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## *Lactarius* subgenus *Plinthogalus* of Malaysia

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Stubbe, D., Nuytinck, J. and Verbeken, A. (2008). *Lactarius* subgenus *Plinthogalus* of Malaysia. *Fungal Diversity* 32: 125-156.

An overview and key of the Malaysian species of *Lactarius* subgenus *Plinthogalus* are given. Three species with strikingly blue colour changes were described before. Eight new species (not blueing) are proposed and fully described and illustrated: *L. cinereobrunneus*, *L. cretaceus*, *L. flavorosescens*, *L. ferrugineifolius*, *L. fulvus*, *L. pallidior*, *L. papillatus* and *L. verecundus*. *Lactarius ochrogalactus* Hashiya is for the first time reported in Malaysia. A species, probably identical with *L. sublignyotus* Henn., is also included. The presence of phaeobasidia, never mentioned before in *Lactarius*, is illustrated here in *Lactarius fulvus*.

**Key words:** *Dipterocarpaceae*, ectomycorrhiza, lowland rain forest, *Russulaceae*, Southeast Asia

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### Article Information

Received 28 March 2008

Accepted 8 August 2008

Published online 30 September 2008

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### Introduction

The current knowledge of Malaysian mycoflora is mainly based on the extensive work of E.J.H. Corner (1906-1996). Concerning ectomycorrhizal fungi, Corner has made comprehensive, taxonomical studies on the *Boletales*, *Amanitaceae* and cantharelloid fungi (Corner and Bas, 1962; Corner, 1966, 1970, 1972, 1974). But no such work was done on *Russulaceae* despite their strong presence in the region (Lee *et al.*, 2002, 2003; Watling *et al.*, 2002; Lee and Chang, 2003). Watling *et al.* (2002) and Lee *et al.* (2002, 2003) made several mycological surveys on Peninsular Malaysia, while Tan *et al.* (2007) described a new *Marasmius* species. Only a small percentage of their *Russula* and *Lactarius* collections could be identified, often using North American or European names. From mid August until the end of October 2006, a mycological expedition was undertaken to the Pasoh Forest Reserve and surroundings in Peninsular Malaysia, approximately 140 km southeast of Kuala Lumpur, in the state Negeri Sembilan. This reserve harbours a 600 ha remnant of primary, dipterocarp, lowland rain

forest protected by a buffer zone of secondary, regenerating rain forest, adding up to 2450 ha in total. Over 20 different taxa of *Lactarius* have been found during this expedition, the majority belonging to *Lactarius* subgenus *Plinthogalus* (Berk.) Hesler and A.H. Sm. (Stubbe *et al.*, 2007). For this paper we have also included herbarium specimens of E.J.H. Corner, collected in Borneo during the 1960s, and of R. Watling, who visited Pasoh and the gardens of the Forest Research Institute Malaysia (Kepong, state of Selangor) several times during the 1990s. In this account we do not consider *L. aff. gerardii*, which seems to be common all-over Asia, nor the related *L. bicolor* Masee, which was also found during the expedition. Because of their similar morphology they were long thought to belong to *Lactarius* subgenus *Plinthogalus*, but molecular analyses reject their placement in the subgenus (Stubbe *et al.*, in preparation).

### Materials and methods

The material collected in 2006 is deposited in the herbarium of Ghent University (GENT) and duplicates are available in the herbarium of

the Forest Research Institute Malaysia (KEP). The studied material from Corner and Watling is part of the herbarium of the Royal Botanic Garden of Edinburgh (E).

Specimens were described and photographed in fresh condition during daylight hours. Colour coding is according to Kornerup and Wanscher (1978) and partly adopted from the British Fungus Flora (BFF) (Henderson *et al.*, 1969). For terminology we refer to Vellinga (1988) and specifically for pellis structures to Verbeken (1998). Microscopic features were studied from dried material coloured in 1% Congo Red L4 solution (Clemençon, 1972), shortly heated with a flame to intensify coloration and improve rehydration. For older herbarium specimens rehydration in 10% aqueous potassium hydroxide solution was needed before heating and colouring in 1% Congo Red ammonia solution. Drawings were made using a drawing tube. Spore observations were done in Melzer's reagent. Spores were measured in side-view, averages ( $\bar{x}$ ) and standard deviations (SD) were calculated per collection (20 spores measured per collection). Measurements exclude ornamentation and are given as an interval:  $\{[\bar{x}-2\times SD]_{\text{MIN}} - [\bar{x}+2\times SD]_{\text{MAX}}\}_{\text{length}} \times \{[\bar{x}-2\times SD]_{\text{MIN}} - [\bar{x}+2\times SD]_{\text{MAX}}\}_{\text{width}}$ . The lowest and highest measured values are mentioned in brackets when they exceed the interval values. The lowest and highest averages are mentioned separately. *Q* stands for the length/width ratio and is expressed as an interval of the lowest and the highest measured value and as an interval of the highest and lowest average values. The hymenial elements and the pellis structures are drawn at original magnifications 1600 $\times$ , the spores at 6000 $\times$  and the basidiocarps at life-size.

## Results

Species of *Lactarius* subgenus *Plinthogalus* are recognized in the field by their medium-sized stature, a greyish cream, grey, greyish brown, brown or blackish brown colour of pileus and stipe, less often with ochraceous or orange-brown tinges, almost always lacking zonations or scrobicules, never strongly viscid, in dry conditions with a velutinous aspect in pileus and stipe, the lamellar edge sometimes concolorous with pileus or stipe, the context or latex mostly changing colour when exposed,

often becoming pinkish, but also reddish, red to black, brown, violaceous, lilac, yellow to pink and blue and yellow to blue reactions exist. The spore print is cream to ochraceous or buff.

The combination of microscopical characters is also rather characteristic, with the spores being subglobose, occasionally broadly ellipsoid, bearing mostly prominent ridges, 1-3  $\mu\text{m}$  high, in a zebroid or reticulate pattern, the plage usually distally amyloid, macrocystidia mostly lacking, the pileipellis a palisade or trichopalisade, in some species trichodermic structures occurring, the upper layers often containing brown, intracellular pigmentation.

For all the specimens of 2006, DNA could be extracted and for all, except one (*Lactarius* sp. 1), the species delimitation could be confirmed. The results of the molecular analyses will be published in an integrated study of the phylogeny of the subgenus (Stubbe *et al.*, in prep.). Photographs will be made available on the *Russulales* News website (<http://www.mtsn.tn.it/russulales-news/>).

## Key to the species

1. Context and latex unchanging, or becoming pinkish, reddish or yellow but never blue ..... 2
- 1\*. Context or latex having a blue or bluish green colour reaction when exposed..... 12
2. Distinctly pale basidiocarps: cream-coloured, dirty white or greyish white..... 3
- 2\*. More intensely coloured basidiocarps: ochraceous, orange-brown, chocolate brown, grey-brown or dark grey ..... 5
3. Basidiocarps firm; pileus  $\geq 50$  mm diam.; latex white and thick, rapidly turning yellow, soon fading to white; context first staining yellow then slowly turning pale pink; terminal elements pileipellis 10-35(40)  $\times$  3-8  $\mu\text{m}$  ..... **10. *L. pallidior***
- 3\*. Context turning pinkish or reddish without any preceding yellow discoloration..... 4
4. Context slowly turning reddish to reddish brown; spores with zebroid and winged ornamentation up to 2-3  $\mu\text{m}$  high; terminal elements pileipellis long and slender, 30-60  $\times$  2-5  $\mu\text{m}$  ..... **2. *L. cretaceus***
- 4\*. Context staining bright pink; spore ornamentation a nearly closed reticulum of ridges 1.5-2  $\mu\text{m}$  high; terminal elements pileipellis 10-35  $\times$  3-6  $\mu\text{m}$  ..... **14. *Lactarius* sp. 1**
5. Macrocystidia present ..... 6
- 5\*. Macrocystidia absent ..... 7
6. Pileus sepia or umber-brown; latex watery and yellow or yellowish brown at first, later staining

- vinaceous; spore ornamentation of interconnected, blunt spines; macrocystidia  $\leq 110 \mu\text{m}$  long, narrowly subcylindrical and thin-walled ..... **9. *L. ochrogalactus***
- 6\*. Pileus pale fawn; latex white at first, later staining rufous pink; spore ornamentation a reticulum of ridges; macrocystidia  $\leq 55 \mu\text{m}$  long, subclavate and contents with fine, needle-like crystals ..... **11. *L. papillatus***
7. Pileus and stipe ochraceous, rusty orange to orange-brown; lamellae dull orange to orange-grey or concolorous with pileus ..... 8
- 7\*. Pileus and stipe grey, grey-brown, chocolate brown or blackish brown; lamellae cream or pale ochraceous coloured ..... 9
8. Context unchanging when cut; latex white and unchanging; phaeobasidia absent or scarce; pseudocystidia distinctly clavate and  $\leq 10 \mu\text{m}$  broad ..... **4. *L. ferrugineifolius***
- 8\*. Context turning pink when cut; latex white and drying grey with a pinkish tinge; abundant phaeobasidia; pseudocystidia submoniliform and usually branching towards the apex ..... **6. *L. fulvus***
9. No colour reaction in context or latex; spores with reticulate ornamentation ..... 10
- 9\*. Context ultimately turning pinkish or reddish; spores with zebroid ornamentation ..... 11
10. Pileus and stipe grey-brown; pileus surface smooth, never wrinkled; lamellar margin concolorous or grey; spores on average  $6.5\text{-}6.9 \times 5.8\text{-}6.2 \mu\text{m}$ ; slender terminal elements in pileipellis:  $20\text{-}55 \times 3\text{-}8 \mu\text{m}$  ..... **1. *L. cinereobrunneus***
- 10\*. Pileus and stipe blackish brown; pileus surface reticulately wrinkled; lamellar margin fuscous; spores on average  $8.1\text{-}8.2 \times 7.5 \mu\text{m}$ ; stout terminal elements in pileipellis ( $5\text{-}20 \times 5\text{-}10 \mu\text{m}$ ) ..... **13. *Lactarius* cfr. *sublignyotus***
11. Basidiocarp firm, chocolate brown, with firm and terete stipe; context first staining yellow due to latex, afterwards slowly turning pale pink; spores on average  $7.4\text{-}8.4 \times 6.7\text{-}7.8 \mu\text{m}$  ..... **5. *L. flavorosescens***
- 11\*. Basidiocarp grey-brown and context never staining yellow; spores on average  $6.6 \times 6.1\text{-}6.2 \mu\text{m}$  ..... **12. *L. verecundus***
12. Latex thick and white, turning straight to bluish green and bright blue within minutes; lamellae distant; spores  $6\text{-}6.8 \times 5.4\text{-}6.5 \mu\text{m}$  with zebroid ornamentation  $\leq 1.5\text{-}2 \mu\text{m}$  high ..... **3. *L. cyanescens***
- 12\*. Latex first turning yellow before becoming blue or before fading to white again ..... 13
13. Lamellae distant; spores  $7.8\text{-}8 \times 7.4\text{-}7.5 \mu\text{m}$ , with zebroid ornamentation  $\geq 2 \mu\text{m}$  high; pileipellis a trichopalysade or palysade ..... **7. *L. lazulinus***
- 13\*. Lamellae dense, turning blue on bruising; spores  $6.8 \times 5.6\text{-}6.4 \mu\text{m}$  with reticulate ornamentation  $\geq 2 \mu\text{m}$  high; pileipellis a (ixo)trichoderm ..... **8. *L. mirabilis***

***Lactarius cinereobrunneus*** Stubbe and Verbeken **sp. nov.** (Figs 1-7; Fig. 83)

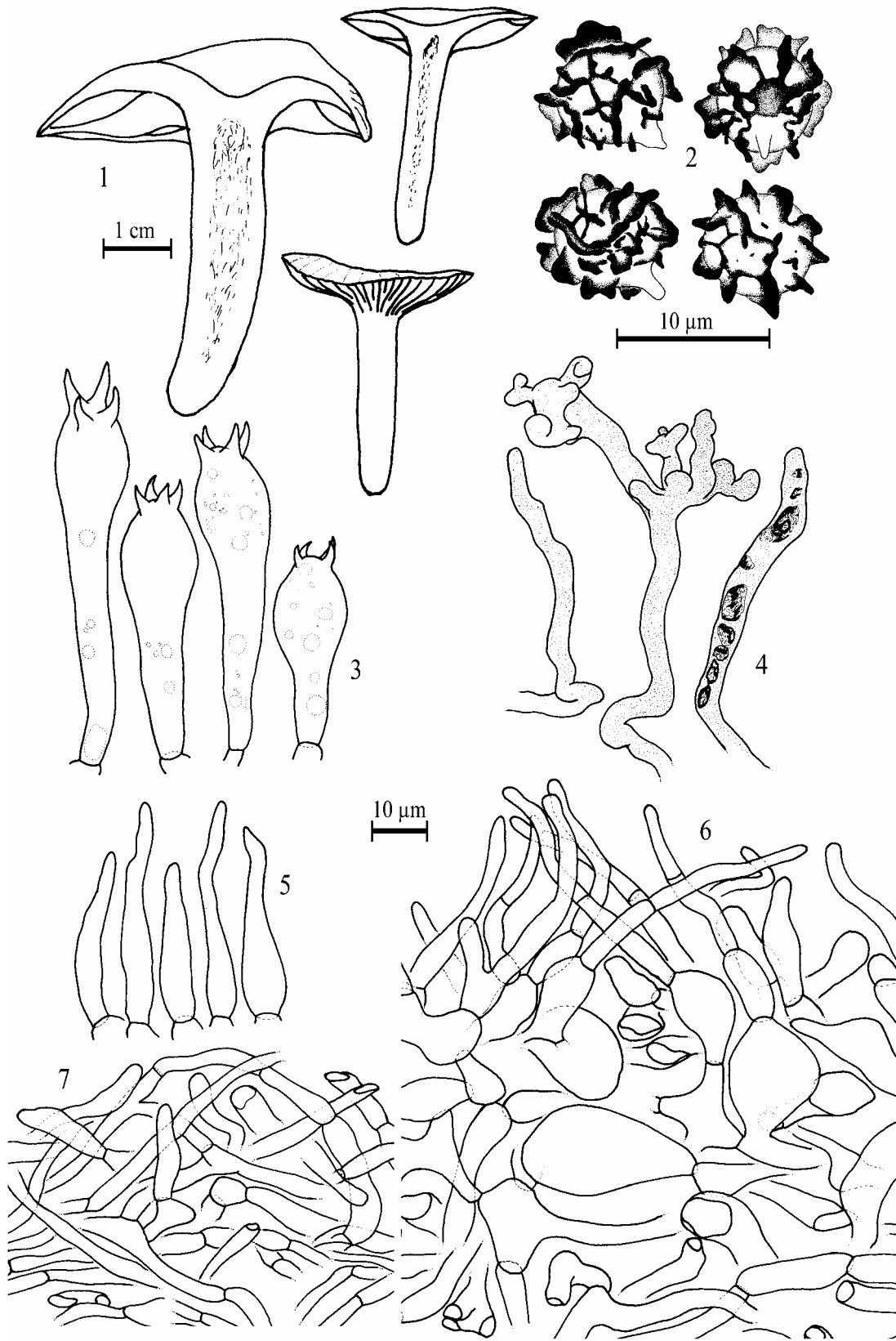
Mycobank: 512241

*Etymology*: *cinereus*, meaning grey, and *brunneus*, meaning brown, referring to the grey-brown colour of pileus and stipe.

*Pileus* 25-55 mm diam., convexus ad planoconvexum, in centro leviter depressus, margine leviter vel distincte crenulato, laevis ad leviter viscosum, cinereobrunneus, griseo-brunneus. *Stipes* 20-50 mm longus, 5-10 mm crassus, siccus, leviter velutinus, griseo-brunneus. *Lamellae* late adnatae, subdecurrentes, moderate densae vel subdistantes, albae ad cremas. *Contextus* albus, immutabilis vel lente pallide roseus. *Latex* albidus. *Sporae*  $6.2\text{-}6.9\text{-}7.7 \times 5.6\text{-}6.2\text{-}6.9 \mu\text{m}$ ,  $Q = 1.04\text{-}1.11\text{-}1.22$ , subglobosae, reticulatae, cristis ornatae usque ad  $2 \mu\text{m}$  altis; macula suprahilaris distale amyloidea. *Macrocystidia* absentia. *Cheiloleptocystidia*  $20\text{-}50 \times 3\text{-}8 \mu\text{m}$ , anguste conica. *Pileipellis* bistrata, 70-100  $\mu\text{m}$  crassa, pigmento brunneo intracellulare, elementa suprapellis  $20\text{-}55 \times 3\text{-}8 \mu\text{m}$ , subcylindrata. *Stipitipellis* trichodermia.

*Typus*: "Malaysia, state of Negeri Sembilan, Pasoh Forest Reserve, along main trail, close to shelter near Old Tree Tower, N02°58.93' E102°18.27', 127m alt., dominated by *Shorea* and *Dipterocarpus*, on soil, 17 September 2006, Stubbe 06-227 (GENT)."

*Pileus* 25-55 mm diam., convex to planoconvex with depressed or slightly depressed centre and wavy margin, smooth or slightly rugulose, becoming faintly to clearly grooved towards the margin; the margin itself faintly to distinctly crenate; surface dry and slightly velutinous, sometimes more strongly so towards the margin, somewhat slippery when moist; unevenly dark brown or dark greyish brown in the central area (6-7F4), paler and greyer towards the margin (6DE3, 5D3-4), sometimes with even paler patches. *Stipe* 20-50  $\times$  5-10 mm, cylindrical, equal or somewhat narrower towards the base, central or eccentric; surface dry, slightly velutinous and faintly, longitudinally rugulose, concolorous with pileus but paler and greyer (5-6DE3, 6D2 and paler), white at the apex. *Lamellae* broadly adnate, sinuate or subdecurrent, moderately dense to subdistant ( $\pm 10 \text{ L+I/cm}$  at pileus midradius), whitish with a pale cream tinge (4A2 and paler) to dark cream-coloured (4A3); edge smooth and mostly concolorous but sometimes lamellae with pale to dark grey edge present. *Context* moderately thin in pileus, solid to stuffed in stipe, white and unchanging or faintly and after at least half an hour reaching not more than a very pale pinkish tinge (paler than 6A2); smell unremarkable; taste mild. *Latex* scarce to moderately abundant, watery



**Figs 1-7.** *Lactarius cinereobrunneus* (Stubbe 06-227, *typus*). 1. Basidiocarp. 2. Basidiospores. 3. Basidia. 4. Pleuropseudocystidia. 5. Cheiloleptocystidia. 6. Pileipellis. 7. Stiptipellis.

white, drying white or with a very pale pinkish tinge on lamellae, unchanging when isolated on glass plate; taste neutral, mild. *Spore print* not observed.

*Basidiospores* 6-7.7(7.8) × 5.3-6.9 μm,  $Q = 1.04-1.22$ , on average 6.5-6.9 × 5.8-6.2 μm,  $Q = 1.11$  (n = 40), subglobose to broadly ellipsoid; ornamentation an almost complete reticulum composed of mostly firm and irregular ridges and a few distinctly thinner and lower ridges, up to 1-2 μm high; edges smooth or minutely crenulate; minute, isolated warts between the ridges absent or weakly amyloid; plage distally amyloid. *Basidia* 35-65 × 12-15 μm, distinctly clavate or narrowly clavate, shorter when nearer to lamella edge, mostly with guttulate contents, 4-spored; sterigmata 3-7 × 1.5-2 μm. *Macrocytidia* absent. *Pleuro-pseudocystidia* 4-6 μm diam., scattered to rather abundant, subclavate and subcylindrical or contorted and strongly branched, slightly emergent, often containing coarse, crystalline granules. *Lamellar edge* predominantly composed of cheileptocystidia, occasionally basidia and basidioles present; *cheileptocystidia* 20-50 × 3-8 μm, narrowly conical, thin-walled. *Lamellar trama* composed of filamentous and inflated hyphae; *lactifers* abundant and broad. *Pileipellis* a trichopalysade, 70-100 μm thick, containing diffuse, intracellular, brown pigmentation in the upper layers, sometimes a faint mucus layer present; suprapellis composed of predominantly long and slender, subcylindrical, terminal elements, 20-55 × 3-8 μm, often 2- to 3-celled, with some subfusiform and clavate cells scattered between them, erect or oblique to recumbent, thin-walled; subpellis a rather irregularly intermixed layer of inflated hyphal and subcellular elements, ≤ 25 μm diam., more orderly arranged in young specimens. *Stipitipellis* a trichoderm, 30-60 μm thick, sometimes with a faint mucus layer; the upper layers containing diffuse intracellular, brown pigmentation; terminal elements cylindrical to subclavate with obtuse apex; hyphae 3-5 μm diam., sometimes slightly inflated, thin-walled.

*Habitat*: Dipterocarp lowland rain forest dominated by *Shorea* and *Dipterocarpus*.

*Known distribution*: Peninsular Malaysia.

*Material examined*: MALAYSIA - state of Negeri Sembilan, Pasoh Forest Reserve, along main trail, close to shelter near Old Tree Tower, N02°58.93' E102°18.27', 127m alt., dominated by *Shorea* and

*Dipterocarpus*, on soil, 17 September 2006, *Stubbe* 06-227 (*typus*: GENT, *isotypus*: KEP) - *ib.*, at beginning of trail along experimental plots, N02°58.25' E102°17.79', 143 m alt., in regenerating lowland rain forest, formerly completely logged over, 7 September 2006, *Stubbe* 06-108.

*Notes*: Morphologically, *L. cinereobrunneus* seems to be similar to the North American species *L. muscicola* Hesler & A.H. Sm., of which the type specimen (*Hesler* 29380, TENN) was examined. *Lactarius muscicola* has bigger spores (7.5-9 × 7-9 μm) and the pileipellis contains clavate and subcapitate terminal elements. Also, the lactifers in the hymenophoral trama of *L. muscicola* are rather inconspicuous, while we find them quite abundant and broad in *L. cinereobrunneus*. The dark, greyish brown colour, the lack of a clear discoloration of the context and the high, reticulate spore ornamentations set this species apart from the other Malaysian members of *Lactarius* subgenus *Plinthogalus*. In the field, it can also resemble *L. gerardii* Peck, but *L. cinereobrunneus* differs by having a whitish zone on the stipe apex where the lamellae are attached, while in *L. gerardii* there is always a strong contrast between the stipe apex and lamellae. Microscopically these two species can be easily distinguished by their spores.

***Lactarius cretaceus* Stubbe & Verbeken sp. nov.** (Figs 8-13; Fig. 84)

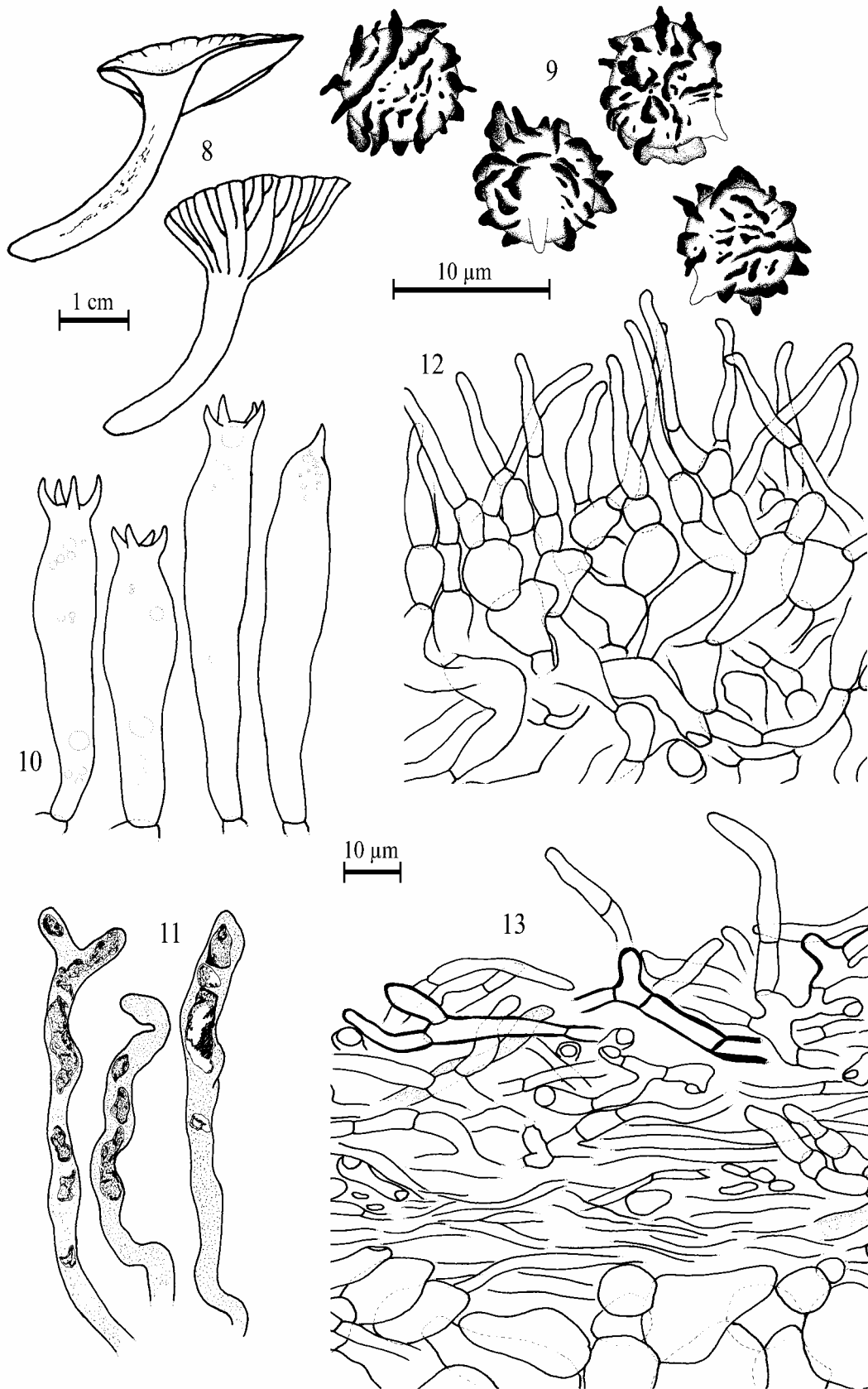
Mycobank: 512242

*Etymology*: *cretaceus*, meaning chalk-white, referring to the basidiocarp colour.

*Pileus* 30-35 mm diam., irregulare concavus, in centro depressus, margine distincte crenulato, siccus, velutinus, rugulosus, pallide cremeo-griseus. *Stipes* 35 mm longus, 4-6 mm crassus, cylindratus, siccus, leviter rugulosus, albidus. *Lamellae* late adnatae, distantes, latae, cremeae, rubescentes ad brunneo-rubescentes. *Contextus* albus, lente rubescens ad brunneo-rubescens. *Latex* aquosus. *Sporae* 6.4-6.9-7.4 × 5.6-6.3-6.9 μm,  $Q = 1.05-1.1-1.23$ , subglobosae, zebroideae, cristis ornatae usque ad 2-2.5(3) μm altis; macula suprahilaris distale amyloidea. *Macrocytidia* absentia. *Cheileptocystidia* absentia. *Pileipellis* bistrata, 80-120 μm crassa, elementa suprapellis 30-60 × 2-5 μm, subcylindrata. *Stipitipellis* trichodermia.

*Typus*: "Malaysia, state of Negeri Sembilan, Kampong Serting Ulu, Hutan Lipur Serting Ulu, on soil, along trail upwards into hillside forest, dominated by *Dipterocarpaceae* and *Fagaceae*, 13 September 2006, *Stubbe* 06-183 (GENT).

*Pileus* 30-35 mm diam., irregularly concave, with depressed centre, grooved



**Figs 8-13.** *Lactarius cretaceus* (Stubbe 06-183, *typus*). 8. Basidocarp. 9. Basidiospores. 10. Basidia. 11. Pleuropseudocystidia. 12. Pileipellis. 13. Stiptipellis.

towards the margin; margin distinctly crenate and inflexed to reflexed; surface dry and velutinous, rugulose in centre, pale greyish cream-coloured (4B2-5B2), in central area with a brownish tinge (5C3, but slightly browner) and more or less plain cream-coloured (4A2) at the margin. *Stipe* 35 × 4-6 mm, cylindrical, gradually tapering downwards and rather slender, eccentric; surface dry, faintly longitudinally rugulose, pale, whitish. *Lamellae* broadly adnate, distant (5-6 L+1/cm), broad (up to 6 mm), without anastomosing veins, cream-coloured (4A2-3), slowly (within half an hour) staining reddish and later on reddish brown (8BCD6-8) where bruised and injured; edge smooth, paler than lamellae surface. *Context* thin in pileus, stuffed in stipe, whitish with a very pale cream-coloured tinge, when exposed staining very slowly (half an hour to an hour) reddish and later on reddish brown (8BCD6-8), mostly near stipe surface, not so much in pileus context; smell unremarkable, fungoid; taste mild. *Latex* scarce, watery and transparent. *Spore print* not observed.

*Basidiospores* 6.4-7.4 × 5.6-6.9(7) μm,  $Q = 1.05-1.23$ , on average 6.9 × 6.3 μm,  $Q = 1.1$  (n = 20), subglobose; ornamentation amyloid, distinctly zebroid or winged, composed of long, firm and thick ridges up to 2-2.5(3) μm high, with crenulate edges, rarely branching or interconnecting, but with abundant low and isolated, short ridges and warts present; plage distally amyloid. *Basidia* 50-75 × 10-15 μm, long and narrowly clavate, 4-spored, though 1-spored basidia occasionally observed, very often with guttulate contents; sterigmata 4-7 × 1.5-2 μm. *Macrocystidia* absent. *Pleuropseudo-cystidia* 4-6 μm diam., abundant, subclavate or irregularly cylindrical with obtuse apex, sometimes branched, containing coarse, amorphous but refringent granules. *Lamellar edge* containing basidia and basidioles, no obvious *cheiloleptocystidia* present. *Lamellar trama* predominantly composed of inflated hyphae intermixed with cellular elements; *lactifers* abundant. *Pileipellis* a trichopalissade to palissade, 80-120 μm thick, hyaline; suprapellis composed of long and slender terminal elements, 30-60 × 2-5 μm, often septate, subcylindrical, tapering towards the apex, thin-walled or with slightly refringent cell wall, erect or oblique; the apex sometimes

subcapitate; subpellis composed of subcellular and inflated hyphal elements, up to 25 × 15 μm but smaller towards the terminal elements of the suprapellis, thin-walled. *Stipitipellis* a trichoderm, rather thin (40-90 μm thick), composed of filamentous and slightly inflated hyphae, 2-5 μm diam., thin-walled or with refringent cell walls but also clearly thick-walled elements present (cell wall ≥ 1 μm); terminal elements subcylindrical, repent, recumbent or erect, hyaline; delimited by a thin but dense layer of parallel hyphae above the underlying trama; pseudocystidia and lactifers moderately abundant.

*Habitat*: Dipterocarp lowland rain forest, dominated by dipterocarps and *Fagaceae*.

*Known distribution*: Peninsular Malaysia.

*Material examined*: MALAYSIA - state of Negeri Sembilan, Kampong Serting Ulu, Hutan Lipur Serting Ulu, on soil, along trail upwards into hillside forest, dominated by *Dipterocarpaceae* and *Fagaceae*, 13 September 2006, Stubbe 06-183 (*typus*: GENT, *isotypus*: KEP).

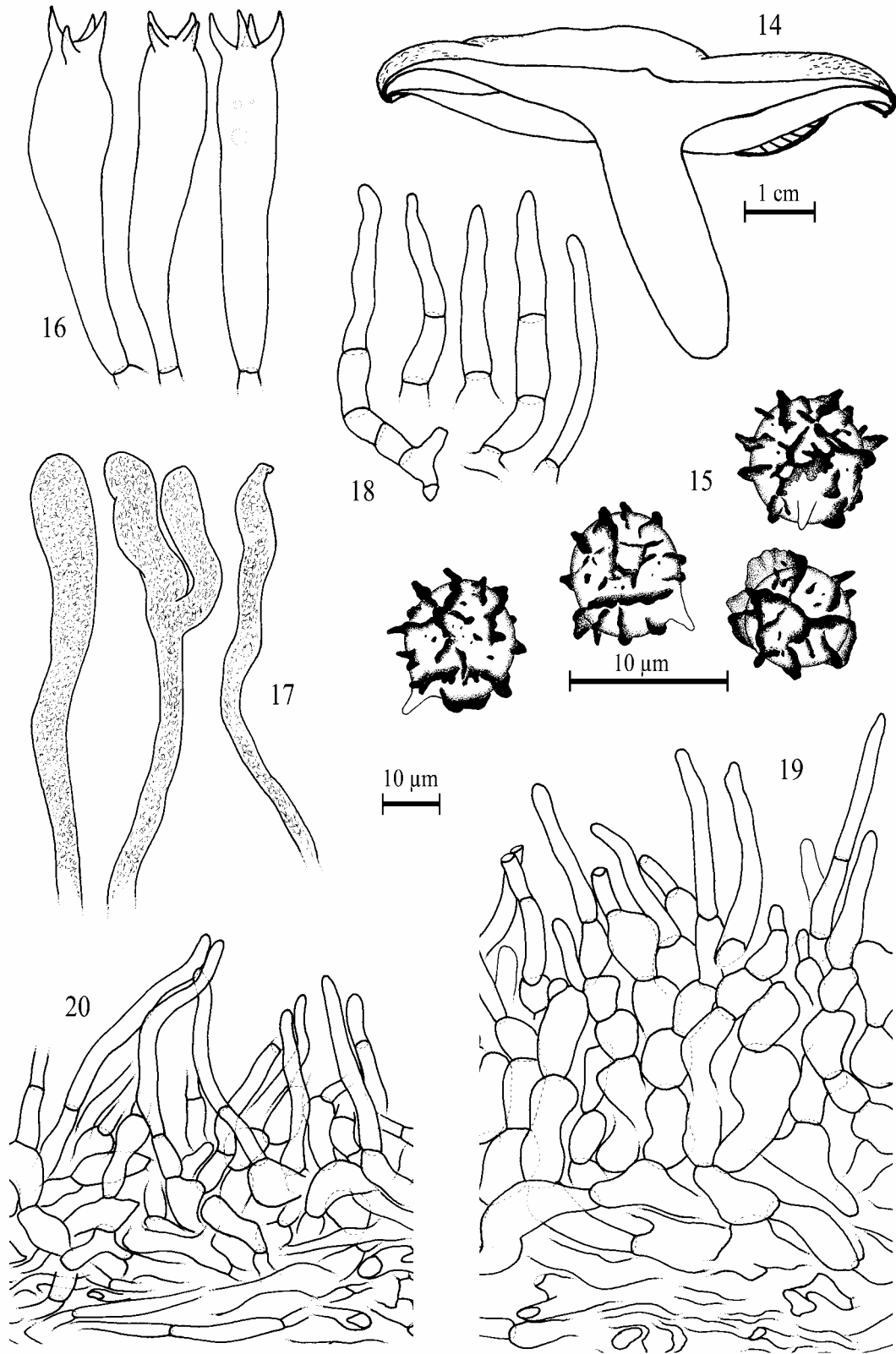
*Notes*: The collection contains one mature fruitbody in good condition. The high, zebroid spore ornamentation and the distant lamellae are reminiscent of *L. subplinthogalus* var. *chiangmaiensis* H.T. Le & Stubbe, which is a pale grey-brown and slightly thick-fleshed mushroom with the context turning pink when exposed and shorter terminal elements in the pileipellis (≤ 45 μm). Its spores have mostly several long and more or less parallel arranged ridges, never reaching 3 μm in height. *Lactarius cretaceus* is a whitish mushroom with a fragile habitus, the context slowly turning dark red and its spores bearing a few long, but also many shorter ridges, in a rather disorderly arrangement and reaching 2 to 3 μm high.

*Lactarius cyanescens* Stubbe, Verbeken & Watling, Belg. J. Bot. 140 (2): 199-202 (2007).  
(Figs 85-86)

Mycobank: 512243

A medium-sized mushroom with brownish grey pileus, concolorous stipe and distant lamellae, easily recognized by its copious, thick, white latex turning bright turquoise-blue. Basidiospores on average 6.0-6.8 × 5.4-6.5 μm with zebroid ornamentation up to 2 μm high.

Illustrations and diagnosis available on the *Russulales* News website.



**Figs 14-20.** *Lactarius ferrugineifolius* (Stubbe 06-261, *typus*). 14. Basidiocarp. 15. Basidiospores. 16. Basidia. 17. Pleuropseudocystidia. 18. Cheileleptocystidia. 19. Pileipellis. 20. Stipitipellis.



***Lactarius ferrugineifolius* Stubbe & Verbeken  
sp. nov.** (Figs 14-20; Figs 87-89)

MycoBank: 512244

*Etymology*: from *ferrugineus*, meaning rusty, and *folium*, referring to the lamellae and their orange-brown colour.

*Pileus* 70-75 mm diam., planoconvexus ad applanatum, velutinus, ferrugineo-aurantiacus ad aurantio-brunneum. *Stipes* 30-35 mm longus, 15 mm crassus, cylindratus ad compressum, velutinus, albido-aurantiacus ad griseo-aurantiacum. *Lamellae* anguste adnatae, moderate distantes, latae, crassae, ferrugineo-aurantiacae ad brunneo-aurantiacas. *Contextus* ex aurantio albidus, gustu mitis. *Latex* albus, immutabilis. *Sporae* 6.5-7.1-7.7 × 5.9-6.4-6.9 μm, *Q* = 1.07-1.11-1.17, subgloboseae, reticulatae, cristis ornatae usque ad 1.5(2) μm altis; macula suprahilaris distale amyloidea. *Macrocystidia* absentia. *Cheiloleptocystidia* 30-50 × 3-5 μm, subcylindrata, subfusiformia. *Pileipellis* bistrata, 90-110 μm crassa, pigmento brunneo, elementa suprapellis 20-50 × 3-5 μm.

*Typus*: “Malaysia, state of Negeri Sembilan, Pasoh Forest Reserve, at beginning of Nature Trail (near the Visitor’s Centre), N02°58.07’ E102°17.81’, 120 m alt., near several large *Shorea* sp., 21 September 2006, *Stubbe* 06-261 (GENT).”

*Pileus* 70-75 mm diam., wavy planoconvex to applanate with a slightly depressed centre, bearing an inconspicuous papilla; the margin remaining inflexed or involute and smooth to somewhat crenulate; surface dry and entirely velutinous, more or less smooth in central area, but radially wrinkled towards the margin, very unevenly coloured in large and indistinct patches going from rusty orange (5BC4-5) to orange-brown (6DEF5), slightly paler near margin. *Stipe* 30-35 × 15 mm, cylindrical to slightly compressed, equal, rather short and stocky; surface dry, velutinous, whitish orange to greyish orange (5BC4) with orange-brown dots and patches (6E4). *Lamellae* narrowly adnate, moderately distant, ≤ 6.5 mm broad, rather thick and firm, few lamellae forking close to the stipe, strikingly dark for the genus *Lactarius*, dull rusty orange or brownish orange, with a whitish tinge (6C3-5 and paler); edge smooth, brownish orange, concolorous with the lamella surface. *Context* rather firm and more or less thick in pileus, solid to stuffed in stipe, dirty white with an orange-brown tinge (paler than stipe surface), unchanging when bruised or cut; smell unremarkable; taste mild. *Latex* abundant, white, watery, unchanging. *Spore print* not observed.

*Basidiospores* (6.4)6.5-7.7 × 5.9-6.9 μm, *Q* = 1.07-1.17, on average 7.1 × 6.4 μm, *Q* =

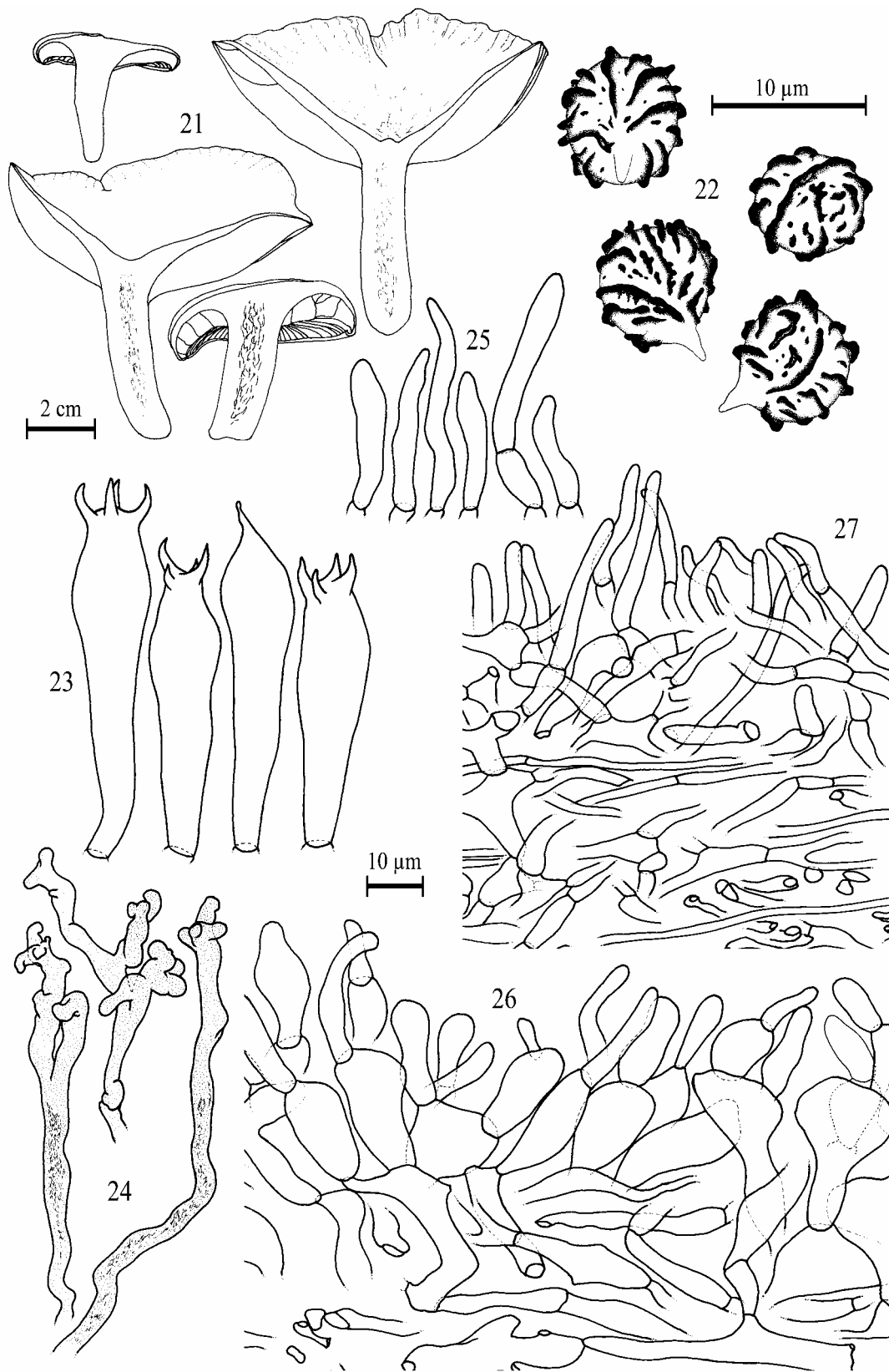
1.11 (n = 20), subglobose; ornamentation reticulate, with ridges up to 1.2-1.5(2) μm high, forming an almost complete reticulum composed of rather irregular ridges; many small, irregularly shaped, isolated warts present; plage mostly distally amyloid. *Basidia* 55-65 × 10-15 μm, narrowly clavate, hyaline, 4-spored; sterigmata 4-8 × 1.5-2 μm. *Macrocystidia* absent. *Pleuropseudocystidia* 5-10 μm broad, abundant, distinctly clavate, sometimes with an apical projection, slightly emergent, contents with tiny, needle-like and refringent particles. *Lamellar edge* sterile; *cheiloleptocystidia* 30-50 × 3-5 μm, abundant, slender and subfusiform or subcylindrical, mostly septate, hyaline; cell wall thin or somewhat refringent. *Lamellar trama* composed of inflated hyphae; *lactifers* abundant and often broad (≤ 17 μm). *Pileipellis* a trichopalisade, 90-110 μm thick, containing pale yellowish brown, intracellular and diffuse pigmentation in the suprapellis and upper layers of subpellis; suprapellis composed of slender, subcylindrical or subfusiform terminal elements, 20-50 × 3-5 μm, often septate, thin-walled or slightly refringent, usually upright; subpellis 45-65 μm thick, composed of more or less anticline series of inflated hyphal elements, somewhat elongated, sometimes almost isodiametrical, up to 25 × 15 μm, thin-walled. *Stipitipellis* a trichopalisade, 60-80 μm thick, containing a very pale, brownish yellow, intracellular and diffuse, pigmentation in the upper layers, with cell walls thin or slightly refringent; suprapellis composed of long and slender, subcylindrical terminal elements, 20-45 × 2.5-4 μm; subpellis 20-30 μm thick, a rather unorganized layer of inflated and sometimes irregularly shaped hyphal elements.

*Habitat*: lowland dipterocarp rain forest, near *Shorea* sp.

*Known distribution*: Peninsular Malaysia.

*Material examined*: MALAYSIA - state of Negeri Sembilan, Pasoh Forest Reserve, at beginning of Nature Trail (near the Visitor’s Centre), N02°58.07’ E102°17.81’, 120 m alt., near several large *Shorea* sp., 21 September 2006, *Stubbe* 06-261 (*typus*: GENT, *isotypus*: KEP).

*Notes*: The collection contained one mature basidiocarp in good condition. The orange-brown colours of the pileus and stipe together with their velutinous aspect could suggest an affiliation with *Lactarius* subgenus *Lactifluus* (Burl.) Hesler & A.H. Sm., however,



**Figs 21-27.** *Lactarius flavorosescens*. **Fig. 21.** *Stubbe* 06-226, *Stubbe* 06-244 and *Stubbe* 06-262. **21.** Basidiocarps. **Figs 22-27.** *Stubbe* 06-244 (*typus*). **22.** Basidiospores. **23.** Basidia. **24.** Pleuropseudocystidia. **25.** Cheiloleptocystidia. **26.** Pileipellis. **27.** Stipitipellis.

the dark lamellae, high spore ornamentations and the trichopalisadic pileipellis lacking thick-walled elements are more typical for *Lactarius* subgenus *Plinthogalus*. The dark and distant lamellae are reminiscent of *L. oomsisiensis* Verbeken & Halling described from Papua New Guinea. Both species also have similar spores. Macroscopically, *L. oomsisiensis* differs by its pale milky-coffee coloured pileus, its white to cream-coloured stipe and the context turning pink when exposed. Microscopically *L. oomsisiensis* is best distinguished by the shorter terminal elements in both pilei- and stipitipellis as well as on the lamellar edge, never exceeding 30  $\mu\text{m}$ .

***Lactarius flavorosescens* Stubbe & Verbeken sp. nov.** (Figs 21-27; Figs 96-98)

Mycobank: 512245

*Etymology*: from *flavus*, meaning yellow, and *rosescens*, meaning pinkening, referring to the latex becoming yellow and then pink.

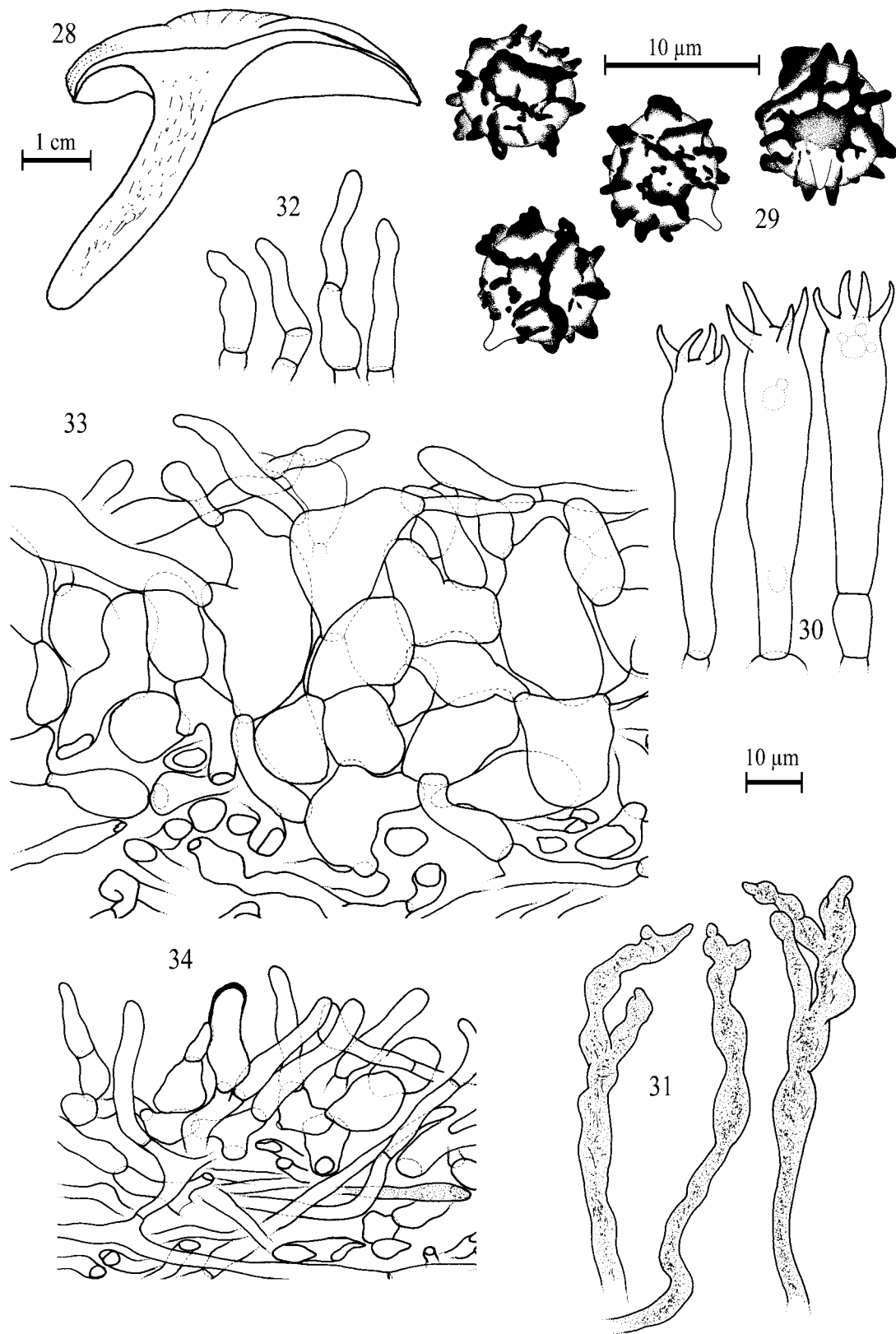
*Pileus* 40-110 mm diam., convexus ad concavum, in centro papillatus, margine crenulato, laevis ad rugulosum, atrobrunneus. *Stipes* 30-55 mm longus, 8-15 mm crassus, cylindratus, siccus, leviter velutinus, brunneus vel albidus. *Lamellae* late adnatae vel decurrentes, moderate densae ad moderate distantes, crassae, cremeae, lente rosescens ad brunneo-rosescentes. *Contextus* albus, flavescens, tum pallide roseus. *Latex* copiosus, albus, primo flavescens, tum rosescens, gustu acris. *Sporae* 7-7.8-8.7  $\times$  6.1-7-7.8  $\mu\text{m}$ ,  $Q = 1.07-1.13-1.29$ , subglobose ad late globosas, zebroideae, cristis ornatae usque ad 2(2.5)  $\mu\text{m}$  altis; macula suprahilaris non amyloidea vel distale amyloidea. *Macrocystidia* absentia. *Cheiloleptocystidia* 10-45(55)  $\times$  2-10  $\mu\text{m}$ , subcylindrata, subfusiformia. *Pileipellis* bistrata, 40-80  $\mu\text{m}$  crassa, pigmento brunneo, elementa suprapellis 5-35  $\times$  3-12, interdum pariete incrassato. *Stipitipellis* trichoderma.

*Typus*: "Malaysia, state of Negeri Sembilan, Pasoh Forest Reserve, near beginning of Nature Trail, N02°58.32' E102°18.19', 127 m alt., next to trail on soil, in secondary lowland rain forest dominated by *Dipterocarpaceae*, 19 September 2006, *Stubbe* 06-244 (GENT)".

*Pileus* 40-110 mm diam., convex to plano-convex with an involute margin when young, becoming appanate to wavy concave or wavy infundibuliform, always with a small, sometimes minute, papilla; surface smooth to faintly rugulose in the central area and radially rugose or radially grooved in the marginal zone when mature, with the margin becoming crenate, the surface texture dry and entirely velutinous (in dry conditions), dark brown, more or less chocolate brown (5-6F4-8, 6E4) with small and

irregular paler, to almost whitish brown or brownish grey mottles (5-6D3). *Stipe* 30-55  $\times$  8-15 mm, cylindrical and equal, often rather short compared to pileus diameter, sometimes tapering and curved towards the base; surface dry and velutinous or faintly velutinous, concolorous though often paler than pileus and with a more whitish or greyish hue, occasionally almost predominantly dirty white and then with large, indistinct brownish grey patches (5-6D3); the extreme base often whitish. *Lamellae* sinuate, broadly adnate or subdecurrent, moderately crowded to moderately distant, broad (8-13 mm) and subventricose when mature, rather thick, pale to dark cream-coloured, slowly staining pink to brownish pink when bruised or damaged (7BC3-4, 7D4-5); the edge smooth and concolorous with lamella surface. *Context* moderately thin at pileus midradius, firm in pileus and solid to stuffed in stipe, white but within several seconds staining pale yellow (2A4) due to the latex, after a few minutes slowly turning pale pastel pink (5A3, 6A2-3 up to 7-8A2-3); smell faint, sweetish fungoid; taste mild at first, soon becoming acid but fading again. *Latex* moderately abundant to rather copious, white or watery white, droplets on context and lamellae within  $\pm$  1 minute becoming bright pale yellow (2A4) but soon fading again and then slowly, after several minutes (or longer, especially the droplets on the lamellae), turning pale pink together with the surrounding context (5A3, 6A2-3 up to 7-8A2-3) and ultimately drying in brownish pink stains on lamellae and context (7BC3-4), the latex isolated on a glass plate remaining white or becoming yellow and drying whitish, but never turning pink; taste acid. *Spore print* not observed.

*Basidiospores* (6.5)6.7-9.2(9.5)  $\times$  6-8.7 (9)  $\mu\text{m}$ ,  $Q = 1.01-1.29$ , on average 7.4-8.4  $\times$  6.7-7.8  $\mu\text{m}$ ,  $Q = 1.05-1.13$  (n = 160), globose to broadly ellipsoid; ornamentation zebroid, 1.5-2 (< 2.5)  $\mu\text{m}$  high, composed of often long and rather straight ridges, sometimes thick ( $\leq$  1  $\mu\text{m}$ ), mostly isolated with some or few ridges branching but never reticulate and the edges of high ridges often finely crenulate; numerous small, isolated warts present; plage not or distally amyloid. *Basidia* 40-65  $\times$  11-17  $\mu\text{m}$ , clavate or narrowly clavate, hyaline, 4-spored, though sometimes very few 1- and 2-spored



**Figs 28-34.** *Lactarius fulvus* (Stubbe 06-298, *typus*). 28. Basidiocarp. 29. Basidiospores. 30. Basidia. 31. Pleuropseudocystidia. 32. Cheiloleptocystidia. 33. Pileipellis. 34. Stiptipellis.

basidia present; sterigmata  $3-7 \times 1.5-2 \mu\text{m}$ , rather long and firm. *Macrocystidia* absent. *Pleuropseudocystidia*  $2-5 \mu\text{m}$  diam., mostly scarce or dispersed, sometimes moderately abundant, knobby tortuous, often branching towards the apex, sometimes corkscrew-like, shortly emergent, often containing needle-like crystals. *Lamellar edge* sterile, composed entirely of cheiloleptocystidia; *cheiloleptocystidia*  $10-45(55) \times 2-10 \mu\text{m}$ , predominantly subcylindrical and narrowly subfusiform, sometimes clavate, hyaline, thin-walled or sometimes refringent. *Lamellar trama* composed of broad or inflated hyphae and subcellular elements; *lactifers* abundant or moderately abundant. *Pileipellis* a trichopalisade,  $40-80 \mu\text{m}$  thick, containing dark brown, intracellular pigmentation; terminal elements  $5-35 \times 3-12 \mu\text{m}$ , subcylindrical, subfusiform and subclavate, both slender and stout, sometimes exceeding  $35 \mu\text{m}$  but then 2-celled, with cell walls thin or refringent; sometimes elements with irregularly thickened cell walls scarcely present; subpellis composed of inflated cells, up to  $25 \times 15 \mu\text{m}$ , mostly more or less elongated and irregularly shaped, intermixed with inflated hyphae, thin-walled. *Stipitipellis* a trichoderm containing inflated, hyphal elements, sometimes almost a trichopalisade,  $50-90 \mu\text{m}$  thick, with pale brown, intracellular pigmentation in the upper layers; terminal elements,  $\leq 4 \mu\text{m}$  broad, subcylindrical with obtuse apex, upright, anticline or oblique, cell walls thin or refringent.

*Habitat*: Lowland to mid-elevation rain forest, dominated by dipterocarps.

*Known distribution*: Peninsular Malaysia and Borneo.

*Material examined*: **MALAYSIA** - state of Negeri Sembilan, Pasoh Forest Reserve, near beginning of Nature Trail,  $\text{N}02^{\circ}58.32' \text{E}102^{\circ}18.19'$ , 127 m alt., next to trail on soil, in secondary lowland rain forest dominated by *Dipterocarpaceae*, 19 September 2006, *Stubbe* 06-244 (*typus*: GENT, *isotypus*: KEP) - *ib.*, along beginning of Main Trail,  $\text{N}02^{\circ}58.19' \text{E}102^{\circ}17.84'$ , 130 m alt., on soil, in secondary lowland rain forest dominated by *Shorea leprosula* and *Dipterocarpus spp.*, 17 September 2006, *Stubbe* 06-226 - *ib.*, in experimental plots,  $\text{N}02^{\circ}58.30' \text{E}102^{\circ}17.76'$ , on soil, in regenerating lowland rain forests (formerly completely logged over), dominated by *S. leprosula*, 21 September 2006, *Stubbe* 06-262 - *ib.*, on trail alongside experimental plots in regenerating lowland rain forest dominated by *S. leprosula*, 25 September 2006, *Stubbe* 06-302 - *ib.*, in Arboretum, 11 September 1995, *Watling* 26672 - *ib.*, 11 September 1995, *Watling* 26673 - *ib.*, in secondary

lowland rain forest, on path alongside Visitor's Centre, 12 March 1992, *Watling* 24192 - Borneo, state of Sabah, Mount Kinabalu area, alongside Mesilau river, 1700 m alt., 21 April 1964, *Corner* RSNB8399.

*Notes*: A yellow colour change in the latex is uncommon in *Lactarius* subgenus *Plinthogalus*. It is known from the North American species *L. xanthydorheus* Singer, *L. subtomentosus* Berk. & Ravenel, the African taxon *L. undulatus* var. *rasis* Verbeken and the Malaysian species *L. mirabilis* Stubbe *et al.* and *L. lazulinus* Stubbe *et al.* *Lactarius flavorosescens* is the first species known to exhibit a subsequent pink colour change of the context. In the field it is further characterized by its firm stature, with, especially in mature specimens, the wide pileus and relatively short stipe, both in a more or less chocolate brown colour, and by the broad and dark cream lamellae. *Lactarius flavorosescens* was one of the more frequently encountered *Lactarius* species in the investigated area. Young specimens could be mistaken for *L. cinereo-brunneus*, but this species is smaller and has no obvious colour changes in the context or latex. Its habitus and microscopic features fully support the position in *Lactarius* subgenus *Plinthogalus*. Though neither Watling nor Corner mentioned a yellow discoloration on their specimens, the morphological data leave no doubt about the conspecificity with the recent collections made in 2006.

*Lactarius fulvus* Stubbe & Verbeken **sp. nov.**  
(Figs 28-34; Figs 90-92)

MycoBank: 512246

*Etymology*: *fulvus*, meaning dull yellow with a mixture of grey and brown, yellowish brown.

*Pileus* 55-60 mm diam., convexus, in centro depressus, sulcatus, margine laevi ad crenulatam, velutinus, fulvus ad ferrugineo-brunneum. *Stipes* 45 mm longus, 7-9 mm crassus, excentricus, cylindratus, leviter rugulosus, leviter velutinus ad laevem, albido-aurantiacus ad griseo-aurantiacum. *Lamellae* adnatae ad subdecurrentes, distantes, latae, griseo-aurantiacae. *Contextus* tenuis, albidus tum roseus, gustu leviter acris. *Latex* albus, in sicco roseo-grisescens vel griseo-rosescens. *Sporae*  $6-6.8-7.7 \times 5.5-6.2-6.8 \mu\text{m}$ ,  $Q = 1.04-1.11-1.26$ , subgloboseae, reticulatae, cristis ornatae usque ad  $1.5-2 \mu\text{m}$  altis; macula suprahilaris distale ad omnino amyloidea. *Macrocystidia* absentia. *Cheiloleptocystidia*  $10-45 \times 3-7 \mu\text{m}$ , subfusiformia. *Pileipellis* bistrata,  $50-100 \mu\text{m}$  crassa, pigmento brunneo, elementa suprapellis  $5-30 \times 2-8 \mu\text{m}$ .

*Typus*: "Malaysia, Negeri Sembilan, Pasoh Forest Reserve, along trail south of experimental plots,

N02°58.18' E102°17.75', 141 m alt., in formerly completely logged-over area, now regenerating rain forest, 25 September 2006, *Stubbe* 06-298 (GENT)."

*Pileus* 55-60 mm diam., convex with depressed centre, radially grooved towards the margin, near the margin concentrically wrinkled; margin smooth to irregularly crenate; surface dry and velutinous (in dry conditions), pale dirty ochraceous with a weak orange tinge in the central area (5A3-4, 5B4-5), with rusty brown spots and smudges (5C5-6), greyish orange towards the margin (5BC3-4). *Stipe* 45 × 7-9 mm, cylindrical, equal, somewhat eccentric; surface dry, slightly longitudinally rugulose, minutely velutinous to nearly glabrous, orange-white (5A2-3) with greyish tinges (5BC2-3). *Lamellae* sinuate, adnate or subdecurrent, distant, broad (up to 9 mm), dark greyish orange or orange-grey with a whitish bloom (5D4, 5C3-4); edge smooth, concolorous. *Context* thin in pileus, solid to stuffed in stipe, whitish, staining pink when exposed (7AB5); taste slightly acrid. *Latex* rather abundant, white, watery, drying grey with a pinkish tinge (7B2 to 7B3), on lamellae the latex very slowly (after more than one hour) drying dirty orange-pink (7B4-5), latex remaining and drying white when isolated on a glass slide. *Spore print* not observed.

*Basidiospores* 6-8(8.3) × (5.3) 5.5-7.7 (7.8) μm,  $Q = 1.01-1.26$ , on average 6.8-7.5 × 6.2-7.1 μm,  $Q = 1.06-1.11$  (n = 60), subglobose; ornamentation an almost complete reticulum composed of ridges, 1.5-2 μm high, irregular and thick (0.5-1 μm thick), with crenulate edges; only a few isolated warts present; plage distally to almost totally amyloid. *Basidia* 45-65 × 10-15 μm, narrowly clavate, 4-spored; basidia and basidioles with yellowish brown, intracellular pigmentation (*i.e.* phaeobasidia) scattered to very abundant; sterigmata 5-9 × 1.5-2 μm, firm. *Macrocystidia* absent. *Pleuro-pseudocystidia* 4-10 μm diam., abundant, mostly emergent, submoniliform or subclavate mostly with some branches towards the apex, often containing more or less coarse, needle-like and crystalline particles. *Lamellar edge* mostly sterile and composed of *cheiloleptocystidia*, 10-45 × 3-7 μm, subfusiform, sometimes septate, thin-walled sometimes containing yellowish brown pigmentation similar to that of basidia. *Lamellar trama* predominantly filamentous but with cellular clusters; *lactifers*

abundant. *Pileipellis* a palisade or trichopalysade, 50-100 μm thick; suprapellis composed of subfusiform to subclavate terminal elements, 5-30 × 2-8 μm, moderately abundant, oblique, recumbent or short repent, thin-walled or refringent, containing pale or dark brown, intracellular and diffuse pigmentation; subpellis composed of broadly inflated hyphal elements up to 35 × 20 μm, mostly irregularly shaped, some nearly isodiametrical, thin-walled. *Stiptipellis* a trichopalysade, 25-70 μm thick; terminal elements 5-30 × 2-10 μm, subfusiform, subcylindrical to subclavate, oblique or erect, thin-walled or refringent, containing brown, intracellular and diffuse pigmentation; subpellis composed of hyphae and inflated hyphal elements up to 25 × 15 μm, thin-walled.

*Habitat*: regenerating lowland rain forest dominated by dipterocarps.

*Known distribution*: Peninsular Malaysia.

*Material examined*: MALAYSIA -state of Negeri Sembilan, Pasoh Forest Reserve, along trail south of experimental plots, N02°58.18' E102°17.75', 141 m alt., in formerly completely logged-over area, now regenerating rain forest, 25 September 2006, *Stubbe* 06-298 (*typus*: GENT, *isotypus*: KEP) - *ib.*, along the path of the Visitor's Centre, 17 March 1992, *Watling* 24791 - *ib.*, along the Nature Trail, 22 March 1997, *Watling* 27028.

*Notes*: The macroscopical description is based on *Stubbe* 06-298. *Watling's* specimens have been annotated only mentioning a reddening context and referring to *L. subplinthogalus* Coker. The latter is a North American species without any rusty orange tinges, and having spores with a non-reticulate, spore ornamentation. Another difference is the strikingly dark, greyish orange lamellae that are reminiscent of *L. oomsisiensis*. This species however, lacks ochraceous orange tinges in pileus and stipe. Also, *L. fulvus* is a thin-fleshed mushroom, whereas *L. oomsisiensis* and *L. ferrugineifolius* are moderately thick-fleshed in the pileus. In the field, *L. ferrugineifolius* and *L. fulvus* appear similar. The context of *L. fulvus* turns pink when cut, while *L. ferrugineifolius* does not exhibit any colour change. In the pilei- and stiptipellis *L. fulvus* does not have the long and slender terminal elements as in *L. ferrugineifolius*. The spores of *L. fulvus* can be distinguished by the near absence of minute, isolated warts which are abundant on the spore surface of *L. oomsisiensis* and *L. ferrugineifolius*. A distinct

microscopical character of *L. fulvus* is the presence of basidia and basidioles with yellow-brown contents, so-called phaeobasidia. So far this character has not been reported from other *Lactarius* species.

***Lactarius lazulinus*** Stubbe, Verbeken & Watling, Belg. J. Bot. 140 (2): 202-204 (2007). MycoBank: 512247

A greyish brown mushroom with white latex immediately turning yellow, slowly staining the context blue to bluish green; basidiospores bearing zebroid ornamentation  $\geq 2 \mu\text{m}$  high, the ridges strongly curved and with crenulate edges.

Diagnosis available on *Russulales*-News website.

***Lactarius mirabilis*** Stubbe, Verbeken & Watling, Belg. J. Bot. 140 (2): 204-207 (2007). (Figs 93-95)

MycoBank: 512248

A brownish grey species with crowded, blue bruising lamellae and context, white latex rapidly becoming yellow before fading to white again; small basidiospores ( $6.1\text{-}6.8 \times 5.6\text{-}6.4 \mu\text{m}$ ) bearing  $1.5\text{-}2 \mu\text{m}$  high, reticulate ornamentation.

Illustrations and diagnosis available on *Russulales*-News website.

***Lactarius ochrogalactus*** Hashiya, Mycoscience 47: 232-234 (2006). (Figs 35-40)

*Pileus*  $< 90$  mm diam., convex then deeply cyathiform-infundibuliform, dry, innately velutinous, slightly radially sulcate, sepia to umber-brown, paler on expansion. *Stipe*  $50 \times 11$  mm, subcylindrical with attenuate base, concolorous with the pileus, completely sepia, velutinous, base white. *Lamellae* decurrent, distant (22 lamellae), broad (up to 7 mm), thick, interstices smooth, cream-white, lamellulae of 3 to 4 different lengths. *Context* pallid subochraceous; taste mild; smell strong, rather sour. *Latex* watery, yellow, turning vinaceous pink on exposure. *Spore print* not observed.

*Basidiospores* ( $6.9\text{--}7.2\text{--}9.2 \times 6.2\text{--}8.3 \mu\text{m}$ ),  $Q = 1.04\text{--}1.3$ , on average  $8.2 \times 7.3 \mu\text{m}$ ,  $Q = 1.13$ , ( $n = 20$ ), subglobose to broadly ellipsoid; ornamentation amyloid, a rather dense network of more or less conical to slightly flattened spines with blunt apex,  $0.5\text{--}1$  ( $1.3$ )  $\mu\text{m}$  high,

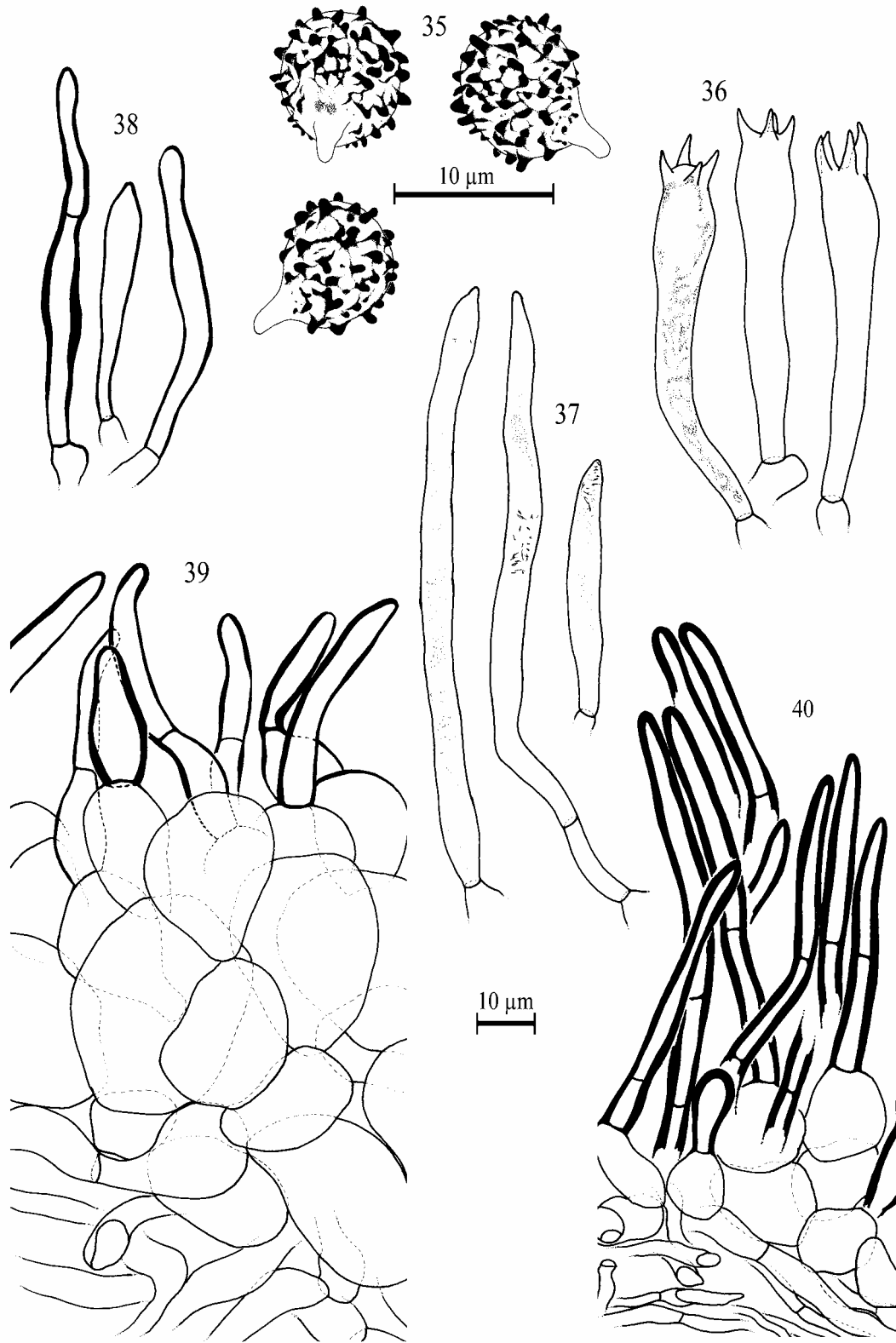
interconnected by fine lines and low ridges; plage inamyloid or diffusely, centrally amyloid. *Basidia*  $60\text{--}80 \times 9\text{--}12 \mu\text{m}$ , narrowly clavate, sometimes containing coarsely granular, refringent material (more frequently present in basidioles), 4-spored; sterigmata  $6\text{--}11 \times 1.5\text{--}2 \mu\text{m}$ , sturdy and long. *Pleuromacrocystidia*  $45\text{--}110 \times 5\text{--}7 \mu\text{m}$ , rather abundant, emergent or not, narrowly fusiform or cylindrical with a slightly tapering apex, minutely granular (or guttulate) contents, sometimes containing needle-like, refringent granules, very thin-walled. *Pleuropseudocystidia* rare. *Lamellar edge* completely composed of *cheilocystidia*,  $60\text{--}90 \times 5\text{--}7 \mu\text{m}$ , long and slender, cylindrical to subfusiform with obtuse apex and mostly thickened cell walls, sometimes septate, hyaline. *Lamellar trama* composed of hyphae and sphaerocytes; *lactifers* moderately abundant. *Pileipellis* a palisade,  $90\text{--}120 \mu\text{m}$  thick, containing brown, intracellular, diffuse or somewhat coagulated pigmentation in the suprapellis and upper layer of the subpellis; suprapellis composed of slender, subcylindrical and subfusiform terminal elements,  $30\text{--}65 \times 5\text{--}7 \mu\text{m}$ , mostly septate and with thickened cell walls, predominantly erect or oblique; subpellis composed of several layers of sphaerocytes, thin-walled. *Stipitipellis* a lampropalisade,  $100\text{--}130 \mu\text{m}$  thick, with long, cylindrical, terminal elements,  $50\text{--}100 \times 5\text{--}7 \mu\text{m}$ , septate and often containing brown, coagulated or vacuolised pigmentation; cell walls more or less  $1 \mu\text{m}$  thick; subpellis thin, composed of one or two layers of hyaline and thin-walled sphaerocytes.

*Habitat*: mid-elevation rainforest, fagaceous forests dominated by *Castanopsis*, *Quercus*, *Fagus* or *Lithocarpus*.

*Known distribution*: Japan, China (Yunnan Prov.), Borneo.

*Material examined*: MALAYSIA - Borneo, state of Sabah, Mount Kinabalu, alongside Mesilau river, at 1700 m alt., in humus of forest floor, 16 March 1964, Corner RSNB 5806. JAPAN - Ohe, Funaoka-cho, Yazu, Tottori, in *Quercus serrata*-*Castanea crenata* forest, 19 July 1980, Nagasawa 80-102 (*typus*: TMI 26082) - Hiruzen Experimental Forest of Tottori Univ., Kaqakami-son, Maniwa-gun, Okayama, in *Quercus serrata* forest, 13 September 1983, Nagasawa s. n. (TMI 26088).

*Notes*: *Lactarius ochrogalactus* was described from Japan and has also been reported from southern China (Wang *et al.*, 2006). The species is characterized by the



**Figs 35-40.** *Lactarius ochrogalactus* (Corner RSNB 5806). 35. Basidiospores. 36. Basidia. 37. Macrocystidia. 38. Cheileleptocystidia. 39. Pileipellis. 40. Stipitipellis.



brown coloured basidiocarps and the yellow or yellowish brown latex staining the context vinaceous, the thick-walled terminal elements from the pilei- and stipitipellis, the long, thick-walled cheilocystidia and the presence of the slender, thin-walled macrocystidia over 100  $\mu\text{m}$  long. Though the Malaysian specimen is much darker than its Japanese congeners, described as (pale) yellowish brown, the similarities are undeniable. The position of *L. ochrogalactus* is uncertain, sharing characters of both *Lactarius* subgenus *Lactifluus* and *Lactarius* subgenus *Plinthogalus* (Wang *et al.*, 2006). Since no molecular data could be obtained, we continue to treat this species as a putative member of *Lactarius* subgenus *Plinthogalus*. However, its white spore print makes an affinity with *L. gerardii* very likely. Other characters they have in common are the brown pileus and stipe, the distant lamellae, the well-developed palisade in the pileipellis and the subglobose to broadly ellipsoid spores with a dense reticulum.

***Lactarius pallidior* Stubbe & Verbeken sp. nov.** (Figs 41-47; Figs 101-103)  
MycoBank: 512249

*Etymology*: the comparative degree for the Latin word pallidus, meaning pale.

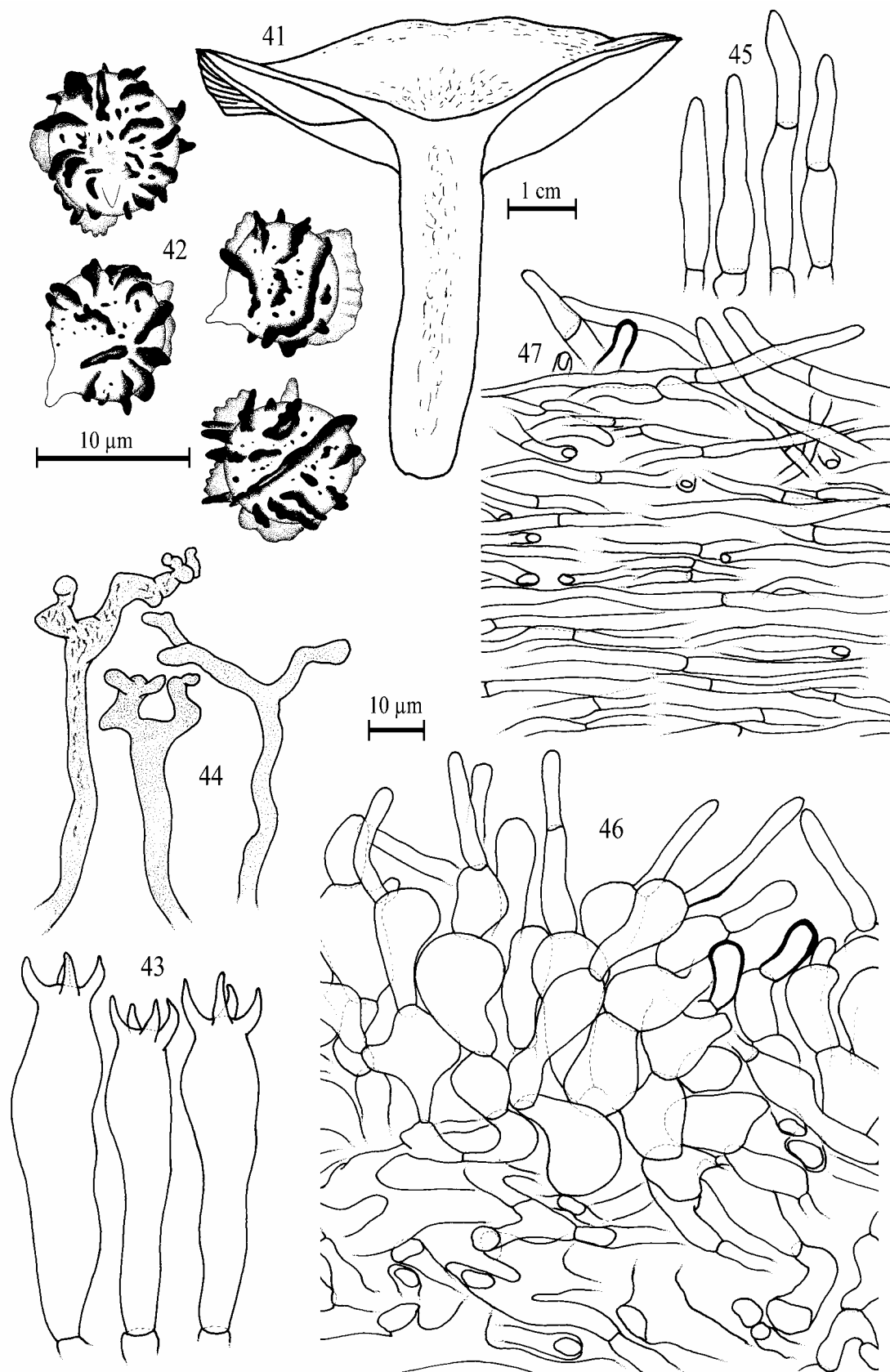
*Pileus* 50-75 mm diam., planoconvexus ad plano-concavum, rugulosus, velutinus, albidus, cremeus. *Stipes* 40-50 mm longus, 9-11 mm crassus, cylindratus, pileo concolorus vel pallidior. *Lamellae* distantes, cremeae, leviter flavescens. *Contextus* albidus, primo flavescens tum rosescens; gustu leviter acris. *Latex* albus, flavescens, rosescens in sicco. *Sporae* 7.7-8.4-9.2  $\times$  7.4-8-8.5  $\mu\text{m}$ ,  $Q = 1.02-1.06-1.10$ , subgloboae, incomplete reticulatae, cristis brevis usque ad 2(2.5)  $\mu\text{m}$  ornatae; macula suprahilaris distale amyloidea. *Macrocystidia* absentia. *Cheiloleptocystidia* 10-50  $\times$  3-6  $\mu\text{m}$ , subcylindrata, subfusiformia vel sublageniformia. *Pileipellis* bistrata, 80-100  $\mu\text{m}$  crassa, vix pigmento pallide brunneo, elementa suprapellis 10-35(40)  $\times$  3-8  $\mu\text{m}$ , subpellis ex cellulis globosis et hyphis. *Stipitipellis* trichodermia.

*Typus*: "Malaysia, state of Negeri Sembilan, Pasoh Forest Reserve, along trail south of experimental plots, N02°58.20' E102°17.65', 160 m alt., on soil in regenerating rain forest, formerly completely logged-over, dominated by *Dipterocarpaceae*, 25 September 2006, Stubbe 06-297 (GENT)".

*Pileus* 50-75 mm diam., plano-convex to plano-concave, with centre slightly depressed and radially rugulose, towards the margin concentrically rugulose to wrinkled; margin smooth and slightly waving; surface dry and velutinous (in dry conditions), mainly dirty

white to pale cream-coloured (4A2), with a faint pinkish tinge in central area (5A2), and slightly more yellowish at the margin (4A3). *Stipe* 40-50  $\times$  9-11 mm, straight, cylindrical and equal; surface dry, smooth to minutely velutinous or faintly subtomentose, dirty white but a tinge paler than the pileus. *Lamellae* sinuately attached, moderately distant, rather thick and up to 5-7 mm broad, warm cream-coloured (4A3) and darker than stipe, staining slightly yellowish when bruised, rarely anastomosing; edge smooth, concolorous. *Context* moderately thin at pileus midradius, stuffed to somewhat hollow in stipe, white but soon staining bright yellow by the latex (2A4-5), shortly after, fading and slowly becoming pale pinkish (6A2); smell somewhat fruity; taste acrid but not for long. *Latex* rather abundant and thick, white, turning rapidly bright yellow (2A4-5), then soon fading again to white and slowly staining the exposed context pale pink; droplets on lamellae or on stipe surface usually remaining white after turning yellow and drying dirty white to grey, sometimes with a greenish tinge, when isolated on a glass slide becoming yellow and drying white. *Spore print* not observed.

*Basidiospores* 7.7-9.2  $\times$  7.4-8.5(8.7)  $\mu\text{m}$ ,  $Q = 1.02-1.10$ , on average 8.4  $\times$  8  $\mu\text{m}$ ,  $Q = 1.06$  ( $n = 20$ ), subglobose; ornamentation composed of mostly isolated long and shorter ridges or wings, up to 1.5-2 (2.5)  $\mu\text{m}$  high, fairly wide-spaced, some branching; the edges mostly distinctly crenulate; numerous small, isolated warts present; plage mostly distally amyloid. *Basidia* 50-60  $\times$  12-17  $\mu\text{m}$ , clavate or subclavate and rather slender, 4-spored but also 1- and 2-spored basidia present; sterigmata 4-8  $\times$  1.5-2  $\mu\text{m}$ , rather robust. *Macrocystidia* absent. *Pleuropseudocystidia* 3-5  $\mu\text{m}$  diam., scarce to scattered, mostly tortuous and branching towards the apex, not or hardly emergent, sometimes containing needle-like crystals. *Lamellar edge* sterile, entirely composed of cheiloleptocystidia; *cheiloleptocystidia* 10-50  $\times$  3-6  $\mu\text{m}$ , sometimes longer but then septate, mostly subcylindrical to subfusiform or narrowly sublageniform, thin-walled or with slightly refringent cell wall, hyaline. *Lamellar trama* predominantly filamentous but with clusters of cellular elements; *lactifers* abundant. *Pileipellis* a trichopalysade to palisade, 80-100  $\mu\text{m}$  thick;



**Figs 41-47.** *Lactarius pallidior* (Stubbe 06-297, *typus*). 41. Basidiocarp. 42. Basidiospores. 43. Basidia. 44. Pleuropseudocystidia. 45. Cheiloleptocystidia. 46. Pileipellis. 47. Stiptipellis.

most cells practically hyaline, some containing very pale brown, intracellular and diffuse pigmentation; suprapellis composed of cylindrical to subfusiform terminal elements,  $10\text{--}35(40) \times 3\text{--}8 \mu\text{m}$ , cell wall mostly refringent, sometimes thickened, sometimes 2-celled; subpellis composed of inflated cells and hyphal elements, up to  $30 \times 17 \mu\text{m}$ , thin-walled or refringent. *Stipitipellis* a trichoderm, hyaline; terminal elements  $3\text{--}5 \mu\text{m}$  diam., subcylindrical, subclavate or subfusiform, erect, oblique or pericline, with cell wall often refringent; subpellis a dense layer of parallel hyphae.

*Habitat*: regenerating lowland rain forest dominated by dipterocarps.

*Known distribution*: Peninsular Malaysia.

*Material examined*: MALAYSIA - state of Negeri Sembilan, Pasoh Forest Reserve, along trail south of experimental plots, N02°58.20' E102°17.65', 160 m alt., on soil in regenerating rain forest, formerly completely logged-over, dominated by *Dipterocarpaceae*, 25 September 2006, Stubbe 06-297 (*typus*: GENT; *isotypus*: KEP).

*Notes*: *Lactarius pallidior* is closely related to *L. flavorosescens*, which differs by the chocolate brown colour of the pileus and stipe. The spores of *L. pallidior* are slightly bigger and bear ridges that are coarser and conspicuously crenulate compared to *L. flavorosescens*. The dual discoloration of the context, first staining yellow and afterwards pink, is characteristic for both species.

***Lactarius papillatus* Stubbe & Verbeken, sp. nov.** (Figs 48-55)

MycoBank: 512250

*Etymology*: bearing a papilla.

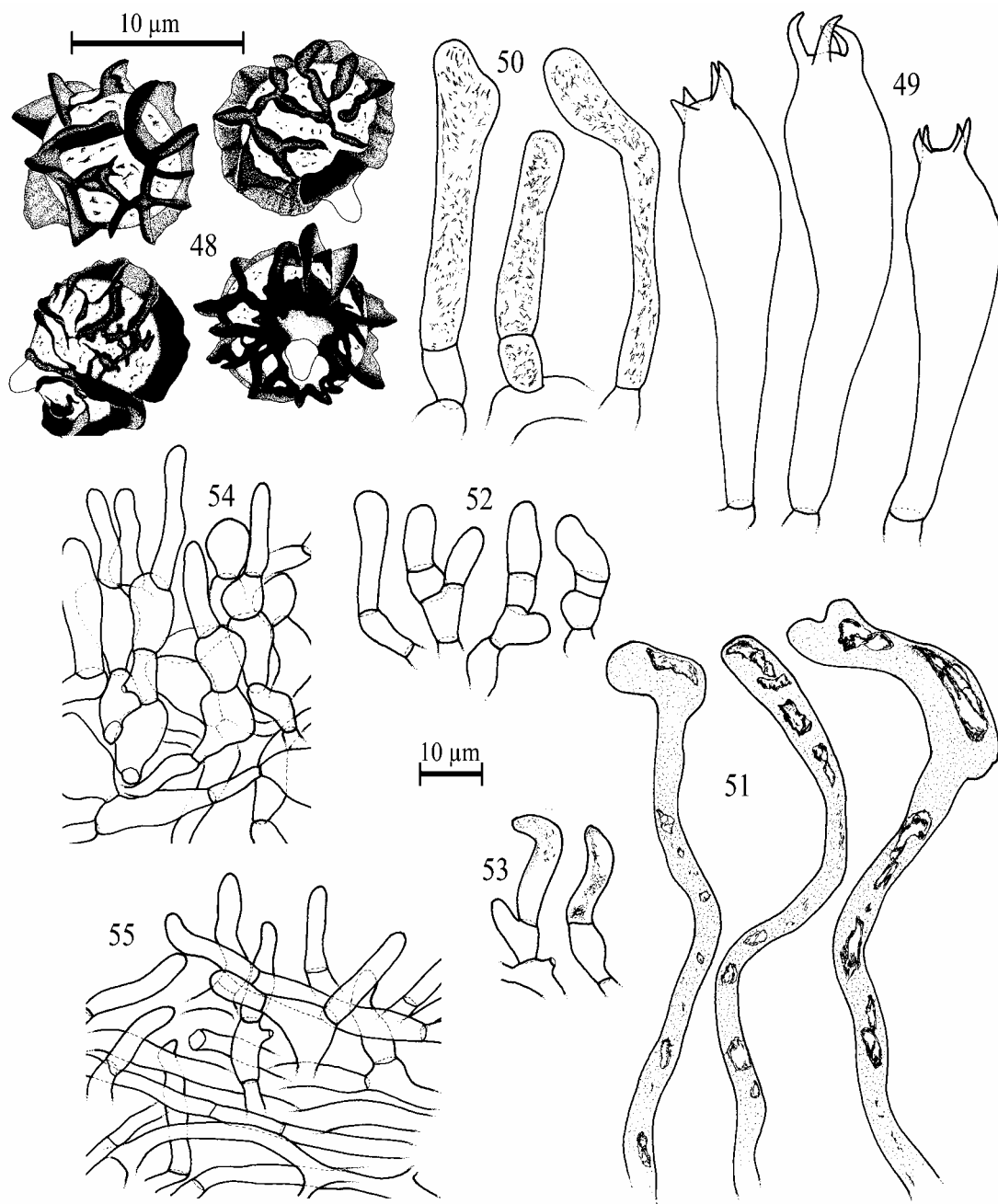
*Pileus* usque ad 70 mm diam., convexus ad concavum, acute umbonatus, papillatus, siccus, ex carneo hinnuleus. *Stipes* 40-60 mm longus, 7-10 mm crassus, subcylindratus, pileo concolorus. *Lamellae* adnatae ad decurrentes, distantes, latae, pileo concolores. *Contextus* albidus ad pallide hinnuleum. *Latex* albus, ferrugineo-rosescens. *Sporae*  $7.9\text{--}8.6\text{--}9.4 \times 7.3\text{--}7.9\text{--}8.5 \mu\text{m}$ ,  $Q = 1.05\text{--}1.09\text{--}1.16$ , subglobosae, reticulatae, cristis acutis usque ad  $2 \mu\text{m}$  ornatae; macula suprahilaris distale ad fere omnino amyloidea. *Macrocyttidia* moderate abundantia,  $45\text{--}55 \times 4\text{--}10 \mu\text{m}$ , subcylindrata ad anguste subclavata. *Cheiloleptocystidia*  $10\text{--}20 \times 5\text{--}8 \mu\text{m}$ , cheilomacrocyttidia moderate abundantia,  $10\text{--}20 \times 4\text{--}6 \mu\text{m}$ . *Pileipellis* bistrata,  $60\text{--}90 \mu\text{m}$  crassa, elementa suprapellis  $10\text{--}30 \times 3\text{--}10 \mu\text{m}$ , subpellis ex cellulis globosis et hyphis. *Stipitipellis* trichodermia.

*Typus*: "Malaysia, Borneo, state of Sabah, Mount Kinabalu, alongside Mesilau river, 1600 m alt., in humus of forest floor, 2 April 1964, Corner RSNB 8057 (E)."

*Pileus* < 70 mm diam., convex to applanate

and concave, often acutely umbonate, dry, matt, pale fawn tan or tinged flesh-coloured. *Stipe*  $40\text{--}60 \times 7\text{--}10 \text{mm}$ , subcylindrical, concolorous with pileus. *Lamellae* adnate-decurrent, distant, broad, 5-10 mm wide, interstices smooth, 23-32 lamellae, 2-3 lengths of lamellulae, concolorous with the pileus or paler. *Context* 3-4 mm thick in the centre of the pileus, solid in stipe, firm, white to pale fawn. *Latex* white, copious, turning rufous pink on exposure; taste acrid. *Spore print* not observed.

*Basidiospores*  $7.9\text{--}9.4(9.5) \times 7.3\text{--}8.5(8.7) \mu\text{m}$ ,  $Q = 1.05\text{--}1.16$ , on average  $8.6 \times 7.9 \mu\text{m}$ ,  $Q = 1.09$  (n = 20), subglobose; ornamentation amyloid, an almost complete but rather disorderly reticulum, composed of acute and slightly sinuous ridges,  $1.5\text{--}2 \mu\text{m}$  high; abundant, very minute, isolated warts present; plage distally to almost completely and diffusely amyloid. *Basidia* distinctly clavate and large,  $55\text{--}80 \times 12\text{--}16 \mu\text{m}$ , 4-spored, usually hyaline; sterigmata sturdy,  $4\text{--}9 \times 1.5\text{--}2 \mu\text{m}$ . *Pleuromacrocyttidia* moderately abundant,  $45\text{--}55 \times 4\text{--}10 \mu\text{m}$ , subcylindrical to narrowly subclavate or clavate with obtuse apex, sometimes septate at the base, completely filled with strongly refringent, finely granular and needle-like contents, emerging from hyaline hyphae, slightly emergent, thin-walled. *Pleuropsseudocystidia* moderately abundant,  $4\text{--}10 \mu\text{m}$  broad, usually strongly enlarged at the apex, emergent, containing aggregated lumps of amorphous, refringent material. *Lamellar edge* nearly completely composed of *cheiloleptocystidia*,  $10\text{--}20 \times 5\text{--}8 \mu\text{m}$ , predominantly broadly clavate and hyaline, as terminal cells of chains composed of short, inflated hyphal elements; *cheilomacrocyttidia* scattered to moderately abundant,  $10\text{--}20 \times 4\text{--}6 \mu\text{m}$ , fusiform and thin-walled, containing refractive, granular debris-like material. *Lamellar trama* composed of filamentous and inflated hyphae; lactifers abundant to very abundant. *Pileipellis* a trichopalisade,  $60\text{--}90 \mu\text{m}$  thick, hyaline or containing a faint, yellowish brown pigmentation, all elements thin-walled; suprapellis composed of erect and mostly cylindrical terminal elements, intermixed with fusiform and broadly clavate elements,  $10\text{--}30 \times 3\text{--}10 \mu\text{m}$ , sometimes more or less inflated at the apex, sometimes septate; subpellis composed of a layer of inflated or subcellular hyphae, oriented perpendicularly to



**Figs 48-55.** *Lactarius papillatus* (Corner RSNB 8057, *typus*). 48. Basidiospores. 49. Basidia. 50. Pleuromacrocytidia. 51. Pleuropseudocystidia. 52. Cheiloleptocystidia. 53. Cheilomacrocytidia. 54. Pileipellis. 55. Stipitipellis.

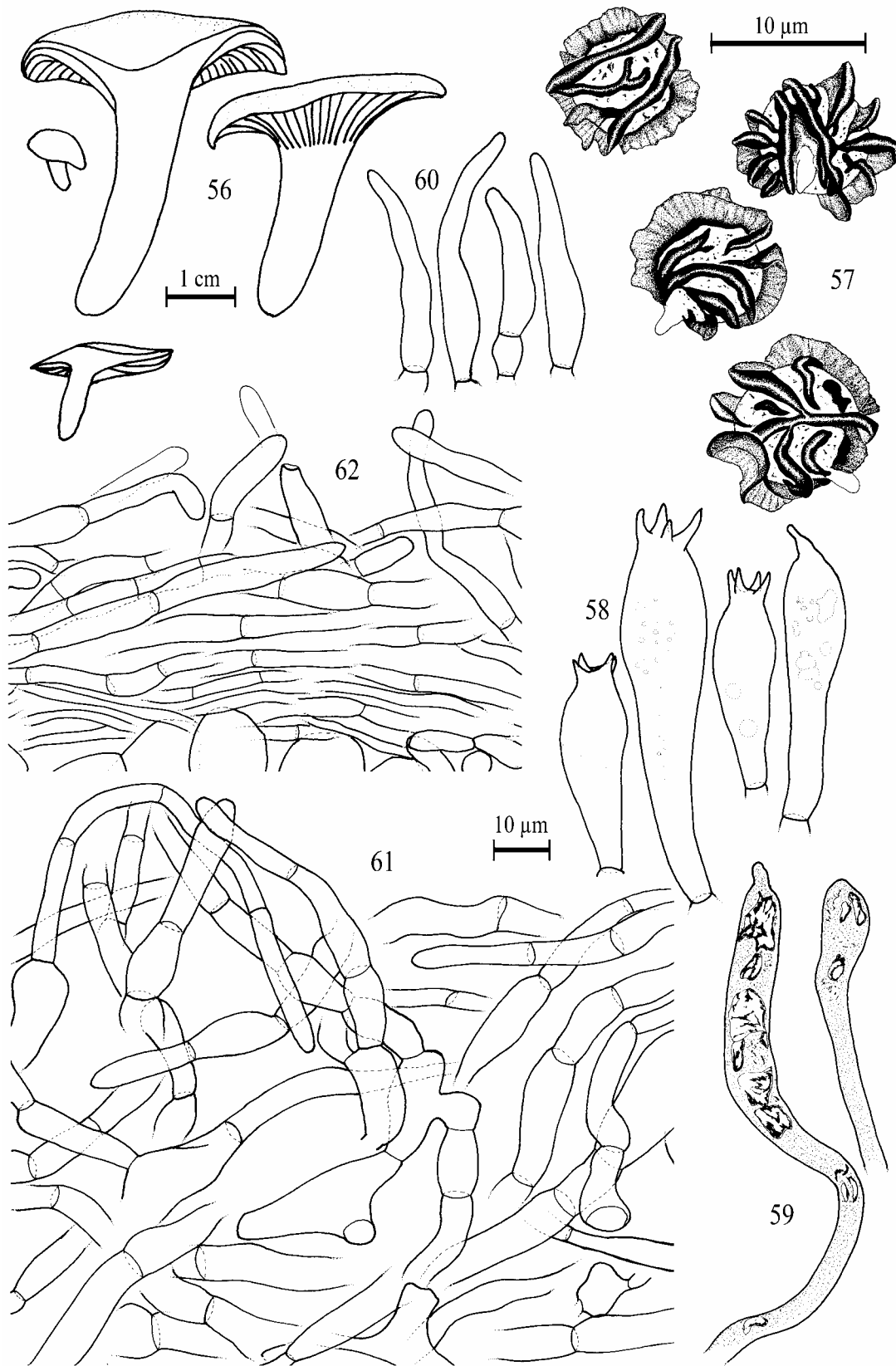
the pileus surface; lactifers and pseudocystidia moderately abundant. *Stipitipellis* a trichoderm, 100 µm thick, hyaline or with very faint, yellowish brown pigmentation; hyphae 3-5(10) µm broad, with scattered inflated hyphal elements; the terminal elements cylindrical with obtuse apex, erect, recumbent or oblique; lactifers moderately abundant.

*Habitat:* mid-elevation dipterocarp rain forest.

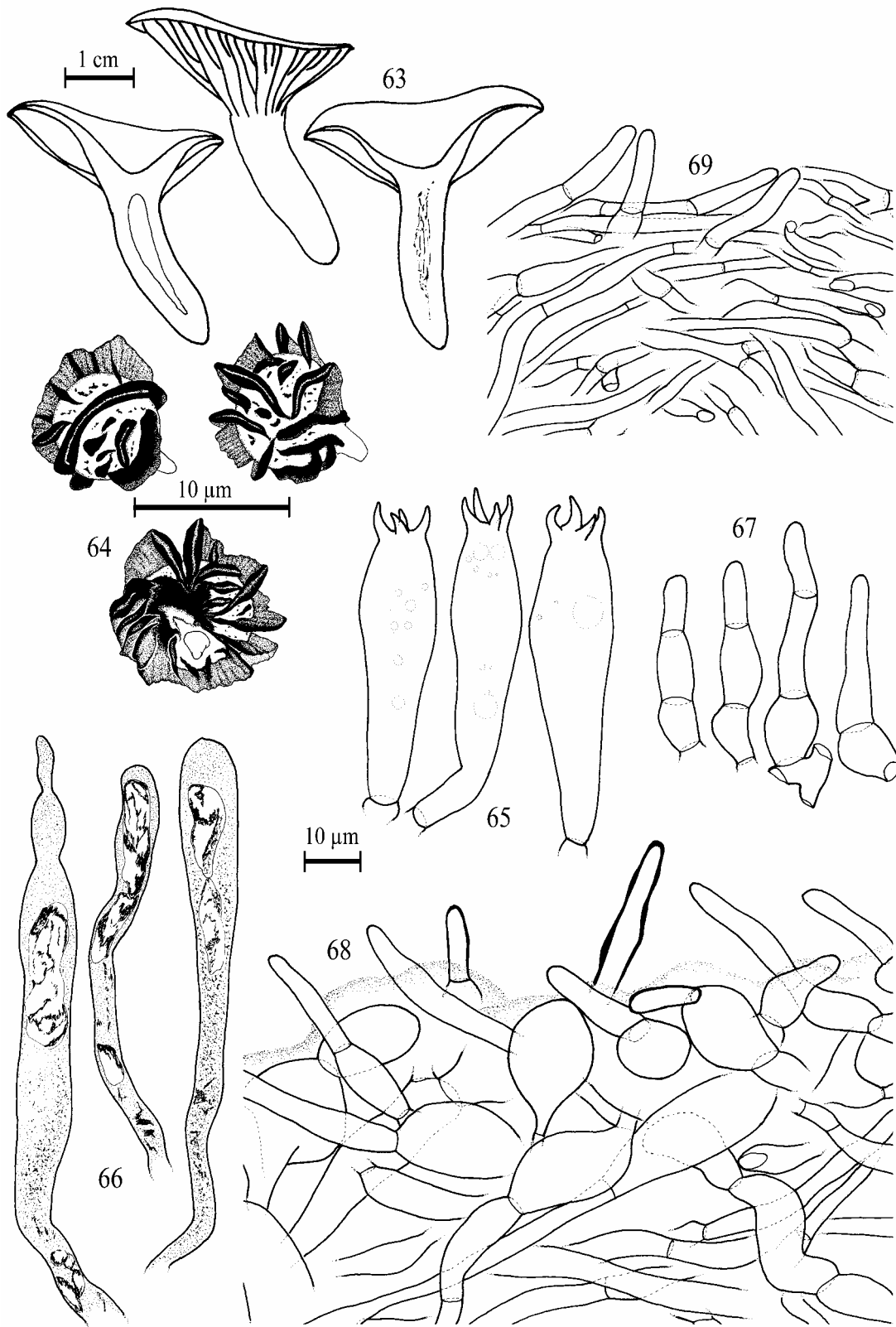
*Known distribution:* Borneo.

*Material examined:* MALAYSIA - Borneo, state of Sabah, Mount Kinabalu, alongside Mesilau river, 1600 m alt., in humus of forest floor, 2 April 1964, Corner RSNB 8057 (*typus*: E).

*Notes:* The notes of Corner also mention a specimen Corner RSNB 8058, which could not be retrieved. It was collected the same day in the same area, and recognized as 'merely an old RSNB 8057'. Except for the transversely rugulose interstices between the lamellae and



**Figs 56-62.** *Lactarius verecundus* (Stubbe 06-032, *typus*). **56.** Basidiocarps. **57.** Basidiospores. **58.** Basidia. **59.** Pleuropseudocystidia. **60.** Cheiloleptocystidia. **61.** Pileipellis. **62.** Stipitipellis.



**Figs 63-69.** *Lactarius verecundus* (Stubbe 06-184). 63. Basidiocarps. 64. Basidiospores. 65. Basidia. 66. Pleuropseudocystidia. 67. Cheileleptocystidia. 68. Pileipellis. 69. Stipitipellis.

the mild taste, the macroscopic features mentioned in the description are similar with *Corner* RSNB 8057. The species is characterized by the tan colour of the pileus, reflected in both stipe and lamellae, the presence of a papilla and the rufous discoloration of the latex. This could lead to confusion with *L. fulvus*. Microscopically, *L. papillatus* is set apart by a different structure in the pileipellis, more pronounced ridges on the spores and, most of all, the presence of macrocystidia, which is uncommon in the subgenus.

***Lactarius verecundus* Stubbe & Verbeke, sp. nov.**

(Figs 56-69; Figs 99-100)

MycoBank: 512251

*Etymology:* *verecundus*, meaning modest, referring to its inconspicuous appearance in the field.

*Pileus* 10-50 mm, convexus ad planoconvexum, tum infundibuliformis, siccus, velutinus griseo-brunneus ad atrobrunneum. *Stipes* 6-35 mm longus, 3-8 mm crassus, cylindricus, velutinus, atrobrunneus, rugis atris. *Lamellae* adnatae, subdecurrentes, moderate densae, angustae, flavidocremae. *Contextus* salmonescens. Latex albus, aurantioroseus in sicco. *Sporae* 5.9-6.6-7.4 × 5.5-6.1-6.6 μm,  $Q = 1.04-1.10-1.14$ , subgloboseae, zebroideae, cristis usque ad 2 μm altis ornatae; macula suprahilaris non amyloidea. *Macrocystidia* absentia. *Cheileleptocystidia* 20-50 × 4-7 μm, subfusiformia, sublageniformia. *Pileipellis* trichoderma, 100-150 μm crassus, pigmento brunneo, elementa suprapellis 5-15 μm diam. *Stipitipellis* trichoderma.

*Typus:* "Malaysia, state of Pahang, Hutan Lipur Lentang, near Bukit Tinggi, along highway E8, on trail towards end of the forest, N03°22.82' E101°53.12', 164 m alt., near *Shorea* sp., 25 August 2006, *Stubbe* 06-032 (GENT)."

*Pileus* 10-50 mm diam., convex when young, then plano-convex and depressed or infundibuliform with inflexed margin, the margin remaining smooth or becoming faintly crenate; surface in young specimens dry and velutinous, dark greyish brown or almost blackish brown (7E3, 7F3-4; BFF 33), in mature and older specimens the blackish brown velvety hairs visibly more dispersed and revealing the paler, brownish grey and slightly shiny surface (BFF 32), resulting in a minutely punctate aspect of the expanding pileus, the central area remaining velutinous and darker. *Stipe* 6-35 × 3-8 mm, cylindrical and tapering downwards, with central or slightly eccentric attachment to pileus; surface velutinous and almost smooth when young, mature specimens with fine, blackish and longitudinally stretched wrinkles on a brownish and somewhat silvery

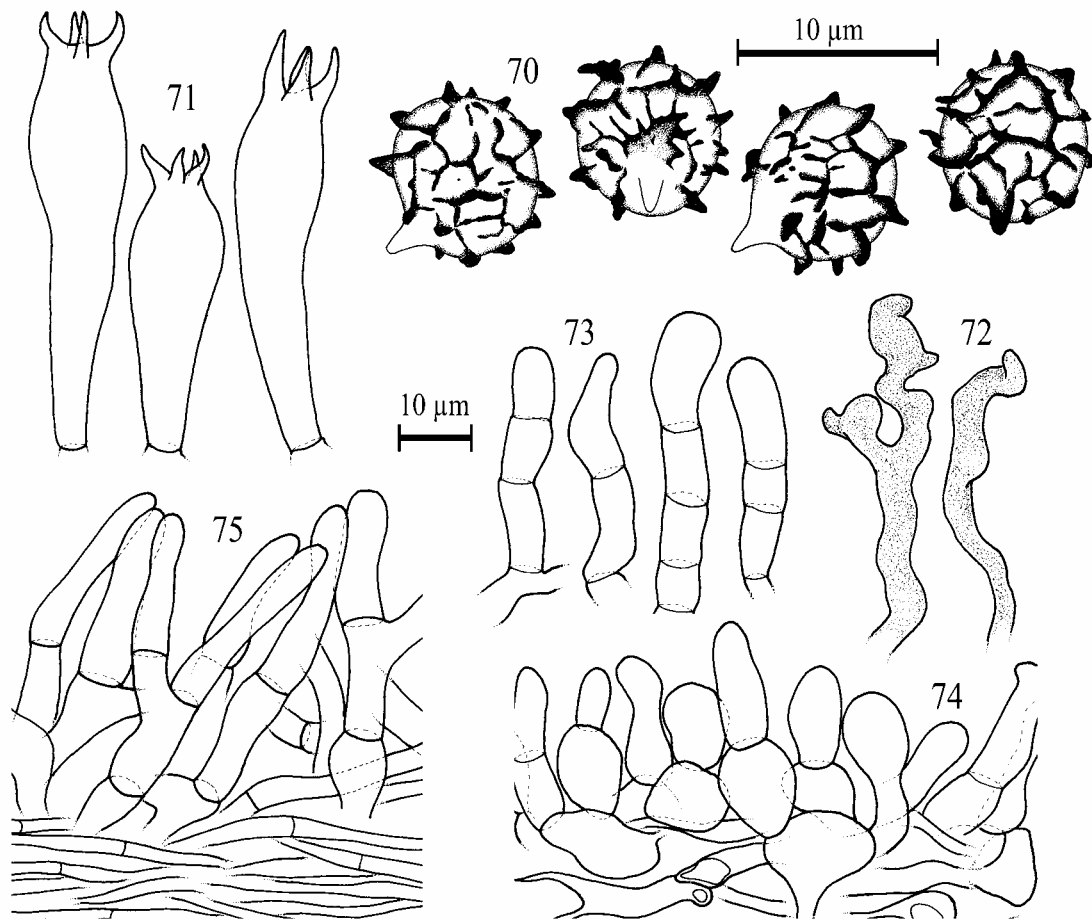
grey and slightly shiny surface. *Lamellae* adnate or subdecurrent, moderately dense, rather narrow (1-3 mm) and thin, yellowish cream-coloured (4A2-3(4)); edge smooth and concolorous with the lamella surface. *Contextus* firm, solid in pileus and stipe, in young specimens within several minutes staining completely orange-pink (like smoked salmon) (6AB3-6); colour reaction fainter and in patches in older specimens; smell unremarkable; taste faint. *Latex* scarce, white, staining context orange-pink; taste unremarkable or somewhat acrid. *Spore print* not observed.

*Basidiospores* 5.8-7.4 × (5.4)5.5-6.9 μm,  $Q = 1.02-1.14$ , on average 6.6 × 6.1-6.2 μm,  $Q = 1.06-1.10$  (n = 40), subglobose; ornamentation zebroid and winged, the ridges 2 μm high or slightly higher, firm and thick with rather blunt edges, often with some long ridges parallel arranged, sometimes branching, and intermixed with shorter ridges; minute, isolated warts present on spore surface; plage not or faintly amyloid. *Basidia* 35-70 × 10-17 μm, clavate or subclavate, mostly rather stout, 4-spored, occasionally 1-spored basidia observed, often with guttulate contents; sterigmata 2-5 × 1-2 μm. *Macrocystidia* absent. *Pleuropseudo-cystidia* 4-12 μm diam., scarce, not or hardly emergent, narrowly clavate, clavate or clavate with a finger-like projection, often with crystalline contents. *Lamellar edge* sterile and composed completely of *cheileleptocystidia*, 20-50 × 4-7 μm, slender, subfusiform or narrowly sublageniform. *Lamellar trama* rather thin, mainly filamentous but with inflated hyphal elements present; *lactifers* scarce to moderately abundant. *Pileipellis* a trichoderm, 100-150 μm thick, with broad or slightly inflated hyphal elements, 5-15 μm diam., upper layers containing brown, intracellular, diffuse pigmentation; terminal elements subcylindrical, recumbent, erect or somewhat repent; cell walls mostly thin, sometimes refringent. *Stipitipellis* a trichoderm, 30-60 μm thick, hyphal elements 2-8 μm diam., upper layers containing brown, intracellular, diffuse pigmentation, terminal elements subcylindrical, repent or oblique, sometimes upright, 4-8 μm diam., thin-walled or slightly refringent.

*Habitat:* lowland, dipterocarp rain forest.

*Known distribution:* Peninsular Malaysia.

*Material examined:* MALAYSIA - state of



**Figs 70-75.** *Lactarius* cfr. *sublignyotus* (Corner RSNB 8211). 70. Basidiospores. 71. Basidia. 72. Pleuropseudocystidia. 73. Cheiloleptocystidia. 74. Pileipellis. 75. Stipitipellis.

Pahang, Hutan Lipur Lentang, near Bukit Tinggi, along highway E8, on trail towards end of the forest, N03°22.82' E101°53.12', 164 m alt., near *Shorea* sp., 25 August 2006, *Stubbe* 06-032 (*typus*: GENT, *isotypus*: KEP) - state of Negeri Sembilan, Pasoh Forest Reserve, along Nature Trail, in secondary lowland rain forest, 13 September 1995, *Watling* 26711 - state of Negeri Sembilan, Kampong Serting Ulu, Hutan Lipur Serting Ulu, trail upwards into hillside forest, dominated by *Dipterocarpaceae* and *Fagaceae*, 13 September 2006, *Stubbe* 06-184.

*Notes:* *Lactarius verecundus* is fairly well recognizable by its brownish grey pileus with the darker centre and paler marginal area which, in mature specimens, has a dispersed velutinous covering giving it a minutely punctate aspect. Other characteristics are the depressed pileus centre, its smooth margin, dense lamellae and the stipe with its darker, low and longitudinally stretched ridges. It might be mistaken for *L. cinereobrunneus*, though this species is browner and not as grey,

does not have the ridges on the stipe and lacks a clear colour change in the context. Microscopic features that set this species apart are the trichoderm in the pileipellis, where most species of the subgenus have a palisade or trichopalisade, and the spores with high (2 µm) and long ridges in a zebroid pattern. The orange-pink discoloration of the context is common in *Lactarius* subg. *Plinthogalus*, but not in combination with a trichodermic pileipellis. *Lactarius pudorinus* Verbeke & Bougher, shares these features but is distinguished by a brownish to pale orange pileus, white stipe and low, reticulate spore ornamentation. The European species *L. ruginosus* Romagn. and *L. pterosporus* Romagn., both possessing high, zebroid spore ornamentations, are brown or yellowish brown and lack the greyish tinges of *L. cinereobrunneus*. One deviating specimen, *Stubbe* 06-184, has been found. It is identical to



the other specimens, except for the pileus that lacks a punctate aspect in the marginal zone. This is microscopically paralleled by a clear trichopalisade in the pileipellis, in stead of a trichoderm. As in the other specimens, it also has the characteristic, grey ridges on the stipe.

***Lactarius* cfr. *sublignytus*** (Figs 70-75)

*Pileus* 40-60 mm diam., soon concave, with or without small umbo, with reflexed, undulate or sinuate, scalloped margin, dry, opaque, fuscous fawn, all-over darker ruguloso-reticulate, or becoming smooth in the centre. *Stipe* 40-60 × 4-6 mm, cylindrical, rather slender, stuffed, fuliginous-fuscous or sepia to fuscous-tan, wholly finely sepia scurfy-pruinose, at base white villose-strigose. *Lamellae* adnate to decurrent, distant, broad, 5-10 mm wide, about 20 lamellae, 3-4 lengths of lamellulae. with smooth or slightly ribbed interstices, white to pale pinkish or pale pinkish ochraceous; edge pale fuscous sepia. *Latex* white, fluid, unchanging. *Context* white, thin; smell strong, sour and reminding of *Ganoderma* sp.; taste mild, then subacid. *Spore print* pale ochraceous.

*Basidiospores* 7.1-9.4 × 6.5-8.4(8.5) μm,  $Q = 1.03-1.18$ , on average 8.1-8.2 × 7.5 μm,  $Q = 1.09-1.10$  (n = 40), subglobose; ornamentation amyloid, a closed reticulum, rather dense and disorderly, composed of ridges of irregular thickness, ± 1 μm high, with acute and sometimes blunt edges; few isolated warts present; plage distally amyloid. *Basidia* 40-60 × 10-15 μm, clavate or narrowly clavate, 4-spored; sterigmata 4-9 × 1-2 μm, most rather sturdy. *Macrocyttidia* absent. *Pleuropseudo-cystidia* moderately scarce to moderately abundant, 3-6 μm broad, slightly emergent, irregular and tortuous, sometimes branching; apices blunt; contents refractive. *Lamellar edge* composed completely of *cheiloleptocystidia*, 10-30 × 5-10 μm, broadly clavate or subfusiform, mostly as the terminal cell of a chain-like series, often resembling small basidioles, containing brown, intracellular and diffuse or coagulated pigmentation. *Lamellar trama* composed of inflated hyphae and cellular elements; *lactifers* moderately abundant. *Pileipellis* a palisade, in young fruitbodies sometimes almost a hymeniderm, 45-55 μm

thick, containing brown, diffuse, intracellular pigmentation; suprapellis of stout, broadly fusiform or subclavate terminal elements, 5-20 × 5-10 μm; subpellis thin, composed of one to three layers of globose or subglobose, cellular elements and inflated hyphae. *Stipitipellis* a trichoderm, 50-60 μm thick, containing brown, intracellular and diffuse pigmentation, composed of broadly cylindrical elements (3-6 μm), mostly 1- to 3-celled and occasionally branching, forming a more or less regular turf, rather abruptly and anticlinally emerging from a dense layer of narrow and parallel hyphae.

*Habitat*: mid-elevation dipterocarp rain forest.

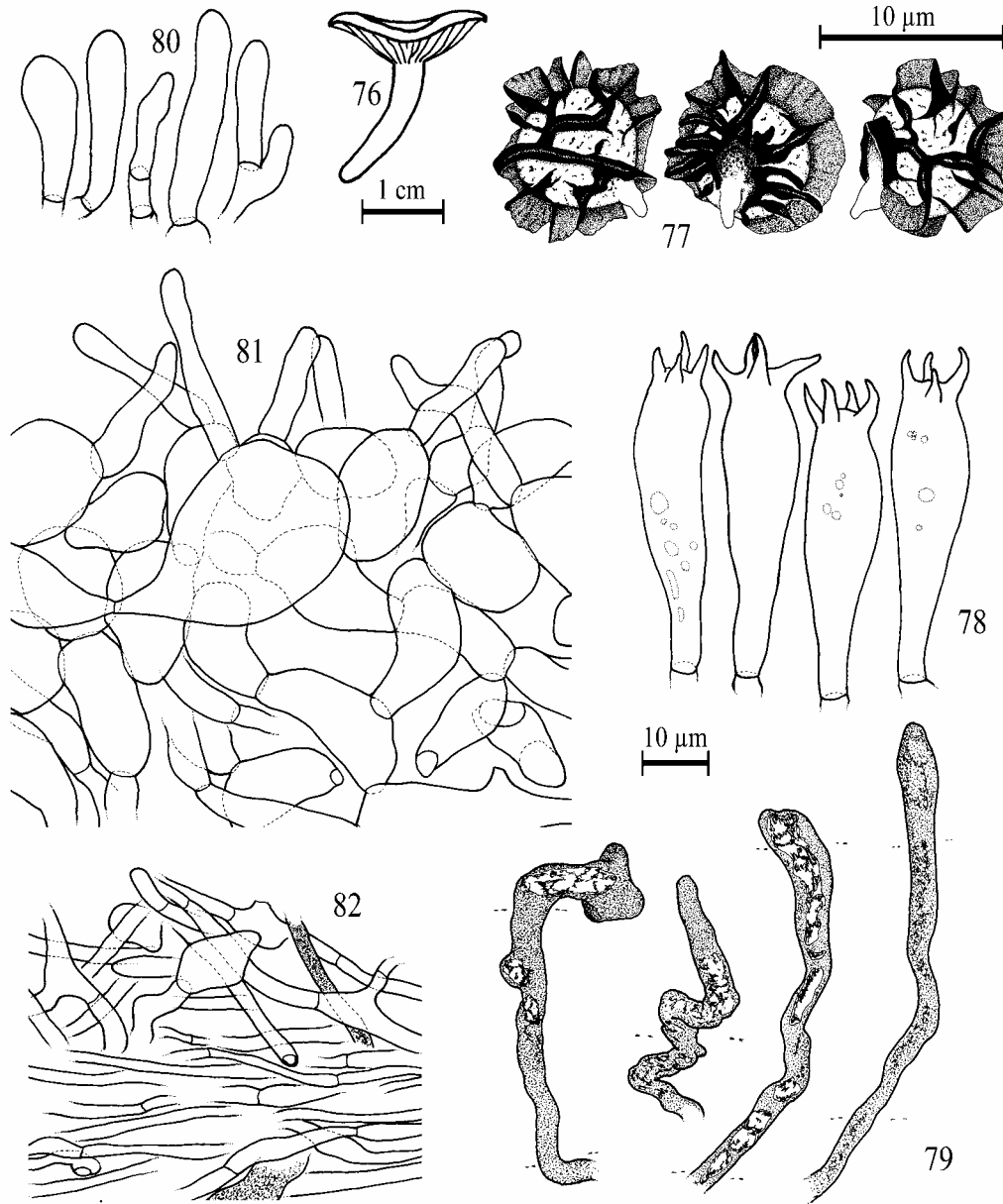
*Known distribution*: Borneo.

*Material studied*: MALAYSIA - Borneo, state of Sabah, Mount Kinabalu, alongside Mesilau river, at 1700 m alt., in humus of forest floor, 10 April 1964, *Corner* RSNB 8211 - *ib.*, 22 April 1964, *Corner* RSNB 8211A.

*Notes*: This specimen is reminiscent of *L. sublignytus* Henn. Unfortunately, the type of this species, collected in Java, (Tjibodas, > 1500 m alt.) is lost. The wrinkled, black-brown pileus together with the yellow-tinged lamellae with fuscous margin, and the unchanging latex and context are characteristic for this species. The original description mentions the lamellae as adnate, not decurrent, and rather dense, which is often the case in young basidiomes (pileus diam. in the original description is 35 mm) and the spores are described as *echinulato* (*i.e.* somewhat spiny), which is possible when not observed in Melzer's reagens (Hennings, 1899). This species seems to bear a macroscopical resemblance to *L. bicolor* Masee, which differs by its white spore print and lamellae remaining white, even in older basidiomes. Since we lack any reference material or recent descriptions of *L. sublignytus*, we hesitate to identify Corner's specimens as this species, and we believe it is not opportune to describe them as a new species.

***Lactarius* sp. 1** (Figs 76-82; Figs 104-106)

*Pileus* 22 mm diam., plano-convex and depressed, margin more or less smooth to weakly crenate; surface dry, radially wrinkled, towards the margin grooved and faintly concentrically zonate, entirely cream-coloured with a warm, pinkish tinge (5A2). *Stipe* 20 × 3.5 mm, cylindrical and slightly tapering downwards; surface longitudinally, minutely



**Figs 76-82.** *Lactarius* sp. 1 (Stubbe 06-035). 76. Basidiocarp. 77. Basidiospores. 78. Basidia. 79. Pseudocystidia. 80. Cheilocystidia. 81. Pileipellis. 82. Stipitipellis.

rugulose, dry, concolorous with pileus but paler towards the apex. *Lamellae* adnate to slightly decurrent, rather distant,  $\leq 2$  mm broad, concolorous with pileus but slightly darker (5A3); staining pink because of the latex; edge smooth, concolorous. *Context* rather thin fleshed in pileus, solid to stuffed in stipe, whitish, turning bright pink within minutes (7A3-5); taste very faintly acid; smell unremarkable. *Latex* not abundant, white, quickly turning pink (7A3-5) on context and lamellae.

*Spore print* not observed.

*Basidiospores*  $6.5-7.5 \times 5.9-7.3 \mu\text{m}$ ,  $Q = 1.01-1.11$ , on average  $7 \times 6.6 \mu\text{m}$ ,  $Q = 1.06$  ( $n = 20$ ), globose to subglobose; ornamentation amyloid, forming a nearly closed reticulum of rather irregular ridges  $1.5-2 \mu\text{m}$  high; numerous minute and coarse warts present between the ridges; plage distally or completely and usually strongly amyloid. *Basidia*  $35-55 \times 10-13 \mu\text{m}$ , clavate, often with guttulate contents, 4-spored; sterigmata  $4-7 \times 1-1.5 \mu\text{m}$ . *Macrocystidia* absent.



**Figs 83-89.** Basidiocarps. **83.** *Lactarius cinereobrunneus* (Stubbe 06-227, *typus*). **84.** *Lactarius cretaceus* (Stubbe 06-183, *typus*). **Figs 85-86.** *Lactarius cyanescens*. **85.** Stubbe 06-103, *typus*. **86.** Stubbe 06-058. **Figs 87-89.** *Lactarius ferrugineifolius* (Stubbe 06-261, *typus*).





**Figs 90-98.** Basidiocarps. **Figs 90-92.** *Lactarius fulvus* (Stubbe 06-298, *typus*). **Figs 93-95.** *Lactarius mirabilis*. **93.** Stubbe 06-086. **94.** Verbeke-Walley 06-072. **95.** Stubbe 06-284. **Figs 96-98.** *Lactarius flavorosescens*. **96.** Stubbe 06-244, *typus*. **97-98.** Stubbe 06-262.





**Figs 99-106.** Basidiocarps. **Figs 99-100.** *Lactarius verecundus*. **99.** *Stubbe* 06-032, *typus*. **100.** *Stubbe* 06-184. **Figs 101-103.** *Lactarius pallidior* (*Stubbe* 06-297, *typus*). **Figs 104-106.** *Lactarius* sp. 1 (*Stubbe* 06-035).

*Pseudocystidia* 4-6 µm diam., moderately scarce to rather abundant, emergent or not, irregularly cylindrical or clavate, sometimes the emergent part bent, containing fine, crystalline particles or coarse, refringent granules. *Lamellar edge* sterile; *cheiloleptocystidia* 10-35 × 10-13 µm, narrowly clavate to subcylindrical, resembling slender basidioles; cell wall thin or slightly refringent. *Lamellar trama* predominantly filamentous; *lactifers* abundant. *Pileipellis* a palisade, 80-100 µm thick, hyaline; suprapellis composed of subcylindrical to subclavate terminal elements, 10-35 × 3-6 µm, erect, oblique or somewhat repent, with obtuse apex, cell wall thin or slightly refringent; subpellis composed of subcellular elements and inflated hyphae, thin-walled. *Stipitipellis* a trichoderm containing inflated hyphal elements, 50-90 µm thick, hyaline, hyphae 2-4 µm diam., inflated elements ≤ 10 µm diam., terminal elements cylindrical to subclavate; *lactifers* abundant.

*Habitat*: lowland rain forest near *Shorea* sp.

*Known distribution*: Peninsular Malaysia.

*Material examined*: MALAYSIA - state of Pahang, Hutan Lipur Lentang, near Bukit tinggi, along highway E8, on trail towards end of the forest, N03°22.82' E101°53.12', 164 m alt., in between roots of *Shorea* sp., 25 August 2006, *Stubbe* 06-035.

*Notes*: Molecular analyses reveal a close affinity to the northern Thai species *L. friabilis* H.T. Le & Stubbe. Whether or not this Malaysian specimen falls within the species delimitation of *L. friabilis* could not be ascertained with our current data. Generally this Thai species has greyish tinges in the pileus, but in weathered condition it can become completely cream-coloured with pinkish tinges, like *Stubbe* 06-035. The Malaysian specimen appears to be smaller and has slightly smaller spores, though still within a possible range. It also has a strongly wrinkled pileus surface, but other than that, there are no decisive characters that set the two apart. Since only one Malaysian collection has been found, we do not describe this as a new species yet.

## General discussion

Except for *L. ochrogalactus* and *Lactarius* cfr. *sublignytus*, which were both found on higher altitudes (> 1500 m alt.), no species overlap has been found with previously investi-

gated areas in Asia. The most plausible hypothesis for this disparity would be the difference in habitat, since most Asian *Lactarius* species so far, have been described from tropical montane or non-tropical forests. The Pasoh Forest Reserve is a lowland tropical rain forest that lies in the rainshadow of two foothills, leaving it relatively dryer than the average rain forest, though still influenced by both the southwest and the northeast monsoons. The two rainy seasons result in the occurrence of two mushroom fruiting seasons at the end of each intervening drier period (February-March and August-September) (Watling *et al.*, 2002). The vegetation is strongly dominated by *Dipterocarpaceae* which account for 30% of the tree basal area in this forest (Davies *et al.*, 2003). Other well represented families are the *Euphorbiaceae*, *Fabaceae* and *Burseraceae*. Tropical montane forests of Southeast Asia can still contain dipterocarps at mid-elevation altitudes (up to ± 900 m), but with an increasing proportion of *Fagaceae* (*Lithocarpus*, *Castanopsis*, *Nothofagus*) and the presence of *Pinaceae* (*Pinus*), as can be observed in northern Thailand (Le *et al.*, 2007a,b). Verbeke and Horak (1999) have investigated the lowland rain forest of Papua New Guinea. Here, dipterocarps are much rarer and more scattered than in Malaysia and despite a two-year-long study of the area, only five species of *Lactarius* have been described from these lowland rain forests.

Of the *Lactarius* species formerly described or reported from Southeast Asia, 15 taxa have been assigned to *Lactarius* subgenus *Plinthogalus*. From northern Thailand, *L. friabilis*, *L. crassiusculus* H.T. Le & Stubbe and *L. subplinthogalus* var. *chiangmaiensis* have been described and *L. atromarginatus* Verbeke & E. Horak (syn. : *L. lavandulus* H.T. Le & Stubbe), *L. oomsisiensis* and *L. montoyae* K. Das & J.R. Sharma have been reported (Le *et al.*, 2007b). From Java *L. reticulatovenosus* Verbeke & E. Horak and the enigmatic *L. sublignytus* have been described (Hennings, 1899; Verbeke *et al.*, 2001). From Papua New Guinea, *L. atromarginatus* Verbeke & E. Horak, *L. venosus* Verbeke & E. Horak, *L. oomsisiensis* and *L. pudorinus* have been described (Verbeke and Horak, 2000; Verbeke *et al.*, 2002). In

Malaysia, three blueing species have already been described: *L. cyanescens*, *L. mirabilis* and *L. lazulinus* (Stubbe *et al.*, 2007). With the eight new species described herein and *L. ochrogalactus*, the total number of Southeast Asian taxa of *Lactarius* subgenus *Plinthogalus* runs to 23. Knowing that almost 65 species of *Lactarius* have been reported from Southeast Asia (of which almost 55 species have been described from this region), the proportion of *Lactarius* subgenus *Plinthogalus* appears to be remarkably higher than in other parts of the world. This observation, however, is only provisional, since the exploration rate is low and more new species are to be expected in all groups. The high number of new species following a single mycological expedition emphasizes the under-explored mycological diversity in these dipterocarp lowland rain forests.

The collections of Watling and Corner contain more species than included in this paper, but these were withheld due to a lack of macroscopical data. Watling *et al.* (2003) and Lee *et al.* (2002) have identified some of their collections as *L. sumstinei* Peck, *L. subplinthogalus* (both described from North America) and *L. ruginosus* (described from Europe) but after further examination these names could not be confirmed. Based on all the collections studied, we estimate that *Lactarius* subgenus *Plinthogalus* comprises at least 8 more species in Malaysia.

## Acknowledgements

The authors would like to thank dr. Lee Su See of the Forest Research Institute Malaysia (FRIM) for her kind assistance which made this expedition possible. Their sincere gratitude goes out to dr. Jean Weber and Khadijah Rambe for their generous hospitality and support. The authors are greatly indebted to Dr. Roy Watling and the curator of the herbarium of the Royal Botanic Garden of Edinburgh for the loan of Malaysian specimens. The Economic Planning Unit is thanked for allowing the research to be conducted in Malaysia. The expedition was funded by the Foundation of Scientific Research-Flanders (FWO-Vlaanderen). Dirk Stubbe is supported by the Institute for the Promotion of Innovation through Science and Technology in Flanders (IWT-Vlaanderen).

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