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Fungal Biodiversity Profiles 81-90

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Valerie HOFSTETTER, Arvind PARIHAR, Alfredo VIZZINI,
Tai-Min XU, Chang-Lin ZHAO & Bart BUYCK

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Xiang-Hua WANG
CAS Key Laboratory for Plant Diversity and Biogeography of East Asia,
Kunming Institute of Botany, Chinese Academy of Sciences, Lanhei Road 132, Kunming 650201 (China)
xhwang@mail.kib.ac.cn

Kanad DAS
Ishika BERA
Cryptogamic Unit, Botanical Survey of India, P.O. Botanic Garden, Howrah 711103 (India)
daskanadbsi@gmail.com
iamishika6@gmail.com

Yu-Hui CHEN
College of Life Sciences, Southwest Forestry University, Kunming 650224 (China)

Rajendra Prasad BHATT
Aniket GHOSH
Department of Botany & Microbiology, H.N.B. Garhwal University (A Central University),
Srinagar, Garhwal, 246174, Uttarakhand (India)
bhatt.rajendra123@gmail.com
ghosh.aniket87@gmail.com

Manoj Emanuel HEMBROM
Central National Herbarium, Botanical Survey of India, P.O. Botanic Garden, Howrah 711103 (India)
manojhembrom@yahoo.co.in

Valérie HOFSTETTER
Department of Plant Protection, Agroscope Changins-Wädenswil – ACW,
Rte De Duiller, CH-1260 Nyon 1 (Switzerland)
valerie.hofstetter@agroscope.admin.ch

Arvind PARIHAR
Cryptogamic Unit, Botanical Survey of India, P.O. Botanic Garden, Howrah 711103 (India)
arvind_peace@rediffmail.com

Alfredo VIZZINI
Department of Life Sciences and Systems Biology, University of Torino,
Viale P.A. Mattioli 25, I-10125 Torino (Italy)
alfredo.vizzini@unito.it

Tai-Min XU
College of Life Sciences, Southwest Forestry University, Kunming 650224 (China)

Chang-Lin ZHAO
College of Biodiversity Conservation and Utilisation, Southwest Forestry University,
Kunming 650224 (China)
fungichanglinz@163.com

Bart BUYCK
ISYEB (CNRS, Sorbonne Université, EPHE)
Institut de Systematique, Évolution, Biodiversité, Muséum national d'Histoire naturelle,
case postale 39, 57 rue Cuvier, F-75231 Paris cedex 05 (France)
bart.buyck@mnhn.fr (corresponding author)

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ABSTRACT
In this new series of Fungal Biodiversity Profiles, the authors describe seven new Russulales: five new species of *Lactarius* subg. *Russularia* and two new Russulas: descriptions and ITS sequences are provided for *L. aurantiobrunneus* X.H. Wang, sp. nov., *L. collybioides* X.H. Wang, sp. nov., *L. exilis* X.H. Wang, sp. nov., *L. flaviaquosus* X.H. Wang, sp. nov., and *L. resinosus* X.H. Wang, sp. nov., from China, as well as for *Russula clavatohyphata* R.P. Bhatt, A. Ghosh, Buyck & K. Das, sp. nov., from Indian Himalaya, and *R. capillaris* Buyck, sp. nov., from Madagascar. In addition, first ITS sequences are provided for several specimens of the North American *R. burlinghamiae* Singer. Two bamboo-inhabiting species are described from Asia: *Serpula dendrocalami* C.L. Zhao, sp. nov., in Boletales, is described from China, while *Hymenochaete sharmae* Hembrom, K. Das & A. Parihar, sp. nov., in Hymenochaetales, is described from India. Finally, in Agaricales, *Laccaria indohimalayana* K. Das, I. Bera & Vizzini, sp. nov., is described from Indian Himalaya.

KEY WORDS
Agaricales,
Boletales,
Hymenochaetales,
Russulales,
new species.

RÉSUMÉ
Profils de la Biodiversité fongique 81-90.
Dans cette nouvelle série de Profils de la Biodiversité fongique, les auteurs décrivent sept nouvelles Russulales : cinq nouvelles espèces de *Lactarius* subg. *Russularia* et deux nouvelles Russulas : des descriptions et des séquences ITS sont fournies pour *L. aurantiobrunneus* X.H. Wang, sp. nov., *L. collybioides* X.H. Wang, sp. nov., *L. exilis* X.H. Wang, sp. nov., *L. flaviaquosus* X.H. Wang, sp. nov., et *L. resinosus* X.H. Wang, sp. nov., de Chine, ainsi que pour *Russula clavatohyphata* R.P. Bhatt, A. Ghosh, Buyck & K. Das, sp. nov., de l'Himalaya indien et *R. capillaris* Buyck, sp. nov., de Madagascar. De plus, les premières séquences ITS sont fournies pour plusieurs spécimens de *R. burlinghamiae* Singer d'Amérique du Nord. Dans les Boletales et les Hymenochaetales, deux espèces poussant sur du bambou mort sont décrites : *Serpula dendrocalami* C.L. Zhao, sp. nov., de Chine, et *Hymenochaete sharmae* Hembrom, K. Das & A. Parihar, sp. nov., de l'Inde. Enfin, dans les Agaricales, *Laccaria indohimalayana* K. Das, I. Bera & Vizzini, sp. nov., est décrit dans l'Himalaya indien.

MOTS CLÉS
Agaricales,
Boletales,
Hymenochaetales,
Russulales,
espèces nouvelles.

In this new series of Fungal Biodiversity Profiles, the authors describe seven new Russulales: five new species of *Lactarius* subg. *Russularia* and two new Russulas: descriptions and ITS sequences are provided for *L. aurantiobrunneus* X.H. Wang, sp. nov., *L. collybioides* X.H. Wang, sp. nov., *L. exilis* X.H. Wang, sp. nov., *L. flaviaquosus* X.H. Wang, sp. nov., and *L. resinosus* X.H. Wang, sp. nov., from China, as well as for *Russula clavatohyphata* R.P. Bhatt, A. Ghosh, Buyck & K. Das, sp. nov., from Indian Himalaya and *R. capillaris* Buyck, sp. nov., from Madagascar. In addition, first ITS sequences are provided for several specimens of the North American *R. burlinghamiae* Singer. In Boletales and Hymenochaetales, two bamboo-inhabiting species are described, individually: *Serpula dendrocalami* C.L. Zhao, sp. nov., from China and *Hymenochaete sharmae* Hembrom, K. Das & A. Parihar, sp. nov., from India. Finally, in Agaricales, *Laccaria indohimalayana* K. Das, I. Bera & Vizzini, sp. nov., is described from Indian Himalaya.

Phylum BASIDIOMYCOTA R.T. Moore
Class AGARICOMYCETES Doweld
Order HYMENOCHAETALES Oberw.
Family HYMENOCHAETACEAE Imazeki & Toki

81. ***Hymenochaete sharmae***
Hembrom, K. Das & A. Parihar, sp. nov.
(Figs 1-5)

Distinct from other *Hymenochaete* species by the combination of resupinate, closely adnate, greyish white to purplish grey basidiomata with chalky white floccose margins when fresh, its cracked, separable hymenophore becoming rusty brown to charcoal black and papery thin when mature, ellipsoid basidiospores (5-6.26-7 × 3-3.68-5 µm) and occurrence on bamboos.

TYPUS. — **India**. Jharkhand, Sahibganj district, Taljhari block, Sogorbhanga village, on the dead stump of bamboos, 40 m a.s.l.,

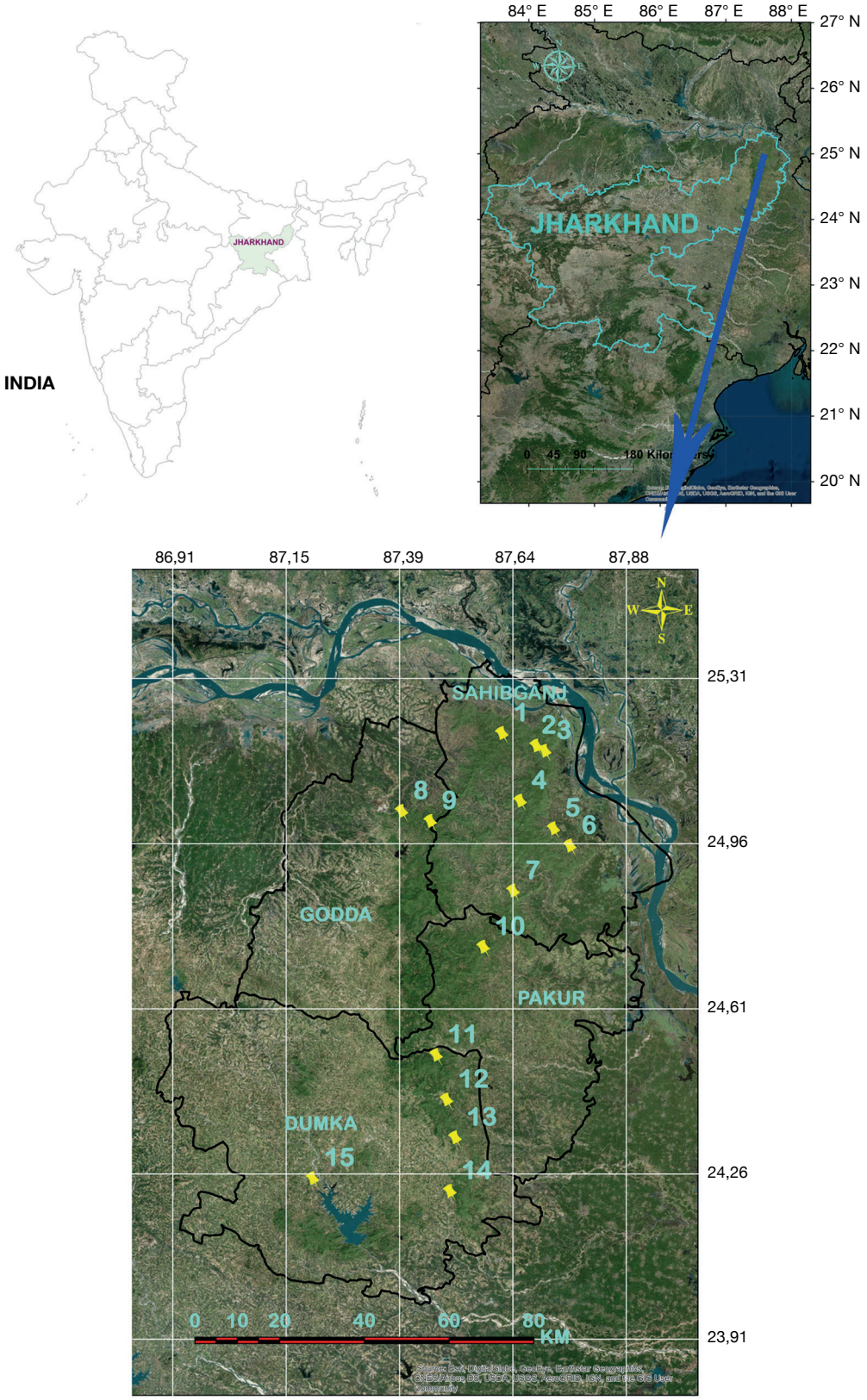

Fig. 1.— Distribution of *Hymenochaete sharmae* Hembrom, K. Das & A. Parihar, sp. nov., in Rajmahal hills, Jharkhand, India. Map was prepared with the help of ArcGIS installed in Central National Herbarium of Botanical Survey of India, Howrah, India.

24°59’07.3”N, 87°43’27.8”E, 13.XI.2016, M.E. Hembrom, *MEH-70191* (holo-, CAL[CAL 1535]!).

Mycobank. — MB 830163.

Genbank. — KY929017, MK588753 (nrITS,), KY929018, MK588836 (nrLSU).Etymology. — Commemorating Dr. Jai Ram Sharma, the pioneer worker who revised Indian Hymenochaetaceae.

Other specimens examined. — **India**. Jharkhand: Sahibganj district, Mandro Block, Chaldi on the forest track to Chaldi from Solbandha, Sahibganj, 210 m a.s.l., 25°11’16.0”N, 87°36’52.7’E, on dead roots of Bamboos, 9.XI.2011, M.E. Hembrom, *MEH-70173*; Sahibganj district, Borio block, Simaljori from Kairasol Pir-Baba, 119 m a.s.l., 25°09’40.0”N, 87°41’15.1”E, on dead roots of bamboos, 30.IX.2017, M.E. Hembrom, *MEH-70191*; Borio block, Dalabari village, 122 m a.s.l., 25°02’38.2”N, 87°39’12.2”E, on standing dead bamboos, 26.VIII.2013, M.E. Hembrom, *MEH-66088*; Sahibganj district, Taljhari block, Gogi approach from Simaljori to Karanpurato, 228 m a.s.l., 25°09’00.1”N, 87°42’21.6”E, on dead bamboo stump, 30.IX.2017, M.E. Hembrom, *MEH-70198*; Taljhari block, Dhamdhamia village, 40 m a.s.l., 24°56’55.4”N, 87°45’32.7”E, on dead stump of bamboos, 28.IX.2015, M.E. Hembrom, *MEH-69985*; Sahibganj district, Pathna-Barharwa block, Chandragoda paharia hilly areas, 240 m a.s.l., 24°51’10.0”N, 87°38’18.4”E, on dead stump of bamboos, 7.IX.2013, M.E. Hembrom, *MEH-66204*; Rajmahal hills, Godda district, Boarijor block, Tatkunda from Boarijor-Lalmatia road, 225 m a.s.l., 25°01’19.3”N, 87°24’07.0”E, on dead stump of bamboos, 1.IX.2013, M.E. Hembrom, *MEH-66168*; Boarijor block, Amarpur Puriabadar, 398 m a.s.l., 25°00’03.0”N, 87°27’45.8”E, on dead stump of bamboos, 8.IX.2014, M.E. Hembrom, *MEH-66450*; Rajmahal hills, Pakur district, Litipara block, Charaknarapahar from Sathia-Narchi, 356 m a.s.l., 24°44’01.3”N, 87°34’30.3”E, on dead stump of bamboos, 18.VIII.2014, M.E. Hembrom, *MEH-66912*; Pakur district, Hiranpur block, Dangapara, 310 m a.s.l., 24°37’05.6”N, 87°28’30.2”E, on dead stump of bamboos, 28.VIII.2014, M.E. Hembrom, *MEH-66258*; Rajmahal hills, Dumka district, Ramgarh block, Kakni, Karbindha, 214 m a.s.l. 24°30’14.2”N, 87°16’06.9”E, on dead bamboos, 17.IX.2015, Samuel Murmu, *SM-15-09*; Dumka district, Gopikandar block, Gariapani to Dumurtola, 130 m a.s.l., 24°24’32.2”N, 87°29’49.6”E, on dead stump of bamboos, 20.X.2015, M.E. Hembrom, *MEH-69927*; Dumka district, Kathikund block, Kanhaideeh village, 140 m a.s.l., 24°19’42.0”N, 87°30’54.7”E, on dead stump of bamboos, 18.IX.2015, M.E. Hembrom, *MEH-69912*; Dumka district, Sikaripara block, Karakata forest area, 323 m a.s.l., 24°12’52.9”N, 87°30’15.3”E, on dead stump of bamboos, 23.X.2015, M.E. Hembrom, *MEH-69957*; Dumka district, Maslia block, Madhuban bichkhora hills, 160 m a.s.l., 24°14’31.9”N, 87°12’45.6”E, on dead stump of bamboos, 21.X.2015, Samuel Murmu, *SM-15-16*.

Description

Basidiomata

Annual, resupinate, widely effused up to 600 mm or more long in the longest direction, papery thin, 160-500 µm thick in section, closely adnate, inseparable when fresh, initially appearing as small slightly grayish brown patches, then growing in irregular pattern in all directions on the host surface and finally becoming fused with adjacent basidiomata covering entire lower part of bamboo nodes, internodes and roots before fading to give appearance of a mark of grayish white ‘paint’.

Hymenophore

Smooth when fresh but gradually cracking into distinct various angular shapes and finally detaching off from host as brittle papery crust, irregularly and distantly papillate, azonate, grayish brown then violet white to pale violet to dark brown to pale blue, becoming greyish violet at maturity, finally chestnut brown to charcoal brown in old specimens.

Margin

1-5 mm wide, floccose, chalky white. *Subiculum* smooth, sandy, duplex, pale orange to greyish orange towards host surface while greyish white towards hymenophore.

Hyphal system

Monomitic, septate, hyphae swelling in KOH, IK-, CB-, older tissue more or less darkening towards substrata and mostly unchanging toward hymenium in KOH. *Subiculum* of repeatedly branched, compactly interwoven generative hyphae and setae; cortex absent. Generative hyphae 3-6 µm wide, septate, much branched, moderate to distinctly thick-walled, pale yellow to hyaline. Setae evenly distributed throughout the context, 10-80 × 6-15 µm, acuminate (mostly) to few with lateral swellings; tip acute (mostly) to more or less obtuse, few sheathed with hyaline crystalline contents, with or without lumen, hyaline to dark brown.

Hymenium

Generative hyphae 2-4 µm wide, septate, branched, thin-walled, interwoven, hyaline.

Setae

25-80 × 9-15 µm, randomly and sparsely distributed, subulate; tip acute to obtuse, sheathed (mostly) with crystalline hyaline contents, emergent up to 25 µm, dark brown.

Cystidia

Absent.

Cystidioles

Present, 16.5-24 × 3-3.5 µm, thin-walled, hyaline.

Hyphidia

Emergent, septate, sparsely branched, obtuse to ampullate, hyaline.

Basidia

12-16 × 4-6 µm, clavate, 4-sterigmate, septate at base.

Basidioles

11-16 × 4-5 µm, clavate, septate at base.

Basidiospores

5-6.26-7 × 3-3.68-5 µm, **Q** = 1.4-1.66-1.96, ellipsoid, thin-walled, smooth, hyaline, inamyloid, acyanophilic.

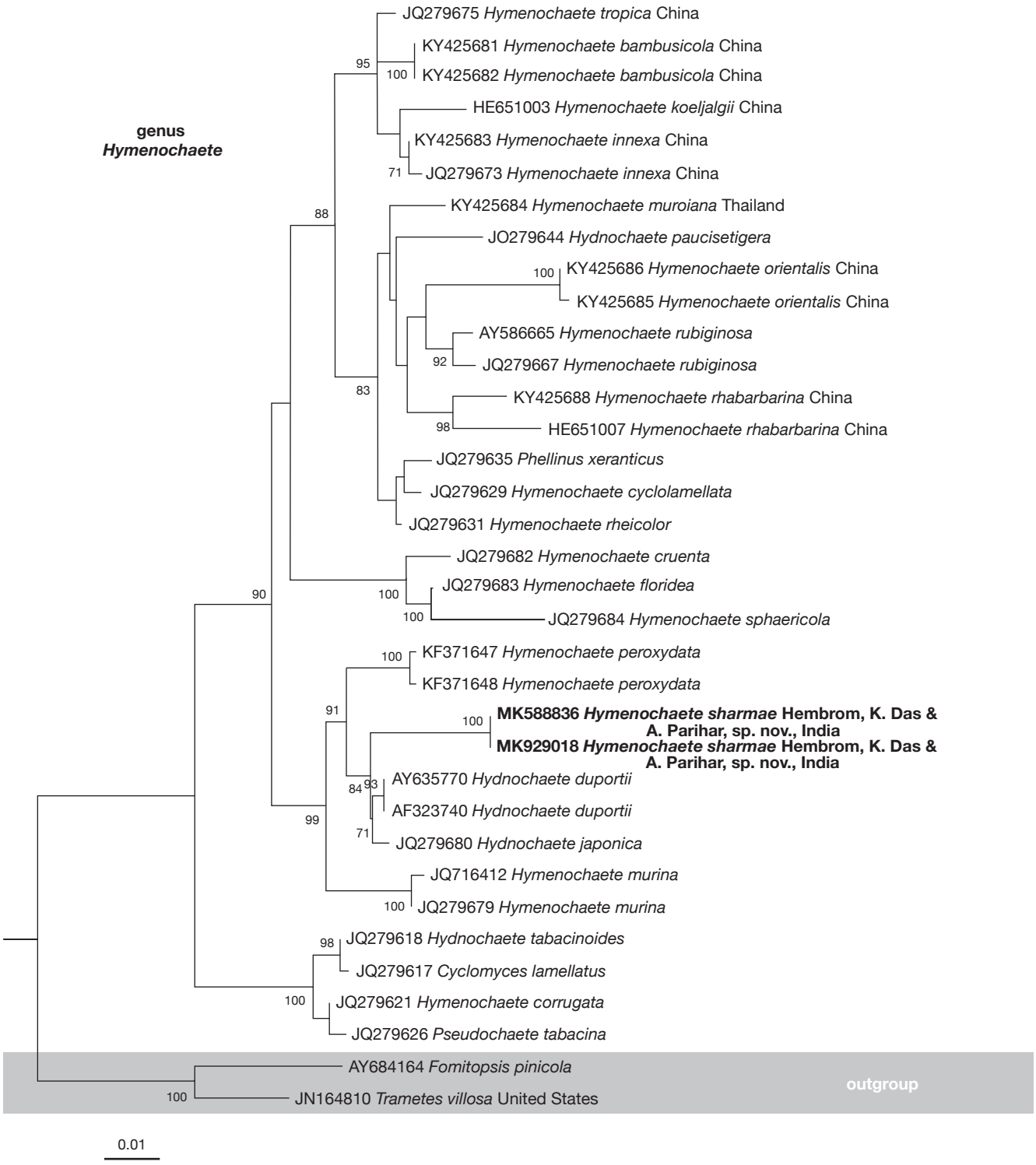

Fig. 2. — Phylogram inferred from Maximum Likelihood analysis using raxmlGUI based on nrITS sequences. One thousand bootstrap replicates were analyzed to obtain the nodal support values. Bootstrap support values (>70%) obtained from ML analysis are shown above or below the branches at nodes. The novel species *Hymenochaete sharmae* Hembrom, K. Das & A. Parihar, sp. nov., (KY929018, MK588836) is shown in bold.

Notes

This species is one of the common wood-rotting corticoid fungi in Rajmahal Hills of Jharkhand, India (Fig. 1). It can easily be recognized in the field by its exclusive occurrence on bamboos, on which it forms remarkably thin, membranous, closely adnate, smooth to slightly papillate (under 10×), purplish grey to grayish white basidiomata which gradually crack into easily separable dark brown

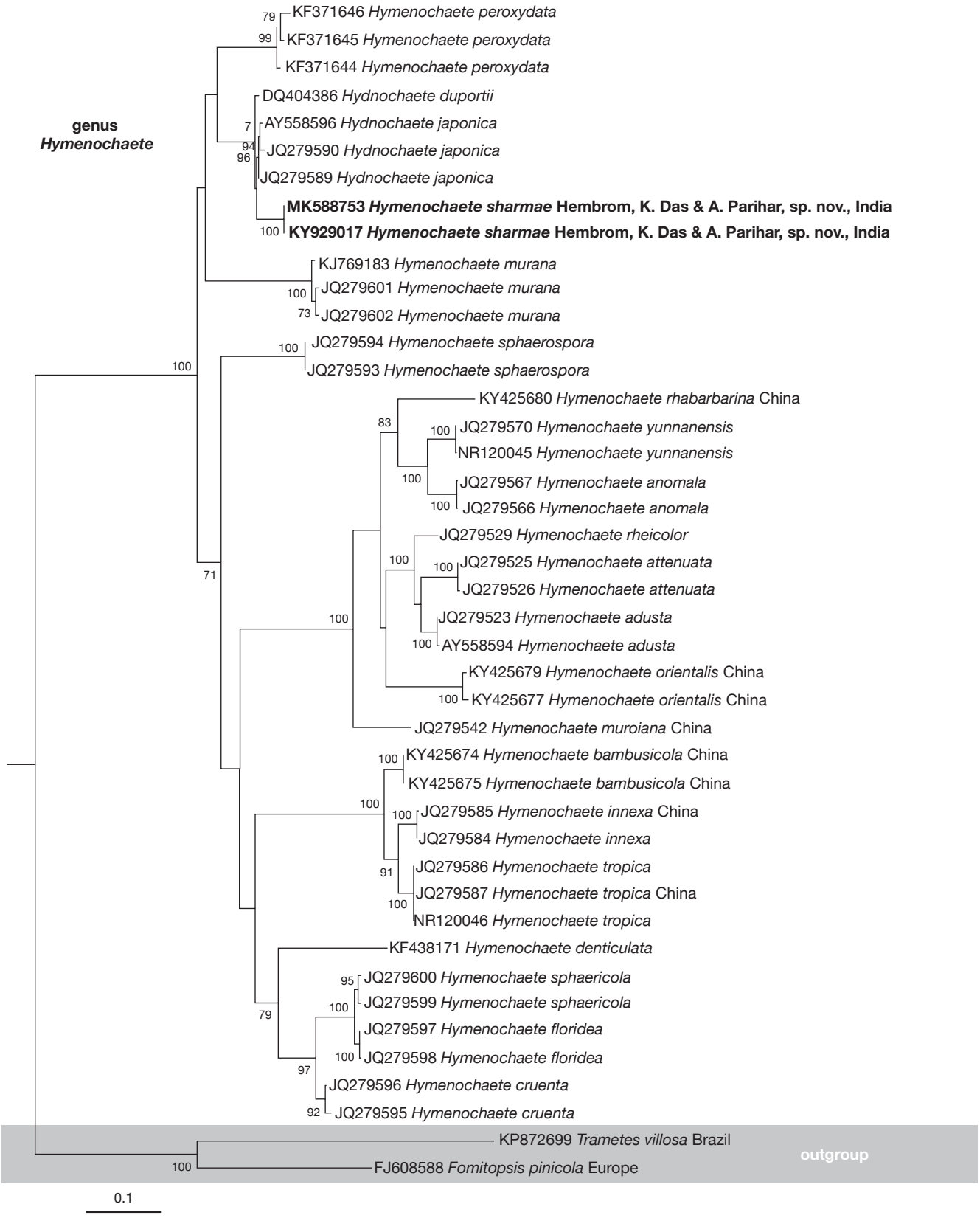

Fig. 3. — Phylogram inferred from maximum likelihood analysis using raxmlGUI based on nrLSU sequences. One thousand bootstrap replicates were analyzed to obtain the nodal support values. Bootstrap support values (>70%) obtained from ML analysis are shown above or below the branches at nodes. The novel species *Hymenochaete sharmae* Hembrom, K. Das & A. Parihar, sp. nov., (KY929017, MK588753), is shown in bold.

Fig. 4. — *Hymenochaete sharmae* Hembrom, K. Das & A. Parihar, sp. nov., (MEH-70191, holotype), morphological features: **A-C**, basidiomata in the field; **D**, margin; **E-G**, hyphidia; **H**, cystidioles; **I-N**, setae; **O**, basidiospores. Scale bars: C, 50 mm; D, 10 mm; E-O, 10 µm.

FIG. 5. — *Hymenochaete sharmae* Hembrom, K. Das & A. Parihar, sp. nov., (MEH-70191, holotype), microscopic features: **A**, transverse section through basidiomata showing arrangement of hyphae, setae, basidia, basidioles, cystidioles and hyphidia; **B**, setae; **C**, basidiospores; **D**, hyphidia; **E**, basidia; **F**, cystidioles; **G**, basidioles. Scale bars: A-G, 10 µm.

crusts (partially lamellate when associated with other wood inhabiting lower fungi). Under the microscope, the combination of emergent setae and hyphoid elements coupled with the relatively large-sized, ellipsoid basidiospores are significant taxonomic features. Further diagnostic features include the chalky white, floccose margin with highly variable size of setae.

The above-mentioned combination of morphological features is very distinct from six additional bambusicolous species of *Hymenochaete* reported from South East Asia (Nie *et al.* 2017). *Hymenochaete bambusicola* S.H. He is distinct microscopically due to the presence of unusual dimitic hyphal system while absence of any hyphal layer in *H. innexa* G. Cunn. is quite characteristic (Nie *et al.* 2017). Absence of any hyphoid elements in the hymenium of *H. muroiana* I. Hino & Katum., *H. orientalis* S.H. He, *H. rhabarbarina* (Berk.) Cooke, and *H. tropica* S.H. He & Y.C. Dai segregates them from our species (Nie *et al.* 2017).

Our nrITS- and nrLSU-based phylogenies (Figs 2, 3), with 43 and 35 sequences respectively, fully resolved the genus *Hymenochaete*. Respective sequences (KY929017, MK588753 for MEH-70191 and MEH-66088 in case of nrITS; KY929018, MK588836 for MEH-70191 and MEH-66088 in case of nrLSU) derived from present Indian species are found to be clustered amongst few Asian species of *Hymenochaete* in both of our phylogenetic estimations. However, *H. sharmae* Hembrom, K. Das & A. Parihar, sp. nov., is recovered with strong support as a distinct taxon in both these phylogenetic analyses, being sister to the clade leading to *H. japonica* Yasuda and *H. duportii* Pat.

Morphologically, the present species resembles *Hydnochaete duportii* because of the formation of resupinate, effused basidiomata, cracking at maturity. However, the latter species differs by its umber brown margin, relatively thick basidiomata, and cylindrical basidiospores 4-5 × 1.5-2 µm (Ryvarden 1982). Similarly, *Hydnochaete japonica*, originally reported from Japan, is phylogenetically close to the present species but its pileate to effused reflexed basidiomata (more than 2 mm thick), dark brown to black hymenophore and rusty brown margin (Ryvarden 1982) allow to separate it.

Another resupinate, papery thin species, *Hymenochaete murina* Bres. (included in both of our phylogenetic analyses) is very distinct because of its concolorous margin and medium-sized setae measuring 45-50 × 7-10 µm (Léger 1998). *H. peroxydata* (Berk. ex Cooke) Baltazar *et al.* has relatively thick basidiomata exceeding 2 mm in thickness, cinnamon colored margin, cylindrical basidiospores measuring 3-4 × 1.5-2 µm, and blunt, medium to long, 35-70 × 7-15 µm setae (Ryvarden 1982) and occurrs on dicotyledonous hosts. The resupinate *H. sphaerospora* J.C. Léger & Lanq., which shares with our species the presence of hyphoid elements in the hymenium, differs in its 0.5-1 mm thick basidiomata and globose to subglobose basidiospores (Léger 1998).

Order AGARICALES Underw.
Suborder AGARICINEAE Fr., *emend.* Aime, Dentinger & Gaya
Family HYDNANGIACEAE Gäum. & C.W.Dodge

82. *Laccaria indohimalayana*
K. Das, I. Bera & Vizzini, sp. nov.
(Figs 6-8)

Distinct from similar looking *Laccaria* spp. mainly by nrITS data and the large basidiomata with pileus measuring 40-95 mm diam. and stipe 80-150 × 12-65 mm.

TYPUS. — **India**. Sikkim, South district, between Rayong and Damthang, 27°15.258'N, 88°21.643'E, 2244 m a.s.l., under *Castanopsis* sp. in temperate broadleaf forest, 24.VIII.2017, Kanad Das, *KD 17-20* (holo-, CAL[CAL 1754]!).

MYCOBANK. — MB 830142.

GENBANK. — MK584157 (nrITS, holotype), MK575505 (nrITS) .

ETYMOLOGY. — Referring to the Indian Himalaya ("indohimalayana") in the state of Sikkim, the type locality.

OTHER SPECIMENS EXAMINED. — **India**. Sikkim: East district, Fambon Lho wildlife sanctuary, 27°21.631'N, 88°33.922'E, 2098 m a.s.l., under *Castanopsis* sp. in temperate broadleaf forest, 26.VIII.2017, Kanad Das, *KD 17-46* (CAL[CAL 1755]).

DESCRIPTION

Pileus
40-95 mm diam., plano-convex to applanate, gradually infundibuliform when mature and radially sulcate throughout; surface glabrous, hygrophanous, brownish orange/Sahara when wet and light orange when dry; margin wavy to irregularly lobed, sometimes slightly uplifted at maturity.

Lamellae
Subdecurrent, subdistant to rather close (8-9/cm at pileus margin) at maturity, greyish red to dull red or paler or concolorous to pileus, unchanging on bruising; edge entire; lamellulae present in 5 series.

Stipe
80-150 × 12-65 mm, twisted, strongly fibrillose-striate, darker than pileus, brown with silky to pinkish fibrils, surface wet, base strigose with whitish to pink-white basal mycelium.

Context
Pithy.

Odor
Strong fungal smell.

Spore print
White.

Basidiospores
6.88-7.60-8.26 × 6.59-7.19-8.09 µm, (n = 30, Q = 1.01-1.02-1.13), mostly subglobose, sometimes globose; ornamentation inamyloid, echinulate; under SEM ornamentations composed

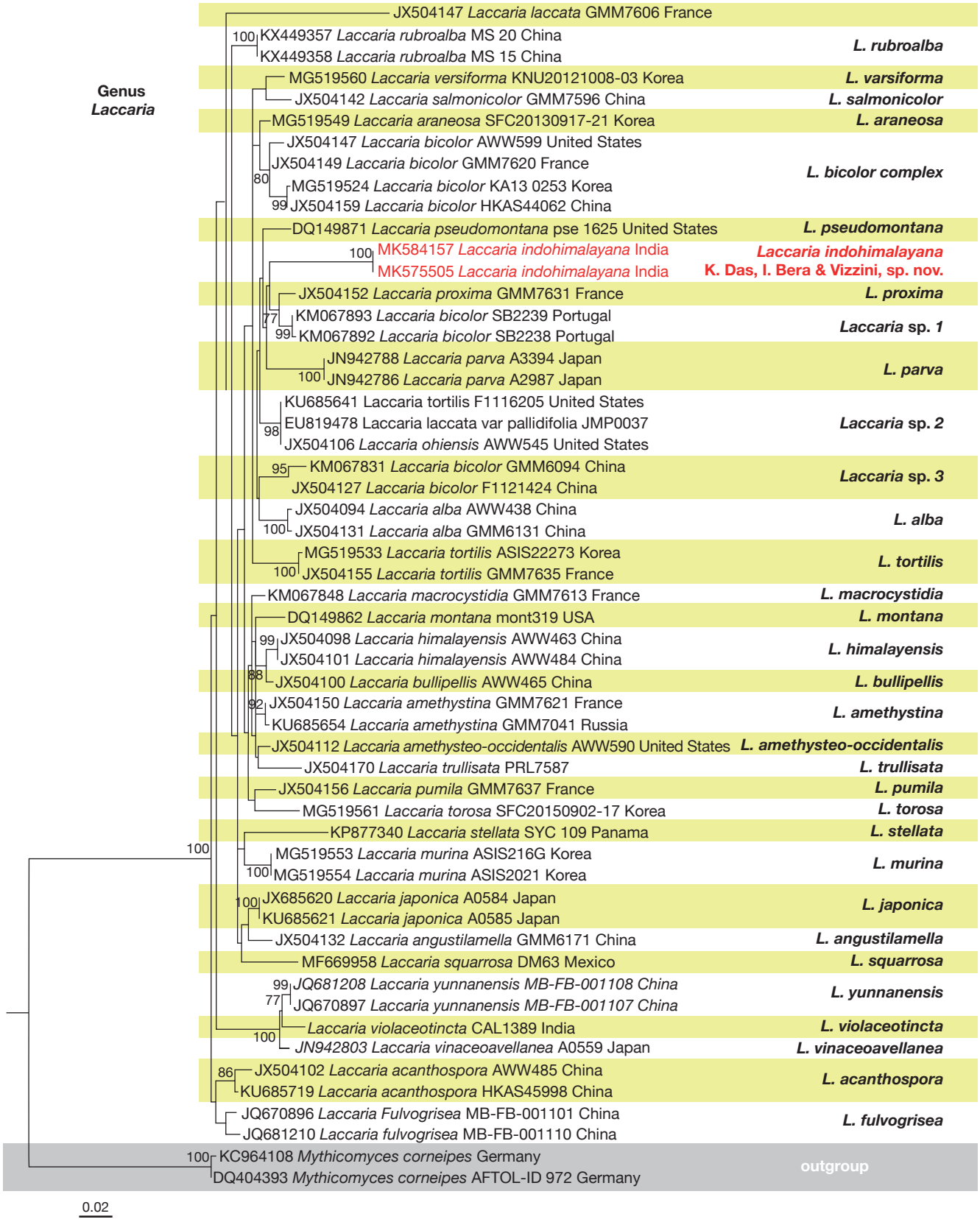

Fig. 6. — A maximum likelihood (ML) phylogram inferred from raxmlGUI (Silvestro & Michalak 2012) based on nrITS sequences. One thousand bootstrap replicates were analyzed to obtain the nodal support values. Bootstrap support values (>70%) obtained from ML analysis are shown above or below the branches at nodes. Two collections (KD 17-20 and KD 17-46) of the novel Indian species *Laccaria indohimalayana* K. Das, I. Bera & Vizzini, sp. nov., are shown in bold red with GenBank accession numbers MK584157 and MK575505 respectively.

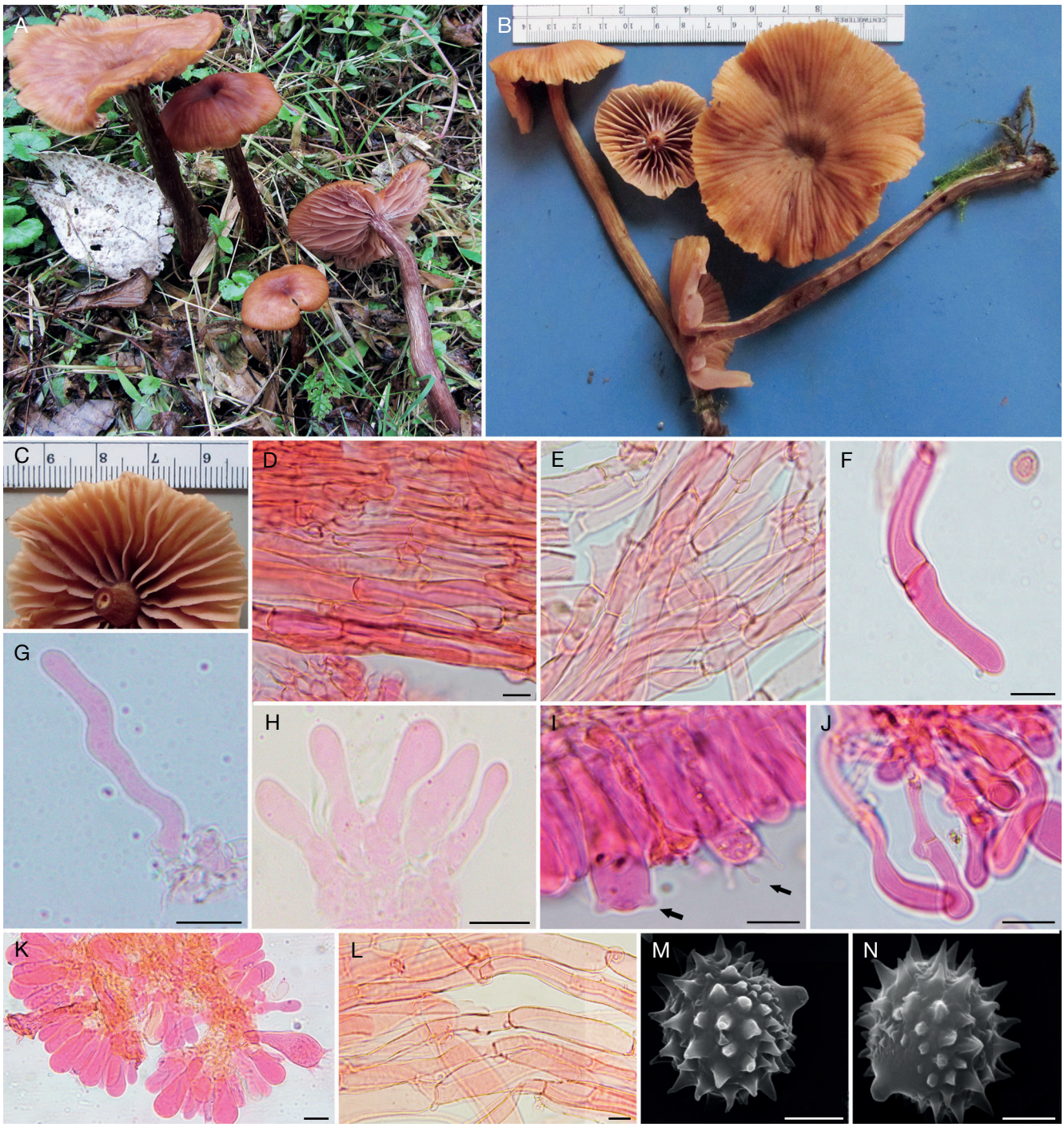

FIG. 7. — *Laccaria indohimalayana* K. Das, I. Bera & Vizzini, sp. nov. (KD 17-20, holotype): **A**, **B**, fresh basidiomata in the field and basecamp; **C**, lamellae; **D**, **E**, transverse section through pileipellis; **F-H**, sterile elements on the face of the lamellae; **I**, 2- to 4-spored basidia; **J**, **K**, sterile elements on the edge of the lamellae; **L**, transverse section through stipitipellis; **M**, **N**, basidiospores under SEM. Scale bars: D-L, 10 µm; M, N, 2 µm.

of long dense spinoid warts (0.9-1.5 × 0.8-1.0 µm) with intermediate small isolated warts (0.4 × 0.5 µm) never forming any reticulum, with shorter warts always surrounding hilum area; hilum blunt; suprahilar plage inamyloid.

Basidia
25-44 × 9-11.5 µm, clavate or rarely subclavate, 2- to 4-spored; mature sterigmata 3-7.5 × 2-2.5 µm.

True hymenial cystidia
Absent.

Sterile cells on face of lamellae
Common, 15.5-39 × 3-5 µm, mostly cylindrical with rounded apex, often with sub-fusoid apex, thin-walled, hyaline.

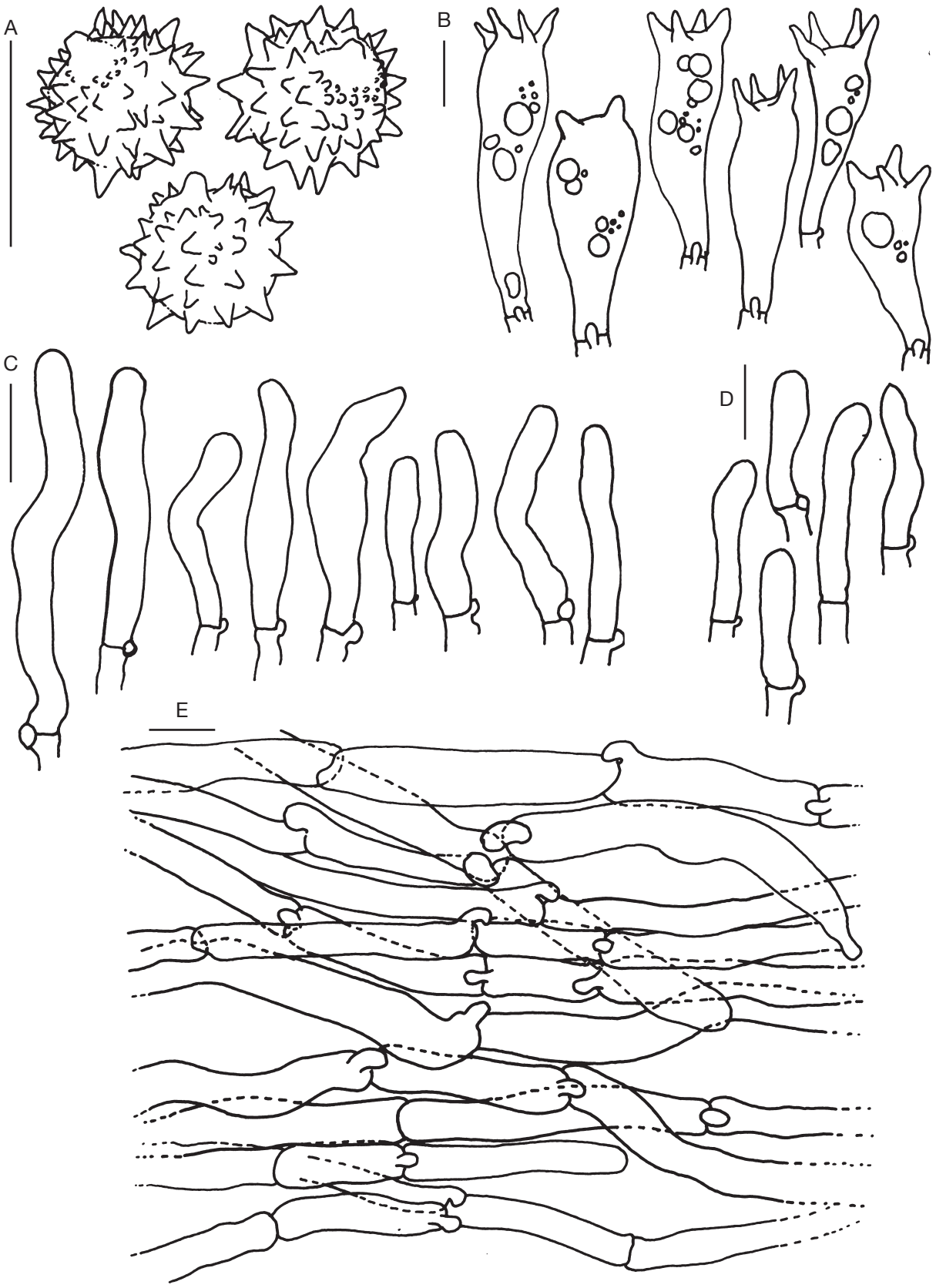

FIG. 8. — Line drawings of *Laccaria indohimalayana* K. Das, I. Bera & Vizzini, sp. nov. (KD 17-20, holotype): **A**, basidiospores; **B**, basidia; **C**, sterile elements on face of the lamellae; **D**, sterile elements on edge of lamellae; **E**, hyphal elements in pileipellis. Scale bars: A-E, 10 µm.

Sterile cells on edge of lamellae
18.8-28.6 × 3.6-6.0 µm, cylindrical with rounded to subfusoid apex, thin-walled, hyaline.

Hymenophoral trama
Up to 95 µm thick, composed of subparallel to interwoven, cylindrical, hyaline hyphae (3-5.5 µm wide); subhymenium undifferentiated.

Pileipellis
Up to 100 µm thick, a cutis composed of repent, parallel to subparallel, mostly interwoven, cylindrical, hyaline, with walls up to 1 µm thick, hyphae (4.5-9.5 µm wide).

Stipitipellis
Composed of repent, subparallel, interwoven, cylindrical, hyaline hyphae (3-10 µm wide);

Caulocystidia
Absent.

Clamp-connections
Present in all tissues.

NOTES
This Asian species is characterized by the combination of a large (40-95 mm diam.) brownish orange pileus, very tall (80-150 mm) darker stipe with white basal mycelium and strigose base, medium-sized globose to subglobose (Q = 1.01-1.02-1.13) basidiospores ornamented with isolated spines up to 1.5 µm high mixed with smaller intermediate warts, and its occurrence under broadleaf trees in temperate forests. Some species like *Laccaria laccata* (Scop.) Cooke, *L. proxima* (Boud.) Pat., *L. torosa* H.J. Cho & Y.W. Lim, *L. pseudomontana* Osmundson *et al.*, *L. versiforma* H.J. Cho & Y.W. Lim are somewhat similar, but all these close taxa have a much smaller pileus and shorter stipe. Moreover, the European *L. laccata* has subglobose to broadly ellipsoid (Q = 1-1.3) basidiospores, while the European *L. proxima* has also subglobose to broadly ellipsoid (Q = 1.2-1.35), larger basidiospores (8-11[12.5] × [6.5]7-8.7[9.2] µm) with spines < 1 µm high, and a pileus which is squamulose at centre. The Asian *L. torosa* lacks a strigose stipe base with white basal mycelium, while *L. versiforma* possesses spines "1 µm in length". The North American *L. pseudomontana* has basidiospores with fine spines "1 (-1.8) µm in length, 0.4-0.6 µm wide at base" (Mueller 1992; Vellinga 1995; Osmundson *et al.* 2005; Vesterholt 2012; Cho *et al.* 2018). Another recently discovered Indian species, *L. violaceotincta* K.P.D. Latha *et al.*, occurs in the tropical region and has distinctively smaller greyish violet coloured basidiomata with pileus 4-38 mm diam. and stipe 16-50 × 1.5-4 mm (Latha *et al.* 2019).

Our nrITS-based phylogenetic analysis (Fig. 6) suggests, however without support, that the new species (MK584157 and MK575505) is sister to a subclade bearing *L. proxima* (JX504152) and two samples from Portugal, submitted in NCBI as *L. bicolor,* but apparently representing a still undescribed species. Other suggested, phylogenetically close species include the Asian *L. parva* H.J. Cho & Y.W. Lim and American *L. pseudomontana*.

Order RUSSULALES Kreisel ex P.M.Kirk, P.F.Cannon & J.C.David
Family RUSSULACEAE Lotsy

83. *Lactarius aurantiobrunneus*
X.H. Wang, sp. nov.
(Figs 9; 10A; 11)

Differs from *L. hirtipes*, *L. alpinihirtipes* and *L. fulvihirtipes* in the spores with high ornamentation not forming a reticulum, and from *L. furfuraceus* in the less furfuraceous pileus and less reticulate spores.

TYPUS. — **China**. Guizhou Prov., Leishan Co., Leigong Mt. nature reserve, 26°23'05.4"N, 108°11'38.9"E, 1850 m a.s.l., under *Quercus engeriana*, 23.VI.2017, coll. X.H. Wang, no. *4234* (KUN[HKAS 101912]!).

MYCOBANK. — MB 829369.

GENBANK. — MK351921-MK351925 (ITS).

ETYMOLOGY. — Aurantio- = orange, -brunneus = brown, referring to the orange brown fruiting bodies.

ADDITIONAL SPECIMENS EXAMINED. — **China**. Guizhou Prov.: Suiyang Co., Kuankuoshui, near tea farm, 1500 m a.s.l., 23.VI.1988, coll. P.G. Liu, no. *48* (KUN[HKAS 20560]); Suiyang Co., Kuankuoshui nature reserve, 1500 m a.s.l., 24.VII.2010, coll. X.H. Wang, no. *2399* (KUN[HKAS 61365]); Leishan Co., Leigong Mt. nature reserve, 26°23'2"N, 108°11'35"E, 1800 m a.s.l., 24.VI.2017, coll. X.H. Wang, no. *4256* (KUN[HKAS 101913]). — Yunnan Prov., Xinping Co., Ailao Mts. nature reserve, road from Gasa to Zhenyuan, 23°56'07"N, 101°27'49"E, 2090 m a.s.l., 13.VIII.2017, coll. X.H. Wang, no. *4543* (KUN[HKAS 104224]), no. *4544* (KUN[HKAS 104225]).

HABIT, HABITAT AND DISTRIBUTION. — 1-3 individuals together, in fagaceous forests. Southwestern China (Yunnan and Guizhou Provinces).

DESCRIPTION
Basidiomata
Small to medium-sized, slender.

Pileus
20-35 mm in diam., at first convex with a pointed papilla, becoming plano-convex with a depressed center when mature; surface dry, hygrophanous, ± strongly rugose, occasionally concentrically cracked, transparently sulcate to sulcate when wet and fully mature, margin often crenulate, reddish brown when young, light brown to reddish brown when mature.

Context
0.5-1 mm thick, paler than or nearly concolorous with lamellae.

Lamellae
2.5-3 mm broad, decurrent, medium spaced, grayish orange when young, brownish orange to light brown or concolorous with the pileus when mature.

Stipe
40-80 × 3-5 mm, cylindrical, equal or gradually enlarged toward base, hollow; surface dry, nearly smooth, concolorous with the pileus; base often strigose with reddish brown hairs.

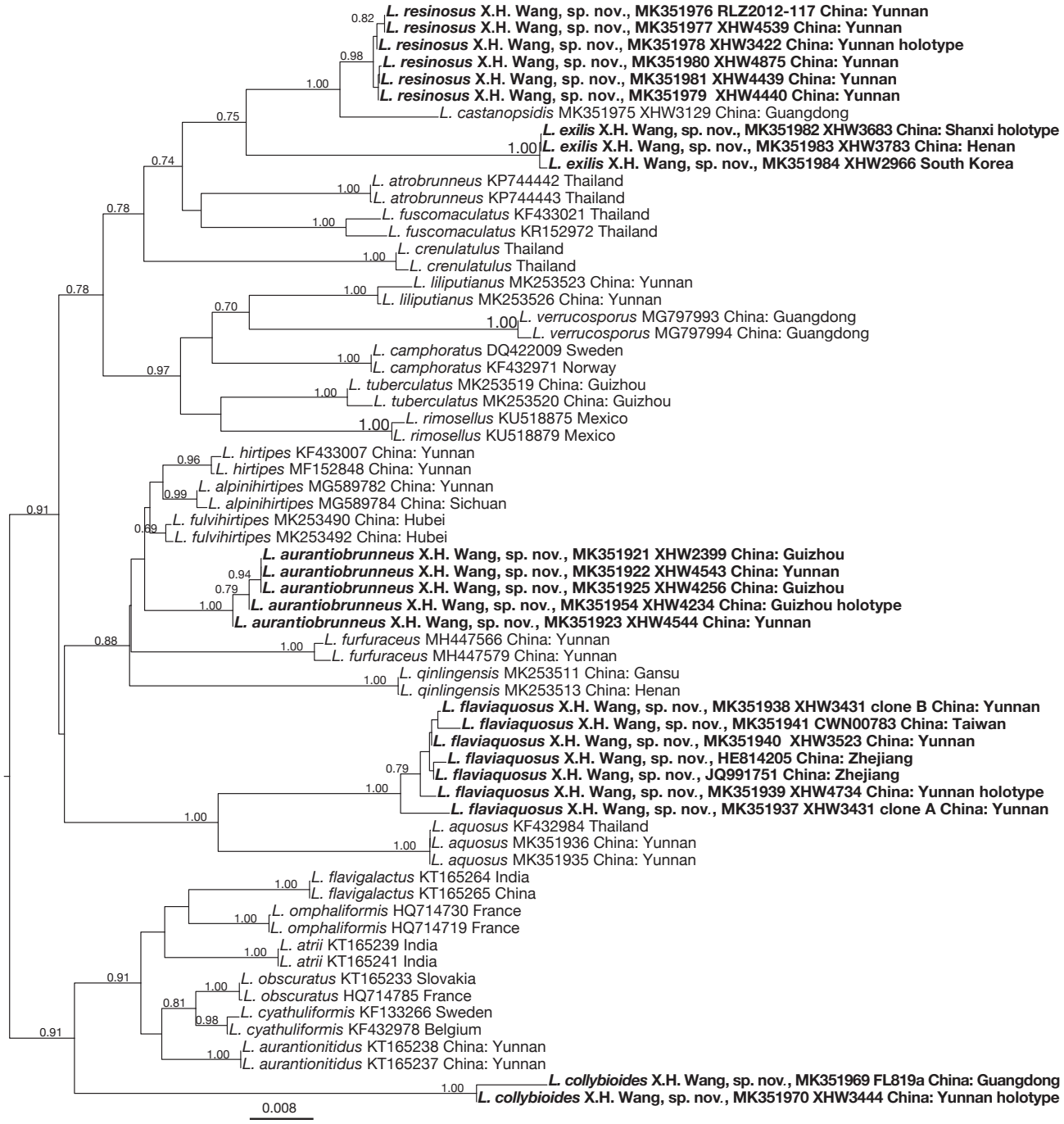

Fig. 9. — Original tree generated by Neighbor-Joining (NJ) phylogenetic analysis, rooted with midpoint. NJ analysis was conducted in MEGA X, using bootstrap method (1000 replicates), p-distance as substitution model, transitions and transversions both included, uniform rates among sites, homogeneous pattern among lineages and pairwise deletion for gaps treatment. The bootstrap proportions higher than 70% are indicated above the nodes. New species are in bold. Sample labels are provided in the order of species name, GenBank accession, and geographical origin. For new species, sample numbers with initials of collectors are provided after GenBank accessions.

Latex
Watery or cream-watery, neither discoloring nor staining.

Odor
None.

Spore print
Not obtained.

Basidiospores
(140/7/6) 7.0-7.8-8.5 (10.5) × (6.0) 6.5-7.0-8.0 (8.5) µm [Q = (1.00) 1.04-1.19 (1.26), Q = 1.12 ± 0.05] [holotype (40/2/1): 7.0-7.8-8.5 (9.0) × 6.5-6.9-7.5 (8.0) µm, Q = (1.00) 1.07-1.19 (1.22), Q = 1.12 ± 0.05], subglobose, broadly ellipsoid, rarely ellipsoid; ornamentation 1.0-2.0 µm high, of broad ridges and subtransparent wings, connecting into closed meshes, not forming a reticulum, free ends of ridges

Fig. 10. — Basidiocarps: **A**, *Lactarius aurantiobrunneus* X.H. Wang, sp. nov. (HKAS 101912, holotype); **B**, *L. exilis* X.H. Wang, sp. nov. (HKAS 90043); **C**, *L. collybioides* X.H. Wang, sp. nov. (HKAS 76002, holotype); **D**, *L. flaviaquosus* X.H. Wang, sp. nov. (HKAS 104207, holotype); **E**, *L. resinosus* X.H. Wang, sp. nov. (HKAS 104241).

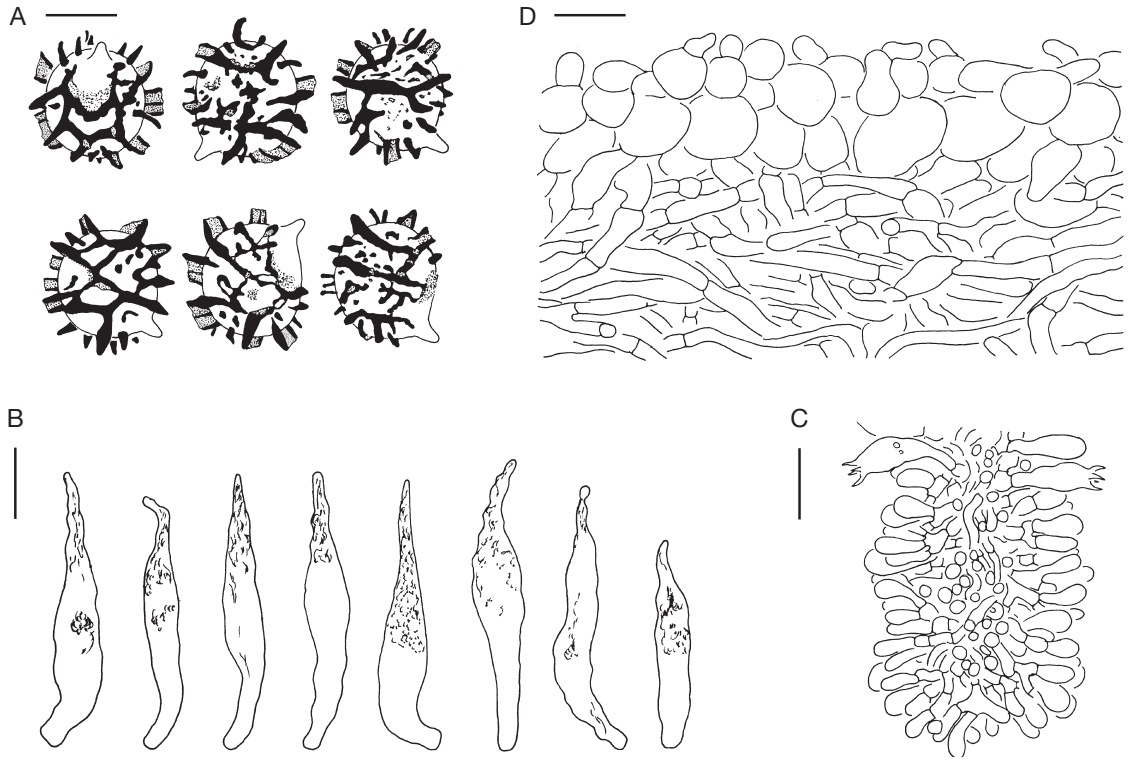

Fig. 11. — *Lactarius aurantiobrunneus* X.H. Wang, sp. nov. (HKAS 101912, holotype): **A**, basidiospores; **B**, pleuromacrocystidia; **C**, lamella edge; **D**, pileipellis. Scale bars: A, 5 µm; B, 20 µm; C, D, 25 µm.

and isolated warts common; plage not, distally or totally amyloid.

Basidia
4-spored, 32-55 × 10-15 µm, clavate, subfusiform.

Pleuromacrocystidia
Common to numerous, mostly emergent, (25) 45-83 × (6) 8-14 µm, fusiform, sublanceolate, some with a moniliform apex, with strongly refractive granular or agglomerated contents, projecting up to 40 µm beyond the basidia layer, originating from trama, subhymenium or at the same depth as the basidia.

Hymenophoral pseudocystidia
Scattered to common, 3-4 µm broad, some gradually enlarged toward apex, with refractive contents.

Lamella edge
Sterile; marginal cells 7-20 × 4-10 µm, similar to basidioles in shape, clavate, cylindrical; cheilomacrocystidia absent.

Pileipellis
An epithelium, locally with hyphoid extremities, 30-60 µm thick, with yellowish brown pigmentation; terminal cells of suprapellis 10-25 × 6-15 µm, ellipsoid, short cylindrical, globose; cells of subpellis 10-30 µm in diam., globose, ellipsoid, rarely pyriform; hyphae beneath pileipellis 5-15 µm broad.

Stipitipellis
A cutis, of closely packed, predominantly longitudinally arranged hyphae, with pale yellowish brown pigmentation; hyphae 3-12 µm broad, often inflated to ventricose, yellowish brown, slightly to medium thick-walled (0.5-1.0 µm).

Lactifers
Scattered, colorless.

Pileus and stipe trama
Lacking rosettes.

Notes
One more species of the *L. hirtipes* species complex. *Lactarius aurantiobrunneus* X.H. Wang, sp. nov., is more orange than *L. hirtipes* J.Z. Ying and *L. alpinihirtipes* X.H. Wang but less yellow than *L. fulvihirtipes* X.H. Wang. The color approaches *L. furfuraceus* X.H. Wang. The spore dimension is intermediate between *L. hirtipes* and *L. alpinihirtipes-L. fulvihirtipes-L. furfuraceus* (Wang & Liu 2002; Wang 2017, 2018; Wang *et al.* 2018a). The spore ornamentation is never as reticulate as the other four relatives. In the field it was easily confused with *L. hirtipes* or *L. furfuraceus* although the medium distant lamellae and nearly smooth pileus slightly deviate from those two species respectively. *Lactarius aurantiobrunneus* X.H. Wang, sp. nov., is less common than *L. hirtipes* and often found in well-preserved natural habitats.

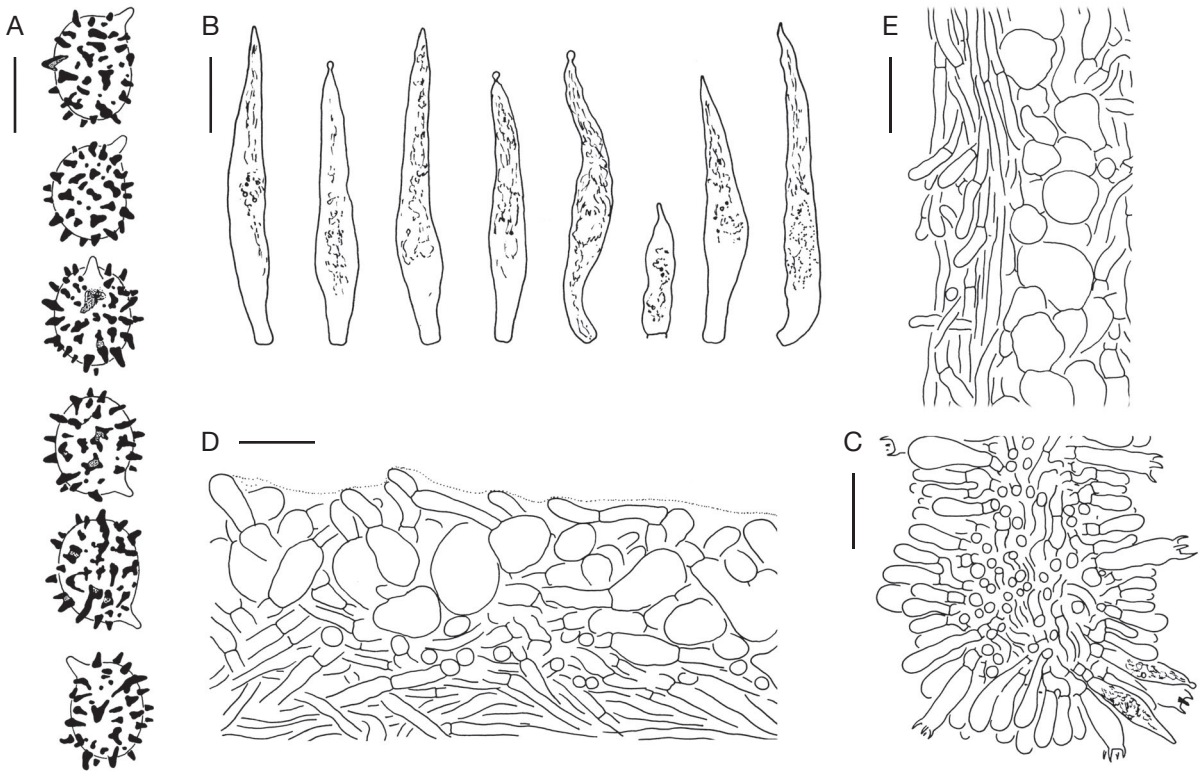

Fig. 12. — *Lactarius collybioides* X.H. Wang, sp. nov. (HKAS 76002, holotype): **A**, basidiospores; **B**, pleuromacrocystidia; **C**, lamella edge; **D**, pileipellis; **E**, stipitipellis. Scale bars: A, 5 µm; B, 20 µm; C-E, 25 µm.

84. *Lactarius collybioides* X.H. Wang, sp. nov. (Figs 9; 10C; 12)

A small slender species characterized by very pale fruiting bodies with a collybioid habit, ellipsoid spores with nearly isolated conical warts, pileipellis an (ixo)hymeno-hyphoepithelium and emergent pleuromacrocystidia.

TYPUS. — **China**. Yunnan Prov., Puer, road from Ninger to Puer, 1500 m a.s.l., in fagaceous forest, 5.VII.2012, coll. X.H. Wang, no. *3444* (holo-, KUN[HKAS 76002]!).

MYCOBANK. — MB 829279.

GENBANK. — MK351969, MK351970 (ITS).

ETYMOLOGY. — Referring to the small slender fruiting bodies with a collybioid habit.

ADDITIONAL SPECIMENS EXAMINED. — **China**. Guangdong Prov., Fengkai Co., Heishiding nature reserve, 5.VIII.2012, coll. F. Li, no. *819a* (KUN[HKAS 77710]). — Yunnan Prov.: Puer, Hongqi reservoir, 450 m a.s.l., 3.VIII.1991, coll. Z.L. Yang, no. *1380* (KUN[HKAS 24649]); Xishuangbanna, Jinghong, Dadugang, under fagaceous trees, 31.VIII.2004, coll. X.H. Wang, no. *1807* (KUN[HKAS 47727]).

HABIT, HABITAT AND DISTRIBUTION. — In group, growing on humus, under fagaceous trees. South (Guangdong Prov.) and tropical southwestern (Yunnan Prov.) China.

DESCRIPTION

Basidiomata

Small, slender.

Pileus

10-20 mm in diameter, at first concave with a slightly decurved margin, soon fully concave to shallowly infundibuliform, ½ to ⅔ of the radius transparently striate; surface nearly dry, hygrophanous, pale yellow when young, remaining so or pale yellow to pale orange in age.

Context

0.5-1.5 mm thick, pale cream-colored.

Lamellae

1-1.5 mm broad, medium crowded, broadly adnate to decurrent, pale yellow to pale orange when young, grayish orange when fully mature.

Stipe

20-35 × 1-3 mm, cylindrical, equal or slightly enlarged downward, hollow; surface nearly smooth, hygrophanous, concolorous with the pileus or brownish orange.

Latex

Watery, not changing or staining, acrid.

Spore print
Not obtained.

Basidiospores
(140/7/4) 5.5-6.3-7.0 (7.5) × 4.5-5.2-6.0 µm [Q = (1.09) 1.13-1.32 (1.43), Q = 1.22 ± 0.06] [holotype (40/2/1) (5.5) 6.0-6.4-7.0 (7.5) × 4.5-5.2-6.0 µm, Q = 1.09-1.34 (1.43), Q = 1.24 ± 0.08], ellipsoid, rarely broadly ellipsoid; ornamentation 0.6-1.0 (1.3) µm high, of isolated conical warts, a few of them fused or connected by fine lines; plage distally amyloid.

Basidia
4-spored, 25-40 × 7-12 µm, clavate, rarely cylindrical.

Pleuromacrocystidia
Rare to common, more common at the lower side of the cap between the lamellae, often emergent, projecting up to 50 µm beyond the basidia layer, (34) 50-85 × 7-12 µm, fusiform, sublanceolate, sharply pointed, some with a moniliform apex, with dense yellowish granular or crystalline contents.

Hymenophoral pseudocystidia
Uncommon, 3-4 µm broad.

Lamella edge
Sterile or fertile; cheilomacrocystidia rare to common, similar to pleuromacrocystidia in shape but smaller.

Pileipellis
An ixo-hymenoepithelium or ixo-hymenoepithelium with a sparse slimy layer, 30-50 µm thick; terminal cells of suprapellis (7) 10-35 × 4-12 (17) µm, ellipsoid, clavate, cylindrical; cells of subpellis 10-40 × 10-20 µm, globose, ellipsoid, pyriform, rarely hyphoid, slightly gelatinized.

Stipitipellis
An (ixo)cutis; 15-30 µm thick; hyphae closely packed, 2-4 µm broad, rarely slightly thick-walled, terminal cells 15-50 × 3-5 µm, with a blunt apex, slightly gelatinized.

Lactifers
Rare to common, robust, nearly colorless.

Pileus and stipe trama
With numerous rosettes.

NOTES
This species is distinctive in *L.* subg. *Russularia* because of its pileipellis a hymenoepithelium with a slimy layer and spores with isolated warts. In *L.* subg. *Russularia*, ornamentation of isolated warts have been found in the following species: Chinese *L. flaviaquosus* X.H. Wang, sp. nov. (described below), *L. minimus* var. *macrosporus* Z.S. Bi & G.Y. Zheng (Bi *et al.* 1985), *L. tuberculatus* X.H. Wang (Wang 2018), *L. verrucosporus* G.S. Wang & L.H. Qiu (Wang *et al.* 2018b); *L. liliputianus* Verbeken & E. Horak from Papua New Guinea (Verbeken & Horak 2000); North American *L. highlandensis* Hesler & A.H. Sm. and *L. rimosellus* Peck (Hesler & Smith 1979); European *L. camphoratus* (Bull.) Fr. (Heilmann-Clausen *et al.* 1998; Basso 1999). *Lactarius minimus* var. *macrosporus* does not have macrocystidia and its pileipellis lacks a slimy layer (Wang 2007). The spores are more round in *L. minimus* var. *macrosporus* and *L. verrucosporus* and spore warts of *L. liliputianus* and *L. verrucosporus* often have a truncate apex. In the two North American species, the pilei are areolate-rimose when mature and macrocystidia are absent. *Lactarius camphoratus* and *L. tuberculatus* have bigger fruiting bodies and their spore ornamentations are less isolated. Indian *L. atrii* Van de Putte & K. Das has a slimy layer in the pileipellis. The spore warts of this species are blunt and the pileipellis lacks isodiametric cells (an ixocutis) (Wisitrassameewong *et al.* 2016).

85. ***Lactarius exilis*** X.H. Wang, sp. nov.
(Figs 9; 10B; 13)

A small slender species with pileus with a conical center, white latex, globose reticulate spores, absence of pleuromacrocystidia, numerous cheilomacrocystidia and pileipellis a (hymeno)epithelium. A long INDEL in the ITS1 region is also characteristic.

TYPUS. — **China**. Shanxi Prov., Xia Co., Sijiao, Tanghui, under *Quercus* trees, 15.VIII.2015, coll. X.H. Wang, no. *3683* (holo-, KUN[HKAS 89954]!).

MYCOBANK. — MB 829288.

GENBANK. — MK351982-MK351984 (ITS).

ETYMOLOGY. — Referring to the slender fruiting bodies.

ADDITIONAL SPECIMENS EXAMINED. — **China**. Henan Prov., Xinyang, Jigong Mt., between Laoyingwo and Xiannütan, 295 m a.s.l., 25.VIII.2015, coll. X.H. Wang, no. *3783* (KUN[HKAS 90043]).

South Korea. Seoul, Donggureung Nine Royal Tombs, under *Quercus* trees, 15.VIII.2011, coll. X.H. Wang, no. *2966* (KUN[HKAS 73523]).

HABIT, HABITAT AND DISTRIBUTION. — Caespitose or 1-4 individuals growing together, in fagaceous forests. Northern (Shanxi Prov.) and central (Henan Prov.) China and South Korea.

DESCRIPTION
Basidiomata
Small, slender.

Pileus
6-15 mm in diam., at first convex with a pointed papilla, becoming plano-convex with a depressed center when mature, ± sulcate, margin sometimes crenate; surface dry, somewhat areolate-rimose, dark brown or dark reddish brown when

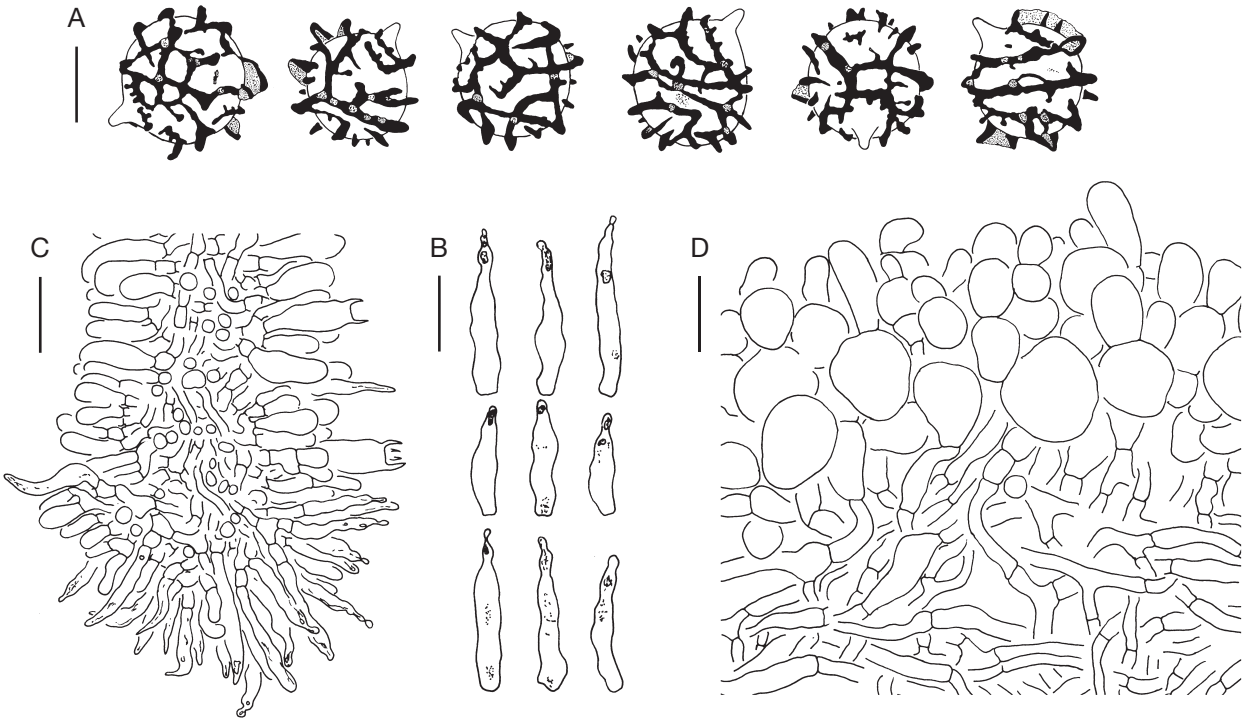

FIG. 13. — *Lactarius exilis* X.H. Wang, sp. nov. (HKAS 89954, holotype): **A**, basidiospores; **B**, cheilomacrocystidia; **C**, lamella edge; **D**, pileipellis. Scale bars: A, 5 µm; B, 20 µm; C, D, 25 µm.

young, later remaining so or becoming yellowish brown, orange brown, hygrophanous, radially rugose.

Context
Very thin (< 0.5 mm), concolorous with the lamellae.

Lamellae
1-3 mm broad, decurrent, subdistant, pale yellow, grayish orange.

Stipe
20-40 × 1-2 mm, cylindrical, equal or gradually enlarged downward; surface dry, smooth, with silky luster, nearly concolorous with the lamellae or light brown.

Latex
White, watery, neither discoloring nor staining.

Odor
None.

Spore print
Not obtained.

Basidiospores
(80/4/3) 7.0-7.7-8.5 (9.0) × 6.5-7.2-8.0 (8.5) µm [Q = 1.00-1.12 (1.14), Q = 1.06 ± 0.03] [holotype (40/2/1) 7.0-7.7-8.5 (9.0) × 6.5-7.3-8.0 (8.5) µm, Q = 1.00-1.10 (1.14), Q = 1.06 ± 0.03], globose, subglobose; ornamentation 0.8-1.5 (2.0) µm high, of ridges connected, forming an incomplete to complete reticulum, often with subtransparent (less amyloid) dots in the ridges or at the crossing points of ridges; plage not amyloid or slightly distally amyloid.

Basidia
4-spored, 35-52 × 8-13 µm, clavate.

Pleuromacrocystidia
Absent.

Pseudocystidia
Uncommon to common, 2-4 µm broad, often slightly enlarged at the apex, some forking.

Lamella edge
Sterile, rarely with scattered basidia; cheilomacrocystidia numerous, 25-60 × 4-7 µm, subfusiform, cylindrical, apex mostly mucronate or moniliform, with sparse to agglomerated contents.

Pileipellis
An epithelium, 50-100 µm thick; cells 15-30 µm in diam., globose, ellipsoid, terminal cells often ellipsoid, colorless, hyphae beneath globose cells 5-10 µm broad, colorless.

Stipitipellis
A cutis, 40-50 µm thick, closely packed; hyphae 3-5 µm broad, pale yellowish brown.

Pileus and stipe trama
With numerous rosettes.

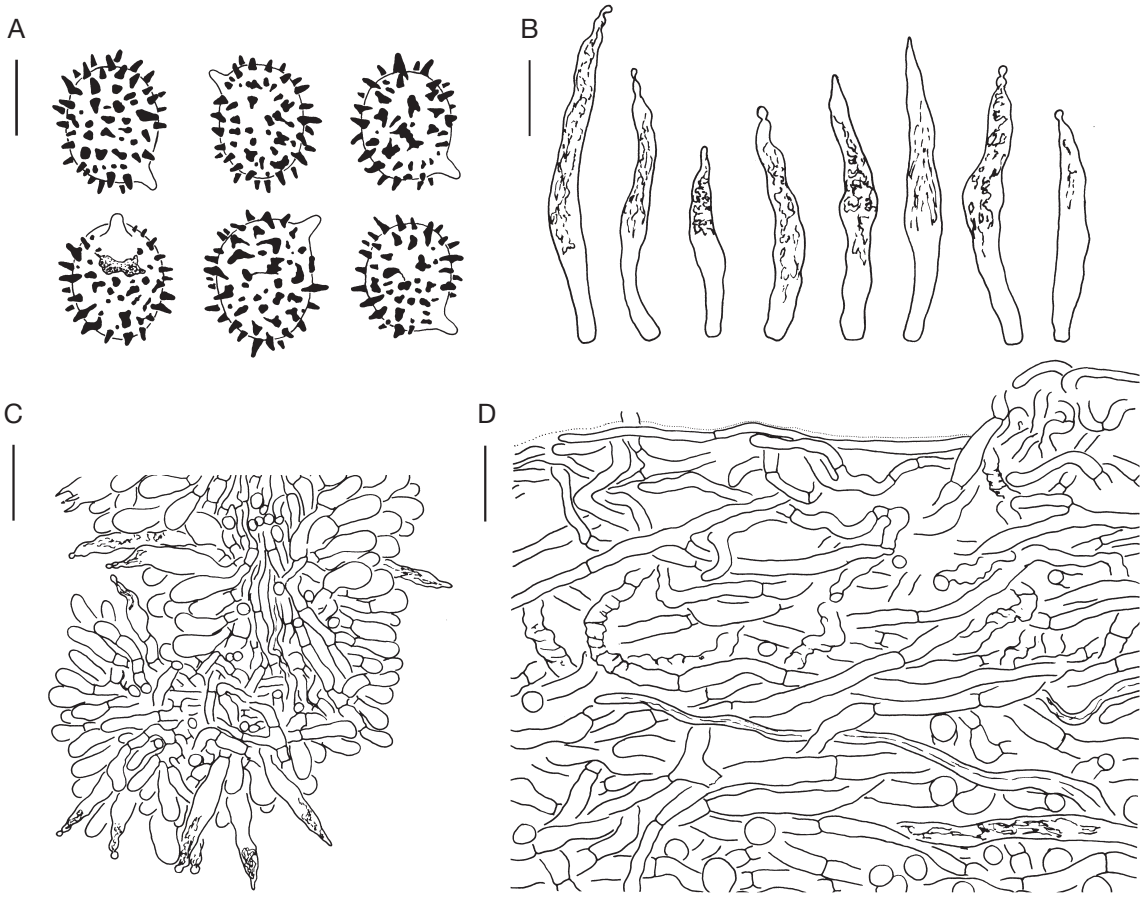

Fig. 14. — *Lactarius flaviaquosus* X.H. Wang, sp. nov. (HKAS 104207, holotype): **A**, basidiospores; **B**, pleuromacrocystidia; **C**, lamella edge; **D**, pileipellis. Scale bars: A, 5 µm; B, 20 µm; C, D, 25 µm.

Notes

The combination of pileipellis an epithelium, absence of pleuromacrocystidia and abundant cheilomacrocystidia of *L. exilis* X.H. Wang, sp. nov., is shared by *L. castanopsidis* and *L. resinosus* X.H. Wang, sp. nov. (described below). Those two species have spores with deeply winged zebroid ornamentations and brownish hyphae underlying the pileipellis. *Lactarius exilis* X.H. Wang, sp. nov., is similar to European *L. obscuratus*, *L. cyathuliformis* and *L. omphaliformis* and Thai *L. crenulatulus* Wisitrassameewong & Verbeken in the slender habit and the pileipellis an epithelium. The three European species have pleuromacrocystidia and ellipsoid spores (Heilmann-Clausen *et al.* 1998; Basso 1999). The Thai species lacks cheilomacrocystidia and has a more crenulate pileus and white pruinose stipe base (Wisitrassameewong *et al.* 2014). Japanese *L. cyathula f. japonicus* Hongo looks similar. It has bigger ellipsoid spores and lacks macrocystidia (Hongo 1971).

The long INDEL in the ITS1 region in *L. castanopsidis*, *L. exilis* X.H. Wang, sp. nov., and *L. resinosus* X.H. Wang, sp. nov., is unique among the members of *L.* subg. *Russularia.* This long INDEL is also present in several species of *L.* subg. *Lactarius* with violeting latex [e.g. *L. cascadensis* Hesler & A.H. Sm. and *L. luridus* (Pers.) Gray]. Using the whole ITS or ITS1 region to BLAST gave hits to these not closely related species.

86. ***Lactarius flaviaquosus*** X.H. Wang, sp. nov.
(Figs 9; 10D; 14)

A medium-sized species with faintly zonate pileus, latex yellow or white changing to yellow and watery instantly, rarely white or watery, ellipsoid spores with isolated conical warts and pileipellis an (ixo-)lattice

Typus. — **China**. Yunnan Prov., Maguan Co., Dalishu, Adushangba, 27°03'3.28"N, 104°08'18.52"E, 1800 m a.s.l., in fagaceous forest, 13.X.2017, coll. X.H. Wang, no. *4734* (holo-, KUN[HKAS 104207]!).

Mycobank. — MB 829289.

Genbank. — MK351937-MK351941 (ITS).

Etymology. — Flavi- = yellow, -aquosus = water, referring to the yellow latex or white then changing to yellow and watery.

Additional specimens examined. — **China**. Yunnan Prov.: Baoshan, Gaoligong Mts. nature reserve, old road from Baoshan to Tengchong, 20 km to Bawan, 17.VII.2003, coll. X.H. Wang, no. *1553* (KUN[HKAS 43947]); Lüchun Co., Huanglian Mt. nature reserve, near Huanglianshan reservoir, 8.VII.2012, coll. X.H. Wang, no. *3523* (KUN[HKAS 76060]); Maguan Co., Gulinqing, 2000 m a.s.l., 29.VI.1992, coll. Z.L. Yang, no. *1821* (KUN[HKAS 25946]); Malipo Co., Laojun Mt. nature reserve, 1500 m a.s.l., 23.VI.1992, coll. Z.L. Yang, no. *1763* (KUN[HKAS 25950]); ibid, 24.VI.1992, coll. Z.L.

Yang, no. *1794* (KUN[HKAS 25951]); Pingbian Co., Dawei Mt. nature reserve, 1800-2100 m a.s.l., 4.VII.1992, coll. Z.L. Yang, no. *1877* (KUN[HKAS 25947]); ibid, 4.VII.1992, coll. P.G. Liu, no. *1280* (KUN[HKAS 25948]); Pingbian Co., near the county town, 1500 m a.s.l., 21.VII.2005, coll. X.H. Wang, no. *1934* (KUN[HKAS 49562]); Zhenyuan Co., 313 provincial road (from Zhenyuan to Mengda), 4.VII.2012, coll. X.H. Wang, no. *3431* (KUN[HKAS 75992]). — Taiwan Prov.: Ilan Co., Fushan Botanical Garden, 600 m a.s.l., 20.IV.1993, coll. W.N. Chou, no. *CWN-TF615* (TNM[F0023042]); Nantou Co., Hsinyi, Tachieshan, 13.IV.1995, coll. W.N. Chou, no. *CWN00783* (TNM[F0003237]); Nantou Co., Yuchih Hsiang, Lienhuachih, 22.IV.2006, coll. W.N. Chou, no. *CWN07078* (TNM[F0027273]).

Habit, habitat and distribution. — 1-4 individuals growing together, in fagaceous forest. Southwestern (Yunnan Prov.) and southeastern (Taiwan and Zhejiang Provinces) China (Gao *et al.* 2013; GenBank accession JQ991751).

Description

Basidiomata
Small to medium-sized.

Pileus
20-50 mm in diam., depressed with an expanded margin, with age often translucently striate at margin; surface smooth, slightly viscid when wet, yellowish brown, reddish brown, brownish orange, darker at center, faintly zonate.

Context
1 mm thick, pale brown.

Lamellae
2-3 mm broad, straight to short decurrent, crowded, concolorous with pileus.

Stipe
20-70 × 3-7 (10) mm, cylindrical, equal, solid then hollow; surface smooth, dry, concolorous with pileus or with more reddish tinge, light brown, often strigose at the base.

Latex
Yellow or white changing to yellow watery instantly, rarely white or watery and unchanging, acrid, sharp.

Spore print
not obtained.

Basidiospores
(340/17/10) (6.0) 6.5-7.4-8.5 (9.5) × (5.0) 5.5-5.9-6.5 (7.5) µm [Q = (1.09) 1.17-1.36 (1.43), Q = 1.26 ± 0.06] [holotype (40/2/1) (6.5) 7.0-7.4-8.0 (8.5) × (5.0) 5.5-5.8-6.5 µm, Q = (1.17) 1.21-1.38 (1.43), Q = 1.28 ± 0.06], ellipsoid, rarely broadly ellipsoid; ornamentation 0.6-1.3 (1.5) µm high, of isolated conical warts, few of them fused or connected by fine lines; plage distally amyloid or inamyloid.

Basidia
4-spored, 30-45 × 8-13 µm, clavate.

Pleuromacrocystidia
Uncommon to numerous, emergent, projecting up to 30 µm beyond the basidia layer, originating from subhymenium or hymenophoral trama, (40) 50-100 (120) × 7-12 (15) µm, subfusiform, sublanceolate, rarely subcylindrical, with a sharp apex, with dense yellowish granular or crystalline contents.

Lamella edge
Fertile with few basidia; cheilomacrocystidia common to numerous, 20-60 × 5-9 µm, fusiform, subcylindrical, apex often moniliform or with apical appendices, with strongly refractive granular, crystalline or agglomerated contents; marginal cells 7-30 × 4-10 µm, clavate, cylindrical.

Hymenophoral pseudocystidia
Rare to common, 2-3 µm broad, rarely forking, with refractive contents.

Pileipellis
An (ixo)cutis or (ixo)lattice, 50-170 µm thick; hyphae (3) 4-10 (12) µm broad, terminal cells 15-65 × 3-6 µm, with a blunt apex, some shrivelled, hyphae in subpellis gelatinized, colorless to pale yellow, some slightly thick-walled (0.5 µm).

Stipitipellis
A cutis, 30-60 µm thick; hyphae closely packed, 3-6 µm broad, with a blunt apex, gelatinized, slightly thick-walled, nearly colorless.

Lactifers
Numerous, in hymenophoral trama nearly colorless to pale yellowish brown, in pileus and stipe trama robust, pale to golden yellowish brown.

Pileus and stipe trama
With numerous rosettes.

Notes

The holotype has white milk that changed yellow instantly, whereas ZLY1763, 1794, 1821, 1877 and XHW3431 have yellow milk. The milk of XHW3525 is watery and unchanging. The holotype, XHW3431, and XHW3525 are sequenced and they have nearly identical ITS sequences (Fig. 9). As the latex of this species seems variable, three specimens with the same microscopical characters but whitish milk (XHW1553, XHW1934 and PGL1280) are here also identified to belong to the same species. The ellipsoid spores with isolated warts and the pileipellis an ixocutis-lattice with inflated hyphae are good specific characters. Indian *L. atrii* seems to be similar, but has bigger spores with blunt warts and azonate pileus. Thai *L. aquosus* H.T. Le & K.D. Hyde, a species showing affinity to this new species in the ITS phylogeny, has unchanging watery latex, reticulate spores and much broader hyphae in the pileipellis (Wisitrassameewong *et al.* 2015). Two species of *L.* subg. *Russularia* with yellowing latex are reported from subalpine southwestern

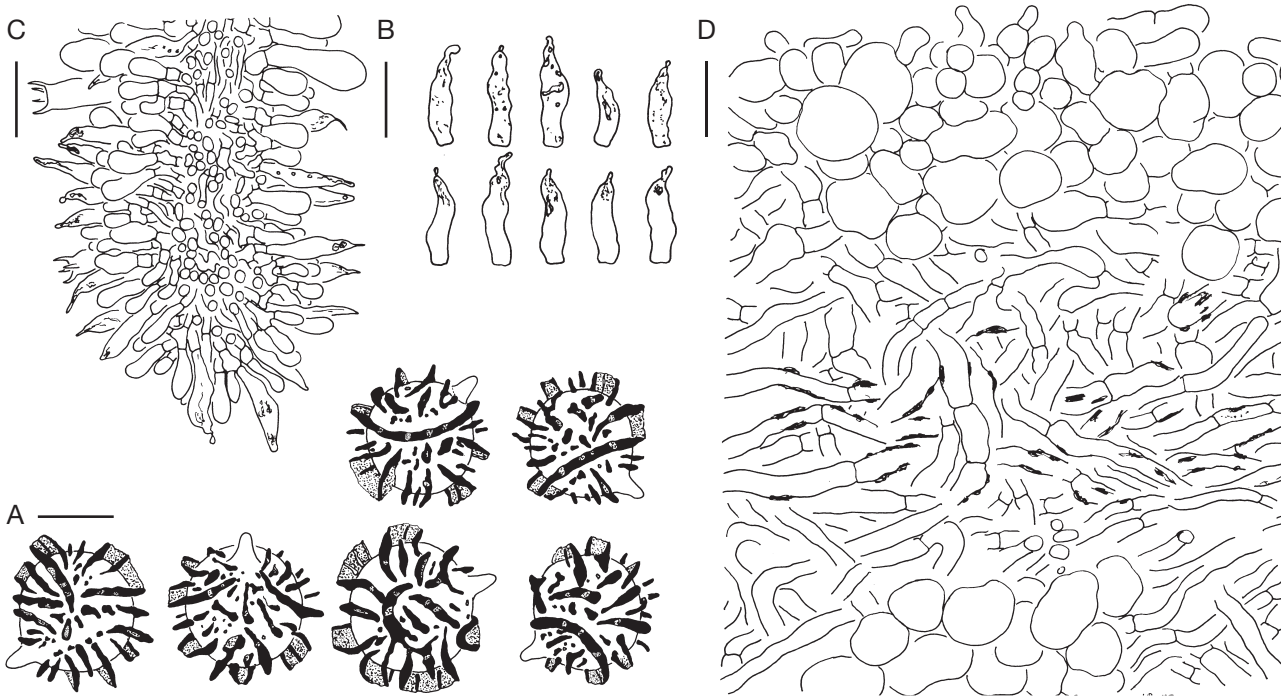

Fig. 15. — *Lactarius resinosus* X.H. Wang, sp. nov. (all from HKAS 75984-holotype, except B from HKAS 104241): **A**, basidiospores; **B**, lamella edge; **C**, cheilomacrocystidia; **D**, pileipellis. Scale bars: A, 5 µm; B, 20 µm; C, D, 25 µm.

China (Wisitrassameewong *et al.* 2016). They both have azonate pileus and more connected spore ornamentation. For notes on species with isolated warts, see under *L. collybioides*.

87. ***Lactarius resinosus*** X.H. Wang, sp. nov. (Figs 9; 10E; 15)

Characterized by slender fruiting bodies, strongly rugose pileus, globose spores with zebroid-winged ornamentation and pileipellis an epithelium with resin-like encrustations on the hyphae beneath the globose cells. Differing from *L. castanopsidis* and *L. corrugatus* in having bigger fruiting bodies and dark reddish brown pileus. A long INDEL in the ITS1 region is also characteristic.

Typus. — **China**. Yunnan Prov., Nanjian Co., Lingbao Mt. forest park, 2300 m a.s.l., 4.VII.2012, coll. X.H. Wang, no. *3422* (holo-, KUN[HKAS 75984]!).

Mycobank. — MB 829371.

Genbank. — MK351976-MK351981 (ITS).

Etymology. — Referring to the resin-like encrustations on the hyphae beneath the subglobose cells of pileipellis.

Additional specimens examined. — **China**. Yunnan Prov.: Cangyuan Co., Nangunhe nature reserve, 6.VII.2012, coll. R.L. Zhao, no. *2012-117* (KUN[HKAS 85367]); Maguan Co., Gulinqing nature reserve, Piaochang, 22°51'38.2"N, 104°00'08.6"E, 1750 m a.s.l., 9.VIII.2017, coll. X.H. Wang, no. *4439* (KUN[HKAS 104242]), no. *4440* (KUN[HKAS 104240]); ibid, 19.X.2017, coll. X.H. Wang, no. *4875* (KUN[HKAS 104241]); Xiping Co., Ailao Mts. nature reserve, Jinshan virgin forest park, 23°56'26"N, 101°30'09"E, 2400 m a.s.l., 13.VIII.2017, coll. X.H. Wang, no. *4539* (KUN[HKAS 104239]).

Habit, habitat and distribution. — 1-4 individuals growing together, under fagaceous trees. Subtropical-tropical Yunnan, China.

Description

Basidiomata

Small to medium-sized.

Pileus

25-45 mm in diam., at first convex with a pointed papilla, becoming plano-convex with a depressed center when mature, margin crenulate; surface yellowish brown, brown, dark brown, sometimes with irregular darker strips, hygrophanous, rugose-granulose all over.

Context

0.5-1 mm thick, cream-flesh colored.

Lamellae

1.5-5 mm broad, decurrent, medium crowded to subdistant (9-15 L/cm), yellowish white, light yellow to grayish yellow, changing to pale brown when bruised, light brown when fully mature.

Stipe

30-50 × 3-6 mm, cylindrical, slightly enlarged downward, nearly hollow, base strigose with reddish brown hairs; surface dry, smooth, dark brown.

Latex
White watery to cream watery, neither discoloring nor staining, mild.

Odor
None or of bugs.

Spore print
Cream-ochre.

Basidiospores
(140/7/6) (6.5) 7.0-7.6-8.5 (9.0) × 6.5-7.2-8.0 (8.5) µm [Q = 1.00-1.10 (1.14) , Q = 1.05 ± 0.03] [holotype (40/2/1) (6.5) 7.0-7.4-8.0 (8.5) × 6.5-7.1-7.5 (8.0) µm, Q = 1.00-1.11, Q = 1.05 ± 0.03], globose, subglobose; ornamentation 1.5-2.0 (2.5) µm high, of ridges variable in size and elongate warts, rarely connected, arranged in a typical spiral or zebroid pattern, with numerous subtransparent (less amyloid) dots in the ridges or warts; plage not amyloid.

Basidia
4-spored, 32-55 × 10-14 µm, clavate, subfusiform.

Pleuromacrocystidia
Absent.

Hymenophoral pseudocystidia
Rare to common, 3-6 µm broad, some branching, some enlarging toward apex, with refractive contents.

Lamella edge
Sterile; cheilomacrocystidia abundant, small but easily seen, 17-40 × 4-7 µm, fusiform, sublanceolate, subcylindrical, with a mucronate or moniliform apex, in the upper part of apex with strongly refractive granular, crystalline or agglomerated contents; marginal cells 10-26 × 5-10 µm, clavate, cylindrical, rarely capitate.

Pileipellis
A (hymeno)epithelium, 50-70 µm thick, yellowish brown; cells globose, subglobose, ellipsoid, 10-35 × 10-30 µm, terminal cells ellipsoid, short largeniform, rarely cylindrical, pyriform or hyphoid, 8-15 (25) × 5-8 µm; hyphae beneath the pileipellis 5-10 µm broad, some coated with dark yellowish brown resinous encrustations, not dissolving in 5% KOH.

Stipitipellis
A cutis, 50-60 µm thick, of closely packed, predominantly longitudinally arranged hyphae; hyphae 4-7 µm broad, yellowish brown, walls 0.5-0.7 µm thick, some with dark yellowish brown resinous encrustations.

Lactifers
Very scattered, rarely common in hymenophoral trama, colorless to very pale yellowish brown.

Pileus and stipe trama
With numerous rosettes.

NOTES
The medium-sized, strongly rugose, yellowish brown to dark reddish brown pileus, the watery latex, the globose spores with high zebroid ornamentation and the pileipellis an epithelium with resin-like encrustations on the hyphae underlying the globose cells make this species distinct. *Lactarius resinosus* X.H. Wang, sp. nov., resembles *L. castanopsidis* and *L. corrugatus* in the strongly wrinkled pileus, deeply winged spores and pileipellis an epithelium. Microscopic observations on the type of *L. castanopsidis* found similar dark-brown hyphae underlying the globose cells in the pileipellis, but it has much smaller fruiting bodies (Hongo 1979) while *L. corrugatus* lacks cheilomacrocystidia (Verbeken & Horak 2000). In *L.* subg. *Russularia,* spores with high ridges and wings arranged in a zebroid pattern have also been found in *L. qinlingensis* X.H. Wang, a species with olivaceous brown areolate-rimose pileus and emergent macrocystidia (Wang 2018). Thai *L. fuscomaculatus* Wisitrassameewong & Verbeken and *L. atrobrunneus* Wisitrassameewong & K.D. Hyde have similar pilei (Liu *et al.* 2015; Wisitrassameewong *et al.* 2015). Both species have low reticulations on the spores. Moreover, *L. fuscomaculatus* has crowded lamellae and pleuromacrocystidia, while *L. atrobrunneus* has more distant lamellae and lacks macrocystidia. For more notes, see above under *L. exilis*.

88. ***Russula capillaris*** Buyck, sp. nov.
(Figs 16-18)

Well-characterized by the combination of its medium-sized, firm stature, white and hard stipe, smooth and cream to pale yellowish brown pileus, nearly globose spores, (6.9)7.13-7.48-7.8(8.1) - (6.4)6.6-6.95-7.2(7.5) µm, Q = (1.03)1.05-1.08-1.11(1.13), with very low, dense spore ornamentation of minute warts and invisible suprahilar spot, a pileipellis composed of ascending, slender, irregularly wavy-undulate hyphal extremities that are often inflated at the tip, submerged pileocystidia, pale spore print and slightly unpleasant smell, as well as by its habitat in tapia (*Uapaca bojeri*) woodland on the Central Plateau in Madagascar.

TYPUS. — **Madagascar**. Central Plateau, along RN7 between Antsirabe and Ambositra, at km 40, in secondary *Uapaca bojeri* woodland with *Pinus* ingression, 26.I.2008, *563/Buyck 08.172* (PC[PC0124764]).

MYCOBANK. — 832120.

GENBANK. — MK929284 (ITS), KU237553 (LSU), KU237399 (mitSSU), KU237839 (RPB2), KU237982 (tef1alpha), all from holotype.

ETYMOLOGY. — named after the resemblance of the pileipellis structure with a nice hair cut.

DESCRIPTION
Basidioma
Growing single, medium-sized.

Pileus
83 mm diam., quite regular in shape to slightly wavy near the margin, hardly depressed in the center, not becoming deeply infundibuliform, smooth near margin; surface

Fig. 16. — *Russula capillaris* Buyck, sp. nov. (holotype), morphology of fresh basidioma: **A**, detail of pileus and stipe surface; **B**, section showing stipe interior; **C**, details of gills. Photos: B. Buyck.

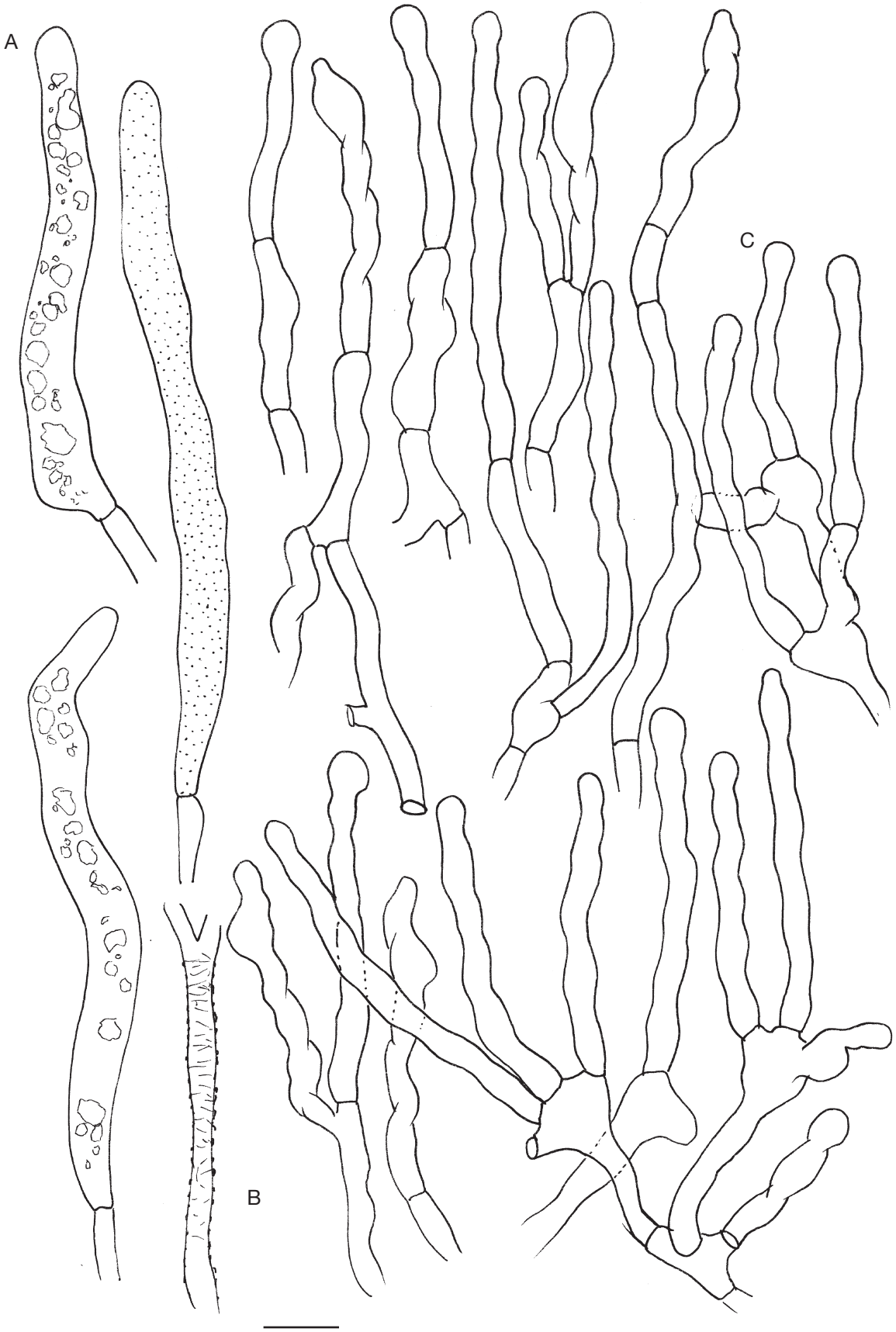

Fig. 17. — *Russula capillaris* Buyck, sp. nov. (holotype), microscopic features of pileipellis: **A**, pileocystidia near the trama-subpellis transition with schematic contents in one and indication of refringent conglomerates in both other cells; **B**, detail of zebroid incrustations observed on most subpellis and context hyphae; **C**, hyphal extremities of the pileus surface. Scale bar: 10 µm. Drawings: B. Buyck.

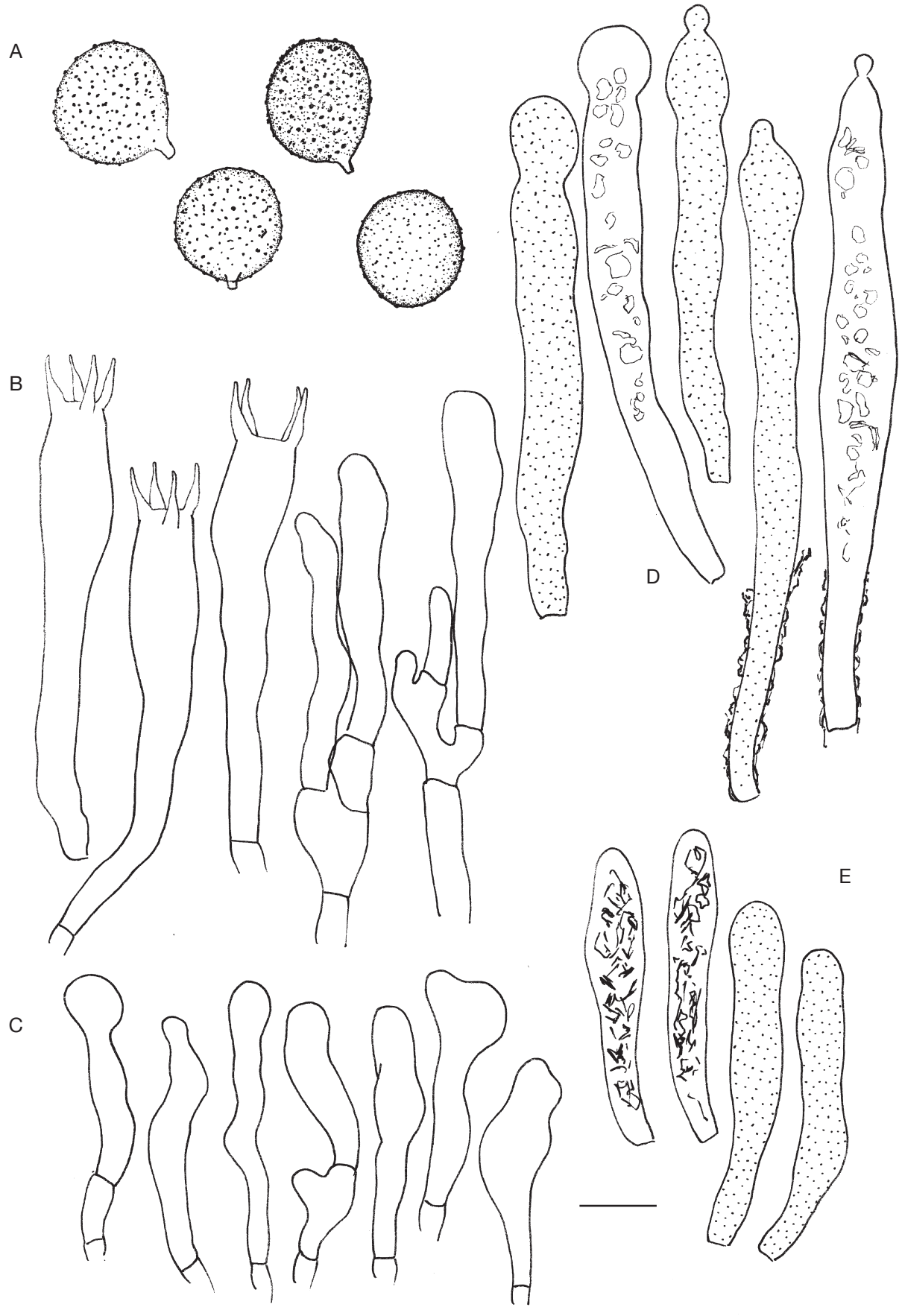

Fig. 18. — *Russula capillaris* Buyck, sp. nov. (holotype), microscopic features of the hymenophore: **A**, spores; **B**, basidia and basidiola; **C**, marginal cells of the gill edge; **D**, gloeocystidia on gill sides; **E**, gloeocystidia on gill edge. Cystidial contents are mostly schematic, note also the presence of incrusting material that is easily observed near the base of many pleurogloeocystidia. Scale bar: 10 µm, but only 5 µm for spores. Drawings: B. Buyck.

glabrous, hardly separable, not viscid, probably even not when wet, continuous and smooth in the pileus center, dull, pale-colored, from whitish to cream or pale yellowish to pale yellowish brown, not concentrically zonated, not particularly darker in the center.

Gills
Adnate, with frequent lamellulae but less than normal gills, not or rarely forking, *c.* 6-7 mm high, thin and fragile, normally spaced (*c.* 1L+l/mm), pale yellowish; gill edge even, concolorous.

Stipe
Central, 43 × 16 mm, not annulate, subcylindrical, longitudinally wrinkled, glabrous, off-white, surprisingly hard and firm considering the interior is developing up to four cavities.

Context
Firm, fleshy, c. 9 mm thick above gill attachment to stipe, whitish, unchanged when cut, in the stipe with a faint creamish-pinkish tinge.

Taste
Not observed.

Odor
Faintly disagreeable.

Spore print
Unsufficient, obviously pale.

Spores
Globose to subglobose, (6.9)7.13-7.48-7.8(8.1) × (6.4)6.6-6.95-7.2(7.5) µm, Q = (1.03)1.05-1.08-1.11(1.13); ornamentation consisting of a minute, dense, granular-reticulate pattern, < 0.1-0.2 µm high and weakly amyloid; suprahilar spot invisible; apiculus very short and small.

Basidia
Slender, widest in their upper part, 53-61 × 8-10 µm, four-spored; sterigmata rather slender, approximately 7 × 1-2 µm.

Hymenial gloeocystidia
Very abundant (c. 4000/mm^2), thin-walled or nearly so, not strongly emergent, on the gill sides, 60-90 × 8-9 µm, fusiform to subclavate or almost cylindrical, frequently distinctly inflated at the apex and widely capitate (often wider than the rest of the cystidium), some also tapering, near the apex obtuse-rounded or more frequently minutely mucronate, containing poor contents in the form of dispersed, refringent masses or conglomerates; the basal part of the cystidia often sheathed with encrusting material; near the gill edge distinctly smaller and mostly simply clavate to almost subcylindrical, 34-46 × 6-7(-8) µm, and then nearly subcylindrical to clavulate, obtuse rounded at the tip, filled with more abundant, granular-crystalline contents, weakly reacting to SV.

Subhymenium
Dense, composed of cells that are hardly wider than the basal parts of the basidia.

Lamellar trama
With sphaerocytes, rather dense.

Marginal cells
Well-differentiated, thin-walled, smaller than basidia, consisting of a basal or stalk cell holding a terminal fusiform, clavate or lageniform cell that is often terminally inflated, 22-39 × 5-9 µm, occupying the whole gill edge, optically empty, mixed with small gloeocystidia.

Pileipellis
Orthochromatic in cresyl blue, poorly delimited from the underlying trama, one-layered to obscurely two-layered, forming a very dense tissue up to 200 µm thick of closely packed hyphae (but easily dissolving in KOH); the lower hyphae intertwined-intricate, gradually more to very irregularly inflated, strongly branching, emitting densely packed, vertical to ascending hyphal extremities; these *c.* 4 µm wide, thin-walled, irregularly undulate-twisted, composed of 2-3 subcylindrical cells with the second or third cell often branching and giving rise to two or more terminal cells; these even more irregularly undulate or wavy in outline, not exceeding 60 µm long, often distinctly inflated near the apex. Subpellis composed of cylindrical, distinctly zebroid encrusted hyphae. Pileocystidia quite common to abundant below the pileipellis, but apparently absent from the pileus surface; immerged, subcylindrical, thin-walled gloeocystidia are very apparent immediately below the subpellis because of their poor, yet very visible contents in the form of dispersed, refringent masses of variable size and because of their relatively important size compared to the surrounding hyphae and other elements, continuing but less abundant in trama underneath.

Clamp connections
Absent in all tissues.

NOTES
This apparently very rare species – we have only seen it once in more than twenty years of fungal exploration in Africa and Madagascar – has been placed by a recently published multigene phylogeny of *Russula* (Buyck *et al.* 2018) in *R.* subgenus *Malodora* Buyck & V. Hofst., where it occupies a more or less isolated position, belonging neither to section *Pseudocompactae* Buyck & V. Hofst. nor to section *Edules* Buyck & V. Hofst. (see Das *et al.* 2017).

Both in the field and under the microscope, it reminds rather of some species formerly placed in *R.* subg. *Archaea* Buyck &V. Hofst., in particular the North American *R. fattoensis* Buyck, because of the very similar structure and composition of the pileipellis. It differs nevertheless from all species placed in subg. *Archaea* in its much larger spores.

89. ***Russula clavatohyphata***
R.P. Bhatt, A. Ghosh, Buyck & K. Das, sp. nov.
(Figs 19-21)

Differs from *R. luteobasis* Peck essentially by the reddish pink coloration of the stipe and the slightly more ellipsoid spores, as well as because of its association with *Pinus roxburghii* Sarg.

TYPUS. — **India**. Utttarakhand, Rudraprayag district, Hariyali Devi forest, 30°15.955'N, 79°03.719'E, 1651 m asl., under *Pinus roxburghii* in temperate pure coniferous forest, 27.VII.2015, Aniket Ghosh, *AG 15-756* (holo-, CAL[CAL 1756).

MYCOBANK. — 830765.

GENBANK. — MG934209 (ITS holotype), MG934210 (ITS paratype).

ETYMOLOGY. — referring to the clavate hyphal tips in pileipellis.

OTHER SPECIMENS EXAMINED. — *Russula clavatohyphata*. **India**. Rudraprayag district, Hariyali Devi forest, 30°15.952'N, 79°03.712'E, 1649 m asl., under *Pinus roxburghii* in temperate coniferous forest, 26.VII.2016, Aniket Ghosh, *AG 16-1223* (para-, CAL[CAL 1757]). — *Russula burlinghamiae*. **United States of America**. Pennsylvania, Monte Alto, in mixed deciduous forest adjacent to University campus, 11.VIII.2005, *548/Buyck 05.108* (PC[PC0124708], GenBank MK929285); North Carolina, near Ashville, 17.VII.2004, *600/Buyck 04.287* (PC[PC0124773], GenBank MK929286); **Costa Rica**. San José, Perez Zeledón, C.A.T.I.E. Experimental Forest of Villa Mills, 9.6989 -83.9419, 2850 m asl, in montane *Quercus costaricensis* forest, 12.VI.2001, leg. Buyck & Halling, *599/Buyck 01.237* (PC[PC0124772]f, GenBank MK929287).

DESCRIPTION

Basidiomata
30-62 mm in height.

Pileus
32-52 mm in diam., broadly convex when young, gradually planoconvex to applanate with depressed center, sometimes uplifted (towards margin) at maturity, sometimes broadly umbonate in the center; margin decurved to plane when mature, sometimes uplifted with maturity, entire, shortly tuberculate-striate; surface dry, viscid when moist, cracked to areolate with maturity, red to vivid red and paler towards the margin, peeling 1/2 of pileus radius, turning pale yellow to pastel yellow with 3% KOH.

Lamellae
Adnexed, subdistant (7-10 L/cm at pileus margin), yellowish white, sometimes forked near the stipe apex; edges marginate and red, at least near the pileus margin.

Lamellulae
Rare.

Stipe
53-58 × 6-14 mm, cylindric to subclavate, tapered at the base, central, dry, smooth, pale red or pastel pink to rose pink, tinged with ochraceous to ferruginous yellow near the base where the cuticle often cracks horizontally; stipe surface reacting straw yellow, wax yellow to mustard yellow and high red or vivid red with 3% KOH and guaiacol respectively.

Stipe context
Chalky white, stuffed to hollow with maturity; brownish orange to light brown after bruising or handling.

Taste
Mild.

Odour
Indistinctive.

Spore print
Pale yellowish white.

Basidiospores
(6.0-)6.34-6.98-7.63(-8.5) × (5.0-)5.53-6.11-6.7(-8.0) µm, [n= 30, Q=(1.0-)1.05-1.15-1.24(-1.43)], subglobose to broadly ellipsoid, rarely ellipsoid; ornamentation amyloid (up to 0.5 µm high), composed of conical to hemisphaerical warts mostly connected or aligned to give short ridges along with few isolated warts, either never forming incomplete reticulum or at most broken reticulum; suprahilar plage amyloid; apiculi up to 1.5 µm high.

Basidia
22-54 × 9-13 µm, 4-spored, subclavate to clavate; sterigmata up to 7 µm long.

Pleurocystidia
47-73 × 9-11 µm, subclavate to clavate, at apex appendiculate (appendages up to 30 µm long), sub-moniliform, mucronate or rounded-obtuse, emergent up to 32 µm beyond the basidiole tips, partly filled with heteromophous to granular or crystalline refringent content, SV-negative.

Lamella edges
Fertile with basidia and cystidia, and few cystidioid hyphal elements.

Cheilocystidia
35-60 × 7-10 µm, subclavate to clavate with appendiculate, lageniform (appendages up to 11 µm long) or rounded-obtuse apex with heteromophous and partly also filled with granular to crystalline refringent content, SV-negative.

Subhymenium layer
Up to 15 µm thick, pseudoparenchymatous.

Hymenophoral trama
Mainly composed of large sphaerocytes and connecting hyphae.

Pileipellis
Up to 49 µm thick, orthochromatic in cresyl blue, not sharply delimited from the underlying sphaerocytes of the context, trichoderm type, composed of erect to ascending, branched,

FIG. 19. — Phylogram generated from Maximum Likelihood approach (ML) in raxmlGUI 1.2 (Stamatakis *et al.* 2008; Silvestro & Michalak 2012) with 1000 bootstrap replicates. One thousand bootstrap replicates were analyzed to obtain the nodal support values. Bootstrap support values (>70%) are shown above or below the branches at nodes. The Indian specimens of *Russula clavatohyphata* R.P. Bhatt, A. Ghosh, Buyck & K. Das, sp. nov., with GenBank Accession Numbers are shown in bold red.

FIG. 20. — *Russula clavatohyphata* R.P. Bhatt, A. Ghosh, Buyck & K. Das, sp. nov. (AG 15-756): **A**-**D**, fresh and sectioned basidiomata in the field and basecamp; **E**-**G**, radial section through pileipellis showing elements; **H**-**K**, transverse section through lamellae showing pleurocystidia; **L**, SEM micrograph of basidiospores. Scale bars: A, 50 mm; E-K, 10 µm; L, 3 µm.

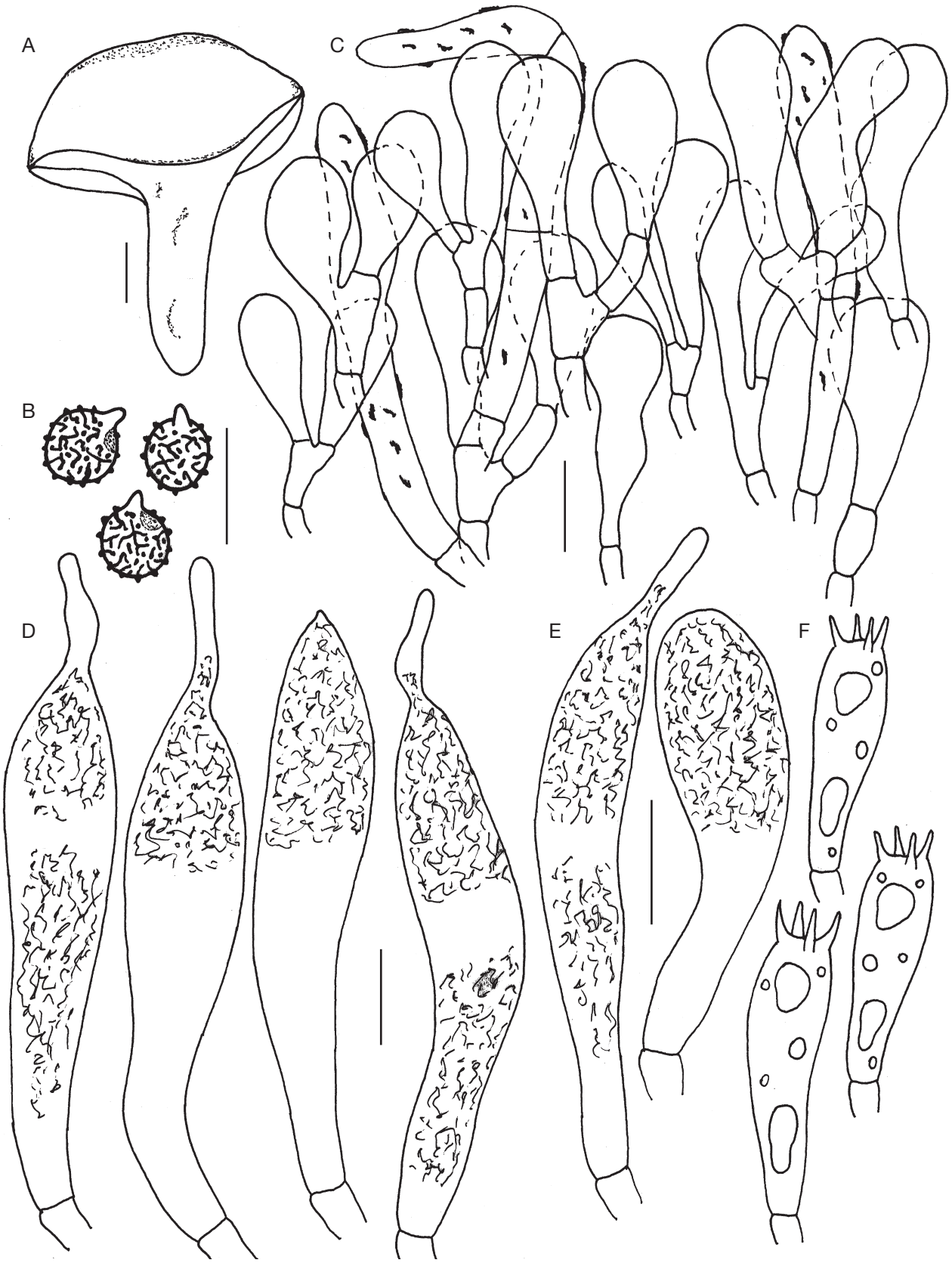

Fig. 21. — *Russula clavatohyphata* R.P. Bhatt, A. Ghosh, Buyck & K. Das, sp. nov. (AG 15-756): **A**, sectioned basidiome; **B**, basidiospores; **C**, hyphal extremities at the pileus surface; **D**, pleurocystidia; **E**, cheilocystidia; **F,** basidia. Scale bars: A, 10 mm; B-F, 10 µm.

septate, compact hyphal ends and with distinct primordial hyphae. Hyphal extremities near the cap margin composed of a single or a few cells only, terminal cells mostly bulbous, clavate, pyriform to subclavate with tapered base, measuring 9-34 × 5-11 µm, with rounded or obtuse tips, subterminal cells cylindrical; in the cap center almost similar, mostly bulbous, clavate, pyriform to subclavate, measuring 10-37 × 6-12 µm, with rounded or obtuse tips, subterminal cells cylindrical. Pileocystidia and cystidioid hyphae absent from all tissues. Primordial hyphae comparatively longer than the other extremities and often protruding or repent on the cap surface, occurring mostly singly, 4-7 µm broad, thick-walled (up to 0.8 µm), long, cylindrical, tapered at apex, septate (0-3 septa) with rounded, blunt or obtuse apex; incrustations present.

Clamp connections
Absent.

Notes
In the field *Russula clavatohyphata* R.P. Bhatt, A. Ghosh, Buyck & K. Das, sp. nov., is characterized by its red to vivid red coloured pileus and pale red or pastel pink to rose pink stipe. It may be confused with the unrelated *R. sanguinea* Fr. or *R. rhodopus* Zvára, two European species that are also ectomycorrhizal with coniferous trees, but both are moderately acrid or sometimes bitter, and differ further from the present taxon in their narrower, cylindrical pilear hyphae mixed with numerous pileocystidia with abundant contents (Kränzlin 2005, Sarnari 2005, Knudsen *et al.* 2012).

The acystidiate pileipellis, amyloid suprahilar dot on the spores, mild taste, pale cream spore print and bulbous to clavate terminal cells mixed with dispersed, protruding primordial hyphae in pileipellis, undoubtedly place our species in the crown clade of Russula subg. *Russula* (sensu Buyck *et al.* 2018), near subsections *Chamaeleontinae* Singer and *Amethystinae* (Romagnesi) Bon. It differs from species in both latter subsections in the distinctly paler spore print, and from *Chamaeleontinae* additionally in its more robust and firm field habit.

Two species that are morphologically very similar to *R. clavatohyphata* R.P. Bhatt, A. Ghosh, Buyck & K. Das, sp. nov., were described from America, but both are relatively unknown as they are apparently very rarely sporulating and have hardly been recollected. The first is *R. burlinghamiae* Singer, which principally differs from our species in the overall yellowish color and lack of any reddish tints. Since its original description, a modern, more detailed account of this rare North American species was published by Buyck *et al.* (2003) who also described a forma *claricolor* Buyck from the montane *Quercus* forests in Talamanca, Costa Rica. *Russula burlinghamiae* was placed with significant support in a clade comprised of *Amethystinae* and *Chamaeleontinae* in a recent multigene phylogeny (Buyck *et al.* 2018). The second American species, *R. luteobasis* Peck, is even more similar to *R. clavatohyphata,* and even more rare than the previous one. It was in the past century only recollected in West Virginia (see mycoportal.org), but there are no reports or publications available for *R. luteobasis* since it was first described by Charles Peck (1904), except for the recently published type study (Adamčík *et al.* 2018). Peck's species differs from *R. clavatohyphata* R.P. Bhatt, A. Ghosh, Buyck & K. Das, sp. nov., essentially in the absence of a red color on the stipe surface and, most likely, also by its association with deciduous trees, but its major characters, such as spore ornamentation, composition and structure of pileipellis, spore print color, etc. are essentially the same.

Our ITS phylogeny retrieved no significant support to group *R. burlinghamiae* and *R. clavatohyphata*, nor did it obtain support to group either of these species with any other particular subsection (but neither did the multigene phylogeny by Buyck *et al.* 2018). Yet, it is almost certain that, once sequences will become available for *R. luteobasis,* the latter will turn out to be sister to the Indian species. The pale cream spore print of these American and Indian species adds support to their suggested basal position versus *Amethystinae* and *Chamaeleontinae*.

Phylum BASIDIOMYCOTA R.T. Moore
Class AGARICOMYCETES Doweld
Order BOLETALES E.-J. Gilbert
Family Serpulaceae Jarosch & Bresinsky

90. ***Serpula dendrocalami*** C.L. Zhao, sp. nov.
(Figs 22-26)

Differs from other *Serpula* species by the larger, pileate basidiocarps with poroid hymenophore and a dimitic hyphal system with wider, encrusted generative hyphae in context (3-6.5 µm) and subglobose, bright yellow, thick-walled basidiospores measuring as 4.5-5.5 ′ 3.5-4 µm.

Typus. — **China**. Yunnan Prov., Puer, Taiyanghe Forestry Park, on root of the living bamboo of *Dendrocalamus*, 30.IX.2017, C.L. Zhao, *Zhao 3321* (SWFC).

Mycobank. — MB 830774.

Genbank. — MK863397-MK863407 (ITS); MK863391-MK863396 (LSU).

Etymology. — *dendrocalami* (Lat.). — referring to the host, the bamboo genus *Dendrocalamus*.

Additional specimens examined. — **China**. Yunnan Prov.: Puer, Taiyanghe Forestry Park, on root of living bamboo of *Dendrocalamus*, 30.IX.2017, C.L. Zhao, *Zhao 3111*, *3113*, *3136*, *3203*, *3318*, *3447*, *4805*; Jingdong Co., Wuliangshan National Nature Reserve, on root of living bamboo of *Dendrocalamus*, 2.X.2017, C.L. Zhao, *Zhao 3521*, *3607*, *3626*, *3632* (SWFC).

Description
Basidiocarps
Annual, pileate, solitary or gregarious, fleshy and more or less watery when fresh, becoming corky and brittle upon drying, distinctly light in weight when dry.

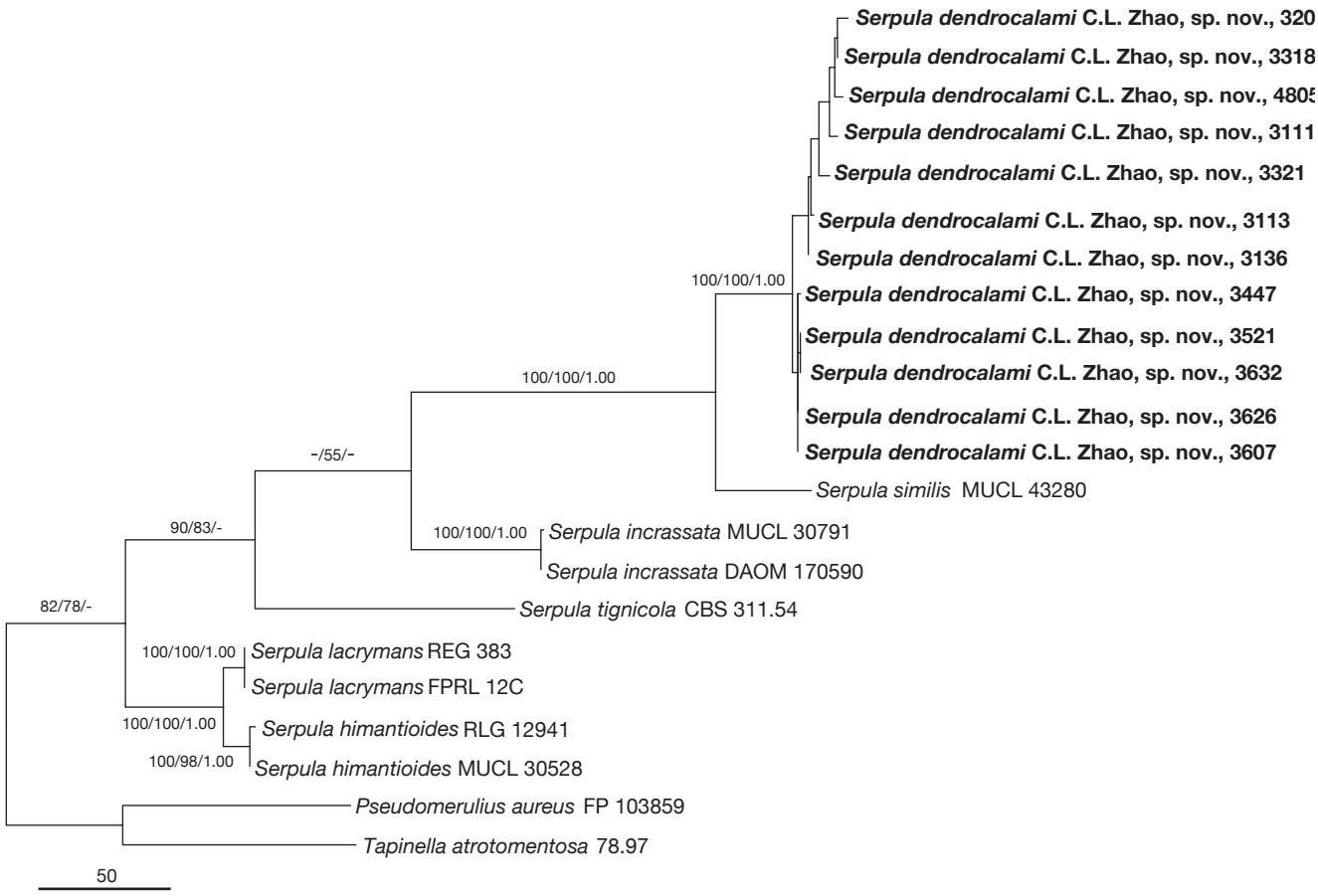

Fig. 22. — Maximum parsimony strict consensus tree illustrating the phylogeny of *Serpula dendrocalami* C.L. Zhao, sp. nov., and related species in *Serpula* based on ITS sequences. Branches are labeled with parsimony bootstrap values (before slash) higher than 50% and Bayesian posterior probabilities (after slash) equal to and more than 0.95. The ITS dataset included sequences from 22 fungal specimens representing 8 taxa. The dataset had an aligned length of 905 characters in the dataset, of which 441 characters are constant, 163 are variable and parsimony-uninformative, and 301 are parsimony-informative. Maximum parsimony analysis yielded 1 equally parsimonious tree (TL = 795, CI = 0.815, HI = 0.185, RI = 0.897, RC = 0.731). Best model for ITS estimated and applied in the Bayesian analysis: GTR+I+G, lset nst = 6, rates = invgamma; prset statefreqpr = dirichlet (1,1,1,1). Bayesian analysis resulted in the same topology with an average standard deviation of split frequencies = 0.001810. Sampled specimens of the new species, *Serpula dendrocalami* sp. nov., formed a well-supported monophyletic lineage. The EZNA HP Fungal DNA Kit (Omega Biotechnologies Co., Ltd, Kunming) was used to obtain PCR products from dried specimens, according to the manufacturer's instructions with some modifications. ITS region was amplified with primer pairs ITS5 and ITS4 (White *et al.* 1990). The PCR procedure for ITS was as follows: initial denaturation at 95 °C for 3 min, followed by 35 cycles at 94 °C for 40 s, 58 °C for 45 s and 72 °C for 1 min, and a final extension of 72 °C for 10 min. The PCR products were purified and directly sequenced at Kunming Tsingke Biological Technology Limited Company. All newly generated sequences were deposited at GenBank (Table 1). Branches are lab eled with parsimony bootstrap values (before slash) higher than 50% and Bayesian posterior probabilities (after slash) equal to and more than 0.95.

Pileus
Sessile, flabelliform to semicircular, projecting up to 20 cm, 15 cm wide, 2.5 cm thick at centre. Pileal surface cream to pale brown when fresh and brown upon drying, smooth, and uneven.

Hymenial surface
Poroid, slightly meruloid towards margin, yellowish brown when fresh, yellowish brown to brown, paler towards margin, darker towards centre upon drying; pores angular, 2-3/mm; dissepiments thin. Sterile margin wide, cream to yellowish brown, up to 5 mm wide.

Context
Cream, spongy, up to 2 cm thick.

Tubes
Yellowish brown to brown, up to 5 mm long.

Type of rot
Brown rot.

Hyphal system
Dimitic; generative hyphae with clamp connections, IKI-, CB-, tissues unchanged in KOH.

Context
Generative hyphae dominant, hyaline, thin-walled, occasionally branched, interwoven, 3-6.5 µm in diameter, frequently encrusted with crystals; skeletal hyphae hyaline, thick-walled with a lumen, branched, 0.8-3 µm in diam.

Tubes
Generative hyphae hyaline, thin-walled, occasionally branched, interwoven, 2.5-5 µm in diameter, frequently encrusted with crystals; skeletal hyphae absent. Cystidia and cystidioles absent.

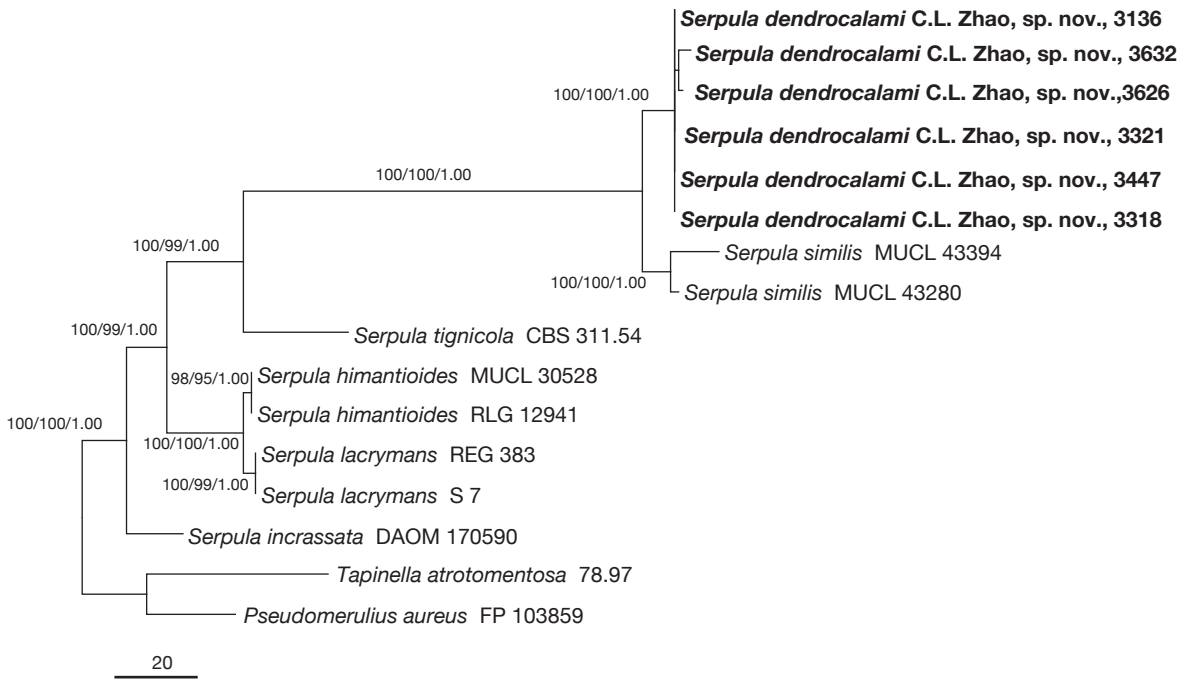

Fig. 23. — Maximum parsimony strict consensus tree illustrating the phylogeny of *Serpula dendrocalami* C.L. Zhao, sp. nov., and related species in *Serpula* based on nLSU sequences. Branches are labeled with parsimony bootstrap values (before slash) higher than 50% and Bayesian posterior probabilities (after slash) equal to and more than 0.95. The nLSU dataset included sequences from 16 fungal specimens representing 8 species. The dataset had an aligned length of 1411 characters, of which 1158 characters are constant, 69 are variable and parsimony-uninformative, and 184 are parsimony-informative. Maximum parsimony analysis yielded 4 equally parsimonious trees (TL = 321, CI = 0.854, HI = 0.146, RI = 0.947, RC = 0.808). Best model for the nLSU dataset estimated and applied in the Bayesian analysis: GTR+I+G, lset nst = 6, rates = invgamma; prset statefreqpr = dirichlet (1,1,1,1). Bayesian analysis and ML analysis resulted in a similar topology as MP analysis, with an average standard deviation of split frequencies = 0.003841 (BI). This phylogenetic analysis demonstrated that our species was closely related to *S. similis* (Berk. & Broome) Ginns. Nuclear LSU region was amplified with primer pairs LR0R and LR7 (http://www.biology.duke.edu/fungi/mycolab/primers.htm). The PCR procedure for nLSU was as follows: initial denaturation at 94 °C for 1 min, followed by 35 cycles at 94 °C for 30 s, 48 °C 1 min and 72 °C for 1.5 min, and a final extension of 72 °C for 10 min. The PCR products were purified and directly sequenced at Kunming Tsingke Biological Technology Limited Company. All newly generated sequences were deposited at GenBank (Table 1). Branches are labeled with parsimony bootstrap values (before slash) higher than 50% and Bayesian posterior probabilities (after slash) equal to and more than 0.95.

Basidia clavate to pyriform, with four sterigmata and a basal clamp connection, 25-35 × 7-8.5 µm; basidioles in shape similar to basidia, but slightly smaller.

Basidiospores

Subglobose, bright yellow, thick-walled, smooth, IKI-, cyanophilous, (4-)4.5-5.5(-6) × 3.5-4(-4.5) µm, L = 5.13 µm, W = 3.83 µm, Q = 1.26-1.42 (n = 360/12).

Notes

Wood-rotting fungi is an extensively studied group of Basidiomycota (Gilbertson & Ryvarden 1987; Núñez & Ryvarden 2001; Bernicchia & Gorjón 2010; Dai 2012; Ryvarden & Melo 2014), but the Chinese wood-rotting fungi diversity is still not well known. This is especially the case for the subtropical and tropical zones, from which many recently described taxa of wood-rotting fungi were described (Chen & Shen 2014; Zhao *et al.* 2014; Zhou 2015; Qin *et al.* 2016; Song *et al.* 2016).

Serpula (Pers.) Gray (Serpulaceae, Boletales) is a genus typified by *S. lacrymans* (Wulfen) J. Schröt (Gray 1821), which is a small genus characterized by a combination of resupinate to effuse-reflexed, or pileate basidiocarps mostly with merulioid to poroid hymenophore, a dimitic hyphal system with clamp connections on generative hyphae, presence of skeletal hyphae in the context, clavate basidia and ellipsoid to ovoid, smooth, thick-walled, brownish, not or weakly dextrinoid, cyanophilous basidiospores, and all causing a brown rot (Gray 1821; Bernicchia & Gorjón 2010). So far about 17 species have been accepted in the genus worldwide (Gray 1821; Karsten 1884; Schröter 1888; Cooke 1957; Ginns 1971; Mata & Ryvarden 2007; Bernicchia & Gorjón 2010).

Recently, several molecular studies addressed the genus *Serpula* (Binder & Hibbett 2006; Larsson 2007; Binder *et al.* 2010; Zhao *et al.* 2017). Binder & Hibbett (2006) suggested that the genus *Serpula* clustered into the Serpulaceae in Boletales where it grouped with *Coniophora marmorata* Desm. and *Tapinella atrotomentosa* (Batsch) Šutara. Larsson (2007) introduced a phylogenetic classification for corticioid fungi at the family level confirming that the genus *Serpula* was nested into the Boletales clade where it grouped with *Coniophora olivacea* (Fr.) P. Karst. and *Pseudomerulius aureus* (Fr.) Jülich. A few years later, Binder *et al.* (2010) included five species of *Serpula* in a study focusing on early branching clades in Agaricomycetidae. Again, these *Serpula* clustered with *Leucogyrophana montana* (Burt) Domański and *T. atrotomentosa* in the order Boletales. In their six-gene phylogenetic overview of Basidiomycota, Zhao *et al.* (2017) demonstrated that the type species of *Serpula*, *S. lacrymans*, clustered with *Coniophora arida* (Fr.) P. Karst. and *Gyrodontium sacchari* (Spreng.) Hjortstam in the Boletales.

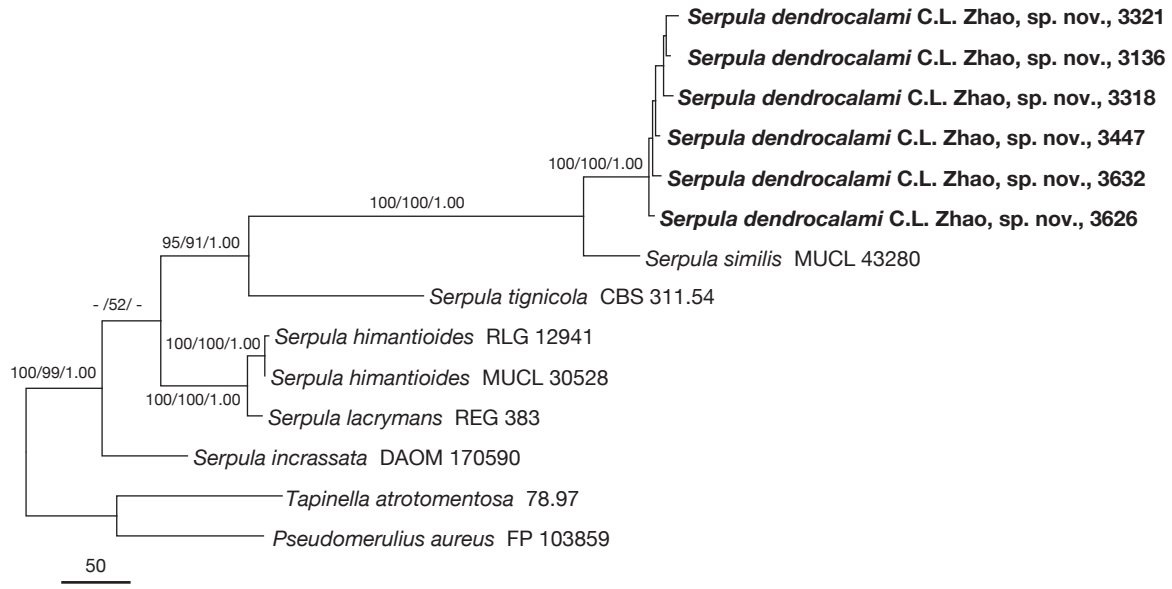

Fig. 24. — Maximum parsimony strict consensus tree illustrating the phylogeny of *Serpula dendrocalami* C.L. Zhao, sp. nov., and related species in *Serpula* based on combined ITS+nLSU sequences. Branches are labeled with parsimony bootstrap values (before slash) higher than 50% and Bayesian posterior probabilities (after slash) equal to and more than 0.95. This phylogenetic analysis shows that our new species formed a monophyletic entity with high support, 100% BS, 100% BP and 1.00 BPP, and grouped with *S. similis*. Sequences from 14 fungal specimens representing 8 species are included. The dataset had an aligned length of 2389 characters, of which 1638 characters are constant, 271 are variable and parsimony-uninformative, and 480 are parsimony-informative. Maximum parsimony analysis yielded 4 equally parsimonious trees (TL = 1144, CI = 0.832, HI = 0.168, RI = 0.891, RC = 0.741). Best model for the ITS+nLSU dataset estimated and applied in the Bayesian analysis: GTR+I+G, lset nst = 6, rates = invgamma; prset statefreqpr = dirichlet (1,1,1,1). Bayesian analysis and ML analysis resulted in a similar topology as MP analysis, with an average standard deviation of split frequencies = 0.001815 (BI). Branches are labeled with parsimony bootstrap values (before slash) higher than 50% and Bayesian posterior probabilities (after slash) equal to and more than 0.95.

Table 1. — A list of species, specimens, and GenBank accession number of sequences used in this study.

Species name	Sample no.	GenBank accession no. ITS	GenBank accession no. nLSU	References
Pseudomerulius aureus	FP 103859	GU187534	GU187590	Binder *et al.* 2010
***Serpula dendrocalami* C.L. Zhao, sp. nov.**	**CLZhao 3111**	MK863397	—	Present study
***S. dendrocalami* C.L. Zhao, sp. nov.**	**CLZhao 3113**	MK863398	—	Present study
***S. dendrocalami* C.L. Zhao, sp. nov.**	**CLZhao 3136**	MK863399	MK863391	Present study
***S. dendrocalami* C.L. Zhao, sp. nov.**	**CLZhao 3203**	MK863400	—	Present study
***S. dendrocalami* C.L. Zhao, sp. nov.**	**CLZhao 3318**	MK863401	MK863392	Present study
***S. dendrocalami* C.L. Zhao, sp. nov.**	**CLZhao 3321**	MK863403	MK863393	Present study
***S. dendrocalami* C.L. Zhao, sp. nov.**	**CLZhao 3447**	MK863402	MK863394	Present study
***S. dendrocalami* C.L. Zhao, sp. nov.**	**CLZhao 3521**	MK863408	—	Present study
***S. dendrocalami* C.L. Zhao, sp. nov.**	**CLZhao 3607**	MK863404	—	Present study
***S. dendrocalami* C.L. Zhao, sp. nov.**	**CLZhao 3626**	MK863405	MK863395	Present study
***S. dendrocalami* C.L. Zhao, sp. nov.**	**CLZhao 3632**	MK863406	MK863396	Present study
***S. dendrocalami* C.L. Zhao, sp. nov.**	**CLZhao 4805**	MK863407	—	Present study
S. himantioides	MUCL 30528	GU187545	GU187600	Binder *et al.* 2010
S. himantioides	RLG 12941	GU187547	GU187602	Binder & Hibbett 2006
S. incrassata	DAOM 170590	GU187541	GU187595	Binder *et al.* 2010
S. incrassata	MUCL 30791	HM135647	—	Binder *et al.* 2010
S. lacrymans	REG 383	GU187542	GU187596	Binder *et al.* 2010
S. lacrymans	FPRL 12C	AF335270	—	Larsson 2007
S. lacrymans	S7	—	AM946629	Unpublished
S. similis	MUCL 43280	GU187546	GU187601	Binder *et al.* 2010
S. similis	MUCL 43394	—	AY491669	Unpublished
S. tignicola	CBS 311.54	GU187543	GU187597	Binder *et al.* 2010
Tapinella atrotomentosa	78.97	GU187549	GU187603	Binder *et al.* 2010

Fig. 25. — *Serpula dendrocalami* C.L. Zhao, sp. nov. (holotype): basidiocarps. Scale bars: A, 5 cm; B, 4 cm.

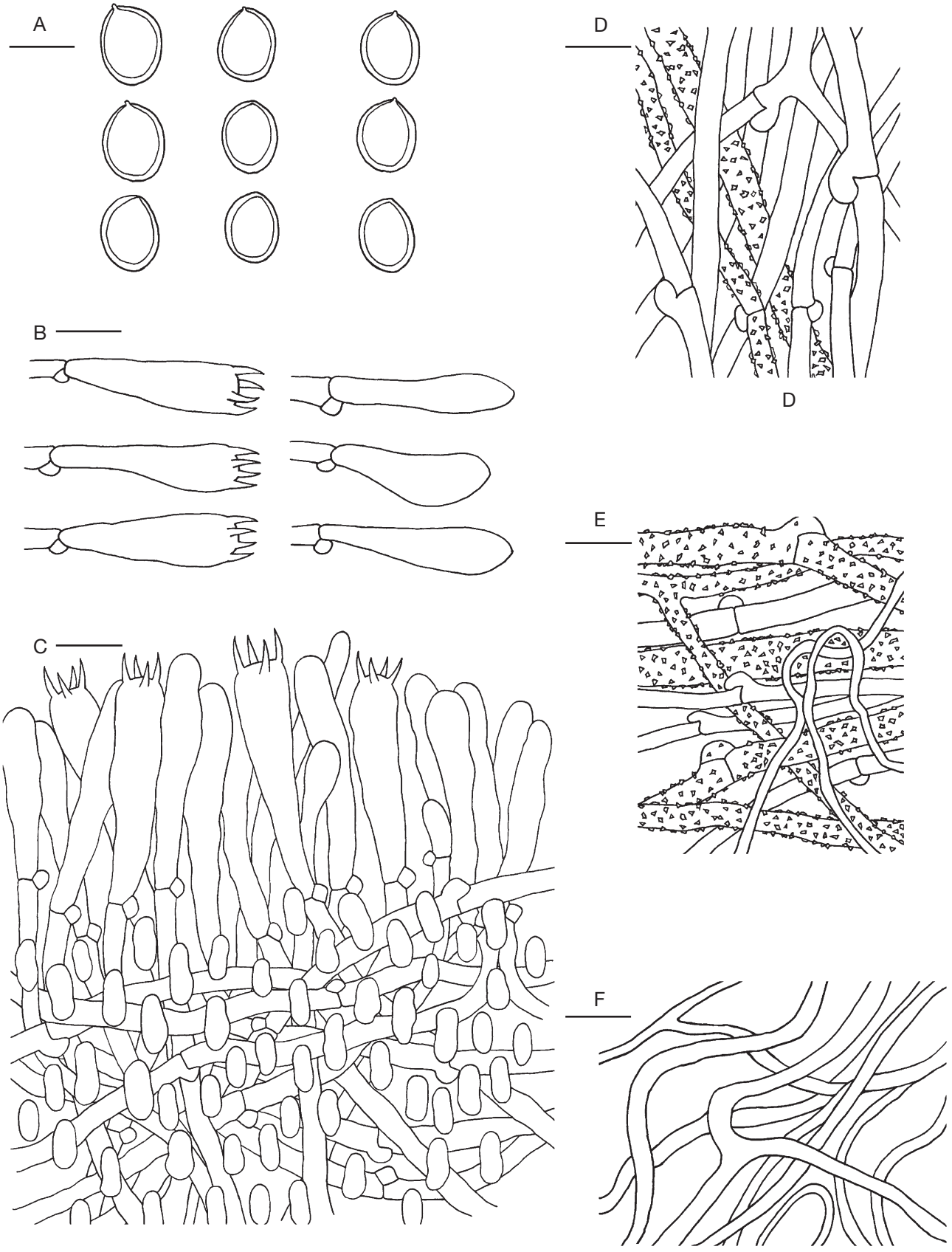

Fig. 26. — *Serpula dendrocalami* C.L. Zhao, sp. nov. (holotype), microscopic structures: **A**, basidiospores; **B**, basidia and basidioles; **C**, a section of hymenium; **D**, hyphae from trama; **E**, hyphae from context; **F**, skeletal hyphae from context. Scale bars: A, 5 µm; B-F, 10 µm.

In our phylogenetic analyses (Figs. 19-21), *Serpula dendrocalami* sisters to *S. similis* in the phylogeny with strong supports (100% BS, 100% BP, 1.00 BPP,) but the latter differs from *S. dendrocalami* by its smaller basidiocarps projecting up to 3 cm, 5 cm wide, 5 mm thick at centre (Dai 2004) with pruinose or tomentose margin, the meruloid folded hymenium, and 1 mm thin context with numerous crystals that are not incrusting the hyphae, and smaller basidiospores measuring 4-5 × 3-3.5 µm (Ginns 1971). In addition, its habitat is linked to sandy soil.

Two other species in the genus *Serpula* from China are similar to the new taxon: *S. himantioides* (Fr.) P. Karst. and *S. lacrymans* (Wulfen) J. Schröt. The former differs from *S. dendrocalami* by the membranaceous basidiocarps with smooth hymenophore and larger basidiospores, 9-12 × 5-6 µm (Bernicchia & Gorjón 2010), and grows on stumps of *Picea* or *Pinus*. *Serpula lacrymans* is separated from *S. dendrocalami* by its resupinate to effuse-reflexed basidiocarps with rhizomorphs, and larger basidiospores, 9-10.1 × 4.6-5.9 µm (Dai 2004, Bernicchia & Gorjón 2010) and grows on manufactured wood such as in old woody houses.

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