



## Six new records of genus *Amanita* (Amanitaceae) from Uttarakhand, India

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### Abstract

Macrofungi belong to genus *Amanita* was collected during a fungal foray in temperate to subalpine forests in Uttarakhand Himalaya in monsoon period of 2014–2016. Through critical macro- and microscopical examination of these samples, six species were identified as new records to India. *Amanita caesareoides* (sect. *Caesareae*), *Amanita griseofolia* (sect. *Vaginatae*), *Amanita orientifulva* (sect. *Vaginatae*), *Amanita pallidorosea* (sect. *Phalloideae*), *Amanita parvipantherina* (sect. *Amanita*) and *Amanita princeps* (sect. *Caesareae*) are described here with detailed descriptions and illustrations. All these species were found in mycorrhizal association with different host trees, conifers as well as angiosperms. Apart from this, *Amanita princeps* is found as an edible species in various countries, in addition to this species, *Amanita caesareoides* was also reported to be consumed in temperate to subalpine regions of Uttarakhand Himalaya during this study.

**Key words** – macrofungi – new additions – taxonomy – Western Himalaya

### Introduction

*Amanita* is an important ectomycorrhizal (EcM) genus with a worldwide distribution. Most species in the genus are associated with different trees and shrubs including members of *Betulaceae*, *Dipterocarpaceae*, *Fabaceae*, *Myrtaceae*, *Pinaceae*, and *Salicaceae* (Yang 1997, Thongbai et al. 2016, Tibpromma et al. 2017). It comprises of 540 described and validly published species all over the world and about 50 species are reported from India (Bhatt et al. 2003, Thongbai et al. 2016, Das et al. 2017, Tibpromma et al. 2017). *Amanita* is concisely characterized by bilateral lamellar trama, longitudinally acrophysalidic stipe context, schizohymenial development in their agaric and secotioid species (Tulloss et al. 2016, Tibpromma et al. 2017). The genus is divided into two subgenera: *Amanita* subg. *Amanita* (with nonamyloid spores) consisting of three sections—sect. *A. Amanita*, sect. *A. Caesareae* Singer, *A. sect. Vaginatae* sensu Yang (1997) and subg. *Lepidella* (E. J. Gilbert) Veselý emend. Corner & Bas (with amyloid spores) includes four sections namely, *A. sect. Amidella* (E. J. Gilbert) Konrad & Maubl., *A. sect. Lepidella* sensu Bas (1969), *A. sect. Phalloideae* (Fr.) Quél., and *A. sect. Validae* (Fr.) Quél.

In an attempt of macrofungal exploration in Uttarakhand Himalaya, a large number of *Amanita* specimens were collected. Thorough macro- and micromorphological examination of our collections revealed six new records of *Amanita* for Indian mycobiota namely, *Amanita caesareoides* Lj.N. Vassiljeva., *Amanita griseofolia* Zhu L. Yang, *Amanita orientifulva* Zhu L.

Yang, M. Weiss & Oberw., *Amanita pallidrosea* P. Zhang & Zhu L. Yang, *Amanita parvipantherina* Zhu L. Yang, M. Weiss & Oberw. and *Amanita princeps* Corner & Bas. All the six species are described here in detail with illustrations.

## Materials and methods

### *Morphological study*

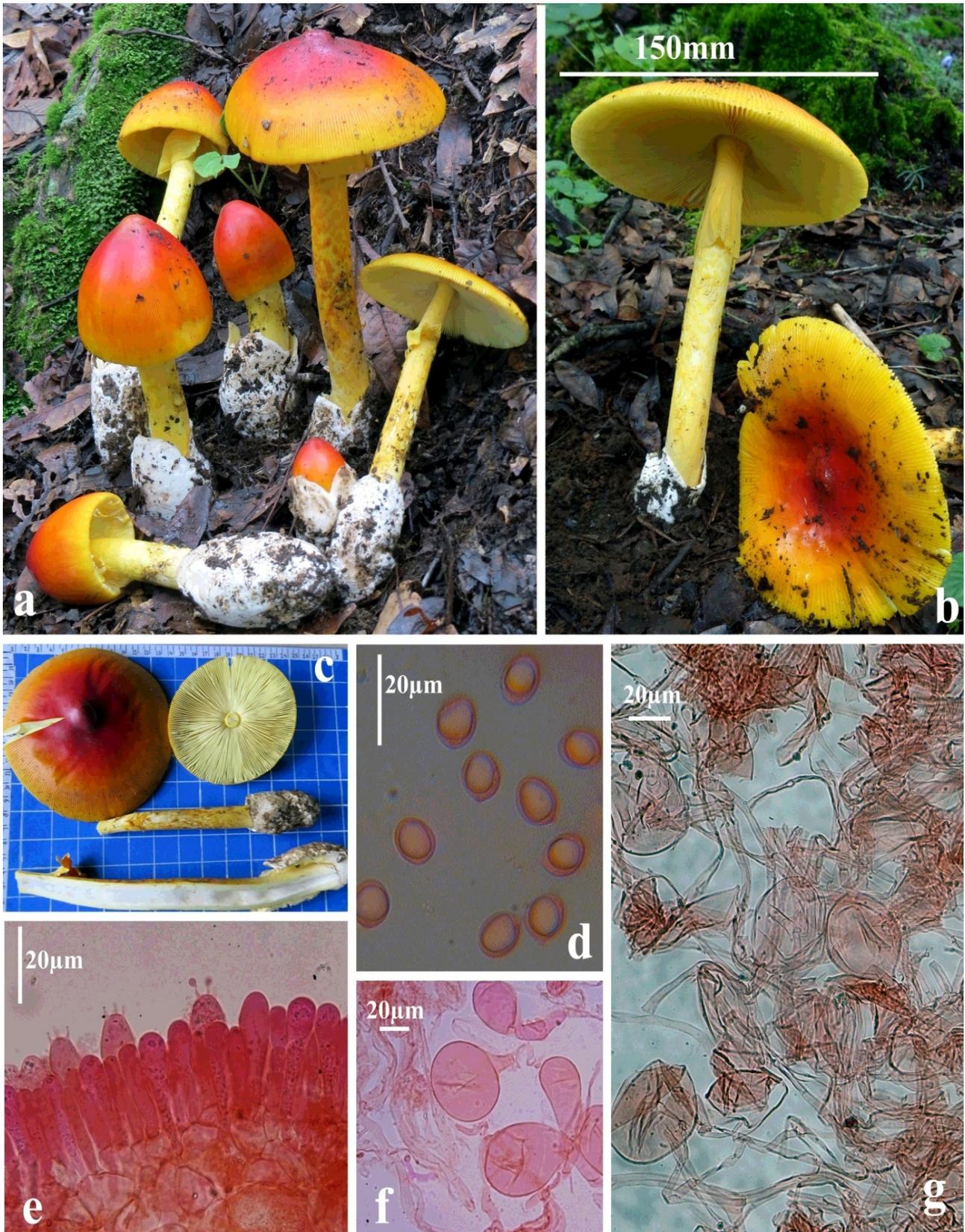
Macromorphological characteristics like shape, size, color, texture, smell, spore print, habit and habitat were documented in the forest or base camp from the fresh and dissected young to mature basidiomata. The photography was accomplished using a digital camera (Sony cyber-shot W730 and Cannon Power Shot SX 50). Color codes and terms mostly follow Methuen Handbook of Colour (Kornerup & Wanscher 1978). Samples were dried with a field drier at (45–55°C). Micromorphological characteristics were observed with the help of a compound microscope (Olympus CH20i) from the dry materials mounted in a mixture of 5% KOH, 1% Phloxin and 1% Congo red. Biometric variables for spores are follow as (Tulloss 2008, Tulloss 2012), i.e. 'L = the average spore length computed for one specimen examined and the range of such averages, L' = the average spore length computed for all spores measured, W = the average spore width computed for one specimen examined and the range of such averages, W' = the average spore length computed for all spores measured, Q = the ratio of length/breadth for a single spore and the range of the ratio of length/ breadth for all spores measured, Q = the average value of Q computed for one specimen examined and the range of such averages; Q' = average value of Q computed for all spores measured'. Drawings of microscopic elements were made with the help of Camera lucida at 2000× magnifications. Microphotography was done with the respective dedicated cameras attached to the compound microscopes: Olympus CH20i and Olympus CX21i LED.

## Results

*Amanita caesareoides* Lj.N. Vassiljeva, Notulae Systematicae e Sectione Cryptogamica Instituti Botanici Nomeine V.L. Komarovii Academiae Scientificaе USSR 6: 199 (1950). Figs 1, 2

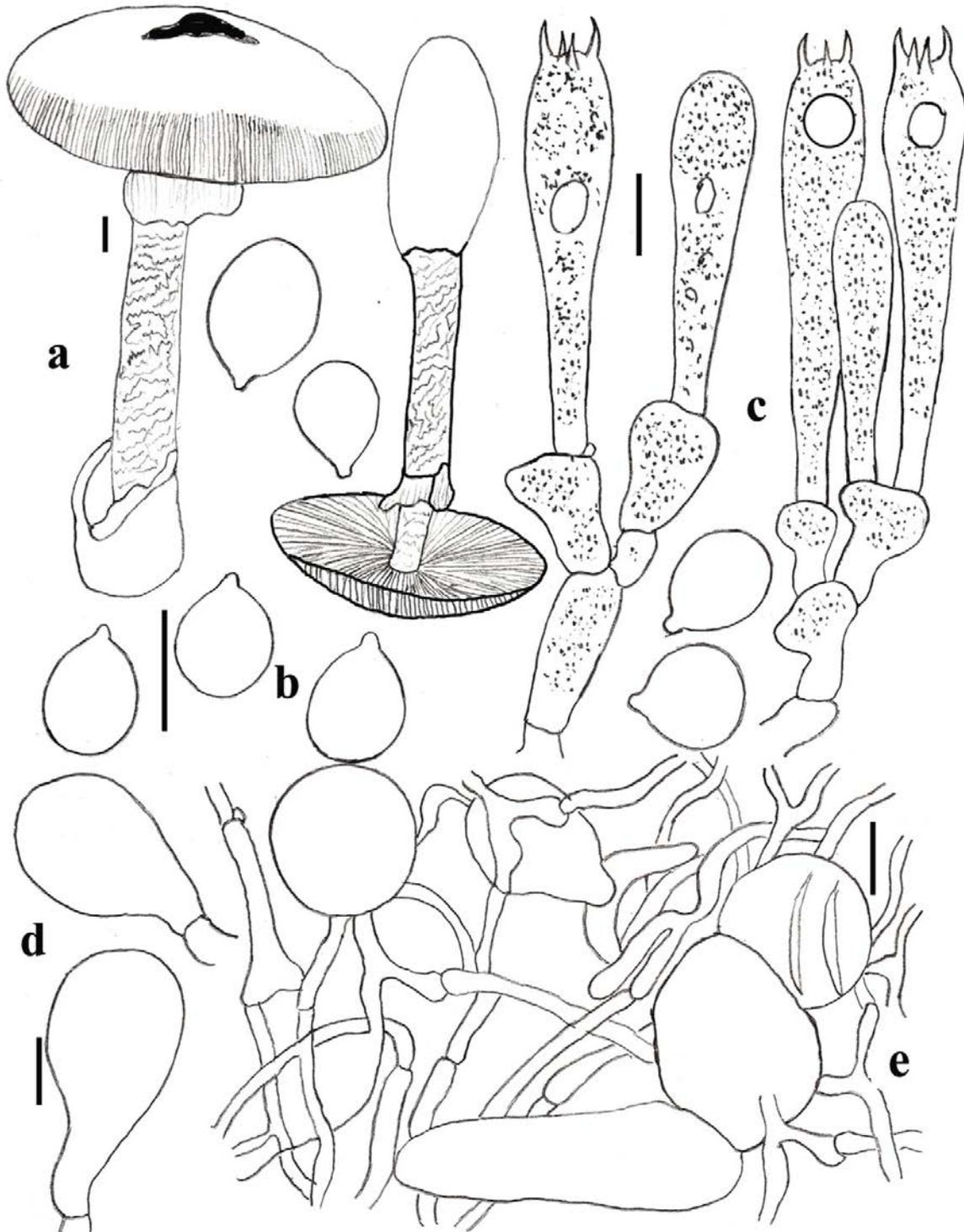
Basidiocarps medium to large sized. Pileus 80–160 mm wide, hemispherical when young then convex to plano-convex and applanate at maturity, with a broad umbo, dry, subviscid when moist, red to orange-red (7A6-8) at centre, yellowish orange (4A6-7) towards margin. Context 8–18 mm thick, white (1A1) to yellowish white (4A2) unchanging when cut or bruised. Margin sulcate striate, striations up to 70–80 mm long, non-appendiculate, uplifted with age. Universal veil on pileus absent. Lamellae free, close to crowded, pale yellow to light yellow (3A3). Lamellulae truncate, unevenly distributed. Stipe 180–263 × 14–28 mm, light yellowish to pale yellow (4A3-5) narrowing upward, fibrillose or decorated with orange yellow (4A7) fibrils. Context white (1A1) to yellowish white (4A2), unchanging when cut or bruised, stuffed with cottony material in young specimes, becoming hollow with age. Partial veil superior, membranous, pendant, yellow (3A6-8), large, margin striate. Universal veil on stipe base as saccate volva, 40–80 × 35–58 mm, robust, thick, leathery, with inner surface yellow white (3A2), outer surface white (2A1), attached only at stipe base. Odour indistinct. Taste mild. Spore print white. Basidiospores (8–)8.5–9.5(–11) × (6.5–)7–8(–8.5) μm, (L = 8–9.5 μm; L' = 9.1 μm, W = 7–7.5 μm; W' = 7.3 μm; Q = (1.14–)1.20–1.29(–1.33); Q = 1.22–1.25; Q' = 1.23), broadly ellipsoid, hyaline, thin walled, smooth, non-amyloid, apiculus sublateral, up to 1.2 μm. Basidia (40–)42–57(–63) × (9.8–)10–11.5(–12) μm, thin-walled, colourless; sterigmata up to 5 μm long. Clamp connections often present at the base of basidia. Lamellar trama bilateral, divergent, mediostratum 25–50 μm wide, filamentous hyphae 3–12 μm wide, branched, hyaline, thin-walled, clavate to subfusiform cells 90–110 × 22–28 μm; vascular hyphae rare. Subhymenium 29–44 μm thick, in 2-3 layers of globose to ellipsoid cells, 13–22 × 11–16 μm. Lamellar edge sterile, filamentous hyphae 2–8 μm wide, with inflated cells; globose to subglobose cells dominating, 23–27 × 17–23 μm, colourless, thin-walled. Pileipellis 90–195 μm

thick, 2-layered, suprapellis 40–95  $\mu\text{m}$  thick, filamentous hyphae 3–8  $\mu\text{m}$  wide, strongly gelatinized, hyaline, branching, thin-walled; subpellis 50–100  $\mu\text{m}$  wide, non-gelatinized, branching,



**Fig. 1** – *Amanita caesareoides* a–c Fresh basidiocarps in the field. d Basidiospores. e Hymenium and subhymenium. f Elements of partial veil. g Elements of universal veil. Scale bars: b= 150 mm, d–g= 20  $\mu\text{m}$ .

hyaline, thin-walled. Pileus context filamentous, hyphae 3–7  $\mu\text{m}$  wide, thin-walled, acrophysalides up to  $260 \times 38 \mu\text{m}$  wide. Universal veil on stipe base filamentous hyphae 3.5–6  $\mu\text{m}$  wide, branching, hyaline, thin-walled; subglobose cells  $20\text{--}28 \times 18\text{--}26 \mu\text{m}$ , ellipsoidal cells  $47\text{--}52 \times 12\text{--}18 \mu\text{m}$ , hyaline, thin-walled. Stipe context longitudinally acrophysalidic; filamentous hyphae 5–7  $\mu\text{m}$  wide, hyaline, acrophysalidic cells up to  $135 \times 33 \mu\text{m}$ , thin-walled, hyaline. Partial veil filamentous undifferentiated hyphae 3.5–5  $\mu\text{m}$  wide, inflated cells dominant, clavate cells  $80\text{--}145 \times 29\text{--}41 \mu\text{m}$  wide, hyaline. Clamp connections often present in all tissue.



**Fig. 2** – *Amanita caesareoides*. a Basidiocarp. b Basidiospores. c Hymenium & subhymenium. d marginal cells. f Elements of partial veil; Scale bars: a=10 mm. b–d = 10  $\mu\text{m}$ . e = 20  $\mu\text{m}$ .

Habit and Habitat – Solitary-scattered on ground in temperate mixed forest under the trees of *Quercus floribunda* and *Q. semecarpifolia*.

Known distribution – This species was originally described from Russia. It has also been recorded from China and Japan. It is being recorded and described here in detail for the first time from India.

Specimens examined – *Baniyakund*, 2550 m, 24<sup>th</sup> July, 2015 *T. Mehmood & R.P. Bhatt*, 15-740; N30°28.914' E79°10.854'; *Baniyakund*, 2<sup>nd</sup> Aug. 2015, *T. Mehmood & R.P. Bhatt*, 15-814; *Duggalbitta*, 5<sup>th</sup> Aug. 2015 *T. Mehmood & R.P. Bhatt*, 15-843. 2352 m, N30°29.380' E79°09.671'; *Baniyakund*, 28<sup>th</sup> Aug. 2015 *T. Mehmood & R.P. Bhatt*, 15-991; *Baniyakund*, 29<sup>th</sup> Aug. 2015 *T. Mehmood & R.P. Bhatt*, 15-1000; *Baniyakund*, 28<sup>th</sup> Aug. 2015 *T. Mehmood*, 15-984; *Duggalbitta*, 30<sup>th</sup> Aug. 2015 *T. Mehmood & R.P. Bhatt*, 15-1012; *Chopta*, 11<sup>th</sup> Aug 2015 *T. Mehmood & R.P. Bhatt*, 15-1016; *Baniyakund*, 25<sup>th</sup> Aug. 2016 *T. Mehmood & R.P. Bhatt*, 16-1356.

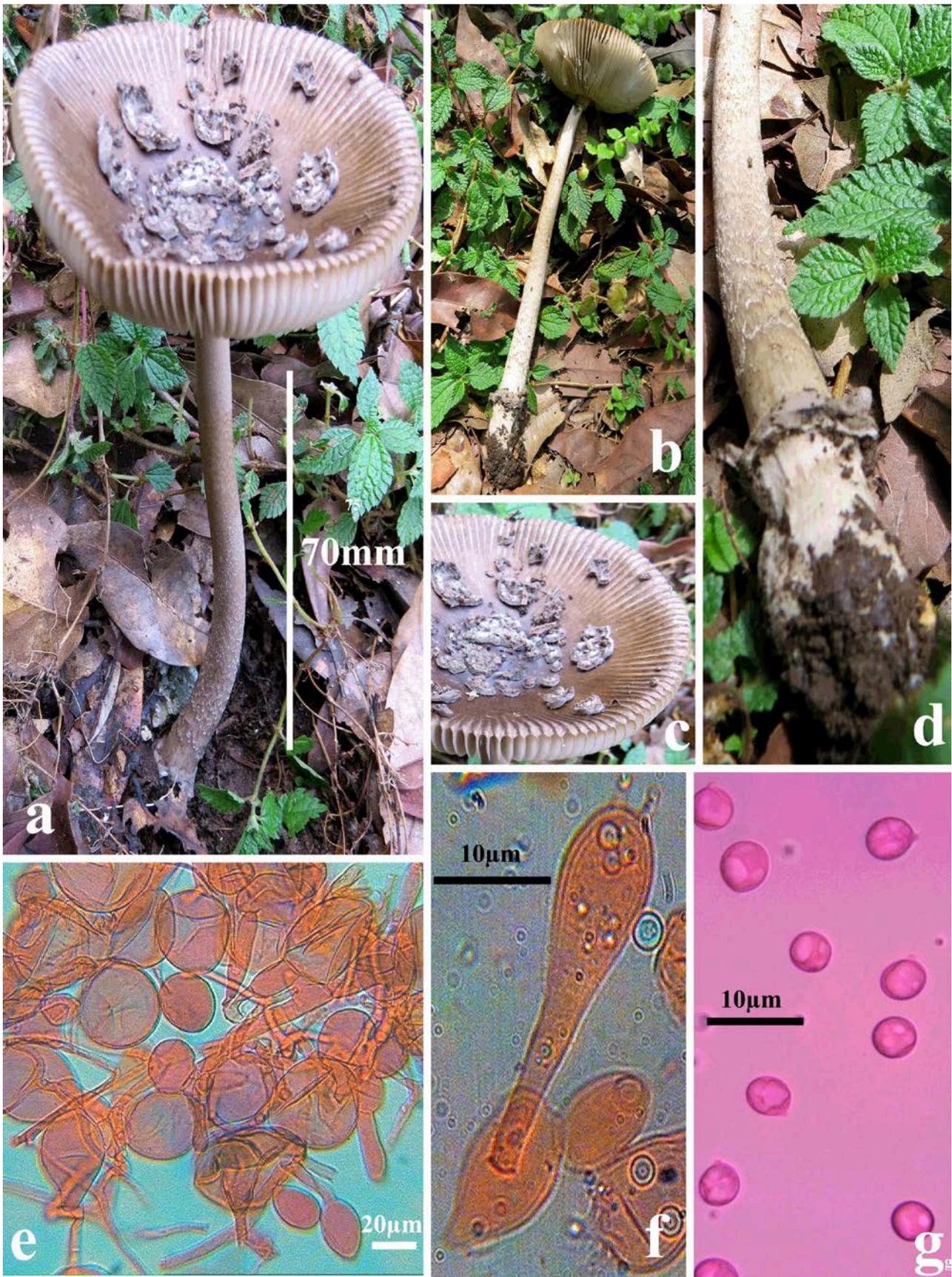
Discussion – *Amanita caesareoides* is a member of sect. *Caesareae*. In the field, the distinguishing morphological characteristics of *A. caesareoides* include distinctive long, sulcate striations on the margin of the pileus, red to orange-red color at center, yellowish orange toward margin, yellowish partial veil and white saccate volva.

In eastern Asia, *A. caesareoides* might be confused with *A. hemibapha* var. *hemibapha* (Berk. & Broome) Sacc., however the latter differs by its pileus often lacking an umbo (Berkeley & Broome 1871, Vrinda et al. 2005, Sanmee et al. 2008). *Amanita hemibapha* var. *ochracea* Zhu L. Yang (originally described from China), differs from *A. caesareoides* by its pileus which is brown over the centre and white lamellae with yellowish brown edges (Yang 1997). *Amanita rubromarginata* Har. Takah. differs from *A. caesareoides* by distinctive long-sulcate striations on the margin of the pileus, carrot red to deep orange to brownish orange, greyish orange or apricot colours toward the margin (Thongbai et al. 2016). *Amanita caesareoides* also differs from *A. javanica* (Corner & Bas) T. Oda, C. Tanaka & Tsuda by its yellow to orange-yellow pileus (Oda et al. 1999). *Amanita caesareoides* is reported to be a common edible mushroom from higher elevations of Uttarakhand Hills in present study.

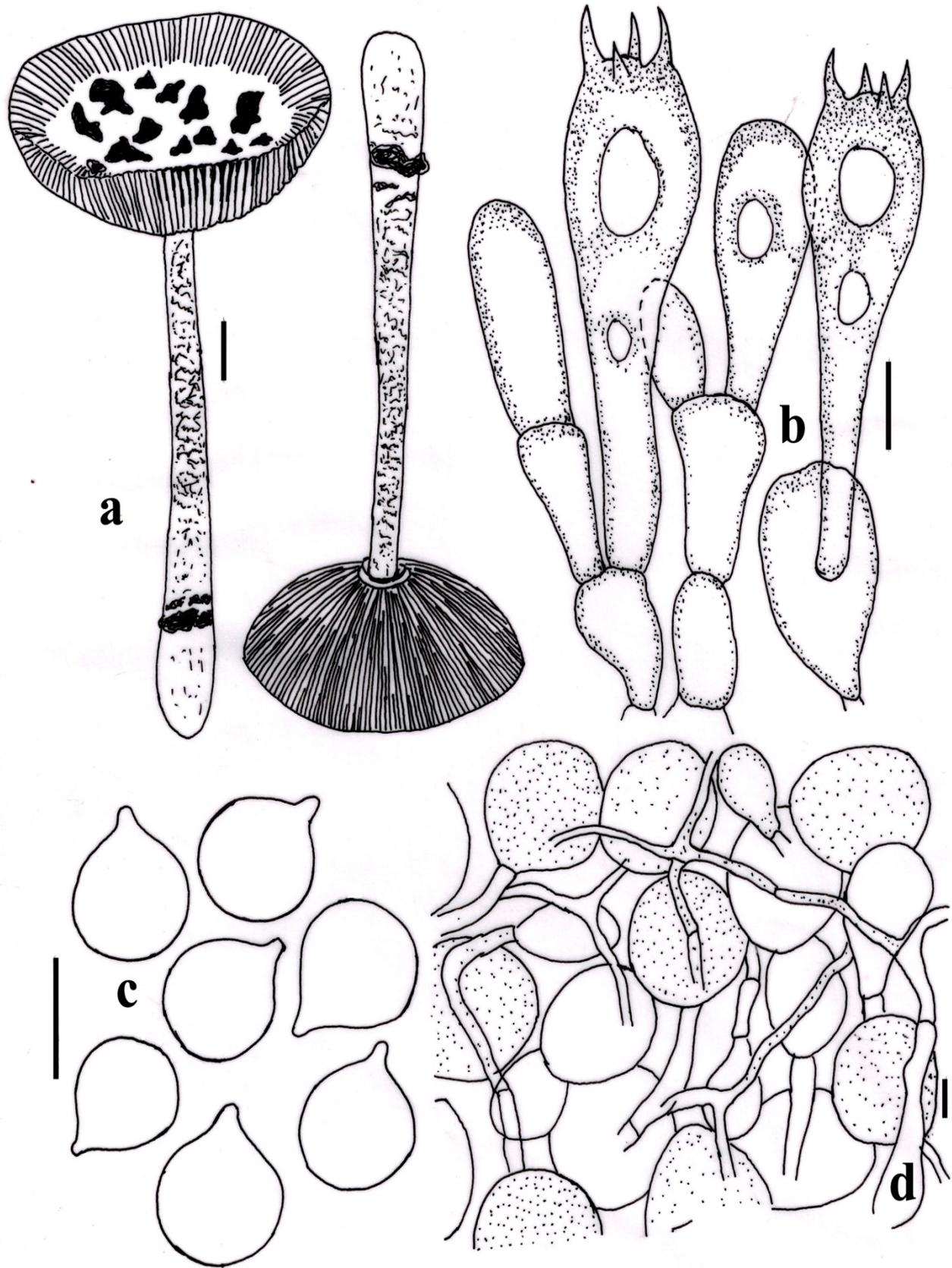
*Amanita griseofolia* Zhu L. Yang, Mycologia 96(3): 636–646.2004.

Figs 3, 4

Basidiocarps small to medium-sized. Pileus 40–82 mm wide, grey to greyish brown (5E1–3) darker over disk, becoming paler toward margin, initially hemispherical, then convex to plano-convex without an umbo, dry. Context 20–23 mm thick, white, darker with age unchanging when cut or bruised. Margin tuberculate striate, striation up to 17 mm long, non appendiculate. Universal veil on pileus as dark grey (1F1) felty patches. Lamellae free, crowded, initially white (5A1), greyish white to grey (1B1–1C1) with age. Lamellulae truncate, abundant, unevenly distributed. Stipe 90–180 × 13–25 mm, tapering upward, initially white (5A1), covered by grey (5D1) fibrillose squamules. Context white, hollow, unchanging. Partial veil absent. Basal bulb lacking, volval remnants on stipe base grey (1B1) to dark grey (1C1) felty to verrucous, irregularly distributed. Odour indistinct. Taste not recorded. Spore print white. Basidiospores (9–) 9.5–13(–14.5) × (8–) 9–12.5 (–14) μm, (L = 10–13.5 μm; L' = 12.16 μm, W = 11–12.5 μm; W' = 11.75 μm; Q = (1.04–)1.1–1.13(–1.21); Q = 1.05–1.11; Q' = 1.07) globose to subglobose, rarely broadly ellipsoid, apiculus up to 1.5 × 1 μm, hyaline, thin-walled, smooth, non-amyloid. Basidia (32–) 46–60 (–68) × (15–) 16–18(–19.5) 2- to 4-spored, thin-walled, colourless; sterigmata 3–5 × 1.5–2 μm. Clamp connections not observed at the base of basidia. Lamellae edge sterile; inflated cells globose to subglobose, 20–48 × 18–36 μm, colourless, thin-walled, infrequent. Subhymenium  $w_{st-near}$  = 40–70 μm;  $w_{st-far}$  = 52–78 μm, basidia arising from inflated cell (up to 18 × 24 μm). Hymenophoral trama bilateral, mediostrium 36–55 μm wide, filamentous undifferentiated hyphae (3–6) μm wide. Pileipellis 70–120 μm thick, in two layers; gelatinized suprapellis (20–50 μm thick) of radially



**Fig. 3** – *Amanita griseofolia*. a–d Basidiocarp in the field. e Elements of universal veil from stipe base. f Basidia g Basidiospores; Scale bars: a=70 mm. e= 20  $\mu$ m. f–g =10  $\mu$ m.



**Fig. 4** – *Amanita griseofolia*. a Basidiocarp. b Hymenium & subhymenium. c Basidiospores. d Elements of universal veil at stipe base; Scale bars: a = 10 mm. b–d = 10  $\mu$ m.

arranged filamentous hyphae (1–3.5 µm wide, thin-walled, colourless; ungelatinized subpellis (90–130) µm thick); filamentous hyphae 2–6 µm wide, radially and compactly arranged with brown intracellular pigments. Pileus context filamentous, hyphae 3–9 µm wide. Universal veil on pileus inflated cells of various type; subglobose to ovoid cells 28–43 × 22–38 µm, clavate cells up to 72 × 34 µm, short ellipsoid cells up to 80 × 21 µm; filamentous hyphae 3–8 µm wide. Stipe context longitudinally acrophysalidic: filamentous hyphae 2–10 µm wide, hyaline; acrophysalides dominant up to (242 × 36 µm), cylindrical or clavate, vascular hyphae 3–13 µm wide. Clamp connections absent in all tissue.

Habit and Habitat – Solitary to subgregarious on ground under mixed forest of *Abies pindrow* and *Quercus* spp.

Known distribution – China (Yang et al. 2004). It is being recorded for the first time from India.

Specimens examined – *Baniyakund*, 26<sup>th</sup> August 2014, *T. Mehmood & R.P. Bhatt*, 14-478; *Baniyakund*, 28<sup>th</sup> August 2014, *T. Mehmood & R.P. Bhatt*, 14-514; *Duggalbitta*, 1<sup>st</sup> August 2015 *T. Mehmood & R.P. Bhatt*, 15-799. 2352 m, N30°29.380' E79°09.671'.

*Amanita griseofolia* can be mistaken for *Amanita ceciliae* (Berk. & Broome) Bas, which has grey brown or olive-brown pileus covered with paler (greyish to brownish) volval remnants and much paler squamules on the stipe. Furthermore, the volval remnants at the base of the stipe in *A. ceciliae* often form a ring like-zone and a floccose, nearly cupulate structure at the very base of the stipe (Phillips 1990, Breitenbach & Kranzlin 1995). *Amanita liquii* Zhu L. Yang, M. Weiss & Oberw. has dark-coloured, robust fruit body with greyish lamellae, dark-coloured volval remnants on the pileus, verrucous volval remnants in belts at the non-bulbous stipe base (Yang et al. 2004).

*Amanita cinctipes* Corner & Bas differs from *A. griseofolia* in having mouse grey to pale greyish brown pileus, volva remnants at stipe base forming 2–3 rings and smaller basidiospores 8.2–11.1 × 7.8–10.1 µm (Corner & Bas 1962).

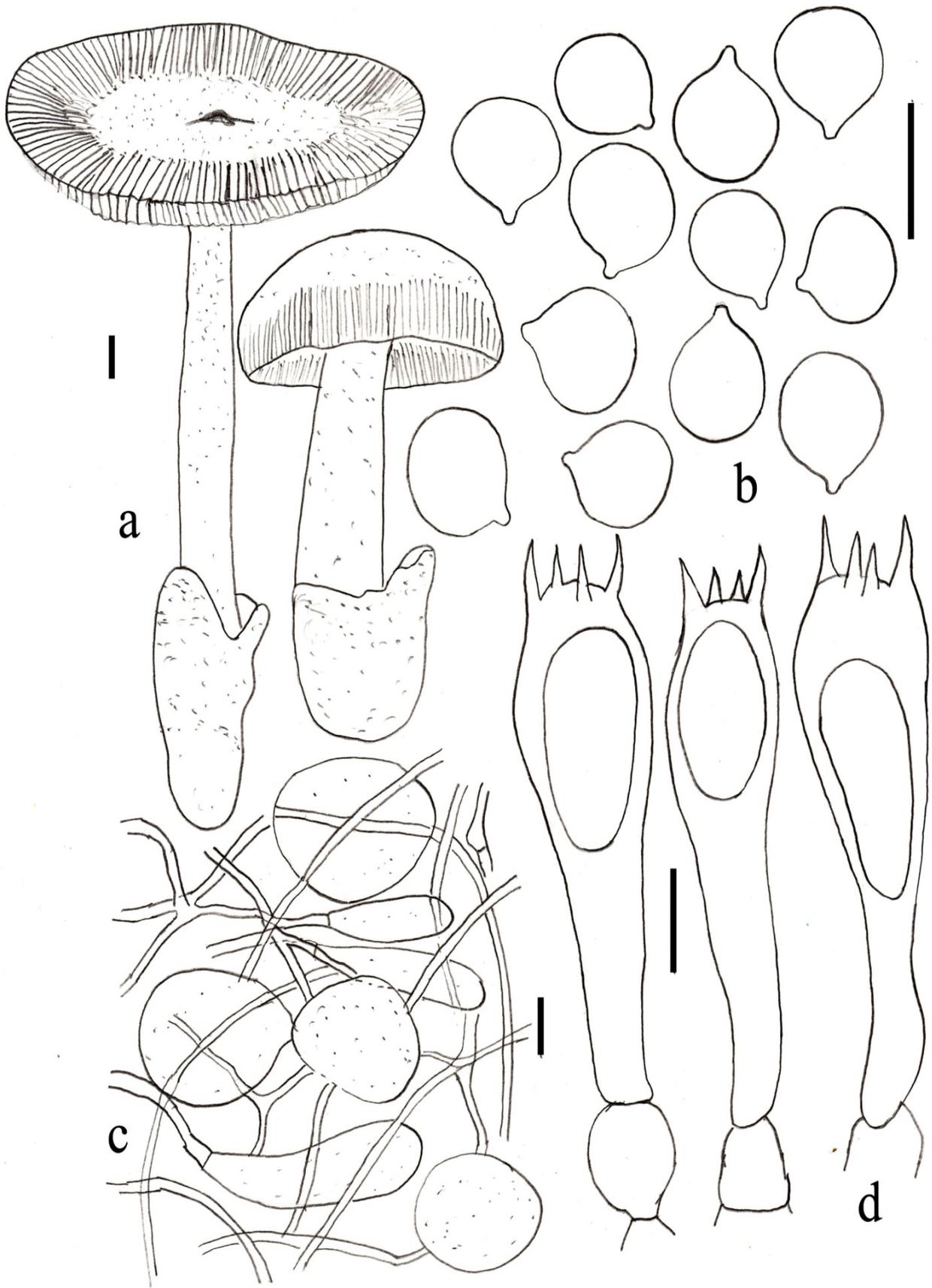
*Amanita orientifulva* Zhu L. Yang, M. Weiss & Oberw., *Mycologia* 96(3): 636–646. 2004.

Figs 5, 6

Basidiocarps small to medium-sized. Pileus 70–100 mm wide, initially hemispherical, convex to plano-convex, umbonate, brownish orange (5C4–6) to golden brown (5D6–7) over center, yellowish brown (5B5) to reddish golden (6C7) toward margin, smooth, dry, shiny. Context white, 3 mm thick, thinning slowly toward margin, white, unchanging when cut or bruised. Margin tuberculate striated, striations up to 18 mm long, non appendiculate, dark ring around the inner ends of marginal striations. Universal veil on pileus usually absent. Lamellae free, crowded, white (1A1), with brownish orange (5C4) edges. Lamellulae truncate, abundant, unevenly distributed. Stipe 80–170 × 12–29 mm, usually tapering upward, with apex slightly expanded, initially white then brownish orange (5C4) covered with reddish golden (6C7) squamules. Context white (1A1), hollow, unchanging when cut or bruised. Partial veil absent. Universal veil at stipe base saccate, 55–80 × 15–37 mm, limb internus is placed at point of attachment between stipe and volval limb; Odour indistinct. Taste not recorded. Spore print white. Basidiospores (10–) 12–14(–14.5) × (9–) 11.5–12.5 (–13) µm, (L = 12.5–13.5 µm; L' = 12.77 µm, W = 11–12.5 µm; W' = 11.75 µm; Q = (1.041–)1.1–1.13(–1.21); Q = 1.1–1.12; Q' = 1.09), globose to subglobose, rarely broadly ellipsoid, hyaline, thin-walled, smooth, nonamyloid, apiculus up to 1 µm. Basidia (52–) 55–60 (–65) × (15–) 16–17(–17.5) µm, thin-walled; sterigmata up to 5 × 1.2 µm. Clamp connections not observed at the base of basidia. Lamellar edge sterile; clavate cells 25–40 × 16–28 µm, colourless, thin walled. Subhymenium  $w_{st-near} = 31–59$  µm;  $w_{st-far} = 44–70$  µm, basidia arising from small inflated cells up to 8–15 × 10–20 µm; vascular hyphae 3–8 µm wide. Hymenophoral trama bilateral, mediostratum 30–61 µm wide, filamentous hyphae 3–7 µm wide. Pileipellis 85–115 µm thick, gelatinized, composed of radially arranged filamentous hyphae up to 2–6 µm wide. Pileus context filamentous, undifferentiated hyphae 3–13 µm wide, slightly thin-walled, hyaline, acrophysalides common up to 135 × 31 µm, slightly thick-walled, vascular hyphae up to 17 × 3.5 µm. Universal veil (on stipe base) filamentous undifferentiated hyphae 4–8 µm wide; subglobose cells up to 43 ×



**Fig. 5** – *Amanita orientifulva*. a–c Fresh basidiocarps in the field. d Hymenium & subhymenium. e section showing lamellae trama, hymenium and subhymenium. f Basidiospores. g Elements of universal veil from stipe base. Scale bars: a–b = 90 mm; d–g = 10 μm.



**Fig. 6** – *Amanita orientifulva*. a Basidiomata b Basidiospores c Elements of universal veil at stipe base d Basidia and element of subhymenium. Scale bars: a = 10 mm; b–d = 10  $\mu$ m.

38 µm, clavate cells up to 64 × 30 µm, ellipsoid cells up to 60 × 18 µm, Stipe context longitudinally acrophysalidic; filamentous undifferentiated hyphae 2–7 µm wide; acrophysalides dominating, 120–160 × 25–32 µm. Clamp connections not observed.

Habit and Habitat – Solitary to Subgregarious under *Abies pindrow* and *Quercus* spp. in temperate mixed forests.

Known distribution – This species was originally described from China (Yang et al. 2004). It constitutes a new record for India.

Specimens examined – *Baniyakund*, 6<sup>th</sup> August 2014, T. Mehmood & R.P. Bhatt, 15–311; *Baniyakund*, 11<sup>th</sup> August 2014, T. Mehmood & R.P. Bhatt, 14–406; *Baniyakund*, 2<sup>th</sup> August 2015, T. Mehmood & R.P. Bhatt, 15–496; *Baniyakund*, 28<sup>th</sup> August 2015 T. Mehmood, 15–984; *Baniyakund*, 24<sup>th</sup> July 2015 T. Mehmood & R.P. Bhatt, 15–1195; *Baniyakund*, 25<sup>th</sup> August 2016 T. Mehmood & R.P. Bhatt, 16–1357; *Baniyakund*, 26<sup>th</sup> August 2016 T. Mehmood & R.P. Bhatt, 16–1377.

Discussion – The combination of macro- and micromorphological features like nonamyloid spores, saccate volva, absence of a bulb and basidial clamps place *Amanita orientifulva* in *Amanita* [subg. *Amanita*] sect. *Vaginatae* sensu Yang (Yang 1997).

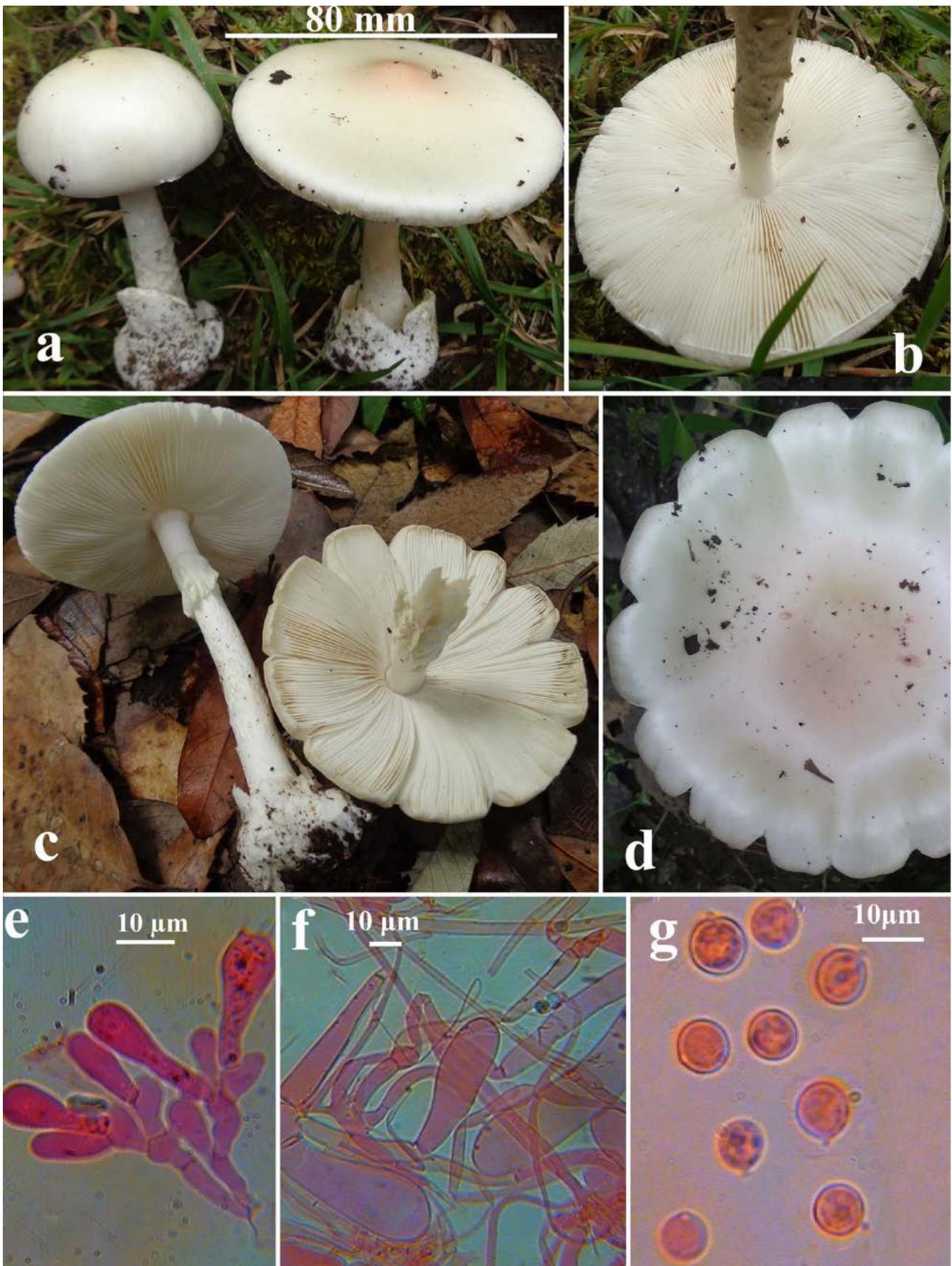
In the field, *Amanita orientifulva* can be easily recognized by its brownish orange to golden brown colour of pileus centre, becoming yellowish brown to reddish golden toward margin and a dark ring around the inner ends of marginal striations. Micromorphologically, it is recognized by globose to subglobose basidiospores and universal veil composed of irregularly arranged filamentous hyphae.

This species is very similar to *A. fulva* (Schaeff.) Fr. which was originally described from Europe. In fact, *A. orientifulva* was usually regarded as *A. fulva* in China (Ying et al. 1994). However, there are a few features separating *A. orientifulva* from *A. fulva*. The main morphological or anatomical difference between *A. orientifulva* and *A. fulva* might be the volval structure. The inner layer is composed predominantly of irregularly arranged filamentous hyphae, mixed with scattered to locally fairly abundant inflated cells in *A. orientifulva*. Furthermore, relatively larger basidiocarps and somewhat larger basidiospores of *A. orientifulva* separate it from *A. fulva* (Tulloss 2000, Yang et al. 2004).

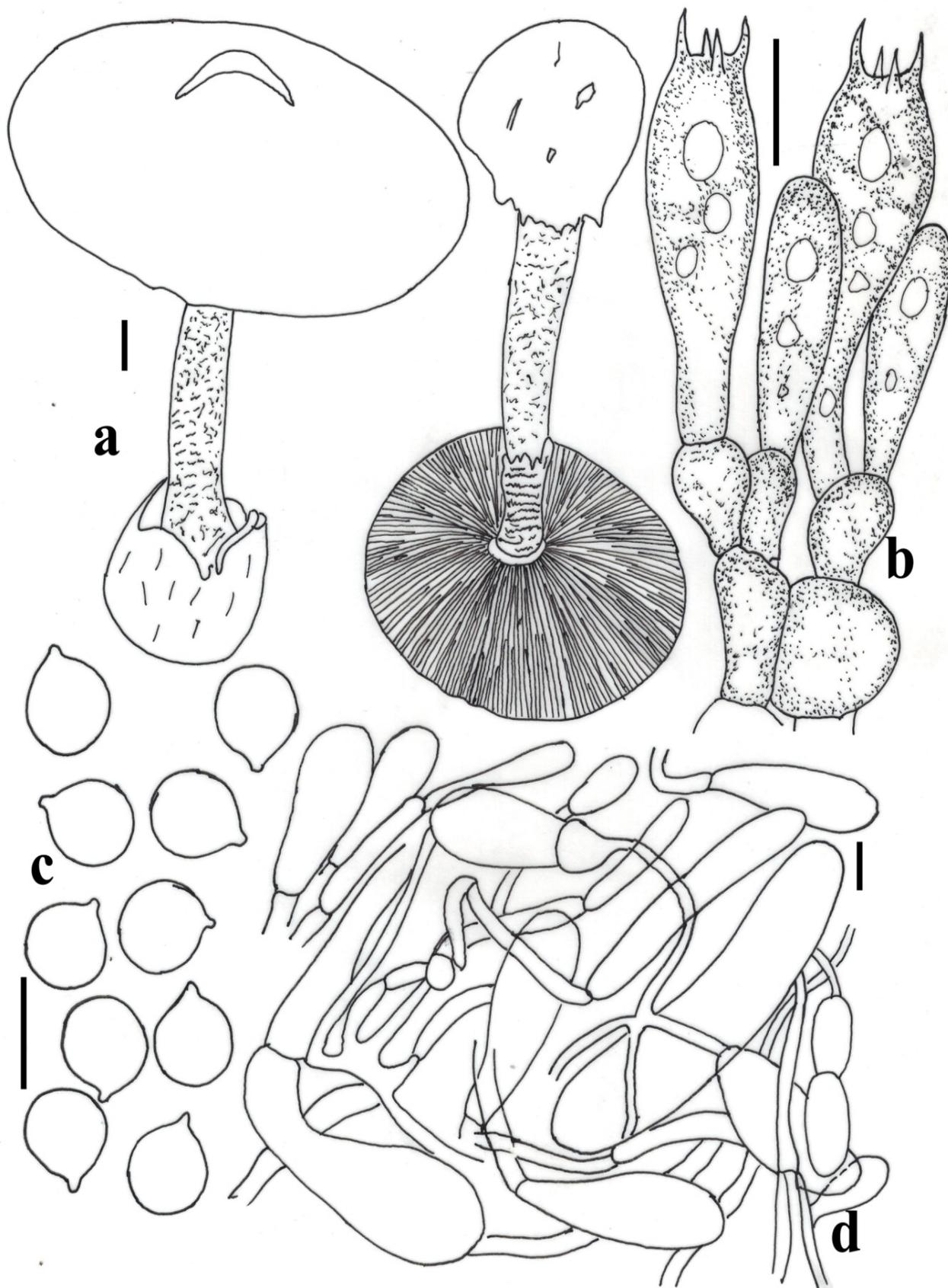
***Amanita pallidorozea*** P. Zhang & Zhu L. Yang, 2010, Fungal Diversity, 42: 125. Figs 7, 8

Basidiocarps small to medium-sized. Pileus 50–90 mm wide, initially hemispherical then convex to plano-convex, finally becoming applanate with an umbo, pinkish or reddish white (9A2) to pale red (9A3) at center, becoming white (6A1) toward margin, smooth, sub-viscid when wet, shiny. Context 2–6 mm thick, thinning slowly toward margin, white, unchanging when cut or bruised. Margin slightly incurved, faintly striate. Universal veil on pileus usually absent. Lamellae free, crowded, white or slightly pinkish with age, with concolorous edges. Lamellulae attenuate, abundant, in 3–4 lengths. Stipe 110–180 × 8–15 mm, subcylindric, white (1A1) to yellowish white (1A2) covered with finely fibrillose squamules. Partial veil apical, thin, membranous, white or slightly yellowish, skirt-like and persistent. Universal veil at stipe base, membranous, bilimbate, both surfaces white. Odour indistinct. Taste not recorded. Spore print white.

Basidiospores (7–) 8–9(–9.5) × (6.5–) 7.5– 8(–8.5) µm, (L = 8.5–9 µm; L' = 8.7 µm, W = 7–8 µm; W' = 7.39 µm; Q = (1.04–) 1.06–1.11(–1.28); Q = 1.06–1.14; Q' = 1.11), globose to subglobose, amyloid, thin-walled, hyaline; apiculus small, sublateral. Basidia (24–) 27–41(–49) × (7.5–)8–11(–1.5) µm, 2–4-spored, thin-walled, colourless; sterigmata 2–3 × 1–1.5 µm. Clamp connections not observed at the base of basidia. Hymenophoral trama bilateral, divergent; w<sub>cs</sub> = 27 – 52 µm filamentous undifferentiated hyphae 2–5 µm wide. Subhymenium w<sub>st</sub>-near = 32–42 µm; w<sub>st</sub>-far = 35–55 µm. Lamellae edge sterile; inflated cells; subglobose to broadly clavate, 17–44 × 10–28 µm, colourless, thin-walled, clamp connections not observed. Pileipellis 105–140 µm thick, in two layers; suprapellis 38–75 µm thick, composed of radially arranged filamentous undifferentiated, thin-walled, colorless hyphae (2–6 µm wide); subpellis 40–65 µm thick; filamentous hyphae compactly arranged interwoven, thin-walled, hyaline 4–7 µm wide. Pileus trama filamentous, hyphae 2–12 µm wide, constricted at septa, slightly thick-walled. Exterior



**Fig. 7** – *Amanita pallidorosea*. a–d Fresh basidiocarps in the field. e Hymenium & subhymenium. f Elements of partial veil. g Basidiospores. Scale bars: a=80 mm e–g= 10 μm.



**Fig. 8** – *Amanita pallidorosea*. a Basidiocarps. b Hymenium & subhymenium. c Basidiospores. d Elements of universal veil at stipe base. Scale bars: a = 10 mm; b–d = 10  $\mu$ m.

surface of universal veil (on stipe base) filamentous undifferentiated hyphae (3–8 µm wide); inflated cells clavate to subglobose, 38–55 × 10–26 µm, thin-walled. Interior surface of universal veil (on stipe base) filamentous, undifferentiated hyphae 2–6 µm wide; inflated cells subglobose, cells up to 35 × 33 µm, with filamentous undifferentiated hyphae 4–8 µm wide. Partial veil filamentous undifferentiated hyphae 3–5 µm, wide, hyaline, slightly thick-walled, mixed with ellipsoid to broadly ellipsoid or pyriform terminal cells, 25–100 × 20–50 µm. Clamp connections not observed.

Known distribution – This species was originally described from China (Zhang et al. 2010). It is being reported here for the first time from India.

Habit and Habitat – Solitary to scattered, growing on ground associated with the trees of *Quercus leucotricophora*, *Rhododendron arboreum*, *Myrica esculenta*, *Lyonia ovalifolia* with scattered trees of *Cupressus torulosa*.

Specimens examined – Phedkhal, 21<sup>th</sup> August 2015 *T. Mehmood & R.P. Bhatt*, 15–436; Phedkhal, 25<sup>th</sup> August 2014 *T. Mehmood & R.P. Bhatt*, 14–578; Phedkhal, 12<sup>th</sup> August 2015, *T. Mehmood & R.P. Bhatt* 15–937, 1904 m, N30°09.681' E78°51.222'; Phedkhal, 03<sup>th</sup> September 2016 *T. Mehmood & R.P. Bhatt*, 16–1384.

Discussion – *Amanita pallidorozea* belongs to the *Amanita* subgenus *Lepidella* section *Phalloideae*. It is characterized by its medium to large-sized basidiocarps, pileus pinkish or reddish white to pale red in the centre, becoming white towards margin, margin faintly striated, lamellae white, slightly pinkish with age, stipe white to yellowish white, annulus white or slightly yellowish, skirt like, volva white, membranous, bilimbate and globose to subglobose basidiospores.

In the field *A. pallidorozea* can be mistaken for *A. virosa* (Fr.) Bertill., *A. subjunquillea* var. *alba* Z.L. Yang, *A. oberwinklerana* Z.L. Yang et Y. Doi, *A. bisporigera* Atk. and *A. ocreata* Peck on account of the large and whitish basidiocarps of similar appearance. *Amanita virosa* differs from *A. pallidorozea* by larger and more ellipsoid basidiospores (8–11 × 7.5–10 µm), longer basidia and different structure of annulus (Neville & Poumarat 2004). *Amanita subjunquillea* var. *alba* (originally described from China) does not have pallid rose colour in the pileus and its basidiocarp has a distinct yellow reaction with 5 % KOH.

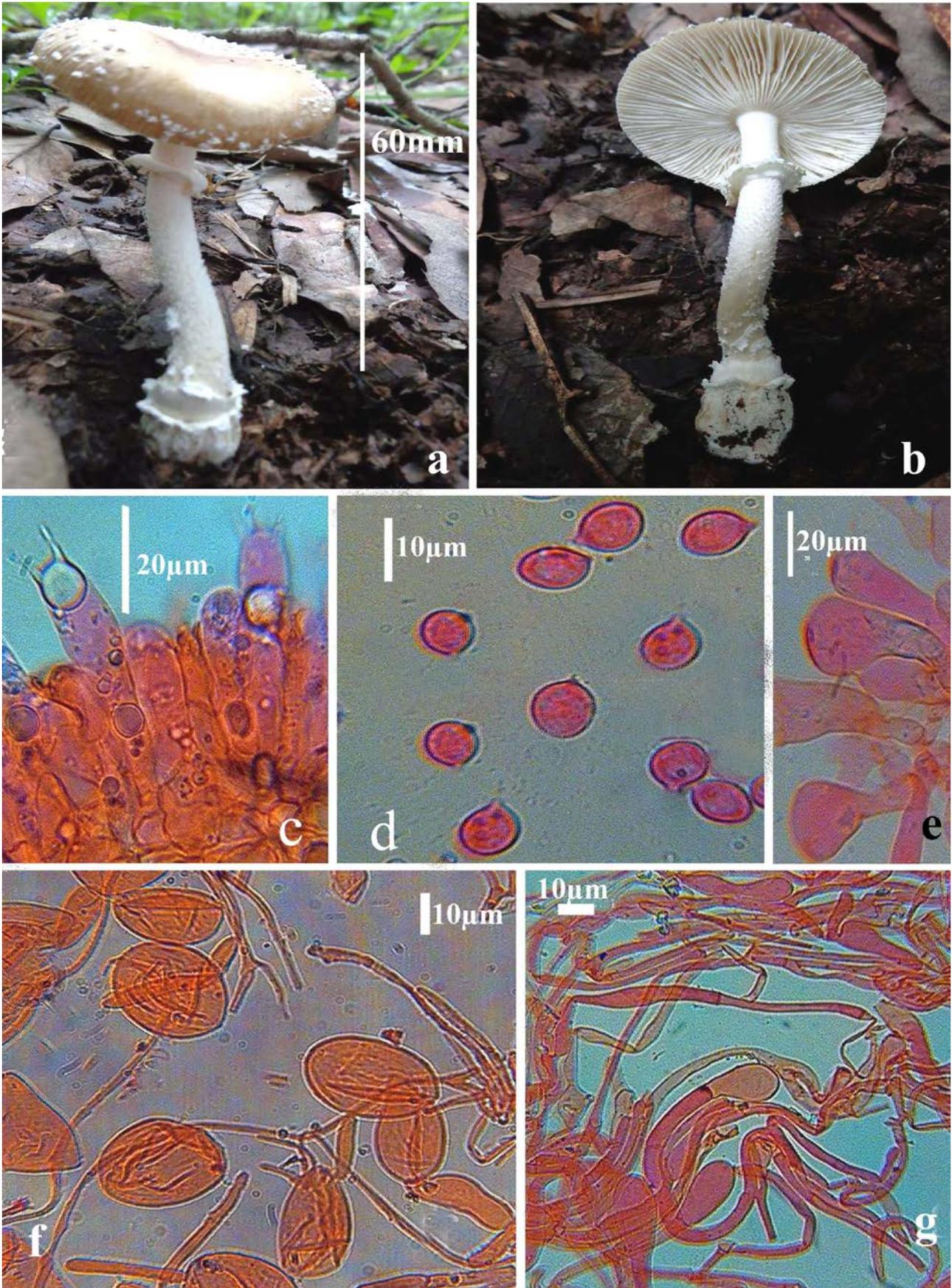
*Amanita oberwinklerana*, described from Japan, is distinguished from *A. pallidorozea* by the presence of volval remnants on pileus and larger ellipsoid basidiospores [(7.5)8–10.5(12.5) × (5.5)6.5–8(8.5) µm] (Yang & Doi 1999). Both *A. bisporigera* and *A. ocreata* are known only from North America. *Amanita bisporigera* have predominantly 2-spored basidia and slightly larger basidiospores (Tulloss et al. 1995). *Amanita ocreata* differs in having larger basidiospores [(6.8) 8.8–12.0(13.8) × (5.9)6.3– 8.5(10.8) µm] and yellow reaction with 5 % KOH (Zhang et al. 2010).

*Amanita parvipantherina* Zhu L. Yang, M. Weiss & Oberw. Mycologia, 96(3): 2004. 636–646.

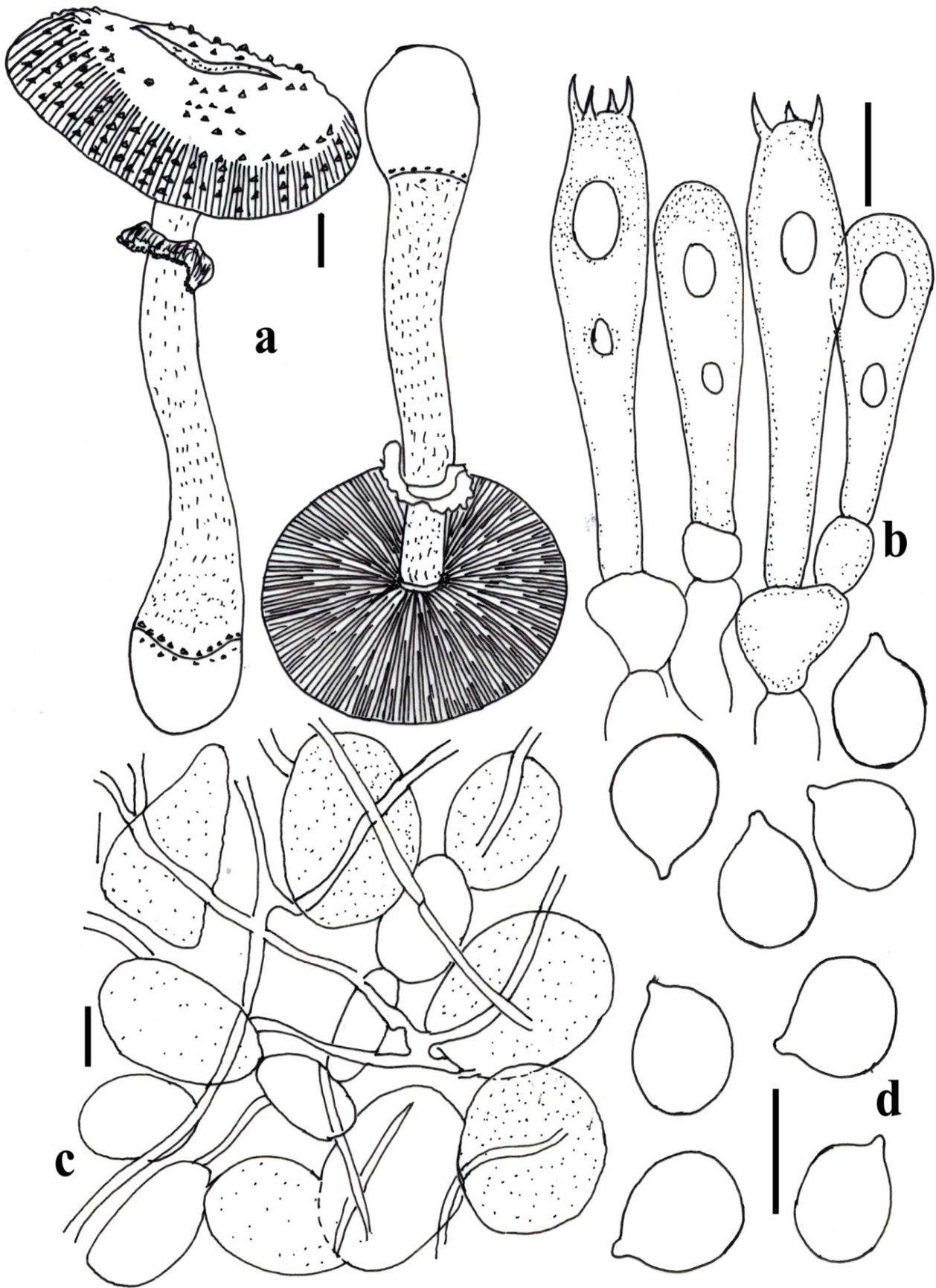
Figs 9, 10

Basidiocarps small to medium-sized. Pileus 40–70 mm wide, convex to plano-convex, slightly depressed at center, light brown (5D4) to brown (5E4) slightly viscid, shiny. Context white (1A1), unchanging when cut or bruised. Margin tuberculate-striate 5–8 mm, non appendiculate. Universal veil on pileus as white (1A1) conical, to granular warts. Lamellae free, crowded (7–9 L/cm), white (1A1). Lamellulae truncate, of various lengths, abundant. Stipe 60–100 × 8–12 mm, slightly tapering upward, apex slightly expanded, white, covered with white (1A1), fine fibrils. Context stuffed to hollow, white (1A1), unchanging when cut or bruised. Bulb subglobose, 15–24 mm wide, white (1A1). Partial veil superior, pendant, thin, membranous, white (1A1). Universal veil at stipe base, white (1A1), granular warts. Odour indistinct. Taste not recorded. Spore print white.

Basidiospores 9–) 9.5–11(–12) × (7–) 7.5–8.5 (–9) µm, (L = 9.5–10.5 µm; L' = 9.5 µm, W = 6.5–8 µm; W' = 7.67 µm; Q = (1.25–) 1.30–1.40(–1.53); Q = 1.30–1.37; Q' = 1.33), broadly ellipsoid to ellipsoid, non-amyloid, thin walled, smooth, contents monoguttulate, hyaline. Basidia (39–) 45–53(–57) × (9–) 10–11(–12) µm, clavate, 4-spored thin-walled, colourless, sterigmata 3.5–6 × 1–1.5 µm. Clamp connections not observed at the base of basidia. Lamellae edge sterile;



**Fig. 9** – *Amanita parvipantherina* a & b Fresh basidiocarps in the field. c Hymenium & subhymenium. d Basidiospores. e lamellae edge cells. f Elements of universal veil from pileus surface. g Elements of partial veil; Scale bars: a = 60 mm; c & e = 20 µm; d, f & g = 10 µm.



**Fig. 10** – *Amanita parvipantherina*. a Basidiocarp. b Hymenium & subhymenium. c Elements of universal veil at stipe base. d Basidiospores; Scale bars: a = 10 mm; b–d = 10  $\mu$ m.

inflated cells clavate or pyriform,  $35\text{--}40 \times 22\text{--}26 \mu\text{m}$ , colourless, thin walled. Subhymenium  $w_{st}$  near =  $40\text{--}65 \mu\text{m}$  thick,  $w_{st}\text{-far}$  =  $60\text{--}78 \mu\text{m}$ , basidia arising from small inflated cells ( $8\text{--}12 \times 9\text{--}14 \mu\text{m}$ ). Pileipellis  $90\text{--}115 \mu\text{m}$  thick, filamentous hyphae  $3.5\text{--}5 \mu\text{m}$  wide. Hymenophoral trama bilateral, divergent; mediostratum  $20\text{--}42 \mu\text{m}$ , filamentous hyphae  $3\text{--}6.5 \mu\text{m}$  wide, thin-walled, hyaline, inflated cells up to  $80 \times 25 \mu\text{m}$ . Pileus cortex filamentous hyphae  $4\text{--}7 \mu\text{m}$  wide, thin-walled, branched, hyaline, acrophysalides up to  $67 \times 16 \mu\text{m}$ , thin-walled, hyaline vascular hyphae not observed. subglobose cells up to  $38 \times 45 \mu\text{m}$ , vascular hyphae rare. Stipe context longitudinally acrophysalidic, filamentous undifferentiated hyphae ( $2\text{--}9 \mu\text{m}$  wide), acrophysalidic cells up to  $285 \times 70 \mu\text{m}$ . Partial veil filamentous hyphae  $4\text{--}8 \mu\text{m}$  wide with cluster of inflated cells; clavate to subclavate cells ( $27\text{--}38 \times 13\text{--}17 \mu\text{m}$ , ellipsoid cells  $88\text{--}106 \times 12\text{--}15 \mu\text{m}$ , occasionally subglobose to ovoid ( $22\text{--}43 \times 14\text{--}27 \mu\text{m}$ ). Clamp connections not observed.

Habit and Habitat – Solitary to scattered on ground in a mixed forest of *Quercus leucotricophora*, *Rhododendron arboreum*, *Myrica esculenta*, *Lyonia ovalifolia* with scattered trees of *Cupressus torulosa*.

Known distribution – This species was originally described from China (Yang et al. 2004). It constitutes a new record for India.

Specimens examined – *Phedkhal*, 9<sup>th</sup> August 2014, *T. Mehmood & R.P. Bhatt* 14-355, 1904 m, N30°09.681' E78°51.222'; *Baniyakund*, 6<sup>th</sup> August 2015, *T. Mehmood & R.P. Bhatt*, 15-883.

Discussion: *Amanita parvipantherina* belongs to *Amanita* subgenus *Amanita* sect. *Amanita*. It is characterized by its small to medium sized basidiocarps, pileus light brown to brown covered by white conical to granular warts of universal veil remnants with tuberculate-striate, non appendiculate margin, lamellae white, stipe white with subglobose bulb, universal veil at stipe base in form of white granular warts, partial veil thin, superior, membranous, white and broadly ellipsoid to ellipsoid, nonamyloid basidiospores.

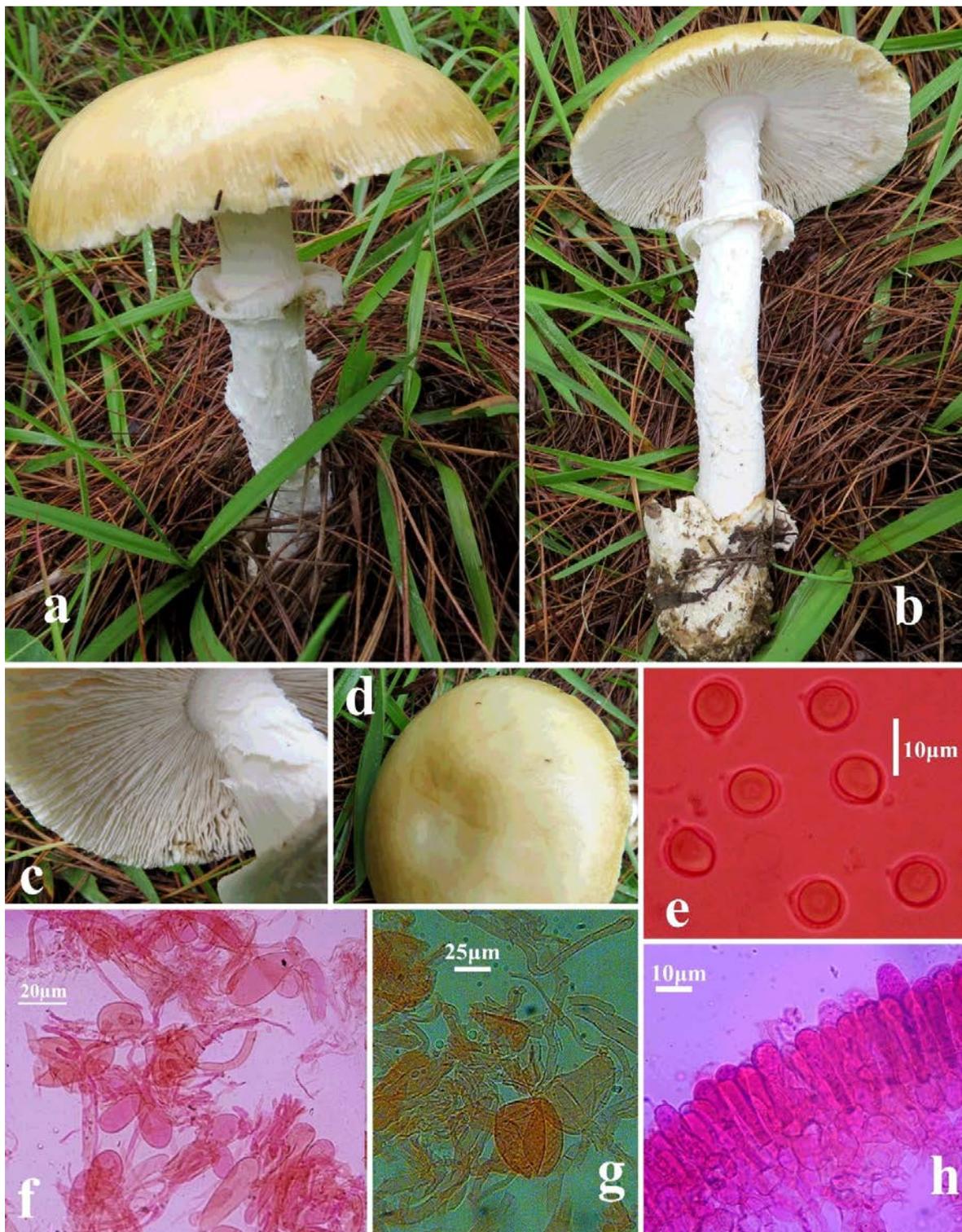
In the field, *A. parvipantherina* can be mistaken for *A. pantherina* (DC.) Krambh. but differs from *A. pantherina* by its smaller light brown basidiocarps. It is also somewhat similar to *A. sychnopyraxis* f. *subannulata* Hongo but differs from the latter by its somewhat smaller basidiocarps with a superior annulus (Hongo 1971).

***Amanita princeps*** Corner & Bas, Persoonia 2: 297, Plate 10; Fig. 51(1962).

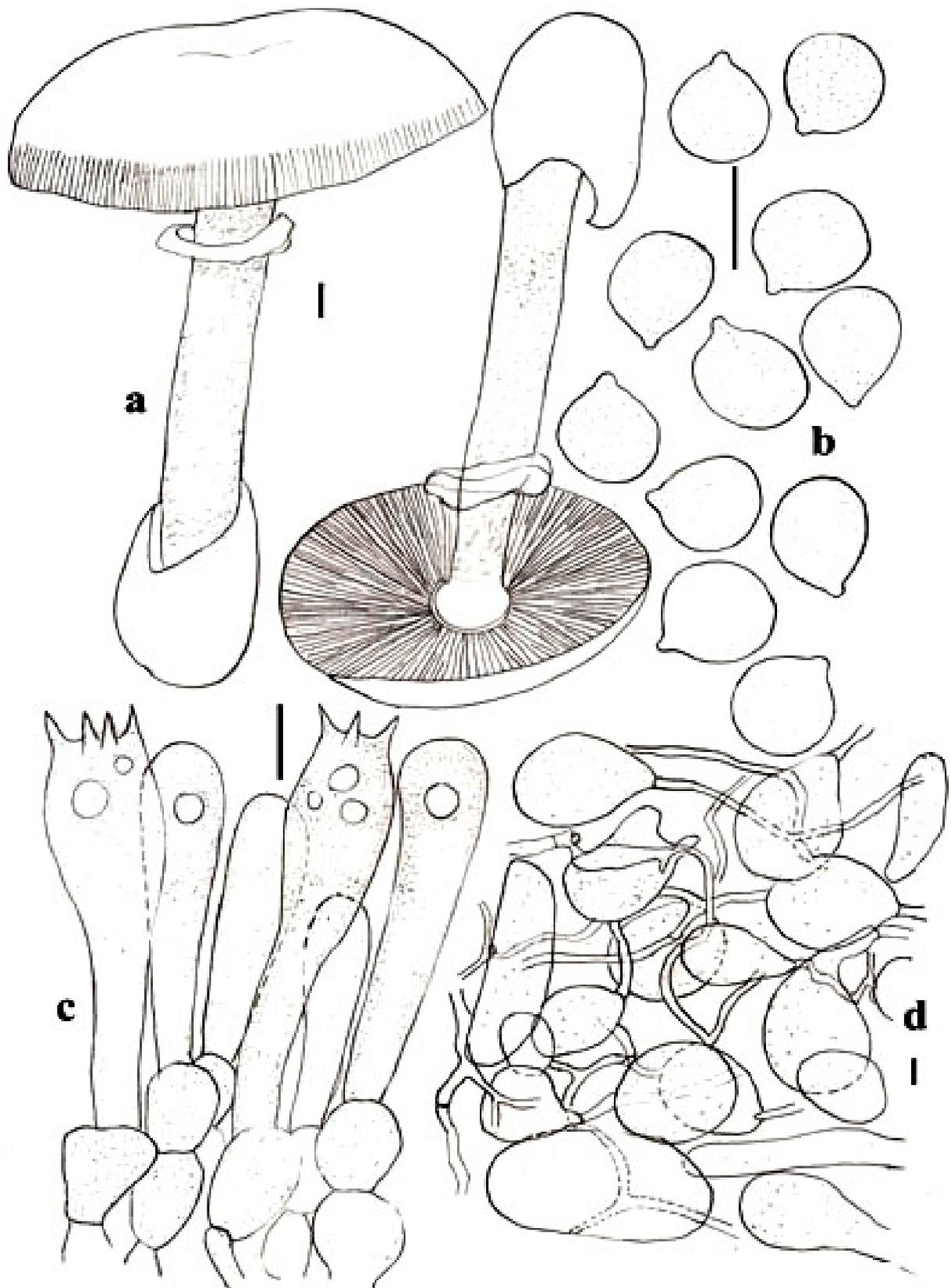
Figs 11, 12

Basidiocarps medium to large-sized. Pileus  $80\text{--}135 \text{ mm}$  wide, initially ovoid, then convex to plano-convex, sometimes slightly depressed at centre, without an umbo, yellowish white (1A2) to light yellow (1A2-3) at centre, paler towards margin, viscid when moist, shining. Context  $5\text{--}12 \text{ mm}$  thick, thinning slowly towards margin, whitish, unchanging when cut or bruised. Margin sulcate-striate, striations up to  $30\text{--}40 \text{ mm}$ , non-appendiculate. Universal veil on pileus usually absent. Lamellae free, crowded ( $6\text{--}8 \text{ L/cm}$ ), white, unchanging when cut or bruised. Lamellulae truncate, of several lengths, abundant, unevenly distributed. Stipe  $150\text{--}225 \times 12\text{--}19 \text{ mm}$ , slightly tapering upwards, white covered by yellow white (1A2) fibrillose above and below annulus. Context white, stuffed, unchanging when cut or bruised. Partial veil superior to subapical, thin, white (1A1). Universal veil saccate,  $35\text{--}70 \times 25\text{--}32 \text{ mm}$ , membranous, both surfaces white (1A1) to whitish, often cracking into thin patches. Odour indistinct. Taste not recorded. Spore print white.

Basidiospores ( $9\text{--}$ )  $9\text{--}11.5\text{--}12.5 \times (8\text{--}) 8.5\text{--}9.5\text{--}10 \mu\text{m}$ , ( $L = 9\text{--}12 \mu\text{m}$ ;  $L' = 10.35 \mu\text{m}$ ,  $W = 8\text{--}9.5 \mu\text{m}$ ;  $W' = 9.56 \mu\text{m}$ ;  $Q = (1.02\text{--})1.05\text{--}1.22\text{--}1.26$ );  $Q = 1.12\text{--}1.22$ ;  $Q' = 1.15$ ), hyaline, thin walled, smooth, non-amyloid, globulose to subglobulose, sometimes broadly ellipsoid, apiculus up to  $1 \mu\text{m}$  long; contents monoguttulate. Basidia ( $44\text{--}$ )  $52\text{--}58\text{--}60 \times (12.5\text{--}) 13.5\text{--}14\text{--}15 \mu\text{m}$ , clavate to pyriform, 4-spored, with sterigmata up to  $3.5\text{--}4 \times 1\text{--}1.5 \mu\text{m}$  long. Clamp connections often present. Lamellar trama bilateral divergent, mediostratum  $26\text{--}38 \mu\text{m}$  wide, filamentous hyphae  $2\text{--}7 \mu\text{m}$  wide, branching, hyaline, thin-walled, with terminus cells clavate to cylindrical  $37\text{--}62 \times 21\text{--}27 \mu\text{m}$ , vascular hyphae rare. Subhymenium  $30\text{--}40 \mu\text{m}$  thick, 2–3 layers of subglobose to ellipsoid cells,  $12\text{--}18 \times 8\text{--}14 \mu\text{m}$ . Pileipellis  $120\text{--}155 \mu\text{m}$  thick, 2-layers, upper layer  $50\text{--}70 \mu\text{m}$  thick, filamentous hyphae  $2\text{--}6 \mu\text{m}$  wide, slightly gelatinized, hyaline, thin walled; lower layer  $70\text{--}85 \mu\text{m}$  thick, filamentous hyphae  $4\text{--}12 \mu\text{m}$  wide, non- intracellular yellowish brown intracellular



**Fig. 11** – *Amanita princeps*. a–d Fresh basidiocarps in the field. e Basidiospores. f Elements of partial veil. g Elements of universal veil from stipe base. h Hymenium & subhymenium; Scale bars: e & h= 10  $\mu\text{m}$ . f= 20  $\mu\text{m}$ ., g= 25  $\mu\text{m}$ .



**Fig. 12** – *Amanita princeps*. a Basidiocarps. b Basidiospores. c Hymenium & subhymenium. d Elements of partial veil; Scale bars: a = 10 mm. b–d = 10  $\mu$ m.

pigment. Pileus context filamentous hypha 4–9 µm wide, thin-walled, hyaline, acrophysalides up to 57 × 14 µm, thin-walled. Lamellar edge cells sterile, with inflated cells subglobose or pyriform, 18–35 × 14–24 µm, colourless, abundant. Partial veil composed of filamentous cells, 2–5 µm wide with clusters of inflated cells; clavate, pyriform or ovoid cells 24–40 × 16–29 µm. Universal veil *on stipe base* filamentous hyphae 3–6 µm wide, branching, hyaline, thin-walled; subglobose to cylindrical cells 25–94 × 22–40 µm, hyaline thin-walled. Stipe trama longitudinally acrophysalidic; filamentous hyphae 3–6 µm wide, branching, hyaline, thin-walled; acrophysalides cells up to 140 × 30 µm. Partial veil filamentous hyphae 2–6 µm wide, hyaline, occasionally with intracellular yellow pigment, thin-walled, with clavate to ellipsoid cells, 20–48 × 14–44 µm, colourless, hyaline; globose to subglobose cells up to 45–102 × 38–96 µm. Stipe context longitudinally acrophysalidic; filamentous hyphae 4–9 µm wide, acrophysalidic dominating, (110–160 × 37–46 µm). Clamp connections often present.

Habit and Habitat – Solitary-scattered. Under *Pinus roxburghii* in subtropical to temperate coniferous forest.

Known distribution – This species was originally described from Singapore. It seems to be common in China (Yang 2007, Sanmee et al.2008). It is recorded and described in detail for the first time from India.

Specimens examined – *Hariyali devi* 1651 m, N30°15.955' E79°03.719', 27<sup>th</sup> July 2015, *T. Mehmood & R.P. Bhatt* 15-757; *Hariyali devi* 26<sup>th</sup> July 2016, *T. Mehmood & R.P. Bhatt* 16-1224.

Discussion – In the field, *Amanita princeps* belongs to the *Amanita* subg. *Amanita* sect. *Caesareae*. It is characterized by its yellowish brown pileus, universal veil often cracking into thin patches and globose to subglobose basidiospores.

In the field *Amanita princeps* can be mistaken for *Amanita caesarea* (Scop: Fr.) Pers. (described from Europe) has a shorter stipe, shorter marginal striations on the pileus, and ellipsoid spores (Breitenbach & Kranzlin 1995). *Amanita princeps* might be confused with *A. hemibapha* var. *ochracea* Zhu L. Yang (Yang 1997) (originally described from China); however, the latter has a pileus that is brown over the centre, ochraceous toward margin. The latter also differs by its white colour lamellae with yellowish brown edges (Yang 1997). *Amanita hemibapha sensu* (Berk. & Broome) Sacc. [known from Sri Lanka and southern India] differs from *Amanita princeps* by its pileus which may often lack an umbo (Berkeley & Broome 1871, Vrinda et al. 2005, Sanmee 2008), yellow stipe covered with brighter colored, appressed fibrillose scales, yellow to yellowish lamellae with bright color edges (Corner & Bas 1962). *Amanita princeps* differs from *Amanita javanica* by its yellow to orange-yellow pileus (Oda et al.1999). *Amanita princeps* is a common edible wild mushroom in northern Thailand (Sanmee et al. 2008) and also consumed in different parts of Uttarakhand Himalaya.

### Key to the species

1. Basidiocarps small to medium.....2
- 1a. Basidiocarps medium to large.....5
2. Partial veil thin, membranous, white or slightly yellowish, pendent.....3
- 2a. Partial veil absent.....4
3. Pileus pinkish or reddish white to pale red at center, becoming white toward margin; lamellae white or slightly pinkish with age; stipe white to yellowish white, covered with finely fibrillose squamules; partial veil thin, membranous, white or slightly yellowish, skirt-like; universal veil at stipe base white, membranous, bilimbate and basidiospores 8–9 × 7.5–8 µm, globose to subglobose, amyloid.....*A. pallidorosea*
- 3a. Pileus light brown to brown; universal veil on pileus as white, conical to granular warts; lamellae white; stipe white covered with white fine fibrils; basal bulb subglobose, white; partial veil superior, pendent, thin, membranous, white; universal veil at stipe base white, granular warts and basidiospores 9.5–11 × 7.5–8.5 µm, broadly ellipsoid to ellipsoid non-amyloid.....*A. parvipantherina*

4. Pileus grey to greyish brown, darker over disc, becoming paler toward margin, universal veil remnants on pileus as dark grey felty patches, lamellae greyish white to grey; stipe greyish white covered by grey fibrillose squamules, basal bulb lacking; volval remnants on stipe base grey to dark grey felty to verrucous and basidiospores  $9.5\text{--}13 \times 9\text{--}12.5 \mu\text{m}$  .....*A. griseofolia*
- 4a. Pileus brownish orange to golden brown over centre, yellowish brown to reddish golden toward margin; lamellae white to cream with brownish orange edges; stipe initially white then brownish orange covered with reddish golden squamules; universal veil at stipe base saccate, membranous, white to whitish, with many brown spot on exterior surface and basidiospores  $12\text{--}14 \times 11.5\text{--}12.5 \mu\text{m}$ .....*A. orientifulva*
5. Pileus red to orange-red at centre, yellowish orange toward margin; lamellae free pale yellow to light yellow; stipe light yellowish to pale yellow; partial veil yellowish, universal veil as white saccate volva and basidiospores  $8.5\text{--}9.5 \times 7\text{--}8 \mu\text{m}$  .....*A. caesareoides*
- 5a. Pileus yellowish white to light yellow at centre, paler towards margin, lamellae white; stipe white covered by yellow white fibrillose, universal veil white, saccate volva often cracking into thin patches and basidiospores  $9\text{--}11.5 \times 8.5\text{--}9.5 \mu\text{m}$ .....*A. princeps*

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