

Ganoderma (Ganodermataceae, Basidiomycota) species from the Greater Mekong Subregion

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1 ***Ganoderma* (Ganodermataceae, Basidiomycota) species from the Greater Mekong**
2 **Subregion**

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27

28 **Abstract**

29 The cosmopolitan *Ganoderma* is an important pathogen on arboreal plant hosts. *Ganoderma*
30 is particularly diverse in tropical and temperate regions. It has long been used as traditional
31 medicine because of its beneficial medicinal properties and chemical constituents. In this
32 study, *Ganoderma* collections were made in tropical regions of Laos, Myanmar, Thailand,
33 Vietnam and temperate Yunnan Province, China. The specimens are described based on
34 micro-macro characteristics and phylogenetic analysis of combined ITS, LSU, TEF1 α , and
35 RPB2 sequence data. In this comprehensive study, we report 22 *Ganoderma* species from
36 temperate and tropical regions of the Greater Mekong Subregion (GMS), namely *G.*
37 *adpersum*, *G. applanatum*, *G. australe*, *G. calidophilum*, *G. ellipsoideum*, *G. flexipes*, *G.*
38 *gibbosum*, *G. heohnelianum*, *G. hochiminhense*, *G. leucocontextum*, *G. lingzhi*, *G. lucidum*, *G.*
39 *multiplicatum*, *G. multipileum*, *G. myanmarensis*, *G. orbiforme*, *G. philippii*, *G. resinaceum*, *G.*
40 *sinense*, *G. subresinosum*, *G. williamsianum*, and *G. tsugae*. Of these species, 12 were
41 collected from Yunnan Province, China; three species, were collected from Laos; three
42 species, 2 new records, and one new species were collected from Myanmar; 15 species, and
43 four new records were collected from Thailand; and one new species was collected from
44 Vietnam. Comprehensive descriptions, color photographs of macro and micro characteristics,
45 the distribution of *Ganoderma* in the GMS and worldwide, and a phylogenetic tree showing
46 the placement of all the *Ganoderma* reported from the GMS are provided.

47

48 **Keywords:** 2 new species, Biogeography, Ecological aspects, Lingzhi, Medicinal mushroom,
49 Morphology

50

51 **INTRODUCTION**

52 *Ganoderma* was established by Karsten (1881) with *Polyporus lucidus* (Curtis) Fr. (=
53 *Ganoderma lucidum* (Curtis) P. Karst.) as the type species (Moncalvo and Ryvarden 1997).
54 The genus has a worldwide distribution but is predominantly found in the tropical and
55 temperate regions, including Africa, America, Europe, and Asia (Pilotti 2005; Cao et al. 2012;
56 Wang et al. 2012; Cao and Yuan 2013). Most members of *Ganoderma* are pathogenic in
57 nature, causing various diseases to plants like white rot, butt rot, root rot, and stem rot as well
58 as wood-decay (Ryvarden 2004; Pilotti 2005; Dai et al. 2007; Cao and Yuan 2013; Coetzee et
59 al. 2015). The genus is circumscribed by sessile to stipitate basidiomata with double-walled
60 basidiospores, and interwall pillars (Karsten 1881; Moncalvo and Ryvarden 1997). Kirk et al.
61 (2008) mentioned that globally there are 80 species of *Ganoderma*, while two global fungal
62 databases viz. Index Fungorum (<http://www.indexfungorum.org/>; accessed date: 23 May
63 2020) and MycoBank (<http://www.mycobank.org/>; accessed date: 23 May 2020) list 456 and
64 398 records respectively.

65 In light of an earlier taxonomic framework, *Ganoderma* included three subgenera viz.
66 *Ganoderma* P. Karst., *Elfvingia* P. Karst., and *Trachyderma* Imazeki (Zhao and Zhang 2000).
67 The subgenus *Ganoderma* includes two sections. *Ganoderma* and *Phaenema* contain laccate
68 species (a cutis surface consisting of a palisade of inflated hyphal ends) with a shiny upper
69 surface, whereas, all non-laccate species (palisade is absent), which have a dull upper surface,
70 are under the subgens. *Elfvingia* (Smith and Sivasithamparam 2000; Richter et al. 2015). The
71 subgenus *Trachyderma* has been deemed illegitimate and is treated as a synonym of
72 *Ganoderma* due to the presence of a lichenised genus, *Trachyderma* (Richter et al. 2015).
73 *Ganoderma* mushrooms have long been used as traditional medicine in many Asian countries
74 (Cao et al. 2012). In the Pharmacopoeia of the People's Republic of China, *Ganoderma*
75 species are recorded as being used over two millennia (Wu et al. 2013). Traditional Chinese

76 books proposed and classified *Ganoderma* species based on basidiocarp colouration (Szedlay
77 2002). *Ganoderma* species are good sources of natural bioactive compounds of high and low
78 molecular weight, especially polysaccharides, protein, sterols, and triterpenoids (Ahmadi and
79 Riazipour 2007; Chan et al. 2007; Chen and Seleen 2007; Richter et al. 2015). These
80 compounds are known to possess extensive therapeutic properties, such as antibacterial,
81 anticancer, antifungal, anti-hypotensive, anti-inflammatory, antioxidant, antitumor, and
82 antiviral agents (Liu et al. 2002; Teng et al. 2011; De Silva et al. 2012a, b; Richter et al. 2015;
83 Hyde et al. 2019). Moreover, these compounds also treat many immunological diseases (Teng
84 et al. 2011; Richter et al. 2015), making *Ganoderma* species a popular functional food (Singh
85 et al. 2013).

86 There is much controversy in the taxonomical efforts to resolve nomenclatural
87 confusion within *Ganoderma*. This is because of the presence of a high level of phenotypic
88 plasticity in *Ganoderma* species (Pilotti et al. 2004; Wang et al. 2009; Cao et al. 2012; Dai et
89 al. 2017; Loyd et al. 2018; Hapuarachchi et al. 2019a). *Ganoderma lucidum* was broadly
90 defined from the original concept (Dai et al. 2017), with variations occurring in macro-
91 characteristics of the basidiomes, resulting in a large number of synonyms and general
92 redundancy in the taxonomy of this species and genus (Dai et al. 2017; Xing et al. 2018).

93

94 **Biogeography and ecological aspects of *Ganoderma***

95 **Biogeography of *Ganoderma***

96 *Ganoderma lucidum* (Curtis) P. Karst., the type species of *Ganoderma* was described based
97 on a specimen collected from the UK. Moncalvo et al. (1995) concluded that *G. lucidum* was
98 distributed across northern and southern Europe and likely extended into China. However,
99 based on analyses of ITS and LSU ribosomal DNA sequences, the illustrated *G. lucidum* from
100 both Europe and mainland China were not conspecific (Moncalvo et al. 1995). Moncalvo et

101 al. (1995), Pegler and Yao (1996), as well as Hong and Jung (2004) confirmed that *G.*
102 *lucidum* is a temperate species, so far only known with certainty from Europe. The name
103 *Ganoderma lingzhi* (Lingzhi) has been adopted in place of *G. lucidum* for specimens native to
104 East Asia (Cao et al. 2012). Among *Ganoderma* species, several species similar to *G. lucidum*
105 have also been described worldwide: *G. multipileum* (Hou 1950), *G. sichuanense* (Zhao et al.
106 1983), and *G. lingzhi* (Cao et al. 2012; Wu et al. 2012) from China; *G. resinaceum* from
107 Europe (Patouillard 1889); and *G. oregonense*, *G. sessile*, *G. tsugae*, and *G. zonatum* from the
108 US (Murrill 1902, 1908). These species are accepted as members of the *G. lucidum* complex.

109 Taxonomic concepts on *Ganoderma* species vary greatly due to the presence of
110 phenotypic plasticity (Moncalvo and Ryvarden 1995; Moncalvo 2000). Some *Ganoderma*
111 species are distributed worldwide, such *G. applanatum* and *G. australe*, while some species
112 are known from specific localities (Moncalvo and Ryvarden 1997; Douanla-Meli and Langer
113 2009). *Ganoderma* taxa are ambiguous due to the lack of holotypes and unclear geographical
114 distributions. Here, we summarize and update the global list of *Ganoderma* species with type
115 localities (Table 1) based on recent literature and our findings. *Ganoderma* species
116 distribution in the GMS is shown in Figure 1.

117

Ecological aspects of *Ganoderma*

Ganoderma species feature a high degree of morphological variation, even within species (Hapuarachchi et al. 2019a). A high level of phenotypic plasticity of the basidiomes at the macroscopic level as well as uniformity of microscopic features has led to considerable confusion and frequent misinterpretations in the taxonomy of *Ganoderma* (Pilotti et al. 2004; Hapuarachchi et al. 2019a). Wu and Dai (2005) mentioned that the morphology of *Ganoderma* species alters due to the influence of variable factors like climate, nutrition, vegetation, and geography, and moreover, morphology is not associated with the genetic material of a particular species. The basidiome feature is influenced by the interaction of both intrinsic (genetic and physiological) and extrinsic (environmental) factors (Moore et al. 2008; Aubin-Horth and Renn 2009; Moore et al. 2011; Murren et al. 2015). Therefore, comprehensive documentation of species ecology is necessary when studying *Ganoderma*. Different authors use various criteria for identification: some strictly focus on geographical distribution, host-specificity, and macro characteristics of basidiomes, while others focus on spore morphology as the primary taxonomic characteristic (Sun et al. 2006; Ekandjo 2012). In the present study, ecological factors such as collection period, season, climate, host plant, and substrate of *Ganoderma* species were recorded.

Ganoderma species are important wood-decaying fungi. Most are regarded as pathogens that possess a wide host range (Wong et al. 2012). These fungi decay lignin, cellulose, and hemicellulose resulting in a severe loss of woody plant strength (Coetzee et al. 2015; Čilerdžić et al. 2017). They possess lignocellulose decomposing enzymes useful for bioenergy production and bioremediation (Kües et al. 2015). Diseases caused by *Ganoderma* species result in lower yields in economically important trees (Wong et al. 2012). Various pathogenic *Ganoderma* species

distributed worldwide, their host plants, distribution range, and references are listed in Table 2.

In the present paper, we update the global biogeography records of *Ganoderma* species by reporting on species distributed in the Greater Mekong Subregion (GMS) and conducting morphological and phylogenetic studies on *Ganoderma* collected from temperate regions in China as well as tropical regions in Laos, Myanmar, Thailand, and Vietnam.

MATERIAL AND METHODS

Study sites

Ganoderma specimens were collected from the temperate parts of Yunnan Province, China, and tropical parts of Laos, Myanmar, Thailand, and Vietnam (Figure 2). Detailed collection site information, such as location, climate, monthly temperature during rainy season, host trees species, and native forest type are provided in Table 3.

Sample collection and isolation

Fresh basidiomes of *Ganoderma* species were collected from China, Laos, Myanmar, Thailand, and Vietnam. The samples were photographed and transported back to the laboratory where fresh macroscopic details were described. The cultures were aseptically isolated by using heat sterilized forceps, transferring sections of internal tissue from fruiting bodies onto potato dextrose agar (PDA) medium and incubated at 25–30° C, for 1–3 weeks, under dark conditions (Luangharn et al. 2017). After incubation, the agar surface was fully covered with white mycelium. The pure stock culture was then covered with mineral oil and deposited in the voucher culture collection of the Mae Fah Luang University culture collection (MFLUCC) Chiang Rai, Thailand. The cultures are being maintained at 4°C for further studies. The

voucher samples were then air dried at 40°C for 48 hours until they were completely dehydrated. Finally, the herbarium material was deposited in the Herbarium of Mae Fah Luang University (MFLU Herb.) with duplicates in the Herbarium of Kunming Institute of Botany, Academia Sinica (HKAS), Yunnan Province, China.

Morphological study

Macro- characteristics were described following the method of Lodge et al. (2004), while color notations were recorded following Ridgeway (1912). Macroscopic characteristics were determined according to the methodology described by Largent (1986). To observe microscopic characteristics, free-hand sections were made under a dissecting microscope (OLYMPUS SZ61) and mounted on a glass slide containing 3–5% KOH, 1–3% Congo red, and Melzer's reagent for highlighting all tissues (Kreisel and Schauer, 1987). Microphotography was done with a Nikon ECLIPSE Ni (Nikon, Tokyo, Japan) compound microscope, with a Canon EOS 600D (Tokyo, Japan) digital camera fitted on the top of the microscope. Basidiospores and hyphal system sizes, colour, and shapes were recorded and photographed. Basidiospore measurement were taken using the Tarosoft® Image Framework program v. 0.9.0.7. For measuring basidiospore statistics, the Tulloss' standard format (Tulloss 2005) was followed [$Q = L/W$], where Q , the quotient of basidiospore length to width (L/W) in side view and Q_m , the mean of Q -values \pm SD. The calculation was done by measuring at least 50 basidiospores from each basidiomata (Miettinen and Larsson 2006). Photographs were edited in Adobe Illustrator CS v. 3.0.

DNA extraction, PCR amplification, and sequencing

Dried internal tissues of the basidiomes were grounded and total DNA was extracted

using the Biospin Fungus Genomic DNA Extraction Kit (BioFlux®). The ITS, LSU, RPB2, and TEF1 α genes were amplified by Polymerase Chain Reaction (PCR). The PCR amplifications were performed in a total volume of 25 μ L of PCR mixtures containing 9.5 μ L ddH₂O, 12.5 μ L of PCR master mix, 1 μ L of DNA template, and 1 μ L of each primer (10 μ M). PCR amplification was carried out using primer pairs ITS5/ITS4 for internal transcribed spacer rDNA region (ITS1, 5.8S rDNA and ITS2), LROR/LR5 for the nuclear ribosomal large subunit 28S rDNA (LSU), fRPB2-5F/fRPB2-7cR for the partial RNA polymerase second largest subunit region (RPB2) (Vilgalys and Hester 1990; White et al. 1990; Liu et al. 1999), and EF1-983F/EF1-2218R for the partial translation elongation factor 1-alpha (TEF1 α) (Sung et al. 2007). The PCR cycling amplification conditions differed following amplified markers. For ITS and LSU, the following condition was used: 3 min at 94°C, followed by 35 cycles of 95°C for 30 s, 55°C for 1 min, 72°C for 1 min, followed by a final extension at 72°C for 10 min. The amplification condition for TEF1 α consisted of initial denaturation at 5.30 min at 95°C, followed by 35 cycles of 94°C for 1 min, 57°C for 30 s and 72°C for 1.30 min, followed by a final extension at 72°C for 10 min. The cycling profile of 3 min at 94°C followed by 35 cycles of 95°C for 1 min, 52°C for 2 min and 72°C for 1 min, followed by a final extension at 72°C for 10 min, was used for RPB2. The sequencing of PCR products was carried out by Sangon Biotech (Shanghai) Co., Ltd., Shanghai, China. The nuclear ribosomal Internal Transcribed Spacer region (nrITS) of the fungi was amplified and the sequence was deposited in GenBank to obtain the accession number.

Sequence alignment and phylogenetic analyses

Ganoderma specimens' sequences were subjected to standard BLAST searches of

GenBank to determine the primary identity of the *Ganoderma* species. All the other sequences of taxa closely related to our *Ganoderma* species were retrieved from GenBank. Sequences with high similarity indices were determined from BLAST searches to find the closest matches with taxa and from recently published literatures (Hapuarachchi et al. 2018a; Xing et al. 2018; Luangharn et al. 2019a, b). All sequences used to construct the phylogenetic tree are listed in Table 4. *Amauroderma rugosum* (Blume & T. Nees) Torrend (Cui 9011) and *Tomophagus colossus* (TC-02) were used as the outgroup taxa (Li and Yuan 2015; Zhou et al. 2015).

Sequences were aligned with MAFFT online server (Kato and Standley 2013), and manually adjusted using Bioedit v. 7.2.5 (Hall 1999) and Clustal X softwares (Thompson et al. 1997). Alignments were checked manually and optimized to allow maximum sequence similarity. Gaps were treated as missing data. Maximum parsimony (MP) analysis was performed using the PAUP beta 10 software version 4.0 (Swofford 2002).

Clades inferred from the MP analyses were further assessed by Maximum likelihood (ML) bootstraps with 1,000 replicates using random step wise sequence additions, performed using RAxML-HPC2 on XSEDE v. 8.2.8 (Stamatakis 2014) on the CIPRES webportal (Miller et al. 2010), and carried out using raxmlGUI v. 1.3.1 (Silvestro and Michalak 2011). The best fitting substitution model for each single gene partition and the concatenated data set were determined in MrModeltest 2.3 (Nylander 2004). Bayesian posterior probabilities (PP) with GTR+I+G model were used for each partition. Bayesian Markov Chain Monte Carlo (MCMC) analyses were conducted in MrBayes v. 3.2.2 (Huelsenbeck and Ronquist 2001). The number of generations was set at 3,500,000, with trees being sampled every 100th generations (a total of 35,000 trees), resulting in an average standard deviation of split frequencies

below 0.01. Based on the tracer analysis, the first sampled topologies of 8,750 trees representing 25% of total trees were discarded in burn-in phase. The remaining 26,250 trees were used for calculating posterior probability (PP) values in the majority rule consensus tree (Larget and Simon 1999).

Phylogenetic trees were visualized with FigTree v. 1.4.0 (Rambaut 2012) and edited using Microsoft Office PowerPoint 2010 before being exported to Adobe Illustrator CS v. 3.0. Maximum likelihood (ML) and Maximum parsimony (MP) bootstrap values equal to or greater than 70% and Bayesian Posterior Probabilities (BP) equal to or greater than 0.95 are presented above the branches.

Table 4 GenBank accession numbers for ITS, LSU, TEF1 α , and RPB2 sequence data of the taxa used in this study and procured from GenBank based on the earlier studies for conducting phylogenetic analyses. Details of newly amplified sequences are represented in bold.

Fungal species	Voucher	Locality	GenBank accession no.				References
			ITS	LSU	RPB2	TEF1 α	
<i>G. adpersum</i>	GACP15061220	Thailand	MK345425	–	MK371437	MK371431	Hapuarachchi et al. 2019b
<i>G. adpersum</i>	MFLU 19-2177	Laos	MN396652	–	MN423113	–	This study
<i>G. adpersum</i>	MFLU 19-2178	Thailand	MN396653	–	MN423114	MN423149	This study
<i>G. adpersum</i>	MFLU 19-2220	Thailand	MN396655	MN428663	MN423116	MN423151	This study
<i>G. angustisporum</i>	Cui 13817 (holotype)	Fujian, China	MG279170	–	MG367507	MG367563	Xing et al. 2018
<i>G. angustisporum</i>	Cui 14578	Guangdong, China	MG279171	–	–	MG367564	Xing et al. 2018
<i>G. applanatum</i>	FIN131R610	–	EF060004	–	–	–	GenBank
<i>G. applanatum</i>	MFLU 19-2175	Thailand	MN396333	–	–	–	This study
<i>G. applanatum</i>	MFLU 19-2188	China	MN396332	–	–	–	This study

<i>G. aridicola</i>	Dai 12588 (holotype)	Durban, South Africa	KU572491	–	–	KU572502	Xing et al. 2016
<i>G. australe</i>	GACP14081671	Hainan Island, China	MH106871	–	–	–	Hapuarachchi et al. 2018c
<i>G. australe</i>	GACP14061914	China	MK345428	–	–	MK371432	Hapuarachchi et al. 2019b
<i>G. australe</i>	MFLU 13-0534	Thailand	KP142173	–	–	MN423152	Luangharn et al. 2017
<i>G. australe</i>	HKAS 97397	China	MN396656	MN428664	–	–	This study
<i>G. australe</i>	MFLU 19-2171	Lao	MN396657	–	–	–	This study
<i>G. austroafricanum</i>	CBS138724	South Africa	KM507324	KM507325	–	–	Coetzee et al. 2015
<i>G. boninense</i>	WD 2028	Japan	KJ143905	KU220015	KJ143964	KJ143924	Zhou et al. 2015
<i>G. boninense</i>	WD 2085	Japan	KJ143906	–	KJ143965	KJ143925	Zhou et al. 2015
<i>G. boninense</i>	GbHap1	–	MK713555	–	–	–	GenBank
<i>G. boninense</i>	GB001	–	KX092000	–	–	–	GenBank
<i>G. calidophilum</i>	MFLU 19-2174	Yunnan, China	MN398337	–	–	–	This study

<i>G. carocalcareus</i>	DMC 322 (holotype)	Cameroon	EU089969	–	–	–	Douanla-Meli and Langer 2009
<i>G. carocalcareus</i>	DMC 513	Cameroon	EU089970	–	–	–	Douanla-Meli and Langer 2009
<i>G. casuarinicola</i>	Dai 16336 (holotype)	Guangdong, China	MG279173	–	MG367508	MG367565	Xing et al. 2018
<i>G. casuarinicola</i>	HKAS104639	Thailand	MK817650	MK817654	MK840868	MK871328	Luangharn et al. 2019b
<i>G. chocoense</i>	QCAM3123	Ecuador	MH890527	–	–	–	Crous et al. 2018
<i>G. curtisii</i>	CBS 100132	USA	JQ781849	–	KJ143967	KJ143927	Zhou et al. 2015
<i>G. destructans</i>	CMW43670	South Africa	KR183856	KR183860	–	–	Coetzee et al. 2015
<i>G. destructans</i>	CMW42146	South Africa	MG020245	–	–	MG020200	Coetzee et al. 2015
<i>G. ecuadoriense</i>	ASL799	Ecuador	KU128524	KX228350	–	–	Crous et al. 2016
<i>G. ecuadoriense</i>	PMC126	Ecuador	KU128525	KU128529	–	–	Crous et al. 2016
<i>G. ellipsoideum</i>	GACP14080966 (holotype)	Hainan, China	MH106867	–	–	–	Hapuarachchi et al. 2018b

<i>G. ellipsoideum</i>	GACP14080968	Hainan, China	MH106868	–	–	–	Hapuarachchi et al. 2018b
<i>G. ellipsoideum</i>	MFLU 19-2221	Thailand	MN398339	–	–	MN423157	This study
<i>G. enigmaticum</i>	Dai 15970	Africa	KU572486	–	MG367513	KU572496	Xing et al. 2016
<i>G. enigmaticum</i>	Dai 15971	Africa	KU572487	–	MG367514	KU572497	Xing et al. 2016
<i>G. flexipes</i>	Wei 5494	China	JN383979	–	–	–	Cao and Yuan 2013
<i>G. flexipes</i>	MFLU 19-2198	Yunnan, China	MN398340	MN428665	–	–	This study
<i>G. gibbosum</i>	SFC20150630- 23	Korea	KY364264	–	–	–	Jargalmaa et al. 2017
<i>G. gibbosum</i>	HKAS 97411	Yunnan, China	MN398341	–	–	–	This study
<i>G. gibbosum</i>	MFLU 19-2176	Thailand	MN396311	–	MN423118	–	This study
<i>G. gibbosum</i>	MFLU 19-2190	Laos	MN396310	–	MN423117	–	This study
<i>G. hochiminhense</i>	MFLU 19-2224	Vietnam	MN398324	MN396390	–	MN423176	This study
Karunaratna, Mortimer, Huyen & Luangharn.	(holotype)						

(2019)

<i>G. hochiminhense</i>	MFLU 19-2225	Vietnam	MN396662	MN396391	–	MN423177	This study
<i>G. hoehnelianum</i>	Dai11995	Yunnan, China	KU219988	–	MG367497	MG367550	Song et al. 2016
<i>G. hoehnelianum</i>	MFLU 19-2168	Myanmar	MN396316	–	MN423123	MN423158	This study
<i>G. leucocontextum</i>	Dai 15601	China	KU572485	–	MG367516	KU572495	Xing et al. 2018
<i>G. leucocontextum</i>	HKAS 97401	Yunnan, China	MN396317	MN428670	MN423124	–	This study
<i>G. lingzhi</i>	Wu 1006-38	Hubei, China	JQ781858	–	JX029980	JX029976	Cao et al. 2012
	(holotype)						
<i>G. lingzhi</i>	MFLU 19-2164	Thailand	MN396324	–	MN423130	MN423163	This study
<i>G. lingzhi</i>	HKAS 97398	Yunnan, China	MN396319	–	MN423126	MN423159	This study
<i>G. lobatum</i>	JV1212/10J	USA	KF605676	–	–	KU572501	GenBank
<i>G. lucidum</i>	Rivoire 4195	France	KJ143909	–	KJ143969	–	Zhou et al. 2015
<i>G. lucidum</i>	Cui 14404	Sichuan, China	MG279181	–	MG367519	MG367573	Xing et al. 2018
<i>G. lucidum</i>	MFLU 19-2161	Yunnan, China	MN396338	–	MN423135	MN423168	This study
<i>G. lucidum</i>	MFLU 19-2162	Thailand	MN396341	–	MN423138	–	This study
<i>G. martinicense</i>	LIP SWMart08-	Martinica,	KF963256	–	–	–	Welti and

	55 (holotype)	France						Courtecuisse 2010
<i>G. mbrekobenum</i>	UMN7-3GHA (holotype)	Ghana	KX000896	KX000897	–	–		Crous et al. 2016
<i>G. mizoramense</i>	UMN-MZ4 (holotype)	India	KY643750	–	–	–		Crous et al. 2017b
<i>G. multiplicatum</i>	Dai 13122	China	KU572488	–	–	KU572498		Xing et al. 2016
<i>G. multiplicatum</i>	MFLU 19-2152	Yunnan, China	MN401405	–	–	MN423171		This study
<i>G. multipileum</i>	CWN 04670	Taiwan PRC, China	KJ143913	–	KJ143972	KJ143931		Zhou et al. 2015
<i>G. multipileum</i>	MFLU 19-2166	Thailand	MN401406	–	MN423142	MN423172		This study
<i>G. mutabile</i> Y. Cao & H.S. Yuan	Yuan 2289	Yunnan, China	JN383977	–	–	–		Cao and Yuan 2013
<i>G. myanmarensis</i> Karunaratna, Mortimer, Cin & Luangharn.	MFLU 19-2167 (holotype)	Myanmar	MN396329	MN428672	–	–		This study

<i>G. myanmarensis</i>	MFLU 19-2169	Myanmar	MN396330	MN398325	–	–	This study
<i>G. nasalanense</i>	GACP17060211	Laos	MK345441	MK346831	–	–	Hapuarachchi et al. 2019b
Hapuar., Pheng., & K.D. Hyde	(holotype)						
<i>G. neojaponicum</i>	ASI 7032	Korea	JQ520193	–	–	–	Park et al. 2012
<i>G. orbiforme</i>	Cui 13918	Hainan, China	MG279186	–	MG367522	MG367576	Xing et al. 2018
<i>G. orbiforme</i>	GACP14061420	Laos	MK345447	MK346833	–	–	Hapuarachchi et al. 2019b
<i>G. orbiforme</i>	MFLU 17-1933	Thailand	MN401408	–	MN423144	–	This study
<i>G. oregonense</i>	CBS 265.88	USA	JQ781875	–	KJ143974	KJ143933	Zhou et al. 2015
<i>G. philippii</i>	E7098	Malaysia	AJ536662	–	–	–	Glen et al. 2009
<i>G. philippii</i>	E7425	Malaysia	AJ608713	–	–	–	Glen et al. 2009
<i>G. philippii</i>	MFLU 19-2222	Thailand	MN401410	MN398326	–	MN423174	This study
<i>G. philippii</i>	MFLU 19-2223	Thailand	MN401411	MN398327	–	MN423175	This study
<i>G. podocarpense</i>	QCAM6422	Ecuador	MF796661	MF796660	–	–	Crous et al. 2017a
J.A. Flores, C.W.	(holotype)						

Barnes & Ordoñez

<i>G. resinaceum</i>	HMAS86599	England	AY884177	–	JF915435	–	GenBank
<i>G. resinaceum</i>	CBS 194.76	Netherlands	KJ143916	–	–	KJ143934	Zhou et al. 2015
<i>G. resinaceum</i>	MFLU 19-2153	Yunnan, China	MN398315	MN398328	–	–	This study
<i>G. ryvardeenii</i>	HKAS 58053 (holotype)	Cameroon, Africa	HM138671	–	–	–	Kinge and Mih 2011
<i>G. ryvardeenii</i>	HKAS 58054	Cameroon, Africa	HM138672	–	–	–	Kinge and Mih 2011
<i>G. sandunense</i> K.K. Hapuar, T.C.	GACP18012501 (holotype)	China	MK345450	–	–	–	Hapuarachchi et al. 2019b
Wen & K.D. Hyde.							
<i>G. sandunense</i>	GACP18012502	China	MK345451	–	–	–	Hapuarachchi et al. 2019b
<i>G. sessile</i>	JV 1209/9	USA	KF605629	–	–	KJ143936	Zhou et al. 2015
<i>G. sessile</i>	JV 1209/27	USA	KF605630	–	KJ143976	KJ143937	Zhou et al. 2015
<i>G. shandongense</i>	Dai 15785	Shandong, China	MG279190	–	MG367526	MG367580	Xing et al. 2018

<i>G. shandongense</i>	Dai 15791	Shandong, China	MG279192	–	MG367528	MG367582	Xing et al. 2018
<i>G. sichuanense</i>	HMAS 42798 (holotype)	Sichuan, China	JQ781877	–	–	–	Cao et al. 2012
<i>G. sichuanense</i>	CGMCC5.2175	Sichuan, China	KC662402	–	–	–	Yao et al. 2013
<i>G. sinense</i>	Wei 5327	Hainan, China	KF494998	KF495008	MG367529	KF494976	Xing et al. 2018
<i>G. sinense</i>	MFLU 19-2172	Thailand	MN398319	MN398332	MN423146	–	This study
<i>G. sinense</i>	MLFU 19-2173	Yunnan, China	MN398316	MN398329	–	–	This study
<i>G. steyaertanum</i>	MEL:2382783	Australia	KP012964	–	–	–	GenBank
B.J. Sm. & Sivasith							
<i>G. steyaertanum</i>	6 WN 20B	Indonesia	KJ654462	–	–	–	Glen et al. 2014
<i>G. subresinosum</i>	7-SU-3-C-70 (M)-B	Indonesia	KJ654472	–	–	–	GenBank
<i>G. subresinosum</i>	MFLU 17-1912	Thailand	MN398321	–	–	–	This study
<i>G. thailandicum</i>	HKAS104640 (holotype)	Thailand	MK848681	MK849879	MK875831	MK875829	Luangharn et al. 2019b
<i>G. thailandicum</i>	HKAS104641	Thailand	MK848682	MK849880	MK875832	MK875830	Luangharn et al.

2019b

<i>G. tropicum</i>	Yuan 3490	Yunnan, China	JQ781880	–	–	KJ143938	Cao et al. 2012
<i>G. tropicum</i>	Dai 16434	Hainan, China	MG279194	–	MG367532	MG367585	Xing et al. 2018
<i>G. tropicum</i>	HKAS 97486	Thailand	MH823539	MH823540	MH883621	–	Luangharn et al. 2019
<i>G. tsugae</i>	Dai12751b	USA	KJ143919	–	KJ143977	KJ143939	Zhou et al. 2015
<i>G. tsugae</i>	HKAS 97406	Yunnan, China	MG279195	–	MG367533	MG367586	This study
<i>G. valesiacum</i>	CBS428.84	USA	JQ520218	–	–	–	Park et al. 2012
<i>G. weberianum</i>	CBS219.36	Philippines	JQ520219	–	–	–	Park et al. 2012
<i>G. weberianum</i>	GanoTK17	Cameroon	JN105705	–	–	–	GenBank
<i>G. wiiroense</i>	UMN-20-GHA (para type)	Ghana	KT952361	–	–	–	Crous et al. 2015
<i>G. williamsianum</i>	Dai 16809	Thailand	MG279183	–	MG367535	MG367588	Xing et al. 2018
<i>G. williamsianum</i>	MFLU 19-2170	Myanmar	MN398323	MN398334	–	–	This study
<i>G. wuzhishanensis</i>	GACP14081689	Hainan, China	KU994772	–	–	–	Li et al. 2016
<i>G. zonatum</i>	FL-02	USA	KJ143921	–	KJ143979	KJ143941	Zhou et al. 2015

<i>Amauroderma</i>	Cui 9011	Guangdong,	KJ531664	–	MG367506	KU572504	Li and Yuan 2015
<i>rugosum</i>		China					
<i>Tomophagus</i>	TC-02	Vietnam	KJ143923	–	–	KJ143943	Zhou et al. 2015
<i>colossus</i>							

RESULTS

Phylogenetic analyses

Phylogenetic analyses were inferred from the combined dataset of ITS, LSU, RPB2, and TEF1 α sequences of 114 taxa of which 112 taxa belongs to the genus *Ganoderma*, and the remaining two, *Amauroderma rugosum* Blume & T. Nees (Cui 9011) and *Tomophagus colossus* (Fr.) Murrill, *Torreya* (TC-02) are the outgroup taxa. The dataset comprised 3524 characters with gaps (637 characters for ITS, 866 characters for LSU, 1016 characters for RPB2, and 1005 characters for TEF1 α), of which 2459 characters were constant, 855 characters were variable and parsimony-informative, and 210 characters were parsimony-uninformative. Tree topologies resulted from the ML analysis were similar to that of the MP and Bayesian analysis. Hence, the best scoring ML tree is shown in Figure 3.

Ganoderma specimens used for this study, based on the collections made from China, Laos, Myanmar, Thailand, and Vietnam, were all placed within the *Ganoderma* clade. The phylogenetic tree includes 14 laccate clades, one non-laccate clade, and an outgroup clade. In this study, of a total of 22 *Ganoderma* species, 13 species (viz. *G. australe*, *G. calidophilum*, *G. flexipes*, *G. gibbosum*, *G. leucocontextum*, *G. lingzhi*, *G. applanatum*, *G. lucidum*, *G. multiplicatum*, *G. resinaceum*, *G. sandunense*, *G. sinense*, *G. tsugae*) from Yunnan Province, China, three *Ganoderma* species (*G. adpersum*, *G. australe*, *G. gibbosum*) from Laos; two *Ganoderma* species (*G. hoehnelianum*, *G. williamsianum*) from Myanmar; and 11 *Ganoderma* species (*G. adpersum*, *G. applanatum*, *G. ellipsoideum*, *G. gibbosum*, *G. lingzhi*, *G. lucidum*, *G. multipileum*, *G. orbiforme*, *G. philippii*, *G. sinense*, *G. subresinosum*) are reported from Thailand. Furthermore, two taxa viz. *G. myanmarensis* from Myanmar and *G. hochiminhense* from Vietnam are described here as new species. The tree topologies provided considerably high support in the terminal nodes but, failed to recover deeper nodes with high statistical support. The details of 13 *Ganoderma* species clades are provided in the following:

Clade 1 was statistically unsupported and comprised four species viz. *G. orbiforme*, *G. ecuadoriense*, *G. sinense* and *G. nasalanense*. Three sequences of the laccate *G. orbiforme* from China, Laos, and Thailand clustered together with significant support values (MLBS = 87%/ MPBS = 91%/ PP = 1.00) suggesting all of them to be the morphotype of the same taxon. However, *G. orbiforme* is closely related to *G. ecuadoriense* but differed by strong statistical support (MLBS = 95%/MPBS = 91%/ PP = 1.00). Two isolates of *G. sinense* from China and Thailand clustered together (MLBS = 100%/ MPBS = 86%/ PP = 0.99) and show genotypic closeness with the taxon *G. nasalanense* (MLBS = 100%/ MPBS = 91%/ PP = 1.00). Clade 2 consists of the laccate *G. angustisporum*, *G. ryvardeenii*, *G. zonatum*, and *G. hochiminhense* (MFLU 19-2224 and MFLU 19-2225). Two sequences of the newly described species, *G. hochiminhense*, from Vietnam clustered together with strong support values (MLBS = 100%/ MPBS = 98%/ PP = 0.99) and comes sister to *G. ryvardeenii* and *G. zonatum* although, this position is statistically unsupported.

Clade 3 was strongly supported (MLBS = 97%/ MPBS = 99%/ PP = 1.00) and contains the laccate *G. casuarinicola* from China (Dai 16336) and Thailand (HKAS 104639), two sequences of *G. thailandicum* (HKAS 104640 and HKAS 104641) from Thailand, *G. enigmaticum* (Dai 15970 and Dai 15971) from Africa, *G. aridicola* (Dai 12588) from South Africa and *G. calidophilum* (MFLU 19-2174) from China. Basal to clade 3, two species viz. *G. williamsianum* and *G. mbrekobenum* formed clade 4. The newly generated sequence of *G. williamsianum* from Myanmar (MFLU 19-2170) clustered with the same taxon sequence, previously deposited in the GenBank nucleotide database from Thailand (Dai 16809), with full support values (MLBS = 100%/ MPBS = 100%/ PP = 1.00). The molecular data confirmed the presence of *G. williamsianum* in Myanmar and this holds the first distributional record of the taxon from Myanmar.

Clade 5 consists of the non-laccate *G. adspersum* from Thailand (MFLU 19-2178 and

MFLU 19-2220) and Laos (MFLU 19-2177) (MLBS = 93%/ MPBS = 75%/ PP = 0.95); holotype sequence of *G. ellipsoideum* from China (GACP14080966 and GACP14080968) and Thailand (MFLU 19-2221) (MLBS = 97%/ MPBS = 96%/ PP = 0.95); *G. gibbosum* from Laos (MFLU 19-2190), Thailand (MFLU 19-2176), China (HKAS 97411), and Korea (SFC20150630-23) (MLBS = 100%/ MPBS = 93%/ PP = 0.95); *G. lobatum* (JV 1212/10J) from USA; *G. mutabile* (Yuan 2289) from China; and five sequences of *G. australe* from China (HKAS 97397, GACP14061914, GACP14081671), Thailand (MFLU 13-0534), and Laos (MFLU 19-2171) (MLBS = 100%/ MPBS = 100%/ PP = 1.00). However, this clade is statistically unsupported.

Clade 6 is formed by the cluster of Ecuadorean *Ganoderma* species viz. *G. chocoense* (QCAM 3123) and *G. podocarpense* (QCAM6422). This clade was unsupported by the maximum parsimony analysis but, weakly supported by the maximum likelihood and bayesian analyses (MLBS = 71%/ PP = 0.95).

Clade 7 is statistically unsupported. This clade comprises of the isolate of the lacate *G. multipileum* from Thailand (MFLU 19-2216) and Taiwan, PRC (CWN 04670) (MLBS = 100%/ MPBS = 76/ PP = 0.95) and shows its genetic closeness with that of *G. steyaertanum*, *G. mizoramense* and *G. destructans*. Two newly amplified sequence of *G. philippii* from Thailand (MFLU 19-2222 and MFLU 19-2223) clustered with strong support values (MLBS = 100%/ MPBS = 99/ PP = 1.00) with the same species sequence, previously deposited from Malaysia (E7098 and E7425). The Chinese (Yuan 3490 and Dai 16434) and Thailand (HKAS 97486) strains of *G. tropicum* comes basal to this clade but, this position is not supported statistically. In Clade 8, two newly amplified sequence of *G. lingzhi* from China (MFLU 19-2164 and Wu1006-38) and Thailand (MFLU 19-2164) clustered with strong support values (MLBS = 96%/ MPBS = 87%/ PP = 0.99) with the sequence of the same species, earlier deposited in GenBank from China (Wu1006-36). However, one of the Chinese sequences,

named *G. sichuanense* (CGMCC52175), clustered with all the three sequences of *G. lingzhi*, suggesting wrong identification. *Ganoderma curtisii* stands sister to *G. lingzhi* and this position is strongly supported (MLBS = 100%/ MPBS =76%/ PP = 0.99).

Clade 9 comprised five small subclades. The lacate *G. sessile* along with *G. neojaponicum* and *G. valesiacum* formed a subclade with moderate support (MLBS = 84%/ MPBS =81%/ PP = 0.99). Sister to this subclade, there remains another subclade containing the Chinese *G. resinaceum* along with sequences of the same taxon from Netherlands (CBS 194.76) and England (HMAS86599) but, this position is statistically unsupported. The newly generated sequence of *G. hoehnelianum* from Myanmar (MFLU 19-2168) formed the next subclade with that of the Chinese collection (Dai 11995) and shows its genetic closeness with the lacate *G. carocalcareus* (DMC 322 and DMC 513) and *G. austroafricanum* (CBS138724) with full support values (MLBS = 100%/ MPBS = 100%/ PP = 1.00). This subclade was followed by the cluster of two species viz. *G. weberianum* (CBS 219.36, GanoTK 17), and *G. sichuanense* (HMAS42798), but the position of these two taxa was statistically unsupported. Two Chinese sequences of *G. sandunense* (GACP18012501 and GACP18012502) forms the next subclade. The basal subclade contained two newly generated sequences of *G. applanatum* from Thailand (MFLU 19-2175) and China (MFLU 19-2188) along with the previously deposited sequence of the same taxon with strong support values (MLBS = 100%/ MPBS = 100%/ PP = 1.00). The newly described taxon, *G. myanmarensis* from Myanmar (MFLU 19-2167 and MFLU 19-2169), falls in clade 10 where the new species shows its genetic similarity with that of the lacate *G. wiiroense* from Ghana (UMN-20-GHA) and *G. destructans* from South Africa (CMW43670). *Ganoderma flexipes* remains basal to this cluster (Wei5494 and MFLU 19-2198). The newly generated sequence of *G. flexipes* (MFLU 19-2198) shows its full identity with one of the previously deposited Chinese *G. flexipes* sequences (Wei5494) and clustered with full support values (MLBS = 100%/

MPBS = 100%/ PP = 1.00).

Clade 11 was enriched with the *Ganoderma lucidum* species complex where, four sequences of *G. lucidum* from three countries viz. Thailand (MFLU 19-2162), China (MFLU 19-2161 and Cui 14404), and France clustered together (MLBS = 100%/ MPBS = 100%/ PP = 1.00) and revealed *G. leucocontextum* (Dai 15601 and HKAS 97401), *G. tsugae* (Dai 12751b, HKAS 97406), *G. oregonense* as sister taxa with strong support values (MLBS = 100%/ MPBS = 99%/ PP = 1.00).

Two sequences of the taxon *G. shandongense* (Dai 15785 and Dai 15791) formed clade 12. This small clade was followed by another clade, clade 13, which comprised of four sequences of *G. boninense* (clade 13).

Clade 14 was the extreme basal clade where the sequence of *G. subresinosum* (MFLU 17-1912), collected from Thailand (MFLU 17-1912), clustered with full support (MLBS = 100%/ MPBS = 100%/ PP = 1.00) with one of the earlier sequences of the same taxon, deposited in the nucleotide sequence database.

TAXONOMY

Ganoderma P. Karst., Revue Mycologique Toulouse. 3(9): 17 (1881)

= *Dendrophagus* Murrill, Bull. Torrey bot. Club. 32(9): 473 (1905)

= *Elfvigia* P. Karst., Bidr. Känn. Finl. Nat. Folk. 48: 333 (1889)

= *Friesia* Lázaro Ibiza, Revista Real Acad. Ci. Madrid. 14: 587 (1916)

= *Ganoderma* subgen. *Trachyderma* Imazeki, Bull. Tokyo Sci. Mus. 1: 49 (1939)

= *Tomophagus* Murrill, Torrey. 5: 197 (1905)

= *Trachyderma* (Imazeki) Imazeki, Bull. Gov. Forest Exp. Stn Tokyo. 57: 97 (1952)

Type – *Ganoderma lucidum* (Leyss: Fr.) Karst.

Notes – (≡) is homotypic, or nomenclatural, synonyms, (=) is heterotypic, or

taxonomic, synonyms.

Descriptions: Basidiomes annual, dimidiate, sessile or sub-stipitate to stipitate.

Pileus sub-dimidiate to dimidiate, flabelliform, perennial, stipitate or sessile. *Pileus surface* non-laccate (dull) or weakly to strongly laccate, glossy, shiny, smooth, spathulate, shallow, furrows, sulcate, several layers thick, with thin- to thick- cuticle cells or cuticle of clavate end cells, thicker at the base than the margin, thin- to thick- crust overlaying the pileus, consistency hard, consistency hard, light weight when dried. *Pileus colour* variable, light yellow to yellow, light brown, slightly brown to dark brown, sometimes homogenous reddish gray to reddish yellow. *Context* brown to dark brown, grayish orange to orange, sometimes grayish yellow, mostly soft, sometimes spongy to firm-fibrous. *Hymenophore* di-trimitic, heterogeneous, non-septate or septate, usually yellow, slightly light orange, or light brown to brown, sometimes with melanoid bands. *Tubes* hard, woody when dried. *Tube layers* single or stratified, pale to purplish brown, almost hyaline with clamp connections, occasionally branched at apex, thin- to thick-walled. *Stipe* central or lateral, glossy with a distinct cuticle. *Margin* actively growing, entirely white when fresh, round, soft and smooth when young, slippery when touched from youth to maturity, and tough when broken. *Pores* 4–7 in number per mm, angular, entire, sub-circular to circular, regular, cream or white when young, light yellow, light orange to brown when mature. *Pore surface* usually white to cream when fresh, turning yellowish white to pale yellow on drying, some sections reddish grey to brown, and brownish grey when wet.

Hyphal structure: hyphal system di-trimitic, including generative, skeletal, and binding hyphae; mostly generative hyphae with clamp connections, hyaline, brown, non-septate or septate, often with long and tapering branches. *Basidia* broadly ellipsoid, tapering abruptly at the base. *Cystidia* absent. *Basidiospores* broadly to narrowly ellipsoid or oblong, sometimes

globose to sub-globose, with double walls, truncate apex, apical germ pore present, usually with light brown to brown endosporium, hyaline exosporium with thin inter-walled pillars, hyaline endosporium with thick outer walls, and some very thin exosporium.

Ecology: mostly on hardwoods, trunks and stumps, occurring on several different living tree host species.

Notes: Justo et al. (2017) treated Ganodermataceae as a synonym of Polyporaceae and included the genus *Ganoderma* under Polyporaceae. Later, Cui et al. (2019) excluded *Ganoderma* from Polyporaceae due to the presence of double-walled basidiospores unlike Polyporaceae. So, the distinctiveness of the genus *Ganoderma* lies in the presence of double-walled and truncate basidiospores. Species with a laccate, glossy surface are present in both of Ganodermataceae and Polyporaceae as centrally and laterally stipitate species.

Taxonomy of *Ganoderma* from China

Ganoderma angustisporum J.H. Xing, B.K. Cui & Y.C. Dai, Mycokeys 34: 98 (2018)

Taxonomy and phylogenetic analysis were described in Xing et al. (2018)

Notes: *Ganoderma angustisporum* is characterized by annual, sessile, broadly basidiomes, strongly laccate on the upper surface of basidiomes, white pore surfaces, and almond-shaped, slightly truncate, narrow $9.0\text{--}11.3 \times 4.0\text{--}5.2 \mu\text{m}$ basidiospores. It is a group of white rot fungi which predominantly grows on living *Casuarina equisetifolia* in Fujian Province, China.

Ganoderma applanatum (Pers.) Pat., Hymenomyc. Eur. (Paris): 143 (1887) (Figure 4)

≡ *Boletus lipsiensis* Batsch, Elenchus fungorum. Continuatio prima.: 183, t. 25:130 (1786)

≡ *Scindalma lipsiense* (Batsch) Kuntze, Revisio generum plantarum. 3(2): 518 (1898)

≡ *Polyporus lipsiensis* (Batsch) E.H.L. Krause, Basidiomycetes Rostochienses.: 54
(1928)

≡ *Agaricus lipsiensis* (Batsch) E.H.L. Krause, Basidiomycetum Rostochiensium, Suppl.
4: 142 (1932)

= *Boletus applanatus* Pers., Observationes mycologicae. 2: 2 (1799)

= *Polyporus merismoides* Corda, Deutschlands Flora, Abt. III. Die Pilze Deutschlands.
3: 139 (1837)

= *Polyporus stevenii* Lév., Annl. Sci. nat., Bot.: 91 (1844)

= *Polyporus leucophaeus* Mont., Sylloge generum specierumque plantarum
cryptogamarum.: 157 (1856)

= *Polyporus leucophaeum* Mont. (1856)

= *Polyporus incrassatus* Berk., Journal of the Linnean Society. Botany. 16: 41 (1877)

= *Polyporus concentricus* Cooke, Grevillea. 9 (49): 13 (1880)

= *Fomes gelsicola* Berl., Malpighia. 3: 373 (1889)

= *Fomes nigriporus* Lázaro Ibiza, Revista de la Real Academia de Ciencias Exactas
Fisicas y Naturales Madri. 14: 662 (1916)

= *Ungularia subganodermica* Lázaro Ibiza, Revista de la Real Academia de Ciencias
Exactas Fisicas y Naturales Madri. 14: 674 (1916)

= *Fomes longoporus* Lloyd, Mycological Writings. 6(62): 940 (1920)

Faces of fungi number: FoF 06249

Basidiomes: annual, perennial, sessile. *Pileus* 1.5–5.8 cm in length, 0.5–4.5 cm in width, and up to 1.5 cm thick at the base. *Pileus* sessile (without stipe), perennial, sub-dimidiolate, sub-flabelliform to flabelliform, usually flat, convex, imbricate, umbonate or uneven, rarely unguulate, glabrous when present, broadly attached when mature, often with undefined

concentric zones at the center that extend to the margin, thick at the base, slightly soft at the margin when mature. *Pileus surface* shiny, silky, smooth, and soft when young, hard when old, frequently furrowed and shallow sulcate, undulating, somewhat spathulate to uneven on upper surface when mature, covered by irregularly ruptured thick-crust, slightly non-laccate (dull) and faded from when mature to old, compact and hard when mature, woody to corky when old. *Pileus color* usually homogenous with greyish orange (6B3–6B5) at the center, slight brownish orange (6C4), orange white (6A2) to pale orange (6A3), with yellowish grey (4B2) at the margin when mature. *Context* up to 0.3–1 cm thick at the base, mostly light brown (7D5), brown (6E8) to dark brown (7F6–7F8) of cuticle cells, with walls varying in thickness to sub-solid hyphae, some fibrous pithy context, usually separated by layers of context tissue at the base, and some occurred woody lines. *Tube* woody, hard, often dark brown (7F7–7F8) when dried, with sulcate at different levels. *Stipe* almost sessile and broadly attached when present, with a differentiated zone at the point of attachment. *Margin* up to 1 cm thick, white (5A1), yellowish grey (4B2) when mature, turns light brown (6D4) to brown (6E8) when scratched or bruised, often slippery when wet, soft when young, thinner than the center. *Pore* 4–6 in number per mm, sub-circular to circular, sometimes angular. *Pore surface* initially white (7A1), greyish orange (7C3–7C4) when mature, turning to light brown (7D6) to brown (7D8) when scratched or bruised.

Hyphal structure: hyphal system trimitic; generative hyphae 0.8–2.6 μm ($\bar{x} = 2.1$, $n = 30$) in diam, almost hyaline, with clamp connections, abundant, thin walled and occasionally thick walled; skeletal hyphae 2.1–4.6 μm width ($n = 30$), usually thick walled, hyaline, sometimes branched; binding hyphal 1.6–3.3 μm width ($n = 30$), thick walled and occasionally thin walled, branched, and intertwined with the skeletal hyphae. *Basidiospores* mostly ellipsoid with double walls, with size range of (9.8–)10.4–11.1–11.9(–12.1) \times (7.3–)8.0–8.6–9.2(–9.9)

μm , ($\bar{x} = 11.3 \times 8.7 \mu\text{m}$, $n = 50$) μm , with $Q = 1.79\text{--}1.86$, $L = 11.23 \mu\text{m}$, $W = 6.12 \mu\text{m}$ (including myxosporium), $(6.2\text{--})7.6\text{--}8.6\text{--}9.7\text{--}(10.4) \times (5.0\text{--})5.8\text{--}7.1\text{--}8.2\text{--}(8.9) \mu\text{m}$ ($\bar{x} = 8.6 \times 7.1 \mu\text{m}$, $n = 50$) μm , with $Q = 1.19\text{--}1.24$, $L = 8.59 \mu\text{m}$, $W = 7.12 \mu\text{m}$ (excluding outer myxosporium), brownish orange (7D4) to brown (7D7–7D8) in KOH, and reddish brown (8E6) to dark brown (8F4) in Melzer's reagent. *Basidia* $14\text{--}20 \times 8\text{--}10 \mu\text{m}$, with 4 sterigmata.

Ecology: solitary, on stump of *Machilus yunnanensis*.

Specimens examined: **CHINA**, Yunnan Province, Baoshan, $25^{\circ}09'35''\text{N}$, $99^{\circ}09'49''\text{E}$, 1973 m elev., on 11 November 2017, T. Luangharn, HKAS 107254, MFLU 19-2188.

Notes: *Ganoderma applanatum* has been treated by some researchers as the correct name for *G. applanatum* (Richter et al. 2015). *Ganoderma applanatum* (= *G. lipsiense*) belongs in the subgenus *Elfvigia*, which is characterized by distinctive non-laccate species, a thin and acute margin of the pileus, and unbranched terminal endings of skeletal hyphae, with ellipsoid basidiospores (Pegler and Young 1973; Ryvarden and Gilbertson 1993; Leonard 1998; Wu and Dai 2005). *Ganoderma applanatum* causes white butt rot on angiosperm trees and is widely distributed in China (Dai 1996). Hence, our specimen of *G. applanatum*, collected from a temperate region of China, is described based on morphological characteristics and molecular phylogenetic data. Our results agree well with those of Ryvarden and Gilbertson (1993).

Ganoderma australe (Fr.) Pat., Bull. Soc. mycol. Fr. 5(2–3): 65 (1889) (Figure 5)

≡ *Polyporus australeis* Fr., Elenchus Fungorum. 1: 108 (1828)

≡ *Fomes australeis* (Fr.) Cooke, Grevillea. 14(69): 18 (1885)

≡ *Placodes australeis* (Fr.) Quél., Enchiridion Fungorum in Europa media et praesertim in Gallia Vigentium. 171 (1886)

≡ *Fomes applanatus* var. *australeis* (Fr.) Cleland & Cheel, Journal of Proceedings of the Royal Society of New South Wales. 51: 518 (1918)

≡ *Ganoderma applanatum* subsp. *australe* (Fr.) Bourdot & Galzin, Bulletin de la Société Mycologique de France. 41: 184 (1925)

≡ *Ganoderma applanatum* f. *australe* (Fr.) Bourdot & Galzin, Bulletin de la Société Mycologique de France. 41: 184 (1925)

≡ *Elfvingia australeis* (Fr.) G. Cunn., Bulletin of the New Zealand Department of Industrial Research. 164: 256 (1965)

= *Polyporus tornatus* Pers., Botanique (Nagpur). 5: 173 (1827)

= *Polyporus scansilis* Berk., Journal of the Linnean Society. Botany. 16: 53 (1877)

= *Fomes annularis* Lloyd, Mycol. Writ. 4(40): 6 (1912)

= *Ganoderma tornatum* var. *tornatum* (Pers.) Bres., Hedwigia. 53(1–2): 55 (1912)

= *Fomes konigsbergii* Lloyd (1915)

= *Fomes polyzonus* Lloyd, Synopsis of the genus *Fomes*. (7): 269 (1915)

= *Fomes pseudoaustraleis* Lloyd, Synopsis of the genus *Fomes*. (7): 269 (1915)

= *Fomes undatus* Lázaro Ibiza, Revista de la Real Academia de Ciencias Exactas Fisicasy Naturales Madri. 14: 661 (1916)

Faces of fungi number: FoF 06242

Basidiomes: annual, perennial, sub-dimidiolate, sessile. *Pileus* 14–28 cm in length, 12–32 cm in width, and 1.4–3.2 cm thick. *Pileus* flabelliform, spathulate, sub-dimidiolate, umbonate, single, sulcate, large, obtuse from host, radial from the center extending the margin, broadly attached, often thick at the center, slightly soft at the margin, consistency hard, and tough to break when dried. *Pileus surface* convex, corky, furrowed, spathulate, mostly umbonate or uneven, non-laccate (dull) on maturity or in old, usually slippery where the new hyphae are in

active development (margin), slightly concentrically sulcate at the center toward margin, smooth, covered with thick and hard crust, irregularly ruptured crust overlying the surface, woody and corky when dried, with cracked crust when mature, and tough to break when dried. *Pileus color* often brown (6E7–6E8) at the base, reddish orange (7B7–7B8), brownish orange (7C6–7C8), almost covered with greyish red (8C4–8C5) on the upper surface when old, slight reddish brown (8F8, 9E7–9E8) close to the margin. *Context* up to 0.5–2 cm thick near stipe, fibrous, composed of coarse loose fibrils, brown (6D7–6D8) to dark brown (6F7), with reddish brown (8D8–8D9) coarse loose fibrils, covered with thick crust. *Tube* 0.4–1.5 cm long, brown (7D8) to dark brown (6F8). *Stipe* sessile, broadly attached. *Margin* soft when young, slippery when fresh, blunt when mature, white (4A1). *Pore* 4–6 in number per mm, sub-circular to circular, sometimes angular. *Pore surface* initially white (4A1), slight to pale yellow (4A3) when mature, turned brownish orange (6C7–6C8) when scratched or bruised or discolored when touched.

Hyphal structure: hyphal system trimitic, dense and hard, thick walled, typically with narrow lumen, flexuous, and many branches, usually brownish orange (6C5–6C7) in KOH; generative hyphae 2.2–3.8 μm broad ($n = 30$), thin-walled, hyaline, tapering at branch, with clamp connections; skeletal hyphae 2.9–4.2 μm broad ($n = 30$), sometimes branched, nearly solid, thick walled; binding hyphae 2.6–4.0 μm broad ($n = 30$), thick walled, branched, more or less solid; hymenial with sword-like apices in the context. *Basidiospores* mostly ellipsoid to broadly ellipsoid, double walls, (6.2–)7.1–9.4–10.4(–11.8) \times (5.2–)6.0–7.4–8.9(–9.7) μm ($\bar{x} = 9.4 \times 7.4 \mu\text{m}$, $n = 50$) μm , with $Q = 1.24$ –1.30, $L = 9.42 \mu\text{m}$, $W = 7.43 \mu\text{m}$ (including myxosporium), (5.3–)6.7–7.8–9.6(–10.5) \times (4.5–)5.1–5.7–6.3(–7.2) μm ($\bar{x} = 7.8 \times 5.7 \mu\text{m}$, $n = 50$) μm , with $Q = 1.31$ –1.38, $L = 7.85 \mu\text{m}$, $W = 5.83 \mu\text{m}$ (excluding outer myxosporium), overlaid by hyaline, apically brown, bearing a fine, distinct, short, echinulae truncate, turgid

vesicular appendix, inner wall orange (6B8) to brownish orange (6C8) or light brown (7D5–7D6) to brown (7E7–7E8), outer wall mostly reddish brown (8E7–8E8, 8F7) in 5% KOH.

Habitat: solitary, growing on living tree of *Neocinnamomum delavayi* (Lec.) H. Liou. Tree or, decaying stump, and living *Fagus* spp. tree.

Specimens examined: **CHINA**, Yunnan Province, Kunming Botanical Garden, 25°08'39"N, 102°44'30"E, 1956 m, on 27 September 2016, T. Luangharn, HKAS 97397.

Notes: *Ganoderma australe* (Fr.) Pat. 1889 belong under the subgenus *Elfvigia* (Moncalvo et al. 1995). This fungus was initially described from the Pacific Islands (Ryvarden and Gilbertson 1993). Recently, the type specimen of this fungus is missing, while the neotype specimen is available in Europe (Ryvarden and Gilbertson 1993). *Ganoderma australe* belongs to the *G. applanatum-australe* complex (Moncalvo and Ryvarden 1997). *Ganoderma australe* was established as a non-laccate (dull) pilei. *Ganoderma applanatum* and *G. australe* from Europe have been confused based on the macro characteristics features (Leonard 1998). The typification of *G. australe* remains unsolved and was exemplified by several authors (Steyaert 1972, 1975; Gilbertson and Ryvarden 1986; Zhao 1989), and its similar cultural characteristics also showed the phenotypic plasticity in morphological level and higher level of nucleotide divergence in ITS rDNA region that made *G. australe* a complex species (Moncalvo 2000).

Ganoderma australe is distinguished from *G. applanatum* by the larger dimensions of its basidiospores, different stipe features, thickness of the cuticle, and color of the context layer, all of which were considered in delimiting *G. applanatum* and *G. australe* (Ryvarden and Gilbertson 1993; Moncalvo and Ryvarden 1997; Leonard 1998). *Ganoderma applanatum* is confined to northern temperate regions, while *G. australe* can be found in tropical and subtropical regions (Ryvarden and Johansen 1980; Corner 1983). *Ganoderma australe* is a cosmopolitan species known to cause the growth of white rot fungus on woody material. It

shows parasitic or pathogenic behavior on a wide range of both dead and living broadleaved deciduous trees (Schwarze and Ferner 2003; Ryvarden and Melo 2014; Overall 2016). *G. australe* is distributed worldwide, especially in tropical regions (Smith and Sivasithamparam, 2000). There are reports on the occurrence of *G. australe* from Australia (Smith and Sivasithamparam 2000), China (Hapuarachchi et al. 2019b), New Zealand (Buchanan and Wilkie 1995), southern India (Yeh and Chen 1990; Kaliyaperumal and Kalaichelvan 2008), Taiwan, PRC (León et al. 2003), and Thailand (Luangharn et al. 2017; Hapuarachchi et al. 2019b).

Ganoderma calidophilum J.D. Zhao, L.W. Hsu & X.Q. Zhang, Acta Mycologica Sinica 19: 270 (1979) (Figure 6)

Faces of fungi number: FoF 06244

Basidiomes: annual, stipitate, sub-dimidiolate. *Pileus* 3–7 cm in length, 2–4 cm in width, and 0.2–1 cm thick. *Pileus* sub-dimidiolate to dimidiolate, spatulate, stipitate, sulcate, umbonate, radial from the center extending to the margin, tough to break when dried, often thick at the center, slightly soft at the margin, and light in weight when dried. *Pileus surface* corky, convex, furrowed, glabrous, glossy, incised, shiny, spatulate, shallow, sulcate when fresh, umbonate or uneven, laccate and glossy when mature, weakly laccate when old and in regions of developing hyphae (margin), slightly concentrically sulcate, layers smooth at the center when young, irregularly ruptured crust overlying the context, and tough to break when dried. *Pileus color* usually homogenous with brownish red (8C7–8C8), brownish red (9C7–9C8), reddish brown (9D6–9D7) center, extending brownish orange (6C7–6C8) towards the stipe, brownish red (9C8) from the center to light brownish orange (6C8), and usually light brown (6D8) at the margin when old. *Context* up to 0.2–0.6 cm thick near stipe, dry, fibrous, composed of coarse loose fibrils, brownish orange (6C5–6C8) upper layers when fresh,

brown (6D7) at lower layers, dark brown (8F7) when dried, covered with thin crust, trimitic hyphal system. *Tube* 0.3–0.9 cm in length, brown (7D8). *Stipe* 5–14 cm long, cylindrical, almost stipitate with broadly, irregularly ruptured crust overlying, strongly laccate with brown (7D8) when mature, dark brown (8F8) when old, and woody or corky when dried. *Margin* soft when young, laccate when mature, weakly laccate to laccate when old, blunt when old, usually light brown (6D8) when mature to old. *Pore* 4–5 in number per mm, sub-circular to circular, sometimes angular. *Pore surface* initially pale orange (5A3) to brownish orange (6D8) when mature, discolored when touched, brown (6E8) when scratched or bruised.

Hyphal structure: hyphal system trimitic hyphal, usually brownish orange (6C5–6C7) in KOH; generative hyphae 1.2–3.2 μm broad ($n = 30$), thin walled, hyaline, without clamp connections; skeletal hyphae 3.2–6.4 μm broad ($n = 30$), sometimes branched, nearly solid, thick walled, without clamp connections; binding hyphae 2.4–5.2 μm broad ($n = 30$), usually thin to thick walled, many branches, nearly solid, hymenial with sword-like apices in the context. *Basidiospores* mostly ellipsoid to broadly ellipsoid, with double wall, with size range of (7.4–)8.5–11.9–12.6(–13.7) \times (6.3–)7.2–8.3–9.1(–9.6) μm ($\bar{x} = 11.9 \times 8.3 \mu\text{m}$, $n = 50$) μm , with $Q = 1.39$ –1.45, $L = 11.92 \mu\text{m}$, $W = 8.35 \mu\text{m}$ (including myxosporium), (6.8–)7.6–10.4–11.3(–12.8) \times (5.4–)6.3–7.0–7.6(–8.1) μm ($\bar{x} = 10.4 \times 7.1 \mu\text{m}$, $n = 50$) μm , with $Q = 1.43$ –1.49, $L = 10.39 \mu\text{m}$, $W = 7.12 \mu\text{m}$ (excluding outer myxosporium), overlaid by hyaline, apically and echinulae, truncate, turgid vesicular appendix, inner wall orange (6B8) to deep orange (6A8), reddish orange (7A8, 7B7–7B8) or yellowish red (8B8), outer wall usually reddish brown (8D7–8D8; 8E8) in 5% KOH.

Habitat: solitary, near the hardwood root of *Castanopsis* spp., living tree of *Machilus yunnanensis*.

Specimens examined: **CHINA**, Yunnan Province, Baoshan, 25°06'29"N, 99°08'29"E, 1973 m elev., on 11 November 2017, T. Luangharn, MFLU 19-2174.

Notes: *Ganoderma calidophilum* is a species originally described from Hainan Province, China by Zhao et al. (1979). Several reports have confirmed this fungus is mentioned in Hainan Province polypore diversity checklists (Zhao 1989; Zhao and Zhang 2000; Li et al. 2010; Dai et al. 2011). This fungus is distinctive in these forms, featuring a laccate pileus with broadly ellipsoid basidiospores with double walls, and it is widely found across subtropical and tropical Asia (Zhao et al. 1979). Wang and Wu (2007) suggested that *G. calidophilum* is a synonym of *G. flexipes*. However, the evaluated *G. calidophilum* and *G. flexipes* are different in terms of pileus color, pileus shape and size, context, and basidiospore size (Wang and Wu 2007). In this study, we present our *G. calidophilum* collection from Yunnan Province, China, based on taxonomic and phylogenetic analyses. Our strain is similar to the described strain of Wang and Wu (2007), Zhao et al. (1979) and Bi et al. (1993).

Ganoderma flexipes Pat., Bulletin de la Société Mycologique de France. 23(1): 75 (1907)
(Figure 7)

≡ *Fomes flexipes* (Pat.) Sacc. & Traverso, Sylloge Fungorum. 19: 710 (1910)

≡ *Polyporus flexipes* (Pat.) Lloyd, Synopsis of the stipitate Polyporoids. (7): 104 (1912)

Faces of fungi number: FoF 06245

Basidiomes: annual or perennial, stipitate. *Pileus* 0.5–3.2 cm in length, 0.5–3 cm broad, up to 0.5 cm thick at the base. *Pileus* stipitate, sub-reniform to reniform, or sub-flabellate to flabellate, concentrically sulcate zones with turberculate, glabrous when young to maturity, bumps when mature, often tough to break when dried. *Pileus surface* shiny, smooth, and soft when young, frequently furrowed and shallow sulcate on upper surface, undulating,

somewhat spatulate to uneven when mature, covered by irregularly ruptured thin crust, faded or weakly laccate when young, and laccate when mature., and woody when old. *Pileus color* usually homogenous with reddish brown (8E8) to dark brown (9F7–9F8) at the center slight to the margin from mature to old. *Context* up to 0.1–0.6 cm thick at the base, very dry, brown (7D7–7D8) to reddish brown (8E7), containing fibrous pithy context and corky when old. *Tube* hard, often dark brown (7F8). *Stipe* almost 3–12 cm in length, 0.3–1.5 in width, sub-cylindrical to cylindrical, often dark brown (7F8), and strongly laccate from mature to old. *Margin* soft when young, laccate when mature, some wavy, often light brown (6D5–6D6) on the upper surface. *Pore* 4–5 in number per mm, sub-circular to circular, sometimes angular. *Pore surface* initially greyish orange (6B4–6B6), turns brown (7D7) to reddish brown (8D5–8D7) when scratched or bruised, discolored when touched.

Hyphal structure: hyphal system trimitic, bearing clamp connections, hyaline, thick walled, tapering branch, some swollen differentiated zone at the point of attachment; generative hyphae (1.8–)2.2–2.9–3.4(–3.8) μm broad ($n = 30$), thin walled, hyaline, unbranched, with clamp connections; skeletal hyphae (3.0–)3.8–4.8–5.4(–6.2) μm broad ($n = 30$), with walls varying in thickness, with sub-solid, binding hyphae (2.2–)2.8–3.8–4.5(–5.1) μm broad ($n = 30$), usually thick walled, appearing alongside Bovista hyphae, and many branches, usually light yellow (4A4–4A5) to yellowish orange (4B8) of thin walled and orange (6A7) to deep orange (6A8) of thick walled in Melzer's reagent. *Basidiospores* mostly ellipsoid to broadly ellipsoid with double wall at maturity, (8.1–)8.8–9.7–10.6(–11.2) \times (6.1–)6.6–7.7–9.7(–10.4) μm ($\bar{x} = 9.7 \times 7.7 \mu\text{m}$, $n = 50$) μm , with $Q = 1.08$ –1.15, $L = 9.68 \mu\text{m}$, $W = 7.72 \mu\text{m}$ (including myxosporium), (7.3–)7.8–8.3–8.7(–9.2) \times (4.0–)4.6–5.4–5.8(–6.2) μm ($\bar{x} = 10.2 \times 6.4 \mu\text{m}$, $n = 50$) μm , with $Q = 1.51$ –1.57, $L = 8.34 \mu\text{m}$, $W = 5.39 \mu\text{m}$ (excluding outer myxosporium), overlaid by hyaline, dextrinoid, echinulae, inner wall echinulate brown (5D8, 7E6–7E8), and outer wall usually dark brown (7E8) to reddish brown (8E6–8E8) in Melzer's

reagent.

Habitat: solitary, on the decaying hardwood of *Pinus* spp.

Specimens examined: **CHINA**, Yunnan Province, Baoshan, 25°06'29"N, 99°08'29"E, 1973 m elev., on November 2017, T. Luangharn, MFLU 19-2189.

Notes: *Ganoderma flexipes* is originally described from Vietnam by Patouillard (1907), it has been recorded from China, India, Laos, Nepal, and Pakistan (Steyaert 1972; Zhao and Zhang, 2000; Wang and Wu 2007; Cao et al. 2012; Hapuarachchi et al. 2019b). *Ganoderma flexipes* is characterized by its small reddish-brown pileus, long and thin stipe, usually reddish-brown to dark-brown context, and ellipsoid or ovoid basidiospores (Ryvarden 1983). Among the Chinese *Ganoderma* species, *G. flexipes* is one of the most similar species to *G. lingzhi* as they share reddish-brown pileal surface, similar basidiospores, and cuticle cells (Cao et al. 2012). Our *G. flexipes* from China is very similar to the description of Ryvarden (1983) and Hapuarachchi et al. (2019b) and basidiospores are within the range of 9.7–10.2 × 6.4–7.7 μm.

Ganoderma gibbosum (Blume & T. Nees) Pat., Ann. Jard. Bot. Buitenzorg, suppl. 1: 114 (1897) (Figure 8)

≡ *Polyporus gibbosus* (Blume & T. Nees), Nov. Act. Academiae Caesareae Leopoldino Carolinae Germanicae Naturae Curiosorum. 13: 19, t. 4(1–4) (1826)

≡ *Fomes amboinensis* var. *gibbosus* (Blume & T. Nees) Cooke, Grevillea. 13(68): 118 (1885)

≡ *Fomes gibbosus* (Blume & T. Nees) Sacc. Syll. Fung. 6: 156 (1888)

≡ *Scindalma gibbosum* (Blume & T. Nees) Kuntze., Revisio generum plantarum 3(2): 518 (1898)

Faces of fungi number: FoF 06246

Basidiomes: annual or perennial, sessile. *Pileus* 8–21 cm in length, 6–13 cm in width, and 1–3.5 cm thick. *Pileus* convex, imbricate, umbonate, uneven, unguulate, sub-flabellate, sub-dimidiata, usually round when present, primordial, somewhat round and plump when young, somewhat imbricate, when seen from above flabelliform (fan-shaped), broadly attached, thick at the base, slightly soft at the margin when mature. *Pileus surface* non-laccate (dull), furrowed, incised, sulcate, smooth when young, usually silky, soft, and slippery surface when fresh, undulating on the upper surface, somewhat spatulate to uneven, with a crust (0.2–0.4 mm), woody from mature to older, and lined or cracked crust occurs when old. *Pileus color* usually homogenous with greyish orange (6B3–6B6), brownish orange (6C5–6C6), and brown (6D7–6D8) at the base extending to the margin of maturity fruiting bodies. *Context* up to 0.5–1.8 cm thick, compact and hard, trimitic hyphal, with clamp connections, hyaline, with walls varying in thickness with simple septa, composed of narrow and sparingly branched; generative hyphae 1.3–3.2 μm broad ($n = 30$) with hyaline; skeletal hyphae 2.8–4.7 μm broad ($n = 30$), usually thick walled; binding hyphal 2.1–4.2 μm width ($n = 30$) with walls varying in thickness. *Hymenophore* reddish brown (8D7). *Tube layers* 0.4–1.2 cm in length. *Stipe* almost sessile and broadly attached when present. *Margin* blunt edged, wavy, slippery from young, softer, and often white (8A1) when youth to maturity, and light brown (6D5) when old, present yellow line between edge of the margin and close to underside of basidiomes. *Pore* 4–7 in number per mm, sub-circular to circular. *Pore surface* white (11A1) when present, pale yellow (4A3) to greyish yellow (4B3–4B4) when scratched or bruised, discolored when touched.

Hyphal structure: hyphal system trimitic hyphal, with clamp connections, usually reddish-brown (8D7–8D8); generative hyphae (1.2–)1.5–2.4–3.0(–3.6) μm broad ($n = 30$), thin walled and hyaline; skeletal hyphae (2.7–)3.2–3.6–4.2(–4.8) μm broad ($n = 30$), dextrinoid, abundant thick wall; binding hyphae (2.5–)3.0–3.5–4.0(–4.4) μm broad ($n = 30$), thick wall,

branched, usually intertwined the generative and skeletal hyphae, mostly dark-brown near the tube layers, appearing alongside Bovista-type ligative hyphae, hymenial, sword-like apices at the context. *Basidiospores* mostly ellipsoid to broadly ellipsoid or oblong with double walls, (5.8–)6.2–7.2–8.4(–9.2) × (5.4–)5.7–5.4–6.8(–7.7) μm (\bar{x} = 7.3 × 5.6 μm, n = 50) μm, with Q = 1.48–1.52, L = 7.32 μm, W = 5.68 μm (including myxosporium), (4.8–)5.2–6.0–6.7(–7.2) × (4.6–)4.9–5.5–5.7(–6.2) μm (\bar{x} = 6.2 × 5.6 μm, n = 50) μm, with Q = 1.08–1.14, L = 6.24 μm, W = 5.67 μm (including myxosporium), overlaid by hyaline, dextrinoid, echinulae, echinulate brown inner wall, light yellow (4A4–4A5) to greyish yellow (4B5–4B6) in 5% KOH. *Basidia* not seen.

Habitat: solitary, on decaying hardwood of *Machilus yunnanensis*, living tree of *Albizia mollis* and *Pinus* spp.

Specimens examined: **CHINA**, Yunnan Province, Kunming Institute of Botany garden, 25°08'39"N, 102°44'30"E, 1956 m elev., 31 December 2016, T. Luangharn, HKAS 97411.

Notes: *Ganoderma gibbosum* belongs to the family Ganodermataceae, was first described from Australia (Saccardo 1888). *Ganoderma gibbosum* has been recorded from China (Zhao et al. 1983), India (Kaliyaperumal and Kalaichelvan, 2007), Korea (Jargalmaa et al. 2017), Laos (Hapuarachchi et al. 2019b), and Thailand (Hapuarachchi et al. 2019b). This species is distinctive in having non-laccate basidiomes, and ellipsoid with double-walled basidiospores (Zhao et al. 1983). *Ganoderma gibbosum* has been reported to cause white rot and several other diseases in hard woods (Ryvarden 2004) and is widely distributed in both tropical and temperate areas (Cao et al. 2012). It was considered to be a subspecies of *G. applanatum* (Zhao 1989), while *G. applanatum* was the earlier name of *G. australe* (Hseu 1990). *Ganoderma australe* and *G. gibbosum* were renamed as *G. incrassatum* based on their monophyletic origin (Smith and Sivasithamparam, 2003), since it had been well recognized that *G. applanatum* was synonymized with *G. applanatum* (Moncalvo and Ryvarden, 1881).

Ganoderma leucocontextum T.H. Li, W.Q. Deng, Sheng H. Wu, D.M. Wang & H.P. Hu,
Mycotaxon. 56: 82 (2015) (Figure 9)

Faces of fungi number: FoF 06247

Basidiomes: flabelliform, sub-dimidiolate, stipitate. *Pileus* 6–14 cm in length, 4–12 cm in width, and 1–3.2 cm thick. *Pileus* flabelliform, spathulate, stipitate, sub-dimidiolate to dimidiolate, umbonate, somewhat semicircular, plump, concentrically sulcate zone, broad and thick at the base, mostly radial from the center extending to the margin, tough to break when dried, often thick at the center, slightly soft at the margin, light in weight when dried, and not woody. *Pileus surface* convex, furrowed, imbricate, incised, glossy, shiny, spathulate, shallow sulcate when fresh, umbonate or uneven, usually smooth layers at center when young to age, non-laccate to weakly laccate when present, strongly laccate and glossy when mature, weakly laccate where the new hyphae are in active development (margin), irregularly ruptured crust overlying the context, and tough to break when dried. *Pileus color* usually homogenous with orange (6A7) and deep orange (6A8) at the center towards stipe, extending deep orange (5A8) from the center, slight deep yellow (4A8) where the new hyphae are in active development when mature, usually red (11B7–11B8) at the center, and orange (6A7) to deep orange (6A8)–(6B8) extending to the upper margin surface from mature to old. *Context* up to 0.3–2.4 cm thick near stipe, white context when fresh, yellowish white (1A2) when dried, soft and fibrous, trimitic hyphal, with clamp connections, hyaline, with walls varying in thickness with simple septa, and unbranched. *Tubes* 0.3–1.2 cm in length. *Stipe* 3–10 cm in length, 4–7 cm in width, sub-cylindrical to cylindrical, almost stipitate, broad at the base, some presented short stipitate, strongly laccate with dark brown (8F7–8F8) to greyish ruby (12E6–12E7) when mature, and greyish brown (8E4) when old. *Margin* wavy, softer, slippery

when young, laccate when mature, strongly laccate when old, orange yellow (4A7) to deep yellow (4D8) where the new hyphae are in active development, deep orange (6A7–6A8) to brown (6D8) from mature to old. *Pore* 4–6 in number per mm, sub-circular, some circular or angular. *Pore surface* white (11A1) when present, yellowish white (2A2) when mature, brownish orange (6C7–6C8) when scratched or bruised, discolored when touched.

Hyphal structure: hyphal system trimitic, usually golden brown (5D7), yellowish brown (5D8) to reddish brown (8D7–8D8) in KOH; generative hyphae 2.3–5.2 μm broad ($n = 30$), thin walled, hyaline, with clamp connections; skeletal hyphae 2.6–5.5 μm broad ($n = 30$), thick walled, unbranched or rarely branched; binding hyphae 1.8–4.2 μm width ($n = 30$), usually thin to thick walled, branched, hymenial with sword-like apices in the context. *Basidiospores* mostly ellipsoid to broadly ellipsoid, double walls, (8.8–)9.3–10.7–11.4(–12.6) \times (6.8–)7.4–8.3–8.7(–9.2) μm ($\bar{x} = 10.5 \times 8.4 \mu\text{m}$, $n = 50$) μm , with $Q = 1.22$ –1.28, $L = 10.52 \mu\text{m}$, $W = 8.41 \mu\text{m}$ (including myxosporium), (7.8–)8.1–8.5–8.8(–9.1) \times (5.2–)5.7–6.0–6.5(–6.9) μm ($\bar{x} = 8.3 \times 6.2 \mu\text{m}$, $n = 50$) μm , with $Q = 1.32$ –1.38, $L = 8.34 \mu\text{m}$, $W = 6.18 \mu\text{m}$ (excluding outer myxosporium), overlaid by hyaline, apically echinulae, truncate, some turgid, vesicular appendix, inner walled echinulate, golden yellow (5B7), greyish orange (5D6) to yellowish brown (5D7), outer walled reddish brown in 5% KOH. *Cystidia absent*.

Cultures characteristics white mycelial after incubation at 30°C for 10 days.

Habitat: solitary, on the decaying hardwood of unknown tree.

Specimens examined: **CHINA**, Yunnan Province, Baoshan, 25°09'35"N, 99°09'49"E, 1973 m elev., on 26 October 2016, J. Xu, HKAS 97401.

Notes: *Ganoderma leucocontextum* was introduced by Patouillard (1907) from the Tibet Autonomous Region of China. This species can be easily recognized by its stipitate, white context, thick stipe, broadly ellipsoid basidiospores (9–12.5 \times 7–9 μm), coarse echinulae, mostly-regular cuticle hyphae, and its deciduous wood habitat (Li et al. 2015). The holotype

is similar to *G. lucidum* from Europe (Li et al. 2015); however, the illustrated differences in macro- characteristics of the European *G. lucidum* are smaller basidiospores ($7\text{--}12 \times 6\text{--}8 \mu\text{m}$), a deeper-colored context that is usually rust colored, becoming dark purple to brown in older portions (Ryvarden 1976; Ryvarden and Gilbertson 1993). Additionally, *G. leucocontextum* also resembles to the widely cultivated *G. lucidum* (*G. lingzhi*) in East Asia (Li et al. 2015), but the Chinese *G. lucidum* has a deeper-colored context and is even darker near the tube layer, with shorter cutis elements ($20\text{--}40 \times 7\text{--}15 \mu\text{m}$) and smaller spores ($8\text{--}11.5 \times 5.5\text{--}8.5 \mu\text{m}$) (including myxosporium) than *G. leucocontextum* (Wang et al. 2012). Our *G. leucocontextum* collection from Hainan Province agrees well with the descriptions provided by Li et al. (2015).

Ganoderma lingzhi S.H. Wu, Y. Cao & Y.C. Dai, Fungal Diversity. 56 (1): 54 (2012)

(Figure 10)

Faces of fungi number: FoF 06248

Basidiomes: annual or perennial, stipitate. *Pileus* 0.5–3.2 cm in length, 0.5–3 cm in width, up to 1 cm thick at the base. *Pileus* reniform to circular, or sub-flabellate when seen from above, concentrically sulcate zones with turberculate, glabrous when youth to maturity, bumps when mature, often tough to break when dried, often with undefined concentric zones at the center that extend to the margin, thick at the center, slightly soft at the margin. *Pileus surface* shiny, silky, smooth, and soft when young, hard and woody old, frequently furrowed and shallow sulcate on upper surface, undulating, somewhat spathulate to uneven when mature, covered by irregularly ruptured thin crust, and strongly laccate from mature to old. *Pileus color* usually homogenous with yellowish red (8A7–8A8) at the center, slight reddish orange (7A7–7A8), and reddish brown (8E8) at the deep-sulcate margin from mature to old. *Context* up to 0.2–0.8 cm thick at the base, some thin-walled, with abundant thick-walled to sub-solid

hyphae, containing fibrous pithy context, bearing clamp connections, with dark brown (7F7) melanoid bands occurring. *Tube* hard and woody, thin walled, frequently branched, with clamped connection, and often dark brown (7F7–7F8) when dried. *Stipe* up to 3–812 cm in length, up to 0.3–1 cm in width, centrally stipitate, almost sub-cylindrical to cylindrical, concolorous with the pileus, often reddish brown (8E7–8E8) and strongly laccate from mature to old. *Margin* soft when young, strongly laccate when mature, some wavy, slippery when wet, smooth, softer, thinner than the base, and soft than the center, often deep orange (5A8) to golden yellow (5B7–5B8) from mature to old. *Pore* 4–6 in number per mm, sub-circular to circular, sometimes angular. *Pore surface* initially white (11A1), pale yellow (3A3) to yellow (3A7) when mature, turns light brown (7D5), brown (7D7–7D8) to dark brown (7F6–7F8) when scratched or bruised, becoming discolored when touched.

Hyphal structure: hyphal system trimitic, with clamp connections, hyaline, thin to thick walled, tapering at branch, sometimes swollen at the attachment point, composed of some narrow hyphae; generative hyphae (1.3–)1.8–2.3–2.6(–2.8) μm broad ($n = 30$), hyaline, and thin walled; skeletal hyphae (2.1–)2.5–3.9–4.8(–5.2) μm broad ($n = 30$) abundant with walls varying in thickness, unbranched, sometimes sub-solid; binding hyphae (1.7–)2.1–2.8–3.6(–4.3) μm broad ($n = 30$), usually with walls varying in thickness, narrow to sub-solid, usually presenting as orange white (6A2), pale orange (6A3) to light orange (5A5) of thin walled, and pale red (6A3) of thick walled, with sub-solid in KOH. *Basidiospores* mostly ellipsoid, some oblong with double walls, (8.0–)8.6–9.6–10.5(–11.0) \times (6.2–)6.7–8.4–9.6(–10.1) μm ($\bar{x} = 9.5 \times 8.3 \mu\text{m}$, $n = 50$) μm , $Q = 1.11$ –1.17, $L = 9.49 \mu\text{m}$, $W = 8.31 \mu\text{m}$ (including myxosporium), (7.0–)7.4–7.9–8.5(–9.0) \times (4.2–)4.5–5.6–5.9(–6.4) μm ($\bar{x} = 7.8 \times 5.6 \mu\text{m}$, $n = 50$) μm , with $Q = 1.36$ –1.41, $L = 7.80 \mu\text{m}$, $W = 5.62 \mu\text{m}$ (excluding outer myxosporium), overlaid by hyaline, dextrinoid, echinulae, inner wall echinulate with greyish orange (6B5–6B6) to brownish orange (7D4–7D5), and outer walled usually dark brown (7E8–7E8) to reddish brown (8E6–

8E8) in KOH.

Habitat: solitary, on the living tree of *Graucoides schotky*.

Specimens examined: **CHINA**, Yunnan Province, Xishan Forest Park, 24°57'53"N, 102°53'10"E, 2013 m elev., on 29 October 2016, T. Luangharn, HKAS 97398.

Notes: *Ganoderma lingzhi* was propose as a new species by Cao et al. (2012), which is limited to the temperate regions of East Asia (Cao et al. 2012). This fungus is regarded as one of the world's most important medicinal fungi, able to prevent or relieve various human diseases (Wasser 2005; Dai et al. 2009). *Ganoderma lingzhi* is characterized by its distinctive yellow context, thick dissepiments, absence of concentric growth zones in the context, basidiospore size, yellow pore surface, and presence of melanoid bands upon maturity (Cao et al. 2012; Dai et al. 2017). *Ganoderma lingzhi* was long assigned to *G. lucidum* as they share similar characteristics, such as a reddish brown pileal surface, basidiospores size, and regular clavate cuticle cells (Cao et al. 2012). *Ganoderma lingzhi* can be distinguished from former species by several characteristics (Cao et al. 2012). The most striking characteristics by which *G. lingzhi* can be distinguished from *G. lucidum* are the distinctiveness of the yellow pore surface and the appearance of melanoid bands when mature (Cao et al. 2012). However, among the Chinese *Ganoderma* species, *G. flexipes*, *G. multipileum*, *G. sichuanense*, *G. tropicum* and *G. tsugae* are the most similar species to *G. lingzhi* because they share a reddish-brown pileal surface, similar basidiospores, and cuticle cells (Cao et al. 2012).

Ganoderma lucidum (Curtis) P. Karst., Revue Mycologique Toulouse. 3(9): 17 (1881)

(Figure 11)

≡ *Boletus rugosus* Jacq., Flora Austriaca. 2: 44, f. 169 (1774)

≡ *Boletus lucidus* Curtis, Fl. Londinensis. 4: 72, t. 224 (1781)

≡ *Polyporus lucidus* (Curtis) Fr., Systema Mycologicum. 1: 353 (1821)

- ≡ *Grifola lucida* (Curtis) Gray, A natural arrangement of British plants. 1: 644 (1821)
- ≡ *Fomes lucidus* (Curtis) Cooke, Grevillea. 13(68): 118 (1885)
- ≡ *Placodes lucidus* (Curtis) Quél., Enchiridion Fungorum in Europa media et praesertim in Gallia Vigentium.: 170 (1886)
- ≡ *Phaeoporus lucidus* (Curtis) J. Schröt., Kryptogamen-Flora von Schlesien. 3-1(4): 491 (1888)
- = *Boletus flabelliformis* Leyss., Flora halensis.: 219 (1761)
- = *Agaricus pseudoboletus* Jacq., Miscellanea austriaca ad botanicum, chemiam et historiam naturalem spectantia. 1: 26, t. 41 (1773)
- = *Boletus obliquatus* Bull., Herbar de la France. 1: t. 7 (1781)
- = *Boletus vernicosus* Bergeret, Phytonomatotechnie universelle. 1: 99 (1783)
- = *Agaricus lignosus* Lam., Encyclopédie Méthodique, Botanique. 1-1: 51 (1783)
- = *Boletus dimidiatus* Thunb., Fl. Japonica.: 348, f. 39 (1784)
- = *Boletus castaneus* Weber, Suppl. Fl. hols.: 13 (1787)
- = *Boletus laccatus* Timm, Flora megapolitanae Prodomus exhibeus plantas ductatus Megapolitano.: 269 (1788)
- = *Boletus crustatus* J.J. Planer, Index Plantarum quas in Agro Erfurtensi sponte provenientes.: 280 (1788)
- = *Agarico igniarium* trulla Paulet, Traité des champignons. 2: 95, pl. 10:1-2 (1793)
- = *Boletus verniceus* Brot., Flora Lusitanica. 2: 468 (1804)
- = *Ganoderma ostreatum* Lázaro Ibiza, Revta R. Acad. Cienc. exact. fis. nat. Madr.: 110(1916)
- = *Ganoderma nitens* Lázaro Ibiza, Revta R. Acad. Cienc. exact. fis. nat. Madr.: 104 (1916)

Faces of fungi number: FoF 06250

Basidiomes: imbricate, reniform, stipitate. *Pileus* up to 2–5 cm in length, 2–4 cm in width, and 0.8–2.2 cm thick. *Pileus* stipitate, reniform, imbricate, irregular, some laterally, and flabelliform with a contracted, concentrically sulcate zone, irregularly ruptured crust overlying the context, radial or branched from the center extending to the margin, tough to break when dried, often thick at the center, slightly soft at margin, and leathery when aged, tough to break when dried. *Pileus surface* weakly laccate when present, strongly laccate and glossy when mature, weakly laccate where the new hyphae are in active development (margin), smooth layer at the center from young to age, usually furrowed, incised, undulate to sulcate, somewhat spatulate to uneven, some woody or corky when old. *Pileus color* usually yellowish red (8B7–8B8) at the center, slight to reddish orange (7B7–7B8), and orange (6A7–6A8) on upper pileus surface. *Context* up to 0.4–1.4 cm thick at the base, abundant thick-walled, sub-solid hyphae, concentric lines of various shade, bearing clamp connections, light brown (6D6) to brown (6D8, 6E8), presenting dark brown (6F8) melanoid bands. *Tube* hard, often brown (7D7) to dark brown (7F7). *Stipe* up to 8–16 cm in length, up to 0.6–1.8 cm in width, central stipe, cylindrical, thick with uneven at the base (up to 1.8 cm), usually dark brown (7F7–7F8), laccate, and cracked when old. *Margin* often 0.4–1 cm, orange (6A7–6A8) on upper surface, and reddish yellow (4A8) under surface, thin and soft than the center. *Pore* (75–)110–145(–165) μm , circular, some angular, 4–6 in number per mm. *Pore surface* white (11A1) to light brown (7D6), turning to brown (7D7–7D8) to dark brown (6F6) when scratched or bruised.

Hyphal structure: *hyphal system* trimitic, with clamp connections, hyaline, thin walled with abundant thick walled with simple septa, sparingly branched, swollen by melanoid bands, usually pale orange (5A3), light orange (5A5), to reddish orange (8A7–8A8) in KOH; generative hyphae up to 1.7–3.2 μm broad ($n = 30$), almost hyaline, usually thin to thick

walled, with clamp connections, and sparingly branched and flexuous; skeletal hyphae 3.0–6.4 μm broad ($n = 30$), usually thick walled with clamp, and abundantly branched and flexuous; binding hyphae 2.0–5.6 μm broad ($n = 30$), usually thick walled with abundant branches, and occurring melanoid bands. *Basidiospores* ellipsoid to broadly ellipsoid, some globose with double walls, with a truncate apex, with double wall, mostly overlaid by hyaline myxosporium, eusporium bearing fine, short, and distinct, coarse, echinulae, hyaline, turgid, vesicular appendix, (7.7–)8.4–9.4–10.6(–11.5) \times (5.2–)5.9–6.3–7.1(–8.4) μm , ($\bar{x} = 9.5 \times 6.4 \mu\text{m}$, $n = 50$) μm , with $Q = 1.47$ – 1.52 , $L = 9.52 \mu\text{m}$, $W = 6.34 \mu\text{m}$ (including myxosporium), (6.0–)6.9–7.3–8.1(–8.5) \times (4.6–)4.9–5.3–5.8(–6.2) μm ($\bar{x} = 7.5 \times 5.2 \mu\text{m}$, $n = 50$) μm , with $Q = 1.41$ – 1.47 , $L = 7.52 \mu\text{m}$, $W = 5.24 \mu\text{m}$ (excluding outer myxosporium), brownish orange (6C8), (6D8) to brown (6E5) of endosporium (inner wall) with brown (7E7–7E8) exosporium (outer wall) in Congo red, brownish orange (6C8) in 5% KOH, and yellowish brown in Melzer's reagent.

Habitat: solitary, on decaying hardwood of *Quercus* sp. in the native forest.

Specimens examined: **CHINA**, Yunnan Province, Honghe, 23°21'50"N, 103°22'24"E, 874 m elev., on 15 August 2017, T. Luangharn, MFLU 19-2161.

Notes: *Ganoderma lucidum* (Curtis) P. Karst., was originally reported from temperate England (Moncalvo and Ryvarden 1997). Previously, it was characterized as *Boletus lucidus* Curtis (1781) and then *Polyporus lucidus* (Curtis) Fr. (1821) (Karsten 1881). The species *P. lucidus* was characterized by having a laccate pileus and stipe. The molecular phylogenetic analyses indicated that the *G. lucidum* from Europe is not conspecific to the Chinese *G. lucidum*; thus, the European *G. lucidum* remained the true *G. lucidum* and the Chinese *G. lucidum* was proposed as *G. lingzhi* (Cao et al. 2012), and most of the collections named *G. lucidum* in East Asia were not conspecific with the *G. lucidum* found in Europe (Yang and Feng 2013). *Ganoderma lucidum* is relatively common in Europe, while its geographic

distribution in East Asia, East Africa, Europe, North America, Asia, and other parts of the world is largely unknown (Moncalvo et al. 1995; Postnova and Skolotneva 2010).

Several studies of *Ganoderma* have used the name *G. lucidum* for any lacate *Ganoderma* species, as *Ganoderma* are ly highly variable, often resulting in taxonomic and phylogenetic confusion, especially with regards to *G. lucidum* (Moncalvo et al. 1995). The taxonomy of *Ganoderma* has been a constant topic of debate due to the high levels of phenotypic plasticity in its species. Several characteristics of *Ganoderma* are similar to *G. lucidum*, such as *G. multipileum* (Hou 1950), *G. oregonense* (Murrill 1902), *G. resinaceum* (Patouillard 1889), *G. tsugae*, *G. lingzhi*, *G. lucidum*, *G. sichuanense*, and *G. sinense* (Zhao et al. 1983; Pilotti et al. 2004; Zhou et al. 2008; Wang et al. 2009; Cao et al. 2012; Dai et al. 2017; Loyd et al. 2018) from China. Cao et al. (2012) has clarified a different new species, Chinese *G. lucidum* as *G. lingzhi* (Lingzhi), which has an East Asian distribution. The most striking characteristics that differentiate *G. lucidum* from *G. lingzhi* are the presence of melanoid bands in the context, a yellow pore surface and thick dissepiments (80–120 µm) at maturity (Cao et al. 2012). The molecular evidence reveals *G. lucidum* and *G. sinense* as two clearly different species (Zhou et al. 2008; Liao et al. 2015).

In China, the first-reported *G. lucidum* was illustrated based on collections from Guizhou Province (Patouillard 1907). Then, Teng (1934) reported more collections from different regions of China, and many subsequent collections have been reported (Tai 1979; Zhao and Zhang 2000; Wu and Dai 2005; Cao et al. 2012; Dai 2012). Recently, this fungus has been reported to be distributed worldwide based on gross similarity of features, e.g., in Europe (Ryvarden and Gilbertson 1993), Asia (Núñez and Ryvarden 2000; Zhao and Zhang 2000), America (Bazzalo and Wright 1982; Gilbertson and Ryvarden 1986), and Africa (Ryvarden and Johansen 1980). Our collection from Yunnan Province, China, also agrees well with the descriptions provided from Asia.

Ganoderma multiplicatum (Mont.) Pat., Bulletin de la Société Mycologique de France 5: 74

(1889)

(Figure 12)

≡ *Polyporus multiplicatus* Mont., Annales des Sciences Naturelles Botanique. 1: 128

(1854)

≡ *Fomes multiplicatus* (Mont.) Cooke, Grevillea. 14 (69): 18 (1885)

≡ *Scindalma multiplicatum* (Mont.) Kuntze, Revisio generum plantarum. 3 (2): 519

(1898)

Faces of fungi number: FoF 06251

Basidiomes: annual or perennial, stipitate with short base.

Pileus 1.5–7.5 cm in length, 0.5–4 cm in width, and up to 1.5 cm thick at the base. *Pileus* dimidiate, flabelliform, reniform, usually flat, convex, imbricate, umbonate or uneven, rarely unguulate, glabrous when present, often with undefined concentric zones at the the center that extend to the margin, and thick at the base, slightly soft at margin when mature. *Pileus surface* shiny, silky, smooth, and soft when young, non-laccate (dull) when mature, hard and woody when old, frequently furrowed and shallow sulcate, undulating, somewhat spathulate to uneven on upper surface when mature, covered by irregularly ruptured thick crust, slightly dull and faded when mature to old, compact and hard when mature, woody to corky from mature to old. *Pileus color* usually homogenous with greyish orange (6B3) at the center slight to brownish orange (6C4) and pale orange (6A3), usually yellowish grey (4B2) at the margin when mature, and brown (6E8) when dried. *Context* up to 0.4–1 cm thick at the base, mostly brown (6E8) to dark brown (7F6–7F8) of cuticle cells, and dark brown (6F6) melanoid bands, thick walled, some fibrous pithy context, usually separated by layers of context tissue at the base. *Tube* woody hard, often with dark brown (7F7–7F8) when dried, with sulcate at

different levels. *Stipe* short stipitate, dark brown (7F7), and a differentiated zone at the point of attachment. *Margin* up to 1 cm thick, initially white (5A1), yellowish grey (4B2) when mature, turns light brown (6D4) to brown (6E8) when scratched or bruised, often slippery when wet, softer when young, thinner than the center. *Pore* 4–7 in number per mm, sub-circular to circular, some angular. *Pore surface* initially white (7A1) to yellowish white (1A2), becoming pale orange (5A3) when mature, light brown (7D6) to brown (7D8) when handled, scratched and bruised.

Hyphal structure: hyphal system trimitic; generative hyphae 2.1–4.8 μm ($\bar{x} = 2.2$, $n = 30$) in diam, clamp, almost hyaline, thin to thick walled, composed of narrow and spare branches; skeletal hyphae 3.2–6.5 μm width ($n = 30$), usually thick walled, hyaline, some branched and intertwined hyphae; binding hyphal 2.4–5.7 μm width ($n = 30$), thick walled, many branches, and comprised Bovista-type ligative hyphae. *Basidiospores* mostly ellipsoid with double walls, (7.8–)8.7–10.8–12.2(–13.3) \times (6.9–)7.4–9.1–10.0(–10.7) μm , ($\bar{x} = 10.7 \times 9.1 \mu\text{m}$, $n = 50$) μm , with $Q = 1.15$ –1.22, $L = 10.79 \mu\text{m}$, $W = 9.13 \mu\text{m}$ (including myxosporium), (5.4–)5.9–6.6–7.1(–7.7) \times (4.9–)5.4–5.8–6.2(–6.7) μm ($\bar{x} = 6.6 \times 5.8 \mu\text{m}$, $n = 50$) μm , with $Q = 1.11$ –1.17, $L = 6.64 \mu\text{m}$, $W = 5.82 \mu\text{m}$ (excluding outer myxosporium), inner walled deep orange (6A8), brownish orange (7C7–7C8) in KOH, outer walled dark brown (7E6), dark brown (7E8) to reddish brown (8E8) in KOH. *Cutis* usually composed of clavate cells.

Habitat: solitary, on stump of *Quercus* spp.

Specimens examined: **CHINA**, Yunnan Province, Jinning District, 24°41'17"N, 102°13'15"E, 1912 m elev., on 8 October 2017, T. Luangharn, MFLU 19-2152.

Notes: *Ganoderma multiplicatum* (Mont.) Pat. was originally collected from French Guyana (Moncalvo and Ryvarden 1997). This species has a distinctive form with its reddish-black pileus, a not-fully homogenous context, tuberculate hyphal ends in cuticle cells, with small sub-globose to broadly ellipsoid basidiospores (7–8 \times 5–6 μm) (Gottlieb and Wright 1999;

Ryvarden 2000; Ryvarden 2004; Bolaños et al. 2016). *Ganoderma multiplicatum* has been considered most similar to *G. chaliceum* (Corner 1983) and also considered a synonym of *G. subamboinense* Henn. (Ryvarden 2000), but Lima et al. (2014) illustrated that *G. chaliceum* and *G. subamboinense* are in different clades, suggesting they are not synonymous.

Our *G. multiplicatum* specimen was collected from Yunnan Province, China. It is similar to the original description, showing ellipsoid basidiospores, while sub-globose basidiospores could not be observed. This species has been reported from Africa, (Steyaert 1980), Asia (Zhao 1989), China (Zhao et al. 1979; Zhao 1989; Zhao and Zhang 2000; Wang and Wu 2007), India (Bhosle et al. 2010), Myanmar (Hapuarachchi et al. 2019b), Taiwan, PRC (Wang and Wu 2007), and Neotropical regions of Brazil, Colombia, and Venezuela (Bolaños et al. 2016).

Ganoderma resinaceum Boud., Bulletin de la Société Mycologique de France. 5; 72 (1889)
(Figure 13)

≡ *Fomes resinaceus* (Boud.) Sacc., Sylloge Fungorum. 9: 179 (1891)

≡ *Scindalma resinaceum* (Boud.) Kuntze, Revisio generum plantarum. 3(2); 519 (1898)

≡ *Friesia resinacea* (Boud.) Lázaro Ibiza, Revta R. Acad. Cienc. exact. fis. nat. Madr.: 591 (1916)

≡ *Ganoderma lucidum* subsp. *resinaceum* (Boud.) Bourdot & Galzin, Bulletin de la Société Mycologique de France. 41; 177 (1925)

≡ *Ganoderma lucidum* var. *resinaceum* (Boud.) Maire, Fungi Catalaunici: Contributions á l'étude de la Flore Mycologique de la Catalogne: 38 (1933)

= *Ganoderma chaffangeonii* Pat., Bulletin de la Société Mycologique de France. 5: 74 (1889)

= *Polyporus polychromus* Copel., Annales Mycologici. 2 (6): 507 (1904)

= *Ganoderma praelongum* Murrill, North American Flora. 9 (2): 121 (1908)

- = *Ganoderma argillaceum* Murrill, North American Flora. 9 (2): 122 (1908)
- = *Ganoderma pulverulentum* Murrill, North American Flora. 9 (2): 121 (1908)
- = *Ganoderma subperforatum* G.F. Atk., Botanical Gazette Crawfordsville. 46 (5): 337 (1908)
- = *Ganoderma areolatum* Murrill, Bulletin of the New York Botanical Garden. 8: 149 (1912)
- = *Mensularia vernicosa* Lázaro Ibiza, Revista de la Real Academia de Ciencias Exactas Fisicas y Naturales Madri. 14: 740 (1916)
- = *Ganoderma subtuberculosum* Murrill, Lloydia. 7 (4): 326 (1945)

Faces of fungi number: FoF 06252

Basidiomes: annual, perennial, short stipitate.

Pileus 1.5–12.5 cm in length, 1–7 cm in width, and up to 2 cm thick at the base. *Pileus* dimidiate, flabelliform, reniform, convex, imbricate, umbonate or uneven, some unguulate, concentric zones at the center that extend to the margin, broadly attached, thick at the base, slightly soft at the margin when mature. *Pileus surface* glossy, shiny, silky, smooth, and soft when young, laccate when mature, furrowed and shallow sulcate, undulating, somewhat spathulate to uneven on upper surface when mature, covered by irregularly ruptured thin crust, slightly dull and faded when mature to old, compact and hard when mature, woody to corky when mature to old. *Pileus color* reddish brown (10E7–10E8) at the center, slight to yellowish red (8B7–8B8), reddish orange (7A7–7A8), and light orange (5A5–5A6) closed to the margin, and white (4A1) at the margin. *Context* up to 0.4–1 cm thick at the base, mostly greyish yellow (4C6) to dark brown (7F6–7F8) cuticle cells, and dark brown (6F6) melanoid bands, thick walled, some fibrous pithy context, usually separated by layers of context tissue at the base. *Tube* woody hard, often dark brown (7F7–7F8) when dried, concolorous with

pore surface, and sulcate at different levels. *Stipe* short stipitate, usually reddish brown (10E7–10E8), and a differentiated zone at the point of attachment. *Margin* up to 1.5 cm thick, initially white (5A1), yellowish grey (4B2) when mature, turning light brown (6D4) to brown (6E8) when scratched or bruised, often slippery when wet, softer when young, thinner than the center. *Pore* 4–7 in number per mm, angular to circular. *Pore surface* initially white (7A1) to yellowish white (1A2), becoming light orange (5A5) when mature, light brown (7D6) to brown (7D8) when handled, scratched, or bruised.

Hyphal structure: hyphal system trimitic; generative hyphae 2.1–4.7 μm ($\bar{x} = 3.6$, $n = 30$) in diam, clamp, almost hyaline, thin walled, composed of sparse branches; skeletal hyphae 3.2–6.2 μm width ($n = 30$), usually thick walled, hyaline, some branched and intertwined hyphae; binding hyphal 2.8–5.1 μm width ($n = 30$), thick walled and occasionally thick walled, without septate hyphae, many branches, and composed of Bovista-type ligative hyphae. *Basidiospores* mostly ellipsoid with double walls, (7.6–)8.4–9.4–10.5(–11.3) \times (6.5–)7.1–8.4–9.0(–9.8) μm , ($\bar{x} = 9.3 \times 8.2 \mu\text{m}$, $n = 50$) μm , with $Q = 1.10$ –1.16, $L = 9.31 \mu\text{m}$, $W = 8.24 \mu\text{m}$ (including myxosporium), (6.5–)7.1–8.2–9.1(–9.8) \times (4.8–)5.3–5.7–6.8(–7.3) μm ($\bar{x} = 8.1 \times 5.6 \mu\text{m}$, $n = 50$) μm , with $Q = 1.42$ –1.48, $L = 8.13 \mu\text{m}$, $W = 5.62 \mu\text{m}$ (excluding outer myxosporium), inner walled orange (5A6) to deep orange (5A7–5A8, 6A8) in KOH and greyish brown (5C5–5C6) in Melzer’s reagent, outer walled dark brown (7E6–7E8) to reddish brown (8E8) in KOH and light brown (6D5–6D6) to brown (6D7–6D8) in Melzer’s reagent.

Habitat: solitary, on living tree of *Albizia mollis* (Wall.) Boiv.

Specimens examined: CHINA, Yunnan Province, Kunming Institute of Botany, 25°08'39"N, 102°44'30"E, 1962 m, on 12 July 2017, T. Luangharn, MFLU 19-2153.

Notes: *Ganoderma resinaceum* was introduced by Boudier in 1889 from France (Patouillard 1889). This species has also been described by Steyaert (1972) and Ryvarden and Gilbertson

(1993). *Ganoderma resinaceum* is distinctively characterized by variable pileus coloration, a fibrous spongy homogeneous context, larger basidiospores, and an amyloid pileipellis (Ryvarden 2004). This species is considered to have characteristics similar to *G. pfeifferi* in its upper crust resinous layers. However, this species has a dark brown to umber context and wider spores. In addition, *G. resinaceum* also shares similarities with *G. lucidum*, while *G. lucidum* possesses a varying light context without a dark zone above the tubes and no resinous layer on the crust (Steyaert 1980; Ryvarden 1985; Ryvarden and Gilbertson 1993). *Ganoderma resinaceum* was evaluated to the species complex base on the molecular evidence (Moncalvo et al. 1995), but in the phylogenetic analysis it cannot be distinguished from *G. lucidum* (Hong and Jung 2004). However, several researchers suggested that *G. resinaceum* differs from *G. lucidum* (Mohanty et al. 2011; Cao et al. 2012; Zhou et al. 2015).

Ganoderma sandunense Hapuar., T.C. Wen & K.D. Hyde, *Mycosphere* 10 (1): 274 (2019)

Taxonomy and phylogenetic analyses are shown in Hapuarachchi et al. (2019b).

Notes: *Ganoderma sandunense* is characterized by its ferruginous laccate pileus, orbicular, strongly laccate, several layers thick, basidiospores $12.1\text{--}13.8 \times 9.2\text{--}10.5 \mu\text{m}$, relatively large broadly ellipsoid to ellipsoid basidiospores, with a light brown eusporium bearing fine, hyaline, short, and distinct echinulae. This fungus is solitary on rotten wood in dry dipterocarp forests and in upper-mixed deciduous forests from Guizhou Province, China.

Ganoderma sichuanense J.D. Zhao & X.Q. Zhang, *Acta mycol. sin.*: 159 (1983)

Taxonomy and phylogeny analysis are shown in Yao et al. (2013) and Thawthong et al. (2017)

Notes: *Ganoderma sichuanense* is characterized by its substipitate to stipitate, flabellate to reniform, laccate, with orange brown to bay on the upper basidiomes, basidiospores $9.0\text{--}11.0$

× 6.5–8.0 μm, relatively ovoid, truncate at the apex, yellowish brown, with a dark brown eusporium bearing thick echinulae, overlaid by a hyaline myxosporium. This fungus is solitary around the stump of *Quercus* sp. from Sichuan Province, China.

Ganoderma sinense J.D. Zhao, L.W. Hsu & X.Q. Zhang, Acta Mycologica Sinica. 19: 272 (1979) (Figure 14)

= *Ganoderma formosanum* T.T. Chang & T. Chen. Transactions of the British Mycological Society. 82(4): 731 (1984)

Faces of fungi number: FoF 06253

Basidiomes: annual, stipitate, sub-dimidiolate.

Pileus 2–6 cm in length, 2–4 cm in width, and 0.3–1 cm thick. *Pileus* stipitate, sub-dimidiolate to dimidiolate, flabelliform, spatulate, umbonate, radial from the center extending to the margin, tough to break when dried, often thick at the center, slightly soft at the margin, light in weight when dried, and without woody. *Pileus surface* laccate, convex, some radial furrowed to furrowed, imbricate, incised, glossy, shiny, spatulate, shallow sulcate when fresh, umbonate or uneven, strongly laccate and glossy when mature, and weakly laccate where the new hyphae are in active development (margin), usually smooth layers at the center when young to age, irregularly ruptured crust overlying the context, and leathery when age when break. *Pileus color* usually homogenous with brownish red (8C7–8C8) to reddish brown (8D7–8D8) at the center towards stipe, extending brownish red (9C8) from the center, slight to the margin when mature, usually reddish brown (8E5–8E8) upper margin surface when old. *Context* up to 0.3–1 cm thick near stipe, dry, upper layer brownish orange (6C8) when fresh, greyish orange (5B5) at lower layers, with dark brown (8F7) when dried, soft and fibrous, covered with thin crust, some present woody, trimitic hyphal, hyaline, thin to thick

walled with simple septa, with branched. *Tube* 0.3–0.6 cm in length, brown (7D8). *Stipe* 4–16 cm in length, sub-cylindrical to cylindrical, almost stipitate with broadly and thick at the base, irregularly ruptured crust overlying, usually strongly laccate with brown (7D8) to dark brown (8F8) when mature, and dark brown (8F8) when old. *Margin* soft, some wavy, laccate when mature, weakly laccate when old, brownish orange (6D8) when mature to old. *Pore* 4–6 in number per mm, sub-circular to circular. *Pore surface* white (11A1) to yellowish white (2A2) when mature, discolored when touched, brownish (6E7) to dark brown (6F7) when scratched or bruised.

Hyphal structure: hyphal system trimitic, with clamp connections, usually light orange (5A5), orange (5A7), golden yellow (5B7–5B8), sometimes brownish red (8C7) in KOH; generative hyphae 1.3–2.4 μm broad ($n = 30$), hyaline, thin walled, with clamp connections; skeletal hyphae 3.1–5.2 μm broad ($n = 30$), usually hyaline, thick walled, unbranched, and solid; binding hyphae 2.9–5.2 μm width ($n = 30$), thin to thick walled, with branched, hymenial with sword-like apices in the context. *Basidiospores* mostly ellipsoid to broadly ellipsoid, with double walls, with size range of (9.5–)10.2–11.4–12.3(–13.1) \times (7.0–)7.6–8.4–9.3(–10.2) μm ($\bar{x} = 11.2 \times 8.5 \mu\text{m}$, $n = 50$) μm , with $Q = 1.28$ –1.36, $L = 11.24 \mu\text{m}$, $W = 8.50 \mu\text{m}$ (including myxosporium), (8.3–)9.4–10.3–11.5(–12.3) \times (6.1–)6.7–7.1–7.5(–8.0) μm ($\bar{x} = 10.2 \times 7.2 \mu\text{m}$, $n = 50$) μm , with $Q = 1.41$ –1.47, $L = 10.32 \mu\text{m}$, $W = 7.13 \mu\text{m}$ (excluding outer myxosporium), overlaid by hyaline, apically, short echinulae, truncate, some turgid vesicular appendix, inner wall echinulate, orange (5A7), deep orange (5A8, 5B8), orange (6B8), with brownish orange (6B8), outer wall usually brownish red (8C7–8C8) in 5% KOH.

Habitat: solitary, on decaying and living tree of *Albizia mollis* (Wall.) Boiv., living tree *Quercus* sp.

Specimens examined: CHINA, Yunnan Province, Baoshan, 25°09'35"N, 99°09'49"E, 1973 m elev., on 11 November 2017, T. Luangharn, MLFU 19-2173.

Notes: Ganoderma sinense was described from China, characterized by a uniformly brown to dark brown context and slightly longitudinally crested basidiospores (Wang and Wu 2007). This species was considered as a species with high phenotypic (Zhao and Zhang 2000; Hapuarachchi et al. 2019). Our *G. sinense* collection was obtained from Yunnan Province, China, and agrees well with the description of the holotype as described by Wang and Wu (2007). Several reports have also illustrated *G. sinense* from China (Bi et al. 1993; Zhao and Zhang 2000; Wu and Dai 2005). *Ganoderma sinense* is considered to have characteristics similar to *G. lucidum*, while *G. sinense* illustrates differences in macro- characteristics in its thin pileus, long stipes, and rarely branched skeletal hyphae with Bovista-type binding hyphae (Pegler and Yao 1996), and these two different species are distinguished in reports (Zhou et al. 2008; Liao et al. 2015). *Ganoderma sinense* is also reported to have similar characteristics with *G. formosanum*, hence *G. formosanum* was treated as synonymous and consequently the earliest used valid name was *G. sinense* (Wang and Wu 2007).

Ganoderma tsugae Murrill, Bulletin of the Torrey Botanical Club. 29; 601 (1902) (Figure 15)

≡ *Fomes tsugae* (Murrill) Sacc. & D. Sacc., Sylloge Fungorum. 17: 123 (1905)

≡ *Polyporus tsugae* (Murrill) Overh.: 714 (1915)

= *Polyporus metallicus* Lloyd, Mycological Writings. 6 65): 1099 (1920)

Faces of fungi number: FoF 06254

Basidiomes: annual, sub-dimidiolate, stipitate.

Pileus 2–16 cm in length, 2–9 cm in width, and 0.5–3 cm thick at the base. *Pileus* stipitate, sub-dimidiolate to dimidiolate, flabelliform, spathulate, umbonate, concentrically sulcate zone, radial from the center extending to the margin, tough to break when dried, often thick at the center, slightly soft at the margin, light in weight when dried, with woody or corky when

dried. *Pileus surface* laccate, convex, radial furrowed, imbricate, incised, glossy, shiny, spathulate, shallow sulcate, umbonate or uneven, strongly laccate and glossy when mature, and weakly laccate where the new hyphae are in active development (margin), usually smooth layers at the center when young to age, irregularly rugose, irregularly ruptured, thin-crust overlying the context, tough to break when dried. *Pileus color* usually homogenous with brownish red (8C7–8C8) to reddish brown (8D7–8D8) at the center towards the stipe and margin surface when mature to old. *Context* up to 0.4–2.2 cm thick near the stipe, brownish orange (7C7–7C8) to brown (7D8) on the upper layers, brownish red (8C6) when dried, soft and fibrous, covered with thin crust, some present woody, dimitic hyphal, hyaline, thin walled with simple septa, branched. *Tube* 0.3–1.6 cm in length, with dark brown (7F5). *Stipe* 4–10 cm in length, 2 cm thick, sub-cylindrical to cylindrical, almost stipitate and broad and thick at the base, irregularly ruptured crust overlying, usually strongly laccate with brown (7D8) to dark brown (8F8) when mature, usually dark brown (8F8) when old. *Margin* soft, some wavy, laccate when mature, and strong laccate when old, brownish red (8C7–8C8) to reddish brown (8D7–8D8) from mature to old. *Pore* 4–6 in number per mm, circular or angular. *Pore surface* yellowish white (4A2) when present to yellowish white (2A2) when mature, discolored when touched, brownish (6E7) when scratched or bruised.

Hyphal structure: hyphal system trimitic, with clamp connections; generative hyphae 3.1–4.8 μm broad ($n = 30$), hyaline, thin walled, with clamp connections; skeletal hyphae 3.1–6.8 μm broad ($n = 30$), usually hyaline, thick walled, non-septate, unbranched, and solid; binding hyphae 3.9–5.0 μm width ($n = 30$), with walls varying in thickness, with many branches, some hymenial with sword-like apices in the context. *Basidiospores* mostly ellipsoid to broadly ellipsoid, with double walls, with size range of (9.7–)10.6–12.7–14.3(–15.8) \times (7.3–)8.4–10.7–11.5(–12.4) μm ($\bar{x} = 12.7 \times 10.5 \mu\text{m}$, $n = 50$) μm , with $Q = 1.18$ –1.24, $L = 12.68 \mu\text{m}$, $W = 10.48 \mu\text{m}$ (including myxosporium), (8.3–)9.4–10.8–12.6(–13.1) \times

(6.1–)6.9–7.6–8.3(–9.2) μm ($\bar{x} = 10.7 \times 7.6 \mu\text{m}$, $n = 50$) μm , with $Q = 1.36\text{--}1.45$, $L = 10.68 \mu\text{m}$, $W = 7.59 \mu\text{m}$ (excluding outer myxosporium), overlaid by hyaline, apically and short echinulae, truncate and turgid vesicular appendix, inner walled echinulate, brownish orange (6C7–6C8), outer walled usually dark brownish (6F7–6F8) in 5% KOH.

Habitat: solitary, on decaying *Quercus* spp. tree.

Specimens examined: **CHINA**, Yunnan Province, Jinning District, 24°41'17"N, 102°13'15"E, 1973 m elev., on 11 November 2017, JC. Xu, HKAS 97406.

Notes: *Ganoderma tsugae* has been treated as a synonym of *G. lucidum* (Atkinson 1908; Haddow 1931; Steyaert 1977). This fungus is characterized by a laccate and concentric yellowish red pileus, stipitate, fan-shaped, sulcated with a yellow margin, ovoid, verrucose, and truncated basidiospores. *Ganoderma tsugae* is widely distributed across the USA (Gilbertson and Ryvarden, 1986; Loyd et al. 2018). The phylogenetic analysis supported *G. tsugae* as an independent species distinct from *G. lucidum*, as it grows exclusively on conifers, especially on *Tsuga* and *Abies* species, while *G. lucidum* inhabits mostly angiospermous trees (Zhou et al. 2015). According to Loyd et al. (2018), *G. tsugae* is similar to *G. oregonense* as they share a distinctly white context tissue, rough basidiospores, and are predominately associated with conifers decay.

Taxonomy of Ganoderma from Laos

Ganoderma adpersum (Schulzer) Donk Proc. K. Ned. Akad. Wet., Ser. C, Biol. Med. Sci.

72(3): 273 (1969)

(Figure 16)

≡ *Polyporus adpersus* Schulzer, Flora.: 11 (1878) [MB#169202]

= *Polyporus linhartii* Kalchbr., Fungi Hong. 252 (1884)

= *Ganoderma europaeum* Steyaert, Bulletin du Jardin Botanique de l'État à Bruxelles.

31: 70 (1961)

Faces of fungi number: FoF 06241

Basidiomes: annual, sub-dimidiolate, sessile.

Pileus 3–22 cm in length, 2–14 cm broad, and 1–4 cm thick at the base. *Pileus* sessile, perennial, sub-dimidiolate to dimidiolate, flabelliform, spatulate, umbonate, concentrically sulcate zone, somewhat round and plump when young, somewhat imbricate with flabelliform (fan-shaped) when seen from above, broadly attached, radial from the center extending to the margin, tough to break when dried, thick at the base, slightly soft at the margin when mature, light in weight with woody or corky when dried. *Pileus surface* non-laccate (dull), convex, radially furrowed, incised, spatulate, shallow sulcate, usually silky, soft, and smooth when young, and slippery surface when fresh, thick crust overlaying the context, a differentiated zone at the point of attachment, and tough to break when dried. *Pileus color* usually homogenous with reddish orange (7A8) to brown (7D7–7D8) at the center when mature, golden yellow (5B7), brownish orange (5C5–5C6, 6D5) when old towards the stipe and margin surface. *Context* up to 0.5–2.5 cm thick near stipe, brown (7D8) to brownish red (8F8) when mature or dried, soft and fibrous, covered with hard and thick crust, woody when old, trimitic hyphal system present, hyaline, thin to thick walled, branched. *Tube* 0.5–1.5 cm in length, usually homogenous with orange (5A7) to dark orange (5A8), reddish orange (7A7–7A8), and greyish red (8C7). *Stipe* 1–5 cm in length, 6 cm thick at the base, almost sessile or some short, stipitate, broad and thick at the base, usually non-laccate, and brown (7D8) to dark brown (8F8) when mature. *Margin* 0.5–4 cm thick, round, soft, brown (7D8) when mature to old, and usually concolourous with the pileus. *Pore* 4–6 in number per mm, sub-circular to circular. *Pore surface* yellowish white (2A2) when mature, discolored when touched, brown (7D8) when scratched or bruised.

Hyphal structure: hyphal system di-trimitic, with clamp connections, orange (6A7) to deep orange (6A8), brownish yellow (6C8) to brownish orange (7C8); generative hyphae 1.4–2.8 μm broad ($n = 30$), hyaline, thin walled, with clamp connections; skeletal hyphae 2.1–4.4 μm broad ($n = 30$), usually hyaline, thick walled, and solid; binding hyphae 1.5–3.6 μm broad ($n = 30$), with walls varying in thickness, with many branches, some hymenial with sword-like apices in the context. *Basidiospores* mostly ellipsoid to broadly ellipsoid, sometimes ovoid, with double walls, with a size range of (6.9–)7.5–9.1–9.8(–10.6) \times (4.7–)5.4–6.4–7.0(–7.7) μm ($\bar{x} = 9.1 \times 6.4 \mu\text{m}$, $n = 50$) μm , with $Q = 1.38$ –1.45, $L = 9.09 \mu\text{m}$, $W = 6.41 \mu\text{m}$ (including myxosporium), (5.6–)6.3–7.6–8.4(–9.2) \times (4.2–)4.7–5.6–6.1(–6.6) μm ($\bar{x} = 7.6 \times 5.7 \mu\text{m}$, $n = 50$) μm , with $Q = 1.35$ –1.40, $L = 7.6 \mu\text{m}$, $W = 5.52 \mu\text{m}$ (excluding outer myxosporium), overlaid by hyaline, apically, and short, echinulae, a truncate and turgid vesicular appendix, light yellow (4A4–4A5), greyish yellow (4B3–4B4) to brownish orange (5C5–5C6), (5B8) of inner wall, outer wall usually yellowish brown (5D8, 5E7–5E8) to brown (6D7–6D8) in 5% KOH.

Habitat: solitary, near the roots of a living *Mangifera indica* tree.

Specimens examined: LAOS, Luang Namtha Province, 20°35'47"N, 101°04'07"E, 935 m elev., on 20 June 2018, T. Luangharn, MFLU 19-2177.

Notes: *Ganoderma adpersum* was first reported by Donk (1969), who described it as *Polyporus adpersus* Schulzer. *Ganoderma adpersum* is characterized by a distinctive non-laccate, sessile, and applanate pileus. *Ganoderma adpersum* is often confused with *G. applanatum*, *G. australe* and *Polyporus vegetus* (Tortić 1971). Ryvarden (1976) and Ryvarden and Gilbertson (1993) considered the correct name of *G. adpersum* as a synonym of *G. australe*, with *G. adpersum* can be differentiated from *G. applanatum* by its thicker at base, and larger basidiospores, while *G. applanatum* tends to emerge sharply at right angles (Steyaert 1972; Ryvarden and Gilbertson 1993), with molecular analysis also supporting the

differentiation (Gottlieb et al. 2000; Moncalvo et al. 2000; Guglielmo et al. 2008; De Simone and Annesi 2012; Arulpanandi and Kalaichelvan 2013; Zhou et al. 2015). Our collections agree well with the description provided by Ryvarden and Gilbertson (1993).

Ganoderma australe (Fr.) Pat., Bull. Soc. mycol. Fr. 5(2, 3): 65 (1889) (Figure 17)

Faces of fungi number: FoF 06242

Basidiomes: annual, perennial, sessile.

Pileus 6–11 cm in length, 2–6.5 cm broad, and 0.8–2 cm thick. *Pileus* single, flabelliform, sub-dimidiolate, spatulate, umbonate, sulcate, obtuse from host, broadly attached, consistency hard and tough when mature, tough to break when dried, often thick at the center, slightly soft at the margin, and usually woody and corky when dried. *Pileus surface* corky, convex, furrowed, spatulate, mostly umbonate or uneven, usually non-laccate (dull) when mature to old, smooth layers when present, deep sulcate at the center, thick and hard crust, irregularly ruptured crust overlying the surface, presented dark brown (7F8) cracked crust when old, and tough to break when dried. *Pileus color* often homogenous with pale red (7A5), reddish orange (7A6–7A7), brown (7D8) to orange red (8B7–8B8) on the upper surface of the base closed to the margin when mature to old. *Context* up to 0.5–1.2 cm thick near stipe, fibrous, composed of coarse loose fibrils, brown (6D7–6D8), dark brown (6F7) to reddish brown (8D8, 8D9), covered with thick crust, trimitic hyphal, thick walled, dense with simple septa, typically with narrow lumen, flexuous, and many branches. *Tube* 0.4–1 cm in length, brown (7D8) to dark brown (6F8). *Stipe* sessile with broad attached. *Margin* white (4A1) when present to mature, soft and slippery when growing fresh, shallow sulcate at the margin, covered and blunt when old. *Pore* 4–6 in number per mm, sub-circular to circular, sometimes angular. *Pore surface* initially white (4A1), slightly yellowish white (3A2) when mature,

brownish red (8C4–8C5) when scratched, bruised, or discolored when touched.

Hyphal structure: *hyphal system* trimitic, with clamp connections, usually brownish orange (6C5–6C7) in KOH; generative hyphae 2.0–3.4 μm broad ($n = 30$), thin walled, hyaline, tapering branches, with clamp connections; skeletal hyphae 3.1–4.5 μm broad ($n = 30$), usually thick walled, sometimes branches, nearly solid; binding hyphae 2.5–3.9 μm width ($n = 30$), usually thick walled, many branches, nearly solid, and hymenial with sword-like apices in the context. *Basidiospores* mostly ellipsoid to broadly ellipsoid, with double walls, with a size range of (6.5–)7.6–10.1–11.4(–12.5) \times (5.9–)6.7–8.5–9.2(–10.3) μm ($\bar{x} = 7.2 \times 5.9 \mu\text{m}$, $n = 50$) μm , with $Q = 1.19$ –1.26, $L = 7.24 \mu\text{m}$, $W = 5.92 \mu\text{m}$ (including myxosporium), (5.1–)6.2–8.3–9.7(–10.9) \times (4.4–)5.6–6.8–7.7(–8.8) μm ($\bar{x} = 8.2 \times 6.8 \mu\text{m}$, $n = 50$) μm , with $Q = 1.17$ –1.26, $L = 8.23 \mu\text{m}$, $W = 6.79 \mu\text{m}$ (excluding outer myxosporium), overlaid by hyaline, brown apically, bearing fine, distinct, short, echinulae, truncate, turgid vesicular appendix, inner wall light brown (6D4–6D5) to brown (7E7–7E8), and outer wall usually reddish brown (8E5–8E6, 8F7) in 5% KOH.

Habitat: solitary, on the decaying hardwood of *Canarium* sp. tree species.

Specimens examined: LAOS, Luang Namtha Province, 20°35'47"N, 101°04'07"E, 935 m elev., on 20 June 2018, T. Luangharn, MFLU 19-2171.

Ganoderma gibbosum (Blume & T. Nees) Pat., Ann. Jard. Bot. Buitenzorg, suppl. 1: 114 (1897) (Figure 18)

Faces of fungi number: FoF 06243

Basidiomes: annual or perennial, sessile, subflabellate or subdimidiate.

Pileus 2–16 cm in length, 2–9 cm broad, and 0.5–2.3 cm thick. *Pileus* conks, convex, imbricate, umbonate, uneven, unguulate, usually round when occurring, primordial, somewhat

round and plump when young, flabelliform (fan-shaped) when seen from above, broadly attached when mature, thick at the base when mature. *Pileus surface* non-laccate, smooth when young, silky, soft, and slippery surface when fresh, furrowed on the surface with sulcate to undulating, somewhat spathulate to uneven, incised, compact, hard, and woody when older, covered with a tough crust (0.1–0.2 mm), usually dull and faded when mature to old, and some occurred the lined or cracked crust when older. *Pileus color* brownish orange (5C5), reddish white (7A2) at the base, and homogenous with greyish orange (6B3), brownish orange (7C5), and light brown (6D4) towards the center of maturity fruiting bodies, white (6A1) at the margin, and usually the color changes to dark brown (8F8) upon touch, becoming greyish red (8C4–8F6), reddish brown (8E6) to dull red (10C3) when old. *Context* up to 0.3–1.3 cm thick, trimitic hyphal with clamp connections, hyaline, with walls varying in thickness, simple septate, composed of narrow, and sparse branches; generative hyphae 1.0–3.4 μm broad ($n = 30$), with walls varying in thickness, and hyaline; skeletal hyphae 4.0–6.4 μm broad ($n = 30$) with thick walls; binding hyphal 2.0–6.5 μm broad ($n = 30$). *Hymenophore* up to 3 mm in length, with reddish brown (8D7). *Tube layers* 0.2–0.8 cm in length, up to 80–163 μm in width, and non-presented when young. *Stipe* almost sessile, broadly attached when present. *Margin* wavy, blunt, slippery when wet, thinner at the base and soft than the center, often white (8A1) from youth to maturity, and light brown (6D5) when old. *Pore* 4–7 in number per mm, when fresh, angular, sub-circular to circular. *Pore surface* white (11A1) to orange white (6A2) when fresh, scratched or bruised, and discolored when touched.

Hyphal structure: hyphal system trimitic, with clamp connections, usually reddish brown (8D7–8D8); generative hyphae 1.0–3.8 μm broad ($n = 30$), with walls varying in thickness, hyaline, and unbranched; skeletal hyphae 4.2–6.4 μm broad ($n = 30$), light brown (7D6) to brown (7D8) in Melzer's reagent with dextrinoid, usually thick walled; binding hyphae 1.8–

6.4 μm broad ($n = 30$), brown (6F8) to reddish brown (8D8) in Melzer's reagent, thick walled, many branches, the generative and skeletal hyphae usually intertwined, mostly dark brown (6F7) near the tube layers; Bovista-type ligative hyphae, hymenial with sword-like apices in the context. *Basidiospores* mostly ellipsoid to oblong ellipsoid or broadly ellipsoid, with double walls, with a size range of (4.4–)6.8–8.2–9.5(–10.2) \times (3.6–)4.2–5.2–5.8(–6.5) μm ($\bar{x} = 8.3 \times 5.4 \mu\text{m}$, $n = 50$) μm , with $Q = 1.49$ –1.56, $L = 8.34 \mu\text{m}$, $W = 5.44 \mu\text{m}$ (including myxosporium), (3.6–)5.3–6.0–7.2(–8.3) \times (2.8–)3.9–4.5–5.4(–6.2) μm ($\bar{x} = 6.2 \times 4.5 \mu\text{m}$, $n = 50$) μm , with $Q = 1.34$ –1.40, $L = 6.24 \mu\text{m}$, $W = 4.51 \mu\text{m}$ (excluding outer myxosporium), overlaid by hyaline, dextrinoid, echinulae, inner wall echinulate brown, light brown (6D6–6D8) to brown (6E8) in 5% KOH, and reddish brown (8F6) to dark brown (8F8) in Melzer's reagent. *Basidia* not seen.

Habitat: occasionally on decaying wood of *Pinus* spp.

Specimens examined: **LAOS**, Luang Prabang, 19°51'51"N, 102°11'39"E, 589 m elev., on 12 July 2018, T. Luangharn, MFLU 19-2190.

Ganoderma nasalanense Hapuar., Pheng. & K.D. Hyde, *Mycosphere* 10 (1): 272 (2019)

Taxonomy and phylogeny analysis are shown in Hapuarachchi et al. (2019b)

Notes: *Ganoderma nasalanense* is characterized by its duplex context, rigid basidiomes, purplish-black laccate crust, dark brown to grey on the upper pileus surface, brown tube layer, purplish-brown pore surface, trimitic hyphal system and relatively large, broadly ellipsoid to ellipsoid light-brown basidiospores (12.1–13.8 \times 9.2–10.5) μm , truncate, with fine and short echinulae (10–12 \times 6.5–7.5) μm , and a cuticle composed of strongly amyloid, clavate cells, usually with several irregular lobes or protuberances (30–80 \times 3–10.5) μm . This fungus is solitary on decaying hardwood tree trunks in Huaphanh Province, Laos.

Taxonomy of Ganoderma from Myanmar

Ganoderma hoehnelianum Bres., Annales Mycologici. 10 (5): 502 (1912) (Figure 19)

Faces of fungi number: FoF 06260

Basidiomes: annual or perennial, sessile.

Pileus is 0.5–4 cm in length, 0.5–3 cm broad, and up to 0.5 cm-thick at the base. *Pileus* is applanate, umbonate, sub-reniform to reniform, or sub-flabellate to glabrous from youth to maturity, small in size, obtuse from host, often with undefined concentric zones at the center that extend to the margin, thick at the center, slightly thin and soft at the margin, and tough to break when dried. *Pileus surface* shiny, smooth, and soft when young, frequently furrowed and shallowly sulcate on the upper surface, which is undulating and somewhat spathulate to uneven in maturity, covered by a thin crust, faded or weakly laccate when young, laccate when mature, and woody when old. *Pileus color* homogenous, reddish-brown (8E4–8E8) to dark brown orange (9F5–9F8) at the center when mature. *Context* up to 0.1–0.3 cm thick at the base, brown (7D7–7D8), reddish brown (8E7–8E8), and dark brown (7F7), abundantly thick walled, with clamp connections, sub-solid hyphae, containing a fibrous pithy context. *Tube layers* hard and corky, branched, with clamped connections, often brown (7D7) to dark brown (7F8). *Stipe* almost sessile, broadly attached when present. *Margin* obtuse from the center, soft and smooth when young, laccate when mature, slightly wavy and slippery when wet, often yellowish white (3A2) on the upper surface and pale yellow (4A3) under the margin. *Pores* 4–6 in number per mm. *Pore surface* usually white (11A1) to light orange (5A4) when young, greyish orange (6B4–6B6) when mature, turning light brown (7D5–7D6), brown (7D7) and reddish brown (8D5–8D7) when scratched or bruised, becoming discolored when touched.

Hyphal structure: *hyphal system* is dimitic, bearing clamp connections, hyaline, with walls varying in thickness with simple septa and some swollen differentiated zones at the point of attachment, composed of several narrow hyphae, and sparingly branched; generative hyphae (1.8–)2.4–3.2–3.7(–4.2) μm broad ($n = 30$) are thin walled and hyaline; skeletal hyphae (3.3–)3.9–5.2–5.8(–6.2) μm broad ($n = 30$) have walls of varying thickness, sometimes sub-solid; binding hyphae (2.3–)2.9–4.2–4.9(–5.6) μm broad ($n = 30$) are usually thick walled with many branches, and appear alongside Bovista hyphae, which are usually present from orange (5A6–5A7) to deep orange (6A8) and thin walled, as well as also reddish brown (8D7–8D8, 9D8) to brownish red (9C8) in Melzer’s reagent. *Basidiospores* are mostly ellipsoid and featuring several ovoid with double walls, (6.7–)7.5–9.8–11.8(–13.2) \times (5.7–)6.4–7.8–9.6(–10.8) μm ($\bar{x} = 9.7 \times 7.8 \mu\text{m}$, $n = 50$) μm , with $Q = 1.22$ – 1.28 , $L = 9.73 \mu\text{m}$, $W = 7.78 \mu\text{m}$ (including myxosporium), (5.8–)6.4–8.5–9.3(–10.2) \times (4.8–)5.3–6.1–6.8(–7.4) μm ($\bar{x} = 8.4 \times 6.4 \mu\text{m}$, $n = 50$) μm , with $Q = 1.29$ – 1.35 , $L = 8.43 \mu\text{m}$, $W = 6.41 \mu\text{m}$ (excluding outer myxosporium), overlaid by a hyaline, dextrinoid, and echinulate whose inner wall presents as brownish orange (5C5–5C6) to brownish yellow (5C7–5C8) and dark brown (6F8) to reddish brown (8E7–8E8) in Melzer’s reagent.

Specimens examined: **MYANMAR**, Chin State, Tedim Township, on 13 July 2019, P. E. Mortimer, MFLU 19-2168.

Notes: *Ganoderma hoehnelianum* was introduced by Bresadola (1912) from Indonesia. Of distinctive note are its context color, basidiospore characteristics, and cuticular cells (Wang and Wu 2010). Wang et al. (2005) reported that the original Chinese *G. hoehnelianum* was an earlier name for *G. shangsiense*, and this fungus was also recorded as *G. shangsiense* in China’s Hainan Province (Li et al. 2010; Song et al. 2016; Dai et al. 2011; Hapuarachchi et al. 2018b). Our *G. hoehnelianum* is first recorded from Myanmar, and its description is consistent with the descriptions provided by Wang and Wu (2010).

Ganoderma myanmarensis Karunarathna, Mortimer, Cin & Luangharn, **sp. nov.** (Figure 20)

Faces of Fungi number: FoF 06262

Index Fungorum number: IF 556794

MycoBank number: MB 832605

Diagnosis *Ganoderma myanmarensis* is characterised by its shell-like pileus with strongly laccate appearance coloured orange, golden yellow at center, extending reddish yellow and yellow at margin, usually homogenous reddish brown when mature, a white to light yellow that indicates active development on the margin of the pileal surface, a white pore surface when fresh, an orange, deep-orange to reddish-orange context, and absence of melanoid bands.

Holotype: **MYANMAR**, Chin State, Tedim Township, on dead wood of *Casternopsis* sp., 13 July, 2019, LT2019 (MFLU 19-2167).

Etymology: The species epithet “*myanmarensis*” refers to the country, Myanmar, where the holotype specimen was collected.

Basidiomes: annual or perennial, stipitate.

Pileus up to 5–16 cm in length, 4–15 cm in width, and 1–2.5 cm thick at the base. *Pileus* shell-like (involute from the margin toward the center), sub-reniform to reniform or sub-flabellate to circular when viewed from above, often with undefined zones at the center that extend to the margin, with a thick center that is slightly soft at the margin, and tough to break when dried. *Pileus surface* shiny, silky, smooth, and soft when fresh, hard when old, furrowed, sulcate to undulating, somewhat spathulate to uneven, incised, faded or weakly laccate when young, strongly laccate on maturity or when old. *Pileus color* homogenous, orange (5A6–5A7, 6B7–6B8), golden yellow (5B6), and yellowish red (8A7–8A8) at the

center, slightly reddish orange (7A7–7A8) and reddish brown (8E8) where deeply sulcate, reddish yellow (4A7) and yellow (2A6) at the margin. *Context* up to 0.6–1.5 cm thick at the base, with some areas thin walled, thick walled, along with sub-solid hyphae, bearing clamp connections, and absence of melanoid bands. *Tube layers* woody and hard, usually thin walled, frequently branched, with clamped connections, and often dark brown (7F7) when dried. *Stipe* up to 3–8 cm in length, up to 1.3–4 cm in width, centrally stipitate, nearly sub-cylindrical to cylindrical, concolorous with the pileus, often dark brown (9F7–9F8) to violet brown (11F7–11F8), strongly laccate from maturity to old. *Margin* obtuse from the center, strongly laccate at the edge, occasionally wavy, slippery when wet, smoother, softer, and thinner, at the base, often yellow (2A6), and deep orange (5A8) to golden yellow (5B7–5B8) on maturity to old. *Pores* 4–6 in number in number per mm, (60–)80–125(–165) μm , angular, sub-circular to circular. *Pore surface* usually white (11A1), turns light brown (7D5), brown (7D7–7D8) to dark brown (7F6–7F8) when scratched or bruised, becomes discolored when touched.

Hyphal structure: hyphal system trimitic, with walls of varying thickness, clamp connections present, simple septate hyphae, hyaline, narrow and sparingly branched; generative hyphae (1.2–)1.8–2.2–2.4(–2.7) μm broad ($n = 30$), hyaline, thin walled; skeletal hyphae (1.8–)2.5–3.8–4.5(–5.0) μm broad ($n = 30$), abundant and thick walled, sometimes sub-solid; binding hyphae (1.5–)1.9–2.7–3.3(–4.3) μm broad ($n = 30$), usually thick walled. *Basidiospores* (8.2–)9.3–11.6–12.5(–13.6) \times (5.3–)6.0–7.1–7.8(–8.6) μm , ($Q_m = 1.7$, $Q = 1.2–2.4$, including myxosporium) ($n = 50$), ($\bar{x} = 11.5 \times 7.1 \mu\text{m}$, $n = 50$) μm , with $Q = 1.57–1.65$, $L = 11.52 \mu\text{m}$, $W = 7.13 \mu\text{m}$ (including myxosporium), (7.5–)8.3–9.1–10.4(–11.9) \times (4.9–)5.4–6.2–6.8(–7.5) μm ($\bar{x} = 9.0 \times 6.3 \mu\text{m}$, $n = 50$) μm , with $Q = 1.40–1.48$, $L = 9.04 \mu\text{m}$, $W = 6.27 \mu\text{m}$ (excluding outer myxosporium), mostly ellipsoid to broadly ellipsoid, or globose, double walls, overlaid by hyaline; exosporium (outer wall) smooth, hyaline, endosporium (inner

wall) coarse and echinulate, with turgid vesicular appendix, and pale-yellow inner wall that can also present in KOH, and yellowish brown (5E6–5E7) to brown (6E6–6E7) in Melzer's reagent, outer wall pale orange (6A3–6A4) to orange (6A6–6A7) in KOH, reddish orange (7A8), greyish red (7B6–7B8), and dark brown (7F7–7F8) in Melzer's reagent.

Habitat: solitary, near the hardwood root of unknown tree species.

Additional specimens: **MYANMAR**, Chin State, Tedim Township, 13 July 2019, P. E. Mortimer, MFLU 19-2167 (holotype) and MFLU 19-2169 (paratype).

Ganoderma williamsianum Murrill, Bulletin of the Torrey Botanical Club 34: 478 (1907)
(Figure 21)

≡ *Elfvigia williamsiana* (Murrill) Imazeki, Bulletin of the Government Forest Experimental Station Meguro. 57: 106 (1952)

Faces of fungi number: FoF 06261

Basidiomes: annual or perennial, stipitate.

Pileus 0.5–1.5 cm in length, 0.5–1 cm in width, and up to 0.5 cm thick at the base. *Pileus* sub-reniform to reniform, or sub-flabellate to circular when young, often with concentric zones at the center that extend to the margin, thick at the center, slightly soft at the margin, tough to break when dried. *Pileus surface* shiny, silky, and soft when young, generally furrowed, smooth, sulcate to undulating, somewhat spatulate to uneven when mature, hard and woody when old, incised on the surface, faded or weakly laccate when young, and usually laccate when mature. *Pileus color* usually homogenous, orange (5A7–5A8) to deep orange (5B7–5B8), slightly white (5A1), and yellowish white (3A2, 4A2) at the margin when young. *Context* is up to 0.3–1.5 cm thick at the base, which is usually thick walled, with

abundant walls varying in thickness, sub-solid hyphae containing a fibrous pithy context with clamp connections, and brown (7D8) melanoid bands when mature. The *tube layers* hard, frequently branched with clamp connections, and often dark brown (7F8). *Stipe* 1.5 cm in length, 1 cm in width when young, lateral to nearly dorsal, entrally stipitate, almost sub-cylindrical to cylindrical, concolorous with the pileus, thick when young, and often brownish orange (7C6) to dark brown (9F7–9F8). *Margin* obtuse from the center, blunted when young, occasionally wavy, slippery when wet, smooth and soft when young (1.5 cm), and often white (3A1) to yellowish white (3A2) when young. *Pore surface* white (11A1) to yellowish white (3A2), turns light brown (7D5) to brown (7D7–7D8) when scratched or bruised, becomes discolored when touched.

Hyphal structure: hyphal system trimitic, bearing clamp connections, hyaline, with walls of varying thickness, simple septate, swollen differentiated zones at the point of attachment, composed of several narrow hyphae, and sparingly branched; generative hyphae (1.6–)1.9–2.3–2.5(–2.6) μm broad ($n = 30$), thin walled and hyaline; skeletal hyphae (3.1–)3.4–3.9–4.3(–4.8) μm broad ($n = 30$), with walls of varying thickness, with some sub-solid; binding hyphae (1.6–)1.9–2.6–2.9(–3.4) μm broad ($n = 30$), usually thick walled, appearing alongside Bovista hyphae with many branches, whose thick walls usually present as light orange (5A5), orange (5A6–5A7, 6B7–6B8) to deep orange (5A8, 6A8), and reddish brown (8D7–8D8) to brownish red (9C8) in Melzer's reagent. *Basidiospores* not observed.

Specimens examined: MYANMAR, Chin State, Tedim Township, on 13 July 2019, P. E. Mortimer, MFLU 19-2170.

Notes: *Ganoderma williamsianum* belongs to the group of laccate *Ganoderma*. This fungus was originally reported in the Philippines and is easily recognized, with its small, dense, ungluate of pileus with pale, yellow pores, large spores, and a short skeletal (Corner 1983; Moncalvo and Ryvarden 1997). Among the *Ganoderma* species, there are some similarities

between *G. williamsianum* and *G. brownii*, such as both having yellow pores (Gilbertson and Ryvarden 1986); however, *G. brownii* can be differentiated from *G. williamsianum* by its dull pileus with a hard crust (Lowe and Gilbertson 1961), skeletal hyphae with occasional branching, and smaller basidiospores (Lowe and Gilbertson 1961; Steyaert 1972; Gilbertson and Ryvarden 1986; Gottlieb and Wright 1999). *Ganoderma williamsianum* is the earliest valid name for *G. meijiangense* (Wang and Wu 2010), containing similarities to *G. meijiangense*, such as both having sessile, annual crust basidiomes, and white margin, but *G. williamsianum* can be differentiated from *G. meijiangense* by its distinguished, dark-brown context without any layer of black crust and a distinct cuticular composition (Zhao 1988). Our *G. williamsianum* collection from Myanmar marks a new record, as it shares the traits similar to Moncalvo and Ryvarden (1997), macro- traits as they how sessile, annual crust like basidiomes, and white margin, trimitic hyphal system bearing clamp connections, hyaline, and walls of varying thickness.

Taxonomy of Ganoderma from Thailand

Ganoderma adpersum (Schulzer) Donk Proc. K. Ned. Akad. Wet., Ser. C, Biol. Med. Sci. (Figure 22)

Faces of fungi number: FoF 06241

Basidiomes: annual to perennial, applanate, sub-dimidiolate.

Pileus 2–14 cm in length, 2–7 cm in width, and 0.5–1.8 cm thick at base. *Pileus* sub-dimidiolate to dimidiolate, flabelliform, spatulate, umbonate, concentrically sulcate zone, sessile or short stipitate, distinctly contracted base, somewhat round and plump when young, somewhat imbricate when viewed from above, flabelliform (fan-shaped), usually broadly

attached with radial from center extending to the margin, tough when break, thick at base, slightly soft at the margin when mature, light weight when dried, and woody and corky texture when dried. *Pileus surface* non-laccate (dull), convex, radial furrowed, incised, spathulate, shallow sulcate, usually silky, soft, smooth when young, and slippery surface when fresh, thick crust overlying the context, differentiated zone at the point of attachment, several layers thick, and leathery when broken. *Pileus color* usually homogenous with brown (7D7–7D8, 7E7–7E8, 8D8) at center towards stipe to margin surface when mature. *Context* up to 0.3–1.3 cm thick near the stipe, brown (7D8) to brownish red (8F8) when mature and dried, soft and fibrous, covered with hard and thick crust, woody when old, trimitic hyphal, hyaline, with walls varying in thickness, with branches. *Tube* 0.2–1 cm in length, usually homogenous with orange (5A7) to dark orange (5A8), reddish orange (7A7–7A8), and greyish red (8C7). *Stipe* 1–3.8 cm in length, 3.5 cm thick at base, almost sessile, some shortly stipitate, broadly thick at base, usually non-laccate, brown (7D8) to dark brown (8F8) when mature. *Margin* round, soft, occurring brown (7D8) from mature to old, presented numerous undulations, and usually concolourous with the pileus. *Pores* 4–6 in number in number per mm, sub-circular to circular. *Pores surface* yellowish white (2A2) when mature, turns brown (7D8) when scratched or bruised.

Hyphal structure: hyphal system di-trimitic, with clamp connections; generative hyphae 1.2–2.8 μm broad ($n = 30$), hyaline, thin walled, with clamp connections; skeletal hyphae 2.0–4.4 μm broad ($n = 30$), usually hyaline, thick walled, solid; binding hyphae 1.6–3.7 μm width ($n = 30$), with walls varying in thickness, many branches, without clamp connections, some hymenial with sword-like apices in the context. *Basidiospores* mostly ellipsoid, sometimes ovoid with double walls, (7.0–)7.7–9.0–9.9(–10.7) \times (4.8–)5.3–6.5–7.1(–7.8) μm ($\bar{x} = 8.9 \times 6.7 \mu\text{m}$, $n = 50$) μm , with $Q = 1.30$ –1.37, $L = 8.91 \mu\text{m}$, $W = 6.69 \mu\text{m}$ (including myxosporium), (5.8–)6.4–7.7–8.6(–9.4) \times (4.1–)4.5–5.6–6.0(–6.5) μm ($\bar{x} = 7.7 \times 5.5 \mu\text{m}$, $n =$

50) μm , with $Q = 1.35\text{--}1.42$, $L = 7.69 \mu\text{m}$, $W = 5.52 \mu\text{m}$ (excluding outer myxosporium), overlaid by hyaline, apically and shortly echinulate, truncate and turgid vesicular appendix, inner wall brownish yellow (5C7–5C8) and light brown (6D7–6D8), outer wall usually brownish orange (7C8), brown (7D7–7D8) to dark brown (7E7) in 5% KOH.

Habitat: solitary, on decaying *Pterocarpus* sp.

Specimens examined: **THAILAND**, Kanchanaburi Province, 15°01'31"N, 98°35'52"E, 495 m, on 10 November 2018, T. Luangharn, MFLU 19-2178.

Ganoderma applanatum (Batsch) G.F. Atk., *Annales Mycologici* 6: 189 (1908) (Figure 23)

Faces of fungi number: FoF 06249

Basidiomes: annual or perennial, subdimidiate to dimidiate, sessile.

Pileus 2–12 cm in length, 2.5–6 cm in width, and 0.8–3.1 cm thick at the base. *Pileus* sessile, perennial, subdimidiate to dimidiate, subflabelliform to flabelliform, convex, imbricate, umbonate or uneven, rarely unguulate, with broadly attached when mature, thicker at base slightly soft at margin when mature. *Pileus surface* furrowed, tuberculate to undulate, uneven, and incised when old, non-laccate (dull), compact and hard when mature, woody to corky texture when mature to old, covered with a thin crust (0.1–0.25 mm) overlies the pileus, and some cracked crust when old. *Pileus color* differentiated zone with peach red (7A4) to reddish orange (7A6, 7B6) at base, towards to brownish orange (7C6–7C8) with radius light brown (7D5) zone at center, and extend to dark brown (6F8) closed to active mycelium (margin) of maturity fruiting bodies. *Context* up to 0.5–2.3 cm thick, mostly brown (6E8) to dark brown (7F6–7F8) of cuticle cells, upper layers light orange (5A5), lower reddish brown (8D8) with fibrous, some fibrous pithy context, usually separated a layers of context tissue at base, and some occurred woody line. *Tubes* 0.8–2 cm in lence, up to 70–160

μm in width, with sulcate at different levels. *Stipe* almost sessile (without stipe) with broadly attached when present, with differentiated zone at the point of attachment. *Margin* up to 1 cm thick, round, soft, often white (5A1), turning to light brown (6D4) and brown (6E8) when scratched or bruised, slippery when wet, soft when young, and thin than the center. *Pore* angular, sub-circular, 4–6 in number per mm. *Pore surface* white (7A1) when fresh, quickly turning to light brown (7D6) to brown (7D8) when handled, scratched and bruised.

Hyphal structure: *hyphal system* trimitic; generative hyphae 0.5–2.8 μm (\bar{x} = 2.4, n = 30) in diam, clamp connections, almost hyaline, abundant thin walled and occasionally thick walled, composed of narrow and sparingly branched; skeletal hyphae 2.7–4.9 μm broad (n = 30), usually thick walled, hyaline, sometimes branched; binding hyphae 1.2–3.6 μm broad (n = 30), thick walled, some branched, and intertwined the skeletal hyphae. *Basidiospores* mostly ellipsoid to broadly ellipsoid, sometimes sub-circular with double walls, overlaid by hyaline, exosporium (outer wall) hyaline, endosporium (inner wall) coarse echinulate, with turgid vesicular appendix, truncate at the distal end, (10.0–)10.5–11.3– 11.9(–12.4) \times (7.2–)8.0–8.8– 9.4(–10.2) μm , (\bar{x} = 11.2 \times 8.6 μm , n = 50) μm , with Q = 1.28–1.33, L = 11.23 μm , W = 8.62 μm (including myxosporium), (6.3–)7.4–8.5–9.3(–10.1) \times (4.9–)6.3–7.4–8.7(–9.3) μm (\bar{x} = 8.4 \times 7.5 μm , n = 50) μm , with Q = 1.09–1.13, L = 8.42 μm , W = 7.58 μm (excluding outer myxosporium), brown (7D7–7D8) in KOH, and reddish brown (8E6) to dark brown (8F4) in Melzer's reagent. *Basidia* 14–20 \times 8–10 μm , with 4 sterigmata.

Habitat: solitary on rotten wood, dead trunks, and decaying stumps of *Artocarpus* spp., and *Dipterocarpus* spp.

Specimens examined: **THAILAND**, Kanchanaburi Province, 14°21'39"N, 99°08'32"E, 525 m elev., on 10 November 2018, T. Luangharn, MFLU 19-2175.

Ganoderma australe (Fr.) Pat., Bull. Soc. mycol. Fr. 5(2, 3): 65 (1889)

Faces of fungi number: FoF 02906

Characteristics follow Luangharn et al. (2017).

Basidiomes: applanate, spathulate

Pileus 2–7 cm in length, 1–15 cm in width, and 0.5–3 cm thick near the base. *Pileus* circular, applanate, spathulate, sometimes flabelliform clusters when young, dimidiate, semicircular at maturity, smooth when present. *Pileus surface* convex, furrow, glabrous, glossy, laccate, and consistently hard when fresh, and tough and light in weight when dry. *Pileus color* distinct concentric zones with light brown (6D4) to brown (6E8) at the center, slightly pale orange (5A3) to white (5A1) at the margin when young, becoming reddish brown (8E6) to dark brown (9F8) at the center, dull red (8C4), and pale red (7A3) to white (8A1) at the margin at old age on the upper surface, brown to dark brown when dried, separated by a layer of context, usually brown to grey in winter or may fade as weathering destroys pigments on the pileus surface. *Tube layers* 0.2–1.2 cm in length, 50–180 µm in width, thick walled. *Stipe* 3–5 cm in length, 1.5–3.5 cm in width, 1.3–3.3 cm thick, applanate, with umbo that slightly extend at the base. *Margin* up to 0.5–3 cm thick, thinner and lighter than the base, soft, round, pale yellow (4A3) to grayish brown (5D3) and reddish grey (8B2), changing to greyish orange (6E3) when touched, thick toward the margin and downward toward the poreless marginal part of hymenophore. *Pore* angular, 4–6 in number in number per mm. *Pore surface* white (2A1) to pale yellow (2A3) in growing specimen, immediately discolored when bruised, cream to grayish brown (5D3) when fresh, with brownish grey (5C2) to brown (4D7) when dried.

Hyphal structure: *hyphal system* di-trimitic, contextual generative hyphae, binding and skeletal hyphae, generative hyphae, 1–5 µm broad, with clamp connections, hyaline, thin walled; binding hyphae 2–6 µm broad, thin to thick-walled, branched, with clamp

connections; skeletal hyphae, hyaline, pale brown to brown, thick walled, 2–7 μm broad. *Basidiopores* (6.4)6.9–9.3–10.4(11.1) \times (5.8)6.4–7.9–8.8(9.7) μm , (\bar{x} = 9.4 \times 7.7 μm , n = 50), with Q = 1.20–1.21, L = 9.63 μm , W = 7.96 μm (including myxosporium), (5.4)6.3–7.0–8.1(8.9) \times (3.4)3.8–5.9–6.5(7.3) μm , (\bar{x} = 7.1 \times 5.8 μm , n = 50) μm , with Q = 1.19–1.25, L = 7.29 μm , W = 5.93 μm (excluding outer myxosporium), reddish brown, mostly broadly ellipsoid at maturity, some distinct tapering at the distal end, truncate, double wall, thick-walled inner endosporium. *Basidia* not observed. *Cultures characteristics* turned white after incubation at 30°C for 10 days. *Odor* distinctive when dried.

Habitat: solitary, on hardwood *Shorea robtusa*, or rotten wood, dead trunks, decaying hardwood, decaying stumps, and occasionally occurring on standing trees or trunks of many broad-leaf trees.

Specimens examined: **THAILAND**, Chiang Mai Province, Chiang Mai University, 18°48'31"N, 98°57'07"E, 371 m elev., on August 2012; T. Luangharn, MFLU 13-0534, MFLUCC 12-0527.

Ganoderma casuarinicola J.H. Xing, B.K. Cui & Y.C. Dai., MycoKeys 34: 93–108 (2018)

Faces of fungi number: FoF 06130

Taxonomy and phylogeny analysis are shown in Luangharn et al. (2019b).

Notes: *Ganoderma casuarinicola* was collected on a *Pinus kesiya* stump in a pine forest. This fungus is distinctive by its strongly laccate, shallow sulcate, reddish-brown pileus surface, lateral stipe, white pore surface, and brown context. Thai *G. casuarinicola* shows its annual, applanate to dimidiate, 3–16 cm long and 1.5–3 cm wide pileus, larger than Guangdong collection. Our *G. casuarinicola* collections show longer tubes of 6–14 mm, while the tubes of the Guangdong collection are 9 mm long; however, our collections reveal a thinner margin

(0.8–1.2 cm thick) than the Guangdong collection (2 cm thick). However, the type of *G. casuarinicola* from the Guangdong collection does not have the melanoid band (Xing et al. 2018), while our collection features a dark brown, melanoid band. Micro- characteristics are dense light-brown to brown context layers; walls of varying thickness in generative hyphae; thin-walled binding hyphae; and a thick-walled skeletal. Our *G. casuarinicola* collection has mostly distinctive yellowish-brown basidiospores, with a smaller size range of $(8.7)10.8\text{--}13.5(14.4) \times (6.6)7.6\text{--}8.9(9.8) \mu\text{m}$ than the type of *G. casuarinicola* $(8.3\text{--})9.0\text{--}10.2(-11.5) \times (4.5\text{--})5.0\text{--}6.0(-7.0) \mu\text{m}$ (including myxosporium).

Ganoderma ellipsoideum Hapuar., T.C. Wen & K.D. Hyde, *Mycosphere*. 9(5): 951 (2018)
(Figure 24)

Faces of fungi number: FoF 06255

Basidiomes: annual, sessile.

Pileus 3–9 cm in length, 2.2–5 cm in width, and 1.5–3.5 cm thick at the base. *Pileus* annual, convex, imbricate, sessile, umbonate, uneven, unguulate, sub-flabellate or sub-dimidiolate, somewhat imbricate, when seen from above flabelliform (fan-shaped), usually round, when present primordial, somewhat round and plump when present, broadly attached, thick at base, slightly soft at margin when mature. *Pileus surface* non-laccate (dull), furrowed, incised, sulcate, smooth when young, undulating on the upper surface, somewhat spatulate to uneven, covered by a thin and hard crust (0.1–0.4 mm), and woody when older. *Pileus color* usually homogenous with reddish brown (9E7–9E8) to dark brown (9F7–9F8) at the base at the center, extending white (4A1) to brown (7E7) on the upper margin surface of maturity fruiting bodies. *Context* up to 0.5–2.5 cm thick, compact and hard, trimitic hyphal, with clamp connections, hyaline, thin walled with simple septa, sparingly branched; generative

hyphae 1.2–3.7 μm broad ($n = 30$), hyaline, simple septate, with clamp connections; skeletal hyphae 1.8–4.2 μm broad ($n = 30$), usually thick walled, unbranched; binding hyphal 2.0–4.8 μm width ($n = 30$) with sparingly branched, thick walled, without clamp connection. *Hymenophore* usually brown (7D8) to reddish brown (8E8). *Tube layers* 0.5–2.2 cm in length. *Margin* blunt edged, wavy, slippery when young, and often white (8A1) where the new hyphae are in active development when young to mature. *Pore* 4–6 in number per mm, angular, sub-circular to circular. *Pore surface* white (11A1) to pale yellow (2A3), turns brown (7E7) to dark brown (7F7–7F8) when scratched or bruised.

Hyphal structure: hyphal system trimitic, with clamp connections, with brown (7E7); generative hyphae (1.2–)1.6–2.4–3.0(–3.8) μm broad ($n = 30$), branched, thin walled, hyaline, with greyish yellow (4B5) in KOH; skeletal hyphae (1.7–)3.1–3.8–4.3(–4.8) μm broad ($n = 30$), dextrinoid, abundant thick walled, with unbranched; binding hyphae (2.1–)3.1–3.7–4.2(–4.6) μm broad ($n = 30$), thick walled, frequently branched, usually intertwined the generative and skeletal hyphae, mostly brown (7E7) to dark brown (7F5) near the tube layers; Bovista-type ligative hyphae, hymenial with sword-like apices in the context. *Basidiospores* mostly ellipsoid with double walls, (4.8–)5.3–6.6–7.2(–7.7) \times (3.1–)3.5–4.3–5.0(–5.4) μm ($\bar{x} = 6.8 \times 4.5$ μm , $n = 50$) μm , with $Q = 1.34$ – 1.43 , $L = 6.28$ μm , $W = 4.52$ μm (including myxosporium), (3.6–)4.1–5.5–6.0(–6.4) \times (1.7–)2.1–2.8–3.3(–3.7) μm ($\bar{x} = 5.49 \times 2.83$ μm , $n = 50$) μm , with $Q = 1.83$ – 1.92 , $L = 5.50$ μm , $W = 2.94$ μm (including myxosporium), overlaid by hyaline, dextrinoid, echinulae, inner wall echinulate brownish yellow (5C7–5C8) to brown (7D7–7D8) in 5% KOH. *Basidia* not seen.

Habitat: solitary, on rotten wood of *Acacia* sp.

Specimens examined: **THAILAND**, Chiang Mai Province, Mae Taeng, Mushroom Research Centre, 19°07'200"N, 98°41'44"E, 652 elev., on 14 June 2019, P. E. Mortimer, MFLU 19-2221.

Ganoderma gibbosum (Blume & T. Nees) Pat., Ann. Jard. Bot. Buitenzorg, suppl. 1: 114
(1897) (Figure 25)

Faces of fungi number: FoF 06246

Basidiomes: annual or perennial, sessile

Pileus 2–12 cm in length, 2–8 cm in width, and 0.5–2.8 cm thick. *Pileus* sessile (without stipe), sub-flabellate or sub-dimidiolate, convex, imbricate, umbonate, uneven, round when occurring, primordial, round and plump when youth, with broadly attached when mature, and thicker at base slightly soft at margin when mature. *Pileus surface* non-laccate (dull), smooth, soft, slightly dull and faded when mature to old, usually silky when young, furrowed, tuberculate to undulate, uneven, and incised when mature, compact and hard when mature, woody when mature to old, covered with a thick crust, and some cracked crust when old. *Pileus color* light orange (6A4–6A5) to grayish orange (6B3–6B5) at base towards the center of maturity fruiting bodies, become grayish green (30E2–30E7) on the upper surface when mature to old. *Context* up to 0.4–2.3 cm thick, tri-dimitic hyphal, with clamps connections, brownish orange (7C7–7C8) to reddish brown (8D7–8D8), mostly dark brown (7F7) near the tube layers, Bovista-type ligative hyphae, hymenial with sword-like apices in the context. *Tube* 0.1–0.6 cm long, up to 80–160 µm in width, and sulcate at different levels. *Stipe* almost sessile with broadly attached when present. *Margin* wavy, blunt edged, slippery when wet, soft when young, thinner than the base and softer than the center, and often white (8A1) when young to mature. *Pore* angular, sub-circular, 4–6 in number per mm in fresh. *Pore surface* initial white (7A1), turns light brown (7D6) to brown (7D8) when scratched or bruised, with a slippery surface when fresh.

Hyphal structure: hyphal system trimitric hyaline, with walls varying in thickness with simple

septa, composed of narrow and sparingly branched; generative hyphae 1.3–4.6 μm broad ($n = 30$), thin walled and hyaline hyphae; skeletal hyphae 4.0–7.3 μm broad ($n = 30$), thick walled and hyaline hyphae; binding hyphae 2.8–6.3 μm broad ($n = 30$), usually with walls varying in thickness. *Basidiospores* (4.2–)6.5–8.1–10.3(–11.2) \times (3.9–)4.8–4.6–5.7(–6.4) μm ($\bar{x} = 8.2 \times 4.7 \mu\text{m}$, $n = 50$) μm , with $Q = 1.70$ –1.76, $L = 8.38 \mu\text{m}$, $W = 4.85 \mu\text{m}$ (including myxosporium), (4.5–)6.1–7.2–8.1(–9.2) \times (3.9–)4.5–5.3–5.2(–6.9) μm ($\bar{x} = 7.4 \times 5.4 \mu\text{m}$, $n = 50$), with $Q = 1.31$ –1.38, $L = 7.53 \mu\text{m}$, $W = 5.60 \mu\text{m}$ (excluding outer myxosporium), ellipsoid or some globose with double walls, overlaid by hyaline, dextrinoid, distinct echinulate, inner wall echinulate brown, light brown (6D4) to brown (6E8) in 5% KOH. *Basidia* not seen.

Habitat: solitary, on standing trees of *Dendrocalamus strictus*.

Specimens examined: **THAILAND**, Chiang Rai Province, 19°48'20"N, 100°04'19"E, 680 m elev., on October 2017, T. Luangharn, MFLU 19-2176.

GenBank numbers – MFLU 19-2176 = ITS: MN396311, RPB2: MN423118.

Ganoderma lingzhi S.H. Wu, Y. Cao & Y.C. Dai. Fungal Diversity. 56(1): 54 (2012)

(Figure 26)

Faces of fungi number: FoF 06248

Basidiomes: annual or perennial, stipitate.

Pileus 15 cm in length, up to 10 cm in width, and 2 cm thick. *Pileus* shell-like (involute from margin into the center), sub-flabellate or reniform to circular when seen from above, often with undefined concentric zones at center and extend to the margin, thick at center slightly soft at margin, and leathery when age when break. *Pileus surface* usually laccate, faded or week laccate when young, and strongly laccate when mature to age, shiny, silky, smooth, and

soft when fresh, furrowed on the surface with sulcate to undulating, somewhat spathulate to uneven, incised, hard and woody when old, and some occurred the brown (7D5) lined when older. *Pileus color* usually homogenous at base at the center with red (9A6–9A7, 9B7–9B8), brownish red (9C6–9C8), and dark red (10C7–10C8), extended to the margin with reddish yellow (4A7), but do not change the color when touched. *Context* up to 0.3–0.5 cm thick at base, abundant thick walled, some thin walled, with sub-solid hyphae, bearing clamp connections, and occurred the dark brown (7F7–7F8) melanoid bands. *Tube layers* usually thin walled, frequently branched with clamped connections, and hard and woody when mature, often brown (7D7). *Stipe* up to 3–8 cm in length, up to 1–3 cm in width, centrally stipitate, almost sub-cylindrical to cylindrical, often red (9A6) to brownish red (9C6), and dark red (10C7) when mature. *Margin* obtuse from the center, some wavy, slippery when wet, softer, strong laccate edged, thin than the base and soft than the center, often reddish yellow (4A7, 4B7–4B8), deep yellow (4A8), and orange (5A6–5A7) to golden yellow (5B7–5B8) when mature to old. *Pore* angular, sub-circular to circular, 4–7 in number per mm, (40–)80–140(–155) μm . *Pore surface* white (11A1) to yellowish white (3A2) when young to mature, turning yellow (3B8) to olive yellow (3C7–3C8) when dried, as well as becoming discolored when touched, turns light brown (7D5), brown (7D7–7D8) to dark brown (7F6–7F8) when scratched or bruised.

Hyphal structure: hyphal system trimitic, with bearing clamp connections, hyaline, with walls varying in thickness with simple septa, composed of narrow and sparingly branched; generative hyphae (1.3–)1.6–1.8–2.2(–2.4) μm broad ($n = 30$), thin walled, hyaline, branched, with clamp connections; skeletal hyphae (1.6–)2.2–3.5–4.2(–4.9) μm broad ($n = 30$), walls varying in thickness, sometimes sub-solid; binding hyphae (1.2–)1.5–1.7–2.0(–2.3) μm broad ($n = 30$), usually thick walled with narrow to sub-solid, with pale orange (5A3) to light orange (5A4) of thin walled, and orange (6B7) to brownish orange (6C8) of thick walled in

Melzer's reagent, and occurred the melanoid bands. *Basidiospores* mostly ellipsoid or oblong ellipsoid, truncate at maturity, with double walls, (8.0–)9.4–11.3–12.2(–13.3) × (4.9–)5.4–6.5–7.1(–7.4) μm, (\bar{x} = 11.2 × 6.6 μm, n = 50) μm, with Q = 1.64–1.51, L = 11.24 μm, W = 6.69 μm (including myxosporium), (7.8–)8.1–8.6–9.9(–11.7) × (4.9–)5.2–5.9–6.7(–7.4) μm (Q_m = 1.5, Q = 1.0–2.0, excluding outer myxosporium) (n = 50), (\bar{x} = 8.7 × 5.8 μm, n = 50) μm, with Q = 1.46–1.53, L = 8.72 μm, W = 5.84 μm (excluding outer myxosporium), overlaid by hyaline, exosporium (outer wall) smooth and hyaline, endosporium (inner wall) coarse echinulate, with turgid vesicular appendix, light brown (7D7) to brown (7D8) in KOH, and reddish brown (8E6) to dark brown (8F4) in Melzer's reagent. *Basidia* 12–17 × 6–9 μm, with 4 sterigmata.

Habitat: occasionally occurring on the decay stump of decaying *Pterocarpus* sp., living tree.

Specimens examined: **THAILAND**, Prachuap Khiri Khan Province, 12°08'52"N, 99°45'41"E, 491 m elev., on 25 June 2018, T. Luangharn, MFLU 19-2164.

GenBank numbers: MFLU 19-2164 = ITS: MN396324, RPB2: MN423130, TEF: MN423163.

Ganoderma lucidum (Curtis) P. Karst., Revue Mycologique Toulouse. 3(9): 17 (1881)

(Figure 27)

Faces of fungi number: FoF 06250

Basidiomes: annual or perennial, sub-reniform to reniform, stipitate

Pileus up to 2–6 cm in length, 1.5–3.0 cm in width, and 0.8–2.0 cm thick at the base. *Pileus* stipitate, sub-reniform to reniform, undefined imbricate, irregular, some laterally, and flabelliform with a contracted, concentrically sulcate zone, irregularly ruptured crust overlying the context, radial from center extending to the margin, tough when broken, often

thick at center slightly soft at margin, and leathery when age when broken. *Pileus surface* smooth layer at center from young to old, usually furrowed, incised, undulate to sulcate, somewhat spatulate to uneven, some woody or corky texture when old, weakly laccate when present, strongly laccate and glossy when mature, and usually weakly laccate where the new hyphae are in active development (margin). *Pileus color* usually brownish red (8C7–8C8) at the center, slight to reddish orange (7B7–7B8), and orange (6A7–6A8) on the upper pileus surface. *Context* up to 0.4–1.4 cm thick at base, abundant thick walled, sub-solid hyphae, concentric lines of various shades, bearing clamp connections, light brown (6D6) to brown (6D8, 6E8), with dark-brown (7F7) melanoid bands. *Tube* usually hard, brown (7D7) to dark brown (7F7). *Stipe* up to 8–16 cm in length, up to 0.8–1.5 cm in width, eccentric stipe, cylindrical to slightly flattened, laccate, and reddish brown (8D7–8D8, 8E7–8E8) from mature to old. *Margin* often 0.5–1.3 cm, orange (6A7–6A8) upper surface, and reddish yellow (4A8) under surface, thinner than the base, and softer than the center. *Pore* 4–6 in number per mm, (70–)110–145(–160) μm , sub-circular to circular, sometimes angular. *Pore surface* white (11A1) when present, yellowish white (2A3) to light brown (7D6) from young to mature, turning brown (7D7–7D8) to dark brown (6F6) when scratched or bruised.

Hyphal structure: hyphal system trimitic, with clamp connections, hyaline, walls varying in thickness with simple septa, sparingly branched, swollen by melanoid bands, usually brownish orange (6C7–6C8) to brown (6D7–6D8) in KOH; generative hyphae up to (1.8–)2.0–2.3–2.7(–3.0) μm broad ($n = 30$), usually thin walled, some thick walled, with clamp connections, branched, and almost hyaline; skeletal hyphae (3.2–)4.3–5.4–6.1(–6.8) μm broad ($n = 30$), usually thick walled with clamp connections, with unbranched; binding hyphae (2.4–)2.9–4.4–5.0(–5.9) μm broad ($n = 30$), walls usually varying in thickness with abundant branched and present the melanoid bands. *Basidiospores* ellipsoid, some sub-globose to globose with double walls, with a truncate apex, size range of (8.2–)8.8–9.8–10.5

(–11.4) × (5.8–)6.2–6.8–7.5(–8.2) μm, (\bar{x} = 10.0 × 6.9 μm, n = 50) μm, with Q = 1.51–1.57, L = 10.65 μm, W = 6.92 μm, (including myxosporium), (6.3–)7.1–7.6–8.2(–8.4) × (4.8–)5.4–5.7–6.1(–6.5) μm, (\bar{x} = 7.5 × 5.8 μm, n = 50) μm, with Q = 1.26–1.31, L = 7.57 μm, W = 5.89 μm (excluding outer myxosporium) (n = 50), brownish orange (6C8, 6D8) to brown (6E5) of endosporium (inner wall) with brown (7E7–7E8) exosporium (outer wall) in Congo red, brownish orange (6C8) in 5% KOH, and yellowish brown (5D8) in Melzer's reagent, mostly overlaid by hyaline, coarse echinulate, hyaline turgid vesicular appendix.

Habitat: solitary, on decaying hardwood of *Dendrocalamus strictus* in dry evergreen forest.

Specimens examined: **THAILAND**, Chiang Rai Province, 19°48'20"N, 100°04'19"E, 680 m elev., on 15 October 2017, T. Luangharn, MFLU 19-2162.

GenBank numbers: MFLU 19-2162 = ITS: MN396341, RPB2: MN423138.

Ganoderma multipileum (as “*multipilea*”) Hou, Q.J. Taiwan Mus. 101 (1950) (Figure 28)

Faces of fungi number: FoF 06256

Basidiomes: annual, stipitate

Pileus up to 6–11 cm in length, 4–9 cm in width, and 1–3 cm thick at base. *Pileus* sub-reniform to reniform, sub-flabellate to flabellate, concentrically sulcate zone, fleshed at center slightly to margin, radial or branched from center extend to the margin when seen from above, tough when break, often thick at center slightly soft at margin, and leathery when age when break. *Pileus surface* weakly laccate to strong laccate at center when mature to age, and faded or weak laccate at active mycelial (margin), smooth, irregularly ruptured crust overlying the context, some woody or corky texture when old, usually furrowed, incised, sulcate to undulating, and somewhat spathulate to uneven on the surface. *Pileus color* usually homogenous brownish red (8C7–8C8) at the base, slight yellowish red (8A7–8A8, 8B7–8B8)

at center, and light brown (7D5) to brown (7D7–7D8) on the upper margin surface. *Context* up to 0.3–1.2 cm thick at the base, with walls varying in thickness, sub-solid hyphae, bearing clamp connections, usually light brown (6D4–6D6) to brown (6D8, 6E8) of hyphae, and dark brown (7F7) melanoid bands in KOH. *Tube* hard, usually thin-thick walled, often with brown (7D7) to dark brown (7F7). *Stipe* up to 4–9 cm in length, up to 1–2.5 cm in width, almost eccentric, sub-cylindrical to cylindrical, plump, strong laccate, often homogeneous with red (9A6) to brownish red (9C6), and dark red (10C7) when mature to old. *Margin* often white (4A1) to pale yellow (4A4) where the new hyphae are in active development, light brown (7D5) to brown (7D7) when bruised, strong laccate, wavy, slippery when wet, softer, thin than the base, and soft than the center. *Pore* angular, 4–6 in number per mm, (99–)120–154(–170) μm in diam, sub-circular to circular. *Pore surface* white (11A1) when present, pale yellow (4A3) to orange white (5A2) when young to mature, light brown (6D4) with age, turning to light brown (7D6), brown (7D7–7D8) when dried or scratched and bruised.

Hyphal structure: hyphal system trimitic, with clamp connections, hyaline, walls varying in thickness with simple septa, sparingly branched, usually light orange (5A4–5A5) to orange (5A6–5A7) in KOH; generative hyphae up to (1.6–)2.2–3.5–4.6(–5.2) μm broad ($n = 30$), usually thick walled, unbranched, flexuous, and almost hyaline; skeletal hyphae (3.8–)4.2–5.1–5.9(–6.7) μm broad ($n = 30$), usually thick walled, unbranched, sometimes sub-solid; binding hyphae (1.4–)2.2–3.6–4.4(–5) μm broad ($n = 30$), usually walls varying in thickness, with flexuous, abundant branched, with Bovista-type binding hyphae, and occurred the melanoid bands. *Basidiospores* mostly ellipsoid, some ovoide, truncate at maturity, with double walls, (7.6–)8.8–11.7–12.4(–13.1) \times (4.9–)5.3–6.1–6.9(–7.4) μm , ($\bar{x} = 11.8 \times 6.3 \mu\text{m}$, $n = 50$) μm , with $Q = 1.84$ – 1.89 , $L = 11.84 \mu\text{m}$, $W = 6.32 \mu\text{m}$ (including myxosporium), (5.9–)6.9–8.2–9.3(–10.6) \times (4.3–)4.9–5.6–6.0(–6.5) μm , ($\bar{x} = 8.3 \times 5.8 \mu\text{m}$, $n = 50$) μm , with $Q = 1.40$ – 1.46 , $L = 8.36 \mu\text{m}$, $W = 5.85 \mu\text{m}$ (excluding outer myxosporium), mostly overlaid

by hyaline, brownish orange (6C8), (6D8) of exosporium (outer wall), endosporium (inner wall) coarse echinulae, with hyaline turgid vesicular appendix, with orange (6A7), (6B7) in KOH.

Habitat: solitary, on decaying stump of *Pinus merkusii*.

Specimens examined: **THAILAND**, Prachuap Khiri Khan Province, 12°08'52"N, 99°45'41"E, 491 m elev., on 26 June 2018, T. Luangharn, MFLU 19-2166.

Notes: *Ganoderma multipileum* was originally reported from Taiwan, PRC (Moncalvo et al. 1995), which presented over half a century ago from Taiwan, PRC (Hou 1950). This fungus was earliest valid name with *G. lucidum* from tropical Asia (Moncalvo et al. 1995); however, Wang et al. (2009) verified that *G. multipileum* is the correct name for this tropical fungus. This fungus is distinctive form with its laccate to strong laccate pileus, stipitate, rarely sessile, irregularly ruptured crust overlying the context, yellow-brown to dark brown context, cream pore surface, flattened or sub-cylindrical, lateral, horizontally lateral, with ovoid to ellipsoid basidiospores ($7.6\text{--}13.5 \times 5.5\text{--}7.5 \mu\text{m}$) (with myxosporium), $6.5\text{--}10.5 \times 4.5\text{--}6.5 \mu\text{m}$ (without myxosporium)), mostly truncate, brown, with a dark-brown (Wang et al. 2009). Some researchers have shown in their phylogenies that *G. tropicum* is phylogeny analysis more similar to *G. multipileum* (Wang et al. 2012; Cao et al. 2012), which considered most resemble to *G. tropicum* in morphology and habitat even though they are distinct species (Wang et al. 2009) and *G. flexipes* (Cao et al. 2012; Yang and Feng 2013; Zhou et al. 2015). Our *G. multiplicatum* was collected from Thailand, are similar to the original described by Wang et al. (2009) by its showed laccate to strong laccate pileus, radial or branched from center extend to the margin, with ellipsoid basidiospores.

Ganoderma orbiforme (Fr.) Ryvardeen, Mycologia. 92(1): 187 (2000) (Figure 29)

≡ *Polyporus orbiformis* Fr., Epicrisis Systematis Mycologici.: 463 (1838)

- ≡ *Fomes orbiformis* (Fr.) Cooke, Grevillea. 14 (69): 18 (1885)
- ≡ *Scindalma orbiforme* (Fr.) Kuntze, Revisio generum plantarum. 3(2): 519 (1898)
- ≡ *Ganoderma lucidum* var. *orbiformis* (Fr.) Rick, Iheringia. 7: 201 (1960)
- ≡ *Ganoderma orbiformum* (Fr.) Ryvarden (2000)
- = *Ganoderma mastoporum* (Lév.) Pat., Bulletin de la Société Mycologique de France. 5: 71 (1889)
- = *Ganoderma fornicatum* (Fr.) Pat., Bulletin de la Société Mycologique de France. 5: 71 (1889)
- = *Ganoderma boninense* Pat., Bulletin de la Société Mycologique de France 5: 72 (1889)
- = *Ganoderma subtornatum* Murrill, Bulletin of the Torrey Botanical Club. 34: 477 (1907)
- = *Ganoderma cupreum* (Cooke) Bres., Annales Mycologici. 9: 268 (1911)
- = *Ganoderma densizonatum* J.D. Zhao & X.Q. Zhang, Acta mycol. sin.: 86 (1986)
- = *Ganoderma limushanense* J.D. Zhao & X.Q. Zhang, Acta mycol. sin.: 219 (1986)

Faces of fungi number: FoF 06257

Basidiomes: annual or perennial, sessile.

Pileus 4–11 cm in length, 3–6 cm in width, and 1–2.4 cm thick at base. *Pileus* sessile, flabelliform or spatulate, convex, imbricate, umbonate, uneven, unguulate, sub-reniform, sub-orbicular, sub-dimidiolate, obtuse from host, broadly attached, somewhat imbricate, thicker at base slightly soft at margin when mature. *Pileus color* usually homogenous with greyish orange (6B3–6B6), brownish orange (6C5–6C6), and brown (6D7–6D8) at base extending to the margin of maturity to old. *Pileus surface* partly non-laccate (dull) to weakly laccate, faded texture when old, furrowed, incised, sulcate, undulating, and somewhat spatulate to uneven

on the upper surface, silky and soft when fresh, woody when mature to older, and covered with compact and hard crust (0.1–0.25 mm). *Context* up to 0.4–1.0 cm thick, trimitic hyphae with clamp connections, hyaline, walls varying in thickness with simple septa, sparingly branched. *Hymenophore* brown (6D7–6D8) to reddish brown (8D7). *Tube layers* 0.3–1.2 cm in length, light brown (6D4–6D5) to brown (7D7). *Stipe* almost sessile with broadly attached when present, with brownish orange (6C8). *Margin* soft, wavy, blunt edged, slippery when young, with greyish orange (6B5–6B6) to brownish orange (6C8) when old. *Pore* 4–6 in number per mm, circular or subcircular, or angular. *Pore surface* white (11A1) when present, turns light brown (7D5) to brown (7D7–7D8) when scratched or bruised, becoming discolored when touched.

Hyphal structure: hyphal system trimitic, with clamp connections, usually orange (6A6–6A8) to brownish orange (6C7–6C8) in KOH; generative hyphae 1.4–5.0 μm broad ($n = 30$), hyaline, thin walled with clamp connections; skeletal hyphae 2.6–5.6 μm broad ($n = 30$), usually thick walled, unbranched; binding hyphae 1.2–4.8 μm width ($n = 30$), usually walls varying in thickness, many branches, hymenial with sword-like apices in the context. *Basidiospores* mostly ellipsoid to oblong ellipsoid or broadly ellipsoid, with double walls, (7.1–)7.9–9.4–11.2(–11.8) \times (5.2–)5.97–6.7–7.1(–7.7) μm ($\bar{x} = 9.6 \times 6.8 \mu\text{m}$, $n = 50$) μm , with $Q = 1.38$ –1.44, $L = 9.63 \mu\text{m}$, $W = 6.82 \mu\text{m}$ (including myxosporium), (6.4–)5.2–6.0–6.7(–10.7) \times (3.9–)4.5–5.3–6.1(–6.6) μm ($\bar{x} = 6.2 \times 5.1 \mu\text{m}$, $n = 50$) μm , with $Q = 1.20$ –1.27, $L = 6.28 \mu\text{m}$, $W = 5.10 \mu\text{m}$ (excluding outer myxosporium), overlaid by hyaline, echinulate, inner wall echinulate brown, some turgid vesicular appendix, light yellow (4A5) to reddish yellow (4B7–4B7) in 5% KOH. *Basidia* not seen.

Habitat: solitary, on the living tree of *Albizia mollis* in deciduous forest, and living tree of *Indochinese* spp.

Specimens examined: **THAILAND**, Chiang Rai Province, 19°48'20"N, 100°04'19"E, 680 m

elev., 21 October 2017, T. Luangharn, MFLU 17-1933.

Notes: Ganoderma orbiforme (Fr.) Ryvardeen was first described as *Polyporus orbiformis*, with the original specimen from the tropical region of Guinea in Africa (Ryvardeen 2000). The fungus was characterized by its distinctive weakly laccate surface or some dull surface areas, brown context, brown pore surface, and brown tube layer, and ellipsoid or ovoid basidiospore. *Ganoderma cupreum*, *G. densizonatum*, *G. fornicatum*, *G. limushanense*, *G. mastoporum*, *G. multiplicatum*, and *G. subtornatum* are similar to *G. orbiforme*; however, taxonomy and molecular analysis treated those taxa as the earliest valid names for *G. orbiforme* (Ryvardeen 2004; Wang et al. 2014). This fungus has been recorded from China, Laos, Myanmar, and Thailand (Hapuarachchi et al. 2019), with our collection is also the collection of *G. orbiforme* from Thailand. Our collection from Thailand is agree well with the described by Ryvardeen (2000) and Wang et al. (2014) reported that this fungus posed a rigid basidiomes, purplish black laccate crust, brown pore surface and tube layer, with ellipsoid or ovoid basidiospores, fine and short echinulate, clavate cells usually with several irregular lobes.

Ganoderma philippii Bres. & Henn. ex Sacc. Bres, Iconographia mycological. 21: 1014, t. 1014 (1932) (Figure 30)

≡ *Fomes philippii* Bres. & Henn. ex Sacc., Sylloge Fungorum. 9: 180 (1891)

≡ *Scindalma philippii* (Bres. & Henn. ex Sacc.) Kuntze, Revisio generum plantarum. 3(2): 519 (1898)

= *Fomes pseudoferreus* Wakef., Bulletin of Miscellaneous Informations of the Royal Botanical Gardens Kew. 1918: 208 (1918)

Faces of fungi number: FoF 06258

Basidiomes: annual, sessile

Pileus 2–9 cm in length, 2–5 cm in width, and 0.4–3.8 cm thick at the base. *Pileus* annual, convex, sessile, umbonate, unguulate, usually round when present, primordial, plump when present, broadly attached and thick at base, slightly soft at margin. *Pileus surface* non-laccate to weakly laccate, furrowed, incised, sulcate, smooth when young, undulating on the upper surface, spatulate to uneven, covered with a crust (0.1–0.3 mm), cracked crust when old, and woody when old. *Pileus color* usually homogenous, brown (7E7–7E8) at base at the center, extending to brownish orange (6C8), and white (4A1) when present, slight yellowish white (2A2) on the upper margin surface of maturity fruiting bodies. *Context* consists of trimitic hyphae, up to 0.3–1.8 cm thick, sparingly branched, walls varying in thickness, compact and hard, with clamp connections, hyaline; generative hyphae 1.8–3.3 μm in width ($n = 30$), brownish yellow (5C7–5C8), thin walled, simple septa, hyaline, with clamp connections; skeletal hyphae 2.8–4.9 μm broad ($n = 30$), brownish yellow (5C7–5C8), usually thick walled, unbranched; binding hyphae 2.0–4.2 μm width ($n = 30$), brownish yellow (5C7–5C8) to brownish orange (6C7–6C8), sparingly branched, walls varying in thickness, and without clamp connections. *Hymenophore* heterogeneous, brown (7C7–7C8, 7D8), and melanoid band present when mature. *Tube layers* 0.3–3.8 cm in length. *Margin* blunt edged, wavy, and often white (8A1) where the new hyphae are in active development to yellowish white (2A2) from young to mature. *Pore* 4–7 in number per mm, sub-circular to circular. *Pore surface* white (11A1) when present, turning brown (7E7) to dark brown (7F7–7F8) when scratched or bruised.

Hyphal structure: hyphal system trimitic, with clamp connections, usually brown (7E7); generative hyphae (1.7–)2.1–2.5–2.9(–3.3) μm broad ($n = 30$), branched, thin walled, hyaline, unbranched, greyish yellow (4B5) in KOH, with clamp connections; skeletal hyphae (2.9–)3.4–4.0–4.4(–5.0) μm broad ($n = 30$), dextrinoid, abundant thick walled, with unbranched;

binding hyphae (2.1–)2.8–3.3–3.8(–4.3) μm broad ($n = 30$), walls varying in thickness, frequently branched, generative and skeletal hyphae usually intertwined, mostly brown (7E7) to dark brown (7F5) near the tube layer; Bovista-type ligative hyphae, hymenial with sword-like apices in the context. *Basidiospores* mostly oblong, double walls, (5.8–)6.4–7.3–7.8(–8.2) \times (4.1–)4.6–6.1–6.7(–7.1) μm ($\bar{x} = 7.4 \times 6.0 \mu\text{m}$, $n = 50$) μm , with $Q = 1.01$ –1.12, $L = 7.32 \mu\text{m}$, $W = 6.98 \mu\text{m}$ (including myxosporium), (5.2–)5.7–6.5–7.1(–7.5) \times (3.7–)4.3–5.5–6.1(–6.5) μm ($\bar{x} = 6.62 \times 5.58 \mu\text{m}$, $n = 50$) μm , with $Q = 1.14$ –1.24, $L = 6.56 \mu\text{m}$, $W = 5.48 \mu\text{m}$ (including myxosporium), overlaid by hyaline, dextrinoid, echinulate, inner wall echinulate, greyish orange (5B4–5B5) in 5% KOH, and yellowish brown (5E8) to light brown (6D8). *Basidia* not seen.

Habitat: solitary, on rotten wood of unknown tree species.

Specimens examined: **THAILAND**, Chiang Mai Province, Mae Taeng, Mushroom Research Centre, 19°07'200"N, 98°41'44"E, 770 m elev., on 14 June 2019, P. E. Mortimer, MFLU 19-2222 and MFLU 19-2223.

Notes: *Ganoderma philippii* was introduced as *Fomes philippii* by Bresadola & Hennings in 1891 (Saccardo 1891) and later transferred to *Ganoderma* (Bresadola 1932). *Ganoderma philippii* causes red root rot disease, one of the most economically important diseases across a wide range of commercial perennial woody crops of tropical *Acacia* species (Agustini et al. 2014; Gafur et al. 2015). The *Ganoderma philippii* species is distributed across Asia, from Philippines in the north to southern Papua New Guinea (Steyaert 1975).

This species is characterized by its sessile, non-laccate pileus surface, with melanoid bands that form a layer distinct from the context, with a di-trimitic hyphal system with clamped connections overlaid by hyaline, echinulate, inner wall echinulate, sometimes turgid vesicular appendix basidiospores (Hood 2006; Singh et al. 2013). In this study, our new record of *G. philippii* collected from Thailand is described based on characteristics and

phylogenetic analyses. Our collection agrees well with the description by Wang et al. (2009).

Ganoderma sinense J.D. Zhao, L.W. Hsu & X.Q. Zhang, Acta Mycologica Sinica. 19: 272
(1979) (Figure 31)

Faces of fungi number: FoF 06253

Basidiomes: annual, stipitate, sub-dimidiolate

Pileus 4–10 cm in length, 6–12 cm in width, 0.3–1.3 cm thick at base. *Pileus* stipitate, sub-dimidiolate to dimidiolate, flabelliform, spathulate, umbonate, concentrically sulcate zone, radial from center extending to the margin, tough when broken, often thick at center, slightly soft at margin, light in weight when dried, and non-woody. *Pileus surface* laccate, convex, some radial furrowed, imbricate, incised, glossy, shiny, spathulate, shallow sulcate when fresh, umbonate or uneven, strongly laccate and glossy when mature, and weakly laccate where the new hyphae are in active development (margin), usually smooth layers at center from young to old age, irregularly ruptured crust overlying the context, and leathery when broken in old age. *Pileus color* usually homogenous and brownish red (8C7–8C8) to reddish brown (8D7–8D8) at center towards stipe and extending brownish red (9C8) from the center slight to the margin when mature, usually reddish-brown (8E5–8E8) upper margin surface when old. *Context* up to 0.3–0.8 cm thick near the stipe, dried, upper layers brownish orange (6C8) when fresh, lower layers greyish orange (5B5), dark brown (8F7) when dried, soft and fibrous, covered with thin crust, some present woody, trimitic hyphae, hyaline, walls varying in thickness with simple septa, with branches. *Tube* 0.3–0.9 cm in length, brown (7D8). *Stipe* 3–12 cm in length, sub-cylindrical to cylindrical, almost stipitate, with broad and thick at base, irregularly ruptured crust overlying, usually strongly laccate, brown (7D8) to dark brown (8F8) when mature, usually dark brown (8F8) when old. *Margin* soft, some wavy,

laccate when mature, weakly laccate when old, brownish orange (6D8) from mature to old. *Pore* 4–6 in number per mm, sub-circular to circular. *Pore surface* white (11A1) when present, to yellowish white (2A2) when mature, turns brownish (6E7) to dark brown (6F7) when scratched or bruised.

Hyphal structure: hyphal system trimitic, with clamp connections, usually light orange (5A5) to orange (5A7), golden yellow (5B7–5B8), sometimes brownish red (8C7) in KOH; generative hyphae 1.2–2.1 μm broad ($n = 30$), hyaline, thin walled, with clamp connections; skeletal hyphae 3.2–5.4 μm broad ($n = 30$), usually hyaline, thick walled, unbranched, and solid; binding hyphae 3.3–5.7 μm width ($n = 30$), walls varying in thickness, with many branches, hymenial with sword-like apices in the context. *Basidiospores* mostly ellipsoid to broadly ellipsoid, double walls, (9.8–)10.4–11.7–12.5(–13.4) \times (7.3–)7.7–8.9–10.0(–10.6) μm ($\bar{x} = 11.8 \times 9.0 \mu\text{m}$, $n = 50$) μm , with $Q = 1.29$ – 1.34 , $L = 11.82 \mu\text{m}$, $W = 9.02 \mu\text{m}$ (including myxosporium), (8.9–)9.8–10.4–12.0(–12.8) \times (6.2–)6.8–7.2–7.9(–8.3) μm ($\bar{x} = 10.6 \times 7.3 \mu\text{m}$, $n = 50$) μm , with $Q = 1.41$ – 1.47 , $L = 10.47 \mu\text{m}$, $W = 7.25 \mu\text{m}$ (excluding outer myxosporium), overlaid by hyaline, apically and shortly echinulate, truncate, some turgid vesicular appendix, inner wall echinulate, orange (5A7), deep (5A8, 5B8), orange (6B8), brownish orange (6B8), outer wall usually brownish red (8C7–8C8) in 5% KOH.

Habitat: solitary, on the living tree of *Dendrocalamus strictus* and *Dipterocarpus* sp.

Specimens examined: **THAILAND**, Nakhon Phanom Province, 17°57'09"N, 104°09'43"E, 38 m elev., on 22 December 2018, T. Luangharn, MFLU 19-2172.

Ganoderma subresinosum (Murrill) C.J. Humphrey, Mycologia. 30 (3): 332 (1938)

(Figure 32)

≡ *Fomes subresinosus* Murrill, Bulletin of the Torrey Botanical Club. 35: 410 (1908)

≡ *Trachyderma subresinosum* (Murrill) Imazeki, Bulletin of the Government Forest

Experimental Station Meguro. 57: 119 (1952)

≡ *Magoderna subresinosum* (Murrill) Steyaert, Persoonia. 7(1): 112 (1973)

≡ *Amauroderma subresinosum* (Murrill) Corner, Beihefte zur Nova Hedwigia. 75: 93 (1983)

= *Polyporus mamelliporus* Beeli, Bulletin de la Société Royale de Botanique de Belgique. 62(1): 62 (1929)

Faces of fungi number: FoF 06259

Basidiomes: annual, sub-dimidiolate, sessile.

Pileus 6–13 cm in length, 4–10 cm in width, and 0.6–2 cm thick. *Pileus* stipitate, flabelliform, spatulate, umbonate, sub-dimidiolate to dimidiolate, single, concentrically sulcate zone, radial from center extending to the margin, tough when broken, often thicker at center, slightly soft at margin, and light in weight when dried. *Pileus surface* convex, glossy, shiny, usually frequently furrowed, shallow sulcate, mostly rugulose, spatulate, umbonate to uneven, laccate when mature, strongly laccate when old, concentrically sulcate with irregularly ruptured crust overlying the context, hard from mature to old, and woody or corky texture when old. *Pileus color* usually dark brown (9F7–9F8) from center to the margin. *Context* up to 0.3–1 cm thick near the base, dry, upper layers greyish orange (5B6) when fresh, lower layers greyish orange (5B5), dark brown (8F7) when dried, covered with crust, woody when dried, trimitic hyphae, hyaline, walls varying in thickness, with simple septa, with branches. *Tube* 0.4–1.2 cm in length, brown (7D8). *Stipe* almost sessile, blunt, broadly attached, and thick at base, irregularly ruptured crust overlying, and usually strongly laccate with brown dark brown (9F7) from mature to old. *Margin* strongly laccate and dark brown (9F7) when mature to old. *Pore* 4–5 in number per mm, sub-circular to circular. *Pore surface* pale yellow (4A3) to pale orange (5A3), turns dark brown (6F7) when scratched or bruised.

Hyphal structure: hyphal system di-trimitic, with clamp connections, usually light yellow (3A5) to greyish yellow (3B5), pale yellow (4A5), light orange (5A5) to orange (5B8) in KOH; generative hyphae 1.0–2.1 μm broad ($n = 30$), thin walled, hyaline, with clamp connections; skeletal hyphae 2.8–5.2 μm broad ($n = 30$), usually unbranched or few branches, and thick walled; binding hyphae 2.5–5.0 μm width ($n = 30$), walls varying in thickness, many branches, some hymenial with sword-like apices in the context. *Basidiospores* mostly ellipsoid to broadly ellipsoid, double walls, (11.6–)12.1–13.5–14.5(–15.8) \times (8.1–)8.9–11.3–11.9(–12.5) μm ($\bar{x} = 13.2 \times 11.4 \mu\text{m}$, $n = 50$) μm , with $Q = 1.12$ –1.19, $L = 13.24 \mu\text{m}$, $W = 11.44 \mu\text{m}$ (including myxosporium), (10.2–)10.9–12.8–13.7(–14.6) \times (6.8–)7.9–8.9–9.6(–10.2) μm ($\bar{x} = 12.6 \times 8.8 \mu\text{m}$, $n = 50$) μm , with $Q = 1.41$ –1.46, $L = 12.63 \mu\text{m}$, $W = 8.84 \mu\text{m}$ (excluding outer myxosporium), overlaid by hyaline, apically and echinulate, truncate, inner wall usually orange (6A7–6A8) to reddish golden (6C7) in KOH, brownish orange (5C5–5C6) in Melzer’s reagent, outer wall usually reddish orange (7A8, 7B8) in 5% KOH and brown (6D7–6D8) in Melzer’s reagent.

Habitat: solitary on the decaying hardwood of *Peltophorum pterocarpum* and *Castanopsis* sp.

Specimens examined: **THAILAND**, Chiang Rai Province, 20°15'03" N, 100°14'17" E, 732 m elev., on 9 October 2017, T. Luangharn, MFLU 17-1912.

Notes: *Ganoderma subresinosum* was introduced as *Fomes subresinosus* with the specimen from Philippines (Murrill 1908). Next, Humphrey (1938) verified this fungus species to the genus *Ganoderma*, and then Imazeki (1952) included this species in the genus *Trachyderma*. *Ganoderma subresinosum* is a species that is distributed worldwide, known from the Philippines to other Asians countries, and distributed across Eastern and Central Africa (Steyaert 1972; Wu et al. 1999; Glen et al. 2014; Hapuarachchi et al. 2019). This fungus is distinctive in form with its laccate pileus, sessile, dark-brown pileus surface, and concentrically sulcate with irregularly ruptured crust overlying the context, with ellipsoid to

elongate basidiospores. *Ganoderma subresinosum* was regarded as a synonym of *Trachyderma tsunodae* Imazeki (Imazeki 1952), *Magoderma subresinosus* (Steyaert 1972), and *Amauroderma subresinosum* (Corner 1983). In China, this fungus was reported by Chinese researchers as *Fomes subresinosum* (Teng 1963; Tai 1979; Teng 1996) and verified to *A. subresinosum* by Zhao (1989), and Zhao and Zhang (2000). Recently, several studies have suggested that those three synonymous fungal species are different from *G. subresinosum* based on emergent morphological and molecular data (Costa-Rezende et al. 2016, 2017). However, this fungus name is in Indexfunorum as *G. subresinosum*. So, this study, we present the first record of *G. subresinosum* from Thailand.

Ganoderma thailandicum T. Luangharn, P.E. Mortimer, S.C. Karunaratna & J.C. Xu, **sp. nov.**

Faces of Fungi number: FoF 06129

Index Fungorum number: IF 556535

MycoBank number: MB 831323

For characteristics see Luangharn et al. (2019b)

Notes: *Ganoderma thailandicum* is characterised by its laccate, deep magenta close to stipe, brownish red at center, and light yellow around active development toward the margin on pileal surface, white pore surface, brownish-red context, and absence of melanoid band.

Ganoderma tropicum (Jungh.) Bres., Annales Mycologici 8(6): 586 (1910)

≡ *Polyporus tropicus* Jungh., Praemissa in floram cryptogamicam Javae insulae.: 63 (1838)

≡ *Fomes tropicus* (Jungh.) Cooke, Grevillea. 14 (69): 19 (1885)

≡ *Scindalma tropicum* (Jungh.) Kuntze, Revisio generum plantarum. 3 (2): 519 (1898)

Faces of fungi number: FoF 05068

For characteristics see Luangharn et al. (2019a).

Notes: *Ganoderma tropicum* was introduced as *Polyporus tropicus* by Junghuhn (1838) with the specimen from Indonesia. Phylogenetic analysis has been well resolved with the aid of molecular data (Wang et al. 2012, Yang and Feng 2013) and transferred this species to *Ganoderma* (Bresadola 1910), where it is considered a member of the *G. lucidum* species complex (Zhou et al. 2015). The fungus is characterized by its distinctive reddish-brown pileal surface, dark-brown context near the tubes, dense context layer, thick near the base, with strongly echinulate basidiospores. Its distribution is highly variable worldwide, scattered across tropical Asian regions, mainland China (Cao et al. 2012; Wang et al. 2012; Hapuarachchi et al. 2018a), South America (Gottlieb and Wright 1999), and Taiwan, PRC (Wang et al. 2009), and it causes white root and butt rot on several tree species (Dai et al. 2007). Furthermore, there are some similarities between *G. tropicum* and other *Ganoderma* species. According to Cao et al. (2012), among the Chinese *Ganoderma* species, *G. flexipes*, *G. multipileum*, *G. sichuanense*, *G. lingzhi*, and *G. tsugae* are similar to *G. tropicum*, having a reddish-brown pileus surface, dark-brown context, ellipsoid basidiospores, strongly echinulate basidiospores, and irregular cuticle cells. Our new record of *G. tropicum* from Northern Thailand was described based on characteristics together with phylogenetic analyses, the details of which are shown in Luangharn et al. (2019a).

Taxonomy of Ganoderma from Vietnam

***Ganoderma hochiminhense* Karunarathna, Mortimer, Huyen & Luangharn, sp. nov.**

(Figure 33)

Faces of fungi number: FoF 06334

Index Fungorum number: IF 556794

MycoBank number: MB 832606

Diagnosis *Ganoderma hochiminhense* is characterised by its strongly laccate appearance, with a reddish-brown color near the stipe, a deep orange to brownish-yellow at the center, a white that indicates active development on the margin of the pileal surface, a yellowish-white pore surface when fresh, an orange, deep-orange to reddish-orange context, and absence of melanoid bands.

Holotype Vietnam, Hochiminh City, on living stump of *Areca* spp., 12 June 2019, LT2019 Gano 305 (MFLU 19-2224) and LT2019 Gano 306 (MFLU 19-2225).

Etymology The specific epithet “*hochiminhense*” refers to the place in Vietnam from where the holotype specimen was collected.

Basidiomes: sessile, orbicular.

Pileus up to 0.8–2.2 cm in length, 0.5–1.4 cm width, and 1.3 cm thick at base. *Pileus* orbicular, undulated, tuberculate, sulcate, single or fused at the base, broadly attached, hard when dried. *Pileus surface* distinctively laccate when young, strongly laccate when mature or dried. *Pileus color* reddish-brown from the base, light to deep-orange, golden-yellow, brownish- to reddish-yellow at the center, with deep yellow to orange-yellow at the margin of the upper surface, generally white where new hyphae are in active development, glossy, shiny, smooth, spathulate, sulcate when fresh, with a thin crust overlying the pileus, which is thicker at the base than at the margin, light weight when dried. *Hymenophore* mostly orange

to brownish-orange in KOH, up to 0.8 cm thick, with a dense but not fully homogenous context layer, bearing distinct layers of concentric growth zones at the center that extend to the margins, thick near the base, non-corky or woody texture when dried, bearing a simple septum at base, tough to break when dried, melanoid bands absent. Context reddish-orange in KOH; generative hyphae up to 2.72–3.82 μm ($\bar{x} = 3.54$, $n = 50$) in diam, almost colorless, thin walled, some expanded at the apex, unbranched, with clamp connections; skeletal hyphae dominant, up to 3.56–7.47 μm ($\bar{x} = 5.85$, $n = 50$), orange to brown, thick walled, unbranched, without clamp connections; binding hyphae 3.23–5.96 μm ($\bar{x} = 4.32$, $n = 50$), almost colorless, walls varying in thickness, with some narrow lumen to subsolid, frequently branched, tortuous, and interwoven at the distal end. *Tubes* hard, brown, up to 0.2–0.5 cm long. *Tubes layers* generative hyphae 2.21–3.03 μm in diam, pale-brown to brown, thin walled, some thick walled, with clamp connections, unbranched; skeletal hyphae 3.23–6.15 μm in diam, distinctly brown, thick walled, some narrow lumen to subsolid, frequently branched; binding hyphae 2.28–4.86 μm in diam, brownish-yellow, thick walled to solid, and frequently branched. *Stipe* short stipe, laccate when developing to maturity, and strongly laccate from maturity to old age. *Margin* white when present to maturity, light-brown to brown between the young to mature stages, turning light-brown when dry, and silky, soft, and slippery to the touch between youth and maturity, usually bruising when touched, and tough to break. *Pore* angular to round, 4–6 in number per mm, with dissepiments slightly thick to thick. *Pore surface* white when fresh, yellowish-white when dried, turns brown to dark-brown when touched.

Hyphal structure: hyphal system trimitic, with tissues yellow, light-orange to orange and brown in KOH; generative hyphae up to 2.70–3.25 μm ($\bar{x} = 3.09$, $n = 50$) in diam, almost colorless, thin walled, unbranched, with clamp connections, some slightly swollen at the distal end; skeletal hyphae-dominant, up to 3.49–7.67 μm broad ($\bar{x} = 5.98$, $n = 50$), pale-

brown to distinctly brown, thick walled, unbranched, without clamp connections, occasionally with narrow lumen, some subsolid, interwoven; binding hyphae 3.12–5.87 μm broad ($\bar{x} = 4.28$, $n = 50$), greyish-orange, walls varying in thickness, frequently branched, tortuous, and interwoven in the distal end. Basidia clavate, 4-sterigmatic, 10.2–14.3 \times 8.6–12.5 μm , yellowish to pale-brown in KOH. *Basidiospores* ellipsoid, sometimes broadly ellipsoid or almond-shaped at maturity, reddish-yellowish, light-brown to brownish-orange, slightly truncate, double walls, exospore smooth, endospore with coarse echinulate, (6.8)8.5–10.4(11.8) \times (5.8)6.9–9.3(10.2) μm ($\bar{x} = 9.4 \times 8.8 \mu\text{m}$, $n = 50$), with $Q = 1.02$ – 1.14 , $L = 9.38 \mu\text{m}$, $W = 8.82 \mu\text{m}$ (including myxosporium), (6.6)7.9–9.4(10.9) \times (5.4)6.3–8.5(9.3) μm ($\bar{x} = 9.0 \times 7.7 \mu\text{m}$, $n = 50$) μm , with $Q = 1.08$ – 1.21 , $L = 8.98 \mu\text{m}$, $W = 7.73 \mu\text{m}$ (excluding outer myxosporium), strongly echinulate, cuticle cells irregular. *Culture characteristics* white active mycelium on PDA, reaching 8 cm diam after 14 days at 25°C.

Habitat: solitary, on *Areca* spp. stumps.

Specimens examined: VIETNAM, Hochiminh City, 8°54'32" N, 98°31'09" E, 427 m elev., 12 June, 2019, S.C. Karunarathna, LT2019 Gano 305 (MFLU 19-2224, holotype) and LT2019 Gano 306 (MFLU 19-2225, paratype).

DISCUSSION AND CONCLUSION

The present study demonstrates the nomenclatural status, characteristics, phylogenetic analysis, host preference, collecting season, climate, and substrate details of *Ganoderma* species from the temperate climate of Yunnan Province, China, and tropical climates of Laos, Myanmar, Thailand, and Vietnam. Detailed characteristics and molecular analyses allow us to define our *Ganoderma* species as a distinctive well-supported clade with new insights to resolve species delimitation. Altogether, this study describes a total of six new records and two new species of *Ganoderma*, composed of two new records (*G. hoehnelianum* and *G.*

williamsianum) and a new species (*G. myanmarensis*) from Myanmar, four new records (*G. ellipsoideum*, *G. multipileum*, *G. philippii*, *G. subresinosum*) from Thailand, and one new species (*G. hochiminhense*) from Vietnam.

The *G. orbiforme* specimens were collected from living *Albizia mollis* and *Indochinese* spp. in a deciduous forest from Thailand. The *G. orbiforme* specimens from Thailand group in the non-laccate *Ganoderma* clade with *G. orbiforme* from Laos (Hapuarachchi et al. 2019) and China (Xing et al. 2018). The Thai *G. orbiforme* shares similar features as mentioned by Hapuarachchi et al. (2019) and Wang et al. (2014), such as possessing an annual to perennial, flabelliform or applanate pileus, with a weakly laccate surface, the presence of several thick layers, an undulate margin, and sub-circular or circular pores. The pileus size of the Thai collection of *G. orbiforme* (4–11 × 3–6 cm) is within the range of Asian collections (3.5–21 × 2.5–12 cm) (Wang et al. 2014) but was larger than the Chinese collection (3–8 × 2.5–6 cm) (Hapuarachchi et al. 2018). These findings are consistent with Ryvarden (2000), who demonstrated that *G. orbiforme* are widely distributed in tropical and temperate regions. This present study reports an additional record of *G. orbiforme* collected from Thailand.

Three *Ganoderma sinense* were collected from decaying as well as living *Albizia mollis* (Wall.) Boiv. and *Quercus* spp. in temperate Yunnan Province, China, and two collections were gathered from living *Dendrocalamus strictus* (Roxb.) Nees. and *Dipterocarpus* spp. in tropical Thailand. The present collections of *G. sinense* grouped together and showed as a sister taxon to the *G. nasalanense* from Laos. *Ganoderma sinense* is regarded as having high phenotypic plasticity and genetic diversity and was associated with substantial intraspecific morphological variation (Pilotti et al. 2003; Hapuarachchi et al. 2018). When considering the morphological differences between these, the Chinese *G. sinense* has a smaller-sized pileus (2–6 × 2–4 cm) and brownish-orange context, while the

Thai *G. sinense* has a larger sized pileus (4–10 × 6–12 cm) with a brown to dark-brown context. However, the Chinese and Thai *G. sinense* also share similar characteristics, such as stipitate, sub-dimidiolate to dimidiolate basidiocarps with a laccate radial pileus that extends from the centre to the margin, coloured dark-brown, cylindrical stipe, and basidiospores measuring 8.5–11.8 × 7.2–10.6 µm. The current findings of *G. sinense* are in agreement with Hapuarachchi et al. (2018), who demonstrated morphological variations across *G. sinense* collected from Hainan and Guizhou Provinces, China. In this study, *G. sinense* from Yunnan Province, China and Thailand were also recorded.

Ganoderma tropicum was introduced by Luangharn et al. (2019a) based on the collection made from Northern Thailand. In this study, phylogenetic analysis demonstrated that this fungus served as the sister clade to *G. multipileum*, *G. parvulum*, and *G. destructans*, and the Thai *G. tropicum* also grouped together with the Chinese *G. tropicum*, forming a sister clade with *G. multiplicatum* and *G. philippii*.

The present study describes a new species, *G. hochiminhense* (MFLU 19-2224 and MFLU 19-2225), from Vietnam. Phylogenetic analyses revealed *G. hochiminhense* collections grouped as sister taxa to the laccate *Ganoderma* clade, and characteristics and molecular analyses provided insights to resolve species delimitation. *Ganoderma hochiminhense* grouped together as a distinct clade with 100% ML, 98% MP, and 0.99 PP support. *Ganoderma hochiminhense* forms a sister clade with *G. zonatum* from the US (Zhou et al. 2015), the holotype *G. rywardenii* from Cameroon (Kinge and Mih, 2011), and the holotype *G. angustisporum* from Africa (Xing et al. 2018). However, those *G. hochiminhense*, *G. zonatum* and *G. rywardenii* share similarities and are sessile, laccate to strongly laccate on the upper pileus surface, and ellipsoid to broadly ellipsoid with truncated apices basidiospores at maturity (Kinge and Mih 2011; Zhou et al. 2015).

Although in the present phylogenetic tree *Ganoderma hochiminhense* clustered with

G. zonatum and *G. ryvardeenii*, their macro- and micro- characteristics are different. *Ganoderma hochiminhense* can be easily distinguished from *G. zonatum* by the size range of its small fruiting bodies (0.8–2.2 × 0.5–1.4 cm diam), single or fused fruiting bodies on hosts, orbicular when present, undulated pileus, reddish brown at base, deep orange, golden yellow, reddish yellow at its centre from maturity to old age, deep yellow and orange yellow on the margin, white pore, reddish-orange context, with (6.6–11.8 × 5.4–10.2 μm) basidiospore size range, while the fruiting bodies of *G. zonatum* are brown on the upper pileus surface, have cream pores, are finely echinulated, with (9.4–8.8 × 9.0–7.7) basidiospore size range. *Ganoderma ryvardeenii* differs from *G. hochiminhense* by its large pileus size range (13 × 8.5 cm), annual, dimidiate, or circular pileus, reddish margin, dark-brown context, and basidiospore size range with (9.0–14.0 × 4–8 μm). *G. zonatum* was regarded as a species distributed in subtropical to tropical climates (Ryvarden 2000; Foroutan and Vaidya 2007; Cong 2010), and our *G. hochiminhense* was also collected from a tropical region. Consequently, we propose that taxa in this clade comprises of species isolated from tropical regions. This study confirmed that the new *G. hochiminhense* were collected on *Areca* spp. stumps in Vietnam's tropical climate.

For detailed characteristics and phylogenetic analyses of *Ganoderma casuarinicola*, *G. thailandicum*, and *G. enigmaticum*, see Xing et al. (2018) and Luangharn et al. (2019). In the present study, *G. calidophilum* collected from China formed a sister clade with the above three *Ganoderma* species, and the clade is distinguished with good statistical support values. Although *G. calidophilum* is sister to the laccate clade, its macro- characteristics are very distinctive, such as a stipitate, sub-dimidiate to dimidiate pileus, homogenous brownish red, reddish brown at the centre, brownish orange towards the stipe, and light brown at margin from maturity to old age, brownish-orange context, and cylindrical stipe.

Ganoderma williamsianum was collected from tropical Myanmar, and the

phylogenetic analysis grouped the present collection with *G. williamsianum* collected from Thailand (Xing et al. 2018). Both *G. williamsianum* strains grouped as sister taxa to the holotype *G. mbrekobenum* from Ghana (Crous et al. 2016) but with low support. The description of our collected *G. williamsianum* is distinctive, having characteristics such as small fruiting bodies with the size range of 0.5–1.5 × 0.5–1 cm, rarely with a stipe-like base, sub-flabellate to circular fruiting bodies, smooth and soft, weakly laccate, and homogenous orange to deep orange context, though the basidiospore could not be observed. The current study allows for comparison between *G. williamsianum* and *G. mbrekobenum*. *G. mbrekobenum* is macro-micro very different from *G. williamsianum*, with its distinctive dimidiate, lateral stipe, dimitic hyphal system, with ovoid to broadly ellipsoid basidiospore (Crous et al. 2016). Xing et al. (2018) also reported the collection of *G. williamsianum* from Thailand with the phylogenic study but without morphological description. *Ganoderma williamsianum* has been reported as a species distributed across China (Wang and Wu 2010), Indonesia (Imazeki 1952; Steyaert 1972), Malaysia (Steyaert 1972), and the Philippines (Murrill 1907; Steyaert 1972). Here, this study introduces a new record of *G. williamsianum* from Myanmar's.

Ganoderma adpersum was collected near the root of the living tree *Mangifera indica* L. in Laos, while the Thai *G. adpersum* strain was collected from the decaying hardwood of *Pterocarpus* spp. Macro- characteristics of our collected *G. adpersum* share similarities with what has already been described by Moncalvo et al. (2000), such as having a non-laccate, sessile, perennial, sub-dimidiate to dimidiate pileus, a sulcate, brown pileus surface and context, and a yellowish-white pore surface, with a similar basidiospore size range (6.9–10.6 × 4.7–7.8). However, their characteristics are also quite different, as the *G. adpersum* from Laos is mostly ellipsoid to broadly ellipsoid, with brownish-orange inner walls of basidiospores, while the Thai *G. adpersum* is mostly ellipsoid, with brownish-yellow inner

walls and brown to dark brown outer walls. It was observed that our Thai *G. adpersum* had a di-trimitric hyphal system, while Hapuarachchi et al. (2019) reported that their Thai *G. adpersum* was composed of a trimitic hyphal system. This fungus is frequently reported in temperate and tropical climates (Moncalvo et al. 2000; Simone and Annesi 2012) where it may grow on many hardwood tree species (Bernicchia 2005; Simone and Annesi 2012). *Ganoderma adpersum* has been reported in Europe (Johnson 2017), India (Arulpandi and Kalaichelvan, 2013), Korea (Jargalmaa et al. 2017), Italy (Nicolotti et al. 1992; Nicolotti et al. 2004; Bernicchia 2005), Laos, Myanmar, and Thailand (Hapuarachchi et al. 2019). In this study, the additional numbers of *G. adpersum* from Laos and Thailand are presented and a recommendation is made for identifying this fungus through using detailed morphological observations and phylogenetic studies.

This study introduces a new record of *G. ellipsoideum*, collected from Chiang Mai Province, Thailand, growing on rotten wood. The newly collected *G. ellipsoideum* serves as the sister group to *G. adpersum* (ML = 97%, MP = 96%, PP = 0.95). It is also correlative to the results by Hapuarachchi et al. (2018). Our collection from Thailand allows us to conduct comparisons with the holotypes of *G. ellipsoideum* from Hainan Province, China. The current *G. ellipsoideum* share similarities with the holotype collection in its annual, sessile, several-layers thick circular or sub-circular pores, and presence of ellipsoid basidiospores. However, the Chinese holotype of *G. ellipsoideum* presents quite a different basidiospore size range (6.1–7.3 × 3.7–4.6 µm) including myxosporium, while the Thai *G. ellipsoideum* was (4.8–7.7 × 3.1–5.4 µm) including myxosporium. The Chinese *G. ellipsoideum* was initially yellowish-white, with later a yellowish-brown to brownish-yellow pore surface, while Thai *G. ellipsoideum* presented white (11A1) to pale yellow (2A3) colouration. *Ganoderma ellipsoideum* also serves as the sister group to the *G. gibbosum* and *G. austral* clade. Our *G. gibbosum* collections were collected from China, Laos, and Thailand. *Ganoderma gibbosum*

macro- and micro- characteristics are quite different. For the variations in *G. gibbosum* see Luangharn et al. (2019), while *G. australe* from Thailand has been described in Luangharn et al. (2017).

Ganoderma multipileum collected from Thailand's tropical climate was collected after the rainy season. Phylogenetic analysis showed our *G. multipileum* close within the clade to *G. multipileum* (CWN 04670) from Taiwan, PRC. Our collection was grouped as a sister to *G. steyaertanum* B. J. Smith & Sivasith, *G. mizoramense* Zothanzama, Blanchette, Held, C.W., Barnes, *G. martinicense* Welti & Courtec, and *G. destructans* M.P.A. Coetzee, Marinc. & M.J. Wingf. These *Ganoderma* species, including *G. steyaertanum*, *G. mizoramense*, *G. martinicense*, *G. destructans*, and *G. multipileum*, share similarities in that they have a laccate to strongly laccate upper pileus surface at maturity. Although *G. steyaertanum* can be easily distinguished from *G. multipileum* by its distinctive kidney-shaped basiodomata, with a dark-brown pileus surface, in addition, this species is similar to *G. multipileum* in that its basiodomata very rarely extends completely to the margin (Smith and Sivasithamparam 2003). *Ganoderma mizoramense* can be differentiated from *G. multipileum* by its reddish-brown when fresh to liver-brown when dry upper pileus surface, dark-brownish to dark-reddish brown context, and lower surface white when fresh (Crous et al. 2017). *G. martinicense* can be differentiated from *G. multipileum* by its generally produced sessile basidiomata, with a dark-cinnamon-brown context (Loyd et al. 2018), while our *G. multipileum* has rarely sessile basidiomata and a light-brown to brown context; however, phylogenetic analysis revealed *G. martinicense* as a close relative to the Asian taxon *G. multipileum* (Welti and Courtecuisse 2010; Loyd et al. 2018). *G. destructans* is significantly different, with its pileus containing a creamy and soft context, presenting mostly ovoid basidiospores (Coetzee et al. 2015).

Ganoderma philippii was collected in the tropical Chiang Mai Province, Thailand.

Phylogenetic analysis reveals it to be close to our Malaysian *G. philippii* strains (Glen et al. 2009). *Ganoderma philippii* is a unique species that grows especially actively in heavy soils with high water content (Steyaert 1975). Our macro and micro characteristics are also correlative to the results by Singh et al. (2013), who reported this fungus as easily identifiable by its non-laccate pileus surface and sessile basidiome, mostly presenting oblong basidiospores. *Ganoderma philippii* formed a sister clade to *G. multiplicatum* and *G. tropicum*. *Ganoderma philippii* are very different, with its distinctive non-laccate, often convex, umbonate, and plump pileus and sessile, with mostly oblong basidiospore, while *G. multiplicatum* is laccate to strongly laccate, radial or branched from the centre, extending to the margin, and presenting mostly as an ellipsoid basidiospores (Wang et al. 2009). *Ganoderma tropicum* was collected from Thailand; although it closed a sister clade with *G. multiplicatum*, its macro-micro characteristics are noticeably different and were detailed by Luangharn et al. (2019a).

In this study, our *G. lingzhi* specimen was collected in the temperate climate of Yunnan Province, China and the tropical climate of Thailand. Phylogenetic analysis placed our collections as sister taxa to the laccate *Ganoderma* clade and close to the holotype *G. lingzhi* from China (Cao et al. 2012). Our collections also share macro-micro characteristics similar to the holotype described (Cao et al. 2012), with their shell-like, reniform to circular pileus, reddish-brown pileal surface, strongly laccate, stipitate, and mostly present ellipsoid basidiospores that truncate at maturity. Among the Chinese *Ganoderma* species, *G. flexipes*, *G. multipileum*, *G. sichuanense*, *G. tropicum* and *G. tsugae* are the species that most most resemble *G. lingzhi*, as their macro-micro characteristics share a reddish-brown pileal surface, similar basidiospores and cuticle cells. Nevertheless, the differences between these *Ganoderma* species were detailed in Cao et al. (2012) and Dai et al. (2017).

Ganoderma resinaceum has long been reported in temperate climates (Moncalvo et al.

1995; Zhou et al. 2015), and our collection is also from the temperate climate of Yunnan Province, China. Our Chinese *G. resinaceum* is close together with the *G. resinaceum* from England and Netherland, with good clade support. Our result is also similar to the phylogenetic analysis by Douanla-Meli and Langer (2009). However, *G. resinaceum* from England and Netherland are without the macro- micro description. Moreover, *G. resinaceum* collections have also been reported from India with descriptions (Mohanty et al. 2011). Their macro- and micro- characteristics are quite different. Our *G. resinaceum* is distinctive with its short stipe, varying reddish-brown upper pileus surface, greyish-yellow to dark-brown context covered by an irregularly ruptured thin crust, and larger pileus size range (1.5–12.5 × 1–7 cm), while the Indian strain is stipitate, with a brown upper pileus surface, round margin, light-brown context, and smaller pileus size range (8–9 × 6–7.5 cm) (Mohanty et al. 2011). Therefore, we conclude that *G. resinaceum* species are phylogenetically similar despite having different characteristics, as evidence suggests that this fungus is widely distributed across both temperate and tropical regions (Moncalvo et al. 1995; Douanla-Meli and Langer 2009; Mohanty et al. 2011; Zhou et al. 2015).

We introduce *G. hoehnelianum* as a new record from Myanmar. This mushroom was collected on the decaying stump of an unidentified dicotyledonous tree species in tropical Myanmar. The phylogeny of our *G. hoehnelianum* is close to the Chinese *G. hoehnelianum* collection (Song et al. 2016) and is well supported. Our collection shares similar macro-micro characteristics to Wang and Wu (2010) and Hapuarachchi et al. (2018), with its distinctive annual, sessile, plano concave, dark-brown upper pileus surface and context, and concentrically sulcate zones with broadly ovoid basidiospores. Our *G. hoehnelianum* grouped with the *G. austroafricanum* H. Xing, B.K. Cui & Y.C. Dai, and *G. carocalcareus* Douanla-Meli clade. *Ganoderma austroafricanum* is distinctive from *G. hoehnelianum*, with its reddish-brown pileus surface, smooth surface, round margin, with a subglobose

basidiospores. *G. carocalcareus* collected from a tropical region in Cameroon is distinctive from *G. hoehnelianum*, with its friable context, and thick towards the margin and downwards to the pore margin (part of hymenophore), red-brown to brown-orange margin, and forming a concentric aporoid zone (Douanla-Meli and Langer 2009).

Ganoderma applanatum (= *G. lipsiense*) was collected from temperate China and tropical Thailand. Phylogenetic analysis shows our *G. lipsiense* clustering as a distinctive group with good support. The name of *Ganoderma lipsiense* has been treated and corrected to *G. applanatum* (Richter et al. 2015), and it is mentioned that *G. lipsiense* also belongs to this complex species. Macro-micro characteristics of our collections are similar to those described in detail in Ryvarden and Gilbertson (1993). Our Chinese and Thai *G. lipsiense* collections have quite different macro characteristics. Chinese *G. lipsiense* shows a smaller pileus size range with 1.5–5.8 × 0.5–4.5 cm, up to 1.5 cm thick at the base, while Thai *G. lipsiense* was 2–12 × 2.5–6 cm, and 0.8–3.1 cm thick at the base. Chinese *G. lipsiense* is distinctive and non-laccate, faded from maturity to old age, while Thai *G. lipsiense* had differentiated zones of peach red and reddish orange at the base, brownish orange with the radius light brown at the centre, and extending to dark brown close to active mycelium (margin). Our results are also correlative to Wang et al. (2012), who has reported that there are high morphological variations within Chinese *Ganoderma*. *Ganoderma* species from different geographic areas have also shown separate lineages in phylogenetic analyses (Moncalvo et al. 1995; Gottlieb et al. 2000).

In this study, we describe a new species of *Ganoderma myanmarensis* collected in Myanmar's. These two *G. myanmarensis* collections grouped as sister taxa to the laccate *Ganoderma* clade, and their characteristics and molecular analyses provided insights to resolve species delimitation. This new species *G. myanmarensis* forms a sister clade with *G. wiiroense* E.C. Otto, Blanchette, C.W. Barnes & Held. from Ghana, *G. destructans* M.P.A.

Coetzee, Marinc, M.J. Wingf. from South Africa, and our *G. flexipes* from China. Macro characteristics of *G. wiiroense* show its annual, dimidiate pileus, sessile, with yellowish-brown to dark reddish-brown (Crous et al. 2015), while our *G. myanmarensis* shows its distinctive sectorial to shell-shaped, sub-reniform to reniform, and orange, golden yellow, and yellowish red at centre, slightly reddish orange and reddish brown (8E8) where deeply sulcate, *G. destructans* shows its distinctive globular pileus, with creamy soft non-poroid tissue (Coetzee et al. 2015), and *G. flexipes* presents very differently from *G. myanmarensis* with its sub-reniform to reniform pileus, small pileus sized range 0.5–3.2 × 0.5–3 cm, homogenous with reddish-brown to dark-brown upper pileus surface, and sub-cylindrical to cylindrical stipe.

Our *G. lucidum* collections were collected from China and Thailand. Phylogenetic analysis showed our strains clustered with *G. lucidum* from France, with good statistical support. The result showed our *G. lucidum* grouped as sister taxa to the laccate *G. leucocontextum* from China. *Ganoderma lucidum* has a high degree of morphological variability, often resulting in taxonomic and phylogenetic confusion (Moncalvo et al. 1995). Our Chinese and Thai *G. lucidum* specimens were analysed by phylogenetic data and described based on macro characteristics, and they showed quite different features. Chinese *G. lucidum* is different from Thai *G. lucidum* with its cylindrical stipe, and when viewed from above, one can observe the presence of a central stipe at the centre of the pileus, while Thai *G. lucidum* presents a cylindrical and eccentric stipe. However, both strains share similarities, with their distinctive stipitate, furrowed, incised, undulate to sulcate, undefined imbricate, yellowish red, brownish red to reddish orange with laccate upper pileus surface, light brown to dark brown context, and presence of dark brown melanoid bands. Our results are also in agreement with those of Wang et al. (2012) who reported that the Chinese *G. lucidum* has a deeper-coloured context that is even darker near the tube layer. Although both *G. lucidum* and

G. leucocontextum form a sister clade, their morphological characteristics are different. *Ganoderma leucocontextum* shows its distinctive white context, thickset stipe, and broadly ellipsoid basidiospores ($9.5\text{--}12.5 \times 7\text{--}9 \mu\text{m}$). For descriptive details please see Li et al. (2015).

Ganoderma tsugae is one of the *Ganoderma* species that shares similar characteristics with *G. lucidum* (Cao et al. 2012). In this study, we collected *G. tsugae* from Yunnan Province, China. In the phylogenetic analysis it clustered with *G. tsugae* from the USA (Zhou et al. 2015) and grouped as a sister to *G. oregonense* (Zhou et al. 2015; Torres-Torres et al. 2015). However, *G. tsugae* has smaller basidiospores ($9\text{--}11 \times 6\text{--}8 \mu\text{m}$) (Overholts 1953) than *G. oregonense* ($13\text{--}17 \times 8\text{--}10 \mu\text{m}$) (Gilbertson and Ryvardeen 1986).

In this study, we introduce a new record of *G. subresinosum* that was collected in Thailand during the rainy season. Phylogenetic analysis indicated our *G. subresinosum* as a distinct clade with good support. Macro-micro characteristics of *G. subresinosum* are similar to Hapuarachchi et al. (2019b), who demonstrated that this fungal species has a distinctively annual, sessile, laccate, dark brown upper pileus surface, concentrically sulcate, irregularly, greyish orange with dried, and woody when old, and presenting ellipsoid to elongate basidiospores.

Based on comprehensive characteristics and molecular analyses, we report twenty-three *Ganoderma* species from GMS, including *G. adpersum*, *G. applanatum*, *G. australe*, *G. calidophilum*, *G. ellipsoideum*, *G. flexipes*, *G. gibbosum*, *G. heohnelianum*, *G. hochiminhense*, *G. leucocontextum*, *G. lingzhi*, *G. lucidum*, *G. multiplicatum*, *G. multipileum*, *G. myanmarensis*, *G. orbiforme*, *G. philippii*, *G. resinaceum*, *G. sinense*, *G. subresinosum*, *G. williamsianum*, *G. tropicum*, and *G. tsugae*, of which 13 *Ganoderma* species were collected from Yunnan Province, China, 3 species from Laos, 3 species from Myanmar, and 12 species from Thailand, including *G. hochiminhense* from Vietnam and *G. myanmarensis* from Myanmar.

Abbreviations

PP: Bayesian posterior probabilities; ML: Maximum likelihood; MP: Maximum parsimony; ITS: Internal Transcribed Spacer; LSU: Large subunit; RPB2: The second largest subunit of RNA polymerase II; TEF1- α : Translation elongation factor 1 α .

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Adherence to national and international regulations

Not applicable.

Authors' contributions

TL data curation, TL and SCK formal analysis, TL and SCK Investigation, KDH, JX and PEM funding acquisition, TL, SCK, CKL, LTH, HNPD and PEM Methodology, JX and PEM Project administration, JC and PEM Supervision, TL, SCK, AKD and SP Writing—original draft, Writing—review & editing, JX, KDH and PEM.

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Conflicts of interest

The authors declare no conflict of interest.

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Figures

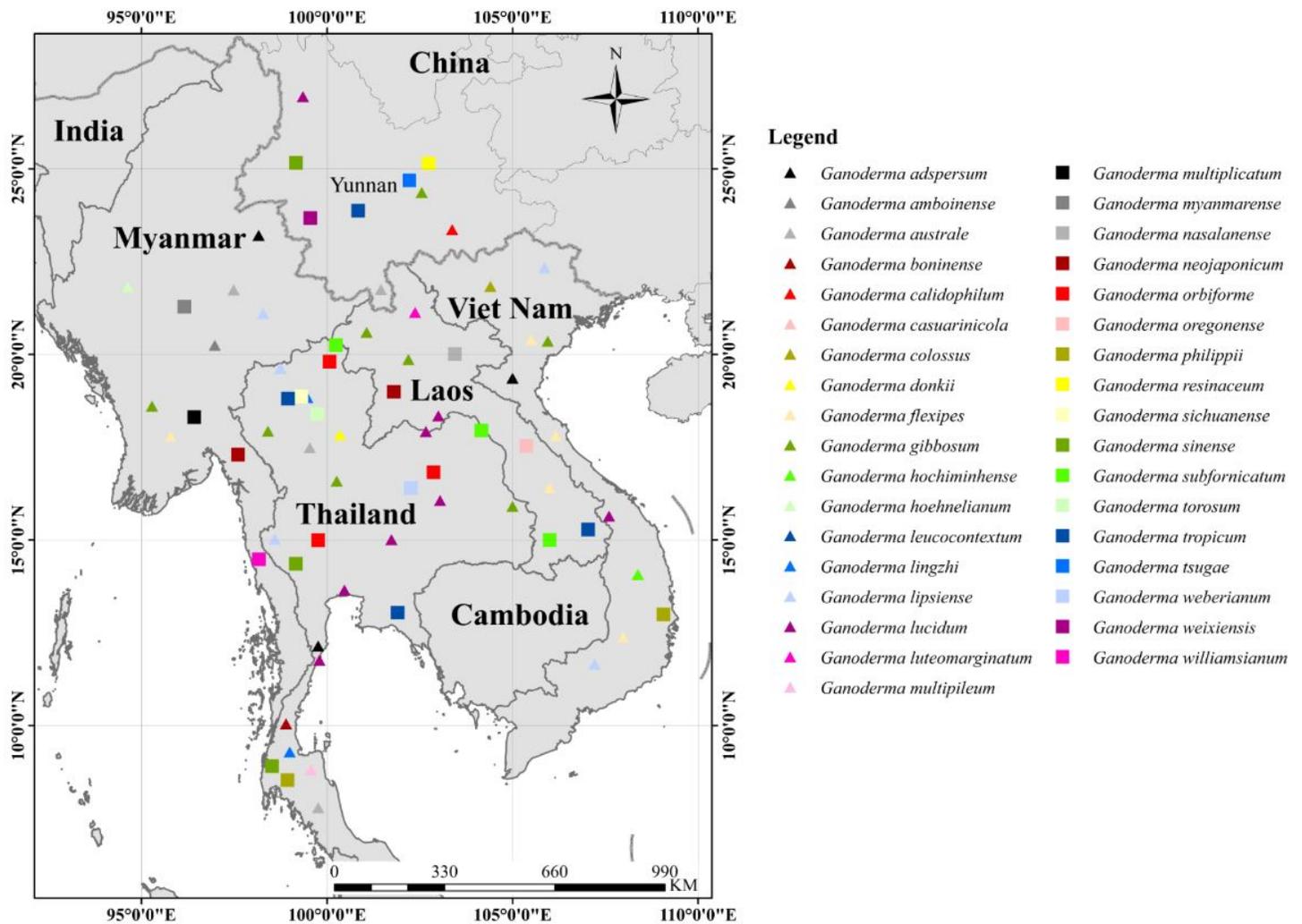


Figure 1

Distribution of *Ganoderma* species in the GMS. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

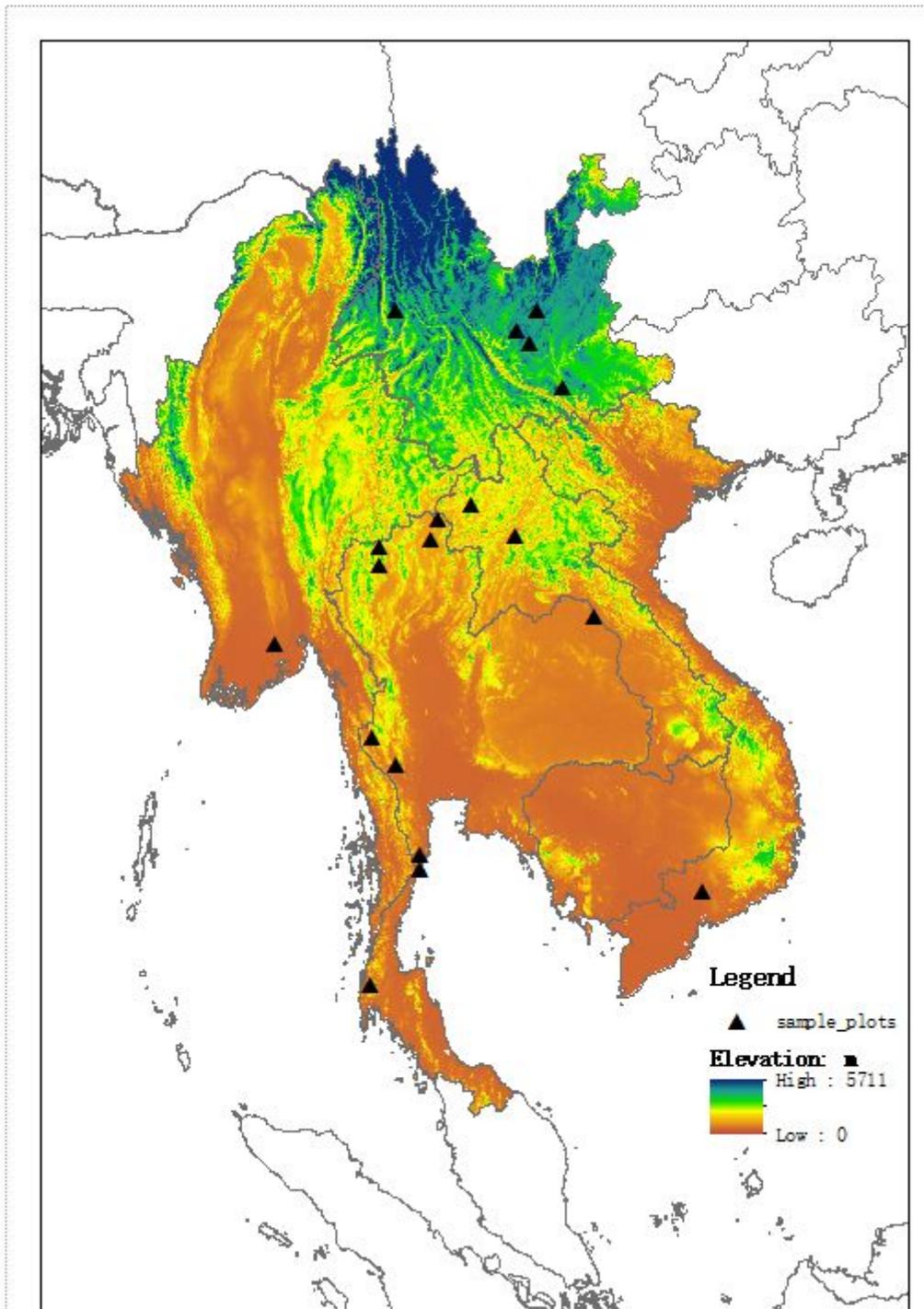


Figure 2

Collection sites in China, Laos, Myanmar, Thailand, and Vietnam. Black triangles indicate collection locations in each country. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

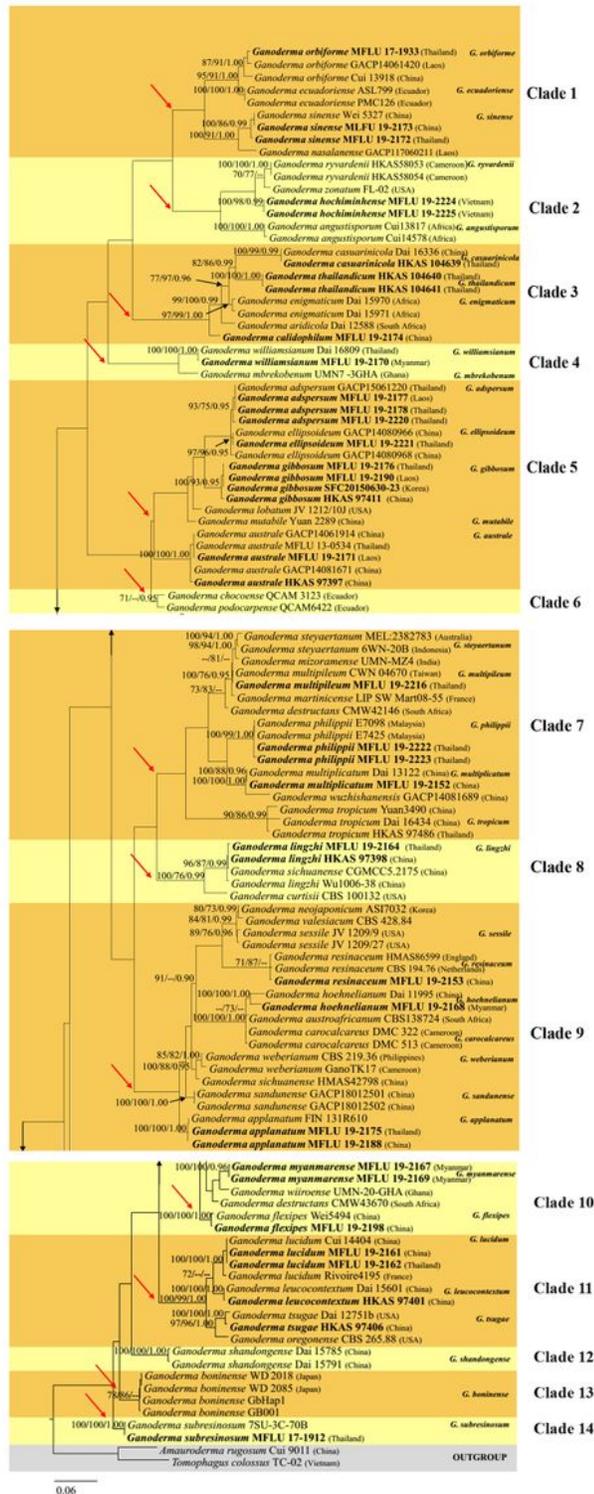


Figure 3

Maximum Likelihood phylogenetic tree ML obtained from the DNA sequence data of ITS, LSU, RPB2, and TEF1 α datasets. Bootstrap values BS from maximum likelihood ML, left, Maximum parsimony MP, middle equal to or greater than 70% and Bayesian posterior probabilities PP, right equal to or greater than 0.95 are indicated above or below the nodes as MLBS/MPBS/PP. The tree is rooted with *Amauroderma*

rugosum Cui 9011 and *Tomophagus colossus* TC-02. New species, new record species, and known species obtained in this study are indicated in bold black

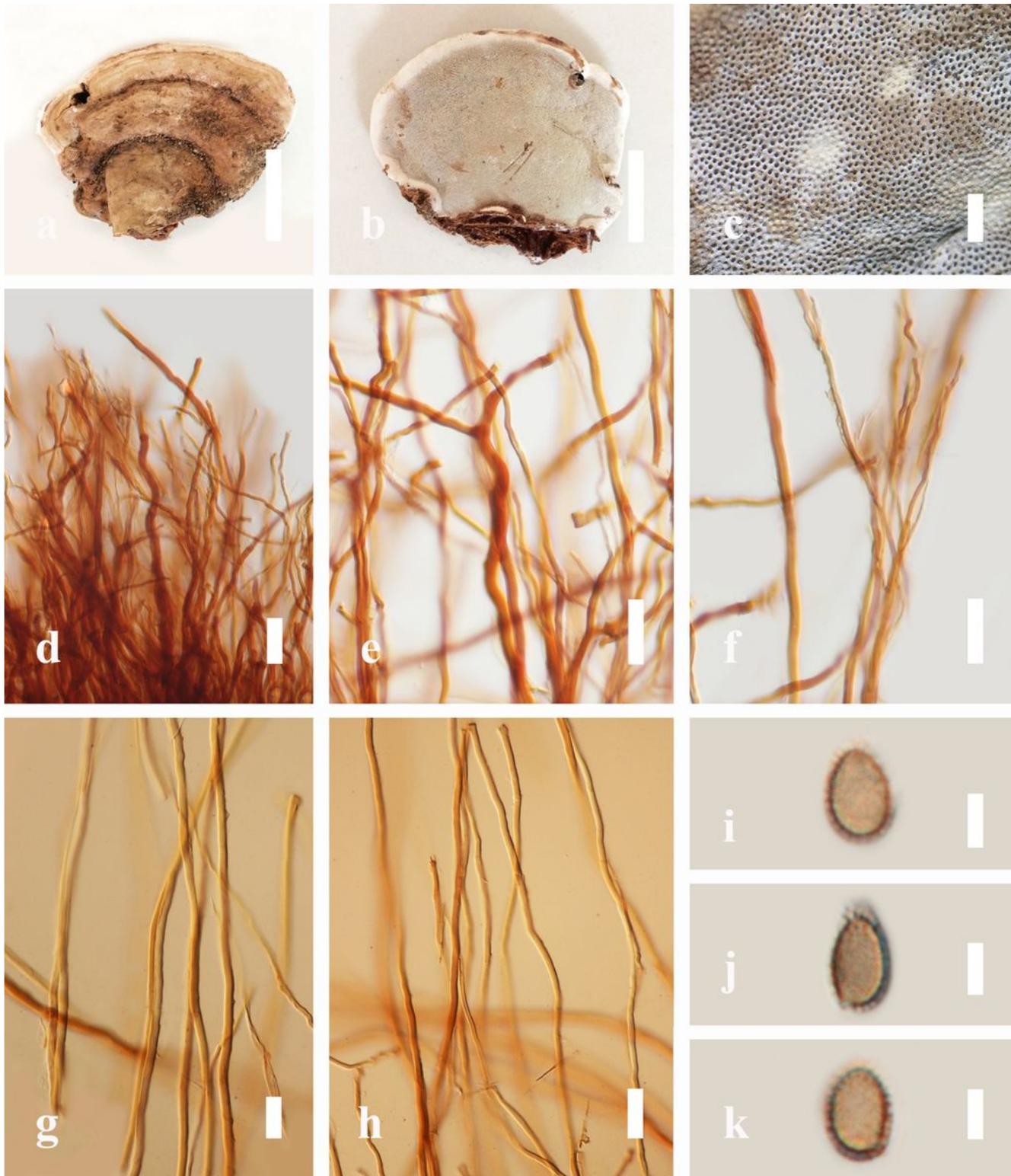


Figure 4

Morphology of *Ganoderma applanatum* HKAS 107254, MFLU 19-2188: a–b Mature basidiomes. c Pore characteristics. d–f Hyphae of trama in KOH. g–h Generative hyphae of context in KOH. i–k Basidiospores. Scale bars: a–b = 2 cm, c = 1000 µm, d–h = 20 µm, i–k = 5 µm

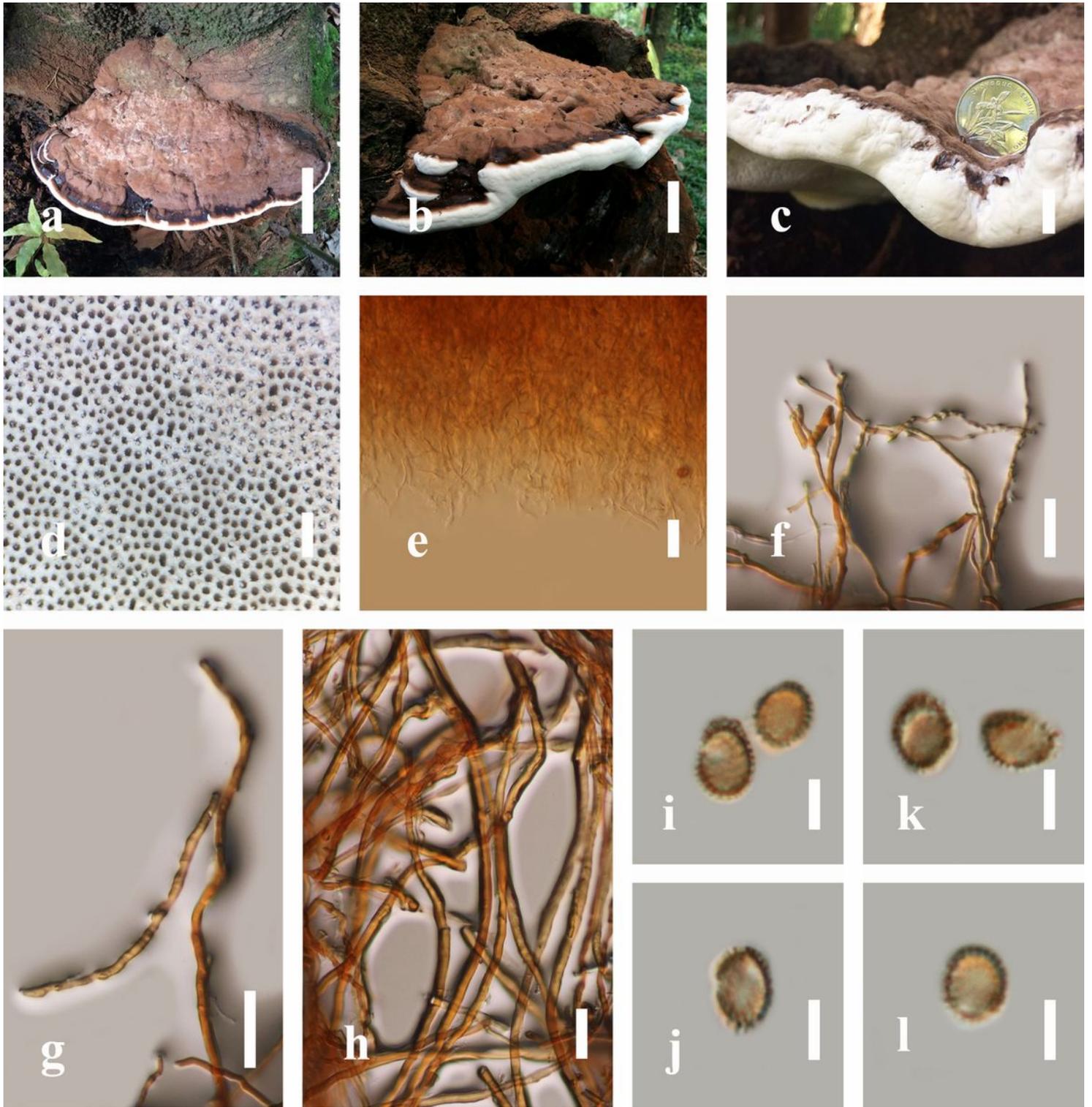


Figure 5

Morphology of *Ganoderma australe* HKAS 97397: a–b Mature basidiomes. c Margin. d Pore characteristics. e Mycelia of tube layers. f–h Context hyphae as seen in Melzer's reagent. i–l Basidiospores. Scale bars: a = 5 cm, b = 3 cm, c = 1 cm, d = 500 μ m, e = 20 μ m, f = 20 μ m, g–h = 10 μ m, i–l = 5 μ m

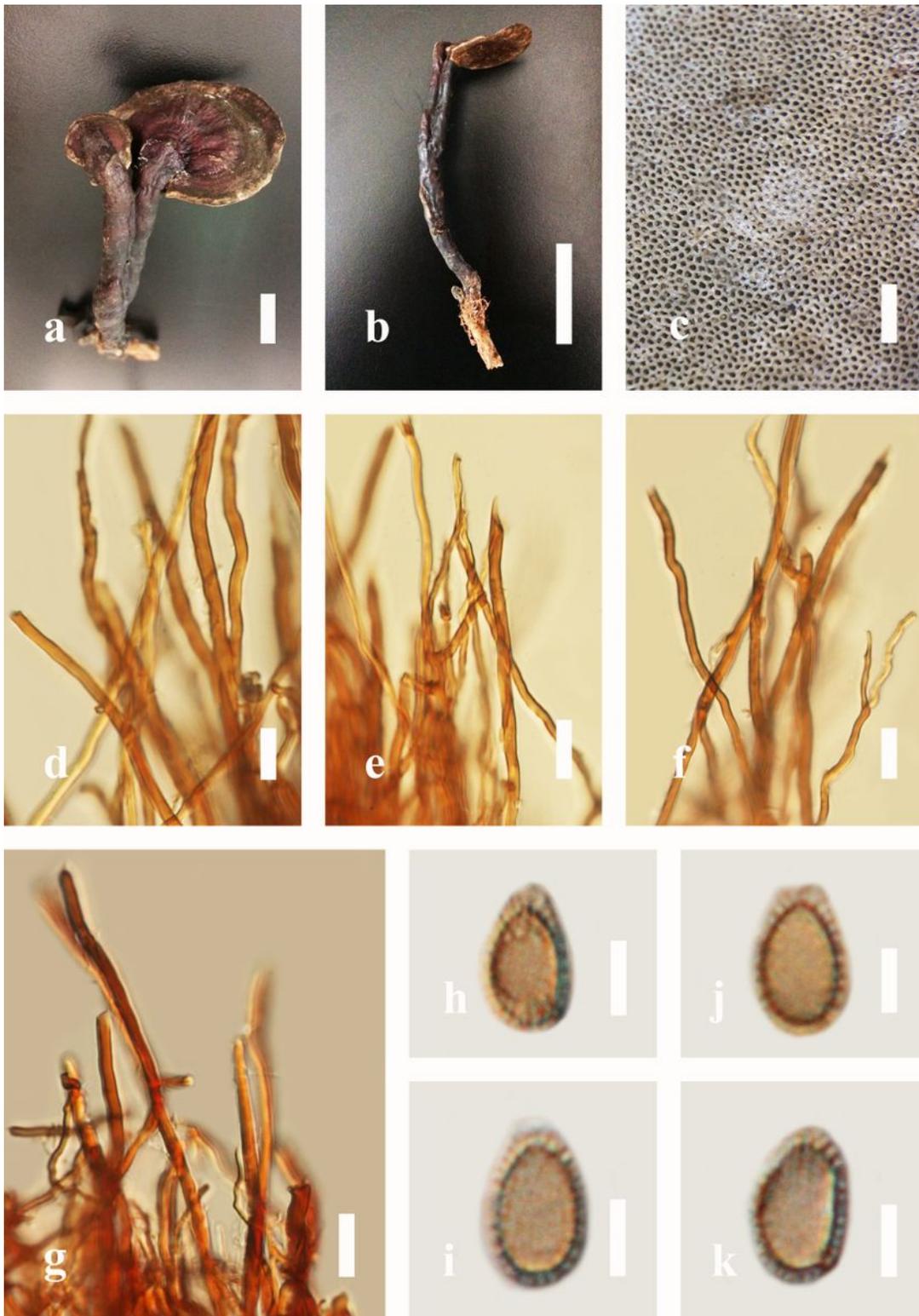


Figure 6

Morphology of *Ganoderma calidophilum* MFLU 19-2174: a–b Mature basidiomes. c Pore characteristics. d–f Context hyphae in Melzer's reagent. g Tube layer hyphae in Melzer's reagent. h–k Basidiospores. Scale bars: a = 2 cm, b = 5 cm, c = 1000 μ m, d–g = 20 μ m, h–k = 5 μ m

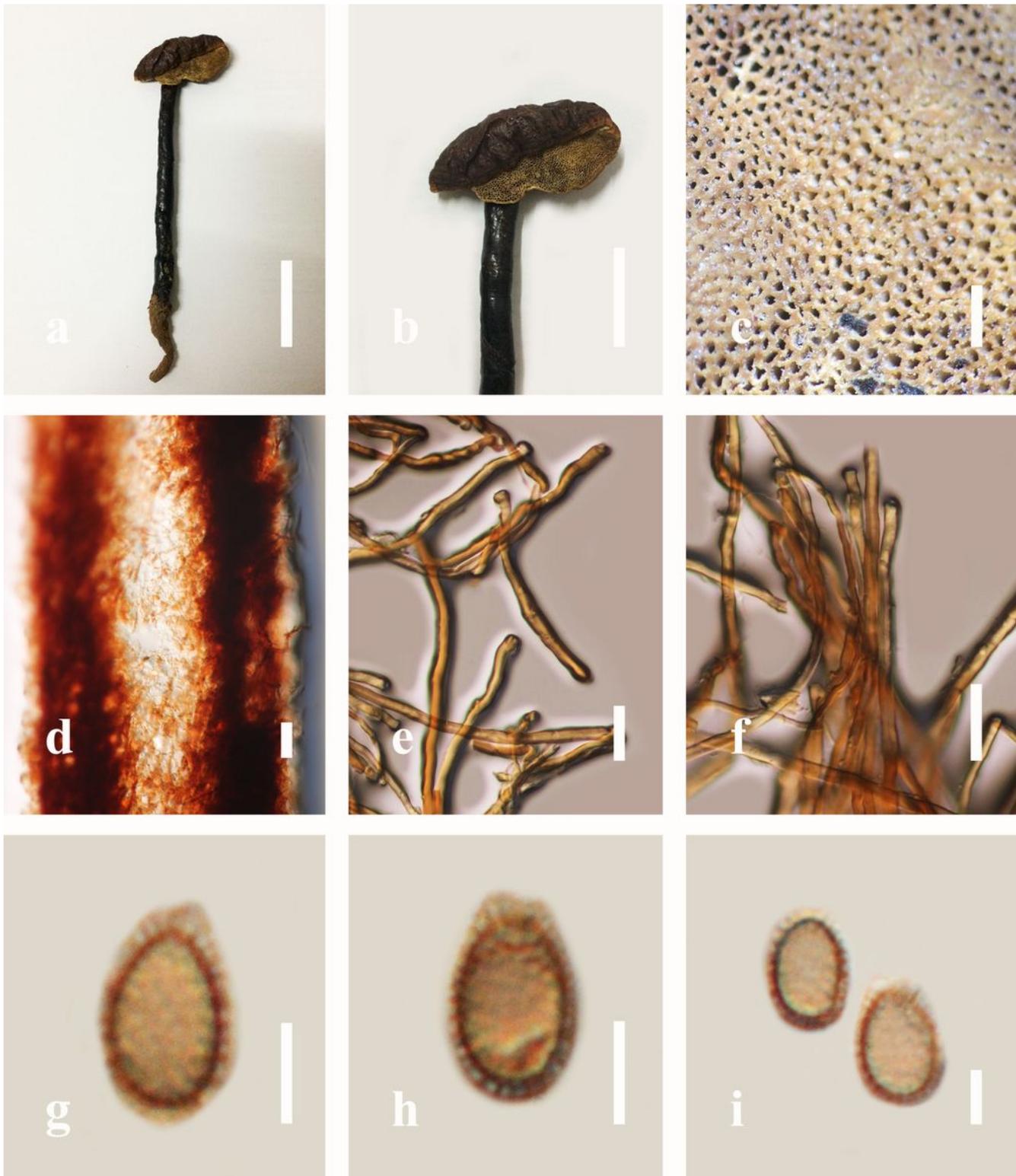


Figure 7

Morphology of *Ganoderma flexipes* MFLU 19-2189: a–b Mature basidiomes, c Pore characteristics. d Hyphae of tube layers in Melzer's reagent. e–f Context hyphae in Melzer's reagent. g–i Basidiospores. Scale bars: a = 3 cm, b = 2 cm, c = 500 μ m, d = 30 μ m, e–f = 20 μ m, g–i = 5 μ m

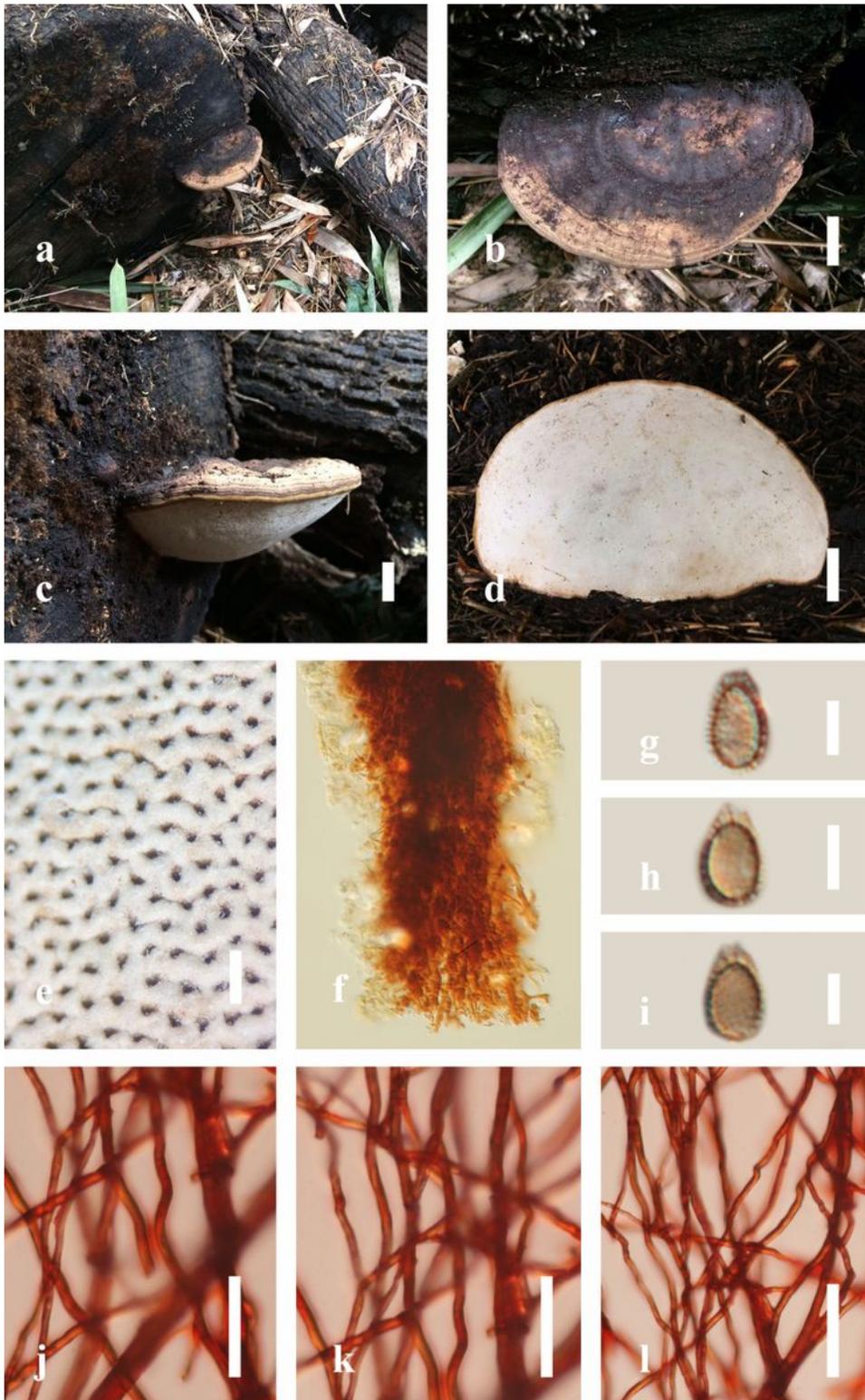


Figure 8

Morphology of *Ganoderma gibbosum* HKAS 97411: a–b Upper surface of mature basidiomes. c Margin. d Under surface of mature basidiomes. e Pore characteristics. f Hyphae of tube layers in Melzer's. g–i Basidiospores in Melzer's. j–l Context hyphae in Congo red. Scale bars: b, d = 3 cm, c = 1 cm, e = 500 μm , g–i = 5 μm , j–l = 20 μm

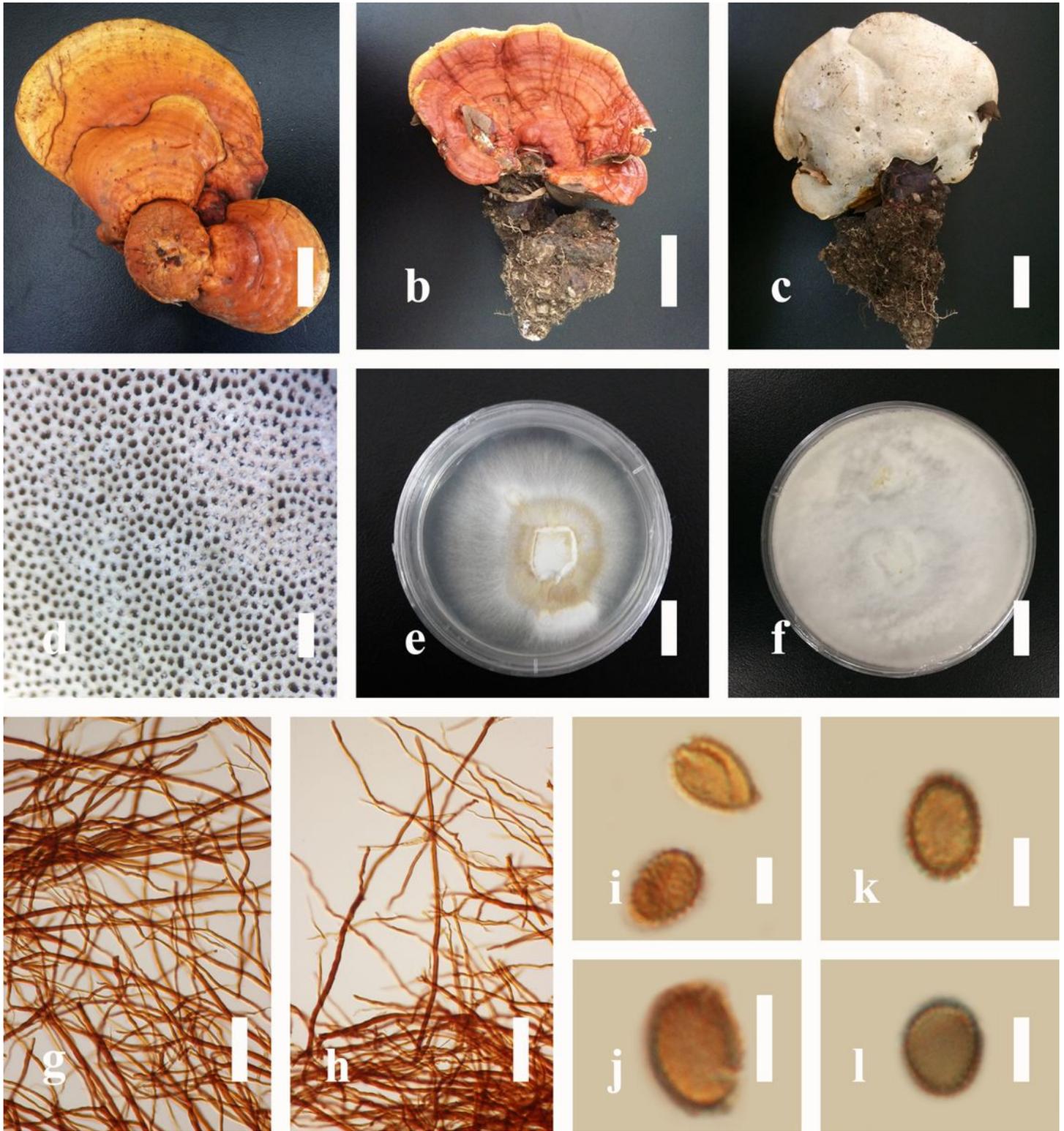


Figure 9

Morphology of *Ganoderma leucocontextum*: a Mature basidiomes of the strain HKAS 97401. b–c Mature basidiomes of the strain MFLU 19-2160. d Pore characteristics. e Culture after incubation at 25 °C for 14 days. f Culture after incubation at 25 °C for 21 days. g–h Context hyphae in KOH. i–l Basidiospores. Scale bars: a, e–f = 2 cm, b–c = 4 cm, d = 500 μ m, g–h = 30 μ m, i–l = 5 μ m

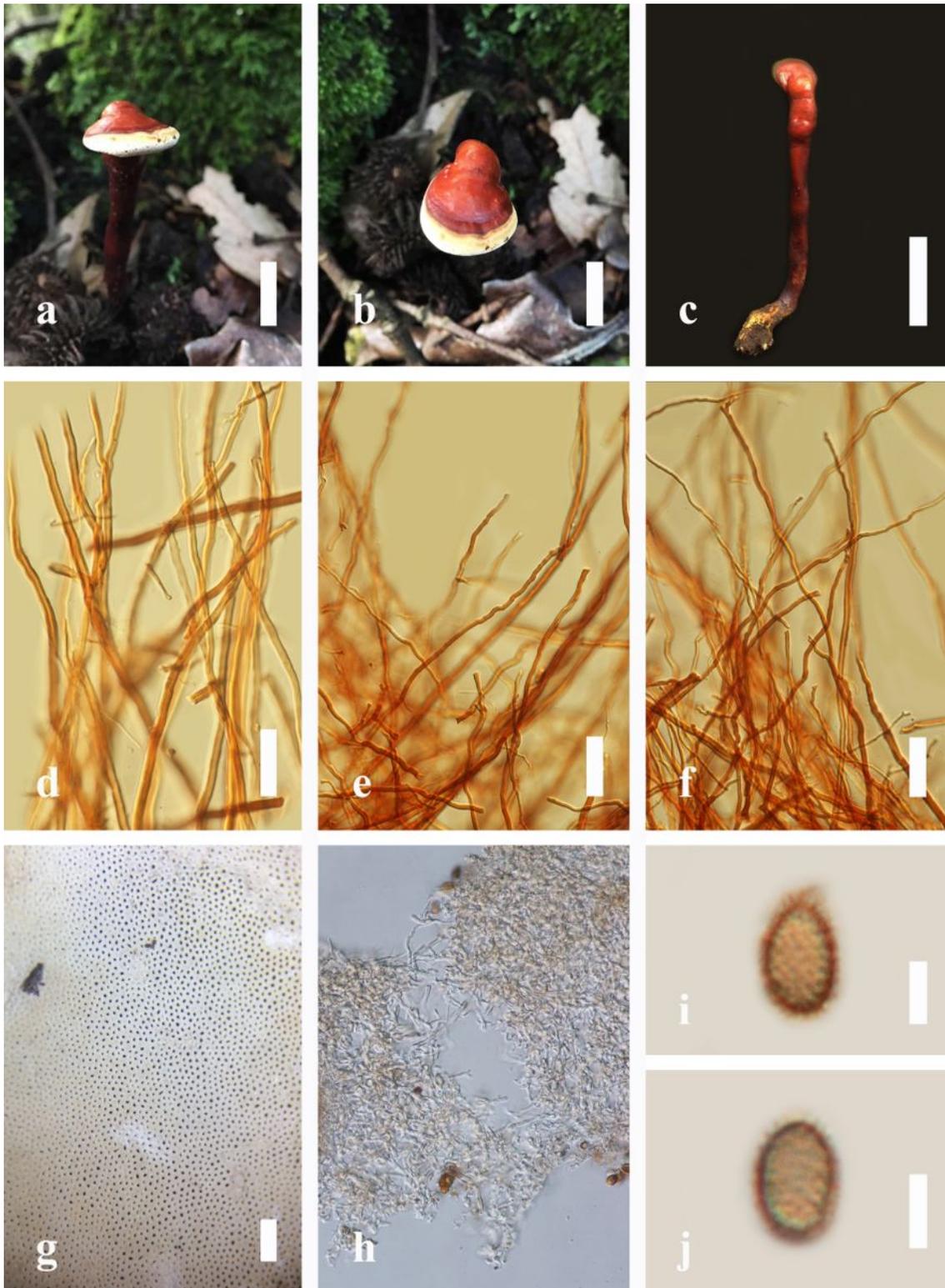


Figure 10

Morphology of *Ganoderma lingzhi* HKAS 97398: a–c Mature basidiomes. d Hyphae of trama in KOH. e–f Context hyphae in KOH. g Pore characteristics. h Hyphae of pore in KOH. i– j Basidiospores. Scale bars: a–b = 1 cm, c = 3 cm, d = 20 μ m, e–f = 30 cm, g = 1000 μ m; i–j = 5 μ m

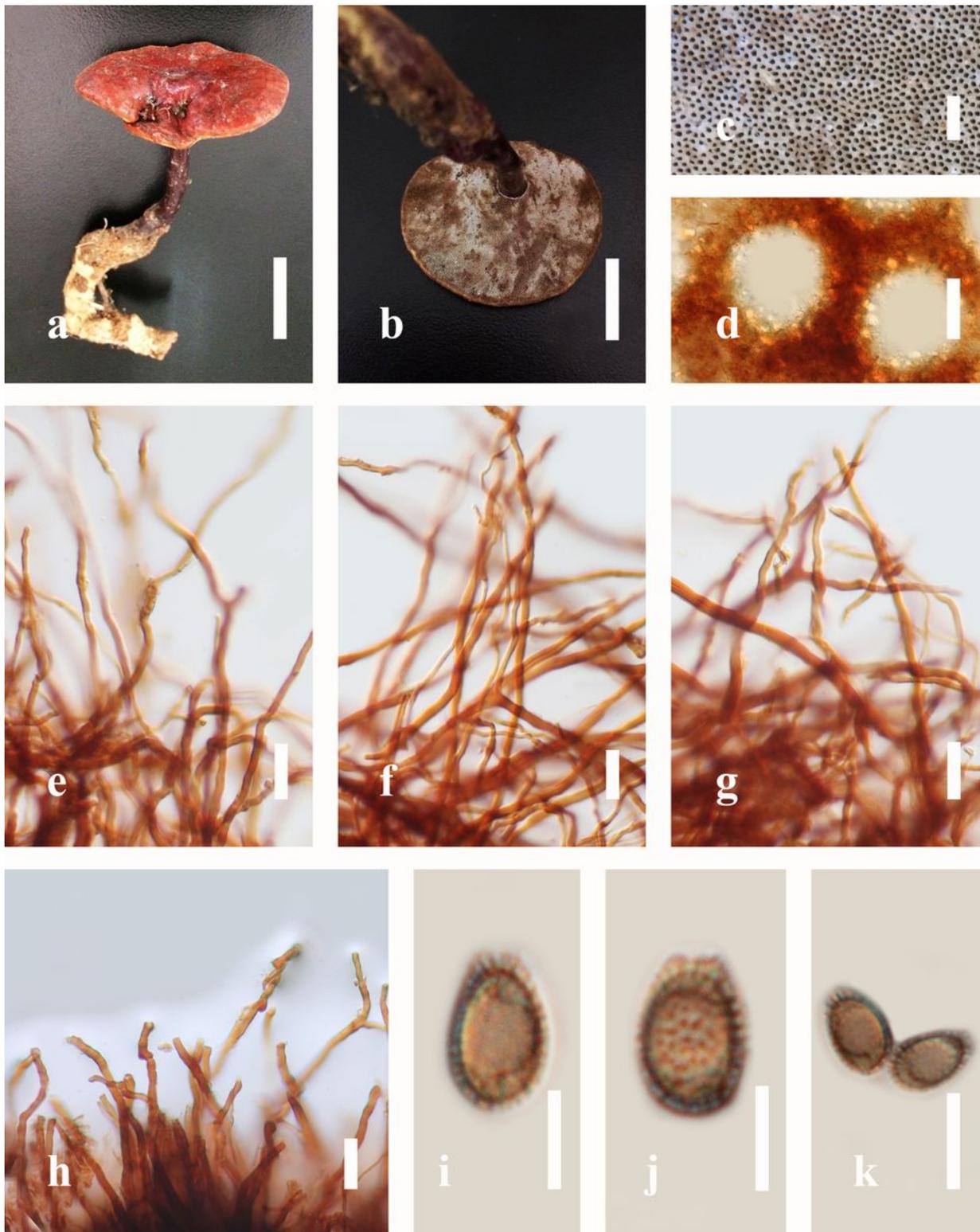


Figure 11

Morphology of *Ganoderma lucidum* MFLU 19-2161: a–b Mature basidiomes. c Pore characteristics. d Hyphae of pore characteristics in KOH. e Hyphae of trama in KOH. f–g Generative and skeletal hyphae of context in KOH. h Hyphae of tube layers in KOH. i–k Basidiospores. Scale bars: a–b = 2 cm, c = 1000 μ m, d = 150 μ m, e–g = 20 μ m, h = 15 μ m, i–k = 5 μ m

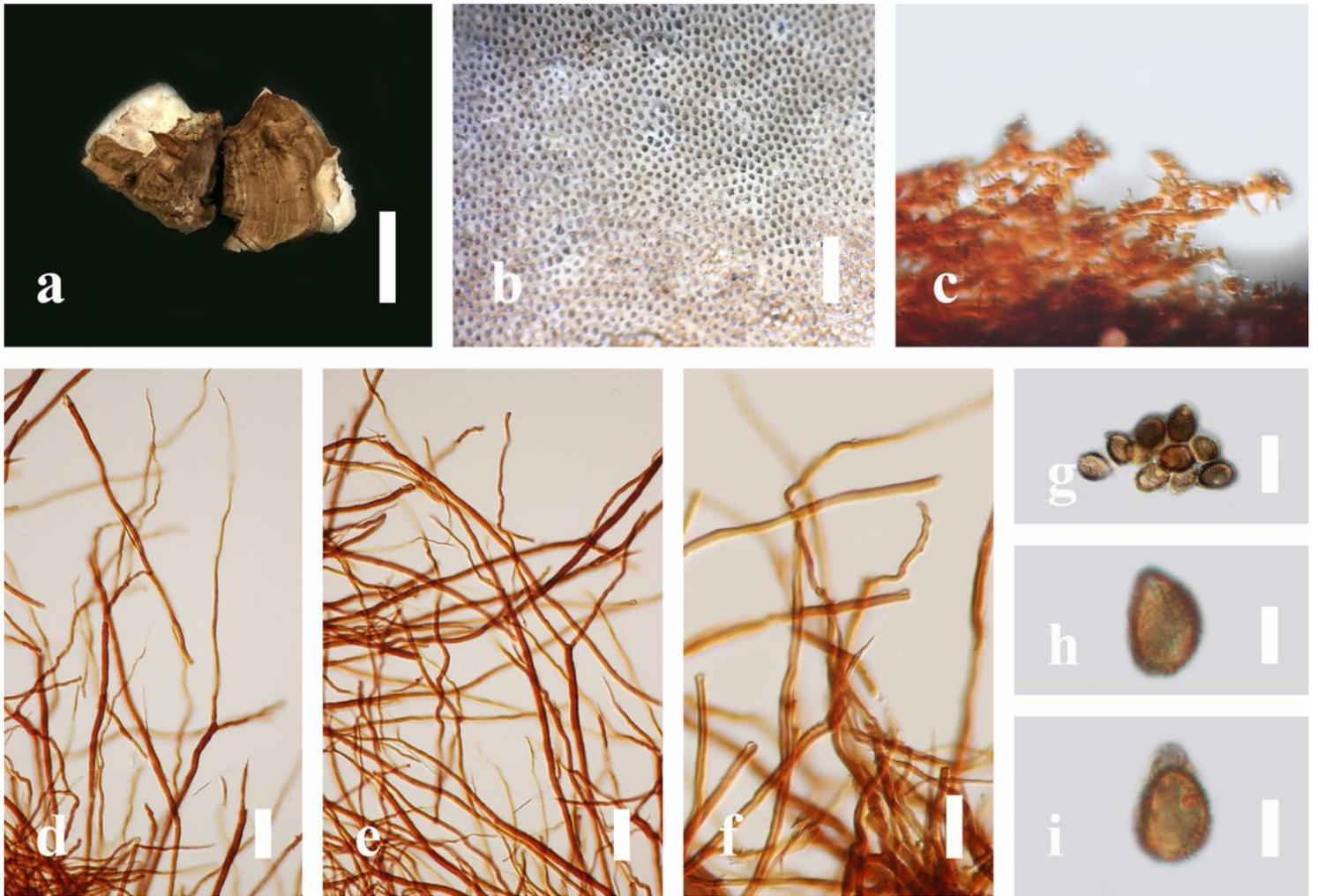


Figure 12

Morphology of *Ganoderma multiplicatum* MFLU 19-2152: a Mature basidiomes. b Pore characteristics. c Hyphae of tube layers in KOH. d-f Context hyphae in KOH. g-i Basidiospores Scale bars: a = 2 cm, b = 1000 μ m, d-f = 20 μ m, g-i = 5 μ m

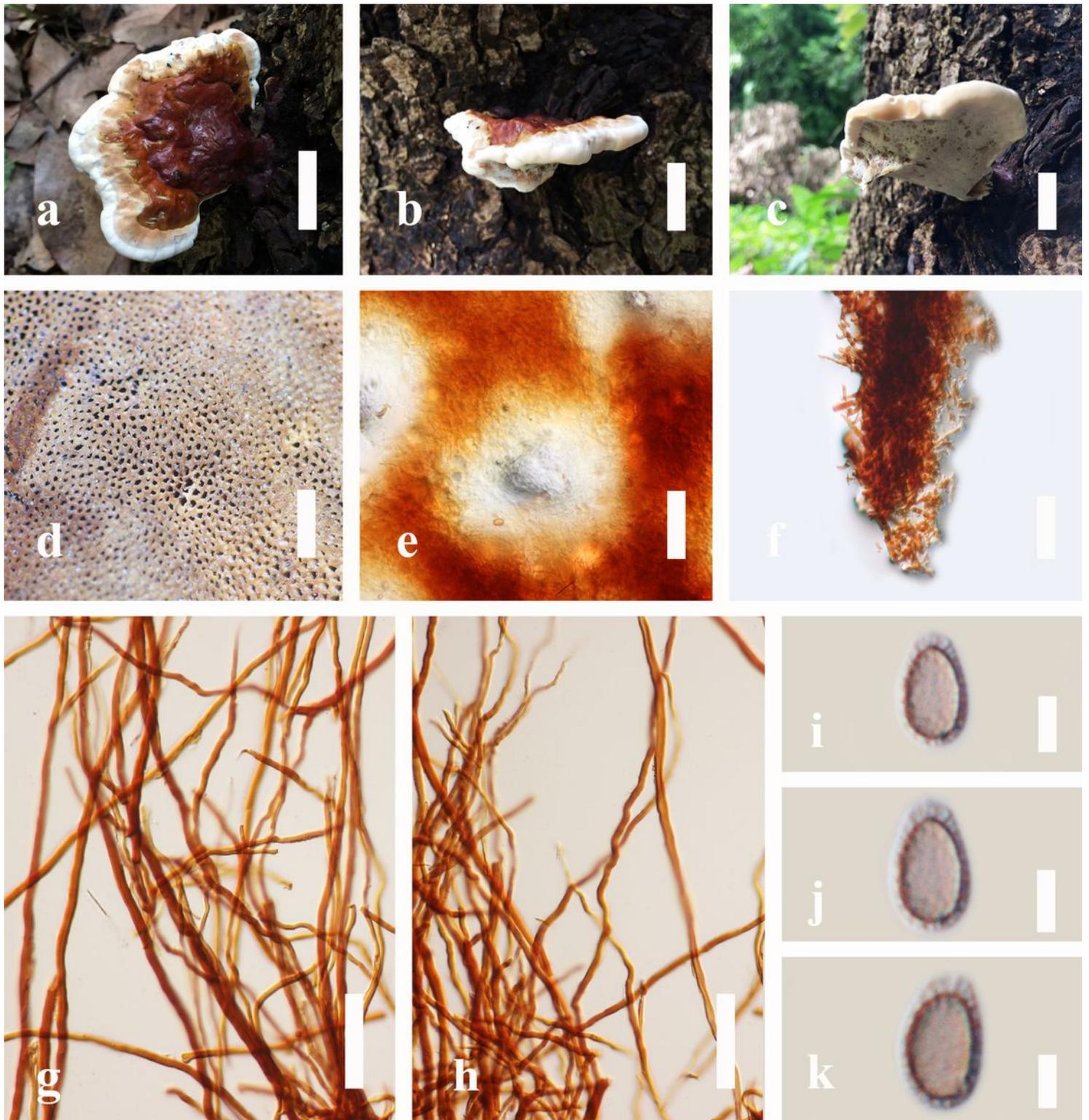


Figure 13

Morphology of *Ganoderma resinaceum* MFLU 19-2153: a–c Mature basidiomes. d Pore characteristics. e Hyphae of pore in KOH. f Hyphae of tube layers in KOH. g–h Context hyphae in KOH. i Basidiospores in Melzer's reagent. j–k Basidiospores in KOH. Scale bars: a–c = 4 cm, d = 1000 μ m, e = 150 μ m, f = 30 μ m, g–h = 50 μ m, i–k = 5 μ m

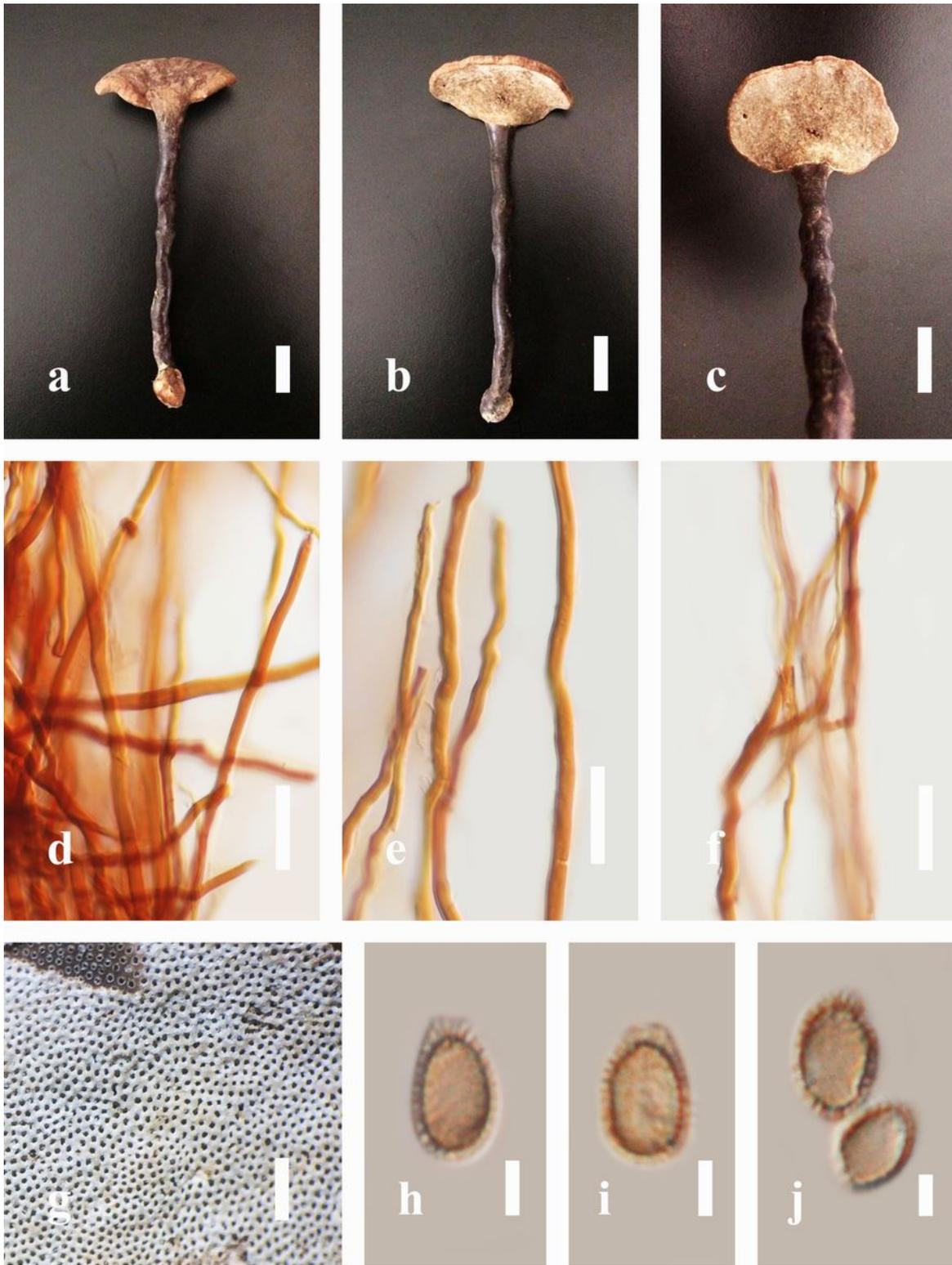


Figure 14

Morphology of *Ganoderma sinense* MFLU 19-2173: a–c Mature basidiomes. d–f Context hyphae in KOH. g Pore characteristics. h–j Basidiospores in KOH. Scale bars: a–c = 2 cm, d–f = 20 μm , g = 1000 μm , h–j = 5 μm

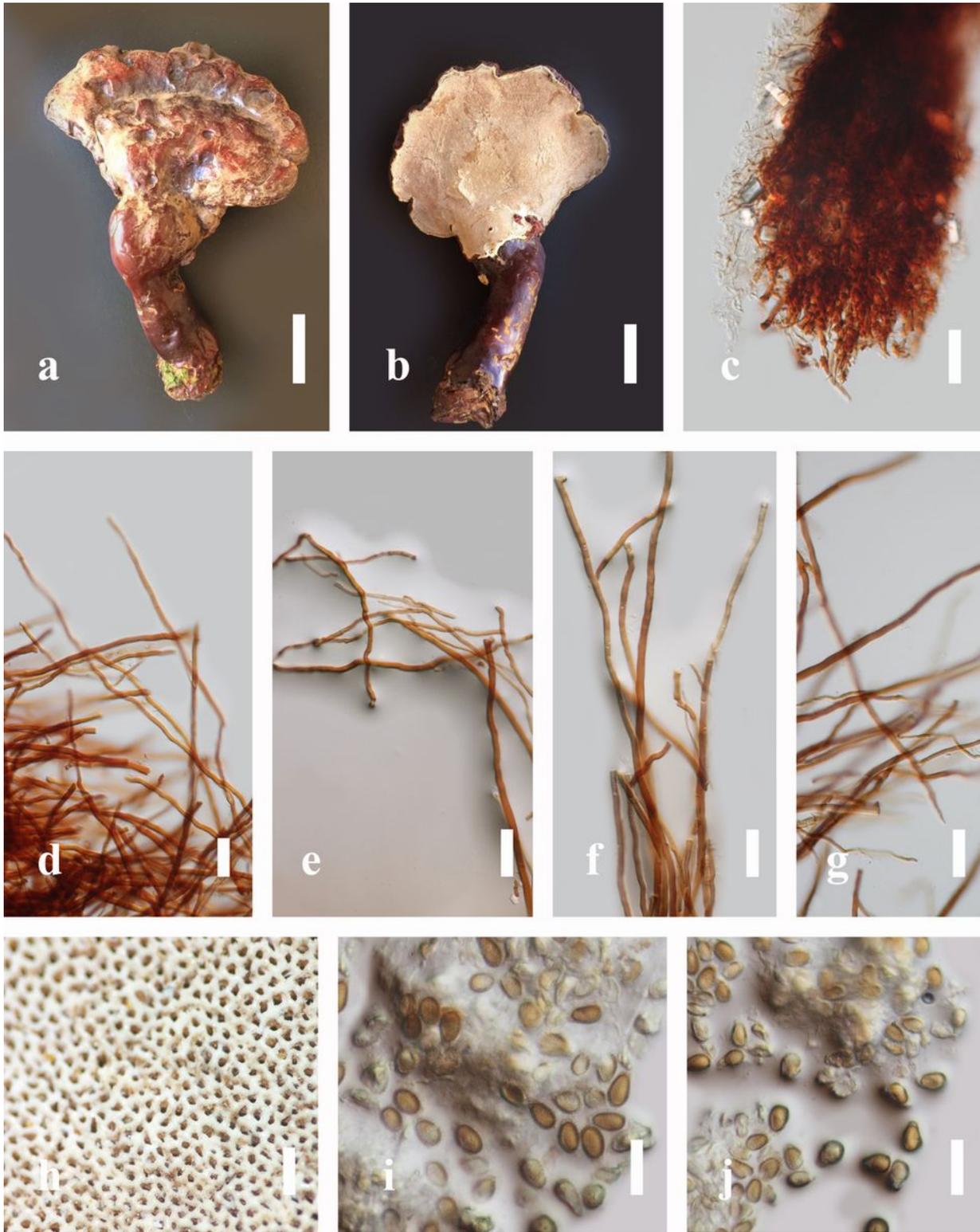


Figure 15

Morphology of *Ganoderma tsugae* HKAS 97406: a–b Mature basidiomes. c Hyphae of tube layers. d–g Context hyphae in KOH. h Pore characteristics. i–j Basidiospores. Scale bars: a–b = 4 cm, c = 30 cm, d–g = 30 μ m, h = 500 μ m, i–j = 5 μ m

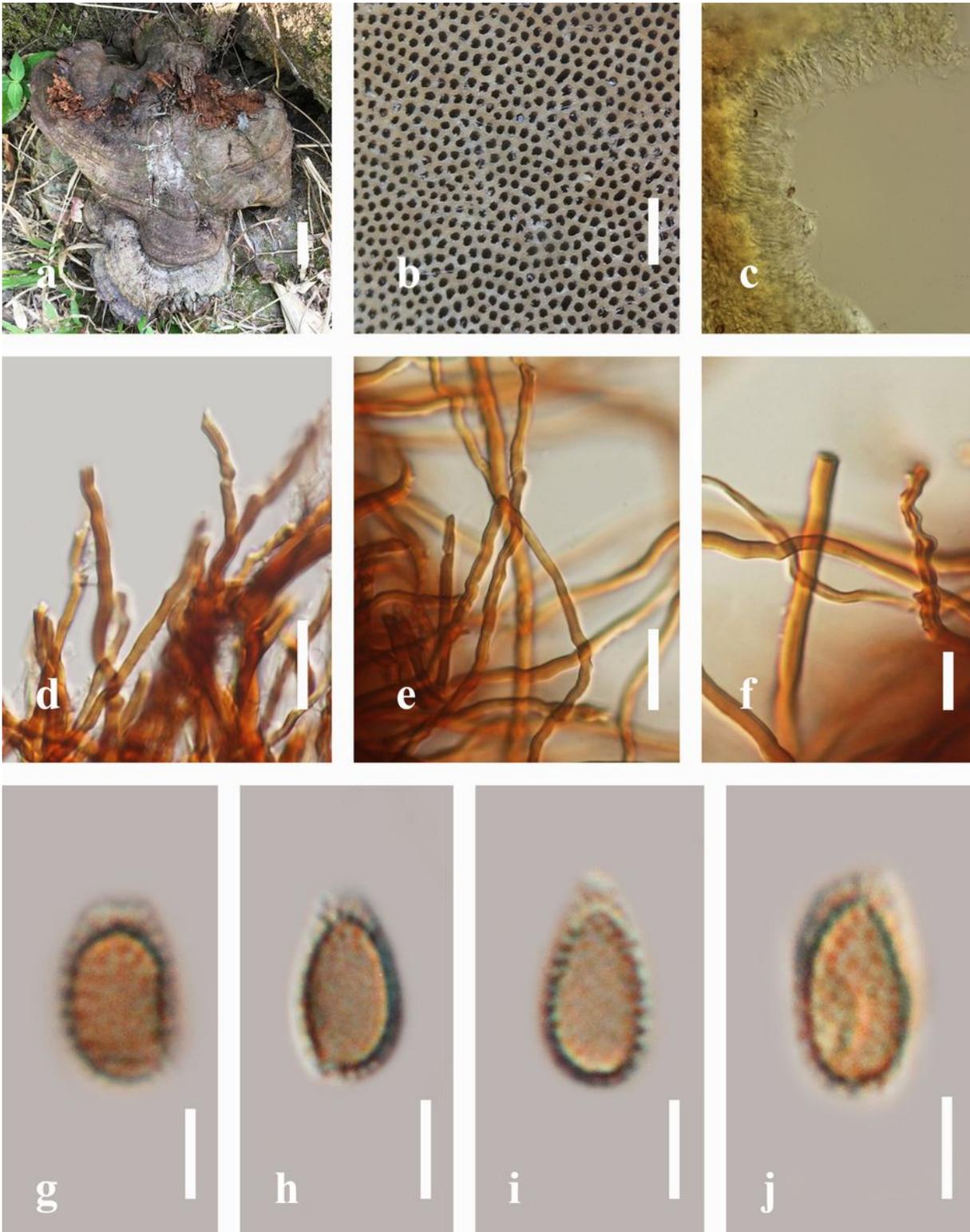


Figure 16

Morphology of *Ganoderma adspersum* MFLU 19-2177: a Mature basidiomes. b Pore characteristics. c Hyphae of pore. d Hyphae of tube layers in KOH. e–f Context hyphae in KOH. g–j Basidiospores. Scale bars: a = 3 cm, b = 1000 μ m, d–e = 20 μ m, f = 10 μ m, g–j = 5 μ m

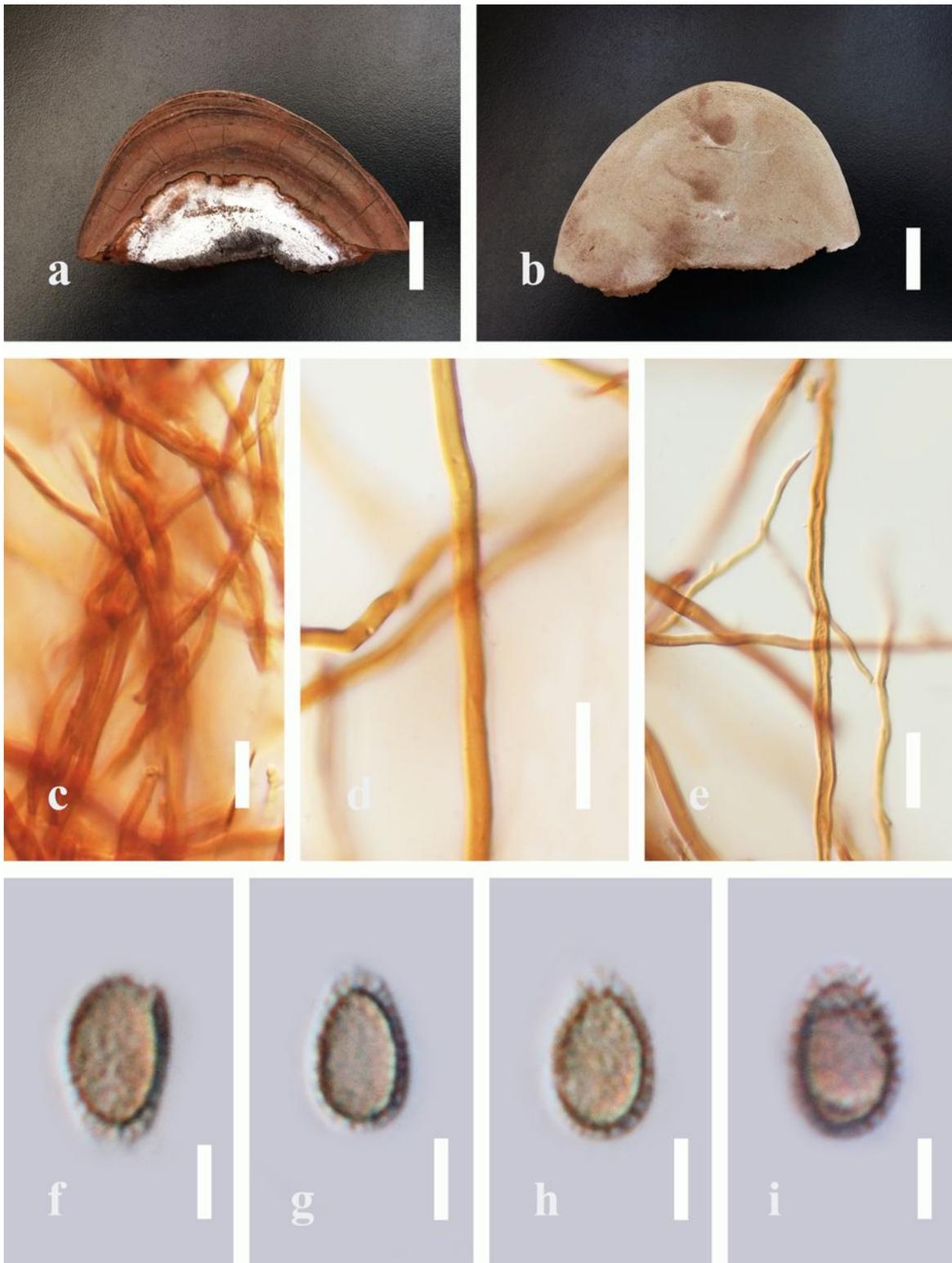


Figure 17

Morphology of *Ganoderma australe* MFLU 19-2171: a–b Mature basidiomes. c–e Context hyphae in KOH. f–i Basidiospores. Scale bars: a–b = 2 cm, c–e = 20 μ m, f–i = 5 μ m



Figure 18

Morphology of *Ganoderma gibbosum* MFLU 19-2190: a–b Mature basidiomes. c–e Context hyphae as seen in Melzer's reagent. f–h Basidiospores. Scale bars: a–b = 2 cm, c–e = 20 μm , f–h = 5 μm

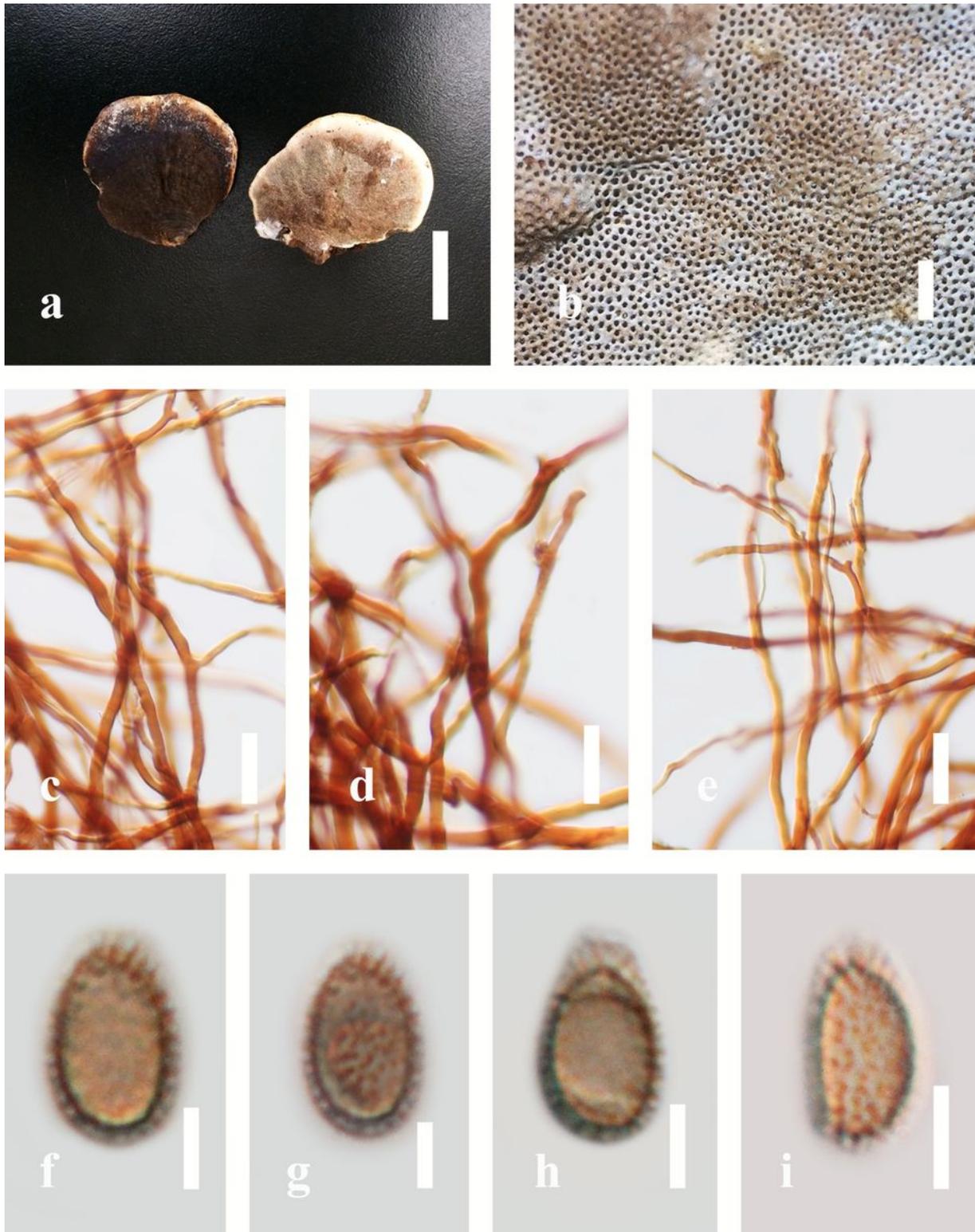


Figure 19

Morphology characteristics of *Ganoderma hoehnelianum* MFLU 19-2168: a Young basidiomes. b Pore characteristics. c–e Context hyphae in Melzer's reagent. f–i Basidiospores Scale bars: a = 2 cm, b = 1000 µm, c–e = 20 µm, f–i = 5 µm



Figure 20

Characteristics of *Ganoderma myanmarensis*: a The upper surface of mature basidiomes of the strain MFLU 19-2167. b The lower surface of mature basidiomes of strain MFLU 19-2167. c The upper surface of mature basidiomes of the strain MFLU 19-2169. d–e Pore characteristics. f Hyphae of tube layers in KOH. g Context hyphae in KOH. h Context hyphae with clamp connections in KOH. i Hyphae of trama in KOH. j–l Basidiospores. Scale bars: a–c = 2 cm, d = 500 μ m, e = 150 μ m, f–i = 20 μ m, j–l = 5 μ m

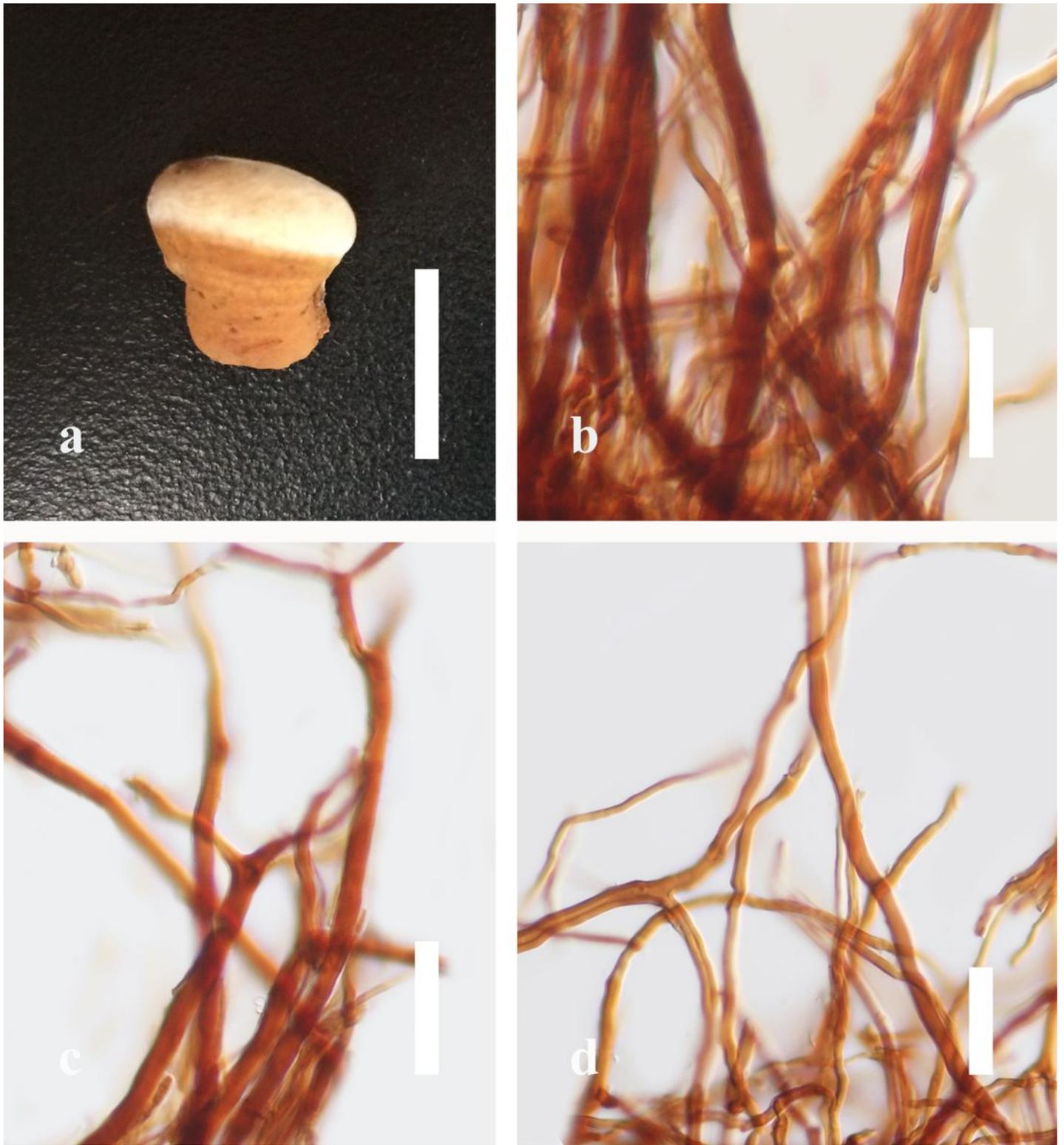


Figure 21

Morphology characteristics of *Ganoderma williamsianum* MFLU 19-2170: a Young basidiomes. b–d Context hyphae in Melzer's reagent. Scale bars: a = 2 cm, b–d = 20 μ m

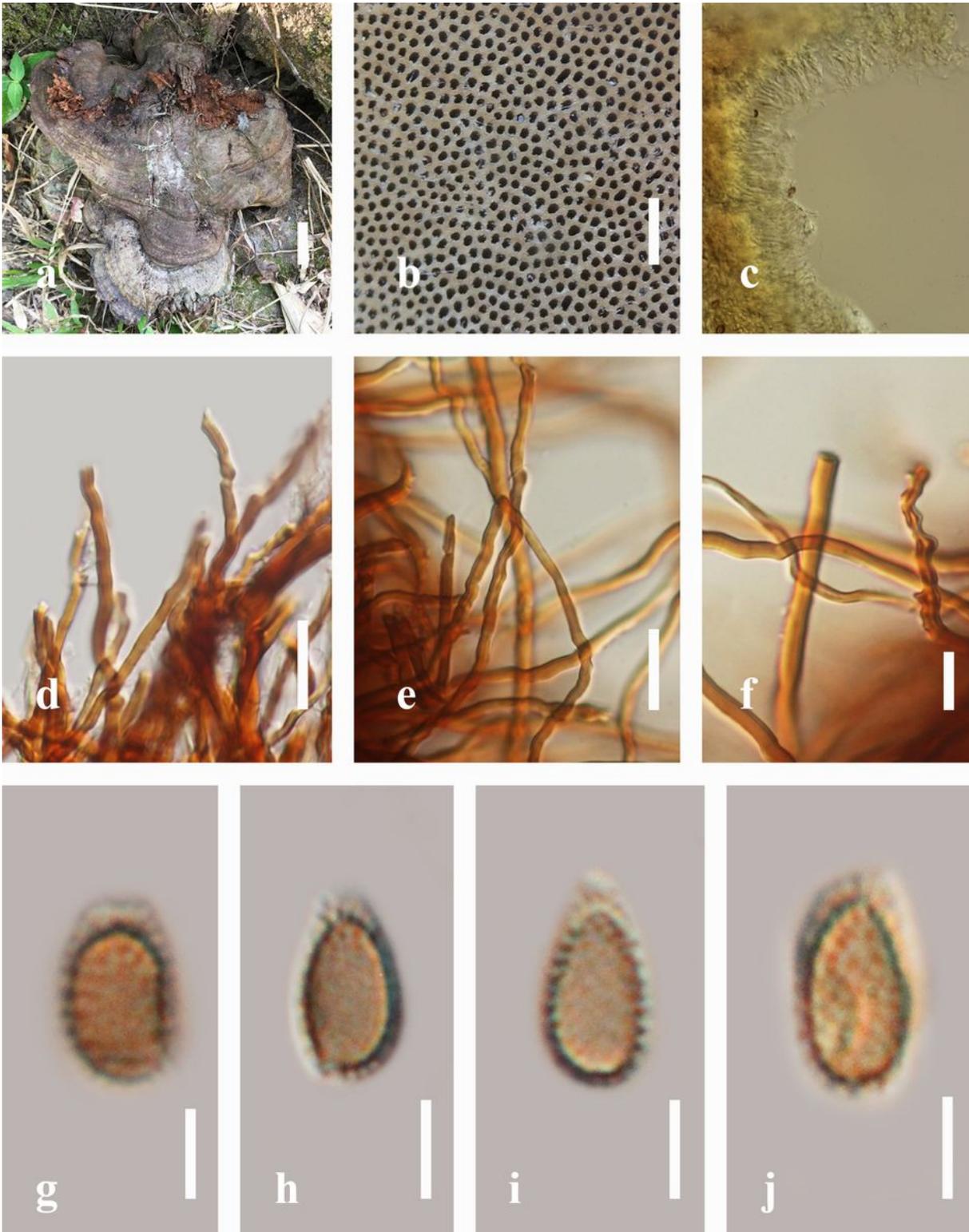


Figure 22

Morphology of *Ganoderma adspersum* MFLU 19-2178: a Mature basidiomes. b Pores characteristics. c Hyphae of tube layers in KOH. d–e Hyphae of thama in KOH. f–h Basidiospores. Scale bars: a = 2 cm, b = 1000 μ m, c–e = 20 μ m, f–h = 5 μ m

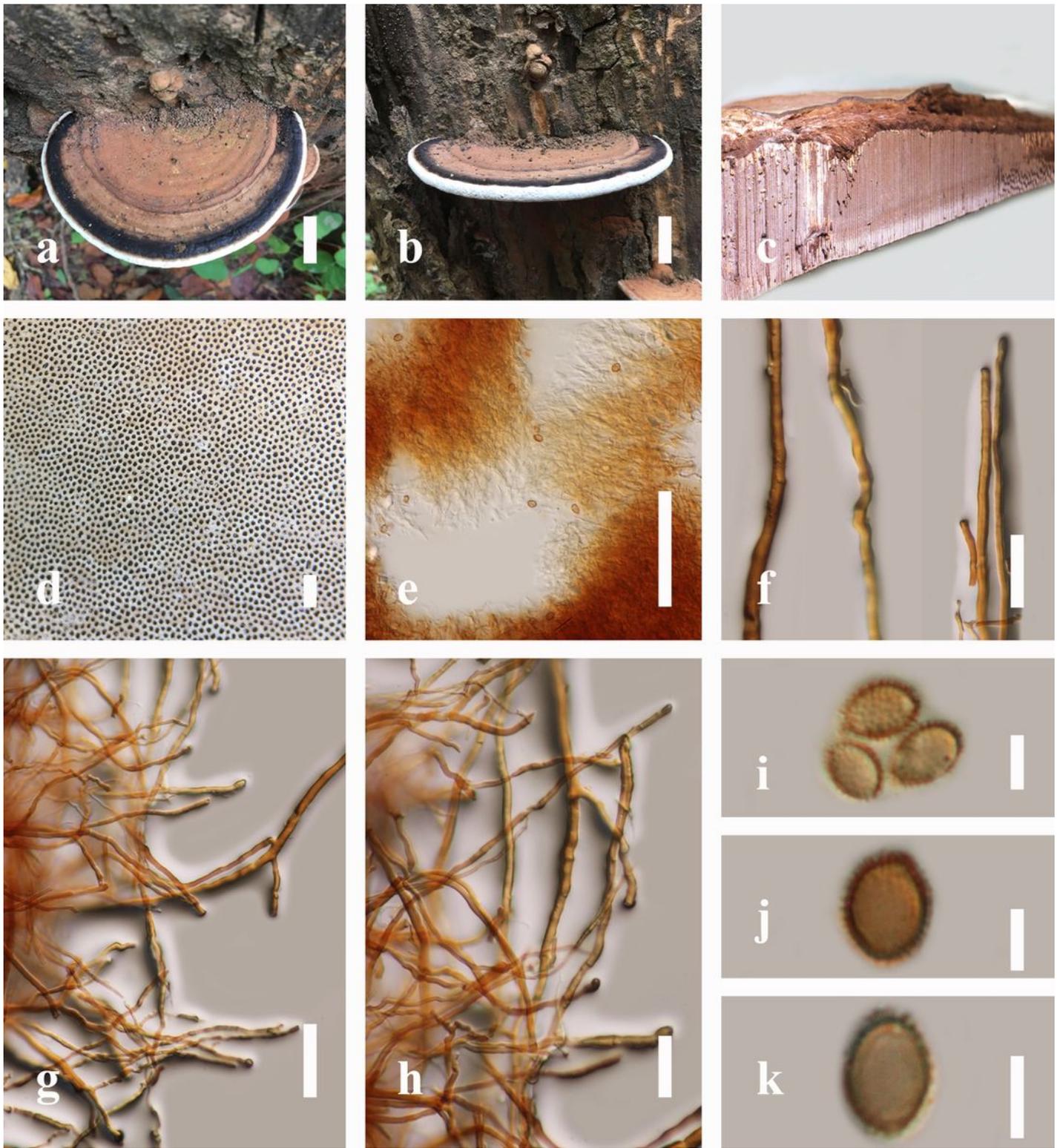


Figure 23

Morphology of *Ganoderma applanatum* MFLU 19-2175: a–b Mature basidiomes. c Section of the basidiomes. d Pore characteristics. e Hyphae of pore layers. f Generative hyphae of context in Melzer's reagent. g–h Thick walled with sparingly branched generative and skeletal hyphae of context in Melzer's reagent. i–k Basidiospores in Melzer's reagent. Scale bars: a–b = 2 cm, d = 50 μm , e = 150 μm , f = 10 μm , g = 30 μm , h = 20 μm , i–k = 5 μm

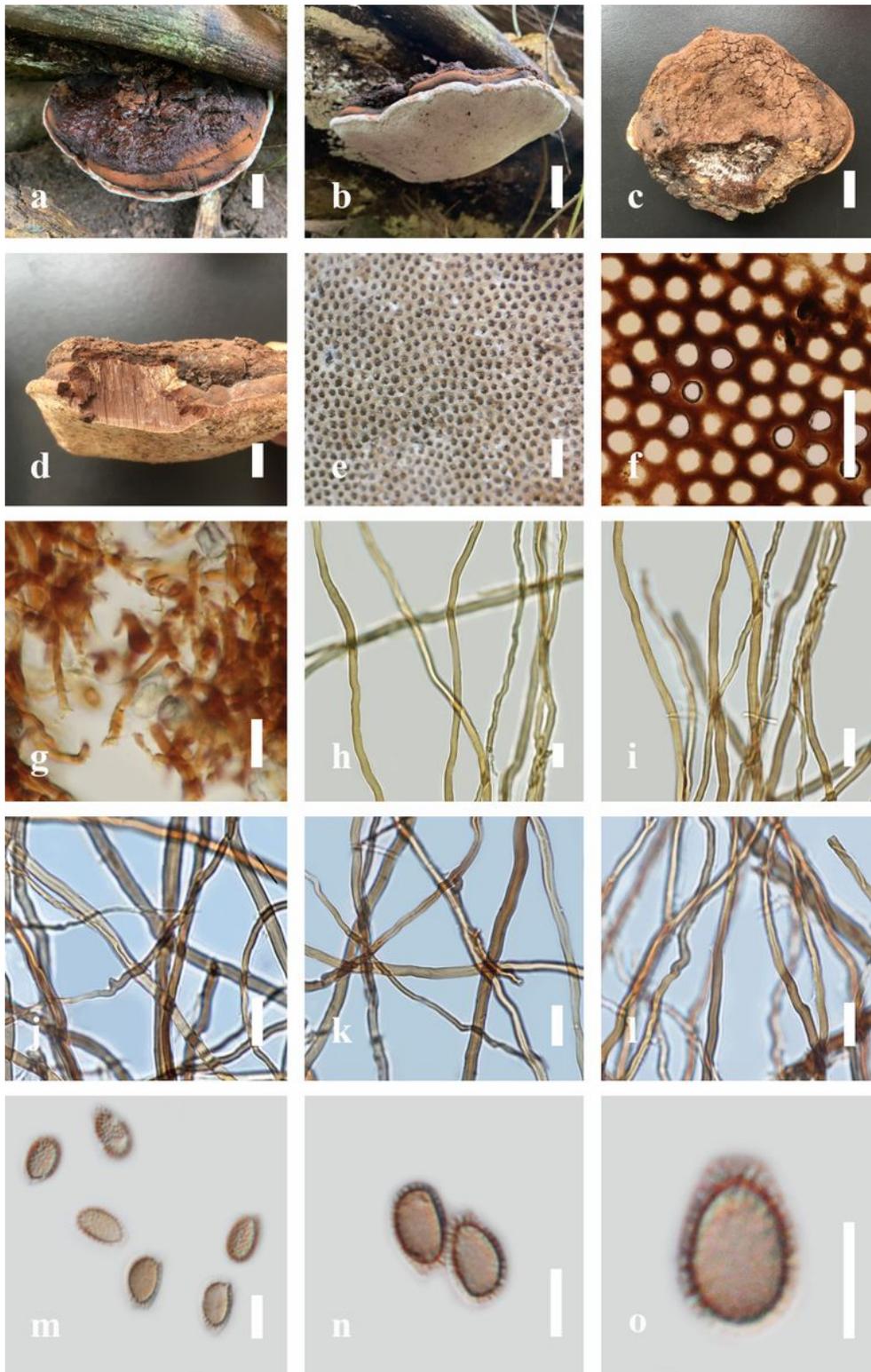


Figure 24

Morphology characteristics of *Ganoderma ellipsoideum* MFLU 19-2221: a The upper surface of mature basidiomes when fresh. b The lower surface of mature basidiomes when fresh. c The upper surface of mature basidiomes when dried. d Margin. e–f Pore characteristics. g Hyphae of tube layers. h–i Hyphae from trama in KOH. j–l Hyphae from trama in KOH. m–o Basidiospores in KOH reagent. Scale bars: a–d = 2 cm, e–f = 500 μ m, g = 200 μ m, g–l = 20 μ m, m–o = 5 μ m



Figure 25

Ganoderma gibbosum MFLU 19-2176: a The upper surface of mature basidiomes. b The lower surface of mature basidiomes. c Margin. d Context morphology. e Pore characteristics. f tube layers. g Generative hyphae of context in Melzer's reagent. h–i Skeletal and binding hyphae of context in Melzer's reagent. j Hyphae and clamp connections of context in Melzer's reagent. k–l Basidiospores in Melzer's reagent. Scale bars: a–c = 2 cm, d = 1 cm, e = 500 μ m, f = 200 μ m, g–i, k, l = 5 μ m, j = 20 μ m

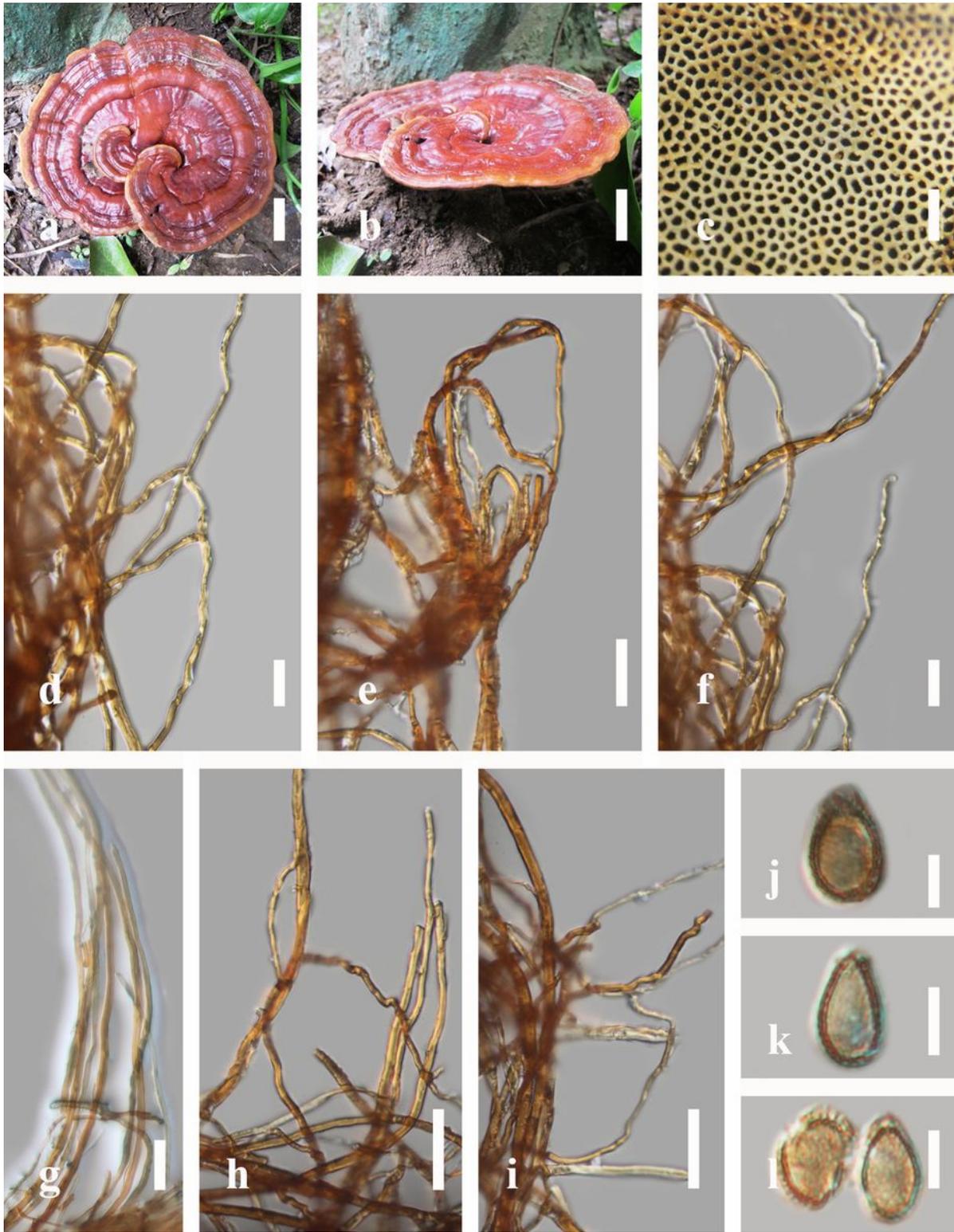


Figure 26

Morphology of *Ganoderma lingzhi* MFLU 19-2164: a–b Mature basidiomes. c Pore characteristics. d–f Walls varying in thickness sparing branched of generative and skeletal hyphae of context in upper part in Melzer’s reagent. g Generative hyphae of context in lower part in Melzer’s reagent. h–i Thick walled sparing branched of generative and skeletal hyphae of context in lower part in Melzer’s reagent. j–l

Basidiospores in Melzer's reagent. Scale bars: a–b = 2 cm, c = 500 μm , d = 50 μm , e–f, h–i = 20 μm , g = 30 μm , j–l = 5 μm

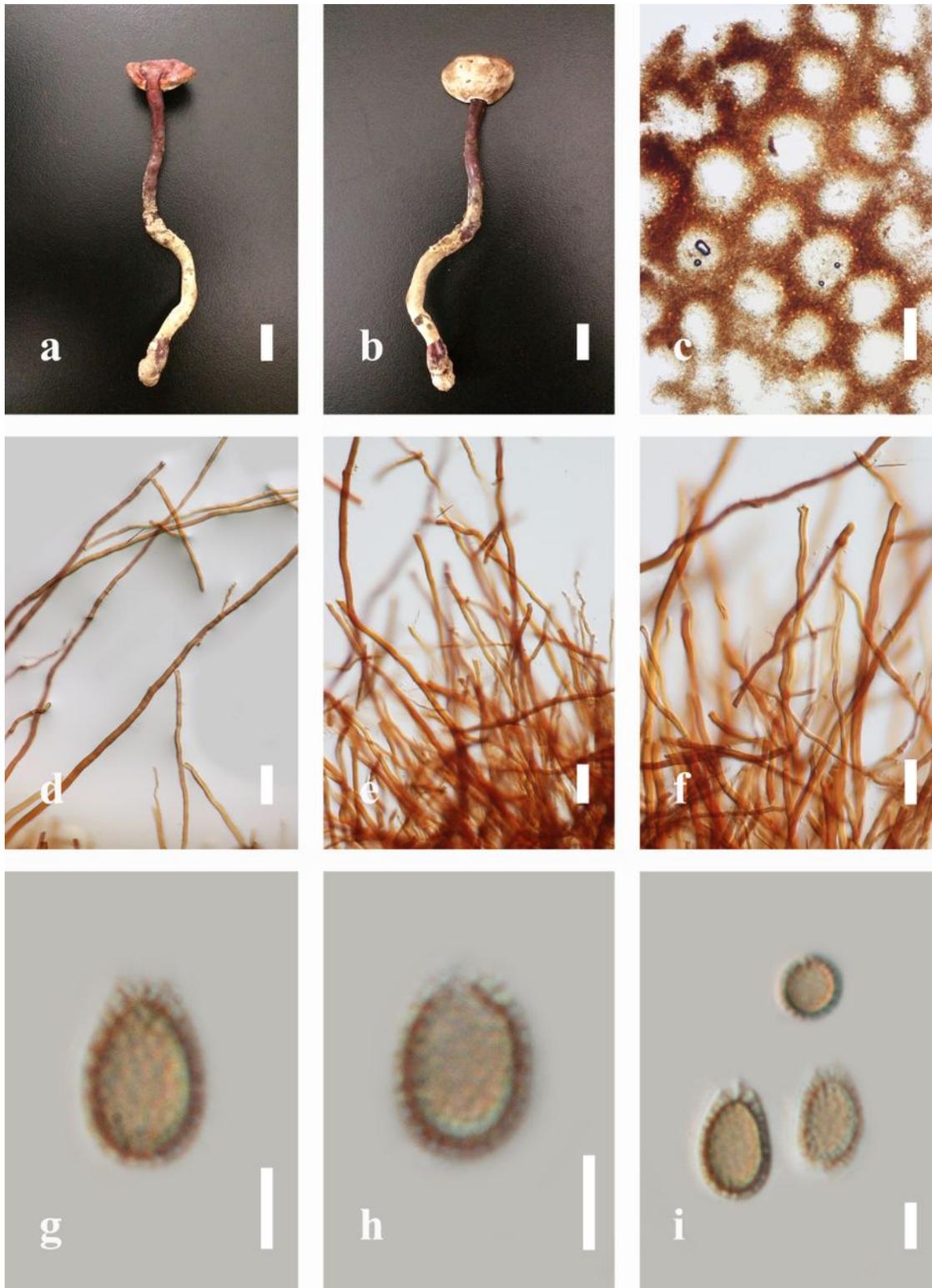


Figure 27

Morphology of *Ganoderma lucidum* MFLU 19-2162: a–b Mature basidiomes. c Pore characteristics. d Generative hyphae of context in KOH. e–f Generative, skeletal and binding hyphae of context in KOH. g–i Basidiospores. Scale bars: a–b = 2 cm, c = 200 μm , d–f = 20 μm , g–i = 5 μm

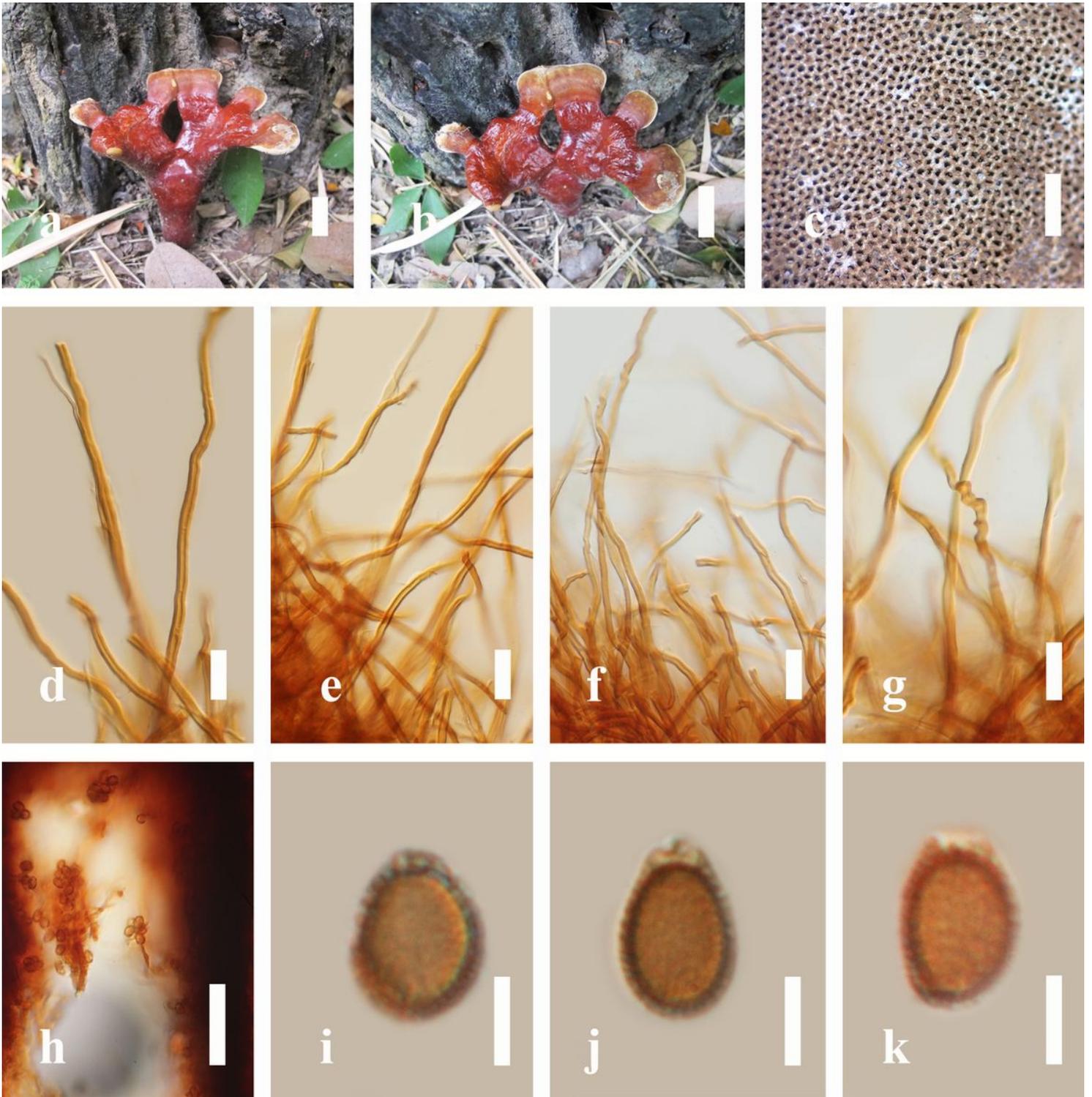


Figure 28

Morphology characteristics of *Ganoderma multipileum* MFLU 19-2166: a–b Mature basidiomes. c Pore characteristics. d Generative hyphae of context in KOH. e–g Generative, skeletal, and binding hyphae of context in KOH. h Basidiospores with tube layers. i–k Basidiospores in KOH. Scale bars: a–b = 3 cm, c = 1000 μ m, d–g = 20 μ m, h = 50 μ m, i–k = 5 μ m

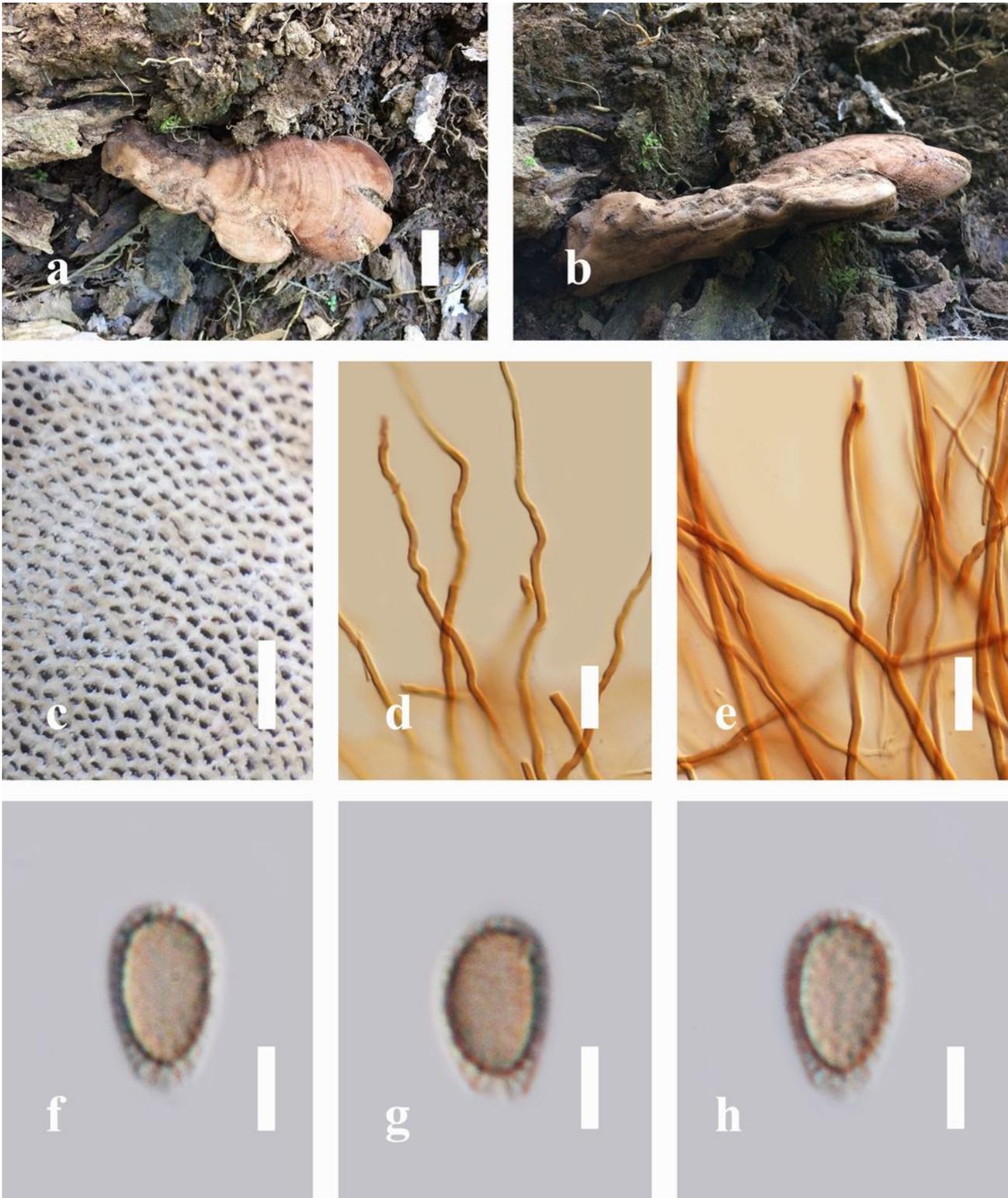


Figure 29

Morphology of *Ganoderma orbiforme* MFLU 17-1933: a–b Mature basidiomes. c Pore characteristics. d–e Context hyphae in KOH. f–h Basidiospores in KOH. Scale bars: a = 2 cm, c = 1000 μm , d–e = 20 μm , f–h = 5 μm

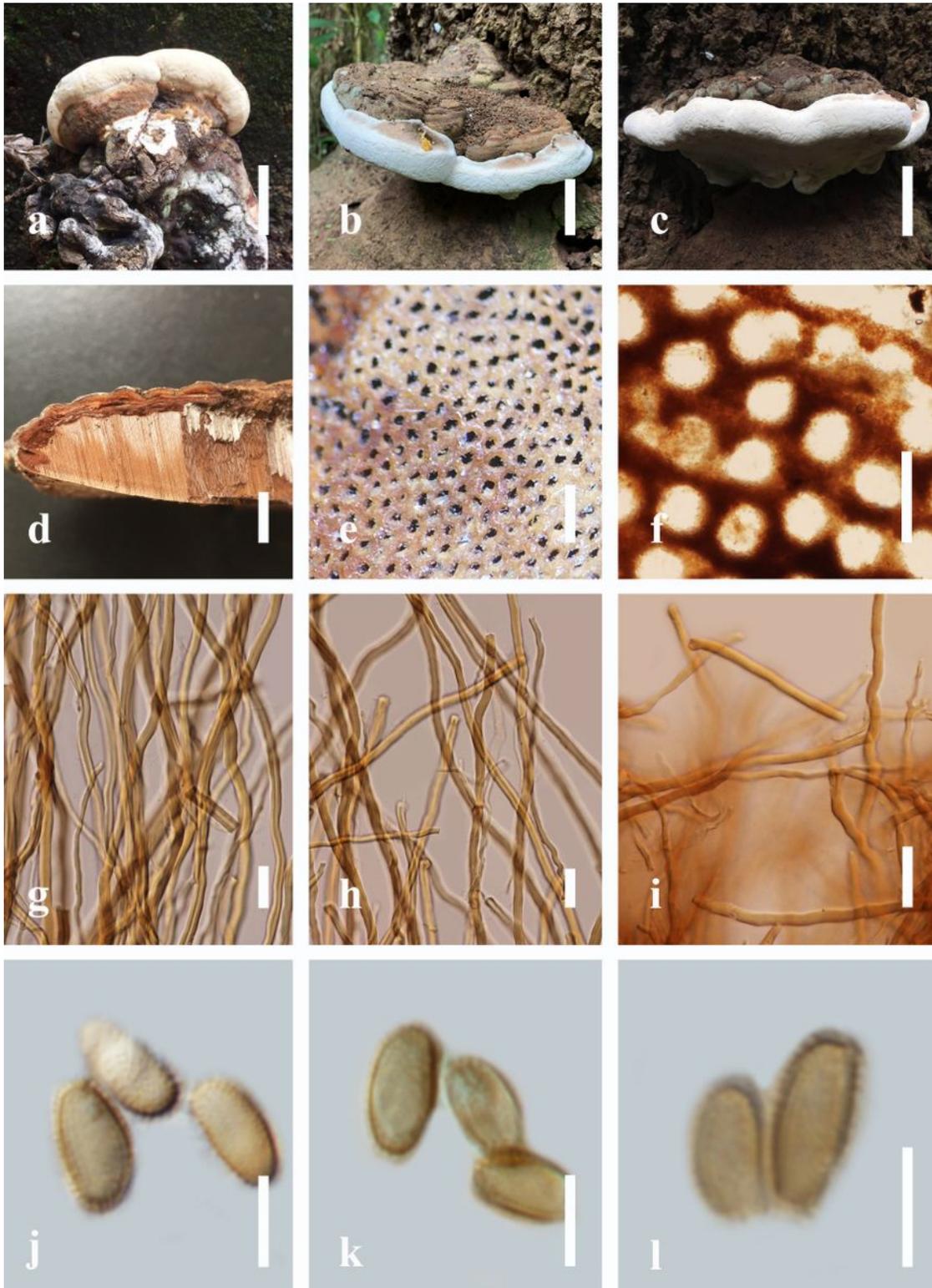


Figure 30

Morphology of *Ganoderma philippii* MFLU 19-2222: a Mature basidiomes of the collection MFLU 19-2222. b–c Mature basidiomes of the collection MFLU 19-2223. d Morphology of the tube layers. e–f Pore characteristics. g–h Context hyphae. i Hyphae from tube layers. j–l Basidiospores in KOH. Scale bars: a–d = 2 cm, e = 500 μm, f = 150 μm, g–i = 20 μm, j–l = 5 μm

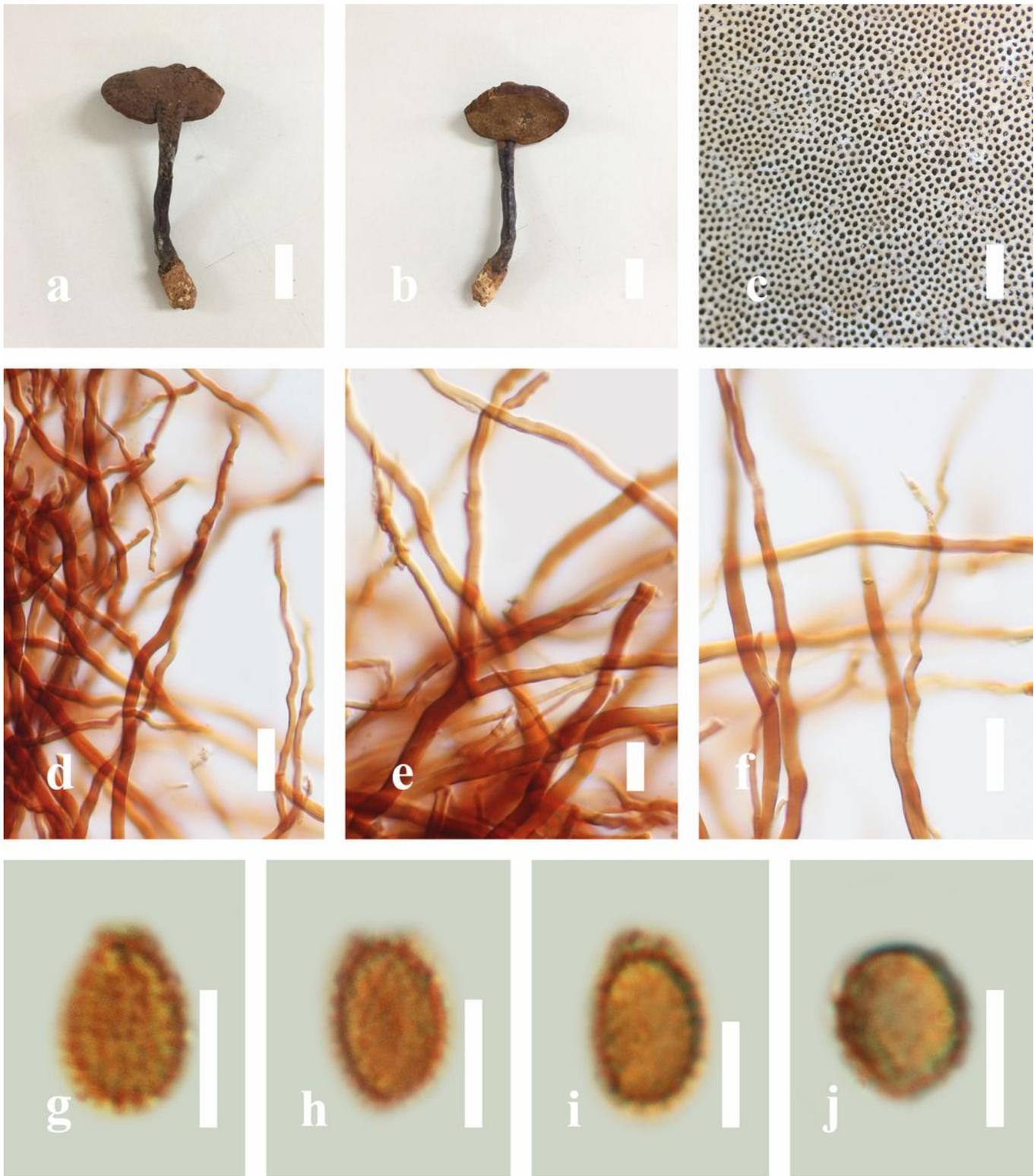


Figure 31

Morphology of *Ganoderma sinense* MFLU 19-2172: a–b Mature basidiomes. c Pore characteristics. d–f Generative, skeletal, and binding hyphae of context in KOH. g–j Basidiospores in KOH. Scale bars: a–b = 2 cm, c = 1000 μ m, d–f = 20 μ m, g–j = 5 μ m

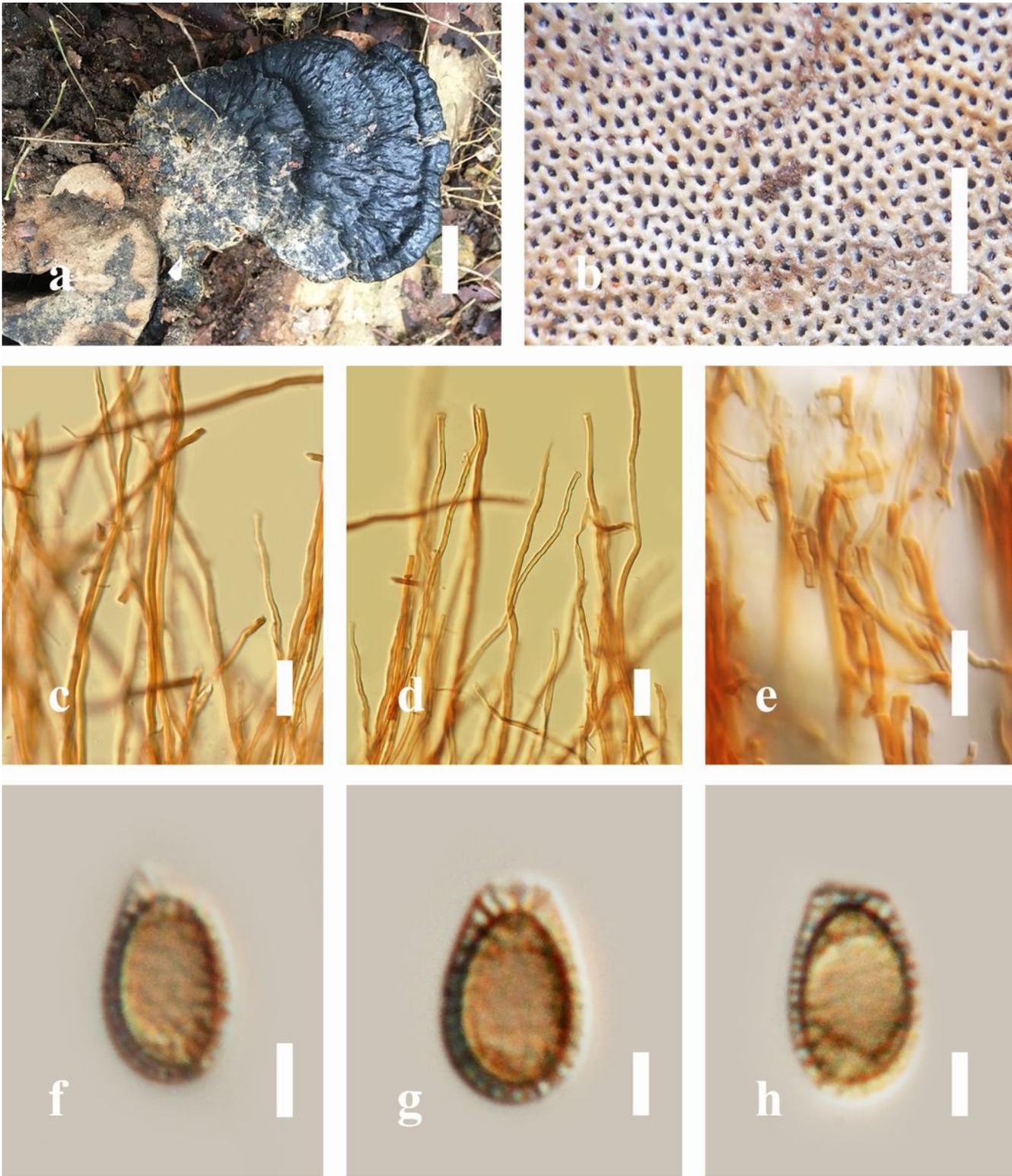


Figure 32

Morphology of *Ganoderma subresinosum* MFLU 17-1912: a Mature basidiomes. b Pore characteristics. c–e Generative hyphae of context in KOH. f–h Basidiospores in KOH. Scale bars: a = 2 cm, b = 1000 μm , c–e = 20 μm , f–h = 5 μm

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