



The genus *Floccularia* (Agaricaceae, Basidiomycota) in India

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Abstract

The present study was undertaken to understand and explore the diversity of genus *Floccularia* collected from the forests of South Kashmir (India). This genus was not earlier reported by any mycologist from India. For the investigation of these fungi, fungal forays were undertaken especially in the spring, summer and autumn season to various forests in South Kashmir, India. These forays resulted various taxa of the genus *Floccularia*. The investigated taxa were identified as *Floccularia straminea* f. *alba*, *F. straminea*, *F. luteovirens*, *F. pitkinensis* and *F. straminea* var. *americana*. The morphoanatomical characteristics of these taxa were studied. In this paper the taxonomic description, distribution and habitat of the collected *Floccularia* have been discussed.

Key words – Fungi – South Kashmir – Taxonomy – Taxonomic Key

Introduction

India has various dominated forests, exhibits incredible habitat for uncommon, unreported and unnoticed lamellate fungi. The studied zones were dominated by conifers other than numerous broad leaved trees. Agarics develop on various substrates, for example, manure, dead or living wood, termite slopes, needle litter, humicolous soil, ectomycorrhizae links, and so forth. In light of their natural surroundings, they are foliocolous, lignicolous, humicolous, coprophilous, terrestrial or in ectomycorrhizal association (ECM) with diverse conifer representatives, especially with family *Pinaceae*. In this way they are diversified and cosmopolitan in occurrence. During fungal invasions attempted to woods of South Kashmir of India, planned approaches and knowledge of the gathered family particularly *Floccularia* Pouzar were noted down along with their distribution, ecology and ectomycorrhizal affiliations. Genus *Floccularia* Pouzar has a medium to enormous measured basidiocarps, typically not growing up out of black rhizomorphs. Pileus is convex to applanate, secured with a group of flaky and scruffy scales; gills adnate to adnexed, even emarginate – sub free or sinuate, never decurrent; stipe central, shaggy, hulking, veil generally very much developed, for the most part forming flak and scarf annulus on the stipe; volva missing; spore print white to tinged yellow; basidiospores ellipsoid, smooth, finally amyloid. Hymenophoral trama is regular. Cystidia is absent. Pileus a cutis consists trichodermal hyphae. Clamp connections are present. The habit and habitat is agaricoid, terrestrial, growing single or dissipated on soil and are generally found in mycorrhizal association. The distribution of this genus is cosmopolitan, mostly growing in temperate to high alpine habitats (Singer 1986, Kirk et al. 2008).

Genus *Floccularia* possesses partially the aspect of an *Amanita* but the type and quality of bilaterality, notably its development and hyphal network, is distinct from that of the *Amanitaceae* sensu stricto, and the resemblance of the genus *Floccularia* is somewhat with *Catathelasma* or *Armillaria* than *Amanita*. It is unusual from *Armillaria* by bearing fully amyloid basidiospores and ectomycorrhizal associations. All other *Tricholomataceae* with bilateral trama have mycenoid, Collyboid or Omphaloid habit, or else pink basidiospores, and the anatomy of the examining layers of the pileus is altogether different. *Armillaria*, as noted by Singer (with type species *Agaricus luteovirens*), consisted of a genus of mycorrhizal species with amyloid basidiospores and a divergent lamellar trama. Accepting *Armillaria* left the taxon observed by Singer nameless until Pouzar (1957) erected this genus *Floccularia* to accommodate *Agaricus luteovirens* as limited out by Bon (1990). The world over 06 species of genus *Floccularia* are recognized so far (Kirk et al. 2008), conferring to Mycobank (2020) presently, this genus is known by 14 species the world over. The main workers on this genus are Pouzar (1957), Bon (1990), Moser et al. (1998), Moser & Peintner (2005), Lange (2008), Kujawa & Gierczyk (2013), Phillips (2013), Xing et al. (2017), and Xie et al. (2015, 2016). This genus wasn't accounted from India. Present study documents 5 species of *Floccularia* from India for the first time.

Materials & Methods

Isolates and morphology

Study area

The Jammu and Kashmir is the North-western state of India, represented by three geographical divisions viz. Jammu, Kashmir and Ladakh. The Kashmir valley lies between 32°17' and 36°58'N latitude and 73°26' and 80°30'E longitude, covering an area of 15,948km² which is bounded in the North by the Great Himalayas and separated from the plains of Northern India by the Pir Panjal range which extends 2621km in length and 50km in width (Qazi 2005). It is rich in forests and occupying 51% of its total geographic area (Anon 1996). Presently, South Kashmir was selected for undertaking the studies on the diversity of agarics. Politically, South Kashmir comprised of districts viz. Kulgam, Anantnag, Pulwama and Shopian. Geographically it is bounded with tehsils of Reasi, Banihal and Kishtwar of Jammu province, and eastern zone with tehsils of Kargil and Ladakh division. Geographically South Kashmir lies between 33°-20' to 34°-15'N latitude and 74°-30' to 75°-35'E longitude with altitude ranging between 1700 to more than 3048m and average annual rainfall 100-155mm. In this area the agaric diversity is rich as it has varied type of topography, climate and rich vegetational zones, consisting rich forests that provides perfect habitat for agaric growth and their ectomycorrhizae. Being rich and unexplored in fungal diversity this area was presently investigated. The data with respect to the fungal forays planned to various localities and sub localities of South Kashmir along with their location (Latitude & Longitude), altitudinal range and forest type surveyed is summarized in Table 1, Fig. 1. The forests of South Kashmir are rich in plant diversity, relative humidity, sunshine, moisture content, temperature variation, precipitation and other climatic conditions. Thus, exhibit great variation in composition with difference in latitude and elevation of different altitudinal and vegetational zones, which makes this geographical region a natural hub and favorable place for the growth of diverse agarics. Every 1000 feet of altitude of Kashmir valley brings new phase of climate and vegetation to this area and the climatic variations are determined at micro-level (Lawrence 1967). The agaric diversity in this particular region is mainly determined by the climate and the vegetation of an area. Vegetation, in general, is largely determined by geology, soil and climate of the region (Champion & Seth 1968). A brief account of the topography, geology, climate and vegetation of the present area of investigation.

Table 1 Distribution, habitat, seasonal availability and putative ECM association of investigated taxa

Name of genus and species	Locality (Altitude)	Date of collection	Growing habit	Habitat / ECM association	Edibility	Herbarium numbers
Genus <i>Floccularia</i> Pouzar						
<i>F. luteovirens</i>	Hallan Manzgam (2658m)	17 July, 2013	Solitary	Coniferous forest, leaf litter of <i>Cedrus deodara</i>	Edible	PUN 9011
	Bangiward (2600m)	20 August, 2015	Solitary	Coniferous forest, putative ECM association with <i>Cedrus deodara</i>		PUN 9012
<i>F. pitkinensis</i>	Tangmarag (2780m)	6 August, 2014	Groups in a linear row	Coniferous forest, needles of <i>Cedrus deodara</i>	Unknown	PUN 9013
<i>F. straminea</i> f. <i>alba</i>	Aharbal (2600m)	11 June, 2015	Groups	Coniferous forest, under <i>Picea smithiana</i>	Unknown	PUN 9014
<i>F. straminea</i> var. <i>americana</i>	Hallan Manzgam (2695m)	17 July, 2013	Solitary	Pure coniferous forest, under <i>Pinus wallichiana</i>	Unknown	PUN 9015
<i>F. straminea</i>	Tangmarg (2500m)	3 August, 2014	Solitary	Pure coniferous forest, under <i>Pinus wallichiana</i>	Edible	PUN 9016
	Verinag (2300m)	11 August, 2015	Solitary	Coniferous forest, ECM association with <i>Pinus wallichiana</i>		PUN 449

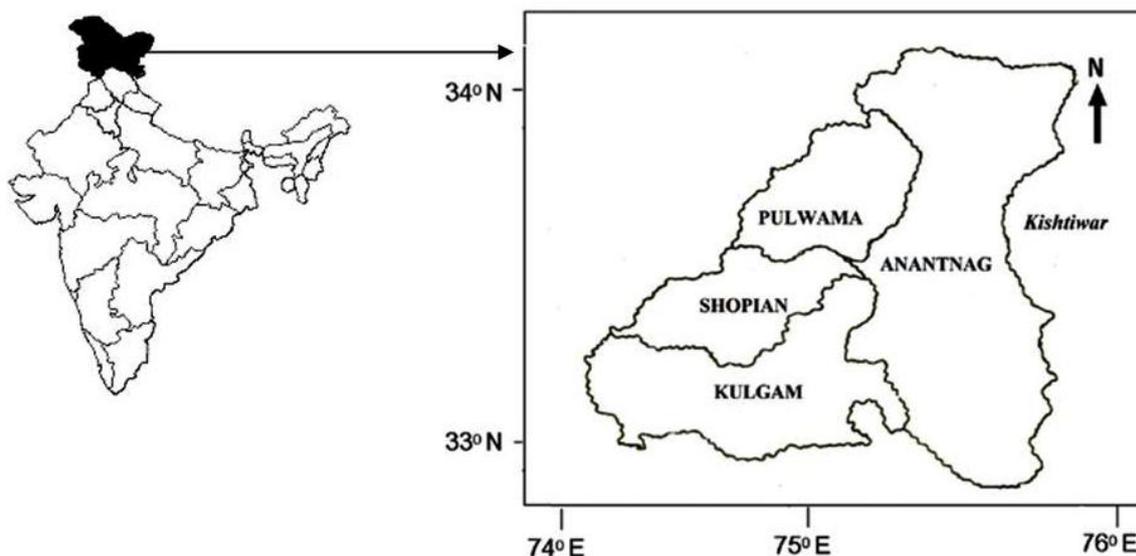


Fig. 1 – Magnified Map depicting South Kashmir, India (statistical analysis of GPS trace data; Malik, 2018)

Collection of material

The basidiocarps collected for the purpose of taxonomic studies were fresh and healthy and wherever possible the whole ranges of developmental stages were collected. The primary data with

respect to the locality, its latitude, longitude, altitude, habit, soil types, soil pH, forest type along with the date of collection and the field photograph numbers were noted down on the field key in the field itself. A collection kit with accessories like knife for digging out the fruit bodies of agarics, waste newspaper for wrapping the collections, camera for taking the photographs of the basidiocarps in the natural habitat, hand lens for critically noting down the morphological characters of the basidiocarps was taken in the field along with pen, pencil, scale and the field keys. Care was taken to place the robust and sturdy basidiocarps at the base of the collection bag and to wrap the collection securely in separate waste paper so as to avoid mixing of the fruit bodies. Every effort was made to interact with the local people with a mind to collect the ethnomycological data regarding the particular agaric collected from the site. The collections were taken to the temporary laboratory set up where they were further analysed, dried and packed.

Morphological observations

Morphological characteristics of the basidiocarps such as shape, size, colour, cap margin, presence or absence of universal veil, annulus, volva, gill attachment, colour changes of various basidiocarp parts, and other details such as taste, odor of flesh, habitat were noted down as per the standard format given by Atri et al. (2005, 2017). Kornerup & Wanscher (1978) was used for the colour terminology in the basidiocarps.

Spore print

For the purpose of noting down the colour of the spore print which is an important taxonomic character, white coloured reference cards measuring 13.5×5.0 cm were used. To take the spore print, a mature, fresh and healthy fructification was selected. The pileus of the selected basidiocarps was separated from the stipe by giving a transverse cut just near its point of attachment to the stipe. This separated cap or a piece of the pileus was then placed on the white paper (13.5×5.0 cm size), marked with the appropriate collection number. A water soaked cotton plug was placed near the spore print paper, in order to provide humidity for the pileus to remain turgid. The spore print paper along with cotton plug was covered with a petridish. Time required to get a thick spore print is more in case of smaller agarics with thin texture as compared to the larger fleshy basidiocarps.

Drying and preservation

A small portion of the material was preserved in the liquid preservative (25 ml Rectified alcohol + 5 ml Formalin + 70 ml distilled H₂O; Hawksworth et al. 1995) for the purpose of conducting microscopic studies. The major portion of the same collection was hot air dried. For this purpose a folding three chambered portable wooden drier especially designed for this purpose was used (Atri et al. 2005, 2017). The small, delicate and fragile specimens were put in the upper chamber while larger ones were dried in the lower and middle chamber of the drier. Specimens were dried slowly at a temperature less than 45°C. Finally, the dried sample was packed in the cellophane sheets with appropriate label and crystals of 1, 4 para-dichlorobenzene (Smith 1949). The standard herbarium bond paper of 15×12 cm size was used to wrap the cellophane packet and pasted with relevant information about each specimen. The packets were vertically put in the cardboard boxes, so as to avoid damage due to the pressure to the specimen. All the collections examined were deposited in the Herbarium of Botany Department, Punjabi University, Patiala under PUN, an abbreviation allotted by the International Bureau for plant taxonomy and nomenclature of the International association for plant taxonomy, Netherlands (Holmgren & Keuken 1974) to the Herbarium of Botany Department, Punjabi University, Patiala. Jayasiri et al. (2015) was followed to register Facesoffungi numbers.

Chemical reactions

The chemical reactions play a major role in the taxonomic observations and identification of gilled fungi. In addition to the morphological characteristics, the chemical reactions were carried

out for the characterization of basidiocarps. These reactions were performed on the surface of the fresh fruiting body as well as for its anatomical details such as:

1. Melzer's Reagent or Iodine Test: [Potassium iodide (1.5 g) + Iodine(0.5 g) + Distilled water (20 ml)+ Chloral hydrate (22.0 g)]. In this reagent amyloidy i.e. wall of the basidiospore turns bluish black or inamyloidy i.e. no change. The walls of basidiospores of *Floccularia* show positive reactions when stained with this reagent.

2. Congo red [Congo red (2 g)+Distilled Water (100 ml)]: The Camera Lucida drawings become easy and clear when the tissue is stained with this chemical.

Microscopic observations

Microscopic observations are a very important component of the taxonomy of agarics. For this purpose the microscopic observations were made under the compound microscope either by making whole mounts of the basidiospores or by cutting the free hand sections of the cap, stipe and gills of the mushroom. The free hand sections were stained either in Cotton blue or Congo red and the internal details of the pileus cuticle, stipe cuticle, trama of the hymenophore and various cystidial elements were observed.

Results

Floccularia straminea f. *alba* (A.H. Sm.) Bon, Doc. Mycol., 20 (79): 57, 1990. Figs 2–4

Mycobank number: 127243; Facesoffungi number: FoF08768

Basidiocarps 2.5–5.0 cm in height. Pileus 1.5–8.0 cm broad, convex while young, flattened depressed at maturity; surface, yellow orange (4B₇) with orange (5B₇) centre in young basidiocarps, pale yellow (2A₃) with grayish orange (5B₄) tinge in the centre in mature basidiocarps, fading to white with age; scaly, scales appressed fibrillose, pale yellow (2A₃), fading to white with age; margin irregular, splitting at maturity; viscid, glabrous, dry at maturity; cuticle fully peeling; flesh up to 1.0 cm thick, white, unchanging; taste and odour mild. Pileal veil appendiculate, cortinoid in young basidiocarp, yellow fading to white. Lamellae up to 1.9 cm broad, adnate, unequal, crowded, forked near the margin, yellow white (2A₂), edges fading to white, lamellulae present; gill edges fimbriate. Stipe central, 2.0–4.5 cm in length, up to 1.0 cm broad near the apex, up to 0.5 cm broad near the base, tapering downwards, somewhat clavate; concolourous with pileus, vivid yellow (3A₈), unchanging, smooth and cracked above annulus; scaly, fibrillose reticulate, pale yellow (2A₃); semisolid; annulate, annulus single, superior, scaly underneath, yellow to white. Basidiospores 5.6–8.0 × 4.0–5.6 μm (excluding apiculus), Q =1.4, ellipsoidal, granular, single walled, strongly amyloid; apiculate, apiculus up to 0.83 μm long. Basidia 24.0–32.0 × 3.2–4.8 μm, clavate, tetrasterigmate, sterigmata 1.6–3.2 μm long. Hymenophoral trama regular. Gill edge fertile. Pleurocystidia and cheilocystidia absent. Pileus cuticle hyphal, ixocutis, made up of 3.2–6.4 μm broad, horizontally placed, hyaline, septate hyphae, giving rise to 4.0–8.0 μm broad, septate, hyaline, regular turf of hyphae; context hyphal, made up of 6.4–9.6 μm broad, septate, hyaline hyphae intermingled with hyaline cells. Stipe cuticle hyphal, made up of 3.2–7.2 μm broad, longitudinally placed, septate, hyaline hyphae; context hyphal, made up of 7.2–9.6 μm broad, septate, hyaline hyphae. Clamp connection present throughout.

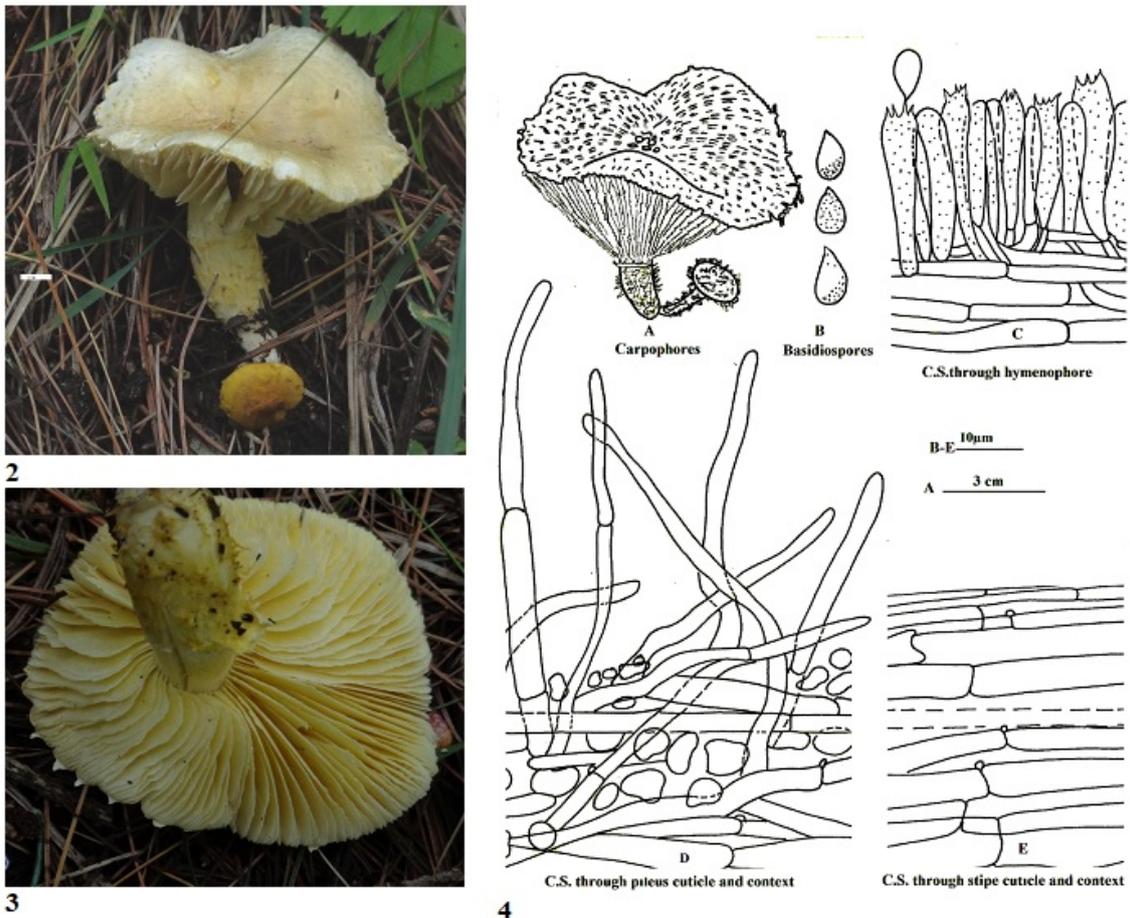
Chemical reactions – The stipe of basidiocarps shows negative reaction with FeSO₄ i.e. no colour change with FeSO₄.

Collection examined – India, South Kashmir, Aharbal (2600m), 33°35.728'N- 074°59.727'E, growing groups under *Picea smithiana* in pure coniferous forest, 11th June 2015, Nazir Ahmad Malik, PUN 9014.

Edibility – Unknown.

Distribution and habitat – Mitchel & Smith (1976) have found *Floccularia straminea* f. *alba* in mycorrhizal association with scattered Aspen grooves, alder and maple in Colorado. Presently, examined collection was found growing in caespitose clusters under *Picea smithiana* in pure coniferous forest in the month of June at an altitude of 2000m.

Notes – All the external and internal details of the present collection accedes with the descriptions provided for *Armillaria albolanaripes* f. *alba* by Mitchel & Smith (1976). Presently, some species of genus *Armillaria* stands shifted to genus *Floccularia* (Volk & Burdsall 1995). *Floccularia straminea* f. *alba* (A.H. Sm.) Bon is a white ('albino') form which is characteristic in all the basidiocarp parts fading from grey yellow to white in age, cap surface glabrescent viscid becoming dry towards maturity also this taxa gives a negative reaction with FeSO₄. *F. straminea* var. *americana* (Mitchel & A.H. Sm.) Bon is an allied species but in this variant the basidiocarps although yellow never becomes white with age and its flesh changes to yellow on exposure (Kuo 2006) whereas it is unchanging in this variant. *Floccularia straminea* f. *alba* is reported as new records to India.



Figs 2–4 – *Floccularia straminea* f. *alba*. 2 Basidiocarp flattened depressed with yellow orange surface growing in natural habitat. 3 Underside view of cap bearing yellow white lamellae with fimbriate edges. 4 Camera Lucida drawings (A-E)

Floccularia straminea (Krombh.) Pouzar, *Ceská Mykologie* 11 (1): 49, 1957.

Figs 5–7

Mycobank number: 330945; Facesoffungi number: FoF 08769

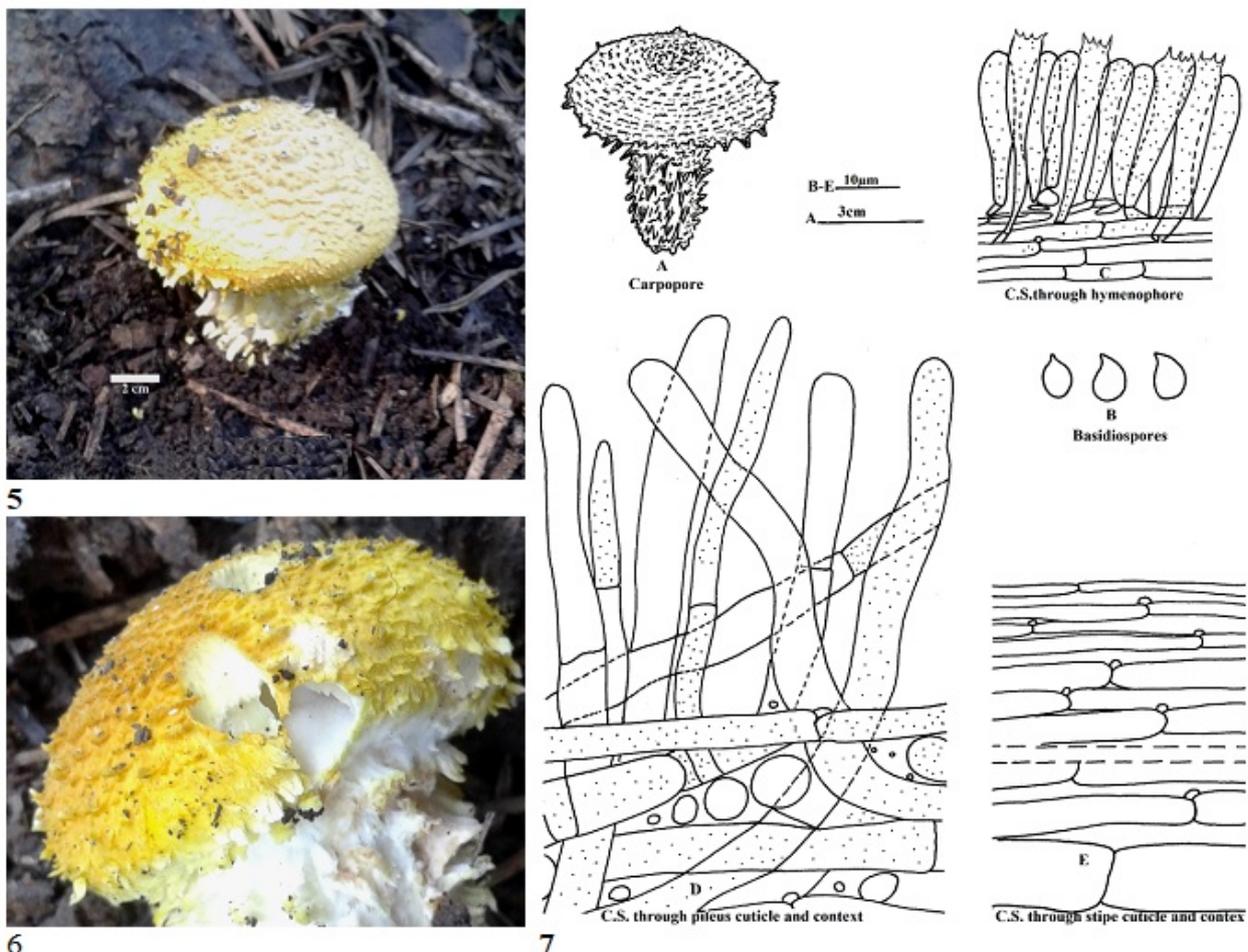
Basidiocarps 5.0–6.0 cm in height. Pileus 3.5–6.2 cm broad, obtuse to convex, appanate at maturity; umbonate, umbo acute, brownish orange (5B₄); surface, vivid yellow (3A₈), grayish yellow (2B₅), fading to dull white at maturity; scaly, scales, appressed fibrillose, recurved with dirty white tips, floccose, covering the entire pileus in concentric rings, yellow (3B₈), grayish yellow (1B₈) at maturity; margin involute while young, regular; moist, hygrophanous; dry at maturity; cuticle fully peeling; flesh up to 0.5 cm thick, white, changing to yellow on exposure; taste mild; odour disagreeable. Pileal veil cortinoid, scaly, appendiculate at maturity. Lamellae 0.2–1.5 cm broad in the centre, adnate, free to adnexed at maturity, unequal, close, white (1A₁) with yellow shade of pileus, unchanging, lamellullae present; gill edges smooth, dentate at maturity.

Stipe central, 4.0–5.5 cm in length, up to 0.5 cm broad above, up to 1.0 cm broad in middle, up to 1.5 cm broad near the base, obclavate; white (2A₁) to grayish yellow (2B₃), changing to pale red (7A₃) on exposure while young; scaly, scales reticulate, fibrillose, white with yellow tips; solid; annulate, annulus single, scaly, scales fibrillose. Basidiospores 4.98–8.3 × 3.32–4.98 μm (excluding apiculus), Q = 1.4, ellipsoidal, hyaline to granular, single walled, strongly amyloid; apiculate, apiculus up to 0.83 μm long. Basidia 25.0–40.0 × 5.0–6.64 μm, clavate, granular, tetrasterigmata; sterigmata 1.6–2.4 μm long. Gill edge sterile. Pleurocystidia and cheilocystidia absent. Pileus cuticle hyphal, ixocutis, made up of 4.8–6.4 μm broad, horizontally placed, granular, septate hyphae, giving rise to 4.8–8.0 μm broad, septate, hyaline to granular, regular turf of hyphae with somewhat inflated tips; context hyphal made up of 4.8–9.6 μm broad, septate, granular, hyphae intermingled with granular cells. Hymenophoral trama regular bears inconspicuous clamp connections. Stipe cuticle hyphal, made up of 3.2–5.6 μm broad, longitudinally placed, septate, hyaline hyphae; context hyphal, made up of 6.4–12.8 μm broad, septate, hyaline hyphae. Clamp connection present throughout.

Chemical reactions – The basidiocarp stipe does not show any reaction with FeSO₄.

Collection examined – South Kashmir, Tangmarg (2500m), 33°34.219'N–075°00.540'E, growing solitary in soil under *Pinus wallichiana* in pure coniferous forest, 3rd August 2014, Nazir Ahmad Malik PUN 9016. India, Kulgam, Verinag (2300m), growing solitary in ECM association with *Pinus wallichiana* in coniferous forest 11th August 2015, PUN449.

Edibility – Arora (1986) mentioned *Floccularia straminea* (as *Armillaria straminea*) as a popular edible mushroom of Colorado.



Figs 5–7 – *Floccularia straminea*. 5 Basidiocarp obtuse to convex with brownish orange surface, growing solitary. 6 Cap with yellow appressed, fibrillose, recurved scales covering the entire pileus in concentric rings. 7 Camera Lucida drawings (A-E).

Distribution and habitat – According to Kuo (2006) *Floccularia straminea* is a mycorrhizal species, growing solitary, scattered, or gregariously in *Populus tremuloides* or in spruce-fir forests during summer to winter in the Rocky Mountains. Presently examined collections were found growing solitary in soil under *Pinus wallichiana* as well as in putative ECM association with *P. wallichiana* in pure coniferous forest of South Kashmir during August between an altitude ranging from 2300-2500m.

Notes – All the morphoanatomical details of the present population match and fits well with the descriptions of *Floccularia straminea* (Krombh.) Pouzar as described by Kuo (2006) and Arora (1986) as *Armillaria straminea*. This species was transferred from genus *Armillaria* to *Floccularia* on the basis of amyloid basidiospores and ECM association (Kuo 2006). The presently examined species is characterized by yellow obtuse cap with yellow scales, strongly amyloid basidiospores, absence of cystidia and having ECM association with *Pinus wallichiana*. It is a new record to India.

Floccularia luteovirens (Alb. & Schwein.) Pouzar, *Ceská Mykologie* 11 (1): 50, 1957. Figs 8–10
Mycobank number: 330944; Facesoffungi number: FoF 04985

Basidiocarps 7.5–9.0 cm in height. Pileus 8.0–10.5 cm broad, convex, flattened depressed at maturity; surface, light yellow (4A₅), grayish orange (5B₆) to orange (5B₈), brownish orange (5C₄), not fading to white; scaly, scales appressed fibrillose to recurved, squamose, pastel red (7A₃) with white shade, covering the entire pileus in concentric rings; margin regular; dry at maturity; cuticle fully peeling; flesh 0.5–0.6 cm thick, white, changing to yellow; taste and odour mild. Pileal veil cortinoid, appendiculate in age, white to yellow. Lamellae 0.5–1.5 cm broad, adnate to adnexed, unequal, subdistant to crowded, grayish yellow (3B₄); lamellulae present; gill edges serrate to dentate. Stipe central, 6.5–8.5 cm in length, 1.8 broad above to 4.0 cm broad below, equal in diameter throughout to sometime tapering above, almost cylindrical; concolourous with pileus, light yellow (4A₄), white near base, smooth and white above annulus; scaly, scales recurved fibrillose, light yellow (4A₅); solid; annulate, annulus double, scaly, fibrillose, light yellow (4A₅), fading to white at maturity. Basidiospores 4.8–6.4 (8.0) × 3.2–5.81 μm (excluding apiculus), Q = 1.4, ellipsoidal, hyaline to granular, single walled, strongly amyloid; apiculate, apiculus up to 0.83 μm long. Basidia 18.26–22.4 × 3.32–6.64 μm, clavate, tetrasterigmate; sterigmata 1.6–2.4 μm long. Gill edge sterile. Pleurocystidia and cheilocystidia lacking. Hymenophoral trama regular. Pileus cuticle hyphal, ixocutis, made up of 3.2–6.4 μm broad, horizontally placed, hyaline, septate hyphae, giving rise to regular turf of 3.2–6.4 μm broad, septate, hyaline, hyphae; context hyphal, made up of 4.8–8.0 μm broad, septate, hyaline hyphae intermingled with hyaline cells. Stipe cuticle hyphal, made up of 3.32–7.47 μm broad, longitudinally placed, septate, granular hyphae; context hyphal, made up of 5.0–9.13 μm broad, septate, granular hyphae. Clamp connection present throughout.

Chemical reactions – The cap does not shows any reaction with FeSO₄.

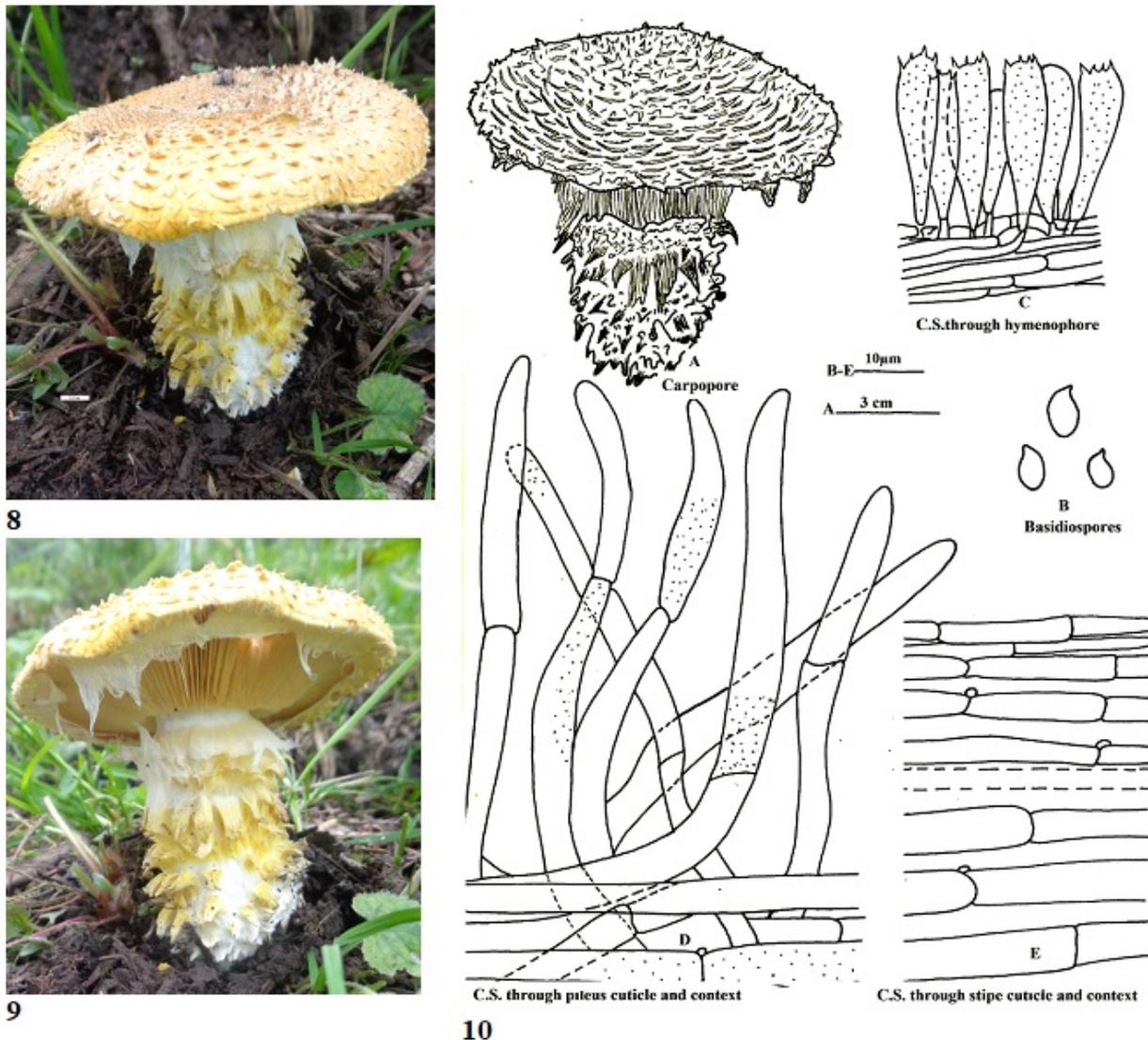
Collection examined – India, South Kashmir, Hallan Manzgam (2658m), 33°35.659' N – 074°50.805E, growing solitary on leaf litter of *Cedrus deodara* in coniferous forest, 17 July 2013, Nazir Ahmad Malik, PUN 9011; Bangiward (2600m), growing solitary in ECM association with *Cedrus deodara* in coniferous forest, 20 August 2015, Nazir Ahmad Malik, PUN 9012.

Edibility – *Floccularia luteovirens* is an edible mushroom (Xing et al. 2017).

Distribution and habitat – *Floccularia luteovirens* has been found growing in conifers or deciduous forests during late summer to autumn in Europe this species is not recorded from Britain (Phillips 2013). It is widely distributed in the Qinghai-Tibet Plateau (QTP), China, in association with *Kobresia humilis* (Xing et al. 2017). However, its presently examined populations were found growing solitary in leaf litter of *Cedrus deodara* as well as in ECM association with *Cedrus deodara* in coniferous forest during July to August between altitude of 2600 to 2680m.

Notes – In all the taxonomic details the presently examined collection match well with the description given for *F. luteovirens* (Alb. & Schwein.) Pouzar by Phillips (2013). This species is characterized in possessing a cap varying from light yellow (4A₅) to grayish orange (5B₆) or orange (5B₈) or brownish orange (5C₄) and covered with concentric rings of Pastel red (7A₃) scales, lamellae adnate to adnexed having serrate edges, amyloid basidiospores. In its appearance this

species is a look alike to *F. albonaripes* (G.F. Atk.) Redhead but can be distinguished on the basis of the presence of bright yellow colour in the cap and raised scales present on the cap as well as stipe, further the gills in *F. luteovirens* are yellowish which is not the case in *F. albonaripes* (Davis et al. 2012). *F. luteovirens* is new fungus record for India.



Figs 8–10 – *Floccularia luteovirens*. 8 Basidiocarp growing solitary on leaf litter of *Cedrus deodara*, flattened depressed with appressed fibrillose to recurved squamose scales. 9 Pileal veil cortinoid, appendiculate and lamellae with serrate to dentate edges. 10 Camera Lucida drawings (A-E).

Floccularia pitkinensis (Mitchel & A.H. Sm.) Bon, *Doc. Mycolog.* 20 (79): 57, 1990. Figs 11–13
Mycobank number: 127245; Facesoffungi number: FoF 08770

Basidiocarps 6.0–13.0 cm in height. Pileus 5.0–11.5 cm broad, convex to applanate when young, flattened depressed at maturity; surface, brownish grey (7C₂) to brownish orange (5C₃) with shades of light orange (5A₄); scaly, scales appressed fibrillose, grey (18B₁), covering the entire pileus; margin irregular, splitting at maturity; dry at maturity, glabrous; cuticle half peeling; flesh up to 1.2 cm thick, white, unchanging; taste and odour mild. Pileal veil appendiculate, dry, white. Lamellae up to 1.0 cm broad, adnate to adnexed, unequal, crowded, pale yellow (3A₂), fading to orange white (5A₂), lamellulae present; gill edges serrate. Stipe central, 4.0–9.0 cm in length, up to 3.0 cm broad, equal in diameter, cylindrical; off white to pale yellow (3A₃), smooth and white above annulus, scaly below, scales recurved pointed, fibrillose, white with yellow (2A₃) tips; solid;

annulate, annulus single, scaly, white with yellow tinges. Basidiospores (4.0) 4.8–6.4 (8.0) × 3.2–4.8 μm (excluding apiculus), Q =1.5, ellipsoidal, granular, single walled, strongly amyloid; apiculate, apiculus up to 0.83 μm long. Basidia 28.8–36.8 × 4.0–6.4 μm, clavate, granular, tetrasterigmate; sterigmata 1.6–2.4 μm long. Gill edge fertile. Hymenophoral trama regular. Pleurocystidia and cheilocystidia absent. Pileus cuticle ixocutis, made up of 3.2–6.4 μm broad, horizontally placed, granular, septate hyphae, giving rise to a regular turf of 3.2–7.2 μm broad, septate, hyaline, hyphae; context hyphal, made up of 3.2–8.0 μm broad, septate, hyaline hyphae intermingled with granular cells. Stipe cuticle hyphal, made up of 1.6–3.2 μm broad, longitudinally placed, septate, granular hyphae; context made up of 4.0–11.2 μm broad, septate, granular hyphae. Clamp connection present throughout.

Edibility – Unknown.

Collection examined – Jammu and Kashmir: South Kashmir, Tangmarag (2780m), 33°38.693N – 074°57.807E, growing groups in a linear row among the needles of *Cedrus deodara* in a coniferous forest, 6th August 2014, Nazir Ahmad Malik, PUN 9013.

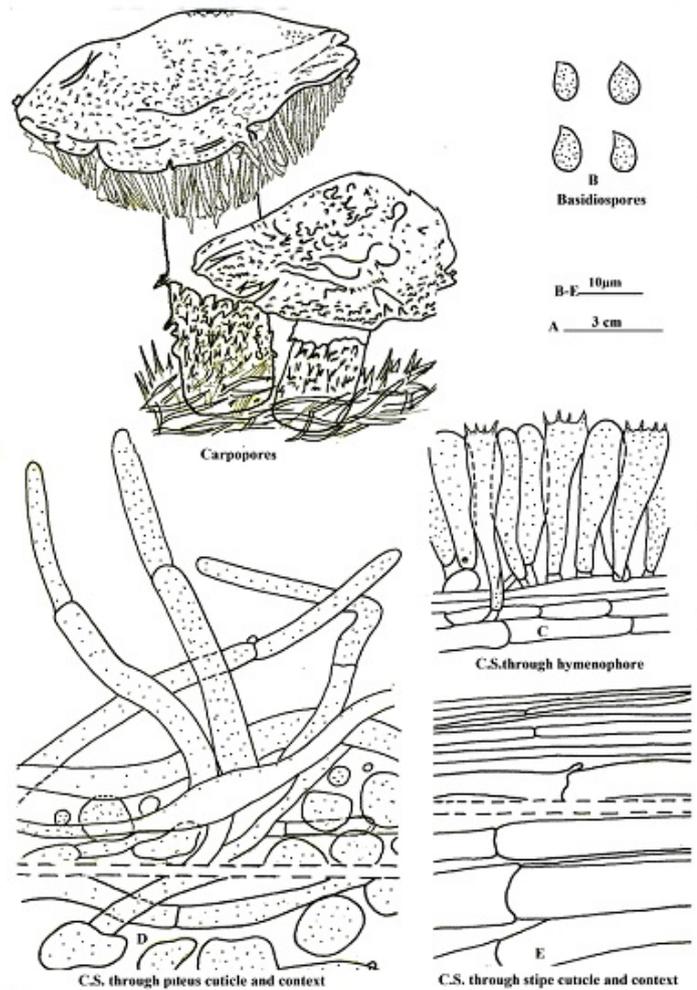
Distribution and habitat – *Floccularia pitkinensis* is an uncommon species found under conifers especially under Spruce and Fir in Colourado after the summer rains on the piles of old needles and cones described as *Armillaria pitkinensis* by Mitchel & Smith (1976). Presently examined collection was found growing on fallen needles of *Cedrus deodara* in coniferous forest of South Kashmir.



11



12



13

Figs 11–13 – *Floccularia pitkinensis*. 11 Basidiocarp in a linear row among the needles of *Cedrus deodara*. 12 Underside view of cap bearing pale yellow lamellae with serrate edges. 13 Camera Lucida drawings (A-E).

Notes – Presently examined collection is characterized by brownish grey (7C₂) to brownish orange (5C₃) with light orange (5A₄) cap consisting grey (18B₁) appressed fibrillose scales, glabrous surface when dry, gill edges entire and flesh unchanging and is growing in a linear row amongst the needles of *Cedrus deodara*. All these details agrees with the description given for *Floccularia pitkinensis* (Mitchel & A.H. Sm.) Bon under the name *Armillaria pitkinensis* by Mitchel & Smith (1976) and Arora (1986). Further, this species resembles with *Floccularia fusca* (Mitchel & A.H. Sm.) Bon (as *A. fusca*) but differs from it because in *F. fusca* no yellow colour is present on the cap where as in present collection their are shades of light orange. In comparison to another allied species *F. albolanaripes* the colour of cap is yellow to golden or brown at the centre which does not matches with the present specimen also the gills are pure white in *F. albolanaripes* while they are yellow in *F. pitkinensis* (Arora 1986, Mitchel & Smith 1976). *A. pitkinensis* later transferred to *F. pitkinensis* by Volk & Burdsall (1995). This species is first time reported from India.

Floccularia straminea var. *americana* (Mitchel & A.H. Sm.) Bon, *Doc.Mycolog.* 20 (79): 57, 1990. Figs 14–16

Mycobank number: 127240; Facesoffungi number: FoF 08769

Basidiocarps 8.0–10.0 cm in height. Pileus 4.0–6.0 cm broad, applanate; surface, yellow orange (4B₇), fading to dull cream white with brownish orange (6C₄) to grayish orange (5B₃) tones; scaly, scales recurved fibrillose near margin, yellow (4B₃); margin involute; dry, glabrous at age; cuticle half peeling; flesh up to 0.1 cm thick, white, changing to yellow on exposure; taste and odour mild. Pileal veil appendiculate, yellow fading to white at maturity. Lamellae up to 1.5 cm broad, adnate, unequal, close, yellow orange (4B₃) with creamy white tones, unchanging; lamellulae present; gill edges serrate, wavy near pileus margin. Stipe central, 6.0–9.0 cm in length, up to 1.5 cm broad near apex, up to 2.0 cm broad in middle, up to 2.5 cm broad near base, obclavate; yellow orange (4B₇) to dirty white near base with brownish tinge, white above annulus; scaly, scales reticulate in rings, yellow, fading to white at age; solid; annulate, annulus double, superior, pendulus, scaly. Basidiospores 5.6–8.0 × 3.2–4.8 μm (excluding apiculus), Q = 1.5, ellipsoidal, hyaline, single walled, strongly amyloid; apiculate, apiculus up to 0.8 μm long. Basidia 24.0–32.0 × 5.6–7.0 μm, clavate, tetrasterigmate; sterigmata 1.6–3.2 μm long. Gill edge sterile. Hymenophoral trama regular without clamp connections. Pleurocystidia and cheilocystidia absent. Pileus cuticle hyphal, ixocutis, made up of 4.8–8.0 μm broad, horizontally placed, hyaline, septate, gelatinized hyphae, giving rise to regular turf of 4.8–7.2 μm broad, septate, hyaline, hyphae with inflated tips; context hyphal, made up of 6.4–9.6 μm broad, septate, hyaline hyphae intermingled with granular cells. Stipe cuticle hyphal, made up of 3.2–5.6 μm broad, longitudinally placed, septate, hyaline hyphae; context hyphal, made up of 4.8–8.0 μm broad, septate, hyaline hyphae. Clamp connection present throughout.

Chemical reactions – The stipe does not shows any reaction with FeSO₄.

Collection examined – South Kashmir, Hallan Manzgam (2695m), 33°35.613'N – 075°50.760'E, growing solitary under *Pinus wallichiana* in pure coniferous forest, 17th July 2013, Nazir Ahmad Malik, PUN 9015.

Edibility – Unknown.

Distribution and habitat – Mitchel & Smith (1976) reported *Floccularia straminea* var. *americana* from Aspen grooves scattered under alder and maple between 2333m to 3000m altitude, during summer rainy period. Presently this Indian collection was found growing solitary under *Pinus wallichiana* in pure coniferous forest during July at an altitude of 2695m.

Notes – All the external and internal details of the present collection match and fits well with the descriptions provided by Kuo (2006) and Mitchel & Smith (1976) for *Armillaria straminea* var. *americana* (Mitchel & A.H. Sm.) Bon, later, Volk & Burdsall (1995) transferred this to genus *Floccularia* and is presently named as *Floccularia straminea* var. *americana* (Mitchel & A.H. Sm.) Bon. This variant is characterized by yellow orange (4B₇) cap scales, cap fading to dull creamish in age with brownish orange (6C₄) to grayish orange (5B₃) tones, flesh changing to yellow on

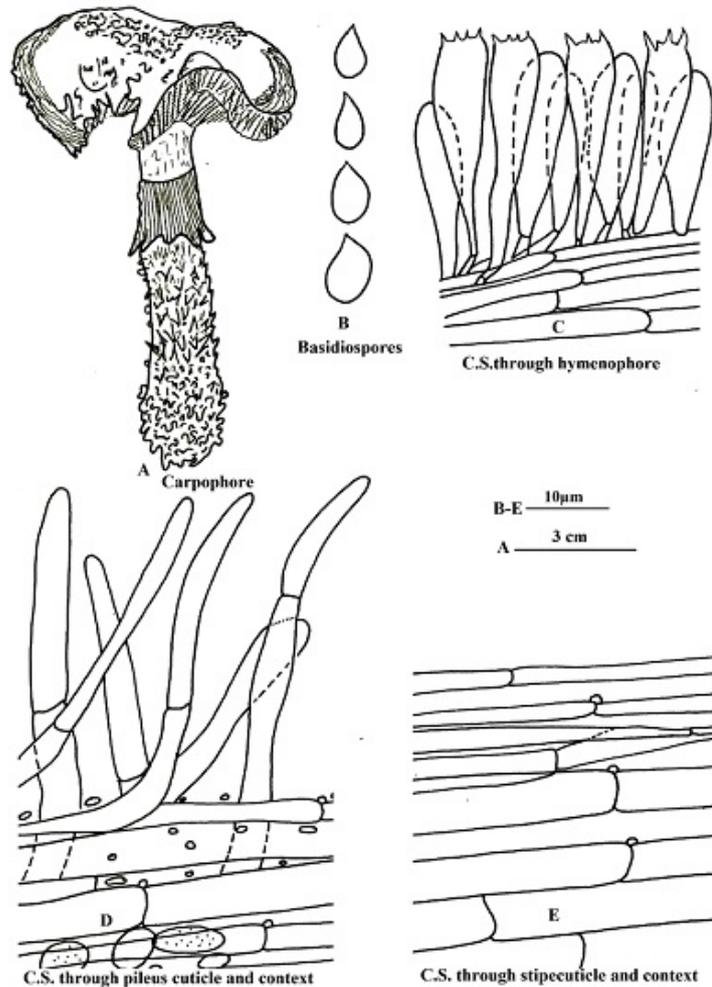
exposure, pileal veil yellow fading to white at maturity, amyloid basidiospores. This species is not earlier reported from India and constitutes a new record from India.



14



15



16

Figs 14–16 – *Floccularia straminea* var. *Americana*. 14 Basidiocarp in its natural habitat. 15 Underside view of cap bearing serrate gill edges. 16 Camera Lucida drawings (A-E).

Key to the species of genus *Floccularia*

1. Basidiocarp up to 5 cm in height; cuticle fully peeling2
- 1'. Basidiocarp 6 – 13 cm in height; cuticle half peeling or rarely fully peeling3
2. Cap colour fading to white with age; umbo absent; margin irregular, splitting at maturity; flesh and stipe unchanging*F. straminea* f. *alba*
- 2'. Cap colour not fading; umbo acute; margin involute; flesh changing to yellow; stipe changing to pale red on exposure*F. straminea*
3. Scales pastel red with shades of white, arranged in concentric rings; cuticle half peeling*F. luteovirens*
- 3'. Scales yellow to grey, scattered over the cap, not in concentric rings; cuticle fully peeling4
4. Growing scattered in linear rows; cap scales grey; annulus single; gill edges fertile*F. pitkinensis*
- 4'. Growing solitary; cap scales yellow; annulus double; gill edges sterile*F. straminea* var. *americana*

Discussion

The present study explores the diversity of unexplored genus *Floccularia* from the forests of South Kashmir (India). This genus belongs to order *Agaricales* under family *Agaricaceae*. The total 6 species are recorded throughout the world in this genus, which have vast distribution in northern temperate regions (Kirk et al 2008) while according to Index Fungorum (2020) 15 species of this genus were reported till now. The fungal forays resulted various taxa of this genus such as *Floccularia straminea* f. *alba*, *F. straminea*, *F. luteovirens*, *F. pitkinensis* and *F. straminea* var. *americana*. In the present study till this report, a total of 5 taxa of genus *Floccularia* were recorded and identified. The Table 1 and in Figure gives detailed information about these harvested taxa. Of the total species, 2 species were identified as edible while rest of the taxa are with unknown. These taxa were collected at high altitude that ranges between 2300 m to 2789 m in the month of June, July and August. The collected taxa were predominantly found to grow in coniferous forests on leaf litter, in ecto-mycorrhizal association and mostly were growing solitary or groups in habit. Among these taxa *F. pitkinensis* was found growing in groups but in a linear row.

Presently, some species of genus *Armillaria* stands shifted to genus *Floccularia* (Volk & Burdsall 1995) such as *Floccularia pitkinensis* which was earlier described as *Armillaria pitkinensis* by Mitchel & Smith (1976). Volk & Burdsall (1995) transferred *Armillaria straminea* var. *americana* to genus *Floccularia* which is newly named as *Floccularia straminea* var. *americana* (Mitchel & A.H. Sm.) Bon. The diversity of this genus in the forests of South Kashmir (India) contribute the growth of forest trees and plays important role in forest ecosystem. The information about edibility has been gathered from local people and the literature. The present study significantly contributes to the ecosystem replenishment and characterization of wild edible species of this genus growing in different localities of South Kashmir from India. Apart from supporting the various ecosystems of forests, many of them are a good source of food with good efficiency of culinary properties. These taxa can be used as a daily food supplement for health beneficial. Conclusively, it is necessary to explore and evaluate the ectomycorrhizal associated species as well as other wild edible species. These taxa with their ectomycorrhizal and edible properties needs to be analyzed and conserve through their tissue cultures as they have significant role in ecology, human welfare, medical industry, food industry and biodegradation.

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