New Species of *Lactarius* Subg. *Plinthogalus* and New Records of *Lactifluus* Subg. *Gerardii* (Russulaceae) from Sikkim, India

Kanad Das[(1*)] and Annemieke Verbeken[(2)]

1. Botanical Survey of India, Sikkim Himalayan Regional Centre, P.O. Rajbhawan, Gangtok 737103, Sikkim, India. Email: daskanadbsi@gmail.com
2. Ghent University, Department of Biology, Research Group Mycology, K.L. Ledeganckstraat 35, BE 9000, Gent, Belgium.
** Corresponding author. Email: mieke.verbeken@ugent.be*

(Manuscript received 15 September 2011; accepted 18 October 2011)

ABSTRACT: *Lactarius* subg. *Plinthogalus* (s.l.) was represented by thirteen taxa from the Indian subcontinent. In this paper, two taxa: *Lactarius crenulatus*, *L. croceigalus* are proposed and described as new species in *Lactarius* subg. *Plinthogalus*. From *Lactifluus* subg. *Gerardii*, two species, *Lactifluus leae* (new record for the Indian mycoflora) and *L. ochrogalactus* (reported earlier) are described for the first time with their macro- and micro-morphological details supported by illustrations. Comparisons with allied Asian taxa are also discussed.

KEY WORDS: Basidiomycota, India, *Lactarius*, *Lactifluus*, Macrofungi, Russulaceae, Sikkim, taxonomy.

INTRODUCTION

Lactarius group *Plinthogalae*, first introduced by Burlingham (1908) as a group under the genus *Lactarius* was considered a section by Singer (1942): *L.* sect. *Plinthogali* (Burl.) Sing. Hesler and Smith (1979), while working on *Lactarius* of North America raised the section into *L.* subgenus *Plinthogalus* (Burl.) Hesler & A.H. Sm. in which two sections, *L.* sect. *Plinthoalus* and *L.* sect. *Fumosi* Hesler & A.H. Sm., were considered. To accommodate some completely different collections from tropical Africa, Verbeken (2000) emended this subgenus including three sections: *L.* sect. *Nigrescentes* Verbeken, *L.* sect. *Pseudofuliginosi* Verbeken and *L.* sect. *Plinthogali* (Bull.) Sing. Studying the Asian samples, Stubbe et al. (2007a) initially extended the dimension of this subgenus by including the species with bluing latex. In general, the representatives of this group are morphologically well-recognized amongst all the other milkcaps by their greyish or brownish pigments and velvety aspect in cap and stipe, by their heavily ornamented, often reticulate spores and by the white latex that often shows spectacular colour changes.

Notwithstanding these striking morphological features, a world-wide phylogeny of this group showed that part of the subgenus and particularly the species affiliated to *L. gerardii*, do not fall in the *Plinthogalus* clade but for a separate, well-supported group, described as *Lactarius* subg. *Gerardii* (A.H. Sm. & Hesler) (Stubbe et al., 2007b, 2010). Since it has been shown that *Lactarius* is not a monophyletic group, two genera of milkcaps are now considered: *Lactarius* and *Lactifluus* (Buyck et al., 2008, 2010) and the former group of so-called well characterized *Plinthogali* falls apart in the two genera *Lactifluus* subg. *Gerardii* shares the macromorphological aspect and the highly and reticulately ornamented spores, the lack of true pleurocystidia and palisade-like pellis structures with *Lactarius* subg. *Plinthogalus*. However, *Lactifluus* subg. *Gerardii* is distinguished from *Lactarius* subg. *Plinthogalus* by the white spore print and the well-developed cellular layer of globose cells in the palisadic pileipellis.

Coming to the Indian context, thirteen taxa of *L.* subg. *Plinthogali* sensu lato: *Lactarius fuliginosus* (Fr.) Fr., *L. montoyae* K. Das & J.R. Sharma, *L. picinus* Fr., *L. lignyotus* var. *lignyotus* Fr., *L. lignyotus* var. *canadensis* A.H. Sm. & Hesler, *L. gerardii* var. *subrubescens* (A.H. Sm. & Hesler) Hesler & A.H. Sm., *L. fumosus* var. *fumosus* Peck, *L. lignyotellus* A.H. Sm. & Hesler, *L. subgerardii* Heasler & A.H. Sm., *L. subisabellinus* var. *murrillianus* (A.H. Sm. & Hesler) Hesler & A.H. Sm., *L. subisabellinus* var. *subisabellinus* Murrill, *L. subvernalis* var. *albo-ochraceous* Hesler & A.H. Sm. and *L. subvernalis* var. *himalayensis* Atri, S.S. Saini, M.K. Saini & A.K. Gupta were reported time to time by different workers (Saini and Atri, 1982; Saini and Atri, 1990; Atri et al., 1990; Atri et al., 1993; Bhatt et al., 2000; Rawla, 2002; Das and Sharma, 2004; Das and Sharma, 2005). As all the reported Indian samples are not yet molecularly analysed and many American names are misapplied, it is hard to divide them in the two genera, but it is to be expected that the species affiliated to *L.* subg. *Gerardii* will fall in *Lactifluus* and the other ones in *Lactarius*. In the present contribution, four taxa recently collected from West district of a small state

臺灣大學學術期刊資料庫

Sikkim (locating in Eastern Himalaya) in India are described with illustrations, out of which two are proposed here as new to science: *Lactarius crenulatus* and *L. croceigalus*. *Lactifluus leae* (Stubbe & Verbeken) Stubbe is reported for the first time from the Indian subcontinent, whereas, *L. ochrogalactus* S. Imai which was mentioned (without macro- and microscopic details) earlier by one of us (KD) is elaborately described with macro- and micro-morphological details coupled with illustrations.

MATERIALS AND METHODS

As a part of routine macrofungal survey to West district of Sikkim, several areas including Yuksom (subtropical to temperate broad-leaved forest dominated by *Castanopsis tribuloides* A. DC., *C. Hystrix* A. DC., *Prunus cerasoides* D. Don, *Michelia velutina* Blume, *Engelhardtia spicata* Blume, *Eurya cerasifolia* (D. Don) Kobuski, *Camellia kissi* Wall., *Macaranga denticulata* Müll. Arg., *Ficus roxburghii* Wall. and *Alnus nepalensis* D. Don), Hilltok (temperate mixed forest dominated by *Castanopsis hystrix*, *Ilex dipyrena* Wall., *Eurya cerasifolia* (D. Don) Kobuski, *Tsuga dumosa* Eichl., *Pinus wallichiana* A.B. Jacks., *Cryptomeria japonica* D. Don, *Macaranga denticulata* and *Alnus* sp.) and Tal (sub-alpine mixed forest dominated by *Abies densa* Griff., *Tsuga dumosa* Eichl., *Lithocarpus pachyphyllus* Rehder and *Rhododendron* sp.) were visited by one of us (KD) during August-September, 2010. A good number of macrofungi were collected. Field photographs of the fresh basidioma were taken with the aid of Nikon D300s. Macromorphological characterizations were made from the fresh basidiomata. Colour codes and terms follow Colour identification chart of the Flora of British fungi (1969) which is indicated in the descriptions as "a" and Kornerup & Wancher (1981), indicated in the descriptions as "b". For noting the colour of the spore prints Kränzlin (2005) was used and is referred to in the descriptions as "c". Basidioma of all the samples were allowed to dry with a field drier.

In the laboratory, micromorphological characters were observed from the dry samples mounted in a mixture of 5% KOH, 1% Phloxin, Congo red and 30% Glycerol and Melzer's reagent. Drawings of basidiospores were made mainly at 6000x magnification. Other micromorphological structures were drawn with the aid of a drawing tube at an original magnification of 1000x. Basidium length excludes the length of sterigmata, gill-density includes lamellae and lamellulae and spore-dimensions exclude the dimension of the ornamentations. Spore measurements are recorded based on that of twenty basidiospores. Spores are measured in side view and sizes are given as KDa-KDc-KDb × KDx-KDz-KDy in which KDa = minimum value for the length of measured collections, KDb = maximum value for the length of measured collections, KDc = mean value for the length of measured collections and KDx = minimum value for the width of measured collections, KDy = maximum value for the width of measured collections, KDz = mean value for the width of the measured collections. Quotient of spore indicates lenght-width ratio (Q = L/W) and is presented here as Qa-Qc-Qb where Qa = minimum quotient value amongst measured collections, Qb = maximum quotient value amongst measured collections, Qc = mean quotient value amongst measured collections. Scanning Electron Microscope (SEM) illustrations of basidiospores were obtained from spore prints that were directly mounted on a double-sided adhesive tape pasted on a metallic specimen-stub and then scanned with gold coating at different magnifications in high vacuum mode to observe patterns of spore-ornamentation. SEM work was carried out with a FEI's Quanta 200 model imported from The Netherlands and installed at the Bose Institute, Kolkata, India. All the materials are deposited at BSHC and GENT (Holmgren et al., 1990).

TAXONOMIC TREATMENTS

Lactarius crenulatus K. Das & Verbeken *sp. nov.*
Figs. 1, 2 & 3

MycoBank: 563239
Etymology: refers to the crenulate margin of pileus.

Pileus 25-30 mm diam., convexus ad planovonvexum, leviter depressus, papillatus, siccus, brunneus, margine crenulato. Lamellae confertae, adnatosubdecurrentes, pallide flavae. Stipes 40-57 × 3.5-5 mm, cylindricus, brunneus. Contextus albus, immutabilis. Latex aquosus, albus, salmonescens. Basidiosporae in cumulo flavae, 7.2-7.9-8.7 × 7.0-7.5-8.3 µm, amyloideae, reticulatae, cristis usque ad 1 µm altis, macula suprahilaris distale amyloidea. Basidia 35-48 × 11-17 µm, bi- vel tetraspora. Pleuromacrocystidia absentia. Pleuropseudocystidia abundantia, irregulare cylindrata ad tortuosa, saepe furcata. Cheilomacrocystidia absentia. Pileipellis bistrata, cellulae terminalis cylindratae vel (sub)clavatae, 19-42 × 9-13 µm, pigmento brunneo. --Typus: INDIA, Sikkim, 28 Aug. 2010, *K. Das*, *KD 10627* (holotypus BSHC, isotypus GENT).

Pileus 25-30 mm diam., at first convex with incurved margin, with slightly depressed centre and with a small papilla, gradually to planoconvex with depressed centre; surface never sticky, wrinkled, subvelvety, date brown (a: 24) to reddish brown (b: 8F8), cigar brown (a: 16), purplish chestnut (a: 21), rarely fulvous (a: 12) to umber

臺灣大學學術期刊資料庫

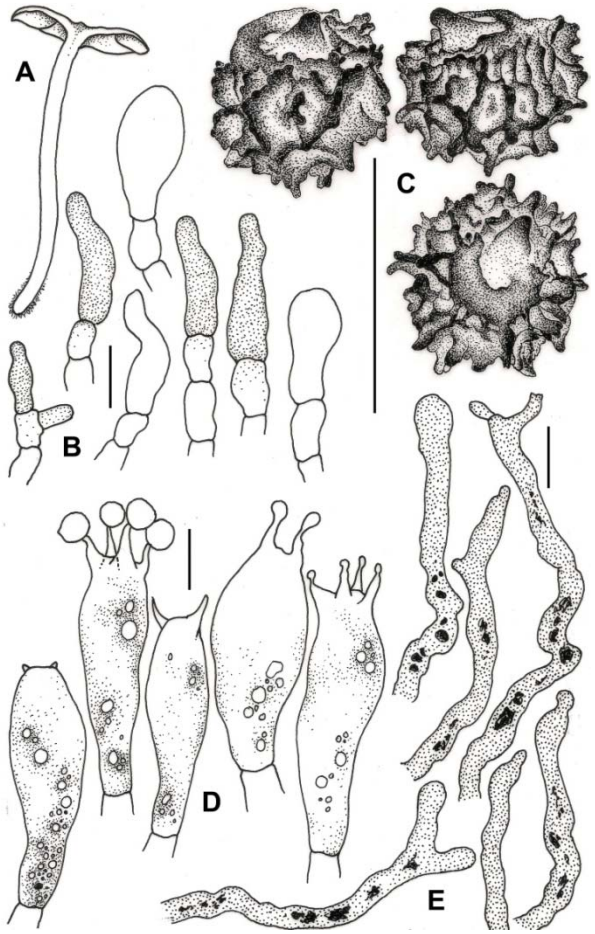


Fig. 1. ***Lactarius crenulatus*** **(Drawn by K. Das from KD 10627). A: Basidiomata showing lamellae and lamellulae. B: Marginal cells. C: Basidiospores. D: Two- and four-spored basidia. E: Pleuropseudocystidia. Bars = 10 µm.**

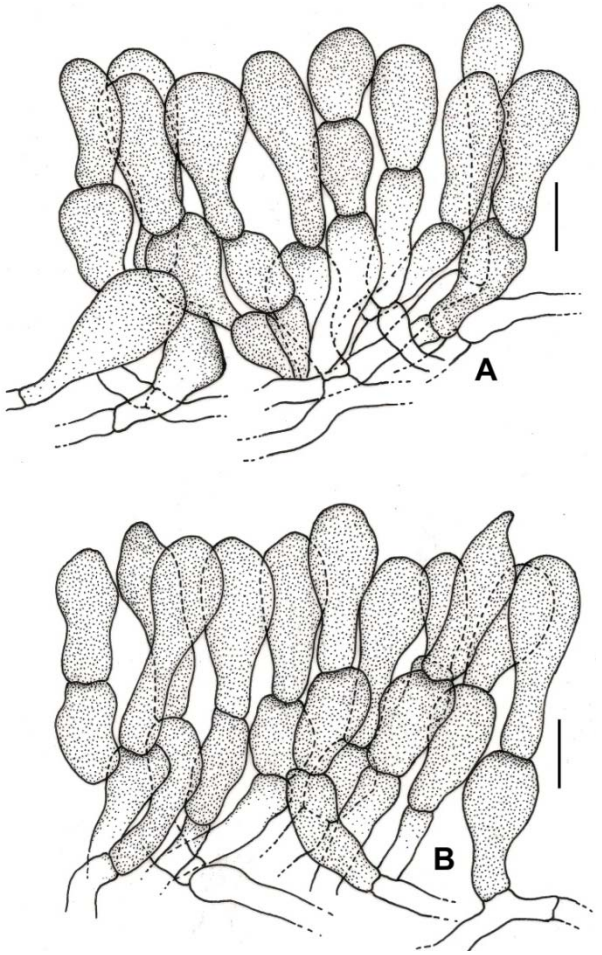


Fig. 2. ***Lactarius crenulatus*** **(Drawn by K. Das from KD 10627). A & B: Radial section through pileipellis. Bars = 10 µm.**

(a: 18); margin non-striate, finely crenulate. Lamellae broadly adnate to subdecurrent, dense (10-11/cm at pileus margin), never forked, pale yellow (c: 20Y, 2M to 30Y, 2M), with lamellulae in 4 series; edge entire, snuff brown (a: 17). Stipe 40-57 × 3.5-5 mm, cylindrical or slightly wider towards base, strigose at base, never sticky, snuff brown (a: 17) or darker at apex, gradually paler (clay buff) towards base, finally white (chalky) at base. Context white (chalky), solid (never hollow) in stipe, unchanging with $FeSO_4$, changing to greyish orange (b: 5A3) with KOH and salmon (a: 45) with guaiac. Latex watery white, not abundant, drying salmon (45). Spore print yellow (c: 40Y, 5M).

Basidiospores 7.2-7.9-8.7 × 7.0-7.5-8.3 µm, (n = 20, Q = 1.00-1.05-1.11), globose to subglobose; ornamentation amyloid, up to 1 µm high, composed of irregular to regular ridges which aligned or connected and forming a complete reticulum; plage distinct and strongly distally amyloid. Basidia 35-48 × 11-17 µm, 2- to 4-spored, clavate to subclavate; sterigmata 5-6 × 2.0-2.5 µm. Pleuromacrocystidia absent. Pleuropseudocystidia abundant, irregularly cylindrical to tortuose, often branched at apex, thin-walled, mostly not emergent, 3-4 µm wide. Lamellar edge sterile. Cheilomacrocystidia absent. Marginal cells 13-25 × 4-10 µm, cylindrical to subclavate, often multiseptate, thin- to slightly thick-walled, with brown intracellular pigmentation. Hymenophoral trama with lactifers. Pileipellis a hymeniderm to trichopalisade, up to 75 µm thick; terminal elements of suprapellis cylindrical to subclavate or clavate, 19-42 × 9-13 µm, with brown intracellular pigmentation; subpellis composed of inflated, subround to cylindrical cells (up to 5 µm wide). Clamp connections absent.

臺灣大學學術期刊資料庫

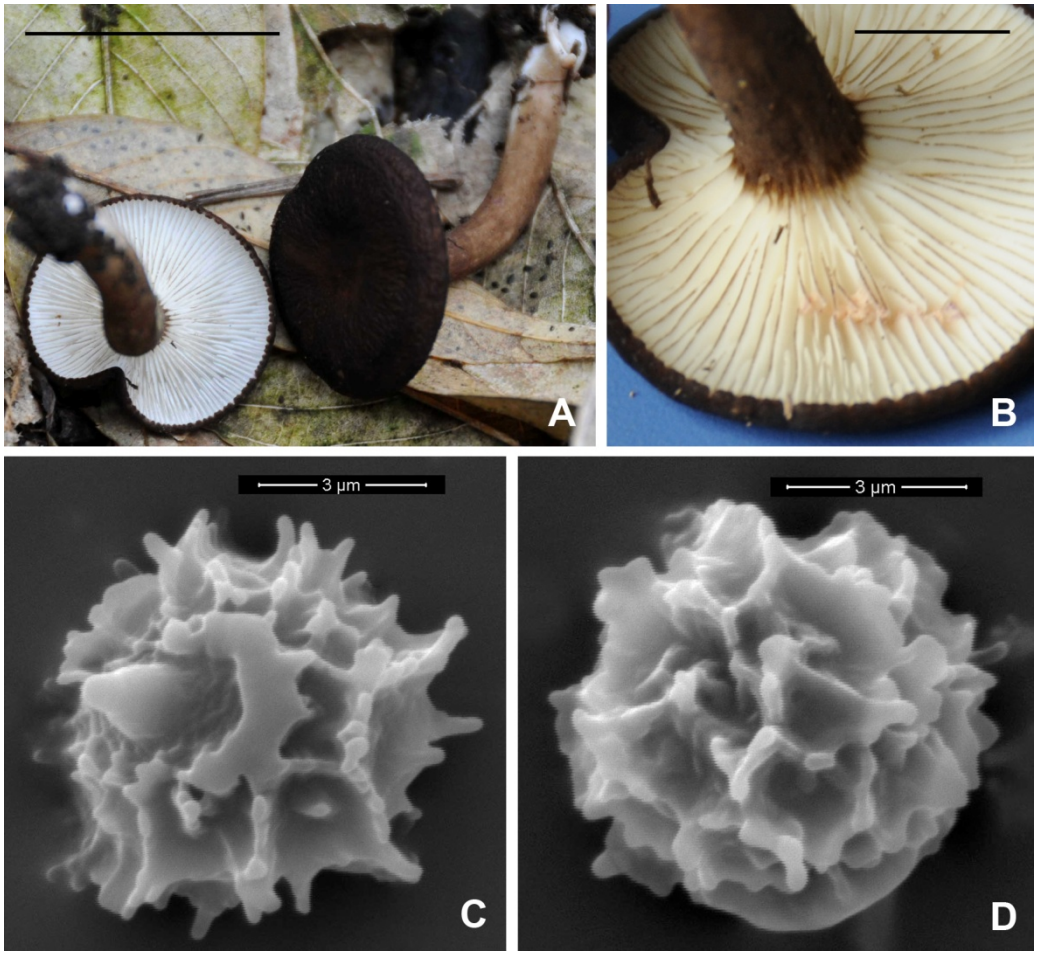


Fig. 3. *Lactarius crenulatus* (Photographed by K. Das). A: Fresh basidiomata. B: Basidiomata showing latex. C & D: Scanning electron micrographs of basidiospores. Bars: A = 3 cm, B = 1 cm, C & D = 3 µm.

Specimen examined: INDIA, Sikkim, Yuksom, alt. 1,693 m, N 27°22'06.0", E 88°13'29.3", under *Castanopsis tribuloides*, subtropical to temperate broad-leaved forest, 28 Aug., 2010, *K. Das*, *KD 10627* (holotype BSHC, isotype GENT).

Notes: The species belongs to *Lactarius* subg. *Plinthogalus*. Micromorphological characteristics for this group are the highly ornamented and reticulate spores, the hymeniderm- or palisade-like pileipellis structure with dark intracelluar pigmentation in the terminal elements. This dark pigmentation is also obvious as the macromorphological features in this group: members of this subgenus have typical grey to brown, often dark coloured pileus and stipe. Furthermore the dry, velvety and sometimes wrinkled aspect is characteristic and many species have context and latex changing pinkish. In *L. crenulatus*, it is remarkable that the latex is drying pinkish but a colour change has not been observed in the context; attention should be given to this feature when more material is collected. The yellow spore print in this proposed species and the pileipellis being a hymeniderm to trichopalisade (having inflated hyphal elements in subpellis) rather than a true palisade, fit very well for its position in *L.* subg. *Plinthogalus*.

Three species, *L. fumosus* Peck, *L. subvernalis* var. *albo-ochraceous* Hesler & A.H. Sm., and *L. subvernalis* var. *himalayensis* Atri, Siani & M.K. Saini in the same subgenus were reported from this subcontinent and appearing to be closely related to *L. crenulatus*. The first two names consider taxa described from North America; real conspecificity between India and North America is doubtful and has not been confirmed molecularly. Morphologically, the three mentioned species can be distinguished from *L. crenulatus* as they do not have a hymeniderm as a pileipellis structure. Moreover, *L. fumosus* (Rawla 2002) has milk-white unchanging latex, hyaline cheilocystidia, unbranched filamentous pleuropseudocystidia, whereas, both *L. subvernalis* var. *albo-ochraceus* and *L. subvernalis* var. *himalayensis* have white latex changing red on drying and are

臺灣大學學術期刊資料庫

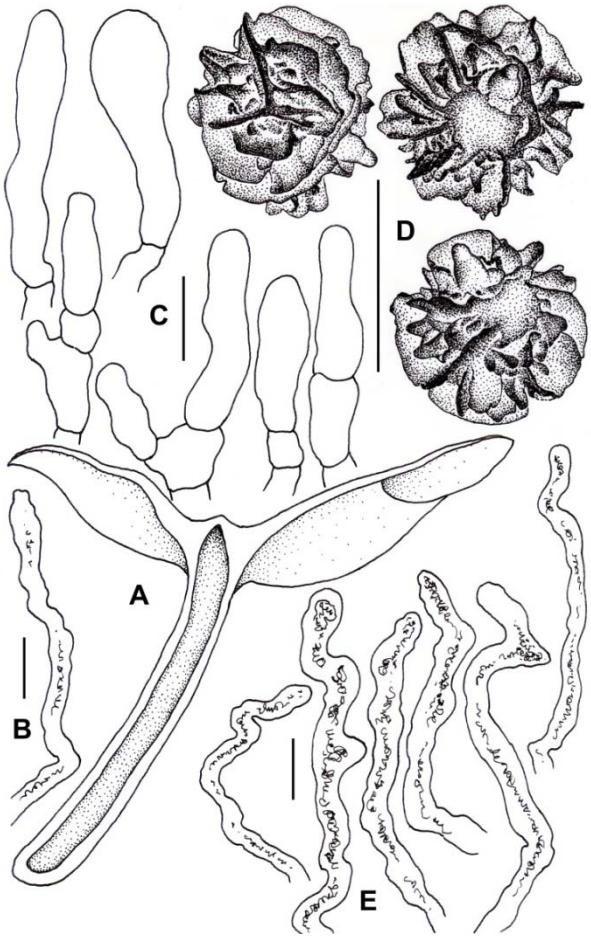


Fig. 4. *Lactarius croceigalus* (Drawn by *K. Das* from *KD 10763*). A: Basidiomata showing lamellae and lamellulae. B: Cheilopseudocystidia. C: Marginal cells. D: Basidiospores. E: Pleuropseudocystidia. Bars = 10 µm.

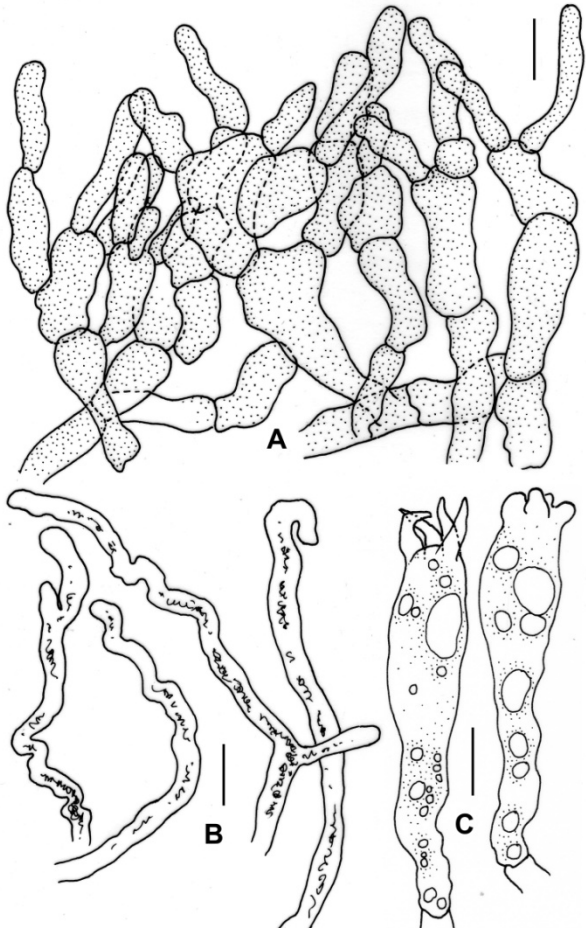


Fig. 5. *Lactarius croceigalus* (Drawn by *K. Das* from *KD 10763*). A: Radial section through pileipellis. B: Pileopseudocystidia. C: Basidia. Bars = 10 µm.

characterized by the presence of pleuro- and cheilo-macrocystidia, a rare character in this subgenus (Atri et al., 1990; Atri et al., 1993).

Lactarius croceigalus K. Das & Verbeken *sp. nov.*
Figs. 4, 5 & 8

MycoBank: 563240

Etymology: refers to the saffron yellow colour of the latex.

Pileus 50-105 mm diam., convexus ad planovonvexum, leviter depressus, papillatus, siccus, rigulosus, brunneus. Lamellae adnatae ad leviter subdecurrentes, distantes, flavae ad pallide aurantiae. Stipes 45-65 × 11-13 mm, cylindricus, bubalinus ad pallide aurantius. Contextus albus, aurantiogrisescens. Latex albus, croceus in sicco. Basidiosporae in cumulo ochraceae, 9.0-9.2-10.1 × 7.8-8.7-9.5 µm, globosae ad subglobosae, amyloideae, subreticulatae ad zebroideae,cristis usque ad 2.3 µm altis, macula suprahilaris distale ad complete amyloidea. Basidia 35-55 × 11-14 µm, bi- vel tetraspora, subclavata. Pleuromacrocystidia absentia. Pleuropseudocystidia abundantia, cylindrata ad tortuosa. Cheilomacrocystidia absentia. Pileipellis bistrata, trichopalisade, cellulae terminalis cylindratae, 8-40 × 4-5 µm, pigmento brunneo. – Typus: INDIA, Sikkim, 7 Sept. 2010, *K. Das*, *KD 10763* (holotypus BSHC, isotypus GENT).

Pileus 50-105 mm diam., at first convex and with centre slightly depressed, gradually planoconvex with broadly depressed centre, with a distinct pointed papilla; surface never sticky, concentrically wrinkled towards margin, umber (a: 18) when young, sienna (a: 11) when mature, paler towards margin, unpolished; margin non-striate, slightly inrolled when young, decurved when

臺灣大學學術期刊資料庫

mature, distinctly wavy. Lamellae adnexed to slightly subdecurrent, sinuate, distant (6/cm at pileus margin), interveined, buff (a: 52) to saffron (a: 49) or light orange (b: 5A5), at most somewhat concolorous with pileus or slightly paler, unchanging after bruising, with lamellulae in 6 series; edge entire, concolorous. Stipe 45-65 × 11-13 mm, cylindric or slightly broader towards base, never strigose at base, never sticky, buff (a: 52) to pale orange, whitish at base. Context thin in pileus, distinctly hollow in stipe, initially white (b: 1A1), turning greyish orange (b: 6B5) after some time, changing yellowish with KOH, unchanging with Guaiac and $FeSO_4$. Latex white (b: 1A1), turning saffron (a: 49) on gills when dry. Spore print ochraceous (c: 60Y18M).

Basidiospores 9.0-9.2-10.1 × 7.8-8.7-9.5 µm, (n = 20, Q = 1.02-1.06-1.12), globose to subglobose; ornamentation amyloid, up to 2.3 µm high, composed mostly of regular, high and narrow ridges which are remarkably crenulate, often parallel and thus forming a zebroid and winged pattern; some aligned or connected forming at the most a partial reticulum; short acute ridges and irregular warts present between long ridges; plage distally to almost totally amyloid. Basidia 35-55 × 11-14 µm, 2- to 4-spored, subclavate; sterigmata 8-9 × 2.5-3 µm. Pleuromacrocystidia absent. Pleuropseudocystidia abundant, up to 6 µm broad, slightly emergent or not, cylindrical to tortuose, sometimes branched with refringent contents. Lamellar edge sterile; cheilo-macrocystidia absent; cheilopseudocystidia up to 5 µm broad, cylindrical, never branched, with refringent contents; marginal cells 20-30 × 5-9 µm, cylindrical or with slightly tapering apex or clavate, often multiseptate, slightly thick-walled (up to 0.6 µm). Hymenophoral trama with numerous lactifers. Pileipellis mostly a trichopalisade, 75 µm thick, composed of chains of elements; terminal elements cylindrical, 8-40 × 4-5 µm, thin- to slightly thick- walled, with buff to cinnamon or fulvous intracellular pigmentation; lower elements globose to elongated; pileocystidia frequent, cylindrical to tortuose, sometimes branched. Clamp connections absent.

Specimen examined: INDIA, Sikkim, West district, Towards Tal, alt. 2989 m, N 27° 12' 37.8" E 88° 07' 10.3", under *Rhododendron* sp. and *Abies densa* Griff., sub-alpine mixed (broad-leaved & coniferous) forest, 7 Sept. 2010, *leg. K. Das, KD 10763* (holotype BSHC, isotype GENT).

Notes: The combination of macro- and micro-morphological characters, such as the brownish unpolished pileus and stipe, ochraceous spore print, lack of macrocystidia, winged spores and a trichopalisade as pileipellisstructure, definitely place the present species in *Lactarius* subg. *Plinthogalus*. Within the group the species is recognized by the presence of a pointed papilla, concolorous (with pileus) to slightly paler lamellae, the hollow stipe, the white context which is changing greyish orange and the latex becoming saffron yellow on the gills and the context. The occurrence in *Rhododendron*-rich coniferous forest also seems characteristic.

Similar Asian representatives of the subgenus are *L. fulvus* Stubbe & Verbeken (described from Malaysia), *L. montoyae* K. Das & J.R. Sharma (reported from India), *L. friabilis* H.T. Le & Stubbe and *L. subplinthogalus* Coker var. *chiangmaiensis* H.T. Le & Stubbe (both reported from Thailand). *Lactarius fulvus* differs from this new species by the darker gills and the remarkable presence of phaeobasidia, the different spore-ornamentation (1.5-2 µm high) and the milk that stains pink (Stubbe et al., 2008). Moreover, stipe context (even after maturity) never becomes hollow in *L. fulvus* which was collected from area dominated by tree members of Dipterocarpaceae (Stubbe et al., 2008). On the other hand, like the present species, *L. montoyae* (perhaps the closest relatives) has distant lamellae, hollow stipe, similar pattern of spore ornamentation (zebroid to winged) and more interestingly, it was collected also from *Rhododendron* dominated area of Western Himalaya, but it can be separated macroscopically by absence of pointed papilla (pileus often umbonate) on pileus and unchanging latex and context (Das and Sharma, 2004). Microscopically, absence of branched pleuropseudocystidia separates this species firmly from *L. croceogalus*. *Lactarius subplinthogalus* var. *chiangmaiensis* has more zebroid spores with very high and more regular (not crenulate) ridges; the latex is either unchanging or turning pale pinkish (Le et al., 2007). *Lactarius friabilis* has more reticulate and lower ornamented spores and the latex that changes to pink on drying (Le et al., 2007).

Lactifluus ochrogalactus (Hashiya) Wang, Mycotaxon: submitted

Lactarius ochrogalactus Hashiya, Mycoscience 42(4): 232, 2006.

Figs. 6, 7 & 8

Pileus 60-85 mm diam., at first convex, in centre slightly depressed, gradually planoconvex with depressed centre, with a distinct papilla, never sticky, surface radially wrinkled, fawn (a: 29) to umber (a: 18), paler towards margin; margin non-striate, decurved with maturity. Lamellae broadly adnate to slightly subdecurrent, distant (6/cm at pileus margin), distinctly forked at pileus margin, yellowish white (b: 2A2) to pale yellow (b: 4A3), changing brick (a: 15) to vinaceous (a: 76) after bruising, with lamellulae in 6 series; edge entire, mostly concolorous but snuff brown (a: 17) or paler towards margin. Stipe 48-60 × 8-13 mm, cylindric or slightly tapering towards base, never strigose at base, never sticky, concolorous to pileus, white at base.

臺灣大學學術期刊資料庫

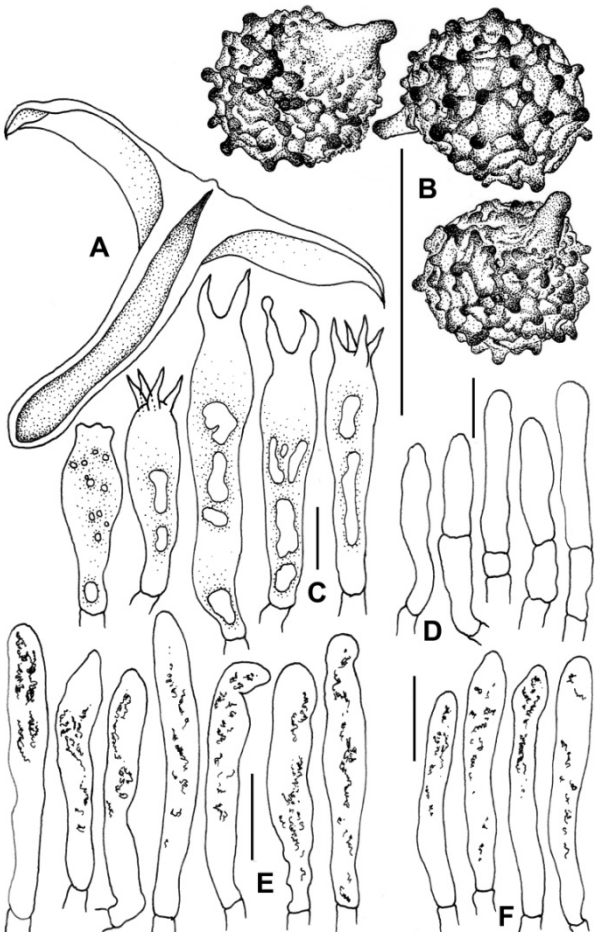


Fig. 6. *Lactifluus ochrogalactus* (Drawn by K. Das from KD 10640). A: Basidiomata showing lamellae and lamellulae. B: Basidiospores. C: Two- and four-spored basidia. D: Marginal cells. E: Pleuromacrocystidia. F: Cheilomacrocystidia. Bars = 10 µm.

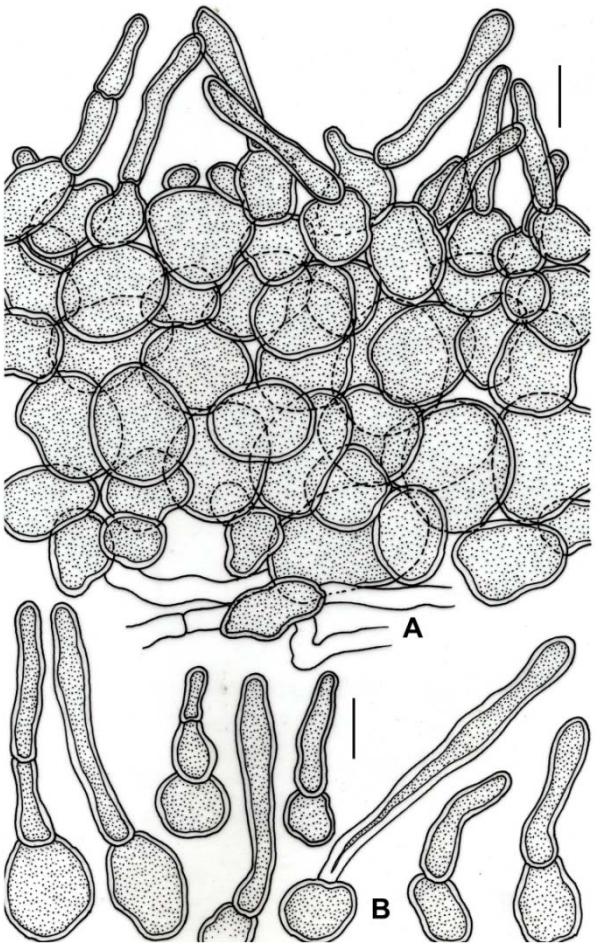


Fig. 7. *Lactifluus ochrogalactus* (Drawn by K. Das from KD 10640). A: Radial section through pileipellis. B: Elements of suprapellis. Bars = 10 µm.

Context white (chalky), hollow in stipe, turning slowly to brick (a: 15) or vinaceous (a: 76) after exposure, changing to dark green (a: 60) with KOH and guaiac, changing to cigar brown (a: 16) with $FeSO_4$. Latex abundant, initially amber yellow (b: 4B6) to brownish yellow (b: 4C7 to 5C8), soon brown (b: 6D8) with a mixture of white (partially), then towards vinaceous (a: 76) after long exposure, turning cut gills grayish red (b: 9B5-9B6). Spore print chalky white (c: 0Y).

Basidiospores 7.4-8.6-9.8 × 6.7-7.5-8.3 µm, (n = 20, Q = 1.07-1.14-1.20 (1.24)) subglobose or broadly ellipsoid; ornamentation amyloid, up to 0.7 µm high, composed mostly of regular cylindrical to pyramidal warts, aligned or connected forming a complete reticulum; plage indistinct. Basidia 28-55 × 8-12 µm, 2- to 4-spored, subclavate; sterigmata 6.5-8.5 × 2.5-3.8 µm. Pleuromacrocystidia abundant, 28-40 × 3.5-5 µm, emergent up to 11 µm, cylindrical to fusiform with tapering, subacute or rounded apex with few slightly needle-like contents. Pleuropseudocystidia not observed. Lamellar edge sterile; cheilomacrocystidia 28-40 × 3.5-5 µm, same as pleuromacrocystidia; marginal cells abundant, 25-40 × 4-6 µm, cylindrical to narrowly clavate or slightly tapering towards apex, often multiseptate, slightly thick-walled (up to 0.5 µm), sometimes with fulvous (a: 12) or paler or without intracellular pigmentation. Hymenophoral trama with few lactifers. Pileipellis a lampropalisade with a well-developed layer of isodiametric cells, 105-150 µm thick; terminal elements mostly cylindrical, 22-60 × 4.5-6 µm, thick-walled (up to 1.7 µm), with cinnamon (a: 10) to fulvous (a: 12) intracellular pigmentation; subpellis composed of mostly isodiametric thick-walled cells, 8-30 × 7-26 µm. Clamp connections absent.

臺灣大學學術期刊資料庫

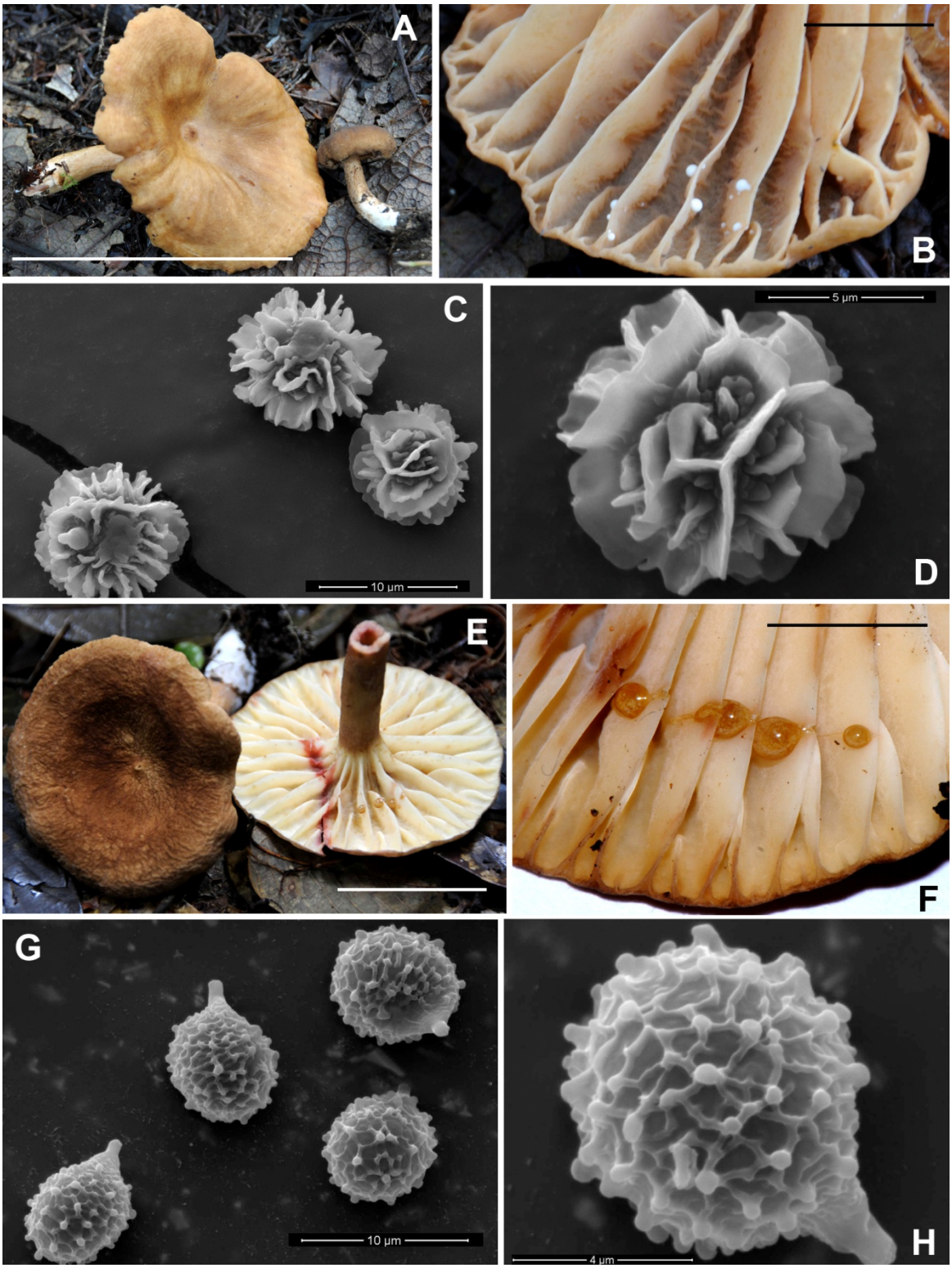


Fig. 8. ***Lactarius croceigalus*** **(Photographed by K. Das). A: Fresh basidiomata. B: White latex on cut lamellae. C & D: Scanning electron micrographs of basidiospores.** ***Lactifluus ochrogalactus*** **(Photographed by K. Das). E: Fresh basidioma. F: Brownish latex on cut lamellae. G & H: Scanning electron micrographs of basidiospores. Bars: A = 10 cm, B & F = 1 cm, C & G = 10 µm, D = 5 µm, E = 3 cm, H = 4 µm.**

臺灣大學學術期刊資料庫

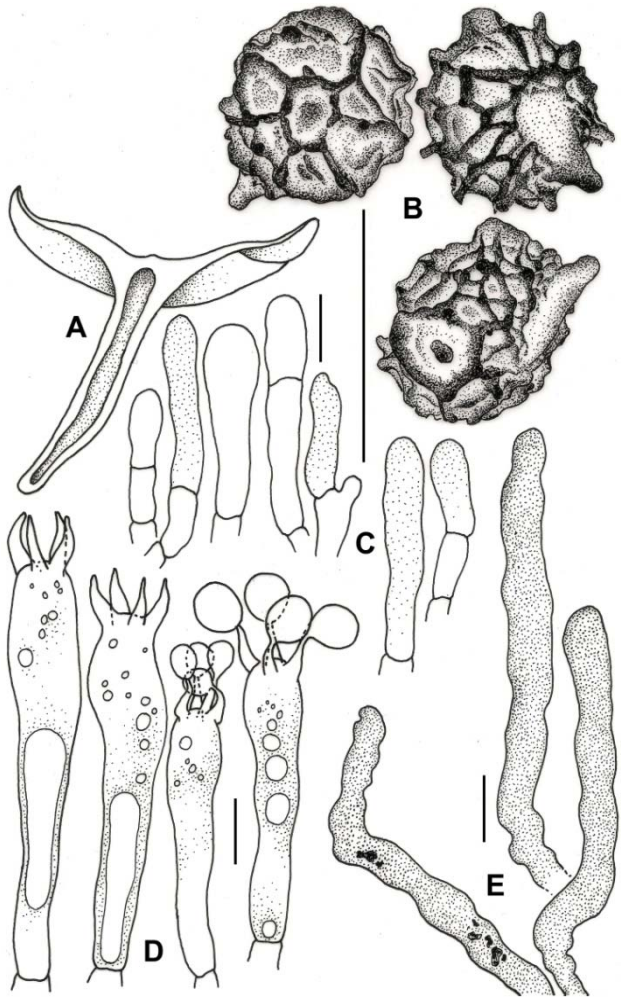


Fig. 9. *Lactifluus leae* (Drawn by K. Das from KD 10693). A: Basidiomata showing lamellae and lamellulae. B: Basidiospores. C: Marginal cells. D: Four-spored basidia. E: Pleuropseudocystidia. Bars = 10 µm.

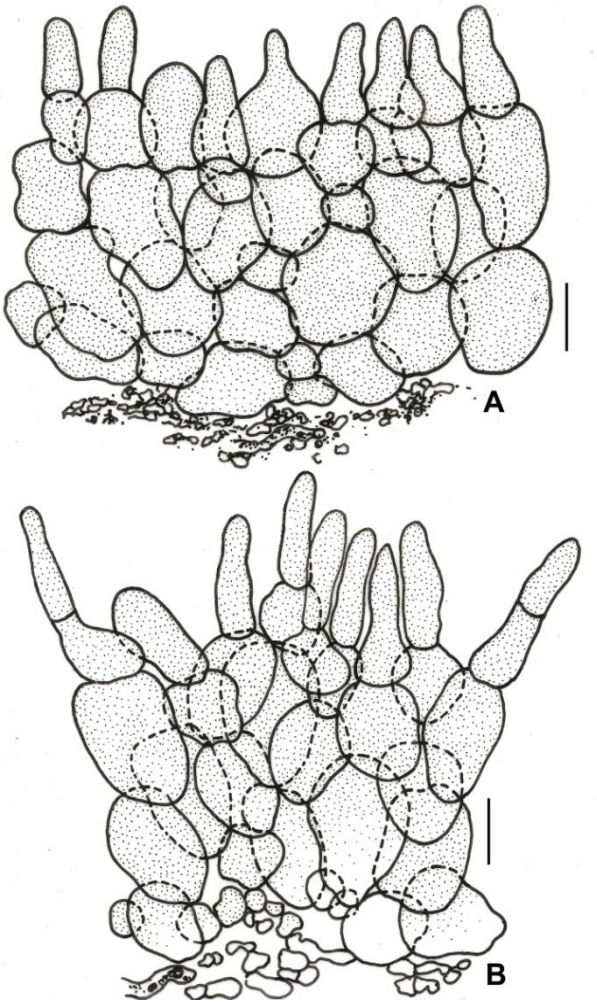


Fig. 10. *Lactifluus leae* (Drawn by K. Das from KD 10693). A & B: Radial section through pileipellis. Bars = 10 µm.

Specimen examined: INDIA, Sikkim, West district, Pemangtse, alt. 2020 m, N 27° 18' 12.4" E 88° 14' 56.8", under *Castanopsis hystrix* A. DC., sub-tropical to temperate broad-leaved forest, 28 Aug. 2010, *leg. K. Das, KD 10640*, (BSHC, GENT).

Notes: The species is a representative of *Lactifluus* subgenus *Gerardii* (notice the white spore print and the lampropalisade structure of the pileipellis with a well-developed layer of globose cells), that has been described from Japan (Wang et al., 2006). It is well-characterized by the yellowish brown latex, the presence of abundant macrocystidia and the thick-walled terminal elements in the pileipellis. This Indian specimen agrees very well with other Asian material (the species is known from Japan, China, Malaysia and Borneo), but shows remarkably forked lamellae and has distinctly shorter hymenial cystidia (75-120 × 4-6 µm in holotype) (Wang et al. 2006). More materials are needed to find out whether a separate but related taxon exists in India.

Lactifluus leae (Stubbe & Verbeken) Stubbe, Mycotaxon: submitted

Lactarius leae Stubbe & Verbeken, Fungal Diversity 52: 154, 2012.

Figs. 9, 10 & 11

Pileus 45-60 mm diam., at first convex and slightly depressed in centre, with a small papilla, gradually planoconvex with depressed centre; surface never sticky, radially wrinkled throughout, snuff brown (b: 17), paler

臺灣大學學術期刊資料庫

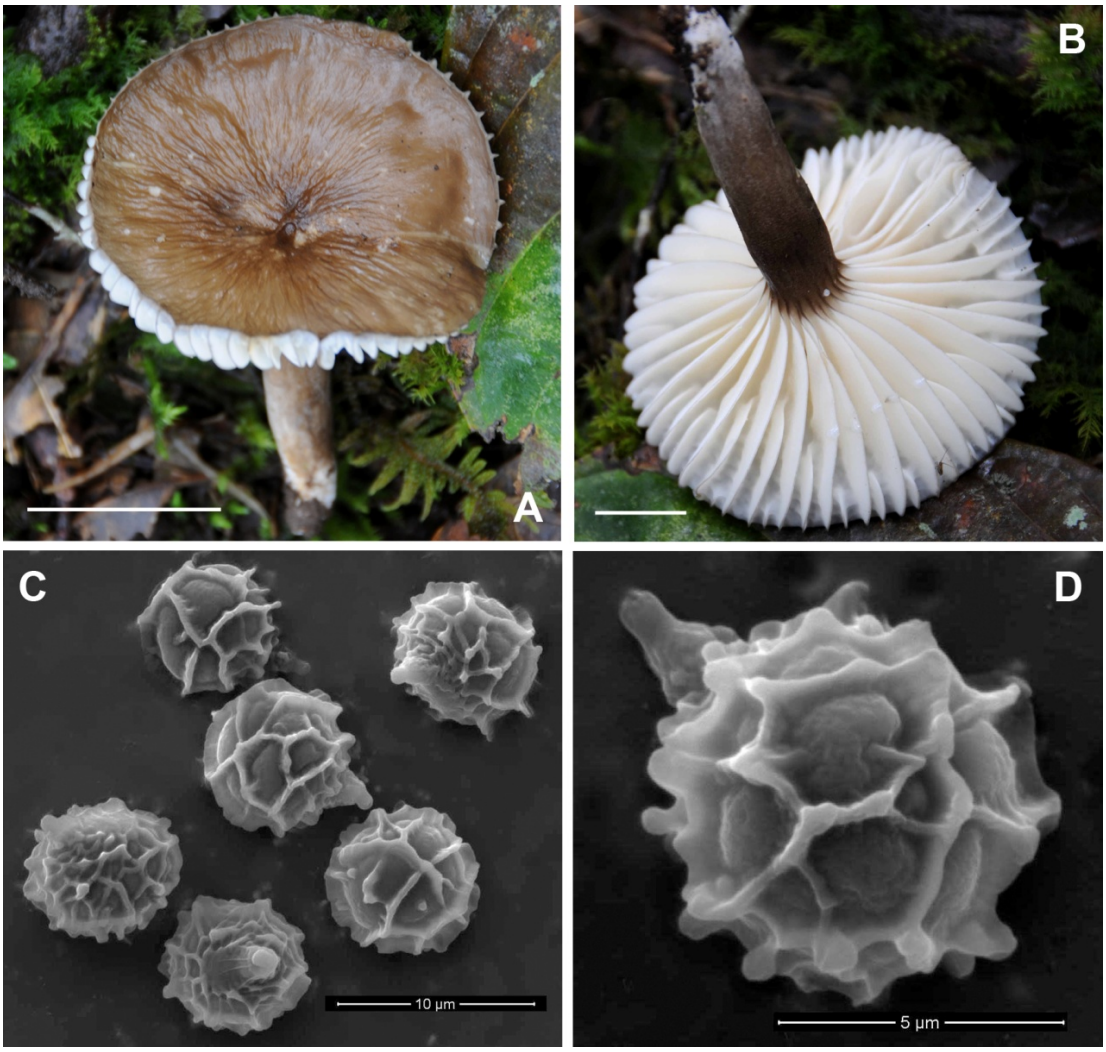


Fig. 11. ***Lactifluus leae*** **(Photographed by K. Das). A & B: Fresh basidiomata. C & D: Scanning electron micrographs of basidiospores. Bars: A = 2 cm, B = 1 cm, C = 10 µm, D = 5 µm.**

towards margin; margin non-striate, distinctly upturned with maturity. Lamellae broadly adnate, distant (5/cm at pileus margin), interveined, never forked, yellowish white (b: 2B) or paler, with lamellulae in 5 series; edge entire, snuff brown (b: 17) or paler. Stipe 35-43 × 8-11 mm, gradually tapering towards base, never strigose at base, never sticky, snuff brown (b: 17), whitish to white at base. Context thin in pileus, hollow in stipe, white (chalky), unchanging, turning pale yellow (a: 3A3-4A3) with $FeSO_4$, and greyish yellow (a: 1B4-2B4) with guaiac but unchanging with KOH, Latex watery white, abundant, unchanging (even on cut gills). Spore print white (c: 0Y).

Basidiospores 7.7-8.5-9.4 × 6.7-7.6-8.2 µm, (n = 20, Q = 1.05-1.12-1.25) globose to subglobose or broadly ellipsoid; ornamentation amyloid, up to 1 µm high, composed of irregular to regular ridges, aligned or connected forming a complete reticulum, with few isolated warts; plage often distinct and distally amyloid. Basidia 40-70 × 9-11 µm, clavate to subclavate, 4-spored; sterigmata 7-10 × 2.5-3.5 µm. Pleuromacrocystidia absent. Pleuropseudocystidia, cylindrical to slightly tortuose, 7-9 µm diam., thin-walled, mostly not emergent even not reaching up to hymenium layer. Lamellar edge sterile; cheilo-macrocystidia absent; marginal cells 20-40 × 4-9.5 µm, cylindrical to clavate, often multiseptate, thin- to slightly thick-walled, sometimes with fulvous (12) to rust (13) intracellular pigmentation. Hymenophoral trama distinctly cellular, with few lactifers. Pileipellis a palisade, 75-80 µm thick; terminal elements of suprapellis cylindrical to ampulliform, 12-25 × 6-13 µm, thick-walled (up to 0.8 µm), with fulvous to rust or paler intracellular pigmentation; subpellis composed of mostly

臺灣大學學術期刊資料庫

globose cells; cells 7-28 × 10-20 µm, thick-walled, wall up to 1 µm thick. Clamp connections absent.

Specimen examined: INDIA, Sikkim, West district, Hilltok, alt. 2262 m, N 27° 11' 19.5" E 88° 04' 33.3", under *Tsuga dumosa* Eichl., temperate coniferous forest, 3 Sept. 2010, *leg. K. Das, det. K. Das & A. Verbeken*, *KD 10693*, (BSHC, GENT).

Notes: *Lactifluus leae* belongs to *L.* subg. *Gerardii* (A.H. Sm. & Hesler) Stubbe (Stubbe et al., 2010). The species is described and so far only known from Thailand. In the field it is recognizable by the snuff brown, radially wrinkled pileus, the brown lamellae edge and unchanging context and latex. Microscopically, it is characterized by the short terminal elements in the pileipellis and the clavate marginal cells. The species is found here under *Tsuga dumosa*, while in Thailand, it occurs in montane rain forests with *Dipterocarpus*, *Castanopsis* and *Lithocarpus*.

ACKNOWLEDGEMENTS

We are thankful to the Director, Botanical Survey of India, Kolkata (India) and Department of Forest, Environment and Wild Life Management, Government of Sikkim for providing all kinds of facilities during this study. Assistance rendered by S.C. Maikap, Bose Institute, Kolkata is duly acknowledged.

LITERATURE CITED

Atri, N. S., S. S. Saini and D. K. Mann. 1990. Studies on North West Indian Agarics: The genus *Lactarius*. Indian Phytopath. **44**: 185-192.

Atri, N. S., S. S. Saini, M. K. Saini and A. K. Gupta. 1993. Systematic studies on Russulaceous fungi – The genus *Lactarius* Pers. J. Indian bot. Soc. **72**: 155-158.

Barlingham, G. S. 1908. A study of the *Lactariae* of the United States. Mem. Torrey Bot. Club **14**: 1-109.

Bhatt, V. K., R. P. Bhatt and R. D. Gaur. 2000. Mushrooms of the Garhwal Himalaya: the genus *Lactarius* Pers. ex. S.F. Gray. Mushroom Res. **9**: 11-18.

Buyck, B., V. Hofstetter, U. Eberhardt, A. Verbeken and F. Kauff. 2008. Walking the thin line between *Lactarius* and *Russula*: the dilemma of *Russula* sect. *Ochricompactae*. Fungal Divers. **28**: 15-40.

Buyck. B., V. Hofstetter, A. Verbeken and R. Walleyn. 2010. Proposal to conserve *Lactarius* nom. cons. (Basidiomycota) with a conserved type. Taxon **59**: 295-296.

Das, K. and J. R. Sharma. 2004. *Lactarius* in Kumaon Himalaya 2: New and interesting species of subgenus *Plinthogali*. Mycotaxon **89**: 289-296.

Das, K and J. R. Sharma. 2005. Russulaceae of Kumaon Himalaya. Botanical Survey of India, Kolkata, India.

Flora of British fungi: Colour identification chart. 1969. Her Majesty's Stationery Office, Edinburgh.

Hesler, L. R. and A. H. Smith. 1979. North American species of *Lactarius*. The University of Michigan Press, Ann Arbor.

Holmgren, P. K., N. H. Holmgren and L. C. Barnett. 1990. Index Herbariorum. Part 1: Herbaria of the world, 86th ed. Bronx: New York Botanical Garden, USA.

Kornerup, A. and J. H. Wancher. 1981. Methuen Handbook of Colour. Eyre Methuen Ltd., London, UK. Reprint.

Kränzlin, F. 2005. Fungi of Switzerland. Volume 6, Russulaceae, Verlag Mykologia Luzern, Switzerland.

Le, H. T., D. Stubbe, A. Verbeken, J. Nuytinck, S. Lumyong and D. E. Desjardin. 2007. *Lactarius* in Northern Thailand: 2. *Lactarius* subgenus *Plinthogali*. Fungal Divers. **27**: 61-94.

Rawla, G. S. 2002. *Lactarius* DC ex S.F. Gray in India – list and critical review. In: Pullaiah, T. (ed.). Biodiversity in India. pp. 221-255. Regency Publications, New Delhi, India.

Saini, S. S. and N. S. Atri. 1982. North Indian Agaricales – III. Soc. Indian natn. Sci. Acad. **48 B**: 453-457.

Saini, S. S. and N. S. Atri. 1990. Two noteworthy taxa of *Lactarius* Pers. from India. J. Indian bot. Soc. **69**: 475-476.

Singer, R. 1942. Das System der Agaricales, II. Ann. Mycol. **40**: 1-132.

Stubbe, D., A. Verbeken and R. Watling. 2007. Blue-staining species of *Lactarius* subgenus *Plinthogali* in Malaysia. Belg. J. Bot. **140**: 197-212.

Stubbe, D., J. Nuytinck and A. Verbeken. 2008. *Lactarius* subgenus *Plinthogalus* in Malaysia. Fungal Divers. **32**: 125-156.

Stubbe, D., J. Nuytinck and A. Verbeken. 2010. Critical assessment of the *Lactarius gerardii* species complex (Russulales). Fungal Biol. **114**(2-3): 271-283.

Verbeken, A. 2000. Studies in Tropical African *Lactarius* species 8. A synopsis of the subgenus *Plinthogali*. Persoonia **17**: 377-406.

Wang, X. H., M. Hashiya and A. Verbeken. 2006. *Lactarius ochrogalactus*, a new species of the genus *Lactarius* (Russulaceae, Russulales) with yellowish-brown latex. Mycoscience **47**: 232-234.

臺灣大學學術期刊資料庫

印度錫金紅菇科（Russulaceae）乳菇屬 *Plinthogalus* 亞屬的新種和 *Lactifluus* 屬 *Gerardii* 亞屬的新記錄種

Kanad Das[(1*)] and Annemieke Verbeken[(2)]

1. Botanical Survey of India, Sikkim Himalayan Regional Centre, P.O. Rajbhawan, Gangtok 737103, Sikkim, India. Email: daskanadbsi@gmail.com
2. Ghent University, Department of Biology, Research Group Mycology, K.L. Ledeganckstraat 35, BE 9000, Gent, Belgium. Email: mieke.verbeken@ugent.be
* 通信作者。*Email: daskanadbsi@gmail.com*

(收稿日期：2011 年 9 月 15 日；接受日期：2011 年 10 月 18 日)

摘要：印度大陸的乳菇屬 *Plinthogalus*（s.l.）亞屬共由 13 個分類群所組成。本文提出並描述乳菇屬 *Plinthogalus* 亞屬的二個新分類群：*Lactarius crenulatus* 和 *L. croceigalus*。有關於 *Lactifluus* 屬 *Gerardii* 亞屬，本文提出印度真菌誌的新記錄種 *Lactifluus leae*，同時對該新記錄種和先前已報導過的 *L. ochrogalactus* 進行詳細地觀察，描述他們的巨觀和微觀形態，並提供手繪圖及照片作為佐證。更進一步將這些物種與亞洲地區相近分類群作比較和討論。

關鍵詞：擔子菌門、印度、乳菇屬、*Lactifluus*、大型真菌、紅菇科、錫金邦、分類學。

臺灣大學學術期刊資料庫