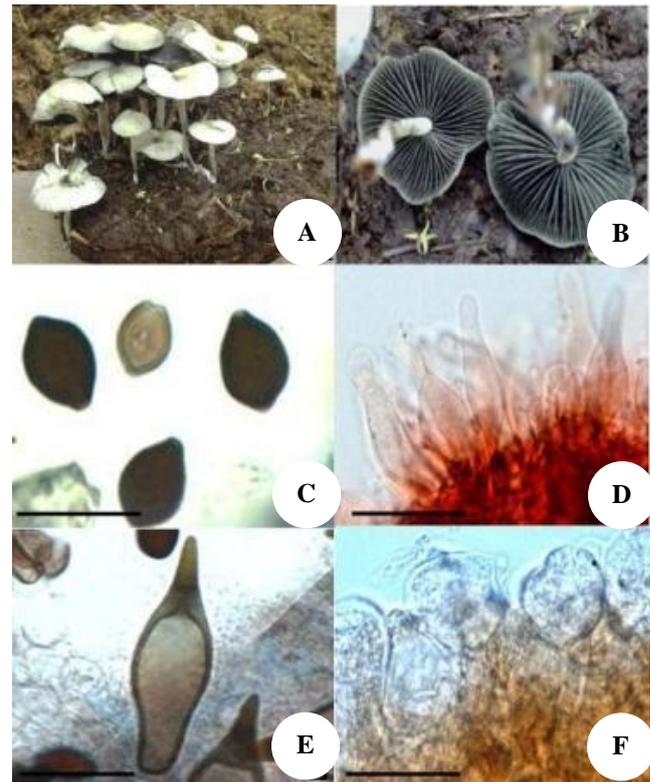
***Panaeolus cyanescens*** (Berk. & Br.) Sacc. in Syll. Fung. 5: 1123, 1887. Figures 10 and 11.

**Basionym.** *Agaricus cyanescens* Berk. & Broome in J. Linn. Soc. Bot. 11: 557, 1871.

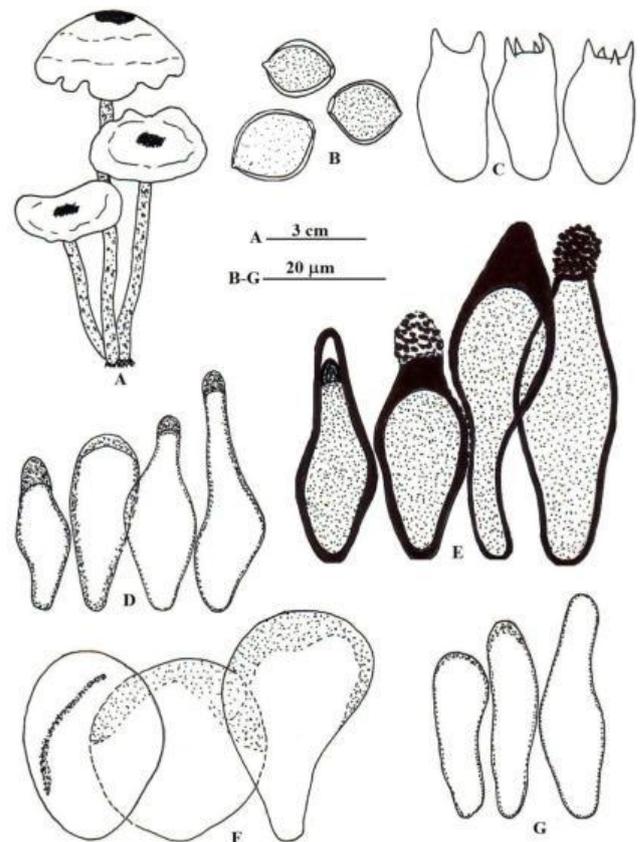
**Synonym.** *Copelandia cyanescens* (Berk. & Br.) Singer in Lilloa 22: 473, 1951.

Carpophores 4.5–11 cm in height; Pileus 1.8–4.7 cm broad, 1.1–2.2 cm high, conico-convex to applanate; surface dry to moist, delicate, pale (2A<sub>2</sub>), with ash gray (1B<sub>2</sub>), brownish gray (6E<sub>2</sub>) to bluish gray (21D<sub>2</sub>) shades, wrinkled, cracked horizontally when dry; pileal veil in the form of hanging remnants along the pileal margin in some carpophores; margin regular to irregular, splitting at maturity, non-striate; cuticle not peeling to fully peeling; flesh thin, pale white, changing to bluish gray on handling; taste and odor mild. Lamellae adnate, unequal, 3-sized, subdistant, moderately broad to broad, 0.3–0.6 cm broad, fragile, grayish-black; gill edges smooth, white. Spore print black. Stipe 4.3–10.8 cm long, 0.15–0.4 cm broad, cylindrical, equal in diameter throughout, first solid then hollow, surface ash gray (1B<sub>2</sub>) to brownish gray (6E<sub>2</sub>) with bluish gray (21D<sub>2</sub>) shades, pruinose to pruinose-fibrillose, shiny; exannulate.

Basidiospores 11.4–16.4×8.5–12 μm (Q=1.35), lenticular, limoniform to slightly hexagonal in face view, ellipsoidal in side view, with a truncate germ pore, thick-walled, smooth, blackish brown, not bleaching in concentrated H<sub>2</sub>SO<sub>4</sub>; apiculate, apiculus 0.7–1.4 μm long. Basidia 13.5–25.5×8.5–13.7 μm, clavate, 2-, 4-spored, thin walled, hyaline; sterigmata 1.4–3.6 μm long. Gill edges sterile. Cheilocystidia 13–40×5–13 μm, polymorphic, cylindrical, clavate, lageniform to ventricose-fusoid, thin-walled, hyaline, some densely granular at apices. Pleurocystidia chrysocystidioid, 23–68×9–24 μm, abundant, metulloid, ventricose-fusoid, thick-walled, golden brown, occasionally with apical incrustations. Pileus cuticle an epithelium with scattered pileocystidia; cellular elements 18.7–41×11.5–51 μm, globose, subglobose, to clavate, thin-walled, hyaline; pileocystidia 30–38.3×5.7–9 μm, lageniform, ventricose-fusoid, thin-walled, hyaline; context homoiomerous, made up of interwoven, thin-walled 2.8–20.4 μm broad hyaline hyphae. Hymenophoral trama regular, composed of thin-walled, 5–27 μm broad hyphae. Subhymenium pseudoparenchymatous. Stipe context made up of longitudinally tangled, thin-walled 2–22 μm broad hyphae. Clamp connections present in stipe context hyphae and basal mycelium.



**Figure 10.** *Panaeolus cyanescens*. A. Carpophores growing in natural habitat; B. Undersurface of the pileus showing grayish-black gills with white edges; C. Basidiospores; D. Cheilocystidia; E. Chrysocystidium; F. Pileus cuticle elements. Bars C-F = 20 μm.



**Figure 11.** *Panaeolus cyanescens*. A. Carpophores; B. Basidiospores; C. Basidia; D. Cheilocystidia; E. Chrysocystidia; F. Pileus cuticle elements; G. Pileocystidia.

**Materials examined.** India, Punjab, Fatehgarh Sahib, Sirhind, 228 m asl., along G.T. Road, in groups on mixed dung and humicolous soil under *Eucalyptus citriodora* tree, 16 September 1995, Amanjeet Kaur, PUN 2708; Fatehgarh Sahib, Sirhind, 228 m asl., in caespitose groups on cattle manure in the field of *Allium sativum* crop, 17 November 1995, Amanjeet Kaur, PUN 2712; Fatehgarh Sahib, Sirhind, 228 m asl., in groups on cattle dung, 17 November 1995, Amanjeet Kaur, PUN 2707; Fatehgarh Sahib, Sirhind, 228 m asl., in groups on cattle manured soil, 27 November 1995, Amanjeet Kaur, PUN 2711; Patiala, Bir Bhunerheri, 250 m asl., scattered on cattle manured soil near *Parthenium* grass, 07 March 1998, Amanjeet Kaur, PUN 2710; Fatehgarh Sahib, Bassi, 228 m asl., scattered on mixed dung, 14 September 1998, Amanjeet Kaur, PUN 2713; Fatehgarh, Sirhind, 228 m asl., in groups on cattle dung manured soil in *Allium sativum* field, 28 November 1998, Amanjeet Kaur, PUN 2709; Sangrur, Malak Majra, 251 m, gregarious on buffalo dung, 23 June 2008, Amandeep Kaur, PUN 4355; Patiala, Dakala, 251 m asl., Dashmesh Nagar, gregarious on cow dung, 25 June 2008, Amandeep Kaur, PUN 4077; Patiala, Chhat Bir, 251 m asl., in caespitose clusters on buffalo dung, 30 June 2008, Amandeep Kaur, PUN 4028; Patiala, Chhat Bir, 251 m asl., gregarious on buffalo dung, 30 June 2008, Amandeep Kaur, PUN 4078; Hoshiarpur, Simbli, 295 m asl., scattered on mixed cattle dung, 19 July 2008, Harwinder Kaur, PUN 4361; Ludhiana, 254 m asl., in groups on cattle dung, 03 September 2008, Baljit Kaur, PUN 3922; Ludhiana, Nasrali, 254 m asl., scattered in groups on mixed cattle dung, 23 July 2009, Amandeep Kaur, PUN 4079; Mohali, Bhajauli, 316m asl., scattered on cow dung heap, 21 August 2009, Amandeep Kaur, PUN 4031; Ropar, Kuraali, 394 m asl., solitary on mixed cattle dung, 21 August 2009, Amandeep Kaur, PUN 4033; Sangrur, Jaatimajra, 251 m asl., gregarious on horse dung, 03 September 2009, Amandeep Kaur, PUN 4080; Patiala, Chhat Bir, 251 m asl., in groups on elephant dung, 10 July 2010, Amandeep Kaur, PUN 4353; Patiala, Chhat Bir, 251 m asl., scattered on elephant dung, 10 July 2010, Amandeep Kaur, PUN 4354; Ropar, near Haveli, 394 m asl., in groups on buffalo dung, 16 July 2010, Arpana Lamba, PUN 4296; Ropar, 394 m asl., in groups on buffalo dung, 25 July 2010, Arpana Lamba, PUN 4297.

**Discussion.** The macro and microscopic details of the Indian collections are in conformity with the details of *P. cyanescens* (Stamets 1996). Pegler (1977, 1983, 1986) reported this species as *Copelandia cyanescens* from Kenya, Tanzania, Uganda, Trinidad and Sri Lanka. This species is distributed widely and reported from different geographical locations (Zhishu et al. 1993; Stamets 1996; Reid and Eicker 1999; Dennis 1970; Guzmán and Pérez-Patrica 1972; Stijve 1992; Guzmán et al. 2000; Wartchow et al. 2010). From India, different workers described it under either as *Copelandia cyanescens* (Bose 1920; Ghosh et al. 1967; Natarajan and Raaman 1983; Manjula 1983; Manimohan et al. 2007) or as *Panaeolus cyanescens* (Abraham 1991; Lakhanpal 1993). It is widely distributed in the coprophilous habitats of Punjab.

*Panaeolus cyanoannulatus* Atri, M. Kaur & A. Kaurin J. New. Biol. Rep. 3 (2): 126, 2014.

**Material examined.** India, Punjab, Hoshiarpur, Jeewanpur Jattan, 295 m asl., in a group on a mixed cow and horse dung heap in a pasture, 18 July 2008, Amandeep Kaur, PUN 4223.

**Discussion.** *Panaeolus cyanoannulatus* is a blue-staining species with well developed annulus on the stipe. It can be distinguished from the other blue-staining allied *Panaeolus* species such as *P. cyanescens* (Berk. & Broome) Sacc., *P. tropicalis* Oláh, *P. cambodginiensis* Oláh & R. Heim and *P. subbalteatus* (Berk. & Br.) Sacc. mainly in being annulate. *Panaeolus semiovatus* (Fr.) Lundell & Nannf. which is also an annulate species differs in the pale cream to pale buff campanulate pileus, chrysocystidia within the hymenium and the basidiospores measuring 16–20×9–11 µm in size (Watling and Gregory 1987), in comparison to yellowish brown conical umbonate pileus, no chrysocystidia and smaller basidiospores in *Panaeolus cyanoannulatus*. It is not yet known outside type locality (Kaur et al. 2014).

*Panaeolus venezolanus* Guzmán in Mycotaxon 7 (2): 221, 1978. Figures 12 and 13.

Carpophores 6.7–7.9 cm in height. Pileus 2–2.3 cm broad, 1.2–1.4 cm high, campanulate; umbonate, umbo acute, brown; surface orange white (5A<sub>2</sub>) to orange gray (5B<sub>2</sub>), dry, smooth; margin regular, splitting at maturity, non-striate, non-appendiculate; cuticle half peeling; flesh thin, 0.1 cm thick, pale, unchanging; taste and odor not distinctive. Lamellae adnate, unequal, 3-sized, distant, moderately broad, up to 0.4 cm broad, fragile, grayish black; gill edges smooth, white. Stipe central, 6.4–7.7 cm long, 0.1–0.2 cm broad, cylindrical, obclavate, solid, surface orange gray (5B<sub>2</sub>), bruising reddish, pruinose; annulate, annulus superior, single, membranous, patchy. Basidiospores 12–15.3×8.5–10 µm (Q=1.47), limoniform-subhexagonal in face view, ovoid to ellipsoidal in side view, with central to slightly eccentric germ pore, thick-walled, smooth, grayish brown, not bleaching in concentrated H<sub>2</sub>SO<sub>4</sub>. Basidia 18.7–35.7×12–16 µm, clavate, 2-, 4-spored, thin-walled, hyaline; sterigmata 3.4–6 µm long. Gill edges sterile. Cheilocystidia 19.5–32.3×5–8.5 µm, cylindrical to clavate, thin-walled, slightly granular. Pleurocystidia absent. Pileus cuticle a cellular epithelium with scattered pileocystidia; cellular elements 12.7–25.5×12–27.2 µm, globose to subglobose, thin-walled, hyaline; pileocystidia 29–52.7×4.3–10 µm, elongated cylindrical to lageniform, thin walled, granular. Hymenophoral trama regular, composed of parallel, thin-walled, hyaline 7–10 µm broad hyphae. Subhymenium pseudoparenchymatous. Stipe cuticle hyphal with caulocystidia scattered in clusters; caulocystidia 16–35.7×5–7.6 µm, cylindrico-clavate or lageniform, thin-walled, granular; stipe context hyphae longitudinally running, thin-walled, hyaline 6.8–22 µm broad. Clamp connections present in stipe context hyphae.

**Material examined.** India, Punjab, Faridkot, Panjgraeen, 196 m asl., in a group on cattle dung and wheat

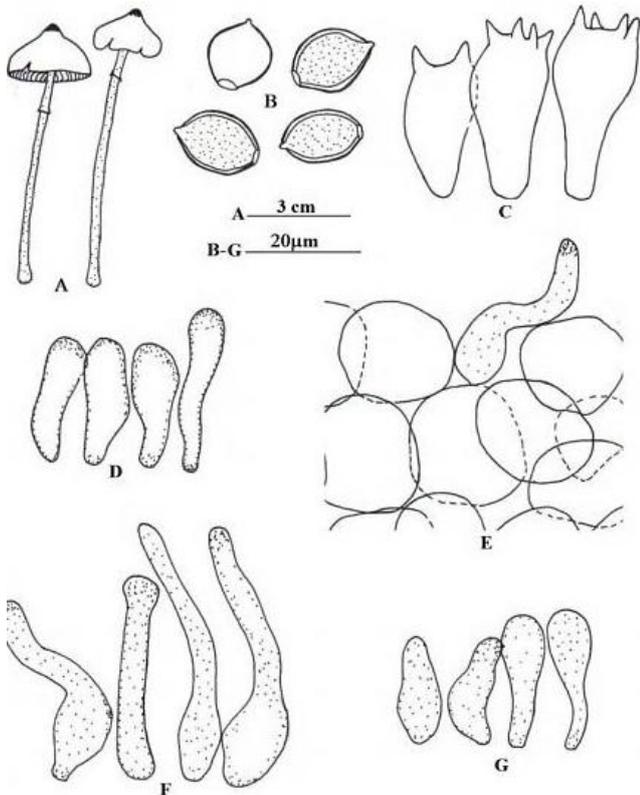
straw mixture heap, 19 August 2011, Amandeep Kaur, PUN 4834.

**Discussion.** *Panaeolus venezolanus* is recognized by the annulate stipe, non-bluing carpophores, large sized limoniform to ovoid basidiospores and absence of pleurocystidia. It is close to *P. papilionaceus* but the presence of an annulus separates it from this species. *Panaeolus solidipes* and *P. semiovatus* though possess annulus can be differentiated by their white carpophores and presence of chrysocystidia within the hymenium.

*Panaeolus venezolanus* was reported by Guzmán (1978) growing gregariously from Venezuela and Mexico. During the present survey, it was recorded growing in a group on cattle dung and wheat straw mixture heap in mid-August for the first time from India.



**Figure 12.** *Panaeolus venezolanus*. A. Carpophores growing in natural habitat; B. Carpophores showing unequal distant gills and reddish bruising on the stipe.



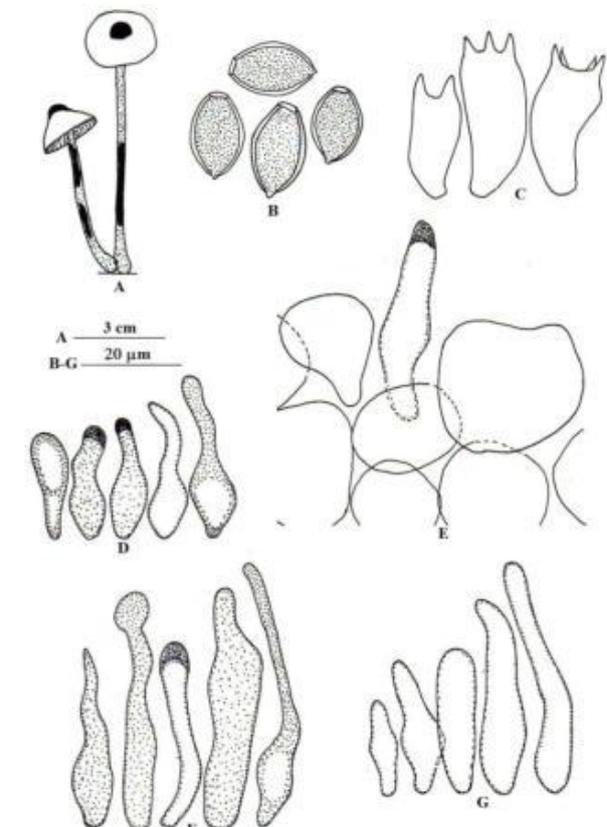
**Figure 13.** *Panaeolus venezolanus*. A. Carpophores; B. Basidiospores; C. Basidia; D. Cheilocystidia; E. Pileal elements; F. Pileocystidia; G. Caulocystidia.

*Panaeolus alcidis* Moser in Mycologia 76: 551, 1984. Figures 14-15.

Carpophores 5.3–8.5 cm in height. Pileus 2.1–2.5 cm broad, 1.2–1.4 cm high, campanulate to convex, umbonate; umbo broad, round, grayish yellow (2B<sub>6</sub>); surface creamish buff, bluish grey when handled, dry, cracked; margin regular, splitting at maturity, non-striate; flesh thin, bluing when exposed, non-deliquestent; cuticle fully-peeling; pileal veil absent; taste and odor not distinctive. Lamellae adnate, unequal, 3-sized, subdistant, broad, up to 0.6 cm broad, fragile, grayish-black; gill edges smooth, white. Spore print black. Stipe central, 5.1–8.3 cm long, 0.1–0.2 cm broad, tubular, slightly bulbous at the base, solid, surface creamish buff, brown when handled, bruised or with age, pruinose; annulus absent.



**Figure 14.** *Panaeolus alcidis*. A. Carpophores growing in natural habitat; B. Carpophore showing adnate, subdistant gills and bulbous stipe base.



**Figure 15.** *Panaeolus alcidis*. A. Carpophores; B. Basidiospores; C. Basidia; D. Cheilocystidia; E. Pileal elements; F. Pileocystidia; G. Caulocystidia.

Basidiospores (14.3) 15.7–18.5×9.2–11.4  $\mu\text{m}$  ( $Q = 1.66$ ), ellipsoidal, truncated with a straight to slightly oblique germ pore, thick-walled, smooth, blackish brown, not bleaching in concentrated  $\text{H}_2\text{SO}_4$ . Basidia 20.4–34×10–13.6  $\mu\text{m}$ , clavate, 2-, 3-, 4-spored, thin-walled, hyaline; sterigmata 3.4–5  $\mu\text{m}$  long. Gill edges sterile. Cheilocystidia 20.4–29×5–10  $\mu\text{m}$ , abundant, polymorphic, cylindrical, clavate, lageniform or bottle-shaped, some with tapering, wavy, filiform tips, thin-walled, granular. Pleurocystidia absent. Pileus cuticle cellular with scattered pileocystidia; cellular elements 15.3–46×13.6–30.6  $\mu\text{m}$ , subglobose, piriform to clavate, thin-walled, hyaline; pileocystidia 34–56×5.0–12  $\mu\text{m}$ , cylindrical, lageniform or filiform, some with incrustated capitate tips, thin-walled, granular; pileus context made up of interwoven 6.8–22  $\mu\text{m}$  broad hyphae. Hymenophoral trama regular composed of 5–18.7  $\mu\text{m}$  broad hyphae. Subhymenium pseudoparenchymatous. Stipe cuticle with caulocystidia scattered in tufts; caulocystidia 17–48×6–10  $\mu\text{m}$ , cylindrical, clavate or lageniform, thin-walled, hyaline; context hyphae 6.8–20.4  $\mu\text{m}$  broad, longitudinally running, cylindrical, thin-walled, hyaline. Clamp connections present in the stipe context hyphae.

**Material examined.** India, Punjab, Moga, Chak Fatehpur, 217 m asl., scattered or in caespitose groups on buffalo dung, 28 June 2011, Amandeep Kaur, PUN 4359.

**Discussion.** *Panaeolus alcidis* is recognized by the absence of annulus, non-appendiculate pileal margin and the large sized ellipsoidal basidiospores.

Moser (1984) reported the species growing on moose dung from Sweden, Saskatchewan and Canada and on roe deer and reindeer droppings from Sweden. It has also been reported growing on cattle dung from Italy (Doveri 2010). It is a new record for India.

***Panaeolus subbalteatus*** (Berk. & Br.) Sacc. in Syll. Fung. 5: 1124, 1887. Figures 16 and 17.

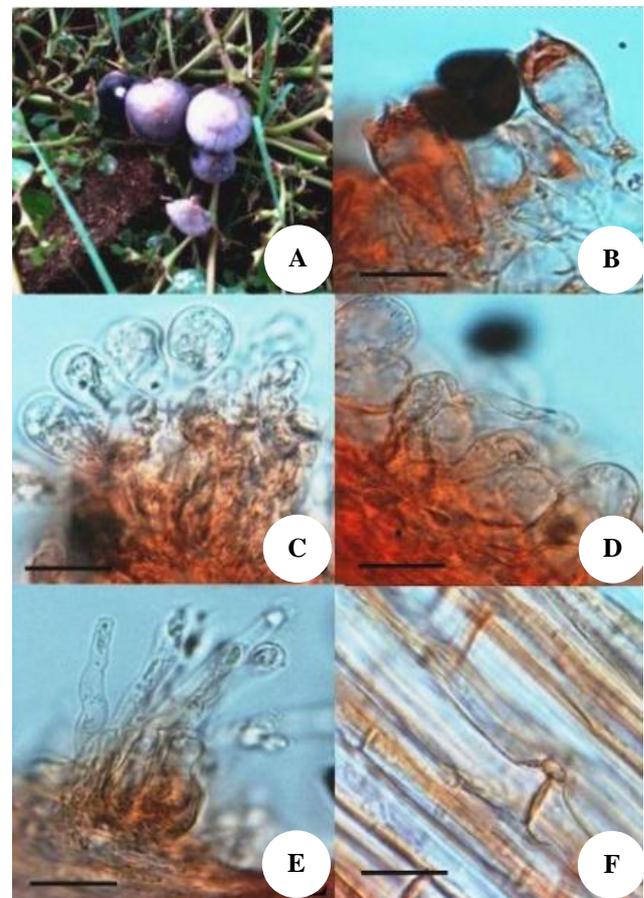
**Basionym.** *Agaricus subbalteatus* Berk. & Br. in Ann. Mag. Nat. Hist. 7: 378, 1861.

Carpophores 5.7–12.8 cm in height; Pileus 1.8–3.2 cm broad, 1.2–1.5 cm high, conico-convex to convex; umbonate, umbo broad, brown; surface pale to reddish gray (12E<sub>2</sub>) when young, bluish gray (21F<sub>3</sub>) at maturity, finally reddish gray (12E<sub>2</sub>) with bluish gray (21F<sub>3</sub>) marginal band, smooth; pileal veil absent; margin regular, not splitting at maturity, non-striate; flesh thin, unchanging, non-deliquescent; cuticle half-peeling to fully peeling; taste and odor mild. Lamellae adnexed to adnate, unequal, 3-sized, subdistant, ventricose, moderately broad to broad (0.3–0.5 cm), fragile, grayish black; gill edges smooth. Spore print grayish black. Stipe central, 5.5–12.7 cm long, 0.2–0.4 cm broad, tubular, equal, with slightly bulbous base, solid, surface reddish gray (12E<sub>2</sub>) changing to reddish brown after bruising, solid, sometimes twisted, pruinose; annulus absent.

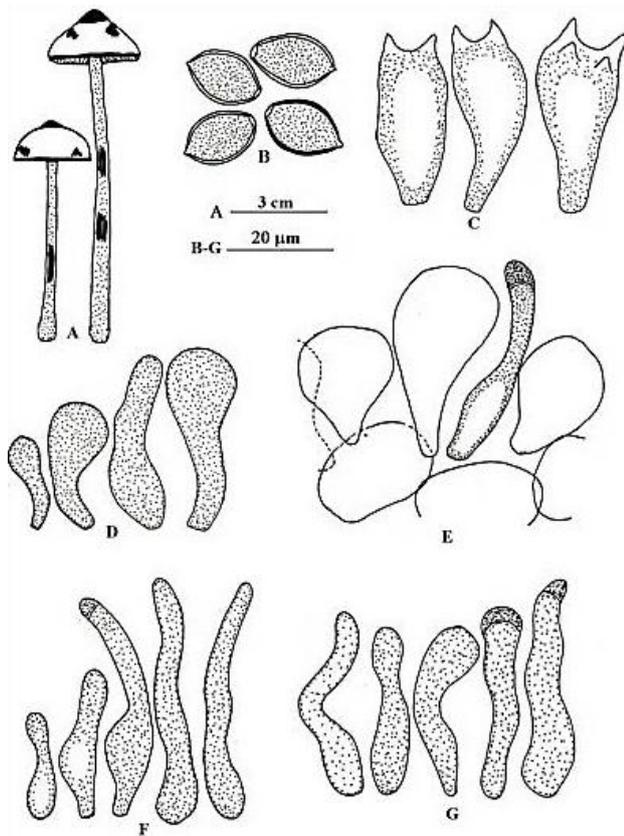
Basidiospores 11.8–14.4 (15.3)×7–9.3 (10)  $\mu\text{m}$  ( $Q = 1.6$ ), lenticular, limoniform in face view, elongated ellipsoidal in side view, with truncate germ pore, thick-walled, smooth, reddish brown to blackish brown. Basidia 14–35.7×7–15.4  $\mu\text{m}$ , clavate, 2- and 4-spored, thin walled, granular, sterigmata 2–3.5  $\mu\text{m}$  long. Gill edges sterile.

Cheilocystidia 14–39×4–14.5  $\mu\text{m}$ , crowded, lageniform, cylindrico-clavate or clavate, with round apex, thin-walled, hyaline to granular. Pleurocystidia absent. Pileus cuticle cellular with scattered pileocystidia; cellular elements 17–37.4×12–25.5  $\mu\text{m}$ , ovoid, piriform or pedicellate clavate, thin walled, hyaline; pileocystidia 17–49×3–10  $\mu\text{m}$ , polymorphic, wavy, filamentous, cylindrical, lageniform or ventricose-fusoid, thin walled, granular, some with densely granular tips; pileus context hyphae thin walled, hyaline, 4–13.6  $\mu\text{m}$  broad. Hymenophoral trama regular composed of parallel, thin-walled, hyaline 5–15.3  $\mu\text{m}$  broad hyphae. Subhymenium pseudoparenchymatous. Stipe cuticle with caulocystidia present in groups; context hyphae parallel, cylindrical, thin-walled, hyaline 5–18.7  $\mu\text{m}$  broad; caulocystidia 18.7–68×3.5–14  $\mu\text{m}$ , similar in shape like pileocystidia. Clamp connections present throughout.

**Materials examined.** India, Punjab, Barnala, Wazeedake, 228 m asl., in groups on buffalo dung among grasses, 31 July 2009, Amandeep Kaur, PUN 4228; Bathinda, Nandgarh, 211 m asl., scattered on buffalo dung, 01 August 2009, Amandeep Kaur, PUN 4227; Ropar, Padiala, 394 m asl., in groups on a mixed cattle dung heap, 21 August 2009, Amandeep Kaur, PUN 4229; Ropar, Kiratpur Sahib, 394 m asl., in groups on mixed cattle dung, 13 July 2012, Harwinder Kaur, PUN 4770.



**Figure 16.** *Panaeolus subbalteatus*. A. Carpophores growing in a natural habitat; B. Basidia; C. Cheilocystidia; D. Pileus cuticle elements; E. Caulocystidia; F. Clamp connection in stipe context. Bars B-F = 10  $\mu\text{m}$ .



**Figure 17.** *Panaeolus subbalteatus*. A. Carpophores; B. Basidiospores; C. Basidia; D. Cheilocystidia; E. Pileus cuticle; F. Pileocystidia; G. Caulocystidia.

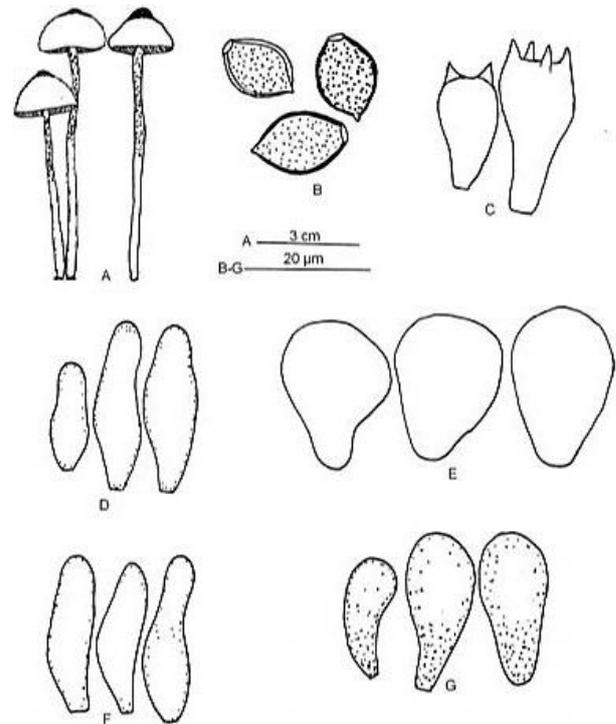
**Discussion.** The macroscopic and microscopic details of the above examined collections are in conformity with *P. subbalteatus* (Watling and Gregory 1987; Stamets 1996). It is characterized by conico-convex to convex, broadly umbonate, reddish gray pileus with a darker band along the margin and stipe bruising reddish brown. *Panaeolus acuminatus* is quite close to this species but differs by narrow stipe (less than 0.3 cm broad) and lacking belted pileal margin (Watling and Gregory 1987). In the literature it is reported to be a psilocybin mushroom (Guzmán et al. 1976; Arora 1986; Stamets 1996).

It is cosmopolitan in distribution and seen on a wide variety of habitats (Allen 1994; Watling and Gregory 1987; Stamets 1996; Doveri 2010; Natarajan and Raaman 1983; Abraham 1991). The species is being reported for the first time from Punjab.

*Panaeolus acuminatus* (Schaeff.) Quél. in Mém. Soc. Émul. Montbéliard 5: 257, 1872. Figure 18.

**Basionym.** *Agaricus acuminatus* Schaeff. in Fung. Bavar. Palat. Nasc. 4: 44, 1774.

**Synonyms.** *Agaricus carbonarius* Batsch in Elench. Fung. p. 69, 1783. *Coprinarium acuminatus* (Schaeff.) P. Kumm. in Der Führer in die Pilzkunde p. 69, 1871. *Chalymnota carbonaria* (Fr.) P. Karst. 1879. *Dryophila carbonaria* (Fr.) Quél. in Enchir. Fung. p. 70, 1886.



**Figure 18.** *Panaeolus acuminatus*. A. Carpophores; B. Basidiospores; C. Basidia; D. Cheilocystidia; E. Pileus cuticle elements; F. Pileocystidia; G. Caulocystidia.

Carpophores 6.3–7.8 cm in height. Pileus 1.7–2 cm broad, 0.9–1.2 cm high, campanulate to broadly conical; umbonate, umbo round, dark brown (8F<sub>7</sub>); surface dark reddish brown (8E<sub>8</sub>), hygrophanous, fading to grayish brown (6E<sub>3</sub>) after some time, smooth; pileal veil absent; margin regular, not splitting at maturity, non-striate; cuticle half-peeling; flesh thin, 0.1 cm thick, pale white, unchanging, non-deliquestent; taste and odor mild. Lamellae adnexed, unequal, 3-sized, subdistant, moderately broad (up to 0.35 cm), fragile, grayish-black; gill edges smooth. Stipe 6.2–7.5 cm long, 0.2 cm broad, tubular, solid, surface reddish brown (8E<sub>8</sub>), unchanging, pruinose near the apex, smooth below, exannulate.

Basidiospores 11.4–15×7.8–11 μm (Q = 1.4), lenticular, limoniform in face view, ellipsoidal in side view, slightly angular in the centre, truncated with a central germ pore, thick-walled, smooth, reddish brown in water, blackish brown in KOH (10%), not bleaching in concentrated H<sub>2</sub>SO<sub>4</sub>. Basidia 17–25.5×8.5–11.5 μm, clavate, 2-, 4-spored, thin-walled, hyaline; sterigmata 2.8–4.3 μm long. Gill edges sterile. Cheilocystidia 15.5–25.5×5.5–8.5 μm, abundant, polymorphic, cylindrical, clavate or sublageniform, thin-walled, hyaline. Pleurocystidia absent. Pileus cuticle a cellular epithelium with scattered pileocystidia; cells 13–24×13–17 μm, clavate or piriform, thin-walled, hyaline; pileocystidia 21–25.5×6.5–8.5 μm, cylindrical or sub-lageniform, thin-walled, hyaline; pileus context made up of interwoven 6–21 μm broad hyphae. Hymenophoral trama regular composed of thin-walled hyphae measuring 4.5–18.5 μm in width. Subhymenium pseudoparenchymatous. Stipe cuticle with caulocystidia

scattered in tufts; context hyphae longitudinally running, cylindrical, thin-walled, hyaline, 4.3–28.3  $\mu\text{m}$  broad; caulocystidia 17–24 $\times$ 7–11.4  $\mu\text{m}$ , cylindrical to inflated clavate, thin-walled, granular, densely granular towards the base. Clamp connections present in the stipe context.

**Material examined.** India, Punjab, Bathinda, Lehra Mohabbat, 211 m asl., gregarious on mixed cattle dung in a pasture, 02 August 2009, Amandeep Kaur, PUN 4030.

**Discussion.** The above collection matches well with the description of *P. acuminatus* which is characterized by campanulate, reddish brown pileus and nipped apex (Pegler 1977; Watling and Gregory 1987). Pegler (1977) reported it from Uganda, Tanzania; Watling and Gregory (1987) from Britain; Stamets (1996) from North America and Europe and Doveri (2010) from Italy. This species has been reported growing scattered on elephant dung from Kerala in South India by Vrinda et al. (1999). It is the first time record from North India.

*Panaeolus sphinctrinus* (Fr.) Quél. in Mém. Soc. Émul. Montbéliard 5: 151, 1872. Figures 19 and 20

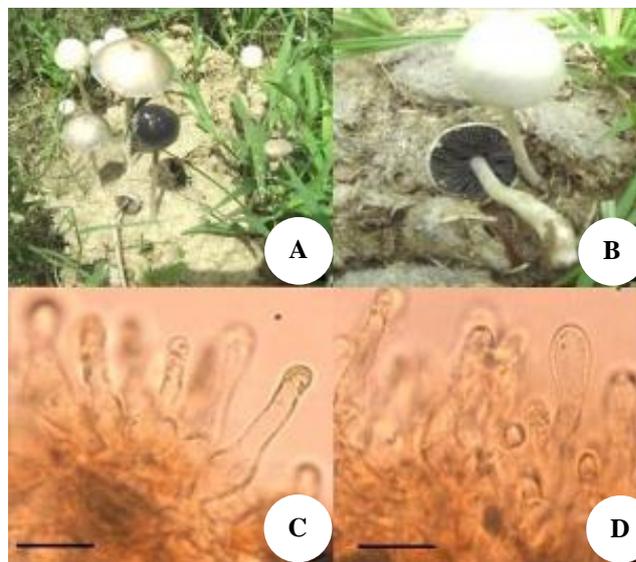
**Basionym.** *Agaricus sphinctrinus* Fr. in Epicr. Syst. Mycol. 235-236, 1838.

**Synonyms.** *Coprinarius campanulatus* var. *sphinctrinus* (Fr.) Quél. in Enchir. Fung. p. 119, 1886. *Panaeolus campanulatus* var. *sphinctrinus* (Fr.) Quél. in Fl. Mycol. France p. 54, 1888.

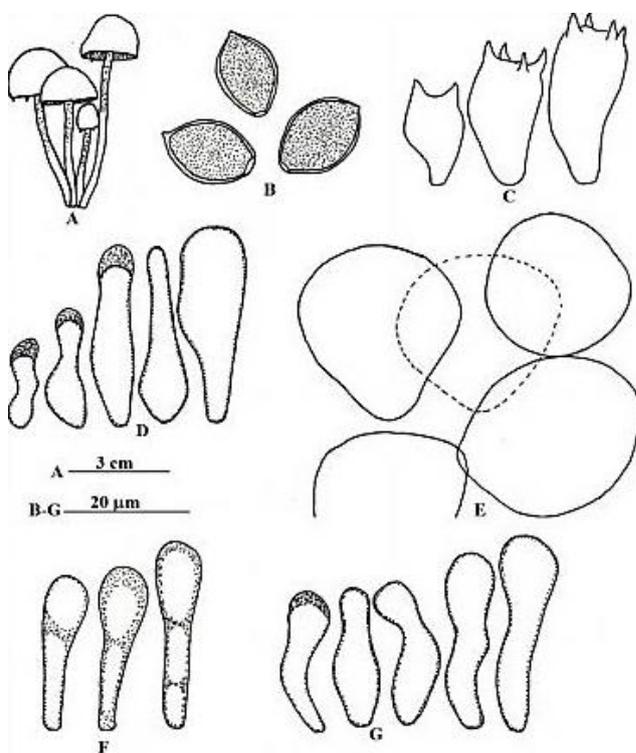
Carpophores 4.5–14.5 cm in height. Pileus 1.7–2.7 cm broad and 0.7–1.5 cm high, obtusely campanulate when young, convex to hemispherical at maturity; surface dry, delicate, buff colored with mouse gray (5E<sub>3</sub>) to bluish gray (21D<sub>2</sub>) shades; pileal veil in the form of whitish, overhanging fibrils along the margin; margin regular, splitting at maturity, non-striate, appendiculate; cuticle fully peeling; flesh thin, slightly deliquescent at maturity; taste mild; odor farinaceous. Lamellae adnexed to broadly adnate, wedge shaped, unequal, 3–sized, subdistant, moderately broad, up to 0.5 cm broad, fragile, grayish-black. Spore print black. Stipe 4.3–14.2 cm long, 0.4–0.6 cm broad, tubular, solid, surface buff to dark smoky gray, pruinose fibrillose; exannulate.

Basidiospores 13–17 $\times$ 8.5–11.5  $\mu\text{m}$  (Q = 1.5), lenticular, limoniform in face view, elongate-ellipsoidal in side view, truncated with a central germ pore, thick-walled, smooth, grayish brown in water, blackish brown in KOH, not bleaching in concentrated H<sub>2</sub>SO<sub>4</sub>. Basidia 14–25.5 $\times$ 10–13  $\mu\text{m}$ , inflated clavate, 2-, 4-spored, thin-walled, hyaline; sterigmata short, 1.4–4.3  $\mu\text{m}$  long. Gill edges sterile. Cheilocystidia 14–33 $\times$ 2.8–13  $\mu\text{m}$ , polymorphic, vesiculose, inflated clavate or lageniform, some with subcapitate apex, thin-walled, hyaline. Pleurocystidia absent. Pileus cuticle two to three layered cellular epithelium with scattered pileocystidia; cellular elements 13–28 $\times$ 11.5–24  $\mu\text{m}$ , globose, subglobose to piriform, thin-walled, hyaline; pileocystidia 22.7–30 $\times$ 6.5–8.5  $\mu\text{m}$ , clavate to elongated cylindrical with rounded apex, thin-walled, hyaline; pileus context homoiomerous, made up of interwoven, thin-walled 2.8–28.4  $\mu\text{m}$  broad hyphae. Hymenophoral trama regular, composed of thin-walled, hyaline 6–25.5  $\mu\text{m}$  broad hyphae. Subhymenium

pseudoparenchymatous. Stipe cuticle hyphal with caulocystidia present in tufts; context hyphae lie parallel, thin-walled, hyaline 4.5–25.4  $\mu\text{m}$  broad; caulocystidia 21–31 $\times$ 6–8.5  $\mu\text{m}$ , fusoid to clavate, some with subcapitate apex, thin-walled, hyaline. Clamp connections present throughout.



**Figure 19.** *Panaeolus sphinctrinus*. A. Carpophores growing in natural habitat; B. Carpophores showing appendiculate pileal veil and grayish-black lamellae; C. Gill edge showing cheilocystidia; D. Caulocystidia. Bars C-D = 10  $\mu\text{m}$ .



**Figure 20.** *Panaeolus sphinctrinus*. A. Carpophores; B. Basidiospores; C. Basidia; D. Cheilocystidia; E. Pileal elements; F. Pleurocystidia; G. Caulocystidia.

**Materials examined.** India, Punjab, Hoshiarpur, Mahilpur, 295 m asl., gregarious on horse dung in a pasture, 18 July 2008, Munruchi Kaur and Amandeep Kaur, PUN 4224; Bathinda, Lehra Mohabbat, 211 m asl., gregarious in caespitose groups on cow dung, 2 August 2009, Amandeep Kaur and Harwinder Kaur, PUN 4029.

**Discussion.** *Panaeolus sphinctrinus* is characterized by smooth pileus with mouse gray shades and appendiculate margin of white partial veil fragments. *Panaeolus campanulatus* is a close species which can be differentiated by the brick red to reddish brown pileus and smaller spores. *P. papilionaceus* differs by whitish or buff pileus which is frequently cracked and stipe with pinkish shades towards the base (Watling and Gregory 1987).

*Panaeolus sphinctrinus* is found throughout the world and is widely distributed in North America, South America, Europe, Iceland, North Africa, Canary Islands, Israel, Siberia, Japan (Dennis 1986). Pegler (1977) reported it from Kenya and Tanzania. Watling and Gregory (1987) reported the species growing on dung of horse, cow and sheep in fields and hill pastures from British Isles. Natarajan and Raaman (1983) reported it growing solitary on ground in the month of August from Tamil Nadu, India. The species is being documented here for the first time from North India.

***Panaeolus papilionaceus* var. *parvisporus*** Ew. Gerhardt in Biblioth. Bot. 147: 58, 1996. Figures 21 and 22.

Carpophores 5.3–9.3 cm in height. Pileus 1.5–2.2 cm broad, 1–1.3 cm high, campanulate to convex; surface yellowish white to grayish white, sometimes with grayish black shades, smooth, delicate; pileal veil absent; margin regular, splitting at maturity, non-striate, non-appendiculate; cuticle fully peeling; flesh thin, unchanging, non-deliquescent; taste and odor not distinctive. Lamellae adnate, unequal, 3-sized, subdistant, moderately broad, up to 0.5 cm broad, fragile, grayish-black. Spore print black. Stipe central, 5.2–9 cm long, 0.2–0.3 cm broad, tubular, solid, surface yellowish white, bruising pinkish brown, pruinose, exannulate.

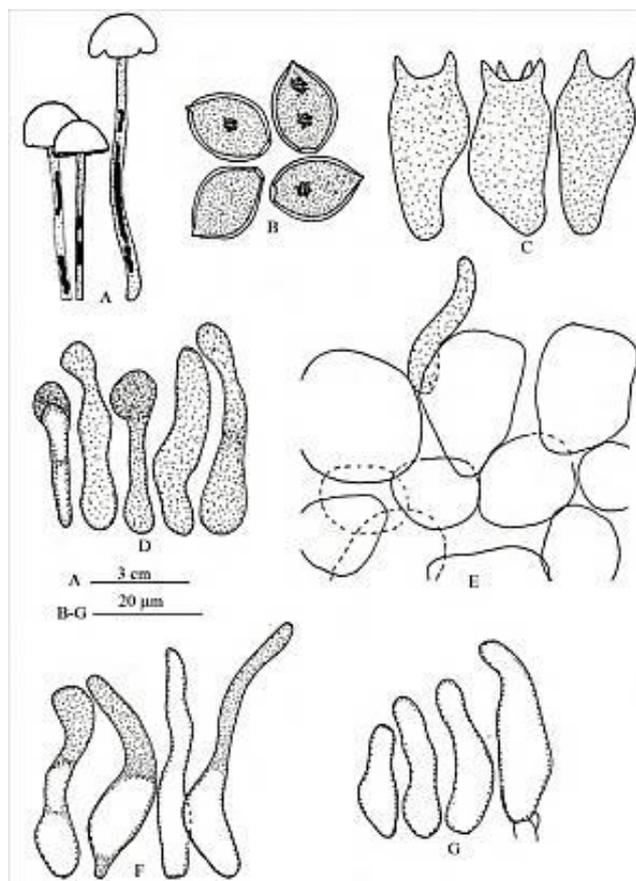
Basidiospores 13.6–17×8.5–12 (12.7)  $\mu\text{m}$  (Q = 1.5), lenticular, limoniform in face view, ellipsoidal in side view, with broader centre, acute base and a broad germ pore, thick-walled, smooth, blackish brown, not bleaching in concentrated  $\text{H}_2\text{SO}_4$ . Basidia 18.7–32.3×12–15.3  $\mu\text{m}$ , clavate, 2-, 4-spored, thin-walled, granular; sterigmata 4.3–6.8  $\mu\text{m}$  long. Gill edges sterile. Cheilocystidia 25.5–44×5–10  $\mu\text{m}$ , abundant, polymorphic, clavate, cylindrical, lageniform to even flask-shaped, some with subcapitate apex, thin-walled, granular throughout, some densely granular at the apices. Pleurocystidia absent. Pileus cuticle a cellular epithelium with scattered pileocystidia; cellular elements 15.3–29×17–25.5  $\mu\text{m}$ , subglobose, ovoid or clavate, non-pedicellate, thin-walled, hyaline; pileocystidia 30.5–54.5×5–13.5  $\mu\text{m}$ , polymorphic, cylindrical, lageniform or ventricose-fusoid, some with subcapitate apex, thin-walled, granular, sometimes with golden contents; pileus context homoiomerous, made up of thin-walled, hyaline 8.5–17  $\mu\text{m}$  broad hyphae. Subhymenium pseudoparenchymatous. Stipe cuticle with caulocystidia

scattered on the surface; context hyphae longitudinally running, cylindrical, thin-walled, hyaline 5–18.7  $\mu\text{m}$  broad; caulocystidia 20.4–42.4×5–10  $\mu\text{m}$ , cylindrical or lageniform, thin-walled, hyaline. Clamp connections present throughout.

**Material examined.** India, Punjab, Sangrur, Dugni, 231 m asl., in groups on buffalo dung among grasses along roadside, 27 June 2011, Amandeep Kaur, PUN 4360.



**Figure 21.** *Panaeolus papilionaceus* var. *parvisporus*. A. Carpophores growing in natural habitat; B. Carpophores showing stipe bruising pinkish brown.



**Figure 22.** *Panaeolus papilionaceus* var. *parvisporus*. A. Carpophores; B. Basidiospores; C. Basidia; D. Cheilocystidia; E. Pileus cuticle elements; F. Pileocystidia; G. Caulocystidia.

**Discussion.** The present collection agrees well with the description by Kuo (2007). The species is distinct by campanulate to convex yellowish white to grayish white pileus, stipe bruising pinkish brown, large basidiospores, presence of pileocystidia, and caulocystidia. *Panaeolus papilionaceus* var. *papilionaceus* differs in having appendiculate pileal margin with remnants of the partial veil. It forms a new record for India.

***Panaeolus speciosus* var. *pilocystidiosus*** Amandeep Kaur, NS Atri & Munruchi Kaur in *Mycosphere* 4 (3): 622, 2013.

**Material examined.** India, Punjab, Barnala, Rarh, 228 m asl., scattered on cattle dung, Amandeep Kaur, PUN 4081, June 26, 2008.

**Discussion.** *Panaeolus speciosus* var. *pilocystidiosus* differs by basidiospores 12.8–15.5×8.5–10 µm in size (Kaur et al. 2013) as compared to 14–20×10–12×8–10 µm in *P. speciosus* (Watling and Gregory 1987). Also the clamp connections are altogether absent while pileocystidia are found present on the pileus cuticle in this variety. The clamp connections are reported to be present while pileocystidia are reported to be absent in *P. speciosus* (Watling and Gregory 1987). Kaur et al. (2013) documented this taxon for the first time from coprophilous habitats of India.

### Remarks

During the study, forty four collections of *Panaeolus* have been critically analyzed and identified to sixteen species. It is inferred that the genus is widely distributed and occurs in a wide variety of dung types. The different dung habitats in the central, north-east and south-west regions of Punjab state in India explored during the present investigation and observed that coprophilous *Panaeolus* were quite frequent in all areas and in all major seasons of the year. The frequency of species found in each season varies and majority (10 species) is encountered during monsoon months, three were collected during summer and two were fruited during both seasons. *Panaeolus cyanescens* was the only species found throughout the year.

Regarding their preference on the type of herbivorous dung, as many as seven different types of dung substrates were identified. It includes mixed, buffalo, cow, horse, elephant and rabbit and some are also fruited on manured soil. Majority of species found exclusively on mixed dung while *Panaeolus ater*, *P. castaneifolius* and *P. subbalteatus* were found growing on both mixed and buffalo dung. *Panaeolus alcidis* and *P. papilionaceus* var. *parvisporus* were encountered only on buffalo dung. *Panaeolus solidipes* was found growing on horse dung and *Panaeolus lepus-stercus* was documented on rabbit dung. However, *Panaeolus cyanescens* was found on a variety of dung and manured soil habitats and have no preference for any particular type of dung.

The growth habits vary from solitary, scattered, gregarious to caespitose groups. Majority of species (7 species) found either scattered or in small groups. *Panaeolus tropicalis* and *P. castaneifolius* were observed growing solitary to scattered. *Panaeolus solidipes*, *P. antillarum* and *P. africanus* var. *diversistipus* were

observed in solitary manner. *Panaeolus acuminatus* and *P. sphinctrinus* were found in gregarious manner. *Panaeolus alcidis* was found in caespitose clusters. *Panaeolus cyanescens* were found in solitary, scattered, gregarious and caespitose clusters manner. The study reveals that dung is an important substrate which serves as a favorable niche for the growth of *Panaeolus* mushrooms in the state of Punjab. Proper management of livestock and pastures are important in the conservation of coprophilous mushrooms of Punjab.

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