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Two new species of *Panaeolus* (Psathyrellaceae, Agaricales) from coprophilous habitats of Punjab, India

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ABSTRACT

Two new coprophilous species of *Panaeolus*, namely *P. cyanoannulatus* and *P. lepus–stercus*, of family *Psathyrellaceae* are described from Punjab, India. *Panaeolus cyanoannulatus* was collected on a mixed cow and horse dung heap from Hoshiarpur district and *P. lepus–stercus* was located growing scattered on rabbit pellets from Pathankot district of Punjab state in India. *Panaeolus cyanoannulatus* is a blue staining mushroom with annulate stipe while *P. lepus–stercus* is characterized by yellowish gray umbonate pileus, 2– and 4–spored basidia, limoniform hexagonal basidiospores, polymorphic chrysocystidia and absence of pileocystidia and clamp connections. In this paper, these two taxa are described, illustrated, and compared with similar species.

Key Words: Agaricomycetes, Basidiomycota, blue staining, mushrooms, taxonomy.

INTRODUCTION

The genus *Panaeolus* (Fr.) Quél. is represented by 15 species the world over (Kirk *et al.* 2008). However, MycoBank mentions 150 legitimate records of *Panaeolus*. The genus is characterized by carpophores which are often bluing when bruised or with age; adnexed to adnate, variegated, grayish–black lamellae; epithelial pileus cuticle and reddish brown to blackish brown spores which do not fade in concentrated sulphuric acid.

From India 24 taxa are already known (Bose 1920, Pathak & Ghosh 1962, Ghosh *et al.* 1967, Sathe & Sasangan 1977, Sarbhoy & Daniel 1981, Natarajan & Raaman 1983, 1984, 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, Amandeep *et al.* 2013). Based on the survey conducted to various dung localities of Punjab, collections assigned to *P. cyanoannulatus* and *P. lepus–stercus* were collected and described as new species.

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MATERIAL AND METHODS

The materials were collected from dung localities in Punjab. The macroscopic characters pertaining to gross morphology, shape, color and size of pileus, stipe, etc. were noted down from the fresh material on the field key especially designed for the purpose (Atri *et al.* 2005). The color terminology used is that of Kornerup & Wanscher (1978). The specimens were hot air dried and packed in cellophane paper bags containing 1–4 dichlorobenzene. The microscopic structures were observed by cutting free hand sections after reviving a part of the dried materials in 10% KOH solution and staining the sections in 0.16% Cotton blue. Line drawings of microscopic details were drawn with the aid of Camera lucida under oil immersion lens. The collections have been deposited in the Herbarium of Botany Department, Punjabi University, Patiala (Punjab), India under PUN (Holmgren & Keuken 1974). The photographs and microscopic details are given in Figs. 1– 2 for *P. cyanoannulatus* and Figs. 3–4 for *P. lepus–stercus.*

TAXONOMIC DESCRIPTIONS

Panaeolus cyanoannulatus Atri, M. Kaur & A. Kaur, sp. nov. **gs. 1–2**

MycoBank no.: MB 805219.

Etymology: The name of the species is based on the development of blue stains on bruising and annulate stipe character.

Diagnosis: It is a typical blue staining species with prominently annulate stipe. It differs from the other *Panaeolus* species in possessing annulate stipe and lacking chrysocystidia within the hymenium.

Carpophores 6.5–7.3 cm in height. Pileus 1.3–1.4 cm broad, 1.3–1.5 cm high, conical with pointed umbo; surface yellowish brown ($5E_8$), staining bluish when bruised, moist, smooth; margin regular, not splitting at maturity, non–striate; cuticle fully–peeling; flesh thin, becoming bluish on exposure; taste and odor mild. Lamellae broadly adnate, unequal, 3–sized, sub–distant, narrow, 0.2–0.25 cm broad, fragile, bluish yellow to bluish brown, finally bluish black; gill edges smooth; spore print black. Stipe 6.4–7.2 cm long, 0.1 cm broad, tubular, equal in diameter throughout, hollow, surface yellowish brown ($5E_8$), bluing when handled, smooth; annulate, annulus single, ring like, membranous, attached near the centre.

Basidiospores 13–15.6 × 7–10 µm (Q = 1.68), elongated ellipsoidal in face view, slightly flattened in side view, with a broad central germ pore, thick–walled, smooth, dark brown, not bleaching in concentrated H_2SO_4. Basidia 14–18.5 × 7–9 µm, cylindrical to clavate, 2–, 4–spored, thin walled, hyaline; sterigmata 2.8–5.7 µm long. Gill edges sterile. Cheilocystidia 14–23 × 2.7–4.3 µm, abundant, cylindrical to clavate, with inflated apex, thin–walled, hyaline, apical region 4.3–7 µm broad. Pleurocystidia absent. Pileus cuticle a four to five layered stratified cellular epithelium with scattered pileocystidia; cellular elements 8.5–17 µm broad, subglobose to globose, thin–walled, hyaline; pileocystidia 34–71 × 5–7.5 µm, polymorphic, cylindrical, lageniform, narrow, wavy, some with subcapitate apex, thin–walled, hyaline; context hyphae interwoven, thin walled, hyaline 6.7–18.7 µm broad. Hymenophoral trama regular composed of thin–walled, 5.7–14 µm broad hyphae. Subhymenium pseudoparenchymatous. Stipe cuticle hyphal; caulocystidia present, similar to cheilocystidia in shape but larger in size measuring 24–45 × 4.4–6.4 µm, arranged in scattered tufts, thin–walled, hyaline, apical region 8–11.4 µm broad; context made up of longitudinally arranged, cylindrical, thin–walled 5.7–17 µm broad hyphae. Clamp connections present in the stipe context hyphae.

Material examined: India, Punjab, Hoshiarpur, Jeewanpur Jattan (295 m), growing in group on mixed cow and horse dung heap in pasture land, 18 July 2008, Amandeep Kaur, PUN 4223 (Holotype).

Remarks: The above examined collection is a blue–staining *Panaeolus* species with well developed annulus on the stipe. It can be distinguished from the other blue–staining allied *Panaeolus* species including *P. cyanescens* (Berk. & Br.) Sacc., *P. tropicalis* Oláh, *P. cambodginiensis* Oláh & R. Heim and *P. subbalteatus* (Berk. & Br.) Sacc. in being annulate. From *P. cyanescens*, it also differs in lacking metulloidal cystidia within the hymenium. In P. *tropicalis*, the spores are 10–12 µm long (Arora 1986) as compared to 13–15.6 µm long in the present collection. Other allied species *P. cambodginiensis* possesses ochre golden brown to pallid straw colored pileus which is often cracked or wrinkled with comparatively smaller spores measuring 10–12.5 × 6.5–9 µm (Stamets 1996). As compared, the presently examined collection has yellowish brown smooth pileus and larger basidiospores. Although *P. subbalteatus* is quite close in spore size (10–14 × 7–9 µm) to the present collection but differs in having exannulate stipe, besides its pileus develops a dark marginal band when it begins to lose moisture and also it occasionally develops a faint blue stain at the base of the stipe (Arora 1986). As compared in the above examined collection the stipe is annulate, the pileus lacks any marginal band and the whole fructification develops bluish tinge when handled. Another species near to the above examined collection is *P. semiovatus* (Fr.) Lundell & Nannf. which also has an annulus, but it has pale cream to pale buff campanulate cap, chrysocystidia within the hymenium and the spores measuring 16–20 × 9–11 µm in size (Watling and Gregory 1987), in comparison to yellowish brown conical umbonate pileus, no chrysocystidia and smaller spores in the presently examined collection. Giving due significance to this blue-staining annulate *Panaeolus*, a new species *P. cyanoannulatus* has been described.

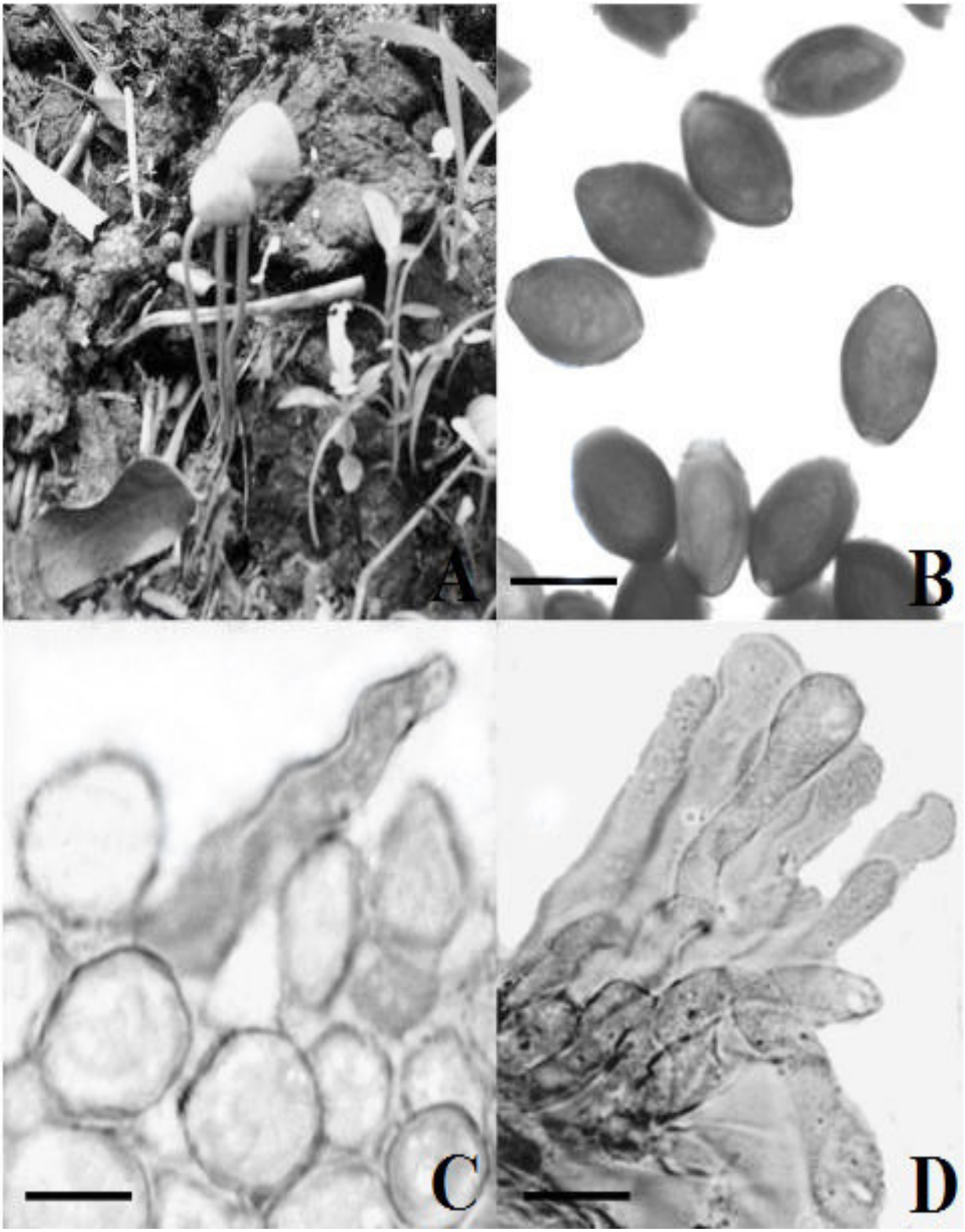

Fig. 1. ***Panaeolus cyanoannulatus***. **A-** Carpophores growing in natural habitat; **B-** Basidiospores; **C-** Pileus cuticle elements; **D-** Caulocystidia. *Scale Bars:* B–D 10 µm.

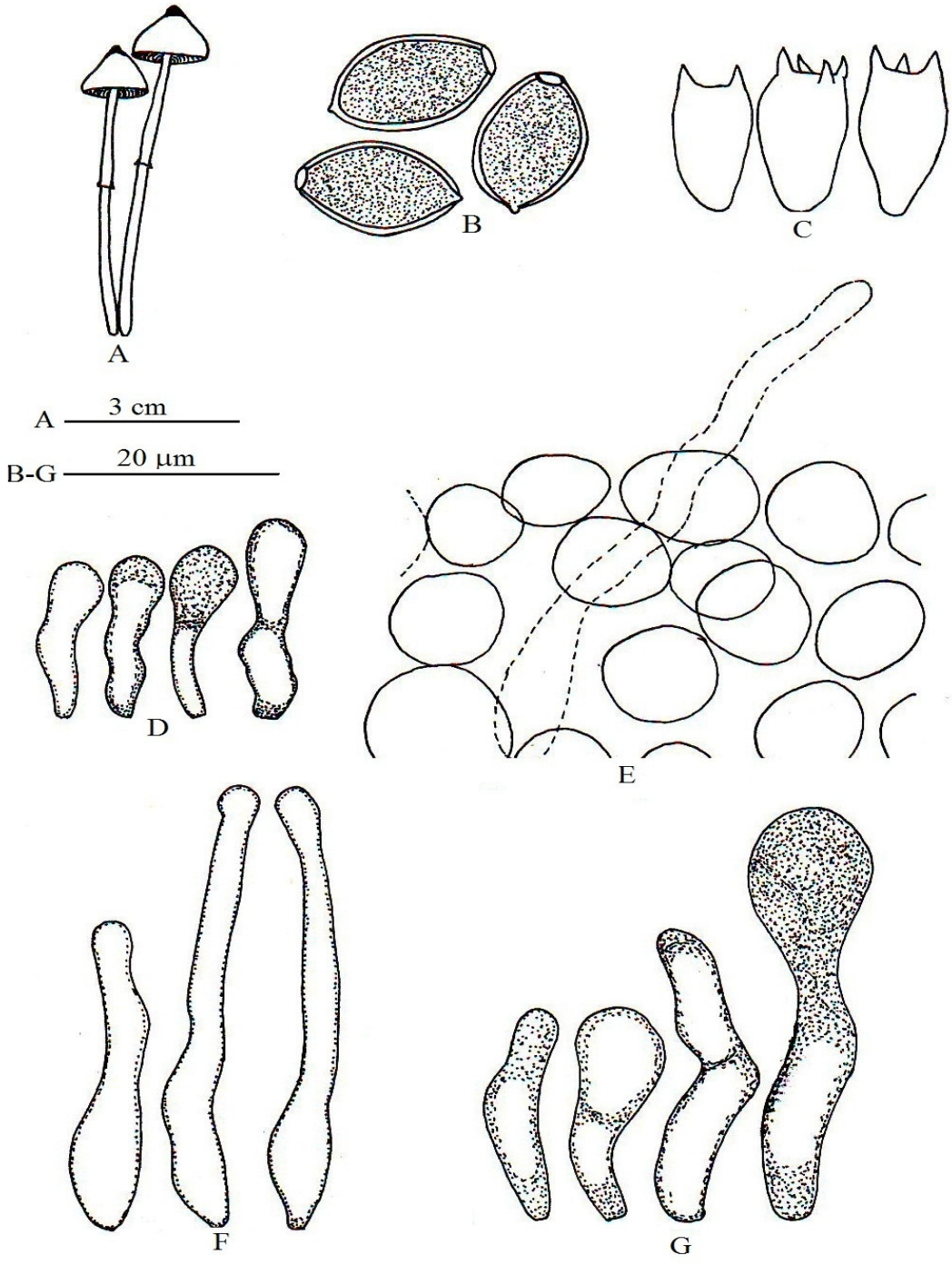

Fig. 2. ***Panaeolus cyanoannulatus***. **A-** Carpophores; **B-** Basidiospores; **C-** Basidia; **D-**Cheilocystidia; **E-** Pileus cuticle elements; **F-** Pileocystidia; **G-** Caulocystidia.

Panaeolus lepus–stercus Atri, M. Kaur & A. Kaur, sp. nov. **Figs. 3–4**

MycoBank no.: MB 805220.

Etymology: The name of the specific epithet has been drawn from the rabbit on whose pellets the fungus was growing.

Diagnosis: Yellowish gray bluing umbonate pileus, 2– and 4–spored (mostly 2–spored) basidia, large sized limoniform–hexagonal basidiospores, polymorphic chrysocystidia, growing habit on rabbit pellets and absence of pileocystidia and clamp connections are principal diagnostic features.

Carpophores 4.4–4.7 cm in height. Pileus 1–1.2 cm broad, 0.8–0.9 cm high, campanulate, umbonate; umbo short, pointed; surface yellowish gray ($2B_2$), bluing when handled, dry, cracked; margin regular, not splitting at maturity, non–striate; cuticle not peeling; flesh thin, yellowish white, unchanging; taste mild, odor not distinctive. Lamellae adnate, unequal, 3–sized, sub–distant, narrow, 0.15–0.2 cm broad, fragile, grayish black; gill edges smooth. Spore print black. Stipe central, 4.3–4.6 cm long, 0.1–0.2 cm broad, tubular, obclavate, solid, surface yellowish gray ($2B_2$), pruinose; annulus absent.

Basidiospores 13.6–17 × 10–12 µm (Q = 1.4), limoniform to hexagonal in face view, ellipsoidal in side view, with a broad central germ pore, thick–walled, smooth, reddish brown, not bleaching in concentrated H_2SO_4. Basidia 23.8–35.8 × 12–13.6 µm, clavate, 2–, 4–spored, mostly 2–spored, thin–walled, granular; sterigmata 3.4–6 µm long. Gill edges sterile. Cheilocystidia 23.8–35.8 × 6.8–12 µm, polymorphic, cylindrical, clavate or lageniform, thin–walled, granular, some with densely granular tips. Pleurocystidia chrysocystidioid, 25.5–53 × 13.5–20.5 µm, polymorphic, ellipsoidal, clavate to ventricose fusoid, thick walled, granular, yellowish brown, some with apical incrustations. Pileus cuticle cellular, cells 17–36 × 15–26 µm, ovoid, subglobose to clavate, thin–walled, hyaline; pileocystidia absent; pileus context hyphae thin walled, hyaline 8.5–15.3 µm broad. Hymenophoral trama regular composed of regular, parallel running, thin–walled, 6.8–17 µm broad hyaline hyphae. Subhymenium pseudoparenchymatous. Stipe cuticle hyphal with scattered caulocystidia; context composed of longitudinally arranged, thin–walled, 8.5–12.7 µm broad hyaline hyphae; caulocystidia 22–43 × 6–15.3 µm, cylindrical or even lageniform, thin–walled, hyaline to granular. Clamp connections absent throughout.

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

Remarks: The above examined collection is characterized by yellowish gray umbonate pileus, bisporic as well as tetrasporic basidia, large limoniform–hexagonal spores, polymorphic chrysocystidia, growth on rabbit pellets and absence of pileocystidia and clamp connections.

The species of *Panaeolus* having chrysocystidia, namely *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. tirunelveliensis* Natarajan & Raaman are quite comparable with the presently examined collection. The spores of this collection (13.6–17 × 10–12 µm) are much bigger in size in comparison to the spores (10–12 × 7–9 µm) of *P. tropicalis* (Stamets 1996). *P. ater* also mainly differs from it in having smaller spores (10–14 × 6–8 µm) with mostly oblique germ pore (Watling and Gregory 1987). Another species *P. rubricaulis* possesses dark brown pileus with white marginal band and appendiculate margin (Pegler 1986). *P. antillarum* can be differentiated from the presently examined collection in having much larger spores (16–20 × 9–12 µm), areolate pileus surface, stipe bruising brown and chrysocystidia with an irregular amorphous refractive body (Watling and Gregory 1987). Another species near to it is *P. cyanescens* which differs in having larger carpophores (5–10 cm long) in comparison to smaller carpophores in this species (4.4–4.7 cm long), exumbonate pileus, presence of pileocystidia and clamp connections, and the absence of caulocystidia (Pegler 1986; Wartchow *et al.* 2010). *P. solidipes* is different in having large sized pure white carpophores, plano–convex pileus, longitudinally twisted stipe and the presence of clamp connections (Arora 1986). Although *P. tirunelveliensis* is quite close to the above examined collection in the absence of pileocystidia and clamp connections, but it has only 2–spored basidia, bluish gray exumbonate pileus and the terrestrial habitat. Also the spores (12.6–14 × 8.4–11.2 µm) and basidia (16.8–22.4 × 7–8.4 µm) of *P. tirunelveliensis* are much smaller in comparison to the spores (13.6–17 × 10–12 µm) and basidia (23.8–35.8 × 12–13.6 µm) in the presently examined collection.

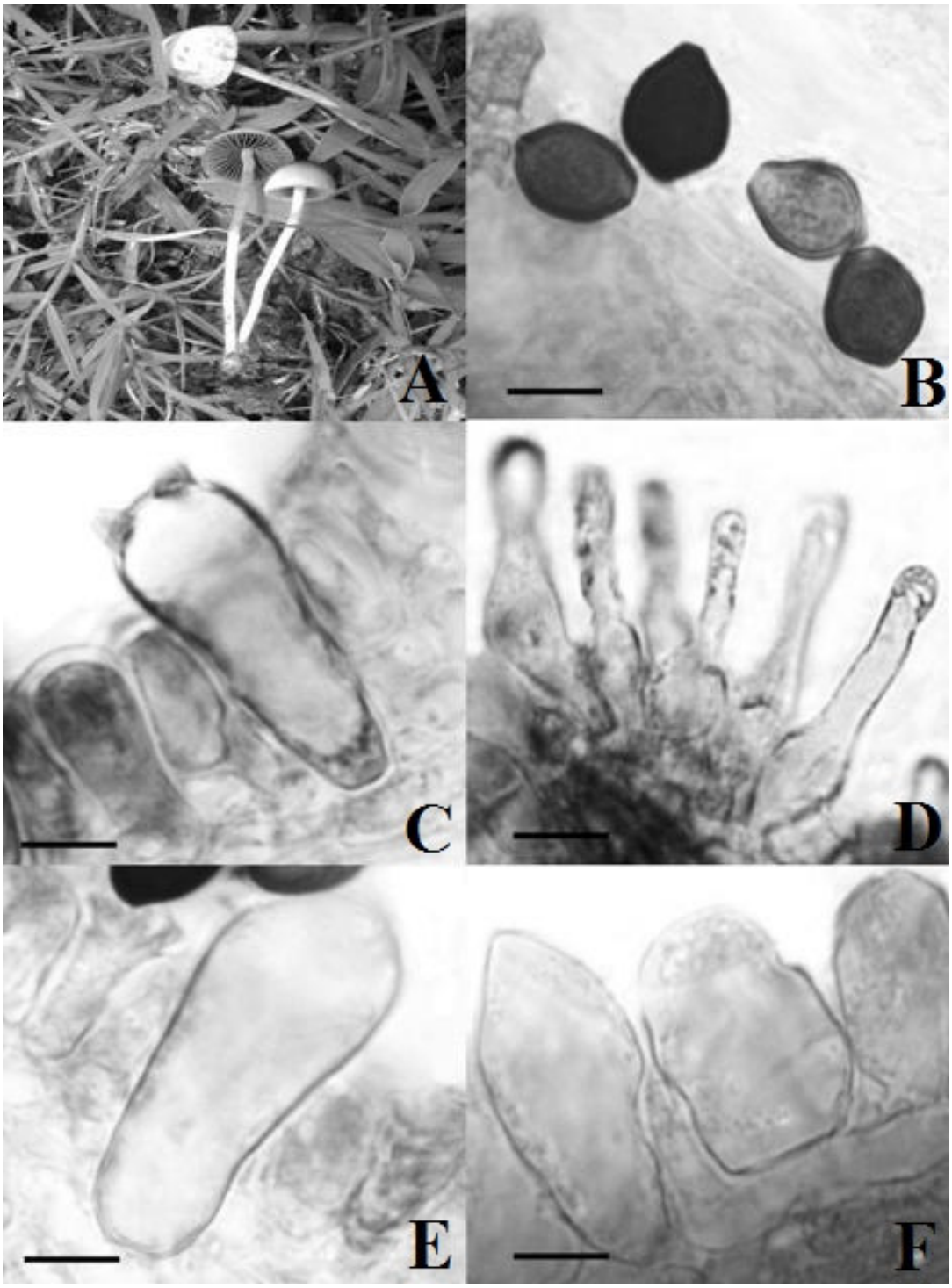

Fig. 3. ***Panaeolus lepus–stercus***. **A-** Carpophores growing in natural habitat; **B-** Basidiospores; **C-** A basidium; **D-** Cheilocystidia; **E-** Chrysocystidium; **F-** Pileal elements. *Scale Bars:* B–F 10 µm.

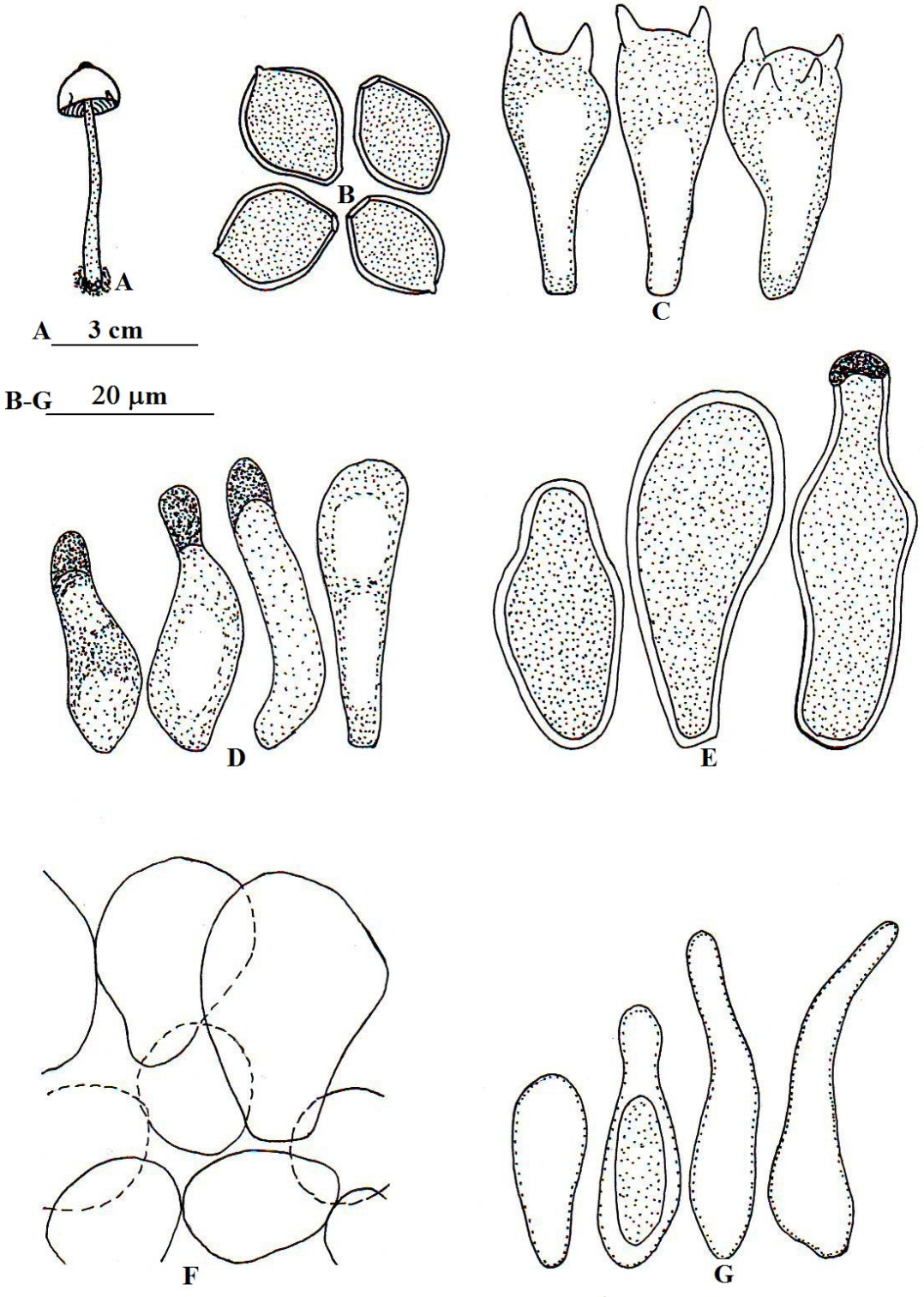

Fig. 4. ***Panaeolus lepus–stercus*. A-** Carpophore; **B-** Basidiospores; **C-** Basidia; **D-** Cheilocystidia; **E-** Chrysocystidia; **F-** Pileus cuticle elements; **G-** Caulocystidia.

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