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Article

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Ganodermataceae (Polyporales): Diversity in Greater Mekong Subregion countries (China, Laos, Myanmar, Thailand and Vietnam)

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Abstract

Taxa of Ganodermataceae have been widely used as traditional medicines for centuries in Asia. Despite several taxonomic investigations, relationships and classification of many species are still unresolved. Species in this family are either pathogenic, wood decaying and/or wood inhabiting. In this paper, we introduce, a collection of Ganodermataceae species based on fresh and dried specimens found within the Greater Mekong Subregion countries; China, Laos, Myanmar, Thailand and Vietnam. *Amauroderma schomburgkii*, *A. rude*, *Haddowia longipes*, *Ganoderma lingzhi*, *G. luteomarginatum*, *G. subresinosum* and *G. tropicum* from Laos, *G. australe* and *G. multiplicatum* from Myanmar, *G. donkii* from Thailand, *G. adspersum* from Thailand and Myanmar, *G. flexipes*, *G. gibbosum*, *G. orbiforme*, and *G. neojaponicum* from both Laos and Myanmar, are newly recorded species for these countries. We also identified *A. schomburgkii* and *A. rude*, based on morphology and the other species based on both morphology and DNA sequence data. Two species; *G. nasalanense* Hapuar., Pheng., & K.D. Hyde, *sp. nov*., and *G. sandunense* Hapuar., T.C. Wen & K.D. Hyde, *sp. nov*., are new to science and established with morphological and DNA sequence based evidence. All taxa collected are described and illustrated with coloured photographs. We present an updated phylogeny for Ganodermataceae based on nrLSU, ITS, nrSSU, TEF1 and RPB2 DNA sequence data and species relationships and classification are discussed.

Key words – new taxa – new records – morphology – pathogenic species – phylogeny

Introduction

Ganodermataceae is a large family of polypores with seven accepted genera: *Amauroderma* Murril, *Foraminispora* Robledo et al., *Furtadoa* Costa-Rezende et al., *Ganoderma* P. Karst,

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Haddowia Steyaert, *Humphreya* Steyaert and *Polyporopsis* Audet (Richter et al. 2015, Costa-Rezende et al. 2017) including 596 epithets, of which most are known as *Ganoderma* species (www.indexfungorum.org, accessed 22 March 2019). This family has received great attention from mycologists for over many decades. Recently the phylogeny of Ganodermataceae and its allied genera has been reconstructed using multigene DNA sequences including ITS, IGS, nrLSU, nrSSU, RPB2, TEF1, β-tubulin, mtSSU, mtLSU, and ATP6 genes (Wang & Yao 2005, Wang 2012, Zhou et al. 2015). These species have a worldwide distribution in green ecosystems, both in tropical and temperate geographical regions, such as East Asia (China, Japan and South Korea), East Africa (Ghana, Kenya and Tanzania) as well as Europe (almost all the European countries), North America (Canada and U.S.A.), Oceania (Australia), South America (Argentina, Brazil and Uruguay), South and Southeast Asia (India, Indonesia, Philippines, Thailand and Vietnam) (Wang et al. 2012, Pilotti et al. 2003). The majority of taxa are facultative parasites that live as saprobes on rotting stumps and roots (Pilotti et al. 2004, Dai et al. 2007).

Ganodermataceae is distinct from other families of polypores, in having a peculiar type of double-walled basidiospores (Adaskaveg & Gilbertson 1988). The inner walls of the Ganodermataceae spores are quite often colored, and usually the surface is ornamented (Donk 1964). Many polypores have bigger basidia than *Ganoderma* species. The hyphal system is usually trimitic and occasionally dimitic or monomitic, which contains hyaline, thin-walled, branched, clamped generative hyphae, pigmented, thick walled, arboriform or aciculiform, branched skeletal hyphae and colorless, terminal branched binding hyphae (Seo & Kirk 2000). *Ganoderma* represents the largest genus of Ganodermataceae (Wu & Zhang 2003). The genus is characterized by double-walled basidiospores with a truncate apex and ornamented endospores (Moncalvo & Ryvarden 1997). Most of the species of *Ganoderma* belong to the *Ganoderma lucidum* species complex. The second largest genus is *Amauroderma* with tropical stipitate to sessile species with non-truncate, globose to subglobose, verrucose to asperulate (smooth in only one species) basidiospores (Ryvarden 2004b). These characteristics distinguish *Amauroderma* from the other genera, as *Ganoderma* and *Humphreya* which have truncated basidiospores and *Haddowia* which has crested basidiospores while *Polyporopsis* has ellipsoidal basidiospores with oily drops (Ryvarden 2004b, Le et al. 2012, Audet 2010, Hapuarachchi et al. 2018c).

Taxa of Ganodermataceae have been widely used as traditional medicines for millennia in Asia (Dai et al. 2007, Zhou et al. 2015). Its species are widely researched, because of their highly prized medicinal value, since they contain many chemical constituents with potential nutritional and therapeutic values (Hapuarachchi et al. 2016a, b, 2017). *Ganoderma* and *Amauroderma* include several species which possess great economic and ecological importance (Correia de Lima et al. 2014). *Ganoderma* species have gained wide popular use as dietary supplements in China, Japan, North America and the other regions of the world (Paterson 2006, Hapuarachchi et al. 2018a). *Ganoderma* has been used as a functional food to prevent and treat immunological diseases (Wang et al. 2012). Several hundreds of metabolites have been obtained from the species of this family including *G. lucidum*, which is the most sought after species of the genus (Dong & Han 2015). *Amauroderma rugosum* is traditionally used by the Chinese to reduce inflammation, to treat diuretic and upset stomach, and to prevent cancer (Dai & Yang 2008).

The traditional taxonomy of Ganodermataceae is based on its morphological traits, however species identification and circumscriptions have been unclear and taxonomic segregation of the genera has been controversial because of different viewpoints among mycologists (Moncalvo et al. 1995a, Moncalvo & Ryvarden 1997). Most of the taxonomists judge the current nomenclatural situation of Ganodermataceae as chaotic and poorly studied (Ryvarden 1991, Smith & Sivasithamparam 2003, Hapuarachchi et al. 2015). Earlier it was believed that this family represented an old lineage from which other groups of polypores have been derived (Corner 1983). Phenotypic plasticity observed in the genus is an indication that species are not evolving rapidly resulting in low speciation rate (Ryvarden 1994), an observation supported by Moncalvo & Buchanan (2008). Use of DNA sequence data especially from ribosomal DNA sequences have clarified to a certain extent classification and species relationships. Some researchers suggested

using a combination of morphological, chemotaxonomic and molecular methods to develop a more stable taxonomy for Ganodermataceae and resolve taxonomic ambuiguities (Richter et al. 2015, Welti et al. 2015). Table 1 lists the recent taxonomic classification system for Ganodermataceae.
The Greater Mekong Subregion covers an area of approximately 2.5 million km^2 including parts of China's Yunnan Province, Cambodia, Laos, Myanmar, Thailand and Vietnam. The Mekong River is one of the largest watercourses flowing through the region. The Mekong is well known for its high levels of biodiversity and famous for its mushroom diversity with at least 650 edible and medicinal species (Mortimer et al. 2014). There is potentially a high number of novel species in the region (Hyde et al. 2018). These mushrooms not only provide a source of food, but a very important source of income and play a vital role in supporting people's livelihoods. Furthermore, the ecological contributions of mushrooms in this region are immense and incredibly important (Mortimer et al. 2014). Furthermore, some species are pathogens for various economic plants and these diseases are major problems can result in consequent economic loss in these regional countries. Hence, it is important to study the diversity of this family in the Greater Mekong Subregion.

Table 1 The recent taxonomic classification system for Ganodermataceae

Taxonomic rank	Taxon	Introduced by (Reference)	Other main references
Family	Ganodermataceae	Donk, M.A. 1948. Notes on Malesian fungi. I. Bulletin du Jardin Botanique de Buitenzorg. 17:473-482	
Genus	*Ganoderma*	Karsten 1881	Steyaert 1972
	Amauroderma (*Magoderna*)	Murrill 1905a	Steyaert 1972
	Magoderna	Steyaert 1972	Moncalvo & Ryvarden 1997, Gomes-Silva et al. 2015
	Haddowia	Steyaert 1972	
	Humphreya	Steyaert 1972	
	Polyporopsis	Audet 2010	Richter et al. 2015
	Foraminispora	Costa-Rezende et al 2017	
	Furtadoa	Costa-Rezende et al 2017	

The objectives of the present study are to document species of Ganodermataceae based on morphological characteristics and compared with similar taxa. Furthermore, we provide a phylogeny for the Ganodermataceae based on combined nrLSU, ITS, nrSSU, EF and RPB2 analyses. A checklist of species of Ganodermataceae reported from Greater Mekong Subregion countries is also given in Table 2.

Table 2 List of Ganodermataceae species known for Greater Mekong Subregion countries.

Taxa	**Status (verified/unverified)**	**Current name**	**Reference**
Amauroderma austrosinense J.D. Zhao & L.W. Hsu (1984)	verified		Wu et al. 1999, Li & Yuan 2015, Hapuarachchi et al. 2018b
A. concentricum J. Song, Xiao L. He & B.K. Cui (2016)	verified		Song et al. 2016
A. conjunctum (Lloyd) Torrend (1920b)	verified		Nguyen & Khanh 2017
A. exile (Berk.) Torrend (1920b)	verified		Nguyen & Khanh 2017

Table 2 Continued.

Taxa	Status (verified/unverified)	Current name	Reference
A. perplexum Corner (1983)	Verified		Dai et al. 2011, Li & Yuan 2015
A. preussii (Henn.) Steyaert (1972)	verified		Wu & Dai 2005, Dai et al. 2011, Hapuarachchi et al. 2018c
A. rude (Berk.) Torrend (1920b)	verified		Zhao & Zhang 2000, Dai et al. 2011, Nguyen & Khanh 2017, This study
A. rugosum (Blume & T. Nees) Torrend (1920b)	verified		Wu et al. 1999, Li et al. 2010, Nguyen & Khanh 2017, Li & Yuan 2015, Hapuarachchi et al. 2018b,c, This study
A. schomburgkii	verified		Zhao 1989, Zhao & Zhang 2000, This study
A. subrugosum Bres. & Pat. (1889)	verified		Zhao 1989, This study
A. yunnanense J.D. Zhao & X.Q. Zhang (1986)	verified		Zhao & Zhang 1986, Li & Yuan 2015
Ganoderma adspersum (Schulzer) Donk (1969)	verified		This study
G. ahmdii Steyaert (1972)	unverified		Wu et al. 1999
G. amboinense (Lam.) Pat. (1887)	unverified		Wu et al. 1999
G. annulare (Jungh.) Gilb. (1962)	verified	*G. australe* (Fr.) Pat. (1889)	Wu et al. 1999, Dai et al. 2011, Hapuarachchi et al. 2018b, This study
G. applanatum (Pers.) Pat. (1887)	verified		Wu et al. 1999, Hapuarachchi et al. 2018b, This study
G. atrum J.D. Zhao, L.W. Hsu & X.Q. Zhang (1979)	unverified	*G. flexipes* Pat. (1907)	Wu et al. 1999, Wang & Wu 2007, Hapuarachchi et al. 2018b, This study
G. australe (Fr.) Pat. (1889)	verified		Wu et al. 1999, Li et al. 2010, Dai et al. 2011, Hapuarachchi et al. 2018b, This study
G. bawanglingense J.D. Zhao & X.Q. Zhang (1987)	unverified		Li et al. 2010
G. boninense Pat. (1889)	unverified	*G. orbiforme* (Fr.) Ryvarden 2000	Wu et al. 1999, Dai et al. 2011, Hapuarachchi et al. 2018b, This study
G. calidophilum J.D. Zhao, L.W. Hsu & X.Q. Zhang (1979)	verified		Li et al. 2010, Dai et al. 2011, Hapuarachchi et al. 2018b
G. capense (Lloyd) Teng (1963)	unverified		Wu et al. 1999
G. chalceum var. *chalceum* (Cooke) Steyaert (1967)	unverified		Wu et al. 1999
G. cochlear (Blume & T. Nees) Merr. (1917)	unverified		Wu et al. 1999
G. cupreum (Cooke) Bres. (1911)	verified	*G. orbiforme*	Wu et al. 1999, Wang et al. 2014, This study
G. curtisii (Berk.) Murr. (1908)	unverified		Wu et al. 1999
G. dahlii (Henn.) Aoshima (1971)	unverified		Wu et al. 1999
G. densizonatum J.D. Zhao & X.Q. Zhang (1986)	verified	*G. orbiforme*	Wu et al. 1999, Wang et al. 2014, This study
G. donkii	verified		Chandrasrikul et al. 2011, This study
G. flexipes Pat. (1907)	verified		Wu et al. 1999, Zhou et al. 2015, Hapuarachchi et al. 2018b, This study
G. fornicatum (Fr.) Pat. (1889)	verified	*G. orbiforme*	Wu et al. 1999, Wang et al. 2014, Hapuarachchi et al. 2018b, This study
G. gibbosum ((Blume & T. Nees) Pat. (1897)	verified		Dai et al. 2011, Hapuarachchi et al. 2018b, This study

Table 2 Continued.

Taxa	Status (verified/unverified)	Current name	Reference
G. hainanense J.D. Zhao, L.W. Hsu & X.Q. Zhang (1979)	unverified	*G. flexipes*	Wu et al. 1999, Wang & Wu 2007, Hapuarachchi et al. 2018b, This study
G. hoehnelianum Bres. (1912)			Wu et al. 1999, Wang & Wu 2010, Hapuarachchi et al. 2018b
G. jiangfenglingense X.L. Wu. (1996)	unverified		Wu et al. 1999
G. 1eytense Steyaert (1972)	unverified		Wu et al. 1999
G. limushanense J.D. Zhao & X.Q. Zhang (1986)	verified	*G. orbiforme*	Wu et al. 1999, Wang et al. 2014, Hapuarachchi et al. 2018b, This study
G. lobatum (Schwein.) G.F. Atk. (1908)	unverified		Wu et al. 1999
G. luteomarginatum J.D. Zhao, L.W. Hsu & X.Q. Zhang (1979)	verified		Wu et al. 1999, Zhao et al. 1979, This study
G. mastoporum (Lev.) Pat. (1889)	verified	*G. orbiforme*	Wu et al. 1999, Wang et al. 2014, Hapuarachchi et al. 2018b, This study
G. multipileum Ding Hou. (1950)	verified		Dai et al. 2011, Wang et al. 2005, Zhou et al. 2015
G. multiplicatum (Mont.) Pat. (1889)	verified		Zhao & Zhang 2000, Wang & Wu 2007, Hapuarachchi et al. 2018b, This study
G. neojaponicum Imazeki (1939)	verified		Tan et al. 2015, This study
G. nigrolucidum (Lloyd) D.A. Reid (1975)	unverified		Dai et al. 2004, Li et al. 2010
G. parviungulatum J.D. Zhao & X.Q. Zhang (1986)	unverified	*G. flexipes*	Wu et al. 1999, Cao et al. 2012, This study
G. ramosissimum J.D. Zhao (1989)	unverified		Wu et al. 1999
G. resinaceum Boud (1890)	verified		Wu et al. 1999 Hapuarachchi et al. 2018b, This study
G. shangsiense J.D. Zhao. (1988)	verified	*G. hoehnelianum*	Li et al. 2010, Wang & Wu 2010, Hapuarachchi et al. 2018b
G. sinense J.D. Zhao. L.W. Hsu & X.Q. Zhang (1979)	verified		Dai et al. 2004, Wang et al. 2005, Hapuarachchi et al. 2018b, This study
G. subresinosum (Murrill) C.J. Humphrey (1938)	verified		Wu et al. 1999, Li et al. 2010, Hapuarachchi et al. 2018b, This study
G. theaecola J.D. Zhao (1984)	verified		Zhao et al. 1984, This study
G. tornatum (Pers.) Bres. (1912)	verified	*G. australe*	Li et al. 2010, This study
G. tropicum (Jungh.) Bres. (1910)	verified		Li et al. 2010, Zhou et al. 2015 Hapuarachchi et al. 2018b, This study
G. tsugae Murrill (1902)	verified		Dai et al. 2007, Zhou et al. 2015
G. valesiacum Boud. (1895)	unverified		Wu et al. 1999
G. weberianum (Bres. & Henn. ex Sacc.) Steyaert (1972)	verified		Wu et al. 1999, Pan & Dai 2001, Wang et al. 2012, This study
G. williamsianum Murrill (1907)	verified		Wang & Wu 2010, Xing et al. 2018, This study
Haddowia longipes (Lév.) Steyaert (1972)	verified		Zhao & Zhang 2000, Zhang et al. 2015, This study

Ecological aspects

Ganoderma species have a global distribution in green ecosystems both in tropical and temperate geographical regions of Asia, Africa, America and Europe (Wang et al. 2012). They are usually found in subtropical and tropical regions since they live in hot and humid conditions (Pilotti 2004). These species are important wood decaying fungi. Most species of *Ganoderma* are pathogenic (Fig. 1) causing root and stem rot on a variety of monocotyledons, dicotyledons and gymnosperms including wide range of economically important trees and perennial crops which results in the death of affected trees (Lee & Chang 2016). Some species are saprobic and cause white rot of wood (Muthelo 2009). Hence, they have ecological importance in the breakdown of woody plants for nutrient mobilization. They possess effective machineries of lignocellulose-decomposing enzymes useful for bioenergy production and bioremediation (Hepting 1971, Adaskaveg et al. 1991, Coetzee et al. 2015, Kües et al. 2015). Plant pathogenic species in this genus can cause severe diseases (stem, butt, and root rot) in economically important trees and perennial crops, especially in tropical countries (Coetzee et al. 2015). *Ganoderma* disease development can be triggered by environmental factors and plant death could be either slow or rapid depending on water availability and temperature. Furthermore, *Amauroderma* species are also considered as parasitic on the roots of living trees (Glen et al. 2009). *Ganoderma boninense* is the most aggressive pathogen to cause the basal stem rot in oil palm (Turner 1981, Wong et al. 2012). Different species have different features and pathogenicity. Accuarate identification of these pathogenic species is problematic and hence results in problems for proper disease mangament (Wong et al. 2012). Members of Ganodermataceae can be of significant importance in horticulture, infecting landscape plants (*Acacia* sp., *Cassia* sp., *Pinus* sp.) and fruit trees (*Avocado*) (Kinge & Mih (2015). Pathogenic, wood decaying and/or wood inhabiting members of Ganodermataceae, diseases caused and corresponding host plants are listed in Table 3.

Materials and methods

Sample collections

Samples of Ganodermataceae were collected during 2014 to 2018 from China, Laos, Thailand, Myanmar and Vietnam and dealt with as in Cao et al. (2012). The materials were deposited at Guizhou University (GACP) and Mae Fah Luang University (MFLU) herbaria.

Macroscopic and microscopic characterization

Macro-morphological characteristics were described based on fresh materials, and the photographs provided here. Colour codes (e.g. 3A3) are from Kornerup & Wanscher (1978). Specimens were dried and placed separately in plastic ziplock bags. For micro-morphological observations, basidiomes were examined under a stereo dissecting microscope (Motic SMZ 168 series) and sections were cut with a razor blade, mounted in 5% KOH, and then observed, measured and illustrated under a compound microscope (Nikon ECLIPSE 80i) equipped with a camera (Canon 600D). Measurements were made using Tarosoft (R) Image Frame Work v. 0.9.7. At least 20 basidiospores were measured from each mature specimen except for very scanty materials. The basidiospore size was measured both with and without the myxosporium, but only spore sizes with myxosporium were used for comparisons. Basidiospore dimensions are given as (a–) b–*c*–d (–e), where a represents the minimum, b (mean average-standard deviation), *c* the average, d (mean average+standard deviation) and e the maximum. $\boldsymbol{Q}$, the length/width ratio (L/W) of a spore in side view and $\boldsymbol{Q_m}$ is the average, smallest and largest $\boldsymbol{Q}$ values given as *Q*. Pellis sections were taken from the mature pileus portion and mounted in Melzer's reagent for observation. The Facesoffungi number is provided as explained in Jayasiri et al. (2015).

DNA Extraction, PCR and Sequencing

Dried samples of basidiomes were used to extract genomic DNA. Genomic DNA was extracted using an EZgene TM Fungal gDNA Kit (Biomiga, CA, USA) according to the manufacturer instructions. DNA concentrations were estimated visually in agarose gel by comparing band intensity with a DNA ladder 1Kb (Invitrogen Biotech). Reaction mixtures (50 µl) contained 2 µl template DNA (ca. 10 ng), 19 µl distilled water, and 2 µl (10 µM) of each primer and 25 µl 2x BenchTopTM Taq Master Mix (Biomigas). Amplification conditions were 40 cycles of 95 °C for 30 s, 59 °C for 30 s and 72 °C for 1 min, followed by a final extension at 72 °C for 10 min for all DNA fragments. The ITS rDNA regions were amplified using the universal primer pair ITS4/ITS5 and the 18S and 28S rDNA genes were amplified using the universal primer pair NS1/NS4 and primer pair LROR/LR5 respectively (Vilgalys & Hester 1990, White et al. 1990, Rehner & Samuels 1994). Two protein coding genes: translation elongation factor-1α (TEF1) and RNA polymerase II gene (RPB2) were amplified using corresponding primer pair 983F/2218R (Rehner & Buckley 2005) and fRPB26f/7CR (Liu et al. 1999). Amplified PCR products were verified by 1% agarose gel electrophoresis stained with ethidium bromide in 1x TBE. The PCR products were sequenced with primers mentioned above by SinoGenoMax Co., Ltd (Beijing).

Sequence Alignment and Phylogenetic Analysis

All the other sequences except which were obtained from this study (Table 3) was retrieved from GenBank based on ITS BLAST searches in GenBank (Benson et al. 2017) and recently published data. Sequences that had possibly been contaminated by micro fungi or other unnamed species (such as those with aff. in the species name) were discarded, ambiguous regions were excluded and gaps were treated as missing data in the analysis (Nilsson et al. 2012). One hundred sixty two nucleotide sequences representing 70 species of Ganodermataceae from Asia, America and Europe were retrieved from GenBank and those retrieved sequences and the newly generated sequences were aligned with MAFFT v. 7 (http://mafft.cbrc.jp/alignment/server/index.html; Katoh & Standley 2013). The resulting alignment was improved manually when necessary using BioEdit v. 7.0.5.2 (Hall 1999). The Maximum Likelihood (ML) analyses were performed using RAxML-HPC2 (Stamatakis 2014) on the CIPRES Science Gateway V. 3.3 (Miller & Blair 2009), with default settings except that the number of bootstrap replicates was set to 1,000. For Bayesian analysis (BY), the GTR+I+G model of nucleotide evolution was selected with the help of MrModeltest 2.2 (Nylander 2004) as the best-fit model and posterior probabilities (PP) (Rannala & Yang 1996) were determined by Markov Chain Monte Carlo sampling (BMCMC) using MrBayes v3.1.2 (Ronquist et al. 2012). BY analyses were conducted with six simultaneous Markov chains and trees were summarized every 100th generation. The analyses were stopped after 5,000,000 generations when the average standard deviation of split frequencies was below 0.01. The convergence of the runs was checked using TRACER v1.6 (Rambaut et al. 2013). The first 25% of the resulting trees were discarded as burn-in, and PP were calculated from the remaining sampled trees. In both ML and BY analyses, *Tomophagus colossus* was selected as the outgroup. ML bootstrap values and BY posterior probabilities greater than or equal to 70% and 0.95, respectively, were considered as significant support. The phylogenetic tree was visualized with FigTree version 1.4.0 (Rambaut 2012) available at http://tree.bio.ed.ac.uk/software/figtree/.

Results

Phylogeny

The tree topologies obtained from ML and BY were identical. Therefore, only the ML tree is shown (Fig. 2). The 162 sequences of *Amauroderma*, *Foraminispora*, *Furtadoa*, *Haddowia*, *Humphreya* and *Ganoderma* clustered in 45 clades in Ganodermataceae (Fig. 2).
Our collections from China, Laos, Myanmar, Thailand and Vietnam clustered with all other *Amauroderma*, *Haddowia* and *Ganoderma* species, including the holotypes (*Amauroderma calcitum, A. concentricum, A. floriformum, A. subsessile, Furtadoa biseptata G. aridicola, G. austroafricanum, G. carocalcareus, G. destructans, G. enigmaticum G. ecuadoriense, G. leucocontextum, G. lingzhi, G. sichuanense, G. ryvardenii, G. mebrekobenum, G. mizoramense, G. podocarpense* and *G. wiiroense*,), paratypes (*G. wiiroense* and *G. mebrekobenum*), and isotype (*A. laccatostipitatum*) in well-

Figure 1 – Pathogenic and wood decaying *Ganoderma* species. a *Ganoderma brownii* found in Cherry plant (*Prunus cerasus*) (GACP18062701). b *Ganoderma applanatum* (GACP18032601). c *Ganoderma applanatum* in Myall tree (*Acacia pendula*) (GACP14081012). d *Ganoderma leucocontextum* in Sweet Acacia plant (*Acacia farneasa*) (GACP18042702). e *Ganoderma australe*. f *Ganoderma tropicum* (GACP18032705) (Photographs taken by TC Wen). *GACP – The Herbarium of Guizhou University (= The Original Herbarium of Guizhou Agricultural College).

Table 3 Pathogenic, wood decaying and/or wood inhabiting species in Ganodermataceae.

Species	Current name	Host plant	Disease	Country	Reference
Amauroderma brasiliense	*Furtadoa brasiliensis* (Singer) Costa-Rezende, Robledo & Drechsler-Santos	Decayed angiosperm wood	Wood decay	Brazil	Coelho et al. 2007, Costa-Rezende et al. 2017
A. calcitum Costa-Rezende & Drechsler-Santos		Roots of angiosperms	Wood decay	Brazil	Costa-Rezende et al. 2016
A. coltricioides T.W. Henkel, Aime & Ryvarden		*Tachigali rusbyi*	Wood decay	Guyana	Aime et al. 2003
A. corneri Gulaid & Ryvarden 1998	*Furtadoa corneri* (Gulaid & Ryvarden) Robledo & Costa-Rezende	Decayed angiosperm wood	Wood decay	Brazil, Guyana, Venezuela	Costa-Rezende et al. 2017
A. elegantissimum Ryvarden & Iturriaga		Deciduous wood	Wood decay	Brazil, Guyana, Venezuela	Gomes-silva et al. 2015
A. elmerianum Murrill	*Amauroderma rugosum*	*Acacia* sp.	White rot, butt rot	China	Dai et al. 2007
A. exile		Deciduous wood	Wood decay	Brazil, Colombia, Honduras, Venezuela	Gomes-silva et al. 2015
A. omphalodes		Deciduous wood	Wood decay	Brazil, Colombia, Guyana, Venezuela	Gomes-silva et al. 2015
A. partitum			Wood decay	Brazil, Colombia, Guyana, Venezuela	Gomes-silva et al. 2015
A. Parasiticum		*Acacia mangium* (Black wattle)	Root rot		Flood et al. 2000
A. preussii		*Garcinia punctate*, *Gibertiodendron dewevrei*	Wood decay	Africa	Steyaert 1972
		Near conifer tree roots		China	Wu & Dai 2005, Dai et al. 2011
		Near conifer tree roots		Laos	This study
A. rude		*Acacia mollissima*	Decay of stumps, roots	South Africa	Van Der Westhuizen 1958
		Near hardwood roots		China, Laos	This study
A. rugosum		*Acacia* sp.	Root rot	Indonesia, Malaysia	Glen et al. 2009
		Dead hardwood	Decay of stumps, roots	China, Thailand	This study
A. sessile		Dead hardwood	Decay of stumps, roots	Brazil	Gomes-silva et al. 2015
A. subsessile Gomes-Silva, Ryvarden & Gibertoni		Dead hardwood	Decay of stumps, roots	Brazil, Costa Rica, Panama	Gomes-silva et al. 2015
Furtadoa biseptata Costa-Rezende, Drechsler-Santos & Reck.		Decayed angiosperm wood	Wood decay	Brazil, Guyana, Venezuela	Costa-Rezende et al. 2017
G. africanum (Lloyd) Doidge (1950)		Unknown	Wood decay	South Africa	Cong 2010
		Delonix regia (Flame tree)		India	Ranadive & Jagtap 2016
G. ahmadii		*Dalbergia sissoo*	Wood decay	China, India, Pakistan	Cong 2010
		Fallen tree trunks			

Table 3 Continued.

Species	Current name	Host plant	Disease	Country	Reference
G. adspersum		*Ficus carica, Prunus dulcis* (Almonds)	Root rot, butt rot	Cyprus	Viney 2005
		Salix sp. (Willow)		Belgium	Guglielmo et al. 2008
		Juglans regia, Aesculus hippocastanum (Horse chestnut), *Cercis siliquastrum, Pterocarya fraxinifolia, Fagus sylvatica, Morus* sp.		Italy	
		Carpinus betulus, *Tilia* sp. (Lime), *Quercus* sp. (Oak), *Fagus*, *Aesculus*		Germany, USA, Czech Republic	Cong 2010
		Melia azadirachta, *Prunus armeniaca*, *Tamarindus indica* (Tamarind), *Terminalia bellerica*, *Grevillea parallela*		Indonesia	Flood et al. 2010
		Salix sp., *Ceratonia siliqua* (Carob tree)			Cong 2010
		Fraxinus sp., *Acacia* sp.		Armenia	Badalyan et al. 2012
		Abies sp. (fir), *C. siliquastrum, F. sylvatica* L., *Pinus pinea, Prunus avium, Quercus* sp., *Robinia* sp., *L. nobilis*		Italy	De simone & Annesi 2012
		Alnus orientalis, *Quercus* sp., *F. carica*, On buried tree trunk		India	Arulpandi & Kalaichelvan 2013, Ranadive & Jagtap 2016
		P. dulcis		USA	Johnson 2017
		Quercus infectoria, *C. siliqua*, *Salix alba*		Cyprus	Loizides 2018
G. applanatum		*Fagus* sp. (Beech), *Ulmus* sp. (Elms), *Quercus* sp. (Oak), *Platanus* sp., (Sycamore), *A. hippocastanum*, *Salix* (Willow), *Juglans* (Walnut)	Root rot, butt rot	UK	Cartwright & Findlay 1958
		Citrus sp.		USA	Farr et al. 1989
		Rhizophora apiculata (Mangrove)	Butt rot	Thailand	Chalermpongse 1991
		Gleditsia triacanthos (Honey locust)		USA	Report in Plant diseases 1999
		Acacia auriculiformis		Australia	Old et al. 1998

Table 3 Continued.

Species	Current name	Host plant	Disease	Country	Reference
		Acer sp. (Maple), *Alnus rubra* (Red alder), *Amelanchier arborea*, *Betula* sp., *Carya tomentosa*, *Cercis Canadensis*, *Fagus grandifolia*, *Juglans cinerera*, *Liriodendron tulipifera*, *Magnolia fraseri*, *Malus sylvestris*, *Populus* sp., *Prunus pensylvanica*, *Pseudotsuga menziesii* (Douglas-fir), *Quercus* sp., *Robinia pseudoacacia*, *Salix* sp., *Tilia heterophylla*, *Thuja plicata* (Western Redcedar), *Tsuga canadensis* (Hemlock), *Ulmus rubra*	White mottled rot	USA, Canada	Allen et al. 1996, Grand & Vernia 2006
		Tectona grandis (Teak), *Xylia xylocarpa*, *Bombax ceiba*, *Terminalia* sp.		India	Florence & Yesodharan 2000
		Acer sp., *Abies* sp., *Betula* sp., *Carpinus* (Hornbeam), *Pinus sibirica* (Siberian pine), *Tilia*, *Salix* sp.		Russia	Kuz'michev & Kulikova 2001
		A. mangium		Indonesia	Glen et al. 2009
		Abies pindrow, *Acacia* sp., *Albizia* sp., *Artocarpus* sp., *Azadirachta indica*, *Camellia sinensis* (Tea), *Caryota urens*, *Cassia* sp., *Celtis tetrandra*, *Cinnamomum cecidodaphne*, *Cocos nucifera* (Coconut), *D. sissoo*, *Dipterocarpus macrocarpus*, *Leucaena leucocephala*, *Mallotus philippensis*, *Morus alba*, *Picea smithiana*, *Pieris ovalifolia*, *Pinus roxburghii*, *Santalum* sp., *Shorea* sp., *Sterculia*, *T.*		India	Sankaran et al. 2005

Table 3 Continued.

Species	Current name	Host plant	Disease	Country	Reference
		grandis, T. bellirica, Toona ciliata			
		Phoenix sylvestris		India	Bhosle et al. 2010, Ranadive & Jagtap 2016
		Betuleceae alnus (Alder), *Maleace malus* (Apple), *Ulmaceae Ulmus* (Elm), *Aesculus* (Horse-chestnut), Acer sp., *Quercus*, *Juglans* (Walnut)		Denmark, Norway, Germany, China, Vietnam, Czech republic	Cong 2010
		Laurus nobilis (Bay laurel)	Wood decay	USA	Glaeser & Smith 2010
		F. sylvatica, L. nobilis	Wood decay	Italy	De simone & Annesi 2012
		Mangifera indica (Mango),	Wood decay	India	Singh et al. 2014
		Swietenia mahagoni (Mahagoni)	Wood decay	Bangladesh	Das & Aminuzzaman 2017
		A. mangium	Wood decay	Australia	Tchotet Tchoumi et al. 2017
		Hardwoods	Wood decay	China, Thailand, Myanmar, Laos	This study
G. amazonense		*Spondiae lutae*	Wood decay	Brazil	Cong 2010
		T. grandis		India	Foroutan & Vaidya 2007, Ranadive & Jagtap 2016
G. amboinense		*Acacia confusa*, Dead wood	Wood decay	Indonesia, India	Cong 2010, Ranadive & Jagtap 2016
G. angustisporum		*Casuarina equisetifolia*	White rot	China	Xing et al. 2018
G. aridicola		*Ficus* sp.	White rot	South Africa	Xing et al. 2016
G. argillaceum	*G. resinaceum*	*Mangifera* sp.		Cuba	Cong 2010
G. atrum		*Fagus* sp., *Coniferous* sp.		China	Cong 2010
G. atkinsonii	*G. carnosum*	*Abies alba*		Bohemia	Cong 2010
G. australe		Angiosperm trees, *Cinnamomum* sp.	White rot, butt rot	China	Turner 1981, Dai et al. 2004, 2007
		M. indica	Wood decay	Malaysia	Abdullah et al. 1997
		Hardwoods		Laos, Thailand, Myanmar	This study
		X. xylocarpa, *Cassia* sp., *Mesua ferrea*	White rot	India	Florence & Yesodharan 2000
		Coffea arabica (Coffee), *Grevillea robusta, M. ferrea*		India	Sankaran et al. 2005, Ranadive & Jagtap 2016
		A. mangium	Root rot	Indonesia, Malaysia	Glen et al. 2009

Table 3 Continued.

Species	Current name	Host plant	Disease	Country	Reference
		Alnus sp., *Castanopsis* sp., *Cunninghamia* sp., *Machilus* sp., *Platycarya* sp., *Sapindus* sp. (Soapberry), *Schima* sp.	Wood decay	China	Dai et al. 2011
		Schizolobium parahybum (Tower tree)	Root rot	Malaysia	Goh et al. 2014
		Camellia sinensis var. *assamica* (Assam tea)	Root rot	Thailand	Tompong & Kunasakdakul 2014
		Eucalyptus pellita	Root rot		Agustini et al. 2014
G. austroafricanum		*Jacaranda mimosifolia*	Root rot, butt rot	South Africa	Crous et al. 2014
G. austrofujianense		*Pinus* sp.		China, India	Cong 2010
G. boninense	*G. orbiforme*	*Elaeis guineensis* (Oil palm)	Basal stem rot, upper stem rot	Indonesia, Malaysia, Thailand	Turner 1981, Idris et al. 2004
		D. regia	Basal stem rot	India	Foroutan & Jafary 2007, Ranadive & Jagtap 2016
G. brownii		*Umbellularia*, *Hakea* sp., *Quercus* sp., *Schinus* sp.	White rot	USA	Gilbertson & Ryvarden 1986, Cong 2010
		Citrus sp.		USA	Farr et al. 1989
		Areca catechu (Arecanut)		India	Foroutan & Vaidya 2007
		Gravillea robusta		India	Singh et al. 2014
		Albizia saman (Rain)		Bangladesh	Das & Aminuzzaman 2017
G. carocalcareus		*Anthocleista nobilis*	White rot	Cameroon	Douanla-Meli & Langer 2009
G. carnosum		*Abies* sp.		Czech republic	Das & Aminuzzaman 2017
G. casuarinicola		*C. equisetifolia*	White rot	China	Xing et al. 2018
G. chalceum		*E. guineensis*	Basal stem rot	Cameroon	Turner 1981, Kinge & Mih 2015
		A. catechu, *A. indica*, *Pongamia pinnata*, *T. indica*, *T. grandis*		India	Foroutan & Jafary 2007, Foroutan & Vaidya 2007, Ranadive & Jagtap 2016
		A. mangium		Australia	Old et al. 1998
		C. equisetifolia		Malaysia	Lee & Chang 2016
G. chenhaiense		*Acacia* sp.		China	Das & Aminuzzaman 2017
G. concinnum		*D. sissoo*		India	Foroutan & Vaidya 2007, Ranadive & Jagtap 2016
G. colossus		*Callitris robusta*, *Eucalyptus* sp., *Pinus* sp.	White rot	South Africa	Lückhoff 1955
		Ciltis laevigata, *F. carica*	Wood decay	USA	Adaskaveg & Gilbertson 1988
		Phoenix canariensis	Wood decay	Oman	Adaskaveg et al. 1991

Table 3 Continued.

Species	Current name	Host plant	Disease	Country	Reference
		(Date palm)			
		E. guineensis			Turner 1981, Idris et al. 2000
		D. regia, *Ficus altissima* (Lofty fig)	White rot	Oman	Al-Bahry et al. 2005
		C. nucifera, *G. robusta*, *Ficus* sp.	White rot	Costa Rica, Vietnam	Sankaran et al. 2005
		Phoenix dactylifera (Date palm)		Oman	Elshafie et al. 2006
		Conifers, hardwoods		Iran	Moradali et al. 2007
		Cedrelae odoratae		Costa Rica	Flood et al. 2010
		Mimosa		Somali	Cong 2010
		Sclerocarya birrea (Marula)	Dieback	Oman	Elshafie et al. 2013
		Ficus sp.	White rot	India	Parihar et al. 2013
		Ziziphus spina-christi (Christ's Thorn Jujbe)	Dieback, wood decay	Oman	El-Nagerabi & Elshafie 2014
		Ficus bengalensis (Indian banyan)	White rot	Oman	El-Nagerabi & Elshafie 2015
		Polyalthia sp.	Wood decay	India	Ranadive & Jagtap 2016
G. cupreum	*G. orbiforme*	*Cassia* sp.		Cameroon	Kinge & Mih 2015
		P. armeniaca, *T. bellerica*		India	Arulpandi & Kalaichelvan 2013
		Hardwoods	Wood decay	China	This study
G. curtisii		*Acer* sp., *Carya* sp., *Lagerstroemia indica* L., *Liquidambar styraciflua*, *Pinus taeda*, *Quercus* sp., *R. pseudoacacia*, *Zelkova serrata*	White rot	USA	Grand & Vernia 2006, Loyd et al. 2017
		Gliricidia sepium		India	Ranadive & Jagtap 2016
		C. nucifera		India	Das & Aminuzzaman 2017
G. dejongii		*M. indica*		India	Foroutan & Jafary 2007
		Ficus benjamina			Ranadive & Jagtap 2016
G. destructans		*J. mimosifolia*	Root rot	South Africa	Coetzee et al. 2015
G. dejongii		*F. benjamina*		India	Foroutan & Vaidya 2007,
		M. indica			Ranadive & Jagtap 2016
G. dimidiatum		Near Dipterocarpus tree roots		China	This study
G. donkii		*A. catechu*		India	Foroutan & Vaidya 2007
		Annona reticulate			Ranadive & Jagtap 2016
G. enigmaticum		*C. siliqua*		South Africa	Coetzee et al. 2015
G. fassii		*G. dewevrei*		Africa	Cong 2010
G. fici		*F. carica*		Tunisia	Cong 2010

Table 3 Continued.

Species	Current name	Host plant	Disease	Country	Reference
G. flexipes		Unknown		India	Cong 2010
		Decaying wood			Ranadive & Jagtap 2016
		Near the hardwood roots	Wood decay	China, Myanmar, Vietnam	This study
G. fornicatum	*G. orbiforme*	*Macademia integrifolia*	Wood decay	Taiwan	Wang 1990
G. frondosum		*Guazuma ulmifolia*		Venezuela	Cong 2010
G. gibbosum		Conifers		China, Brazil, Indonesia	Cong 2010
		Hardwoods	Wood decay	China, Thailand	This study
G. hoehnelianum		*Tjibodas* sp.		Indonesia	Cong 2010
		Decayed tree		China	This study
G. lipsiense	*G. applanatum*	*Betula* sp, *Populus* sp., *Tilia*	Butt rot	China	Dai et al. 1996, 2004, 2007
		C. equisetifolia, A. catechu, Phoenix sylvestris		India	Foroutan & Jafary 2007 Ranadive & Jagtap 2016
G. lobatoideum		*D. regia*		India	Foroutan & Vaidya 2007
G. lobatum		*Carya glabra, Quercus* sp.		USA	Grand & Vernia 2006
		A. catechu, D. regia		India	Foroutan & Vaidya 2007
G. lobenense		*E. guineensis*	Basal stem rot	Cameroon	Kinge & Mih 2015
G. lucidum		*A. auricullformis, A. mangium*	Basal stem rot	India	Bakshi 1971
		Acacia catechu	Root rot	India	Bakshi 1976
		Pinus caribaea (Caribbean pine)	Wood decay	Fiji	Hood & Bell 1983
		Citrus sp.	Heart rot	USA	Farr et al. 1989
		Faidherbia albida (Delile), *Acacia* sp.	Root rot	India	Harsh et al. 1993
		A. mangium	White root rot	India	Mehrotra et al. 1996
		Grewia tiliifolia, dead stumps of *T. grandis, Terminalia* sp.	White spongy rot	India	Florence & Yesodharan 2000
		Acacia sp., *Acrocarpus fraxinifolius, Anacardium occidentale, Aquilaria agallocha, Artocarpus heterophyllus, A. indica, Bambusa* sp., *Bombax* sp., *Boswellia serrate, Caesalpinia pulcherrima, Cajanus* sp., *Cassia* sp., *C. equisetifolia, Cedrus deodara, Cupania anacardioides, D. regia, Dichrostachys cinerea,*	Basal Stem rot, root rot	India	Sankaran et al. 2005

Table 3 Continued.

Species	Current name	Host plant	Disease	Country	Reference
		Diospyros sp., *Dysoxylum malabaricum, E. guineensis, Eucalyptus sp., Ficus* sp., *Guazuma* sp., *Hevea brasiliensis* (Rubber), *Hydnocarpus, J. mimosifolia, Lannea coromandelica, L. leucocephala, Litchi chinensis, M. indica, Melia azedarach, Melocanna baccifera, M. ferrea, Millingtonia hortensis, M. alba, Paraserianthes falcataria, Parkia biglandulosa, Peltophorum pterocarpum, Pleiogynium cerasiferum, P. pinnata, Pterocarpus marsupium, Roystonea regia, Samanea saman, Santalum album, Shorea robusta, Simmondsia chinensis, Sterculia urens, T. indica, Terminalia* sp., *Thyrsostachys oliveri, T. ciliate, A. catechu, C. nucifera*			
		Acer sp., *Betula* sp., *Carya* sp., *Celtis laevigatus, Cornus Canadensis, Dalbergia* sp., *F. grandifolia, Ilex opaca, G. triacanthos, Juglans nigra, L. styraciflua, L. tulipifera, Myrica cerifera, Oxydendrum arboretum, Platanus occidentalis, Quercus* sp. *R. pseudoacacia, Salix* sp.		USA	Grand & Vernia 2006
		A. mangium	Root rot	Indonesia, Java	Irianto et al. 2006
		Caesalpinia coriuria, Dalbergia melanoxylon		India	Foroutan & Jafary 2007
		Populus deltoides (Poplar)		India	Harsh 2012
		Corylus avellana		India	Cong 2010

Table 3 Continued.

Species	Current name	Host plant	Disease	Country	Reference
		Castanopsis sp.	Wood decay	China	Dai et al. 2011
		Castanea sativa	Wood decay	Italy	Badalyan et al. 2012
		Acacia sp., *Albizia labbek, Azardirachta indica*, *D. regia, Prosopis* sp.		India	Bhansali 2012
		Quercus sp.	Wood decay	Italy	De simone & Annesi 2012
		A. confuse, Ficus microcarpa		Hong Kong	Ding 2013
		Quercus alnifolia		Cyprus	Loizides 2018
G. luteicinctum		*S. mahagoni*	Root rot	India	Foroutan & Vaidya 2007
		D. regia			Ranadive & Jagtap 2016
G. mastoporum	*G. orbiforme*	*A. mangium*	Root rot	Indonesia, Malaysia	Glen et al. 2009
G. microsporum		Angiosperm trees	White, rot, butt rot	China	Dai et al. 2007
		Artocarpus integrifolia, A. heterophyllus		India	Foroutan & Jafary 2007, Ranadive & Jagtap 2016
		Salix babylonica (Weeping willow)		Taiwan	Hseu et al. 1989
G. miniatocinctum		*E. guineensis*	Basal tem ot		Turner 1981
G. mirabile		*A. catechu, F. bengalensis, D. regia*		India	Foroutan & Jafary 2007, Foroutan & Vaidya 2007
G. multicornum		*D. regia, A. indica*	Wood decay	India	Foroutan & Vaidya 2007
G. multipileum		Decayed Hardwood	Wood decay	China	This study
G. multiplicatum		*Holoptelea integrifolia, T. indica*	Wood decay	India	Ranadive & Jagtap 2016
G. neojaponicum		Near hardwood roots	Wood decay	Myanmar	This study
G. orbiforme		*D. regia, Leucaena latisiliqua*	Root rot	India	Foroutan & Vaidya 2007, Ranadive & Jagtap 2016
		Decayed hardwood	Wood decay	China, Laos	This study
G. oregonense		*Picea sitchensis*	Root rot	USA	Cong 2010
		Pinus sp., *Abies* sp., *Picea* sp., *Pseudotsuga* sp.	Root rot, butt rot	Canada, Mexico	Torres-Torres et al. 2015
G. ostreatum	*G. lucidum*	*M. indica*	Root rot	India	Foroutan & Jafary 2007
G. parvulum		*Mangifera* sp.		Cuba, Nicaragua	Cong 2010
G. perzonatum	*G. parvulum*	*T. indica*	Root rot	India	Ranadive & Jagtap 2016
G. praelongum	*G. resinaceum*	*Diospyros ebony* (River Abony)	Root rot	Bangladesh	Das & Aminuzzaman 2017
		A. catechu, L. latisiliqua, L. leucocephala, *D. regia*		India	Foroutan & Vaidya 2007, Ranadive & Jagtap 2016
G. pfeifferi		*Ulmus laevis* (Elm)	Wood decay	Poland	Piatek 1999
		Acer saccharinum (Silver			Szczepkowski & Pietka 2003

Table 3 Continued.

Species	Current name	Host plant	Disease	Country	Reference
		maple)			
		M. indica		India	Foroutan & Vaidya 2007, Ranadive & Jagtap 2016
		Abies sp., *Fagus*		Russia	Cong 2010
		F. sylvatica		Czech Republic	Tchoumi et al. 2017
G. philippi		*Camillia sinensis* (Tea), *C. arabica*, *Theobroma cacao* (Cocoa), *H. brasiliensis*	Red root disease	Malaysia Philippines	Zakaria et al. 2009 Monkai et al. 2017
		Schefflera (Dwarf umbrella tree), *Lannea* sp. (Indian Ash), *Melia* (Chinaberry), *Sapindus*, *Vernicia* (Tung-oil)	Root rot	China	Dai et al. 2007
		Mangifera indica, *Albizzia lebbeck*	Root rot	India	Foroutan & Vaidya 2007, Ranadive & Jagtap 2016
		A. mangium	Red root disease	Indonesia, Malaysia	Potter et al. 2006, Glen et al. 2009, Coetzee et al. 2011
		Palaquium ellipticum	Root rot	India	Cong 2010,
		E. pellita	Red root disease	Indonesia	Coetzee et al. 2011, Agustini et al. 2014
G. resinaceum		Oak, Willow, Beach and plane	Heart rot		Phillips & Burdekin 1992
		P. orientalis, *Quercus* sp.	Root rot	India	Sankaran et al. 2005
		Mangifera, *F. sylvatica*		China, Cuba, Mexico, USA	Cong 2010
		D. regia	Root rot	India	Foroutan & Vaidya 2007
		Acacia nilotica	Root rot		Mohanty et al. 2011
		E. guineensis		India	Mohanty et al. 2011
		Populus sp.			Badalyan et al. 2012
		Quercus sp.		Italy	De simone & Annesi 2012
		F. bengalensis		Egypt	El-Fallal et al. 2015
		Q. infectoria		Cyprus	Loizides 2018
		Hardwoods		China	This study
G. ryvardense		*E. guineensis*, *Cassia* sp.	Basal stem rot	Cameroon	Kinge & Mih 2015
G. septatum		*Grevillea* sp.		Africa	Cong 2010
G. sessile		*Salix* sp.			Cong 2010
G. sessiliforme		*P. pinnata*	Wood decay	India	Ranadive & Jagtap 2016
G. sinense		Near hardwood tree roots		China	This study
G. sprucei	*Foraminispora rugosa* (Berk.) Costa-Rezende, Drechsler-Santos & Robledo	Decayed angiosperm wood		Brazil, Costa Rica, Cuba, French, Guiana, Venezuela	Costa-Rezende et al. 2017

Table 3 Continued.

Species	Current name	Host plant	Disease	Country	Reference
G. steyaertanum		*E. guineensis*	Basal stem rot	Cameroon	Kinge & Mih 2015
		A. mangium, A. auriculiformis	Root rot	Indonesia, Java, Malaysia	Glen et al. 2009, Hidayati et al. 2014
G. stipitatum		*D. regia, T. indica*		India	Foroutan & Jafary 2007
G. subincrustatum	*G. resinaceum*	*D. melanoxylon*		India	Foroutan & Jafary 2007
G. theaecolum		*A. confusa*		China	Foroutan & Vaidya 2007
G. tenue				China	Cong 2010
G. testaceum		*A. integrifolia, A. heterophyllus, Peltophorum ferrugeninum*		India	Foroutan & Jafary 2007, Ranadive & Jagtap 2016
G. tornatum	*G. australe*	*E. guineensis*	Basal stem rot	India	Turner 1981
		A. integrifolia, C. nucifera, G. sepium	Root rot	India	Foroutan & Vaidya 2007
		Hardwoods	Wood decay	India	This study
G. trengganuense		*D. melanoxylon*		India	Turner 1981, Foroutan & Jafary 2007
G. tropicum		*E. guineensis, Acacia* sp.		China	Turner 1981, Dai et al. 2007
		F. carica		Indonesia, Malaysia	Cong 2010
		Hardwoods	Wood decay	China	This study
G. trulliforme		*D. regia, Ficus* sp.	Root rot	India	Foroutan & Vaidya 2007
G. tsugae		*Tsuga* sp.	Butt rot	China	Dai et al. 2004
		Larix sp., *Picea* sp.		China	Dai et al. 2007, Cong 2010
		Abies fraseri, Pinus pungens, Tsuga canadensis,		USA	Grand & Vernia 2006
		C. nucifera	Root rot	Bangladesh	Das & Aminuzzaman 2017
		Conifers	Wood decay	China	This study
G. tsunodae		*Litsea cubeba* (Aromatic listea)	Root rot, butt rot	China	Dai et al. 2002
G. vanheurnii		*F. benjamina, T. indica*	Root rot	India	Foroutan & Vaidya 2007
G. valesiacum		*Larix* sp.	Root rot	China, Japan, Sweden	Cong 2010
G. weberianum		*Cassia* sp.	Root rot, butt rot	Cameroon	Kinge & Mih 2015
		Ficus sp.		China	Pan & Dai 2001
G. williamsianum		*A. catechu*	Root rot	India	Foroutan & Vaidya 2007
		Near hardwood roots	Wood decay	China	This study
G. zonatum		*E. guineensis*	Basal stem rot		Turner 1981
		A. catechu	Root rot	India	Foroutan & Vaidya 2007
		Acoelorraphe wrightii, Acrocomia aculeate, Adonidia	Butt rot	USA	Elliott & Broschat 2001

Table 3 Continued.

Species	Current name	Host plant	Disease	Country	Reference
		merrillii, *Aiphanes* sp., *Arenga* sp., *Attalea* sp., *Bactris major*, *Brahea* sp., *Carpentaria acuminate*, *Caryota mitis*, *Chamaerops humilis*, *Coccothrinax* sp., *Cocos nucifera*, *Copernicia curtisii*, *Dictyosperma album*, *Dypsis cabadae*, *Dypsis lutescens* (Areca palm), *Euterpe edulis*, *Gastrococos crispa*, *Hyophorbe indica*, *Livistona* sp., *Nannorrhops ritchiana*, *Phoenix* sp., *Ptychosperma* sp., *Roystonea* sp., *Sabal palmetto* (Sabal palm), *Satakentia liukiuensis*, *Scheelea* sp., *Serenoa repens*, *Syagrus romanzoffiana* (Queen palm), *Washingtonia robusta*			
		Cocos nucifera	Basal stem rot	Brazil, USA	Cong 2010
		Butia odorata (Jelly palm)	Butt rot	USA	Loyd et al. 2017
Haddowia longipes		Near hardwood roots	Wood decay	Laos	This study
Humphreya coffeata		*Elaeocarpus lancifolius*	Root rot	India	Lyngdoh & Dhakar 2014

Sequences, *A. rugosum* from, China (GACP14081009, GACP14080929), Laos (GACP16072714, GACP14061012), and Thailand (GACP14062120); *Haddowia longipes* (GACP17072708, GACP17072709) from Thailand; *G. adspersum* (GACP15061220) from Thailand and Myanmar (GACP14091108); *G. applanatum* from China (GACP14080601, GACP14080603); *G. australe* from, China (GACP14061914) and Thailand (GACP15062160); *G. flexipes* from, Vietnam (GACP17102301) and Laos (GACP17073037); *G. gibbosum* from, China (GACP14070501, GACP14070653), Laos (GACP14061422) and Thailand (GACP15062144); *G. lingzhi* from Laos (GACP18011910, GACP18011911); *G. multiplicatum* from Myanmar (GACP14091107, GACP14091108); *G. neojaponicum*, from Laos (GACP17062350) and Myanmar (GACP14091006); *G. orbiforme* from, Laos (GACP14061420, GACP14061414), Thailand (GACP15061260) and Myanmar (GACP140910138); *G. sinense* from China (GACP17092559, GACP16072729), *G. subresinosum* from Laos (GACP18011907); *G. tropicum* from Thailand (GACP15081610) and *G. williamsianum* from China (GACP14081320, GACP14081321) obtained from our collections, clustered in well-supported clades forming monophyletic groups with, *A. rugosum* (BS = 100%, BPP = 0.99), *H. longipes* (BS = 100%, BPP = 1.0), *G. applanatum* (BS = 100%, BPP = 1.0), *G. australe* (BS = 100%, BPP = 1.0), *G. flexipes* (BS = 100%, BPP = 1.00), *G. gibbosum* (BS = 94%, BPP = 0.97), *G. lingzhi* (BS = 100%, BPP = 1.0), *G. multiplicatum* (BS = 100%, BPP = 1), *G. neojaponicum* (BS = 100%, BPP = 1.00), *G. orbiforme* (BS = 100%, BPP = 1.00), *G. sinense* (BS = 100%, BPP = 1.00), *G. subresinosum* (BS = 100%, BPP = 1.0) and *G. tropicum* (BS = 100%, BPP=1.0), *G. williamsianum* (BS = 100%, BPP=1.0), respectively (Fig. 2).

Taxonomy

Ganoderma P. Karst., 1881, Rev. Mycol. (Toulouse) 3, p. 17.

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

= *Elfvingia* 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, Torreya 5: 197 (1905)

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

See the description at Ryvarden (2004b)

Basidiomes annual or perennial, stipitate to sessile; pileal surface with a thick, dull cuticle or shiny and laccate with a thin cuticle or cuticle of clavate end cells. *Context* cream coloured to dark purplish brown, soft and spongy to firm-fibrous; pore surface cream coloured, bruising brown, the pores regular, 4–7 per mm; tube layers single or stratified, pale to purplish brown; stipe when present central or lateral; hyphal system dimitic; generative hyphae with clamps; skeletal hyphae hyaline to brown, non-septate, often with long, tapering branches; basidia broadly ellipsoid, tapering abruptly at the base; cystidia absent. *Basidiospores* broadly to narrowly ellipsoid with a truncate apex and apical germ pore, wall two-layered, endosporium brown and separated from the hyaline exosporium by inter-wall pillars, negative in Melzer's reagent, 7–30 µm long.

Type species – *Ganoderma lucidum* (Curtis) P. Karst.

Notes – *Ganoderma* was established by Karsten (1881) with *Ganoderma lucidum* (Curtis) P. Karst. as the type species. Traditional Chinese books classified *Ganoderma* into six species with reference to the colour of the basidiome (Szedlay 2002). Patouillard (1889) listed 48 species of *Ganoderma* worldwide. Species of *Ganoderma* have been studied primarily by many researchers (Ryvarden & Johansen 1980, Furtado 1981, Corner 1983, Moncalvo & Ryvarden 1997) who have made major contributions to the nomenclature and taxonomy of the genus. The traditional taxonomy of *Ganoderma* is based on morphological traits and this genus was divided into two distinct groups, the laccate (*G. lucidum* complex) and the non–laccate (*G. applanatum* complex) species, which refer to the subgenera *Ganoderma* and *Elfvingia* respectively (Zheng et al. 2007). Donk (1933) reunite all the taxa under subfamily Ganodermatoideae which previously belong to Polyporaceae. In 1948, he raised up this taxon to family level and established Ganodermataceae on the basis of spore peculiarities with the laccate and stipitate white rot fungus *Polyporus lucidus* Curtis as its type species (Moncalvo & Ryvarden 1997) and placed the family in Polyporales, Basidiomycetes (Schwarze & Ferner 2003).

This classification has subsequently been accepted by most recent workers, however Jülich (1981) introduced the ordinal name Ganodermatales and this was accepted by Pegler in the eighth edition of the *Dictionary of the fungi*, though other workers have continued to use the traditional Aphyllophorales in a broad sense. The genus *Ganoderma* was initially classified on the basis of morphological characteristics, however, environmental factors, variability, interhybridization, and morphological propensity can lead to the inaccurate identification of *Ganoderma* species (Zheng et al. 2007). There are 449 epithets listed in Index Fungorum (2019) for *Ganoderma*, while Kirk et al. (2008) estimates there are 80 species. The taxonomic circumscription within *Ganoderma* is unclear as species and generic concepts are confused because similar fungi are found in *Fomes* (Fr.), *Polyporus* P. Micheli and *Tomophagus* Murril (Paterson 2006). *Ganoderma* species identification and circumscriptions have often been problematic and taxonomic segregation of the genus has been debatable from long time (Moncalvo et al. 1995c).

Table 4 Sequences used in the phylogenetic analysis.

Species	Voucher/strain	Origin	ITS	nrLSU	RPB2	nrSSU	TEF	Reference
Amauroderma aurantiacum (Torrend) Gibertoni & Bernicchia	URM 78847	Brazil	JX310840	-	-	-	-	Gomes-Silva et al. 2015
A. aurantiacum	FLOR:52205	Brazil	KR816510	KU315205	-	-	-	Costa-Rezende et al. 2016
A. austrosinense	Cui 13618	China	KU219973	KU219996	-	-	-	Song et al. 2016
A. calcigenum Berk.) Torrend	URM 83864	Brazil	JX982565	-	-	-	-	Gomes-Silva et al. 2015
A. calcigenum	URM 86847	Brazil	KT006601	-	-	-	-	Gomes-Silva et al. 2015
A. calcitum D.H. Costa & Drechsler-Santos	FLOR:52230 (holotype)	Brazil	KR816529	-	-	-	-	Costa-Rezende et al. 2016
A. calcitum	FLOR:50931	Brazil	KR816528	-	-	-	-	Costa-Rezende et al. 2016
A. camerarium (Berk.) J.S. Furtado	FLOR:52169	Brazil	KR816523	-	-	-	-	GenBank
A. concentricum J. Song, Xiao L. He & B.K. Cui	Cui 12644 (holotype)	Sichuan, China	KU219974	KU219997	-	-	-	Song et al. 2016
A. concentricum	Cui 12648	Sichuan, China	KU219975	KU219998	-	-	-	Song et al. 2016
A. elegantissimum Ryvarden & Iturr.	URM 82787	Brazil	JX310843	KT006616	-	-	-	Gomes-Silva et al. 2015
A. elegantissimum	URM 82789	Brazil	JX310844	KT006617	-	-	-	Gomes-Silva et al. 2015
A. exile (Berk.) Torrend	URM 82794	Brazil	JX310845	-	-	-	-	Gomes-Silva et al. 2015
A. floriformum Gomes-Silva, Ryvarden & Gibertoni	URM83250 (holotype)	Brazil	JX310846	-	-	-	-	Gomes-Silva et al. 2015
A. laccatostipitatum Gomes-Silva, Ryvarden & Gibertoni	URM83238 (isotype)	Brazil	JX310847	-	-	-	-	Gomes-Silva et al. 2015
A. laccatostipitatum	HFSL ACGS7	Brazil	KT006602	-	-	-	-	Gomes-Silva et al. 2015
A. omphalodes (Berk.) Torrend	HUEFS:DHCR499	Brazil	MF409956	-	-	-	-	Costa-Rezende et al. 2017
A. omphalodes	HUEFS:DHCR500	Brazil	MF409957	-	-	-	MF421239	Costa-Rezende et al. 2017
A. perplexum Corner	Cui 6496	Brazil	KJ531650	KU220001	-	-	-	Li & Yuan 2015
A. perplexum	Dai 10811	Brazil	KJ531651	KU220002	-	-	-	Li & Yuan 2015
A. praetervisum (Pat.) Torrend	URM87611	Brazil	KT006606	-	-	-	-	Gomes-Silva et al. 2015
A. praetervisum	URM84223	Brazil	KC348460	-	-	-	-	Gomes-Silva et al. 2015
A. rugosum (Blume & T. Nees) Torrend	GACP1408929	China	MK345420	-	-	-	-	This study
A. rugosum	GACP14081009	China	MK345421	-	-	-	-	This study
A. rugosum	GACP16072714	Laos	MK077647	-	-	-	-	Hapuarachchi et al. 2018c
A. rugosum	GACP14061012	Laos	MK345422	-	-	-	-	This study
A. rugosum	GACP14062120	Thailand	MK077648	-	-	-		Hapuarachchi et al. 2018c
A. rugosum	Cui9012	China	KJ531665	KJ531665	-	-	KU572503	Li & Yuan 2015
A. sessile Gomes-Silva, Ryvarden & Gibertoni	URM83905	Brazil	JX982570	-	-	-	-	Gomes-Silva et al. 2015

Table 4 Continued.

Species	Voucher/strain	Origin	ITS	nrLSU	RPB2	nrSSU	TEF	Reference
A. subsessile Gomes-Silva, Ryvarden & Gibertoni	URM83239 (holotype)	Brazil	JX310860	-	-	-	-	Gomes-Silva et al. 2015
A. schomburgkii (Mont. & Berk.) Torrend	URM 84228	Brazil	KT006608	-	-	-	-	Gomes-Silva et al. 2015
A. schomburgkii	URM 84254	Brazil	KT006611	-	-	-	-	Gomes-Silva et al. 2015
A. yunnanense J.D. Zhao & X.Q. Zhang	Cui 7974	Yunnan, China	KJ531653	KU220013	-	KJ531653	-	Li & Yuan 2015
A. yunnanense	Yuan 2253	Yunnan, China	KJ531655	-	-	-	-	Li & Yuan 2015
Furtadoa brasiliensis (Singer) Costa-Rezende, Robledo & Drechsler-Santos	URM83578	Brazil	JX310841	-	-	-	-	Gomes-Silva et al. 2015
F. brasiliensis	TBG58	Brazil	JX982569	-	-	-	-	Gomes-Silva et al. 2015
F. biseptata (Singer) Costa-Rezende, Robledo & Drechsler-Santos	FLOR50932 (holotype)	Brazil	KU315196	KU315206	-	-	-	Gomes-Silva et al. 2015
Foraminisporus rugosa (Berk.) Costa-Rezende, Drechsler-Santos & Robledo	DHCR554 (HUEFS)	Brazil	MF409962	MF409954	-	-	-	Costa-Rezende et al. 2017
F. rugosa	DHCR560	Brazil	MF409963	MF409955	-	-	-	Costa-Rezende et al. 2017
Haddowia longipes (Lév.) Steyaert	2012BZ01	China	KP226862	-		-	-	Zhang et al. 2015
H. longipes	DN128	Vietnam	MG663597	-	-	-	-	GenBank
H. longipes	GACP17072708	Laos	MK345423	MK346828	-	MK346836	-	This study
H. longipes	GACP17072709	Laos	MK345424	MK346829	-	MK346837	-	This study
Humphreya coffeata	QCAM2955	Ecuador	MH124633	-	-	-	-	GenBank
Ganoderma sp.	FRIM138	Malaysia	AJ698114	-	-	-	-	Glen et al. 2009
Ganoderma sp.	FMD13	Vietnam	KT965501	-	-	-	-	GenBank
Ganoderma sp.	G31	Malaysia	KR093030	-	-	-	-	Goh et al. 2016
Ganoderma adspersum (Schulzer) Donk	SFC20141001-16	Korea	KY364251	-	KY393270	-	KY393284	Jargalmaa et al. 2017
G. adspersum	SFC20141001-22	Korea	KY364252	-	KY393271	-	KY393285	Jargalmaa et al. 2017
G. adspersum	GACP15061220	Thailand	MK345425	-	MK371437	-	MK371431	This study
G. adspersum	GACP14091109	Myanmar	MK345435					This study
G. applanatum (Pers.) Pat.	SFC20150930-02	Korea	KY364258	-	KY393274	-	KY393288	Jargalmaa et al. 2017
G. applanatum	SFC20141001-24	Korea	KY364255	-	KY393273	-	KY393287	Jargalmaa et al. 2017
G. applanatum	GACP XC14080601	China	MK345426	-	-	MK346838	-	This study
G. applanatum	GACP XC14080603	China	MK345427	-	-	-	-	This study
G. applanatum	Dai8924	China	KU219987	-	-	-	-	Song et al. 2016
G. aridicola J.H. Xing & B.K. Cui	Dai12588(holotype)	Durban, South Africa	KU572491	-	-	-	KU572502	Xing et al. 2016
G. australe	K(M)120828	UK	AY884183	-	-	AY884183	-	Arulpandi & Kalaichelvan 2013
G. australe	GDGM25344	China	JX195198	JX195198		JX195198		GenBank
G. australe	GACP14061914	China	MK345428	-	-	-	MK371432	This study

Table 4 Continued.

Species	Voucher/strain	Origin	ITS	nrLSU	RPB2	nrSSU	TEF	Reference
G. australe	GACP15062160	Thailand	MK345429	-	-	-	-	This study
G. austroafricanum M.P.A. Coetzee, M.J. Wingf., Marinc. & Blanchette	CBS138724 (ex-type)	South Africa	KM507324	KM507325	-	-	-	Crouse et al. 2014
G. boninense Pat.	WD 2028 (FFPRI)	Japan	KJ143905	-	KJ143964	-	KJ143924	Zhou et al. 2015
G. boninense	WD 2085 (FFPRI)	Japan	KJ143906	-	KJ143965	-	KJ143925	Zhou et al. 2015
G. carocalcareus	DMC 322 (holotype)	Cameroon	EU089969	-	-	-	-	Douanla-Meli & Langer 2009
G. carocalcareus	DMC 513	Cameroon	EU089970	-	-	-	-	Douanla-Meli & Langer 2009
G. carnosum	MQN001	Nepal	AB763348					GenBank
G. curtisii	CBS 100132	NC, USA	JQ781849	-	KJ143967	-	KJ143927	Zhou et al. 2015
G. destructans M.P.A. Coetzee, Marinc. & M.J. Wingf.	CMW43670 (ex-type)	South Africa	KR183856	-	-	KR183856	-	Coetzee et al. 2015
G. destructans	CMW43671	South Africa	KR183857	-	-	-	-	Coetzee et al. 2015
G. enigmaticum M.P.A. Coetzee, Marinc. & M.J. Wingf.	CMW43669 (ex-type)	South Africa	KR183855	-	-	-	-	Coetzee et al. 2015
G. enigmaticum	Dai 15970	South Africa	KU572486	-	-	-	-	Xing et al. 2016
G. ecuadoriense A. Salazar, C.W. Barnes & Ordoñez	ASL799 (holotype)	Ecuador	KU128524	-	-	-	-	Crous et al. 2016
G. ecuadoriense	PMC126	Ecuador	KU128525	-	-	-	-	Crous et al. 2016
G. flexipes	GACP17102301	Vietnam	MK345430	MK346830		MK346839		This study
G. flexipes	GACP17073037	Laos	MK345431					This study
G. gibbosum (Cooke) Pat.	SFC20150630-23	Korea	KY364264	-	-	-	-	Jargalmaa et al. 2017
G. gibbosum	GACP 14070501	China	MK345432	-	MK371436	-	-	This study
G. gibbosum	GACP14070653	China	MK345433	-	-	-	-	This study
G. gibbosum	GACP15062144	Thailand	MK345434	-	-	-	-	This study
G. gibbosum	GACP14061422	Laos	MK345436	-	-	-	-	This study
G. leucocontextum T.H. Li, W.Q. Deng, Dong M. Wang & H.P. Hu	Dai15601	China	KU572485	-	-	-	KU572495	Xing et al. 2016
G. leucocontextum	GDGM40200 (holotype)	China	KF011548	-	-	-	-	Li et al. 2015
G. lingzhi Sheng H. Wu, Y. Cao & Y.C. Dai	Wu 1006-38 (holotype)	China	JQ781858	-	-	-	-	
G. lingzhi	Cui6982	China	JQ781862	-	-	-	-	Cao et al. 2012
G. lingzhi	Dai12573	China	JQ781855	-	-	-	-	Cao et al. 2012
G. lingzhi	Li245	China	JQ781863	-	-	-	-	Cao et al. 2012
G. lingzhi	GACP18011910	Laos	MK345437	-	-	MK346840	-	This study
G. lingzhi	GACP18011911	Laos	MK345438	-	-	MK346841	-	This study
G. lobatum (Cooke) G.F. Atk.	JV1212/10J	USA	KF605676	-	-	-	KU572501	GenBank
G. lobatum	JV0409/13J	USA	KF605675	-	-	-	-	GenBank
G. lucidum (Curtis) P. Karst.	K 175217	UK	KJ143911	-	KJ143971	-	KJ143929	Zhou et al. 2015

Table 4 Continued.

Species	Voucher/strain	Origin	ITS	nrLSU	RPB2	nrSSU	TEF	Reference
G. lucidum	MT 26/10 (BRNM)	Czech Republic	KJ143912	-	-	-	KJ143930	Zhou et al. 2015
G. martinicense Welti & Courtec	LIP SW-Mart08-44	France	KF963257	-	-	-	-	GenBank
G. martinicense	LIP SW-Mart08-55	France	KF963256	-	-	-	-	GenBank
G. mebrekobenum E.C. Otto, Blanchette, Held, C.W. Barnes & Obodai	UMN7-3 GHA (holotype)	Ghana	KX000896	-	-	-	-	Crous et al. 2016
G. mebrekobenum	UMN7-4GHA (paratype)	Ghana	KX000898	-	-	-	-	Crous et al. 2016
G. mereditheae Adask. & Gilb.	ATCC 64492	USA	JQ520190	-	-	-	-	Park et al. 2012
G. mereditheae	ASI 7140	Unknown	JQ520191	-	-	-	-	Park et al. 2012
G. mizoramense Zothanz., Blanchette, Held & C.W. Barnes	UMN-MZ4 (holotype)	India	KY643750	-	-	-	-	Crous et al. 2017
G. mizoramense	UMN-MZ5	India	KY643751	-	-	-	-	Crous et al. 2017
G. mutabile	Yuan2289	China	JN383977	-	-	-	-	Cao & Yuan 2013
G. multipileum Ding Hou	CWN 04670 (TNM)	Taiwan, China	KJ143913	-	KJ143972	-	KJ143931	Zhou et al. 2015
G. multipileum	Dai 9447 (IFP)	Hainan, China	KJ143914	-	KJ143973	-	KJ143932	Zhou et al. 2015
G. multiplicatum (Mont.) Pat.	Dai 13122	China	KU572488	-	-	-	KU572498	Xing et al. 2016
G. multiplicatum	Dai 13710	China	KU572489	-	-	-	KU572499	Xing et al. 2016
G. multiplicatum	GACP14091107	Myanmar	MK345439	-	-	-	-	This study
G. multiplicatum	GACP14091108	Myanmar	MK345440	-	-	-	-	This study
G. nasalanense Hapuar., Pheng., & K.D. Hyde.	GACP17060211 (holotype)	Laos	MK345441	MK346831	-	MK346842	-	This study
G. nasalanense	GACP17060212 (paratype)	Laos	MK345442	MK346832	-	MK346843	-	This study
G. neojaponicum Imazeki	ASI 7032	Korea	JQ520193	-	-	-	-	Park et al. 2012
G. neojaponicum	GACP14091006	Myanmar	MK345443	-	-	-	-	This study
G. neojaponicum	GACP17062350	Laos	MK345444	-	-	-	-	This study
G. orbiforme (Fr.) Ryvarden	GACP14081202	Hainan, China	MK345445	-	-	-	-	This study
G. orbiforme	GACP14061420	Laos	MK345447	MK346833	-	MK346844	-	This study
G. orbiforme	GACP14061414	Laos	MK345446	-	-	-	-	This study
G. orbiforme	GACP15061260	Thailand	MK345448	-	-	-	-	This study
G. orbiforme	GACP140910138	Myanmar	MK345449	-	-	-	-	This study
G. oregonense Murrill	CBS 265.88	USA	JQ781875	-	KJ143974	-	KJ143933	Zhou et al. 2015
G. oregonense	CBS 266.88	USA	JQ781876	-	KJ143975	-	-	Zhou et al. 2015
G. oregonense	JLF1614	USA	MH277958					GenBank
G. oregonense	JLF1625	USA	MH277959					GenBank
G. philippi (Bres. & Henn. ex Sacc.) Bres.	E7098	Malaysia	AJ536662		-		-	Glen et al. 2009
G. philippi	E7425	Malaysia	AJ608713	AJ608713	-	AJ608713	-	GenBank
G. pfeifferi Bres.	JV 0511/11	Unknown	KF605660		-	-	-	GenBank

Table 4 Continued.

Species	Voucher/strain	Origin	ITS	nrLSU	RPB2	nrSSU	TEF	Reference
G. pfeifferi	K(M)120818	UK	AY884185	-	-	-	-	GenBank
G. podocarpense J.A. Flores, C.W. Barnes & Ordoñez	QCAM6422 (holotype)	Ecuador	MF796661	MF796660	-	-	-	Crous et al. 2017
G. resinaceum Boud.	BCRC 36147	Netherlands	KJ143916	-	-	-	-	Zhou et al. 2015
G. resinaceum	BR4150	France	KJ143915	-		-	-	Zhou et al. 2015
G. ryvardense Tonjock & Mih 2010	HKAS58053 (holotype)	Cameroon	HM138671	-	-	-	-	Kinge & Mih 2011
G. ryvardense	GanoTK32	Cameroon	JN105698	-	-	-	-	Kinge & Mih 2011
G. sandunense Hapuar., T.C. Wen & K.D. Hyde.	GACP18012501 (holotype)	China	MK345450	-	-	-	-	This study
G. sandunense	GACP18012502	China	MK345451	-	-	-	-	This study
G. sessile Murrill	JV 1209/27	AZ, USA	KF605630	KF605630	KJ143976	-	KJ143937	Zhou et al. 2015
G. sessile	JV1209/9	AZ, USA	KF605629	-	-	-	KJ143936	Zhou et al. 2015
G. sessile	165MO	USA	MG654312					Loyd et al. 2018
G. sessile	298NJ		MG654215					Loyd et al. 2018
G. sichuanense J.D. Zhao & X.Q. Zhang	HMAS42798 (holotype)	China	JQ781877	-	-	-	-	Cao et al. 2012
G. sichuanense	Cui7691	China	JQ781878	-	-	-	-	Cao et al. 2012
G. sinense J.D. Zhao, L.W. Hsu & X.Q. Zhang	GACP17092559	China	MK345452	MK346834	MK371435	MK346845	-	This study
G. sinense	GACP17092539	China	MK345453	MK346835	-	-	-	This study
G. sinense	GACP17092587	China	MK345454					This study
G. sinense	Wei5327	China	KF494998	KF495008	-	-	KF494976	GenBank
G. steyaertanum B.J. Sm. & Sivasith.	MEL:2382783	Australia: NT	KP012964	-	-	-	-	GenBank
G. steyaertanum	6-WN-20(BL)-B	Indonesia	KJ654462	-	-	-	-	Glen et al. 2014
G. stipitatum (Murrill) Murrill	THC 16	Unknown	KC884264	-	-	-	-	GenBank
G. subresinosum (Murrill) C.J. Humphrey	5-D-3-D-26	Indonesia	KJ654467	-	-	-	-	Glen et al. 2014
G. subresinosum	GACP18011907	Laos	MK345455	-	-	-	-	This study
G. tropicum (Jungh.) Bres.	Dai9724	China	JQ781879	-	-	-	-	Cao et al. 2012
G. tropicum	Yuan3490	China	JQ781880	-	-	-	-	Cao et al. 2012
G. tropicum	GACP14081518	China	MH106884	-	-	-	-	Hapuarachchi et al. 2018b
G. tropicum	GACP 5081610	Thailand	MK345456	-	-	-	-	This study
G. tsugae Murrill	Dai 12751b (BJFC)	CT, USA	KJ143919	-	KJ143977	-	KJ143939	Zhou et al. 2015
G. tsugae	Dai12760	CT, USA	KJ143920	-	-	-	KJ143940	Zhou et al. 2015
G. weberianum (Bres. & Henn. ex Sacc.) Steyaert	CBS 219.36	Philippines	JQ520219	-	-	-	-	Park et al. 2012
G. weberianum	GanoTK17	Cameroon	JN105705	-	-	JN105726	-	GenBank
G. williamsianum Murrill	Wei 5032	China	KU219994	KU220024		-	-	Song et al. 2016
G. williamsianum	Yuan 5417	China	KU219995	KU220025	-	-	-	Song et al. 2016
G. williamsianum	GACP14081320	China	MK345457	-	-	-	-	This study

Table 4 Continued.

Species	Voucher/strain	Origin	ITS	nrLSU	RPB2	nrSSU	TEF	Reference
G. williamsianum	GACP14081321	China	MK345458	-	-	-	-	This study
G. wiiroense E.C. Otto, Blanchette, C.W. Barnes & Held	UMN-20-GHA (para type)	Ghana	KT952361	-	-	-	-	Crous et al. 2015
G. wiiroense	UMN-21-GHA (holotype)	Ghana	KT952363	-	-	-	-	Crous et al. 2015
G. zonatum Murrill	FL-02 (TNM)	FL, USA	KJ143921	-	KJ143979	-	KJ143941	Zhou et al. 2015
G. zonatum	FL-03	FL, USA	KJ143922	-	KJ143980	-	-	Zhou et al. 2015
Coriolopsis trogii (Berk.) Domański	RLG4286sp	USA	JN164993	-	JN164867	-	JN164898	Jargalmaa et al. 2017

Annotated list of species of Ganodermataceae in Mekong Subregion Countries

1. *Ganoderma adspersum* (Schulzer) Donk Proc. K. Ned. Akad. Wet., Ser. C, Biol. Med. Sci. 72(3): 273 (1969) Fig. 3

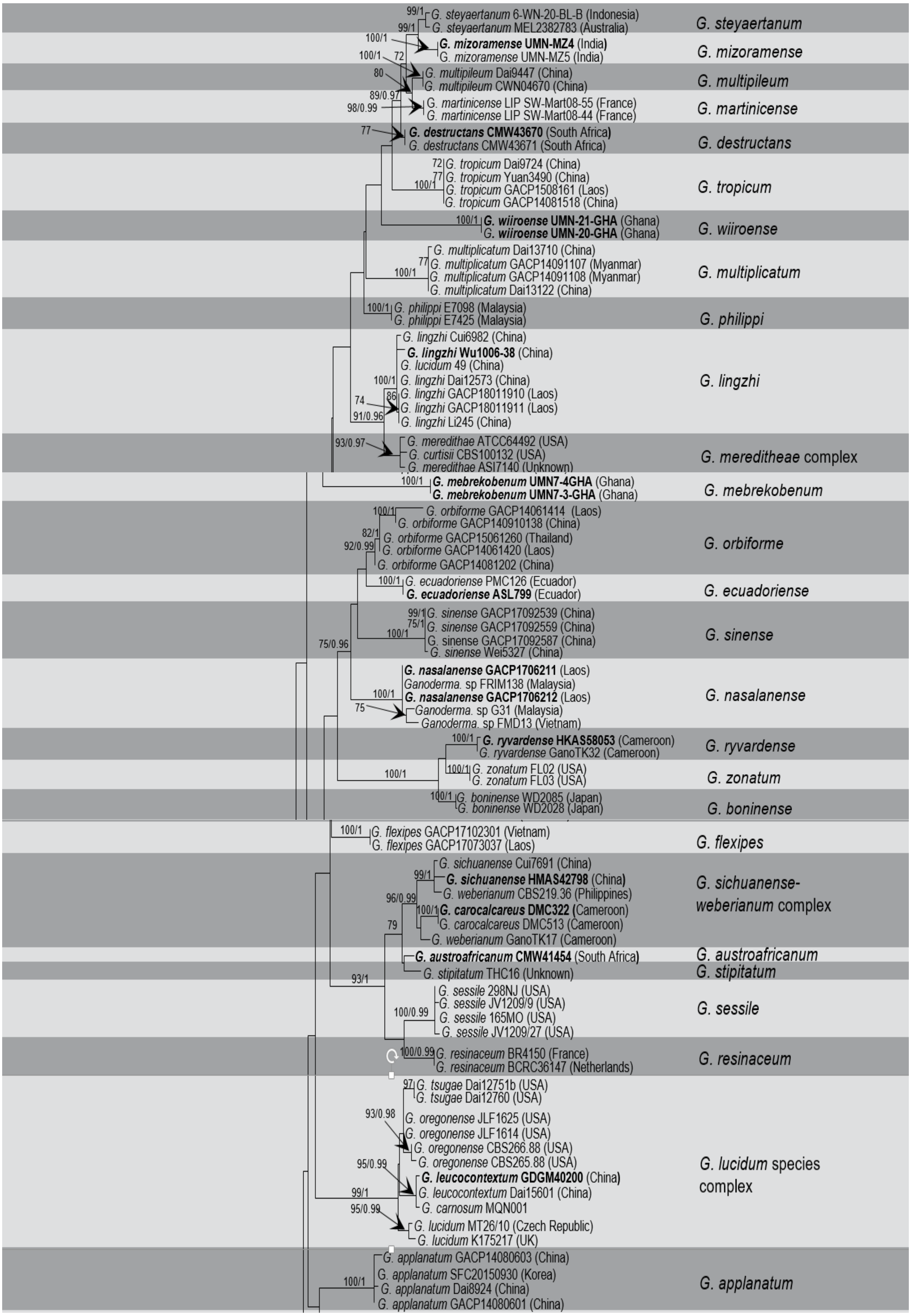
≡ *Polyporus adspersus* Schulzer (1878)

Facesoffungi number: FoF05600

Basidiome annual, with a distinctly contracted base, non-laccate weakly laccate, woody. *Pileus* 10–15 × 4–7 cm, up to 4 cm thick at the base, flabelliform, plano convex, applanate, upper surface; hard, several layers thick, brownish orange (6C8) to light brown (6D4), crust overlies the pellis, concentrically sulcate zones with turberculate bumps and rivulose depressions, differentiated zone at the point of attachment; margin soft, 5 mm thick, rounded, concolourous with the pileus, lower surface greyish yellow (4B3) to light brown (6D5). *Hymenophore* up to 10 mm long, indistinctly stratose, orange grey (6B2), pores circular or sub-circular. *Context* up to 2.5 cm thick, dry, triplex; upper layer dark brown (7F8), pithy, composed of coarse loose fibrils, soft; lower layer light brown (5D4), woody. *Basidiospores* (n = 25) (7.2)8.5–*9.6*–10.5(10.9) × (4.8)5.4–*6.1*–7.3(7.8) µm, (Q_m = 1.1, Q = 0.9–1.8, with myxosporium). (n = 25) (5.9)6.4–*8.2*–9.1(9.7) × (3.2)4.1–*5.2*–5.8(6.1) µm (Q_m = 1.1, Q = 1.0–1.8, without myxosporium), yellowish brown (5D8), ovoid to subglobose, eusporium bearing fine, short, and distinct echinulae, overlaid by a hyaline myxosporium. *Pileipellis* a hymeniderm, dark brown (7F8), composed of apically clavate like branched cells. *Context* trimitic; generative hyphae (n = 25) (0.8–*2.0*–2.5) µm in width, thin-walled, hyaline; skeletal hyphae (n = 25) (1.8–*3.4*–4.2) µm in width, light brown (5D6), thick-walled; binding hyphae (n = 25) (1.4–*3.1*–3.9) µm in width, light brown (5D6), thick-walled, branched, intertwined the skeletal hyphae.

Habitat – On a living Dipterocarpus tree, accompanied in humus rich soil with over heavily rotted litter on the ground.

Specimens examined – THAILAND, Chiang Mai Province, Mushroom Research Center, mixed deciduous forest, 19°20′N–98°44′E, elev. 770 m, 12 June 2015, K.K Hapuarachchi (GACP15061220, GACP15061225, GACP15061226).


G. steyaertanum 6-WN-20-BL-B (Indonesia)
G. steyaertanum MEL2382783 (Australia)
G. steyaertanum
G. mizoramense UMN-MZ4 (India)
G. mizoramense UMN-MZ5 (India)
G. mizoramense
G. multipileum Dai9447 (China)
G. multipileum CWN04670 (China)
G. multipileum
G. martinicense LIP SW-Mart08-55 (France)
G. martinicense LIP SW-Mart08-44 (France)
G. martinicense
G. destructans CMW43670 (South Africa)
G. destructans CMW43671 (South Africa)
G. destructans
G. tropicum Dai9724 (China)
G. tropicum Yuan3490 (China)
G. tropicum GACP1508161 (Laos)
G. tropicum GACP14081518 (China)
G. tropicum
G. wiiroense UMN-21-GHA (Ghana)
G. wiiroense UMN-20-GHA (Ghana)
G. wiiroense
G. multiplicatum Dai13710 (China)
G. multiplicatum GACP14091107 (Myanmar)
G. multiplicatum GACP14091108 (Myanmar)
G. multiplicatum Dai13122 (China)
G. multiplicatum
G. philippi E7098 (Malaysia)
G. philippi E7425 (Malaysia)
G. philippi
G. lingzhi Cui6982 (China)
G. lingzhi Wu1006-38 (China)
G. lucidum 49 (China)
G. lingzhi Dai12573 (China)
G. lingzhi GACP18011910 (Laos)
G. lingzhi GACP18011911 (Laos)
G. lingzhi Li245 (China)
G. lingzhi
G. meredithae ATCC64492 (USA)
G. curtisii CBS100132 (USA)
G. meredithae ASI7140 (Unknown)
G. meredithae complex
G. mebrekobenum UMN7-4GHA (Ghana)
G. mebrekobenum UMN7-3-GHA (Ghana)
G. mebrekobenum
G. orbiforme GACP14061414 (Laos)
G. orbiforme GACP140910138 (China)
G. orbiforme GACP15061260 (Thailand)
G. orbiforme GACP14061420 (Laos)
G. orbiforme GACP14081202 (China)
G. orbiforme
G. ecuadoriense PMC126 (Ecuador)
G. ecuadoriense ASL799 (Ecuador)
G. ecuadoriense
G. sinense GACP17092539 (China)
G. sinense GACP17092559 (China)
G. sinense GACP17092587 (China)
G. sinense Wei5327 (China)
G. sinense
G. nasalanense GACP1706211 (Laos)
Ganoderma. sp FRIM138 (Malaysia)
G. nasalanense GACP1706212 (Laos)
Ganoderma. sp G31 (Malaysia)
Ganoderma. sp FMD13 (Vietnam)
G. nasalanense
G. ryvardense HKAS58053 (Cameroon)
G. ryvardense GanoTK32 (Cameroon)
G. ryvardense
G. zonatum FL02 (USA)
G. zonatum FL03 (USA)
G. zonatum
G. boninense WD2085 (Japan)
G. boninense WD2028 (Japan)
G. boninense
G. flexipes GACP17102301 (Vietnam)
G. flexipes GACP17073037 (Laos)
G. flexipes
G. sichuanense Cui7691 (China)
G. sichuanense HMAS42798 (China)
G. weberianum CBS219.36 (Philippines)
G. carocalcareus DMC322 (Cameroon)
G. carocalcareus DMC513 (Cameroon)
G. weberianum GanoTK17 (Cameroon)
G. sichuanense-weberianum complex
G. austroafricanum CMW41454 (South Africa)
G. austroafricanum
G. stipitatum THC16 (Unknown)
G. stipitatum
G. sessile 298NJ (USA)
G. sessile JV1209/9 (USA)
G. sessile 165MO (USA)
G. sessile JV1209/27 (USA)
G. sessile
G. resinaceum BR4150 (France)
G. resinaceum BCRC36147 (Netherlands)
G. resinaceum
G. tsugae Dai12751b (USA)
G. tsugae Dai12760 (USA)
G. oregonense JLF1625 (USA)
G. oregonense JLF1614 (USA)
G. oregonense CBS266.88 (USA)
G. oregonense CBS265.88 (USA)
G. leucocontextum GDGM40200 (China)
G. leucocontextum Dai15601 (China)
G. carnosum MQN001
G. lucidum MT26/10 (Czech Republic)
G. lucidum K175217 (UK)
G. lucidum species complex
G. applanatum GACP14080603 (China)
G. applanatum SFC20150930 (Korea)
G. applanatum Dai8924 (China)
G. applanatum GACP14080601 (China)
G. applanatum

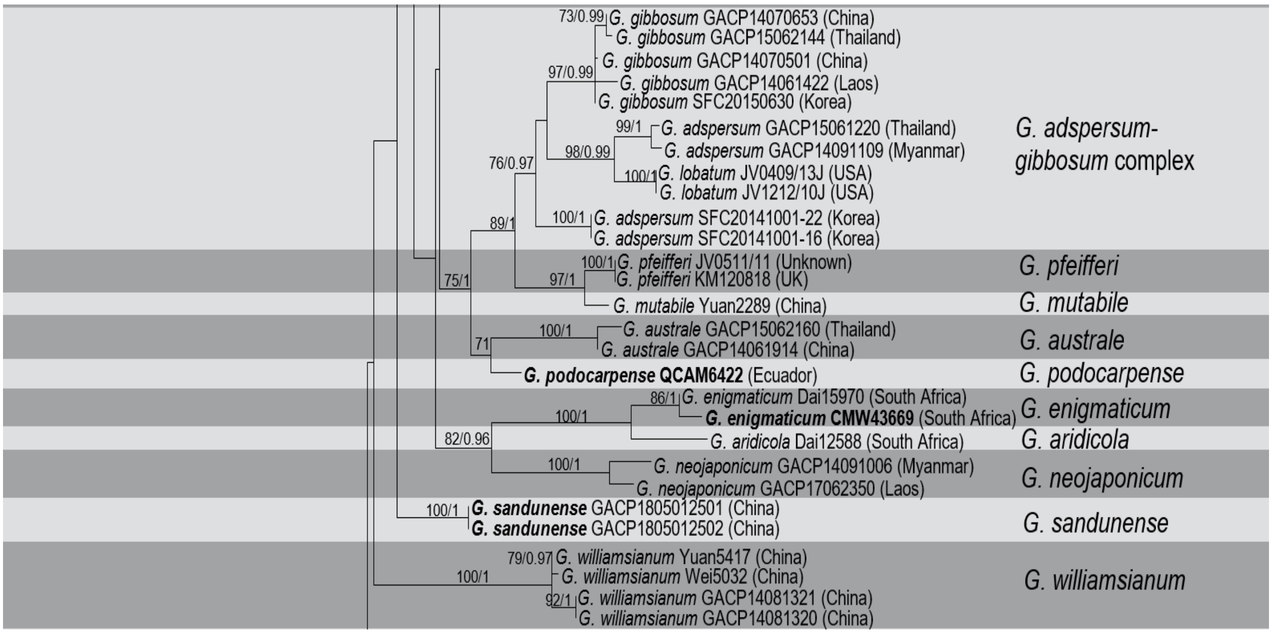


Figure 2 – Phylogram for Ganodermataceae species generated from maximum likelihood analysis of ITS, nrLSU, nrSSU, TEF and RPB2 sequence data. Bootstrap support values for maximum likelihood, greater than 70% and Posterior Probabilities from Bayesian Inference ≥ 0.95 are given above branches. The tree is rooted with *Coriolopsis trogii*. The strain numbers and the countries of origin are mentioned after the species. Type species are indicated in black bold.

Notes – *Ganoderma adspersum* is confused with *G. applanatum*, *G. australe* and *Polyporus vegetus* (Tortić 1971). Steyaert (1961) clearly separated this fungus from *G. applanatum* and he described this species under the name of *G. europaeum.* Donk (1969) concluded that the correct name of this fungus was *G. adspersum* after studying full description and drawings of *Polyporus adspersus* Schulzer, and Tortić (1971) subsequently followed this name. It is difficult to distinguish *G. adspersum* and *G. applanatum* on the basis of morphological characters of basidiome or mycelial cultures (Petersen 1987, Leonard 1998, Moncalvo et al. 2000, Terho et al. 2007, Kaliyaperumal & Pudupalayam 2008, De simone & Annesi 2012). However, *Ganoderma adspersum* is distinguished from *G. applanatum* by having larger basidiospores (Steyaert 1972, Ryvarden & Gilbertson 1993). Furthermore, basidiome of *G. adspersum* are usually thicker than *G. applanatum* at the base. The underside of the basidiome of *G. adspersum* has a decurrent attachment, while *G. applanatum* tend to emerge sharply at right angles from the host stem (Ryvarden & Gilbertson 1993, Schwarze & Ferner 2003). In a radial section of the hymenophore of the older parts of the basidiome, those of *G. adspersum* remain empty but the pores of *G. applanatum* become filled with a white mycelium (Breitenbach & Kränzlin 1986). Our collections agree well with the description provided by (Ryvarden & Gilbertson 1993). Later on, molecular methods have been developed successfully to separate the two latter species (Gottlieb et al. 2000, Moncalvo et al. 2000, Guglielmo et al. 2008, De Simone & Annesi 2012, Arulpandi & Kalaichelvan 2013, Zhou et al. 2015, Jargalmaa et al. 2017).

Some researchers considered the correct name of the *G. adspersum* as a synonym of *G. australe* (Ryvarden 1976, Ryvarden & Gilbertson 1993). Furthermore, morphology, distribution and initial ribosomal sequence analysis could not separate *G. adspersum* from *G. australe* (Moncalvo et al. 1995a). But comparison of ITS rDNA data clearly separated the *G. adspersum* from *G. australe* and was inferred as single species (Smith & Sivasithamparam 2000).

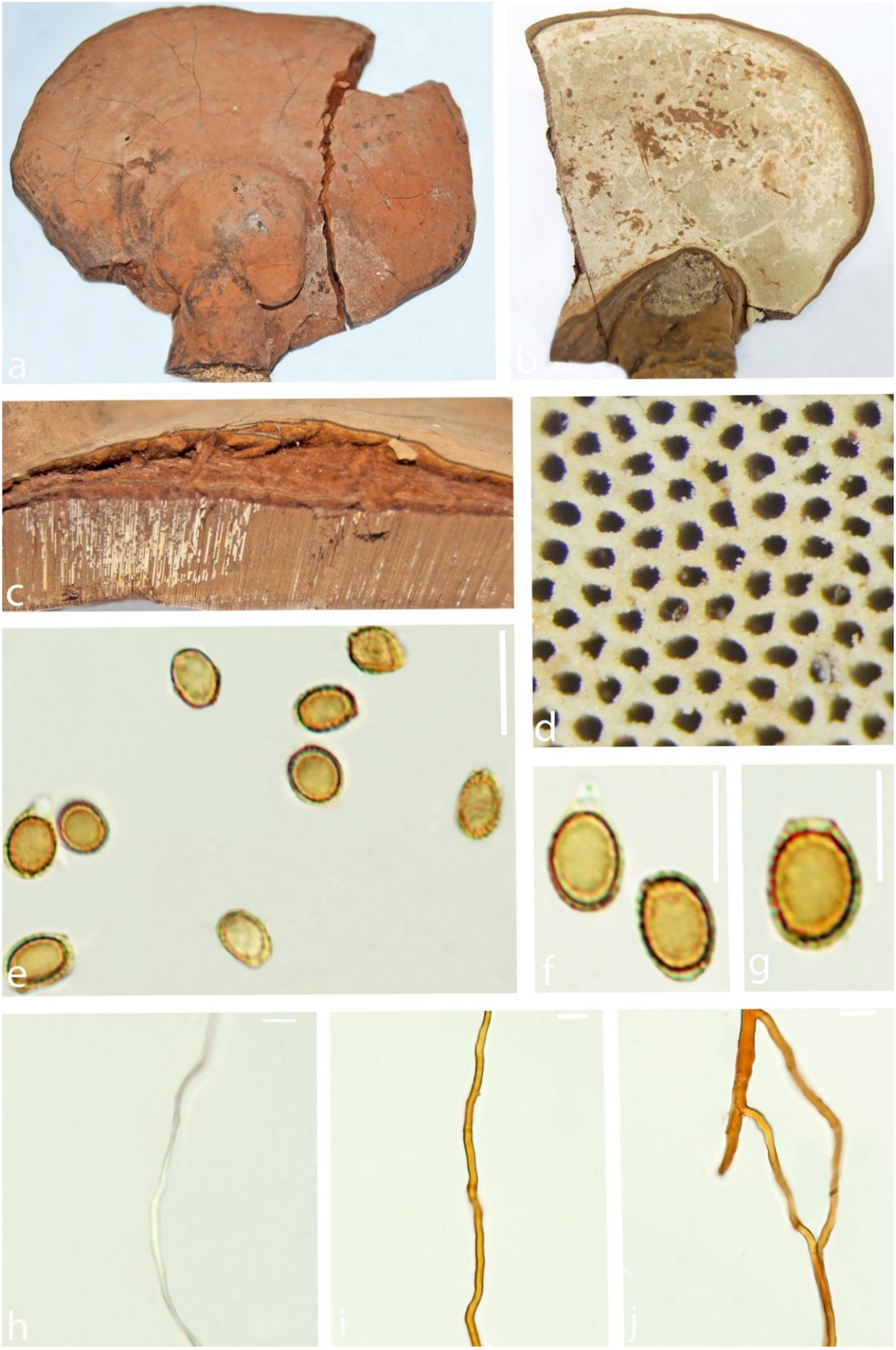


Figure 3 – *Ganoderma adspersum* (GACP15061220). a Upper surface. b Lower surface. c Section of pileus. d Pores in the lower surface (5×). e–g Spores (100×). h Generative hyphae (100×). **i** Skeletal hyphae (100×). **j** Binding hyphae (100×). Scale bars: e–g = 10 µm, g–i = 5 µm.

Ganoderma adspersum has been recorded almost exclusively on hardwoods causing butt rot or root rot (De Simone & Annesi 2012) (Table 3). *Ganoderma adspersum* and *G. applanatum* differ in their ability to break through the reaction zones formed in infected trees. *Ganoderma adspersum* can penetrate intact reaction zones of infected wood blocks, while *G. applanatum* cannot. In the absence of reaction zones, however, *G. applanatum* causes more extensive and intense decay (Schwarze & Ferner 2003). Hence, the correct identification of the causal agent is important for a reliable assessment of the potential risks caused by infected trees.

2. *Ganoderma applanatum* (Pers.) Pat., Hymenomyc. Eur. (Paris): 143 (1887) Fig. 4

≡ *Boletus applanatus* Pers. (1800)

Facesoffungi number: FoF05648

Basidiome annual, sessile (usually with a distinctly contracted base), non-laccate, woody. *Pileus* 7–15 × 4–7 cm, sub-dimidiate, subapplanate; upper surface hard, several layers thick, brown (6E4) to greyish brown (6E3), concentrically sulcate zones with turberculate bumps and ridges and rivulose depressions, radially rugose, with irregularly ruptured crust overlying the pellis; margin soft, 2–3 mm thick, rounded, concolourous with the rest of the pileus; lower surface greyish yellow (4B3) to light brown (6D5). *Hymenophore* up to 15 mm long, indistinctly stratose; pores initially whitish, light brown (6E4), 4–5 per mm; tubes circular or sub-circular. *Context* up to 3 cm thick, dry; lower layer greyish orange (6B3), fibrous/pithy, composed of coarse loose fibrils; upper layer greyish orange (6B3), woody. *Basidiospores* (n = 50) (5.9–)6.3–*7.4*–8.1(–8.8) × (2.2–)4.2–*5.8*–6.3(–6.7) µm (Q_m = 1.8, Q = 1.1–3.4, with myxosporium). (3.1–)4.0–*5.7*–6.4(–7.0) × (1.8–)2.5–*2.8*–3.5(–4.4) µm (Q_m = 2.1, Q = 1.4–2.9, without myxosporium), ellipsoid, sometimes truncate at one end, greyish orange (5B5) to light orange (5A5), eusporium bearing fine, short and distinct echinulae, overlaid by a hyaline myxosporium. *Pileipellis* a hymeniderm, brown (6E4) to greyish brown (6E3), composed of apically acanthus like branched cells. *Context* trimitic; generative hyphae (n = 30) (1.7–)2.5–*2.6*–3.5(–3.6) µm in width, thin-walled, colorless, with clamp connections; skeletal hyphae (n = 30) (3.3–)3.7–*4.3*–5.9(–6.4) µm in width, brown (6E4) to greyish brown (6E3), dextrinoid, thick-walled; binding hyphae (n = 30) (2.9–)3.5–*3.7*–4.4(–5.4) µm in width, brown (6E4) to greyish brown (6E3), thick-walled, frequently branched at apex, septate, intertwined with the skeletal hyphae.

Habitat – On a decaying wood log, accompanied in humus rich soil with over heavily rotted litter on the ground, producing basidiomata from summer to late autumn.

Specimens examined – CHINA, Sichuan Province, Xichang, 01 June 2014, T.C Wen (GACP14080601, GACP14080603, GACP14080604). MYANMAR, 11 September 2014, T.C Wen (GACP14091185, GACP14091188).

Notes – *Ganoderma applanatum* belongs to subgenus *Elfvingia* (non-laccate species) and it has a worldwide distribution and is a central species in *G. applanatum* – *G. australe* complex Richter et al. (2015). This species is characterized by having; a thin, acute margin in pileus, unbranched terminal endings of skeletal hyphae, and (5.5–9.0) µm size ellipsoid basidiospores (Pegler & Young 1973, Ryvarden & Gilbertson 1993, Leonard 1998, Wu & Dai 2005). Our collections agree with the description provided by Ryvarden & Gilbertson (1993). Furthermore, this species could be distinguished chemotaxonomically by the presence of benzopyranone derivatives such a Ganodermaaldehyde and Applanatins which have been isolated from specimens originating from both, North America and Asia (Ming et al. 2002, Wang et al. 2007).

This fungus is mainly a wound parasite that enters particularly through wounds in stems or roots and causes root rot and but rot in many broad leaved plants (Cartwright & Findlay 1958). In America, *G. applanatum* is commonly recorded on deciduous trees, but is also found on a wide range of coniferous tree species (Table 3). *Ganoderma lipsiense* (= *G. applanatum*) causes white butt rot on angiosperm trees, commonly *Betula*, *Populus* and *Tilia* in both natural forests and forest plantations in China (Dai 1996).

Figure 4 – *Ganoderma applanatum* (GACP14080601). a Upper surface. b Lower surface. c Section of pileus. d Pores in the lower surface (5×). e–h Spores (100×). i Generative hyphae (40×). j Binding hyphae (100×). k Skeletal hyphae (100×). Scale bars: e–h = 10 µm, i–k = 5 µm.

3. *Ganoderma aridicola* J.H. Xing & B.K. Cui. in Xing, Song, Decock & Cui, Phytotaxa 266(2): 119 (2016)

See the description and illustration at Xing et al. 2016)

Notes – *Ganoderma aridicola*, a species belong to *G. lucidum* species complex, was introduced by Xing et al. (2016) from South Africa with the aid of molecular data. This species is a white rot fungus found in *Ficus* species (Xing et al. 2016) (Table 3). *Ganoderma aridicola* is characterized by its fuscous to black pileal surface with distinct concentric zones and small pores, furthermore, it was found in an environment with contrasted dry and humid seasons (Xing et al. 2016).

4. *Ganoderma angustisporum* J.H. Xing, B.K. Cui & Y.C. Dai. in Xing, Sun, Han, Cui & Dai, MycoKeys 34: 93–108 (2018)

See the description and illustration at Xing et al. (2018)

Notes – *Ganoderma angustisporum* was introduced from China recently, based on molecular and morphological data (Xing et al. 2016). This species causes white rot in *Casuarina equisetifolia* plants (Xing et al. 2016). *Ganoderma angustisporum* is characterized by its sessile basidiomata, white pore surface, almond-shaped, slightly truncate and narrow basidiospores (Xing et al. 2016).

5. ***Ganoderma australe*** (Fr.: Fr.) Pat., 1889, Bull. Soc. mycol. Fr. 5, p. 71. Fig. 5

≡ *Polyporus australis* Fr.: Fr., 1828, Elench. Fung. 1, p. 108

Facesoffungi number: FoF05649

Basidiome annual, sessile, non-laccate, woody. *Pileus* 6–13 × 5.5–6 cm, sub orbicular, plano-convex, applante, at center slightly swollen: upper surface brownish orange (6C4) to brown (6D4), distinctly concentrically sulcate, with irregularly ruptured crust overlying the pellis; margin soft, slightly lobate and concolorous with the pileus; lower surface yellowish white (4A2). *Hymenophore* up to 9 mm long, indistinctly stratose; pores initially yellowish white (4A2), later brown (6D6), 4–5 per mm; pores circular or sub circular. *Context* up to 1.5 cm thick, dry, duplex; lower layer, brown (6D6), fibrous/pithy, composed of coarse loose fibrils; upper layer dark brown (7F8), woody. *Basidiospores* (n = 40) (6.1–)7.6–*9.2*–10.8(–11.5) × (4.7–)5.3–*7.6*–7.9(–8.5) µm (Q_m = 1.5, Q = 0.9–2.6, with myxosporium). (4.9–)5.3–*6.6*–7.9(–8.5) × (3.1–)3.4–*4.2*–5.1(–5.8) µm (Q_m = 1.5, Q = 0.9–2.9, without myxosporium), ellipsoid, brownish orange (6C8) to brown (6D8), with a brown eusporium bearing fine, short, and distinct echinulae, overlaid by a hyaline myxosporium. *Pileipellis* a hymeniderm, (6–28) µm, brownish orange (6C8) to brown (6D8), composed of apically acanthus like branched cells, dextrinoid. *Context* trimitic; generative hyphae not observed; skeletal hyphae (n = 30) (4.5–3.1–*3.9*–4.1(–4.8) µm in width, thick-walled, sometimes branched, brownish orange (6C8); binding hyphae (n = 30) (3.5–)4.2–*5.6*–5.8(–6.1) µm in width, thick-walled, branched, brownish orange (6C8).

Habitat – On a decaying wood log, accompanied in humus rich soil with over heavily rotted litter on the ground.

Specimens examined – CHINA, Jiangxi Province, 19 June 2014, T.C Wen (GACP14061912, GACP14061914, GACP14061915). THAILAND, Chiang Mai Province, Mushroom Research Center, Coniferous rainforest, 19°20′N–98°44′E, elev. 770 m, 12 June 2015, K.K Hapuarachchi (GACP15061230, GACP15061231). MYANMAR, 11 September 2014, T.C Wen (GACP14091187, GACP14091195).

Notes – *Ganoderma australe* was initially described from Pacific Islands but the type specimen was lost or destroyed and currently only the neotype available is from Europe (Ryvarden & Gilbertson 1993). This species has worldwide distribution (Martinez et al. 1991). *Ganoderma applanatum* and *G. australe* from Europe have been confused longtime with each other (Leonard 1998). *Ganoderma australe* belongs to *G. applanatum – australe* complex and can be clearly distinguished from *G. applanatum* by having larger basidiospores (Martinez et al. 1991, Moncalvo & Ryvarden 1997). Furthermore, basidiospore dimensions, thickness of the cuticle and color of the context layer were considered to be reliable discriminating characters in delimiting *G. applanatum* and *G. australe* (Ryvarden & Gilbertson 1993, Leonard 1998). Our collections agree with the description provided by Ryvarden & Gilbertson (1993). *Ganoderma australe* is common in the tropics and in Europe it was mistakenly identified as the domestic *G. adspersum* (Smith & Sivasithamparam 2000). Both *G. applanatum* and *G. australe* species occur on a variety of broadleaved deciduous trees and cause a mottled white root and butt rot of living and dead hardwoods (Overall 2016) (Table 3).

Ganoderma applanatum is primarily a saprotroph, rarely parasitic and then growing at the base of trees, while *G. australe* can be found on both dead and living trees, being both parasitic and saprophytic (Ryvarden & Melo 2014). *Ganoderma australe* has the ability to penetrate sound sapwood, whereas *G. applanatum* is mainly confined to already damaged wood (Watson & Green 2011). *Ganoderma australe* can breach the reaction zone of a tree and colonize new sapwood, while *G. applanatum* is unable to do so unless the reaction zone had already been breached via prior drilling (Schwarze & Ferner 2003). *Ganoderma australe* causes white root and butt rot in Southern China (Dai et al. 2007), leaf yellowing and shoot dieback in Tower trees (*Schizolobium parahybum*) which a common ornamental plant in Malaysia (Goh et al. 2014) and root rot in Assam tea (*Camellia sinensis* var. assamica) in Northern Thailand (Tompong & Kunasakdakul 2014).

6. *Ganoderma carocalcareus* Douanla-Meli [as 'carocalcareus'], in Douanla-Meli & Langer, Mycol. Progr. 8(2): 149 (2009)

See the description and illustration at Douanla-Meli & Langer (2009)

Notes – *Ganoderma carocalcareus* was introduced by Douanla-Meli & Langer (2009) from Cameroon as a white rot fungus in *G. resinaceum* group. This species is characterized by chalky context, thick-walled chlamydospores and dimorphic basidiomata. *Ganoderma carocalcareus* is parasitic and saprobic to *Anthocleista nobilis* in Cameroon (Table 3).

7. *Ganoderma colossus* (Fr.) C.F. Baker, Brotéria, Sér. Bot. 16: 425 (1918)

≡ *Polyporus colossus* Fr., Nova Acta R. Soc. Scient. upsal., Ser. 3 1(1): 56 (1851)

See the description and illustration at Ryverden (2000)

Notes – *Ganoderma colossum* is a very distinctive species in *Ganoderma* with the yellow, laccate pilear surface, pale context with slightly dextrinoid skeletal hyphae, large basidiospores, and the striking chlamydospores (Ryverden 2000). *Ganoderma colossus* (Fr.) C.F. Baker has been delimited under Ganodermataceae since its double-walled colored ornamented basidiospores and arboriform skeletal hyphae. This species was introduced as *Polyporus colossus* by Fries (1851) from Costa Rica on *Ficus canariensis*. (Murrill 1905c) introduced *Tomophagus* to accommodate *P. colossus* based on its unusually thick and pale context that becomes soft and light when dry. Baker (1918) transferred this species to *Ganoderma*. Later on, *Tomophagus* was not accepted and *T. colossus* was placed as a synonym of *G. colossus* by many authors (Furtado 1965, Steyaert 1972, 1980, Corner 1983, Ryvarden 1991, 2000). However, based upon morphology (Murrill 1905c) together with molecular evidence and studies on the ornamentation of basidiospores placed this species under combination: *Tomophagus colossus* (Moncalvo et al. 1995c, Moncalvo et al. 2000, Wu & Zhang 2003, Hong & Jung 2004, Le et al. 2012) and further, established the validity of this monotypic genus. It is a pantropical species and distribution is Known from Africa (Parihar et al. 2013), Central and South America (Steyaert 1972), Florida in USA (Gilbertson & Ryvarden 1986), Iran (Moradali et al. 2007), India (Parihar et al. 2013), Oman (El-Nagerabi & Elshafie 2014) and Yemen (Kreisel & Al-Fatimi 2008). *Ganoderma colossum* is a common cause of plant diseases and associated with wood decay and losses in numerous economically important trees (El-Nagerabi & Elshafie 2014) (Table 3). This species has been isolated from *Pinus hondurensis* and *Callitris robusta* in Natal, South Africa on which it causes an extensive collar rot. It also attacks eucalypts (Van Der Westhuizen 1958).

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

See the description and illustration at Xing et al. (2016)

Figure 5 – *Ganoderma australe* (GACP14061912). a Upper surface. b Lower surface. c Section of pileus. d Pores in the lower surface (5×). e–g Spores (100×). h Generative hyphae. i Binding hyphae (100×). j Skeletal hyphae (100×). Scale bars: e–g = 10 µm, h–j = 5 µm.

Notes – *Ganoderma casuarinicola* was introduced from China recently, based on molecular and morphological data (Xing et al. 2016). This species causes white rot in *Casuarina equisetifolia* plants (Xing et al. 2016). *Ganoderma casuarinicola* is characterized by its strongly laccate reddish-brown pileal surface, white pore surface, and luminous yellow to yellowish-brown cutis (Xing et al. 2016).

9. ***Ganoderma donkii*** Steyaert, Persoonia 7(1): 75 (1972) Fig. 6

Facesoffungi number: FoF05650

Basidiome annual to perennial, corky, with distinctly contracted base to host, becoming hard corky to woody hard when dry. *Pileus* 3–5.5 cm, up to 1 cm thick at the base, suborbicular, plano convex, applanate; upper surface hard, light brown (6D6) to dark brown (6F6), non laccate, distinctly concentrically sulcate zones, crust overlies the pellis, differentiated zone at the point of attachment; margin 3mm thick, concolorous with the pileus, rounded, inflexed; lower surface yellowish white (4A2) to light brown (6D6). *Hymenophore* up to 8 mm long, indistinctly stratose, orange grey (6B2), pores circular. *Context* duplex, not completely homogeneous in color; upper layer dark brown (7F8), pithy, composed of coarse loose fibrils, soft; lower layer light brown (5D4), woody. *Basidiospores* (n = 25) (6.6)6.7–*7.7*–8.7(11.3) × (4.2)4.6–*5.4*–6.2(7.8) µm (Q_m = 1.4, Q = 1.1–1.7, with myxosporium). (n = 25) (4.7)4.9–*5.8*–6.7(7.8) × (2.5)3.2–*3.9*–4.7(6.2) µm (Q_{m} = 1.4, Q = 1.0–1.8.without myxosporium), ellipsoid, with a yellowish brown (5D8) to brown (6D6) eusporium bearing fine and short echinulae, overlaid by a hyaline myxosporium. *Pileipellis* a hymeniderm, dark brown (6F8), composed of apically acanthus like branched cells. *Context* trimitic; generative hyphae (n = 20) (0.5–*1.1*–2.0) µm in width, colorless, thin-walled; skeletal hyphae (n = 25) (0.9–*1.4*–1.9) µm in width, light brown (6D6), thick walled, sometimes branched; binding hyphae (n = 25) (0.6–*1.0*–1.6) µm in width, light brown (6D6), branched, with clamp-connections, intertwined the skeletal hyphae.

Habitat – On a living Dipterocarpus tree, accompanied in humus rich soil with over heavily rotted litter on the ground.

Specimens examined – THAILAND, Chiang Mai Province, Mushroom research Center, 19°20′N–98°44′E, elev. 770 m, 21 December 2015, K.K Hapuarachchi (GACP15122107, GACP15122108, GACP151221010, GACP151221012).

Notes – *Ganoderma donkii* was introduced by Steyaert (1972) from Indonesia and characterized by radially corrugated pileus, hard context and small, ovoid (truncate when mature) basidiospores (7.5–9 × 5.5–7) µm. This species belongs to *G. applanatum – australe* complex and can be clearly distinguished from *G. applanatum* and *G. australe* by having smaller basidiospores (Steyaert 1972, Martinez et al. 1991, Moncalvo & Ryvarden 1997). *Ganoderma donkii* is distributed in China (Wu & Dai 2005), West Java (Indonesia) (Steyaert (1972) and Thailand (Chandrasrikul et al. 2011). Our collections agree well with the description provided by (Wu & Dai 2005).

10. ***Ganoderma destructans*** M.P.A. Coetzee, Marinc. & M.J. Wingf., in Coetzee, Marincowitz, Muthelo & Wingfield, Mycosphere 6(1): 253 (2015)

See the description and illustration at Coetzee et al. (2015)

Notes – *Ganoderma destructans* was introduced by Coetzee et al. (2015) from South Africa with the aid of morphological and molecular data. This species is characterized by the pileus which contains creamy soft non-poroid tissue showing obvious continuity to hymenophore, ovoid basidiospores (11–14 × 7–9) µm and unique nucleotide polymorphisms at ITS and nrLSU (Coetzee et al. 2015). *Ganoderma destructans* is the most important pathogen resulting in the death of *Jacaranda mimosifolia* trees by root rot in Pretoria, South Africa (Coetzee et al. 2015).

11. ***Ganoderma flexipes*** Pat., Bull. Soc. mycol. Fr. 23(2): 75 (1907) Fig. 7

≡ *Polyporus flexipe*s (Pat.) Lloyd, Mycol. Writ. 3 (Syn. Stip. Polyporoids): 104 (1912)

Facesoffungi number: FoF05651

Basidiome annual, stipitate, laccate, corky, becoming hard corky to woody hard when dry. *Pileus* 2.5–3.5 × 1.0–2.0 cm, up to 0.5 cm thick at the base, flabelliform, rotund, upper surface; reddish brown (8E8), concentrically sulcate zones with turberculate bumps and ridges and rivulose depressions, with irregularly ruptured crust overlying the pellis, margin; soft, yellowish brown (5E8), lower surface; light brown (7D5). *Hymenophore* up to 10 mm long, indistinctly stratose; pores initially greyish brown (7D3), bruising brown (8E8), pores circular or sub-circular or isodiametric, 3–4 per mm. *Context* up to 8 mm thick, triplex, dry; lower layer reddish brown (8E8), fibrous, composed of coarse loose fibrils; upper layer dark brown (8F8), corky to woody. *Stipe* eccentric, dorsally lateral to nearly dorsal, sub-cylindrical, dark brown (8F8), 4.0 × 7.0 cm, 0.4 cm thick at the base. *Basidiospores* (n = 25) (8.3–)9.1–*9.8*–10.5(11.1–) × (–6.5)7.3–*6.1*–9.2(–10.5) µm (Q_m = 1.4, Q = 0.9–2.1 with myxosporium). (6.5–)7.3–*8.3*–9.2(–10.5) × (4.1–)4.4–*4.9*–5.4(–5.9) µm (Q_m = 1.4, Q = 0.9–2.9, without myxosporium), ellipsoid, light orange (5A5), brownish orange (6C8) to light brown (5A5), with a brown eusporium bearing fine, short and distinct echinulae, overlaid by a hyaline myxosporium. *Pileipellis* a hymeniderm, brownish orange (6C8), clavate like cells, dextrinoid. *Context* trimitic; generative hyphae (n = 30) (1.5–)1.2–*1.8*–2.6(–3.9) µm in width, hyaline, thin-walled without clamp connections; skeletal hyphae (n = 30) (3.1–)1.5–*4.4*–5.5(–6.8) µm in width, thick-walled, nearly solid, sometimes branched, greyish brown (5B5) to brownish orange (6C8); binding hyphae (n = 30) (2.4–)3.2–*4.1*–4.9(–5.4) µm in width, thick-walled, branched, nearly solid, light orange (5A5) to brownish orange (6C8).

Habitat – Growing near hardwood roots or rotten woods, in dry dipterocarp forest, coniferous rain forest and in upper mixed deciduous forest, growing up from soil.

Specimens examined – LAOS, Savvanakhet Province, Phin District, Dong Phou Vieng Protected Area, 16°23′N–105°59′E, elev. 283 m, mixed deciduous forest, 27 June 2017, P. Phengsintham (GACP17062724), Huaphanh Province, Samneua District, Nasala Village, 20°22′N-103°98′E, elev. 1346 m, Coniferous rain forest, 30 July 2017, P. Phengsintham (GACP17073037). VIETNAM, Lam Dong Province, Bidoup Nui Ba National Park, 12°26′N–108°30′E, elev. 2050 m, coniferous rain forest, 19 October 2017, T.C Wen (GACP17101903, GACP17101910, GACP17102101, GACP17102301).

Notes – *Ganoderma flexipes* was introduced by Patouillard (1907) from Vietnam and has since been recorded from China, India, Nepal, Pakistan (Steyaert 1972, Zhao & Zhang 2000, Wang & Wu 2007). This species can easily be recognized by its small reddish brown pileus, long and thin stipe, reddish brown to dark brown context, and ellipsoid or ovoid basidiospores. Our collections fall within the range (8–13 × 5.5–8) µm, measured by Steyaert (1972) and fit that of the lectotype (9–11 × 6–7.5) µm, measured by Ryvarden (1983) for *G. flexipes*. We report *G. flexipes* from Laos as a new record.

12. *Ganoderma gibbosum* (Cooke) Pat., Ann. Jard. Bot. Buitenzorg, suppl. 1: 114 (1897) Fig. 8

≡ *Fomes amboinensis* var. *gibbosus* Cooke (1885)

Facesoffungi number: FoF05652

Basidiome annual, sessile (usually with a distinctly contracted base), non laccate, woody. *Pileus* 6–12 × 3.0–6.0 cm, up to 3 cm thick at the base, spathulate, upper surface; hard, several layers thick, light brown (6D5) to light brown (6D6), crust overlies the pellis, concentric zones with turberculate bumps and ridges and rivulose depressions; margin with numerous undulations and irregularities, wavy, 2 mm thick, concolorous with the pileus; lower surface light brown (5D4). *Hymenophore* up to 6 mm long, indistinctly stratose, light brown (5D4), pores circular or sub circular, 4–5 pores per mm. *Context* up to 3 cm thick, dry, duplex, lower layer; brown (6E8), pithy, composed of coarse loose fibrils, upper layer; dark brown (6F8), woody. *Basidiospores* (n = 50) (4.3–)6.9–*7.6*–9.2(–10.5) × (3.8–)4.6–*5.6*–5.7(–6.1) µm (Q_m = 1.7, Q = 0.8–2.5, with myxosporium). (–3.6)4.8–*6.0*–7.6(–8.7) × (–2.0)2.7–*3.5*–4.5(–6.7) µm (Q_m = 1.7, Q = 0.8–3.2, without myxosporium), ellipsoid to elongate, brown (6D8) to light brown (6D6), eusporium bearing fine, short, and distinct echinulae, overlaid by a hyaline myxosporium, bitunicate. *Pileipellis* a hymeniderm, brown (6D8) to light brown (6D6), composed of apically acanthus like branched cells, dextrinoid. *Context* trimitic; generative hyphae (n = 30) (1.3–)1.6–*2.1*–2.7(–3.6) µm in width, thin-walled, hyaline; skeletal hyphae (n = 30) (4.0–)4.8–*4.7*–5.2(–5.8) µm in width, brown (6F8), dextrinoid, thick-walled; binding hyphae (n = 30) (2.6–)3.6–*4.7*–5.8(–6.1) µm in width, brown (6F8), thick-walled, branched, intertwined the skeletal hyphae.

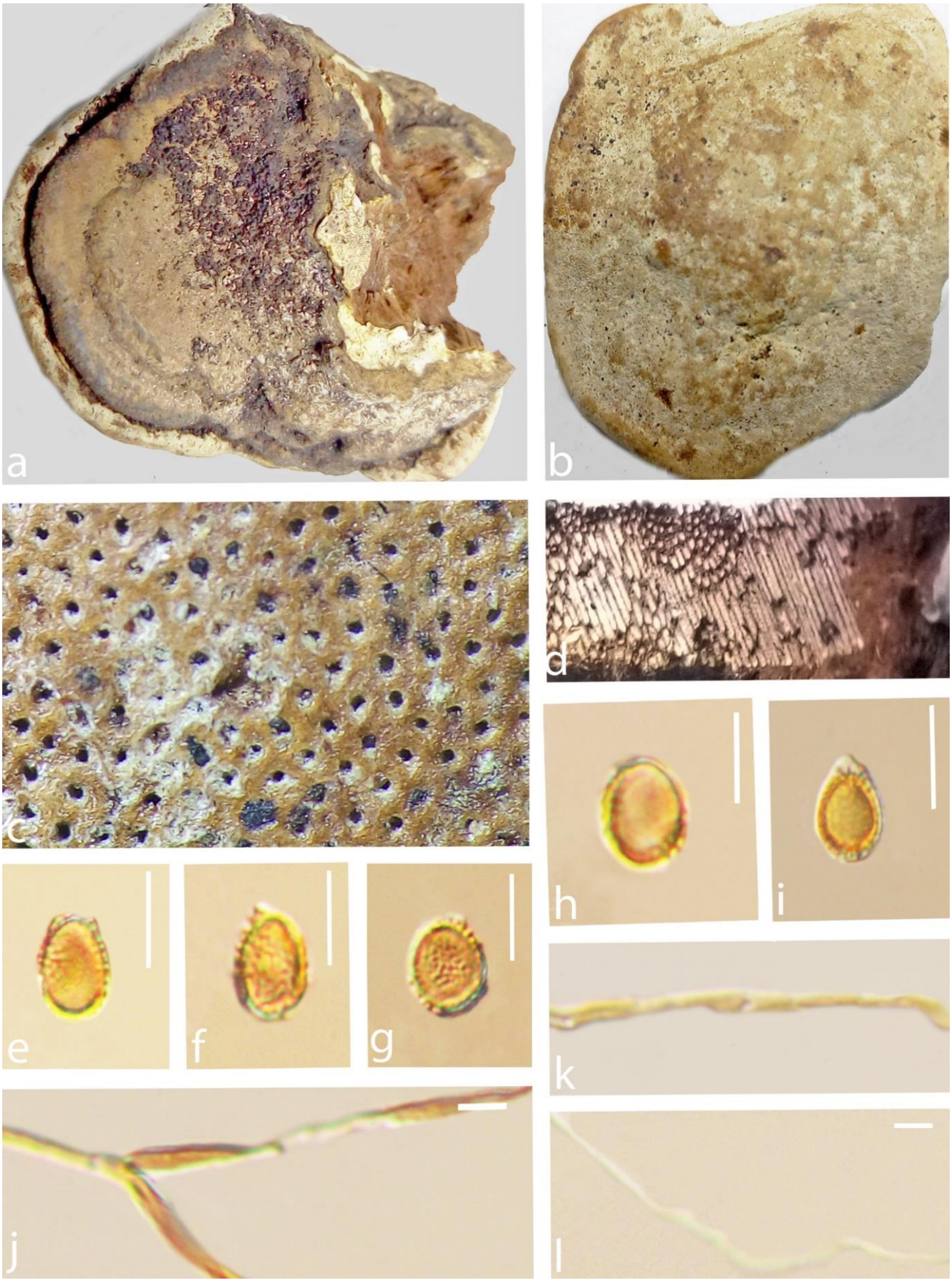


Figure 6 – *Ganoderma donkii* (GACP15122107). a Upper surface. b Lower surface. c Pores in the lower surface (5×). d Section of pileus. e–i Spores (100×). j Binding hyphae (100×). k Skeletal hyphae (100×). l Generative hyphae (100×). Scale bars: e–I = 10 µm, j–l = 5 µm.

Figure 7 – *Ganoderma flexipes* (GACP17073037). a, b upper surface c lower surface. d pores in the lower surface (5×). e Section of pileus. f–h spores (100×). i binding skeletal hyphae (40×). j skeletal hyphae (40×). k generative hyphae (40×). Scale bars: f–h = 10 µm, i–k = 5 µm.

Habitat – On a rotten hardwood, in dry dipterocarp forest and in upper mixed deciduous forest and growing up from soil.

Specimens examined – CHINA, Guizhou Province, 06 July 2014, T.C Wen (GACP YTS14070653, GACP YTS14070655, GACP YTS14070656). THAILAND, Chiang Mai Province, Mushroom Research Center, Coniferous rainforest, 19°20′N–98°44′E, elev. 770 m, 12 June 2015, K.K Hapuarachchi (GACP15061225, GACP15061228, GACP15061230). LAOS, Xiengkhouang Province, Phoukoud District, Ngod Phae Village, Evergreen rainforest, 19°53′N–103° 22′E, elev. 1141 m, 14 June 2014, P. Phengsintham (GACP14061422, GACP14061426). MYANMAR, 11 September 2014, T.C Wen (GACP14091122, GACP14091108).

Notes – *Ganoderma gibbosum* is known from Australia (Saccardo 1888), China (Zhao et al. 1983), Indonesia (Java), Thailand (this study) and Vietnam (Parmasto 1986) but the location of type not known (Moncalvo & Ryvarden 1997). *Ganoderma gibbosum* was considered as a subspecies of *G. applanatum* (Zhao 1989). Smith & Sivasithamparam (2003) renamed *G. gibbosum* as *G. incrassatum* based on the monophyletic origin and low level of sequence variation. However, according to Index Fungorum *G. incrassatum* is synonymized as *G. applanatum* and name of *G. gibbosum* remains as it is. Our collections from Laos well agree with the descriptions provided by Ryvarden (2000). Furthermore, we report *G. orbiforme* from Laos and Myanmar as a new record together with molecular and morphological evidences.

13. ***Ganoderma lingzhi*** Sheng H. Wu, Y. Cao & Y.C. Dai, in Cao, Wu & Dai, Fungal Diversity 56(1): 54 (2012) Fig. 9

Basidiome annual, stipitate, strongly laccate, woody. *Pileus* 8–12 × 3–8 cm, up to 1.5 cm thick at the base, suborbicular to flabelliform, upper surface; reddish brown (8E8) to brownish orange (6C8), radially rugose, irregularly ruptured crust overlying the context, margin; wavy, concolourous with the pileus, lower surface; whitish brown (6E3). *Hymenophore* up to 20 mm long, indistinctly stratose; pores initially greyish brown (6E3), bruising brown, pores circular, 4–5 per mm. *Context* up to 1.5 cm thick, duplex, dry, lower layer brown (6E4) to dark brown (7F8), fibrous, composed of coarse loose fibrils; upper layer dark brown (7F8), corky. *Stipe* eccentric, thick, short, sub cylindrical, concolorous with the pileus, 4 × 1 cm. *Basidiospores* (n = 25) (7.6–)8.1–*9.5*–10.1(10.5–) × (–6.5)7.1–*7.5*–8.1(–8.5) µm (Q_m = 1.5, Q = 1.2–1.6, with myxosporium). (n = 25) (6.5–)6.8–*8.4*–9.4(–9.8) × (4.6–)5.7–*6.5*–7.6(–7.9) µm (Q_m = 1.5, Q = 1.2–1.8, without myxosporium), ellipsoid, light brown (6D4), with a brown (6F4) eusporium bearing fine, short and distinct echinulae, overlaid by a hyaline myxosporium. *Pileipellis* a hymeniderm, brownish orange (6C8), clavate like cells, dextrinoid. *Context* trimitic; generative hyphae (n = 20) (0.5–*1.1*–1.6) µm in width, colorless, thin-walled; skeletal hyphae (n = 20) (3.6–*5.1*–6.0) µm in width, thick walled, nearly solid, sometimes branched, brownish orange (6C8); binding hyphae (n = 20) (2.0–*3.1*–4.2) µm in width, thick walled, branched, nearly solid, light orange (5A5) to brownish orange (6C8).

Habitat – On a rotten hardwood, in dry dipterocarp forest and in upper mixed deciduous forest and growing up from soil.

Specimens examined – LAOS, Xiengkhouang Province, Phoukoud District, Ngod Phae Village, Evergreen rainforest, 19°53′N–103°23′E, elev. 1141 m, 19 January 2018, P. Phengsintham (GACP18011910, GACP18011911).

Notes – *Ganoderma lingzhi* was introduced for "Lingzhi", a species with a wide natural distribution in temperate area and mainly in Fagaceae forests of East Asia (Cao et al. 2012). Using both morphological and phylogenetic evidence, this name unambiguously represents the economically important and widely cultivated Lingzhi species (Dai et al. 2017). *Ganoderma lingzhi* is characterized by its melanoid bands in the context, light buff to buff colour context, thick dissepiments, absence of concentric growth zones in the context, (10.7 × 5.8) µm size basidiospores and sulphur yellow to straw coloured pore surface at maturity (Cao et al. 2012). This species was long being assigned to *G. lucidum* since both species have a reddish brown pileal surface, similarsized basidiospores and mostly regular clavate cuticle cells. However, *G. lingzhi* differentiate from *G. lucidum* by the presence of melanoid bands in the context, a yellow pore surface and thick dissepiments (80–120 µm) at maturity (Cao et al. 2012). Among the Chinese *Ganoderma* species, *G. flexipes*, *G. multipileum*, *G. sichuanense*, *G. tropicum* and *G. tsugae* are the mostly similar species to *G. lingzhi* because they share a reddish brown pileal surface, similar basidiospores and cuticle cells. Nevertheless, *G. lingzhi* can be distinguished from former species by several morphological characteristics (Cao et al. 2012).

14. ***Ganoderma luteomarginatum*** J.D. Zhao, L.W. Hsu & X.Q. Zhang, Acta microbiol. sin. 19(3): 274 (1979) Fig. 10

Facesoffungi number: FoF05654

Basidiome annual, stipitate, strongly laccate, corky. *Pileus* 1.5–5 × 1–3 cm, up to 0.4 cm thick at the base, flabelliform to suborbicular to spathulate, upper surface; reddish black (8E8) to brownish black (6C8), undulate, ferruginous, irregularly ruptured crust overlying the context, margin; 2mm thick, blunt, yellow (4A8); lower surface greyish brown (6E3). *Hymenophore* up to 10 mm long, indistinctly stratose; pores initially brown (6E3), bruising dark brown (6F6), pores circular, 3–5 per mm. *Context* up to 0.8 cm thick, duplex, dry, upper layer dark brown (7F8), fibrous, composed of coarse loose fibrils, corky; lower layer dark brown (7F8), woody. *Stipe* eccentric, sub cylindrical, concolorous with the pileus, 4 × 8 cm, 0.5 cm at the base. *Basidiospores* (n = 20) (8.6–)9.6–*10.7*–11.8(12.1–) × (–6.1)6.3–*7.2*–8.1(–8.6) µm (Q_m = 1.5, Q = 1.3–1.6, with myxosporium). (n = 20) (6.6–)7.9–*9.2*–10.4(–11.7) × (3.7–)4.6–*5.7*–6.9(–7.7) µm (Q_m = 1.6, Q = 1.3–2.3, without myxosporium), ellipsoid to truncate, truncate at the apex, brown (6E6), with a light brown (6D6) eusporium bearing fine, short and distinct echinulae, overlaid by a hyaline myxosporium. *Pileipellis* a hymeniderm, brownish orange (6C8), clavate like cells. *Context* trimitic; generative hyphae (n = 20) (0.4–*0.9*–1.4) µm in width, thin-walled, hyaline; skeletal hyphae (n = 20) (1.6–*2.5*–3.2) µm in width, thick walled, nearly solid, sometimes branched, brownish orange (6C8); binding hyphae (n = 20) (2.5–*3.9*–4.9) µm in width, thick walled, branched, nearly solid, light orange (5A5) to brownish orange (6C8).

Habitat – On a rotten hardwood, in dry dipterocarp forest and in upper mixed deciduous forest and growing up from soil.

Specimens examined – LAOS, Sayabouli Province, Paklay District, Nakhan Village, mixed deciduous forest, 18°41′N–101°46′E, elev. 354 m, 25 August 2016, P. Phengsintham (GACP16082545, GACP6082548, GACP16082549) (from Herbarium of Guizhou Agricultural sciences; GAS3356). MYANMAR, 11 September 2014, T.C Wen (GACP140911224).

Notes – *Ganoderma luteomarginatum* was introduced by Zhao et al. (1979) from China and characterized by strongly laccate, thin, reddish black pileus with yellow margin, small basidiospores (10.7 × 7.2) µm and trimitic hyphal system. The morphology of *G. luteomarginatum* collections from Laos and Myanmar agree well with that of the holotype as described by Zhao et al. (1979). This species morphologically resembles *G. sinense* and *G. austrofujianense*. However, *G. sinense* can be distinguished by having thick, black pileus with a margin concolourous to the pileus and larger basidiospores, and *G. austrofujianense* differed by having white and brown color zones in the pileus. Furthermore, this species has been recorded from Thailand and Vietnam (Kha 2014) with morphological evidence. There is no phylogenetic data available for this species in GenBank. *Ganoderma luteomarginatum* is newly recorded taxa from Laos and Myanmar.

15. *Ganoderma mbrekobenum* E.C. Otto, Blanchette, Held, C.W. Barnes & Obodai (2016)

See the description ad illustration at Crouse et al. (2016)

Notes – *Ganoderma mbrekobenum* was introduced by Crous et al. 2016 from Ghana based on morphology and molecular data. This species is characterized by ovoid to broadly ellipsoid with a truncate base, bitunicate, verruculose basidiospores, dimitic hyphal system and a homogenous context. *Ganoderma mbrekobenum* causes decay in the roots and trunks of angiosperm trees in the southern regions of Ghana (Crous et al. 2016) (Table 3).

16. *Ganoderma microsporum* R.S. Hseu, in Hseu, Chen & Wang, Mycotaxon 35(1): 36 (1989)

See the description at Hseu et al. (1989)_

Notes – *Ganoderma microsporum* was introduced by Hseu et al. (1989) based on morphological data from Taiwan. This species is characterized by small size, (4–5) × (6–8) µm, and ovoid to subspherical basidiospores. However, *G. weberianum* reported from Asia could not be separated from those representing *G. microsporum* based on molecular data (Moncalvo et al. 1995a, 1995b). Later, Smith & Sivasithamparam (2003) showed that the two species could be separated by the presence of gasterospores in *G. weberianum.* This fungus causes white butt rot on angiosperm trees and reported from China and India (Table 3).

Figure 8 – *Ganoderma gibbosum* (GACP YTS14070653). a Upper surface. b Lower surface. c Section of pileus (5×). d Pores in the lower surface. e–g Spores (100×). h Generative hyphae (100×). i Skeletal hyphae (100×). j Binding hyphae (100×). Scale bars: e–g = 10 µm, h–j = 5 µm.

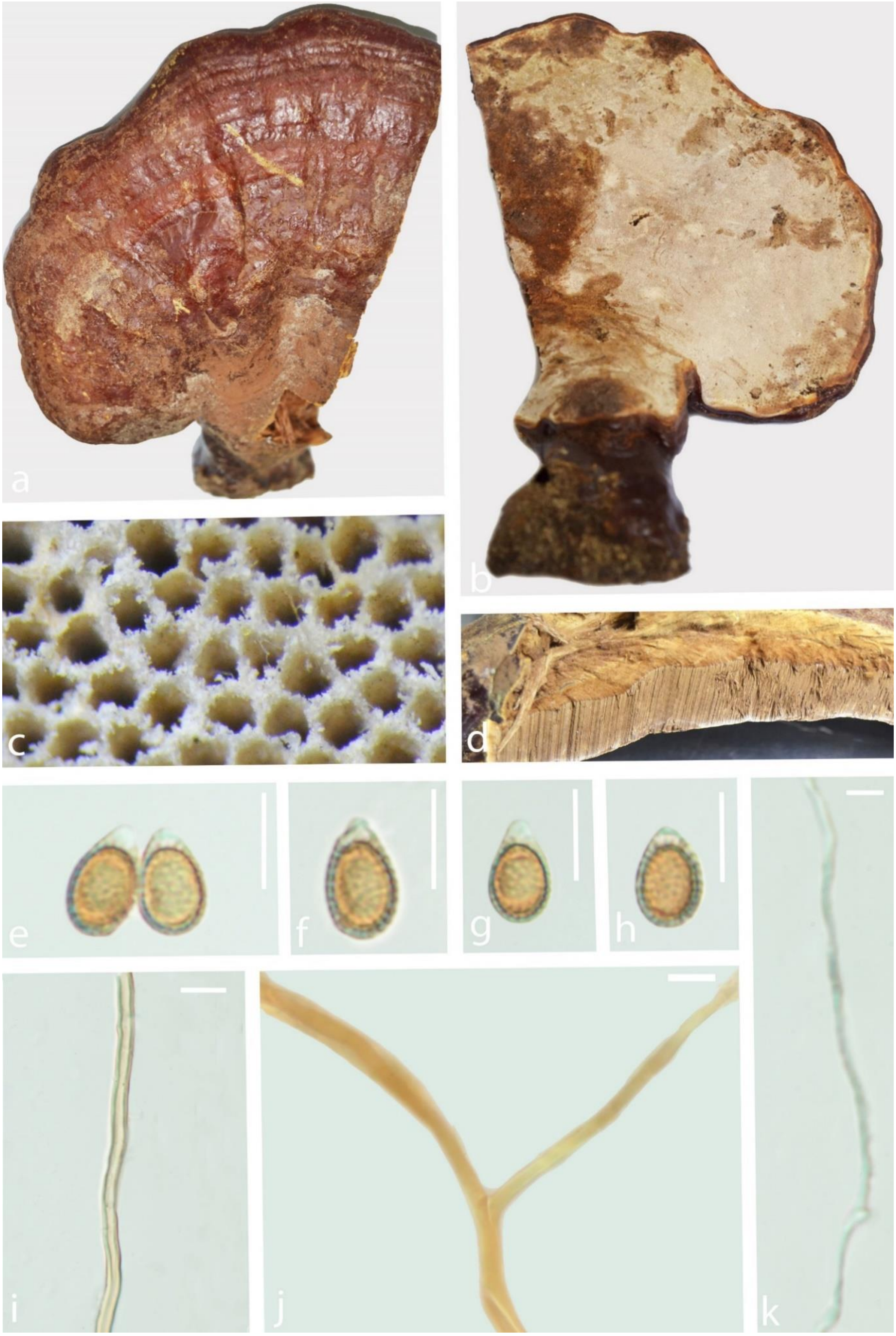


Figure 9 – *Ganoderma lingzhi* (GACP18011910). a Upper surface. b Lower surface. c Pores in the lower surface (5×). d Section of pileus. e–h Spores (100×). i Skeletal hyphae (100×). j Binding hyphae (100×). k Generative hyphae (100×). Scale bars: e–h = 10 µm, i–k = 5 µm.

Figure 10 – *Ganoderma luteomarginatum* (GACP16082545). a,b Upper surface. c Lower surface. d Section of pileus . e Pores in the lower surface (5×). f–i Spores (100×). j Generative hyphae (100×). k Skeletal hyphae (100×). **l** Binding hyphae (100×). Scale bars: f–i = 10 µm, j–l = 5 µm.

17. *Ganoderma multiplicatum* (Mont.) Pat., Bull. Soc. mycol. Fr. 5(2, 3): 74 (1889) Fig. 11

= *Polyporus multiplicatus* Mont. (1854)

Facesoffungi number: FoF05655

Basidiome annual, sessile (usually with a distinctly contracted base), strongly laccate, woody. *Pileus* 6–9 × 3.5–5 cm, up to 3 cm thick at the base, suborbicular, plano convex, sub applante; upper surface hard, several layers thick, orange (6D8) to brown (7E8), crust overlies the pellis, containing fibrous pithy context, swollen differentiated zone at the point of attachment; margin soft or having irregularities, 1 cm thick, rounded, white (5A1); lower surface white (5A1) to orange (5B2). *Hymenophore* up to 4 mm long, indistinctly stratose, white (5A1) to orange (5B2), pores circular or sub circular or isodiametric. *Context* up to 3 cm thick, dry, duplex; lower layer brown (7E8), fibrous, composed of coarse loose fibrils, soft; upper layer pale orange (5A3), woody. *Basidiospores* (n = 30) (4.8–)5.9–*7.1*–8.3(–9.9) × (3.3–)6.6–*4.3*–8.3(–9.6) µm (Q_m = 1.6, *Q* = 1.2–2.0, with myxosporium). (3.8–)4.5–*5.3*–6.2(–7.2) × (1.8–)2.3–*2.6*–3.5(–3.8) µm (Q_m = 1.3, *Q* = 1.3–3.8, without myxosporium), broadly ellipsoid to elongate, greyish orange (5B5) to brown (6E8), eusporium bearing fine, short, and distinct echinulae, overlaid by a hyaline myxosporium, bitunicate. *Pileipellis* a hymeniderm, greyish orange (5B5) to brown (6E8), composed of apically acanthus like branched cells, dextrinoid. *Context* dimitic; skeletal hyphae (n = 30) (2.6–)2.9–*3.4*–3.8(–4.2) µm in width, light brown (6D4), thick walled, sometimes branched; binding hyphae (n = 30) (1.2–)2.1–*2.6*–3.3(–3.7) µm in width, light brown (6D4), thick walled, branched, intertwined the skeletal hyphae.

Habitat – On a decaying wood log, accompanied in humus rich soil with over heavily rotted litter on the ground, mossy temperate mixed coniferous forests. Producing basidiomata from summer to late autumn.

Specimens examined – MYANMAR, 11 September 2014, T.C Wen (GACP14091108, GACP14091109).

Notes – *Ganoderma multiplicatum* (Mont.) Pat. was originally collected in French Guyana (Moncalvo & Ryvarden 1997) and is characterized by a reddish-black pileus, a not fully homogenous context, amyloid slightly tuberculate hyphal ends in the cuticle and the small subglobose to broadly ellipsoid basidiospores (7–8 × 5–6 µm) (Ryvarden 2004b). *Ganoderma orbiforme* has similar tuberculate hyphal ends, but has larger basidiospores (Ryvarden 2004b). The morphology of *G. multiplicatum* collections from Myanmar agree well with that of the holotype as described by Gottlieb & Wright (1999a) and Ryvarden (2000). This species has been considered as similar to *G. chalceum* (Corner 1983) and was synonymized as *G. subamboinense* (Ryvarden 2000). However, Correia de Lima et al. (2014) suggested that *G. chalceum* and *G. subamboinense* are not synonyms of *G. multiplicatum* on the basis of molecular data. This species has a pantropical distribution (Ryvarden 2000) and subsequently found in Africa (Steyaert 1980), Asia (Zhao 1989, Bhosle et al. 2010) and South America (Bolaños-Rojas et al. 2016). Furthermore, *G. multiplicatum* has described from China by many authors (Zhao et al. 1979, 1981, Zhao 1989, Zhao & Zhang 2000, Wang & Wu 2007). Here, we describe *G. multiplicatum* from Myanmar for the first time based on molecular and morphological evidence.

18. *Ganoderma neojaponicum* Imazeki, Bull. Tokyo Sci. Mus. 1: 37 (1939) Fig. 12

Facesoffungi number: FoF05656

Basidiome annual, stipitate, strongly laccate, corky. *Pileus* 3–6 × 1–3 cm, up to 0.5 cm thick at the base, reniform to suborbicular to spathulate, upper surface; reddish black (8E8) to brownish black (6C8), undulate, ferruginous, irregularly ruptured crust overlying the context, margin; blunt, concolorous with the pileus, lower surface; greyish brown (6E3). *Hymenophore* up to 12 mm long, indistinctly stratose; pores initially greyish brown (6E3), bruising dark brown (6F6), pores circular, sub circular or isodiametric, 3–5 per mm. *Context* up to 0.5 cm thick, duplex, dry, upper layer brown (6E4) to dark brown (7F8), fibrous, composed of coarse loose fibrils; lower layer dark brown (7F8), corky. *Stipe* eccentric, sub cylindrical, concolorous with the pileus, 5 × 8 cm, 0.5 cm at the base. *Basidiospores* (n = 25) (9.1–)9.5–*10.5*–13.2(13.5–) × (–5.7)6.3–*7.8*–8.4(–8.9) µm (Q_m =

1.5, Q = 1.1–1.7, with myxosporium). (n = 25) (7.8–)8.1–*8.9*–9.2(–10.5) × (4.7–)5.1–*5.8*–6.2(–6.8) µm (Q_m = 1.5, Q = 1.2–1.8, without myxosporium), ellipsoid, truncate at the apex, brown (6E6), with a light brown (6D6) eusporium bearing fine, short and distinct echinulae, overlaid by a hyaline myxosporium. *Pileipellis* a hymeniderm, brownish orange (6C8), clavate like cells. *Context* dimitic; generative hyphae not observed; skeletal hyphae (n = 30) (3.6–*5.0*–6.2) µm in width, thick walled, nearly solid, sometimes branched, brownish orange (6C8); binding hyphae (n = 30) (2.8–*4.5*–5.4) µm in width, thick walled, branched, nearly solid, light orange (5A5) to brownish orange (6C8).

Habitat – On a rotten wood, in dry dipterocarp forest and in upper mixed deciduous forest and growing up from soil.

Specimens examined – LAOS, Savannakhet province, Phin district, Nathom Xe village, Phou Xang hae, mixed deciduous forest, 16 58′N–105 89′E, 23 June 2017, P. Phengsintham (GACP17062350, GACP17062355). MYANMAR, 10 September 2014, TC Wen (GACP14091009, GACP14091014).

Notes – *Ganoderma neojaponicum* was introduced by Imazeki (1939) from Japan and it's a member of the *Ganoderma lucidum* species complex (Hattori & Ryvarden 1994). This species is rarely saprotrophic and unique with its slender long spores, a black shiny basidiocarp, slender stipe and host range (dead coniferous trees or bamboos) (Imazeki et al 1988, Hsieh & Yeh 2004). This mushroom is distributed in Asian countries including China, Korea, Japan, Taiwan, Malaysia (Tan et al. 2015), Laos and Myanmar (this study).

19. *Ganoderma orbiforme* (Fr.) Ryvarden (as '*orbiformum*') Mycologia 92(1): 187 (2000) Fig. 13

≡ *Polyporus orbiformis* Fr. (1838)

= *Ganoderma mastoporum* (Lév.) Pat. [as 'malosporum'], Bull. Soc. mycol. *Fr.* 5(2, 3): 75 (1889)

= *Ganoderma fornicatum* (Fr.) Pat. sensu Imazeki, Bull. Tokyo Sci. Mus. 1: 47 (1939)

= *Ganoderma cupreum* (Cooke) Bres, Annls mycol. 9(3): 268 (1911)

= *Ganoderma subtornatum* Murrill, Bull. Torrey bot. Club 34: 477 (1907)

= *Ganoderma densizonatum* J.D. Zhao & X.Q. Zhang, in Zhao, Zhang & Xu, Acta Mycol. Sin. 5(2): 86 (1986)

= *Ganoderma limushanense* J.D. Zhao & X.Q. Zhang, Acta Mycol. Sin. 5(4): 219 (1986)

See Index Fungorum for other synonyms

Facesoffungi number: FoF05657

Basidiome annual to perennial, with a distinctly contracted base, weakly laccate, woody. *Pileus* 8–21 × 5–12 cm, up to 4 cm thick at the base, flabelliform, plano convex, applanate, upper surface; hard, several layers thick, alternating brownish orange (6C8) to light brown (6D4) concentrically zones, crust overlies the pellis, concentrically sulcate zones with turberculate bumps and rivulose depressions, differentiated zone at the point of attachment; margin with numerous undulations and irregularities, 4 mm thick, rounded and white (4A1) to yellowish white (4A2). *Hymenophore* up to 3 mm long, indistinctly stratose, orange grey (6B2), pores circular or sub-circular. *Context* up to 2 cm thick, dry, triplex; lower layer dark brown (7F8), pithy, composed of coarse loose fibrils, soft; upper layer light brown (5D4), woody. *Basidiospores* (n = 25) (8.2)10.1–*10.7*–11.4(11.6) × (4.8)5.7–*6.5*–7.2(7.4) µm, (Q_m = 1.6, Q = 1.3–2.1, with myxosporium). (n = 25) (6.8)7.8–*8.7*–9.6(10.3) × (3.7)4.7–*5.4*–6.1(6.7) µm (Q_m = 1.6, Q = 1.2–2.1, without myxosporium), yellowish brown (5D8), elongate, eusporium bearing fine, short, and distinct echinulae, overlaid by a hyaline myxosporium, bitunicate. *Pileipellis* a hymeniderm, dark brown (7F8), composed of apically acanthus like branched cells, dextrinoid. *Context* trimitic; generative hyphae (n = 25) (0.8–*2.2*–2.5) µm in width, thin-walled, hyaline; skeletal hyphae (n = 28) (1.9–*3.7*–4.9) µm in width, light brown (5D6), thick-walled; binding hyphae (n = 28) (1.6–*3.4*–7.2) µm in width, light brown (5D6), thick-walled, branched, intertwined the skeletal hyphae.

Habitat – On a decaying hardwood log, accompanied in humus rich soil with over heavily rotted litter on the ground, producing basidiomata from summer to late autumn.

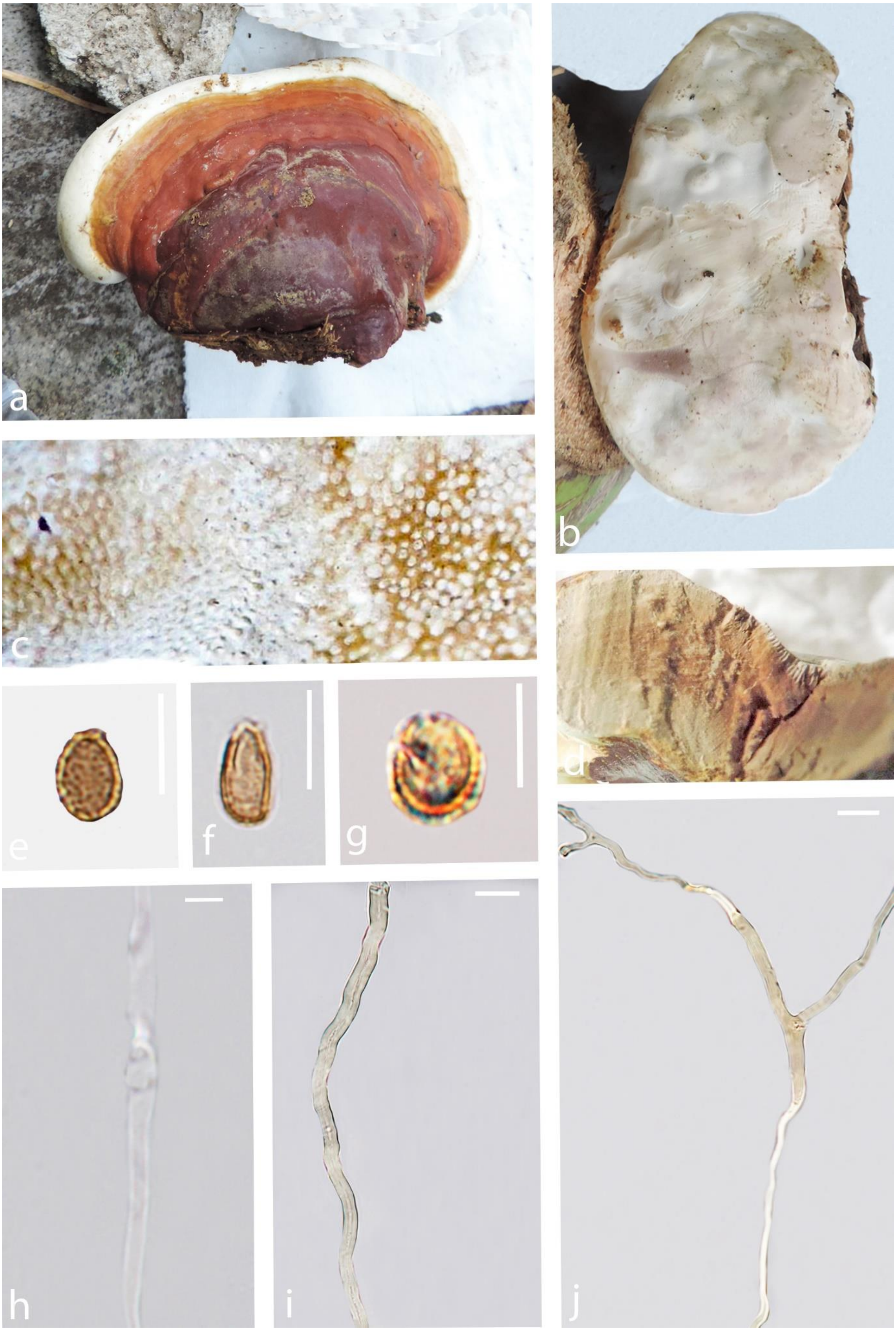


Figure 11 – *Ganoderma multiplicatum* (GACP14091107). a Upper surface. b Lower surface. c Pores in the lower surface (4.5×). d Section of pileus, e–g Spores (100×). h Generative hyphae (100×). i Skeletal hyphae (100×). j Binding hyphae (100×). Scale bars: e–g = 10 μm, h–j = 5 μm.

Figure 12 – *Ganoderma neojaponicum* (GACP17062350). a Upper surface. b Lower surface. c Section of pileus (5×). d Pores in the lower surface. e–h Spores (100×). i Cuticle cells (100×). j Skeletal hyphae (100×). k Binding hyphae (100×). Scale bars: e–i = 10 µm, j–k = 5 µm.

Figure 13 – *Ganoderma orbiforme* (GACP14061420) a upper surface, b lower surface c pores in the lower surface (5×), d Section of pileus , e–g spores (100×), h binding hyphae (100×), i generative hyphae (100×), j skeletal hyphae (100×). Scale bars: e–k = 10 µm, l–n = 5 µm.

Specimens examined – LAOS, Xiengkhouang Province, Phoukoud District, Ngod Phae Village, Evergreen rainforest, 19°53′N–103°22′E, elev. 1141 m, 14 June 2014, P. Phengsintham (GACP14061420, GACP14061414). CHINA, Hainan Province, Jiangfengling Mountain, Coniferous rainforest, 18°N–109°E, elev. 1350 m, 09 August 2014, T.C Wen (GACP14081232, GACP14081235). THAILAND, Chiang Mai Province, Mushroom Research Center, Coniferous rainforest, 19°20′N–98°44′E, elev. 770 m, 12 June 2015, K.K Hapuarachchi (GACP15061260, GACP15061265, GACP15061266).

Note – *Ganoderma orbiforme* (Fr.) Ryvarden was originally described as '*Polyporus orbiformis*' and identified by the rigid basidiocarp, purplish black laccate crust, purplish brown pore surface, brown tube layer, ellipsoid or ovoid, mostly truncate basidiospores with fine and short echinulae (10–12 × 6.5–7.5) µm, and cuticle composed of strongly amyloid, clavate cells usually with several irregular lobes or protuberances (30–80 × 3–10.5) µm)Ryvarden 2000, Wang et al. 2014(. This is a tropical species and was originally described from Guinea in Africa, and also known from Bonin Island in the Pacific and in the Neotropics)Ryvarden 2000(.*Ganoderma orbiforme* possess greater variability in morphology; rigid basidiocarp with a weakly to strongly laccate, partly laccate or dull pileus, variably brown context, ellipsoid to ovoid basidiospores with fine and short echinulae, and purplish brown pore surface at maturity (Wang et al. 2014(. *Ganoderma cupreum*, *G. fornicatum*, *G. mastoporum*, *G. orbiforme*, *G. subtornatum* and the species which originally described from China; *G. densizonatum* and *G. limushanense* are morphologically very similar to one another in basidiome texture, pilear cuticle structure, context and pore color and basidiospore characteristics. Hence, based on morphological and molecular data, it was concluded, that the above mentioned taxa are conspecific and *G. orbiforme* is the earliest valid name for use (Wang et al. 2014). Our collections from Laos well agree with the descriptions provided by Ryvarden (2000). Furthermore, we report *G. orbiforme* from Laos as a new record together with molecular and morphological evidence.

Basal stem rot (BSR) and Upper stem rot (USR) diseases caused by *G. boninense* (= *G. orbiforme)* were first introduced in the Republic of Congo, West Africa in 1915 (Wakefield 1920) and successively in 1931, the disease was found on 25 years old Oil palms (*Elaeis guineensis* jacq.). This species was named as *G. boninense* which originates from USA and it's a white rot fungus (Ariffin et al. 2000). In that era, the disease was not economically important, but after a few years the disease was found in 10-15 years old Oil palms and today the disease can be found even in one year old or immature palms (Wong et al. 2012, Azahar et al. 2008). Many surveys indicated that the disease incidence of BSR is highest in coastal areas and in areas previously planted with coconuts (Turner 1981). The fungus has been recorded causing BSR in Angola, Cameroon, Colombia, Ghana, Honduras, Nigeria, Papua New Guinea, Principe, San Tome, Tanzania, Zambia, Zimbabwe and Thailand (Ariffin et al. 2000) (Table 3). The organism causes economic loss of Oil palm in different regions around the world including Southeast Asia especially Indonesia and Malaysia (Idris et al. 2000, Corley & Tinker 2003). Perennial oilseed crops form a major component of rural economies in the region of wet lowland tropics of South, Southeast Asia and Oceania (Flood et al. 2000). BSR and USR are the South East Asia's most threaten oil palm diseases and some South East Asian countries loss US$500 million a year due to the loss of crops (Flood et al. 2002). The coconut palm (*Cocos nucifera*) is found throughout the tropics, and BSR is a serious disease in coconut caused by *G. boninense* in South India (Kandan et al. 2009) and Srilanka (Peiris 1974).

Ganoderma fornicatum was first published by Fries as '*Polyporus fornicatus*' based on collections from Brazil and Patouillard transferred it to genus *Ganoderma* after studying collections from French Guiana (Wang et al. 2012). *Ganoderma fornicatum* has been accepted as a distinct species by some researches in East Asia (Imazeki 1939, Zhao & Zhang 2000, Wang & Wu 2007). The type of *G. fornicatum* from Brazil is lost and a modern description based on the type lacks. Hence, the identification of the Asian collections to *G. fornicatum* cannot be confirmed in morphology. Since DNA sequence could not obtained from the South American material, it is difficult to prove both Asian and South American collections are molecularly conspecific. Hence, Wang et al. (2014) proposed *G. orbiforme* is the earliest valid name to use for this species whose species identification was verified previously. *Ganoderma orbiforme* is distributed from Guinea to New Guinea, Solomon Islands, China, Japan, India, Thailand, Palau, Pohnpei, Philippines, Malaysia, Singapore and Australia (Smith & Sivasithamparam 2000, 2003). Wang (1990) reported *G. fornicatum* (= *G. orbiforme*) causes wood decaying in *Macademia integrifolia* plants in Taiwan (Table 3).

Lloyd (1912) recognized *G. mastoporum* (= *G. orbiforme*) as a distinct species with a lateral or dorsally-lateral stipes and stipe development varies with different growing environments (Hseu 1990, Moncalvo 2000). Cuticle of *G. mastoporum* is intermediate for hymenioderm is defective and clavate cells disappear in the mature crust (Corner 1983). However, Wang et al. (2014) concluded, based on morphological and molecular data, *G. mastoporum* is conspecific with *G. orbiforme* and the latter is the earliest valid name for use. *Ganoderma mastoporum* occurs widely in Asia and Africa (Corner 1983). This species has been recorded with the association of diseased *A. mangium*, and sometimes co-occurred with *G. philippii* (Table 3). Furthermore, *G. mastoporum* on *A. mangium* in Malaysia conspecific with South Sumatran collections (Glen et al. 2009).

20. *Ganoderma oregonense* Murrill, N. Amer. Fl. (New York) 9(2): 119 (1908)

= *Fomes oregonensis* (Murrill) Sacc. & Traverso, Syll. fung. (Abellini) 19: 715 (1910)

= *Ganoderma nevadense* Murrill, N. Amer. Fl. (New York) 9(2): 119 (1908)

= *Ganoderma sequoiae* Murrill, N. Amer. Fl. (New York) 9(2): 119 (1908)

See the description and illustration at Torres-Torres et al. (2015)

Notes – *Ganoderma oregonense* was introduced by Murril (1908) from Oregon, USA on *Picea sitchensis* tree and characterized by dark colored pileus, large size basidiomata, large pores, wider basidiospores (13–17 × 8–10) µm and homogeneous context (Gilbertson & Ryvarden 1986). This species is morphologically very similar to *G. tsugae* (Torres-Torres et al. 2015), however, the thickness and length of the tubes are different and *G. tsugae* has smaller basidiospores (9–11 × 6–8) µm (Overholts 1953). Furthermore, *G. oregonense* is closely related to *G. lucidum* for which it may be mistaken (Gilbertson & Ryvarden 1986). This species causes root and butt rot of living and dead trees (Table 3). Distribution is known from Canada, Central and South America, and Mexico (Torres-Torres et al. 2015).

21. *Ganoderma philippii* (Bres. & Henn. ex Sacc.) Bres., Iconogr. Mycol. 21: tab. 1014 (1932)

≡ *Fomes philippii* Bres. & Henn. ex Sacc. (1891)

= *Scindalma philippii* (Bres. & Henn. ex Sacc.) Kuntze, Revis. gen. pl. (Leipzig) 3(2): 519 (1898)

= *Fomes pseudoferreus* Wakef., Bull. Misc. Inf., Kew: 208 (1918)

= *Ganoderma pseudoferreum* (Wakef.) Overeem & B.A. Steinm., Bull. Jard. bot. Buitenz, 3 Sér. 7: 437 (1925)

See the description at Hood (2006)

Notes – *Ganoderma philippii* was introduced as *Fomes philippii* by Bresadola & Hennings in 1891 (Saccardo 1891). Later on, Bresadola (1932) transferred this species to *Ganoderma*. This species is characterized by a non-laccate abhymenial surface and sessile basidiome, plecodermis type of pilear crust consisting of densely entwined sub hyaline hyphae impregnated with melanoid substances forming a layer distinct from the context, dimitic or trimitic hyphal system with clamped generative hyphae and especially by a characteristic spore with tiny spines or echinulae positioned between two walls (Hood 2006, Singh et al. 2013). *Ganoderma philippii* causes red root rot disease in a wide range of commercial perennial woody crops such as rubber and tropical acacias (Agustini et al. 2014) (Table 3). This species can survive longer in the soil and then active after two years, furthermore the fungus is especially active in heavy soils with high water content (Steyaert 1975).This species is distributed through South East Asia, from Myanmar through Malaysia and Vietnam in the north; Sri Lanka, Southern India through Indonesia to Papua New Guinea in the south (Steyaert 1975).

22. *Ganoderma pfeifferi* Bres. in Patouillard, Bull. Soc. mycol. Fr. 5(2, 3): 70 (1889)

See Index Fungorum for synonyms

See the description at Corner (1983)

Notes – *Ganoderma pfeifferi* was introduced by Bresadola in 1889 (Patouillard 1889) from Germany. This species is easily identified by its cracked and wrinkled resinous layer on the pileus and its sweet aroma in winter and the production of chlamydospores in culture Hong & Jung 2004). Furthermore, it is distinguished from old specimens of *G. lucidum* and *G. resinaceum* by its dark brown context (Lindequist et al. 2015). Phylogenetically *G. pfeifferi* grouped together with *G.*

resinaceum, *G. subamboinense* and *G. lucidum* from the United States and Taiwan into one monophyletic group (Hong & Jung 2004). *Ganoderma pfeifferi* is a unique species that grows quite exclusively in Europe (Ryvarden & Gilbertson 1993). Mycelia and fruiting bodies of this mushroom species can also be obtained by cultivation in liquid media or on solid substrates (Lindequist et al. 2015). *Ganoderma pfeifferi* is a weak parasitic and inhabits many species of deciduous trees such as *Abies*, *Acer* and *Ulmus* and causes severe root, stem and branch decay (Ryverden & Gilbertson 1993, Szczepkowski & Peitka 2003) (Table 3).

23. *Ganoderma ryvardenii* Tonjock & Mih [as 'ryvardense'], Mycosphere 2(2 (no. 8)): 181 (2010)

See the description and illustration at Kinge & Mih (2011)

Notes – *Ganoderma ryvardenii*, a species causes Basal Stem Rot (BSR) in oil palms in south western Cameroon (Table 3) was introduced by Kinge & Mih (2011) and characterized by having ellipsoid basidiospores with a slightly truncated apex and a truncated base. This species is morphologically similar to *G. boninense* by having clavate pellipelis and similar spore shape Kinge & Mih (2011). However, *G. ryvardense* differs from *G. boninense* that the latter has ellipsoid spores which are slightly truncated at the sides and the apices with slightly different basidiospore measurements. Furthermore, *G. ryvardense* is similar to *G. hildebrandii* in having ellipsoid basidiospores with slightly truncated at the apex. Despite in all other aspects, such as length and width of basidiospores, pileipellis and macro structure, *G. hildebrandii* has drop-shaped basidiospores (Moncalvo & Ryvarden 1995a). *Ganoderma ryvardense* formed a sister group with *G. steyaertanum* but morphologically they are different species Kinge & Mih (2011).

24. *Ganoderma nasalanense* Hapuar., Pheng., & K.D. Hyde, sp. nov. Fig. 14

Index Fungorum number: IF555783, Facesoffungi number: FoF05658

Etymology – Refers to the collecting site‘Nasala’, Laos

Holotype – GACP17060211

Basidiome annual, laccate, sessile, usually with a distinctly contracted base, corky, becoming hard corky to woody hard when dry. Pileus 4.5–10 × 2–5 cm, several layers thick, applanate, subreniform; upper surface dark brown (8F8) to grey (8B1), distinctly concentrically sulcate, irregularly ruptured crust overlying the context; margin 3 mm thick, soft, concolorous with the pileus; lower surface dark brown (7F8). *Hymenophore* up to 15 mm long, indistinctly stratose; pores initially greyish brown (6E3), bruising dark brown (8F6), pores circular or sub circular, 3–5 per mm. *Context* 2 cm thick, duplex; upper layer brown (6E4) to dark brown (7F8), fibrous, composed of coarse loose fibrils; lower layer dark brown (7F8), woody. *Basidiospores* (n = 21) (6.6)8.6–*9.5*–10.4(10.7) × (4.4)4.9–*5.5*–6.1(6.7) µm (with myxosporium, Q_m = 1.7, *Q* = 1.2–2.9). (5.0)6.9–*7.8*–8.8(10.0) × (3.4)4.0–*4.4*–4.9(5.2) µm (without myxosporium, Q_m = 1.7, *Q* = 1.1–2.6), ellongate, with a light brown (6D6) eusporium bearing fine, short and distinct echinulae, overlaid by a hyaline myxosporium. *Pileipellis* a hymeniderm, brownish orange (5C5), clavate like cells. *Context* dimitic; generative hyphae not observed; binding hyphae (n = 25), (1.8–*3.2*–4.8) µm in width, brownish orange (6C8), branched, with clamp-connections, skeletal hyphae (n = 25) (4.2–*6.1*–7.3) µm in width, brownish orange (6C8), thick walled, sometimes branched (Fig. 14).

Habitat – On a decaying hardwood tree trunk, accompanied in humus rich soil with over heavily rotted litter on the ground.

Specimens examined – LAOS, Huaphanh Province, Samneua District, Nasala Village, 20°22′N–103°98′E, elev. 1346 m, 25 August 2016, P Phengsintham (GACP17060211, GACP17060212).

Notes – *Ganoderma nasalanense* is a new member of *Ganoderma* (Fig. 15) and it is distinguished by dark brown to grey pileus, duplex context, trimitic hyphal system and relatively large, broadly ellipsoid to ellipsoid, light brown spores (12.1–13.8 × 9.2–10.5) µm. It clusters with *G. orbiforme* (Fr.) Ryvarden and morphologically similar in having rigid basidiocarp, purplish black laccate crust, purplish brown pore surface, brown tube layer, mostly truncate basidiospores with fine and short echinulae (10–12 × 6.5–7.5) µm, and cuticle composed of strongly amyloid,

Figure 14 – *Ganoderma nasalanense* (GACP17060211 holotype). a Upper surface. b Lower surface. c Section of pileus. d Pores in the lower surface (5×). e–h Spores (100×). i Binding hyphae (40×). j–k Skeletal hyphae (40×). Scale bars: e–h = 10 µm, j–k = 5 µm.

clavate cells usually with several irregular lobes or protuberances (30–80 × 3–10.5) µm. Furthermore, phylogeny (Fig. 2), indicates that it clusters with unidentified *Ganoderma* species recorded from Malaysia (FRIM138 and G31) and Vietnam (FMD13) (descriptions unavailable). The species is currently only known from the type locality, Nasala village, Huaphanh Province, Laos.

25. ***Ganoderma sandunense*** Hapuar., T.C. Wen & K.D. Hyde, sp. nov. Fig. 15

Index Fungorum number: IF555784, Facesoffungi number: FoF05659

Etymology – Refers to the collecting site'Sandu', China

Holotype – GACP18012501

Basidiome annual, stipitate, strongly laccate, corky, becoming woody hard when drying. *Pileus* 2–4 × 1–2.5 cm, several layers thick, orbicular, upper surface; reddish black (8E8) to brownish black (6C8), distinctly concentrically sulcate, undulate, ferruginous, irregularly ruptured crust overlying the context, margin; wavy, concolorous with the pileus, lower surface;
whitish yellow (4A2) to light brown (6D4). *Hymenophore* up to 10 mm long, indistinctly stratose; pores initially greyish brown (6E3), bruising dark brown (8F6), pores circular or isodiametric, 3–5 per mm. *Context* up to 1 cm thick, duplex, dry, upper layer brown (6E4) to dark brown (7F8), fibrous, composed of coarse loose fibrils; lower layer dark brown (7F8), woody. *Stipe* central, sub cylindrical, concolorous with the pileus, 4 × 8 cm, 0.5 cm at the base. *Basidiospores* (n = 25) (10.8–)12.1–*12.9*–13.8(14.3–) × (–8.6)9.2–*9.8*–10.5(–11.1) µm (Q_m = 1.3, *Q* = 1.1–1.5, with myxosporium). (n = 25) (9.6–)10.4–*11.3*–12.3(–12.7) × (6.8–)7.5–*8.3*–9.0(–9.8) µm (Q_m = 1.3, *Q* = 1.1–1.7, without myxosporium), broadly ellipsoid to ellipsoid, brown (7E5), with a light brown (6D6) eusporium bearing thick, short and distinct echinulae, overlaid by a hyaline myxosporium. *Pileipellis* a hymeniderm, brownish orange (5C5), clavate like cells. *Context* trimitic; generative hyphae (n = 20) (1.2–*3.1*–2.0) µm in width, hyaline, thin-walled, with clamp connections, rarely seen; skeletal hyphae (n = 20) (3.0–*3.6*–4.6) µm in width, thick walled, nearly solid, brownish orange (6C8); binding hyphae (n = 20) (1.2–*3.4*–2.1) µm in width, thick walled, branched, nearly solid, light brown (6D4).

Habitat – Rotten wood, in dry dipterocarp forest and in upper mixed deciduous forest and growing up from soil.

Specimens examined – CHINA, Guizhou Province, Sandu Shui Autonomous Country, 24°54′N–107°53′E, elev. 590 m, 25 September 2017, T.C Wen (GACP18012501, GACP18012502).

Notes – *Ganoderma sandunense* is a new to science and it is distinguished by several layers thick, orbicular, ferruginous laccate pileus, relatively large broadly ellipsoid to ellipsoid spores (12.1–13.8 × 9.2–10.5) µm, with a light brown eusporium bearing fine, short and distinct echinulae. Initial blast results of this species in GenBank showed 96% similarity with *G. applanatum*, *G. oregonense*, *G. lucidum* and *G. carnosum*. However, there are 1.7%, 1.6%, 1.5%, 1.8% base pair differences in ITS region between *G. sandunense* and other species; *G. applanatum*, *G. oregonense*, *G. lucidum* and *G. carnosum*, respectively. The new species is established based on recommendations provided by Jeewon & Hyde (2016). In addition, none of these species cluster with *G. sandunense* (Fig. 2) and also the morphology is very different from former species. *Ganoderma sandunense* is currently only known from the type locality, Sandu Shui Autonomous Country, Guizhou Province, China.

26. ***Ganoderma sinense*** J.D. Zhao, L.W. Hsu & X.Q. Zhang, Acta Microbiol. Sin. 19(3): 272 (1979) Fig. 16

Ganoderma formosanum T.T. Chang & T. Chen in Trans. Or. Mycol. Soc. 82: 731 (1984) (Nom. Invalid)

= *Ganoderma japonicum* (Fr. Lloyd in Teng, Fungi of China; 447 (1963): Tai, Syll. Fung. Sin.: 469 (1979), Teng, Fungi of China: 326 (1996), non *Polyporus japonicus* Fr.,Epicrisis: 442 (1838)

= *Ganoderma japonicum* (Fr.) Lloyd, Mycol. Writ. 3: Syn. Stip. Polyp.: 102(1912)

= *Ganoderma lucidum* (Leyss.) P. Karst. var. *japonicum* (Fr.) Bres. in Teng in Sinensia 5:199 (1934). non *Polyporus japonicus* Fr., Epicrisis: 442 (1838).
Facesoffungi number: FoF05660

Figure 15 – *Ganoderma sandunense* (GACP18012501). a upper surface. b lower surface. c Section of pileus (5×). d pores in the lower surface. e–g spores (100×). h generative hyphae (100×). i skeletal hyphae (100×), j binding hyphae (100×). Scale bars: e–g = 10 µm, h–j = 5 µm.

Basidiome annual, stipitate, strongly laccate, branched, corky. *Pileus* 3–7 × 2–4 cm, up to 1.0 cm thick at the base, orbicular; upper surface brown (6E4) to brownish black (6C8), yellowish brown (5D8) at the margin, irregularly ruptured crust overlying the context; margin blunt, yellow brown (5D8); lower surface light brown (6D6). *Hymenophore* up to 20 mm long, indistinctly stratose; pores brownish grey (6D2), circular, 2–4 per mm. *Context* up to 1 cm thick, duplex, dry, upper layer dark brown (7F8), corky; lower layer pale brown (5A5), fibrous, composed of coarse loose fibrils; woody. *Stipe* central, sub cylindrical, concolorous with the pileus, 5 × 8 cm, 1.5 cm at the base. *Basidiospores* (n = 20) (8.0–)9.7–*11.6*–11.2(13.4–) × (–6.3) 7.3–*8.1*–8.8(–9.6) µm (Q_m = 1.4, Q = 1.1–1.6, with myxosporium). (6.6–)8.2–*9.6*–10.9(–11.4) × (5.8–)7.3–*6.7*–7.5(–8.5) µm (Q_m = 1.4, Q = 1.2–1.7, without myxosporium), ellipsoid, brown (6E4), with a pale brown (5A5) eusporium bearing fine, short and distinct echinulae, overlaid by a hyaline myxosporium. *Pileipellis* a hymeniderm, brown (6E4), clavate like cells, dextrinoid. *Context* trimitic; generative hyphae (n = 20) (0.3–*1.3*–2.2) µm in width, colorless, thin-walled; skeletal hyphae (n = 20) (2.6–*3.6*–5.1) µm in width, thick walled, nearly solid, sometimes branched, brown (6E4); binding hyphae (n = 20 (0.9–*2.6*–4.5) µm in width, thick walled, branched, nearly solid, pale brown (5A5).

Habitat – Rotten wood, in dry dipterocarp forest and in upper mixed deciduous forest and growing up from soil.

Specimens examined – CHINA, Guizhou Province, Sandu Shui Autonomous Country, 24°54′N–107°53′E, elev. 590 m, 25 September 2017, T.C Wen (GACP17092530, GACP17092532).

Notes – See Hapuarachchi et al. (2018b, 2019)

27. *Ganoderma steyaertianum* B.J. Sm. & Sivasith. [as 'steyaertanum'], Aust. Syst. Bot. 16(4): 495 (2003)

See the description and illustration at Smith & Sivasithamparam (2003)

Notes – *Ganoderma steyaertanum* was introduced by Smith & Sivasithamparam (2003) from Bali, Indonesia and has previously been mistaken for *Ganoderma lucidum* (Curtis) P. Karst. in Australia and Indonesia. Recent studies have attempted to determine the correct name for non-European collections of '*G. lucidum*' (Wang et al. 2009, 2012, Cao et al. 2012, Yao et al. 2013). This laccate species can be readily distinguished in its large, 50–500 mm diameter, sessile or broadly stipitate basidiome, concentric zones and dark brown (Chestnut) to almost black pileus, thick walled, brown, ovoid and ellipsoid basidiospores Smith & Sivasithamparam (2003). Analysis of ITS rDNA sequence (Smith & Sivasithamparam 2000) indicating allopatric speciation of *G. steyaertanum* from a species from India and the Philippines, suggests the distribution of may not extend much further north of Indonesia. *Ganoderma steyaertanum* has been confirmed as a primary pathogen of *A. mangium* root rot (Hidayati et al. 2014) (Table 3).

28. *Ganoderma subresinosum* (Murrill) C.J. Humphrey, Mycologia 30(3): 332 (1938) Fig. 17

= *Fomes subresinosus* Murrill (1908)

= *Polyporus mamelliporus* Beeli, Bull. Soc. R. Bot. Belg. 62: 62 (1929)

= *Trachyderma subresinosum* (Murrill) Imazeki, Bull. Gov. Forest Exp. Stn Tokyo 57: 119 (1952)

= *Magoderna subresinosum* (Murrill) Steyaert, Persoonia 7(1): 112 (1972)

= *Amauroderma subresinosum* (Murrill) Corner, Beih. Nova Hedwigia 75: 93 (1983)

Facesoffungi number: FoF03808

Basidiome annual, sessile (with distinctly contracted base), weakly laccate, woody. *Pileus* 16–20 × 11–13 cm, up to 4 cm thick at the base, sub-orbicular; upper surface dark brown (8F4), radially rugose, concentrically sulcate with irregularly ruptured crust overlying the context; margin blunt or wavy, yellow brown; lower surface brownish orange (6C4). *Hymenophore* up to 20 mm long, indistinctly stratose; pores initially greyish orange (5B3), bruising brownish orange (6C4), pores circular, 3–5 per mm. *Context* up to 2 cm thick, duplex, dry; lower layer, light orange (5A4), fibrous, composed of coarse loose fibrils; upper layer brownish orange (6C5), corky. *Basidiospores*

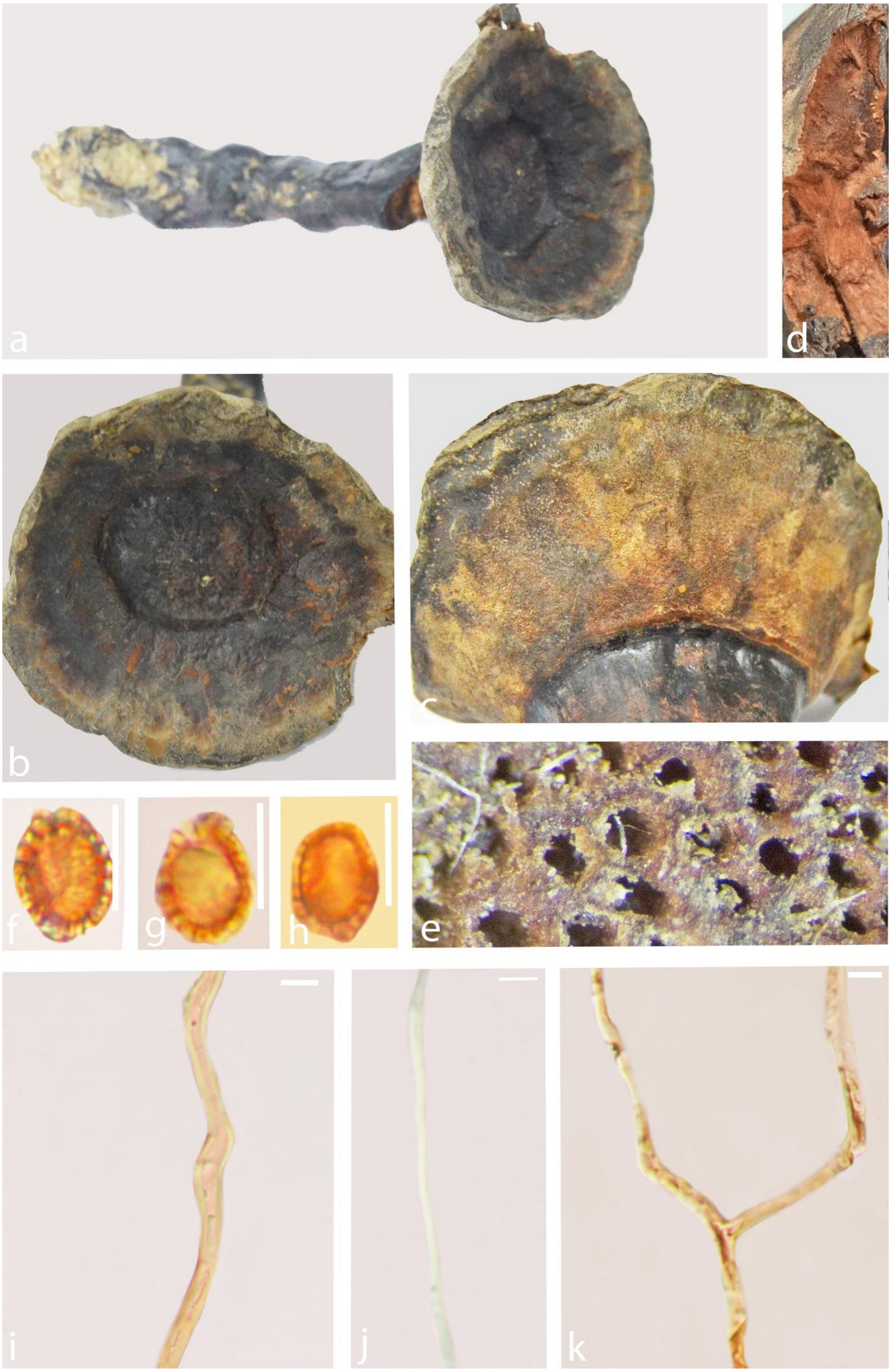


Figure 16 – *Ganoderma sinense* (GACP17092559). a, b Upper surface. c Lower surface. d Section of pileus. e Pores in the lower surface (5×). f–h Spores (100×). i Skeletal hyphae (100×). j Generative hyphae (100×). k Binding hyphae (100×). Scale bars: f – i =10 µm, j – l =5 µm.

Figure 17 – *Ganoderma subresinosum* (GACP18011907). a Upper surface. b Lower surface. c Section of pileus. d Pores in the lower surface (5×). e–h Spores (100×). i Binding hyphae (100×). j Skeletal hyphae (100×). Scale bars: e – h = 10 μm, i – k = 5 μm.

(n = 25) (13.3–)13.9–*15.3*–16.5(–17.8) × (8.0–)9.2–*10.2*–11.1(–12.1) µm (Q_m =1.5, Q = 1.3–1.9, with myxosporium). (11.6–)12.2–*13.5*–14.8(–16.3) × (6.3–)7.3–*8.4*–9.5(–10.4) µm (Q_m =1.6, Q = 1.3–2.2, without myxosporium), ellipsoid to ellongate, orange (6A6), pale orange (6A3) to greyish orange (5B4), with a brown eusporium bearing fine, short, and distinct echinulae, overlaid by a hyaline myxosporium. *Pileipellis* a hymeniderm, light orange (5A4), clavate like cells, dextrinoid. *Context* dimitic; generative hyphae not observed; skeletal hyphae (n = 25) (2.2–*3.1*–4.0) µm in width, thick-walled, nearly solid, sometimes branched, orange white (5A2); binding hyphae (n = 20) (1.4–*2.3*–3.3) µm in width, thick-walled, branched, nearly solid, brownish orange (6C4).

Habitat – On a decaying wood log, accompanied in humus rich soil with over heavily rotted litter on the ground.

Specimens examined – LAOS, Savannakhet Province, Dong Phou Vieng, mixed deciduous forest, 16°23′N–105°59′E, elev. 283 m, 21 June 2017, P. Phensinthgthem (GACP18011907, GACP18011908). CHINA, Hainan Province, Wuzhishan Mountain, Coniferous rainforest, 18°53′N–109°38′E, elev. 1240 m, 16 August 2014, T.C. Wen (GACP14081663, GACP14081690).

Notes – Murrill (1908) introduced this species from the Philippines, as *Fomes subresinosus*, which characterized by smooth and hyaline basidiospores. Humphrey (1938) transferred this species to *Ganoderma* and Imazeki (1952) included this species in the genus *Trachyderma* as *T. tsunodae* Imazeki. Steyaert (1972) introduced the genus *Magoderna*, typified by *M. subresinosus* to accommodate species with dimidiate to pleuropodal basidiomata, anticlinal hyphae in the pilear surface and ovoid-ellipsoid to spherical basidiospores without a truncate apex. Furthermore, the genus has been considered as synonym of *Amauroderma* (*A. subresinosum*) (Corner 1983). However, this species is now recorded as *G. subresinosum* in Index Fungorum (www.indexfungorum/org/names/Names.asp). Later on, some researchers suggested *Magoderna (M. subresinosum*) might be accepted at generic level based on morphological and molecular data (Gomes-Silva et al. 2015, Costa-Rezende et al. 2016, 2017). This species was recorded from China by Teng (1963) as *Fomes subresinosum* and later reported by many Chinese researchers (Tai 1979, Teng 1996, Zhao 1989, Zhao & Zhang (2000). The known distribution of this species extends from the Philippines to West Africa through Malaysia, Myanmar, India, Sri Lanka, Borneo Island and Eastern and Central Africa (Steyaert 1972). In this study, we present first record of this taxon from Laos with the molecular and morphological evidence.

29. ***Ganoderma theaecola*** J.D. Zhao (1984) [as *'theaecolum'*], in Zhao, Xu & Zhang, Acta Mycol. Sin. 3(1): 16 (1984) Fig. 18

Facesoffungi number: FoF05667

Basidiome perennial, sessile, usually with a distinctly contracted base, laccate, woody. *Pileus* 4–8 × 2–5 cm, up to 1 cm thick at the base, sub-orbicular, rotund, upper surface; reddish brown (8E8) to dark brown (8F8) alternating color zones, concentrically sulcate zones with turberculate bumps and ridges and rivulose depressions, with irregularly ruptured crust overlying the pellis, margin; 4 mm thick, blunt, dark brown (8F8); lower surface; light brown (7D5). *Hymenophore* up to 20 mm long, indistinctly stratose; pores initially greyish brown (7D3), bruising dark brown (6E6), pores circular, 3–5 per mm. *Context* up to 0.8 mm thick, duplex, dry; upper layer light brown (6D6), fibrous, composed of coarse loose fibrils; upper layer reddish brown (8E8), woody. *Basidiospores* (n = 20) (7.6–)8.4–*9.2*–10.1(10.6–) × (–6.4)6.6–*7.1*–7.6(–7.9) µm (Q_m = 1.3, Q = 1.1–1.4, with myxosporium). (5.9–)6.9–*7.6*–8.4(–8.9) × (4.6–)5.1–*6.0*–6.9(–9.3) µm (Q_m = 1.3, Q = 0.8–1.7, without myxosporium), ellipsoid, light brown (6D6), with a brown (6E6) eusporium bearing fine, short, and distinct echinulae, overlaid by a hyaline myxosporium. *Pileipellis* a hymeniderm, brownish orange (6C8), clavate like cells, dextrinoid. *Context* trimitic; generative hyphae (n = 20) (0.3–*0.6*–1.1) µm in width, hyaline, thin walled without clamp connections; skeletal hyphae (n = 20) (3.5–*4.0*–4.8) µm in width, thick-walled, nearly solid, sometimes branched, light brown (6D6); binding hyphae (n = 20) (3.2–*4.1*–5.3) µm, thick-walled, branched, nearly solid, light brown (6D6).

Habitat – On a decaying hardwood tree trunk, accompanied in humus rich soil with over heavily rotted litter on the ground.

Specimens examined – CHINA, Hainan Province, Diaoluoshan National Nature Reserve, 18°68′N-109°95′E, elev. 1058 m, collection date unknown, X.L Wu (GACP HNU02, GACP HNU58) (from Herbarium of Guizhou Agricultural sciences; GAS3359).

Notes – *Ganoderma theaecola* was introduced from Guangxi, China as a laccate *Ganoderma* species (Zhao et al. 1984). In Index Fungorum, as an editorial comment, it is mentioned that the orthography of this specific epithet is uncertain (www.indexfungorum.org, accessed 22 December 2018). Since the type specimens located in herbarium of Chinese Academy of Sciences, is scanty and difficult to observe, we have loaned a reference specimen from the herbarium of Guizhou Agricultural Sciences. Basidiospore size is mentioned as (7–9 × 5.2–6.2) µm (Zhao et al. 1984), (6–9 × 5–6) µm (Wu & Dai 2005) and (8.4–10.1 × 6.6–7.6) µm (This study). Furthermore, there is no molecular data available for this species in GenBank.

30. *Ganoderma tropicum* (Jungh.) Bres. Annls mycol. 8(6): 586 (1910) Fig. 19

≡*Polyporus tropicus* Jungh. (1838)

= *Polyporus tropicus* Jungh. (1838)

= *Fomes tropicus* (Jungh.) Cooke, Grevillea 14(no. 69): 19 (1885)

= *Scindalma tropicum* (Jungh.) Kuntze, Revis. gen. pl. (Leipzig) 3(2): 519 (1898)

Facesoffungi number: FoF05661

Basidiome annual, sessile (usually with a distinctly contracted base), strongly laccate, woody. *Pileus* 4–8 × 2.5–6 cm, up to 1 cm thick at the base, spathulate, plano convex; upper surface hard, several layers thick, yellowish brown (5F8), orange (6D8) to brown (7E8), crust overlies the pellis, containing fibrous pithy context, swollen differentiated zone at the point of attachment; margin soft, 1 cm thick, rounded, white (5A1); lower surface white (5A1) to orange (5B2). *Hymenophore* up to 4 mm long, indistinctly stratose, white (5A1) to orange (5B2), pores sub circular or isodiametric, 3–5 per mm. *Context* up to 3 cm thick, dry, duplex; lower layer brown (7E8), fibrous, composed of coarse loose fibrils, soft; upper layer light brown (5A5), woody. *Basidiospores* (n = 25) (10.8–)11.2–*12.1*–12.8(–13.1) × (8.3–)9.6–*10.1*–10.8(–11.1) µm (Q_m = 1.3, *Q* = 0.9–1.5, with myxosporium). (7.9–)8.8–*9.1*–10.2(–10.8) × (5.8–)6.4–*7.3*–7.8(–9.8) µm (Q_m = 1.3, *Q* = 1.1–1.7, without myxosporium), broadly ellipsoid, brownish orange (6C8) to light brown (5A5) eusporium bearing fine, short and distinct echinulae, overlaid by a hyaline myxosporium, bitunicate. *Pileipellis* a hymeniderm, greyish orange (5B5) to brown (6E8), composed of apically acanthus like branched cells, dextrinoid. *Context* trimitic; generative hyphae (n = 30) (0.4–)0.6–*1.4*–1.8(–2.6) µm in width, thin-walled, hyaline skeletal hyphae (n = 30) (2.8–)3.1–*3.4*–3.8(–4.3) µm in width, light brown (6D4), thick walled, sometimes branched; binding hyphae (n = 30) (1.1–)2.2–*2.5*–3.4(–3.8) µm in width, light brown (6D4), thick walled, branched, intertwined the skeletal hyphae.

Habitat – On a decaying Dipterocarpus tree, wood log, accompanied in humus rich soil with over heavily rotted litter in forest, mossy coniferous forests.

Specimens examined – CHINA, Hainan Province, Jiangfengling Mountain, Coniferous rainforest, 18°44′N–108°51′E, elev. 550 m, collection date unknown, X.L Wu (GACP HNU21, GACP HNU25), Wuzshishan Mountain, Coniferous rainforest, 18°53′N–109°38′E, elev. 1240 m, 15 August 2014, T.C Wen (GACP14081511, GACP14081518). LAOS, Savannakhet Province, Phin District, Dong Phou Vieng Protected Area, 16 58′N–105 89′E, elev. 173 m, 07 June 2017, P. Phengsintham (GACP17060701).

Notes – *Ganoderma tropicum* was introduced as *Polyporus tropicus* by Junghuhn (1838) from Java, Indonesia and later, Bresadola (1910) transferred this species to *Ganoderma*. This species widely distributed in lowland of tropical Asia and its taxonomy has been well resolved with the aid of molecular data (Wang et al. 2012, Yang & Feng 2013). *Ganoderma tropicum* consider as a member of *G. lucidum* species complex (Zhou et al. 2015). Among the Chinese *Ganoderma* species, *G. flexipes*, *G. multipileum*, *G. sichuanense*, and *G. tsugae* are the mostly similar species to *G. tropicum* since they share a reddish brown pileal surface, similar basidiospores and cuticle cells,

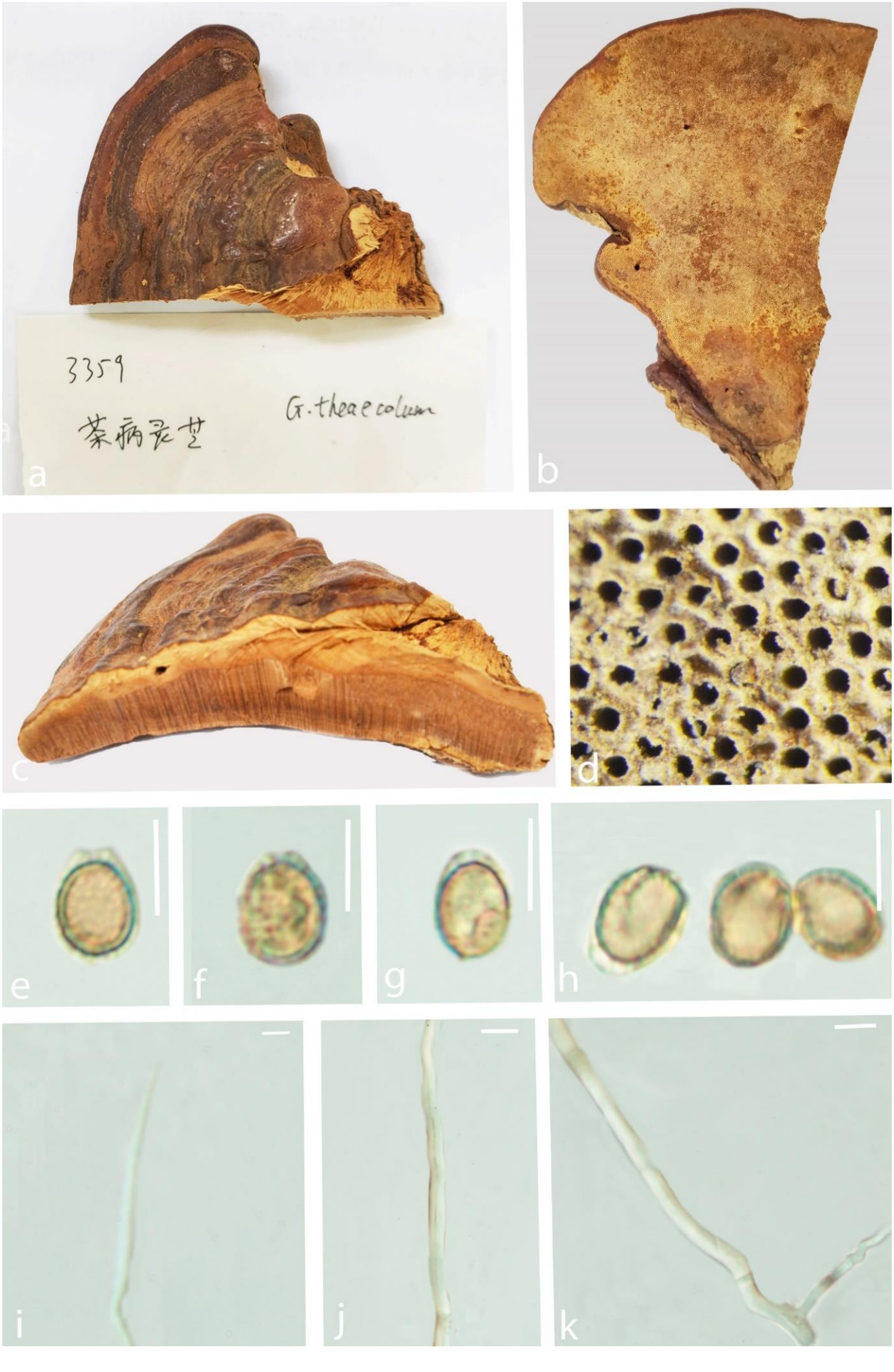


Figure 18 – *Ganoderma theaecola* (GAS3359). a Upper surface. b Lower surface. c Section of pileus. d Pores in the lower surface (5×). e–h Spores (100×). i Generative hyphae (100×). j Skeletal hyphae (100×). k Binding hyphae (100×). Scale bars: e – h =10 µm, i – k = 5 µm.

Figure 19 – *Ganoderma tropicum* (GACP14081511). a Upper surface. b Lower surface. c Section of pileus. d Pores in the lower surface (5×). e–g Spores (100×). h Binding hyphae (100×). i Generative hyphae (100×). j Skeletal hyphae (100×). Scale bars: e–g = 10 μm, h–j = 5 μm.

however *G. tropicum* differs from *G. multipileum, G. lingzhi* and *G. sichuanense* by having strongly echinulate basidiospores, dark brown context, concentric growth zones in the context, mostly irregular cuticle cells and sessile basidiocarps respectively (Cao et al. 2012). *Ganoderma tropicum* inhabits Fabaceae trees (Cao et al. 2012). This fungus causes white root and butt rot on several species of *Acacia* in forest plantations in China (Dai et al. 2007) (Table 3) and it is one of the most aggressive pathogens that causes basal stem rot in oil palm (Turner 1981, Wong et al. 2012).

31. *Ganoderma tsugae* Murrill, Bull. Torrey bot. Club 29: 601 (1902)

= *Polyporus tsugae* (Murrill) Overh., Annual Report of the Missouri Botanical Garden, St. Louis 2: 714 (1915)

See the description and illustration at (Gilbertson & Ryvarden 1986)

Notes – *Ganoderma tsugae* was introduced by Murrill (1902) from USA and characterized by stipitate, fan shaped concentrically sulcated yellowish red pileus with yellow margin, ovoid, verrucose and truncated basidiospores. Distribution is known from USA, Canada to the Gulf Coast region (Gilbertson & Ryvarden 1986). *Ganoderma tsugae* group into *G. oregonense* in the Pacific Northwest and California in USA and the relationship between the two species was not certain (Gilbertson & Ryvarden 1986). Later, this species has been considered as a synonym of *G. lucidum* (Haddow 1931, Steyaert 1977). Moncalvo et al. (1995a) concluded that Asian *G. lucidum* was mistaken for *G. tsugae* based on molecular data. Furthermore, based on morphological data (Cao et al. 2012) suggested that *G. tsugae* found in north eastern China are identified as *G. lucidum* in Europe. However, later on it was concluded that *G. tsugae* as an independent species distinct from *G. lucidum* with the support of phylogenetic analysis (Zhou et al. 2015). *Ganoderma tsugae* is apparently restricted to conifers and causes white butt rot (Gilbertson & Ryvarden 1986) and especially on *Tsuga* and *Abies*, while *G. lucidum* inhabits mostly angiosperm trees (Dai et al. 2007, Zhou et al. 2015) (Table 3).

32. *Ganoderma weberianum* (Bres. & Henn. ex Sacc.) Steyaert, Persoonia 7(1): 79 (1972) Fig. 20

≡*Fomes weberianus* Bres. & Henn. ex Sacc. (1891)

Facesoffungi number: FoF05662

Basidiome annual, sessile (usually with a distinctly contracted base), strongly laccate, woody. *Pileus* 4–8 × 2.5–5 cm, up to 1 cm thick at the base, suborbicular, plano convex; upper surface hard, several layers thick, brown (5F8) to dark brown (6F6), concentric zones, crust overlies the pellis, containing fibrous pithy context, swollen differentiated zone at the point of attachment; margin soft, 0.5 cm thick, obtuse, white (5A1); lower surface light brown (5A5). *Hymenophore* up to 10 mm long, indistinctly stratose, initially light yellow (4A4), greyish yellow (4C5), pores sub circular or isodiametric, 4–6 per mm. *Context* up to 1.5 cm thick, dry, duplex; upper layer grayish yellow (3B5) to light brown (5A5), fibrous, composed of coarse loose fibrils, soft; lower layer dark brown (6F6), woody. *Basidiospores* (n = 25) (9.9–)10.4–*10.7*–11.2(–11.8) × (5.5–)6.7–*7.4*–8.0(–9.1) µm (Q_m = 1.5, *Q* = 1.2–1.9, with myxosporium). (6.2–)8.3–*9.0*–9.8(–10.2) × (4.7–)5.3–*5.8*–6.5(–7.4) µm (Q_m = 1.5, *Q* = 0.9–2.1, without myxosporium), ellipsoid, light brown (5A5) with a brown (6D8) eusporium bearing fine, short and distinct echinulae, overlaid by a hyaline myxosporium, bitunicate. *Pileipellis* a hymeniderm, greyish orange (5B5) to brown (6E8), composed of apically acanthus like branched cells, dextrinoid. *Context* trimitic; generative hyphae (n = 20) (0.7–*1.0*–1.4) µm in width, thin-walled, hyaline; skeletal hyphae (n = 20) (2.8–*3.9*–4.7) µm in width, light brown (6D4), thick walled, sometimes branched; binding hyphae (n = 20) (2.7–*3.5*–4.4) µm in width, light brown (6D4), thick walled, branched, intertwined the skeletal hyphae.

Habitat – On a decaying Dipterocarpus tree, wood log, accompanied in humus rich soil with over heavily rotted litter in forest, mossy coniferous forests.

Specimens examined – Materials from Herbarium of Guizhou Agricultural Sciences (GAS3364).

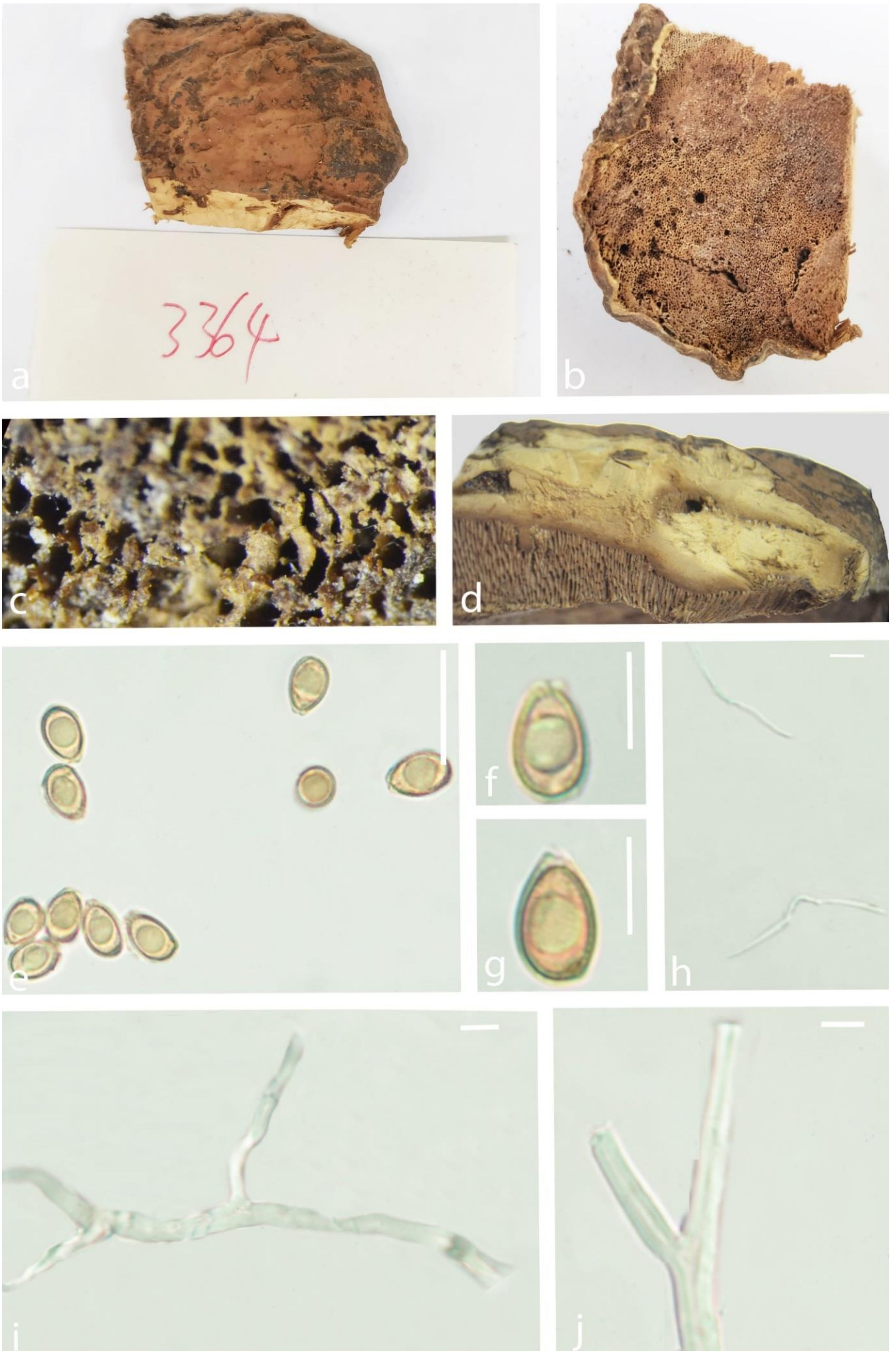


Figure 20 – *Ganoderma weberianum* (GAS3364). a Upper surface. b Lower surface. c Pores in the lower surface (5×). d Section of pileus. e–g Spores (100×). h Generative hyphae (100×). i Binding hyphae (100×). j Skeletal hyphae (100×). Scale bars: e–g = 10 μm, h–j = 5 μm.

Notes – *Ganoderma weberianum* is characterized by hard pileus crust, pale context that changes to yellow when cut with resinous incrustations, cylindrical pileipellis cells with granulations, and small basidiospores (Torres-Torres & Guzmán-Dávalos 2005) with abundant gasterospores in basidiome (Quanten 1997). This species is distributed Africa, Asia and Samoa Island (Steyaert 1972), Southeast Asia and Papua New Guinea (Corner 1983, Quanten 1997), Australia (Smith & Sivasithamparam 2000), China (Pan & Dai 2001, Wang et al. 2005), Singapore (Corner 1983), Brazil (Torres-Torres & Guzmán-Dávalos 2005) and India (Mohanty et al. 2011). *Ganoderma weberianum* is a pathogen of *Ficus*, and causes a white root and butt rot (Pan & Dai 2001).

33. *Ganoderma wiiroense* E.C. Otto, Blanchette, C.W. Barnes & Held. (2015)

See the description and illustration at (Crous et al. 2015)

Notes – *Ganoderma wiiroense* was introduced as a wood decaying *Ganoderma* species from Ghana recently, with the support of molecular data (Crous et al. 2015). This species is characterized by dimidiate, zonate and rounded margin pileus, trimitic hyphal system, ellipsoid to cylindrical-ellipsoid, truncate base, bitunicate and verrucose basidiospores (Crous et al. 2015). *Ganoderma wiiroense* causes decay in the roots and trunks of angiosperm trees in the upper west region of Ghana (Table 3) (Crous et al. 2015).

34. *Ganoderma williamsianum* Murrill, Bull. Torrey bot. Club 34: 478 (1907) Fig. 21

= *Elfvingia williamsiana* (Murrill) Imazeki, Bull. Gov. Forest Exp. Stn Tokyo 57: 106 (1952)

Facesoffungi number: FoF05663

Basidiome annual, sessile (usually with a distinctly contracted base), weakly laccate, woody. *Pileus* 3–7 × 2–6 cm, up to 2 cm thick at the base, suborbicular, plano convex, applanate; upper surface hard, several layers thick, brown (5F8), dark brown (6F6) to brownish red (8C8), orange yellow (4A8) near to edge, concentric zones, crust overlies the pellis, containing fibrous pithy context, swollen differentiated zone at the point of attachment; margin soft, 0.5 cm thick, obtuse, white (5A1); lower surface white (8A1). *Hymenophore* up to 8 mm long, not stratose, initially light brown (6D8), bruising greyish brown (6D3), pores circular, 4–6 per mm. *Context* up to 2 cm thick, dry, duplex; upper layer grayish brown (6D3) to light brown (5A5), fibrous, composed of coarse loose fibrils, soft; lower layer dark brown (6F6), woody. *Basidiospores* (n = 50) (8.7–)9.9–*10.8*–11.7(–12.5) × (5.1–)6.6–*7.5*–8.3(–9.6) µm (Q_m = 1.5, Q = 1.3–1.8, with myxosporium). (7.4–)8.1–*8.9*–9.8(–11.7) × (3.2–)5.0–*5.7*–6.6(–8.4) µm (Q_m = 1.5, Q = 1.3–1.9, without myxosporium), ellipsoid, light brown (5A5) with a brown (6D8) eusporium bearing fine, short and distinct echinulae, overlaid by a hyaline myxosporium. *Pileipellis* a hymeniderm, greyish orange (5B5) to brown (6E8), composed of apically acanthus like branched cells, dextrinoid. *Context* trimitic; generative hyphae (n = 30) (0.3–*0.8*–1.2) µm in width, thin-walled, hyaline; skeletal hyphae (n = 20) (0.4–*2.6*–4.4) µm in width, light brown (6D4), thick walled, sometimes branched; binding hyphae (n = 20) (1.2–*2.1*–3.7) µm in width, light brown (6D4), thick walled, branched, intertwined the skeletal hyphae.

Habitat – On a decaying Dipterocarpus tree, wood log, accompanied in humus rich soil with over heavily rotted litter in forest, mossy coniferous forests.

Specimens examined – CHINA, Hainan Province, Jiangfengling Mountain, Coniferous rainforest, 18°44′N–108°51′E, elev. 550 m, 13 August 2014, T.C Wen (GACP14081320, GACP14081321).

Notes – This common species is introduced from Philippines and easily recognized by small, dense, ungulate pileus with anamixodermic cuticle and pale yellow pores, rather large spores and very short skeletals (Corner 1983, Moncalvo & Ryvarden 1997). *Ganoderma williamsianum* superficially resembles members of the laccate *Ganoderma* group (Wang & Wu 2010). Furthermore, *Ganoderma brownii* is very similar to *G. williamsianum* in color of pore surface (Lowe & Gilbertson 1961, Gilbertson & Ryvarden 1986). However, *G. brownii* can be easily distinguished from *G. williamsianum* by having a dull pileus with a hard crust (Lowe & Gilbertson

1961) formed by hyphae arranged in a trichoderm (Steyaert 1972, Gottlieb & Wright 1999a), skeletal hyphae with occasional branching (Gilbertson & Ryvarden 1986), and smaller basidiospores (Lowe & Gilbertson 1961, Steyaert 1972, Gilbertson & Ryvarden 1986, Gottlieb & Wright 1999a). *Ganoderma williamsianum* is similar to *G. meijiangense* but distinguished from the latter by having dark brown context without any black crustose layer and a distinct cuticular composition (Zhao 1988). Later, based on type specimens it was suggested that *G. williamsianum* is the earliest valid name for *G. meijiangense* (Wang & Wu 2010). Our collections from Hainan Province, China are similar with the descriptions provided by Wang & Wu (2010). This species is distributed in China (Wang & Wu 2010, Xing et al. 2018), Indonesia (Imazeki 1952, Steyaert 1972), Philippines (Murrill 1907, Steyaert 1972) and Malaysia (Steyaert 1972).

35. *Ganoderma zonatum* Murrill, Bull. Torrey bot. Club 29: 606 (1902)

See the description and illustration at Ryvarden (2000)

Notes – *Ganoderma zonatum* is recognized by the distinct strongly amyloid irregular cuticle cells and the oblong basidiospores (Ryvarden 2000). This is a white rot fungus which cause butt rot in Palms (Schubert et al. 1997) and Cycads (Elliot & Broschat 2001) (Table 3) and often referred to as a member of the *G. lucidum* species complex (Adaskaveg & Gilbertson 1989). (Ryvarden 2000) mentioned that this species distribution is only known from USA, however, Foroutan & Vaidya (2007) and Cong (2010) reported this species from India and Brazil respectively.

Amauroderma P. Karst., 1881, Rev. Mycol. (Toulouse) 3, p. 17.

= *Amauroderma* (Pat.) Torrend, Brotéria, sér. Bot. 18: 121 (1920)

= *Ganoderma* sect. *Amauroderma* Pat., Bull. Soc. mycol. Fr. 5(2, 3): 75 (1889)

= *Lazulinospora* Burds. & M.J. Larsen, Mycologia 66(1): 97 (1974)

= *Magoderna* Steyaert, Persoonia 7(1): 111 (1972)

= *Whitfordia* Murrill, Bull. Torrey bot. Club 35: 407 (1908)

See the description at Ryvarden (2004b)

Basidiocarps annual or reviving for a second season, centrally-laterally stipitate, solitary or in small groups with several fused pilei, consistency coriaceous, corky to woody hard, seldom brittle. Pileus round, reniform to fan-shaped, concave, umbilicate to strongly infundibuliform, upper surface in varying colours from white, ochraceous, brown to almost black, finely tomentose to glabrous, dull to glossy with a distinct cortex or cuticle, often concentrically zoned and radially wrinkled, stipe rather thin and long, finely tomentose to glabrous, pore surface whitish to ochraceous when fresh, darkens when dry to brownish colours, pores round to angular and entire, large to small, tubes seldom stratified, context white, ochraceous to dark brown, cystidia absent, hyphal system dimitic, generative hyphae with clamps hyaline and thin-walled, skeletal hyphae arboriform to more rarely unbranched, hyaline to brown, those being hyaline often dextrinoid or without reaction in Melzer´s reagent, basidia bladder-like with 4 large curved sterigmata, basidiospores hyaline to pale yellow, sub-globose to cylindrical, dextrinoid to non-dextrinoid, bitunicate with the inner wall finely asperulate or very rarely smooth.

Type species – *Amauroderma regulicolo*r (Berk. ex Cooke) Murrill (= *Amauroderma schomburgkii*)

Notes – *Amauroderma* is a widespread tropical genus that usually occurs on roots of living or dead trees or, is more rarely, wood inhabiting and cause white rots (Furtado 1981, Ryvarden 2004a). After *Amauroderma* was described, Torrend (1920a,b) worked extensively on this genus in South America and published a crucial work based mainly on spore shape (globose or oblong, never truncate) and the presence of a stipe (usually dull, like the pilear surface) and recorded 28 species of *Amauroderma* placed within three sections. Furtado (1981) carefully revised this genus and recognized 27 species and defined *Amauroderma* by the globose to subglobose basidiospores, with double walls, stipitate basidiomes and a tropical distribution pattern. Twenty one species of *Amauroderma* were described by Ryvarden (2004a) from the Neotropics, using the same genus circumscription. However, according to Index Fungorum (www.indexfungorum.org, accessed 22

Figure 21 – *Ganoderma williamsianum* (GACP14081321). a Upper surface. b Lower surface. c Section of pileus. d Pores in the lower surface (5×). e Section of the context (40×). f–g Spores (100×). h Skeletal hyphae (100×). i Binding hyphae (100×). j Generative hyphae (100×). Scale bars: f–g = 10 µm, h–j = 5 µm.

March 2019), there are 135 binomials of this genus while (Kirk et al. 2008) mentioned 30 species. Macroscopically, *Amauroderma* shares similarities with *Ganoderma*, a similar basidiome shape of central or lateral stipe and laccate or dull surface. *Ganoderma* can be separated from *Amauroderma* by its distinctly truncate basidiospores, and most *Ganoderma* species grow on dead wood, while most *Amauroderma* species grow in the ground from buried roots/woods (Ryvarden 2004b). *Amauroderma* species are regarded as economically valuable because of their important medicinal properties and pathogenicity (Dai et al. 2007, 2009, Jiao et al. 2013, Chan et al. 2013). Taxonomic studies of *Amauroderma* in Asia have been carried out over many years by various researchers (Teng 1936, Zhao et al. 1979, Zhao & Zhang 1987, Li & Yuan 2015, Song et al. 2016). Twenty species have been recorded in China (Zhao & Zhang 2000), but among these, only six have been confirmed as *Amauroderma* based on both morphological characters and phylogenetic analyses: *A. austrosinense* J.D. Zhao & L.W. Hsu, *A. concentricum* Song, Xiao L. He & B.K. Cui, *A. perplexum* Corner, *A. rugosum* (Blume & T. Nees) Torrend, *A. subresinosum* (Murrill) Corner and *A. yunnanense* J.D. Zhao & X.Q. Zhang (Li & Yuan 2015). The other *Amauroderma* species recorded from China, have not been fully studied yet. Furthermore, members of this genus have been subsequently recorded from Thailand (Chandrasrikul et al. 2011), Myanmar (Thaung 2007) and Vietnam (Quang et al. 2011). Here, we record five *Amauroderma* species found within Sub Mekong region countries based on micro- and macro morphological characteristics together with molecular data.

36. *Amauroderma rude* (Berk.) Torrend [as 'rudis'], Brotéria, sér. bot. 18: 127 (1920) Fig. 22

≡*Fomes rudis* Berk. (1885)

See Index Fungorum for synonyms

Facesoffungi number: FoF05664

Basidiome annual, stipitate, laccate, corky. *Pileus* 12–6.5 × 5.5–2.5 cm, up to 0.5 cm thick at the base, orbicular to subreniform, mesopodal; upper surface reddish brown (8E5, 8E6, 8D5) to grayish brown (8F1) alternating colour zones, slightly concentrically sulcate with irregularly ruptured crust; margin soft, grayish brown (8F1); lower surface white (8A1), turns reddish white (8A2) when drying. *Hymenophore* up to 15 mm long, indistinctly stratose; pores initially brownish orange (5C4), bruising brown (6E8), pores circular, 4–6 per mm. *Context* up to 6 mm thick, duplex, dry; upper layer light brown (5D6), fibrous, composed of coarse loose fibrils, brown (6E8), corky; lower layer light brown (5A5), woody. *Stipe* eccentric or central, sub cylindrical, concolorous with the pileus, 4 × 9 cm. *Basidiospores* (n = 20) (11.2–)11.8–*12.5*–13.3(14.5–) × (–8.2)8.8–*9.8*–10.7(–11.3) µm (Q_m = 1.3, Q = 1.1–1.4, with myxosporium). (11.2–)8.3–*9.3*–10.4(–10.6) × (5.6–)5.8–*6.9*–8.0(–8.4) µm (Q_m = 1.3, Q = 1.1-1.6)), subglobose to broadly ellipsoid, brownish yellow (5B3), with a brown eusporium, overlaid by a hyaline myxosporium. *Pileipellis* a hymeniderm, brownish orange (5C4), clavate like cells, dextrinoid. *Context* trimitic; generative hyphae (n = 25) (0.3–*1.2*–2.6) µm, hyaline, thin-walled with clamp connections; skeletal hyphae (n = 25) (1.1–*2.8*–3.6) µm, thick-walled, nearly solid, sometimes branched, light brown (7D5); binding hyphae (n = 20) (0.7–*1.9*–2.5) µm, thick-walled, branched, nearly solid, light brown (7D5).

Habitat – Rotten wood, in dry dipterocarp forest and in upper mixed deciduous forest and growing up from soil.

Specimens examined – LAOS, Savvanakhet province, Phin district Phouxang Hae Protected Area, mixed deciduous forest, 16 58′N–105 89′E, elev. 173 m, 23 June 2017, P. Phengsintham (GACP17062326, GACP17062328). CHINA, Guizhou Province, Kaili, Coniferous rainforest, 18°44′N–108°51′E, elev. 550 m, 12 October 2017, T.C Wen (GACP17101201, GACP17101202). THAILAND, Chiang Mai Province, Mushroom Research Center, Coniferous rainforest, 19°20′N–98°44′E, elev. 770 m, 21 June 2015, K.K Hapuarachchi (GACP15062130, GACP 15062134).

Notes – *Amauroderma rude* was introduced as *Fomes rudis* by Berkeley in 1885 (Cooke 1885). Later, it was transferred to *Ganoderma* and *Amauroderma* (as *A. rude*) by Patouillard (1889) and Torrend (1920b) respectively. This species occurs in Africa, Asia and Oceania, and is mainly characterized by a soft, corky to spongy basidiomata, trichodermal pilear surface and globose to subglobose (9–11 × 7.5–9) µm, double-walled basidiospores with an ornamented inner layer (Furtado 1981). It was considered that *A. intermedium* was a synonym of *A. rude* due to a similar microstructures in pilear surface and spores (Furtado 1981). Later, Gomes-Silva et al. (2015)

suggested to keep these two taxa as distinct species based on the analysis of the type species, on the characteristics described by Furtado (1981) and on geographic distribution. Furthermore, *A. pseudoboletus* is treated as a synonym of *A. rude* (www.indexfungorum.org). However, Furtado (1981) and Ryvarden (2004b) differentiate *A. pseudoboletus* with a cortex-like pileipellis and larger (12–13 × 9–11) µm basidiospores from *A. rude* with a derm-like pileipellis and smaller (9–11 × 7.5–9) µm basidiospores. This concept was subsequently followed by other authors (Campacci & Gugliotta 2009). *Amauroderma rude* is distributed through Tasmania, Australia, Hong Kong, South Africa, New Caledonia (Furtado 1981) and China (Zhao & Zhang 2000). This species is very common in wattle plantations in South Africa and has been reported as the cause of decay of stumps and roots of *Acacia mollissima* (Van Der Westhuizen 1958). Even we were unable to obtain DNA, our collections agree well with the description provided by (Furtado 1981). In this study, we report *A. rude* as the first record from Laos based on morphological evidence.

37. *Amauroderma schomburgkii* (Mont. & Berk.) Torrend, Brotéria, sér. bot. 18(no. 2): 140 (1920) Fig. 23

≡ *Polyporus schomburgkii* Mont. & Berk. (1844)

See Index Fungorum for synonyms

Facesoffungi number: FoF05665

Basidiome annual to perennial, stipitate, corky, becoming hard corky to woody hard when dry. *Pileus* 3.0–4.5 cm, up to 1 cm thick at the base, suborbicular; upper surface when young pale yellow (4A3) to light brown (6D6), becoming brownish orange (6C8), alternating light brown (6D6) to brownish orange (6C8) concentric zones, weakly laccate to non laccate; lower surface usually pale orange; margin 2 mm thick, concolorous with pileus, slightly wavy. *Hymenophore* up to 12 mm long, indistinctly stratose; pores initially brownish orange (5C4), bruising brown (6E8), pores sub circular or isodiametric, 4-6 per mm. *Context* up to 6 mm thick, duplex, dry; upper layer light brown (5D6), fibrous, composed of coarse loose fibrils, brown (6E8), corky; lower layer light brown (5A5), corky. *Stipe* sub cylindrical to cylindrical, lateral to horizontally lateral or eccentric, dark brown (6F6), 2.5 ×4, 0.5 cm at the base. *Basidiospores* (n = 30) (7.5)8.6–*9.8*–11.0(12.3) × (5.4)6.6–*7.9*–9.3(10.8) µm (Q_m = 1.3, Q = 1.1–1.7, with myxosporium) (6.1)6.9–*7.9*–9.0(10.0) × (4.4)5.3–*6.4*–7.5(8.5) µm (Q_m = 1.3, Q = 1.1–1.7, without myxosporium), light brown (6D6), with a dark brown (6F4) eusporium bearing thick echinulae, overlaid by a hyaline myxosporium, sub globose to broadly. *Pileipellis* a hymeniderm, brownish orange (5C4), clavate like cells, dextrinoid. *Context* dimitic; generative hyphae not observed; binding hyphae (n = 25) (1.2–*2.3*–3.1) µm in width, branched, with clamp-connections, light brown (6D6) to brown (6E6); skeletal hyphae (n = 25) (1.3–*2.6*–3.7) µm in width, thick walled, sometimes branched, brown (6E6).

Habitat – Rotten wood, on the soil near in humus rich soil with over heavily rotted litter on the ground, growing up from soil.

Specimens examined – LAOS, Xiengkhouang Province, Phoukoud District, Yai village, Evergreen forest, 19 58′N–103 00′E, elev. 1120 m, 27 July 2016, P. Phengsintham (GACP16072703, GACP16072833). CHINA, Hainan Province, Jiangfengling Mountain, Coniferous rainforest, 18°44′N–108°51′E, elev. 550 m, 25 September 2017, T.C Wen (GACP14080901, GACP14080905).

Notes – *Amauroderma schomburgkii* is the type species of *Amauroderma*. The reddish brown pileus, brown context, small pores and the globose basidiospores characterize this species and *A. sprucei* is separated only by its white to pale cream context (Ryvarden 2004a). Our collections agree well with the descriptions provided by Furtadoa (1981). Basidiomes of *Amauroderma* show a wide variation in dimension, texture, shape and color, which has caused the description of many taxa having same microstructure as *A. schomburgkii* (Furtadoa 1981). This is the most common taxon of *Amauroderma* in Neotropical collections and known from southern Brazil to Cuba, Puerto Rico, Jamaica (Ryvarden 2004a) and China (Zhao 1989, Zhao & Zhang 2000). We report *A. schomburgkii* from Laos as a new record based on morphological evidence.

Haddowia Steyaert, Persoonia 7(1): 108 (1972)

See the description at Ryvarden & Johansen (1980)

Basidiome stipitate, pileate with shiny laccate pileus, reddish to blackish-brown, stipe laccate and shiny, pore surface light-colored, context white to pale straw-colored, pores 2–3 per mm, hyphal system trimitic with clamped generative hyphae, binding hyphae and skeletal hyphae, spores with longitudinal double crests connected by small transverse membranes.

Type species: *Haddowia longipes* (Lév.) Steyaert.

Notes – *Haddowia* was introduced by Steyaert (1972) to accommodate *Polyporus longipes* and *Haddowia aetii*. This genus is characterized by pale context and longitudinally crested 'amaurodermatoid' basidiospores (Costa-Rezende et al. 2017).

38. *Haddowia longipes* (Lév.) Steyaert, Persoonia 7(1): 109 (1972) Fig. 24

≡*Polyporus longipes* Lév. (1846)

Facesoffungi number: FoF05666

Basidiome annual to perennial, stipitate, mesopodal, corky, becoming woody when dry. *Pileus* 3–8 cm, up to 0.3 cm thick at the base, reniform; upper surface light yellow (3A5) to yellowish white (3A2) when young, becoming brown (6E4) when old, strongly laccate, slightly concentrically sulcate, slightly depressed in the mid; margin soft, obtuse, 1 mm thick, white (4A1); lower surface white (4A1). *Hymenophore* up to 5 mm long, indistinctly stratose, pores circular, sub circular or iso diametric, 2–3 pores per mm. *Context* up to 3 mm thick, dry, duplex, not completely homogeneous in color, upper layer light brown (5D6), fibrous, composed of coarse loose fibrils, brown (6E8), corky; lower layer pale brown (5A5), woody. *Stipe* stout cylindric, concolorous with the pileus, lateral to horizontally lateral or eccentric, 12 × 7 cm. *Basidiospores* (n = 25) (10.8)11.6–*12.7*–13.8(14.6) × (9.3)10.3–*10.9*–11.6(12.0) µm (Q_m = 1.2, Q = 0.9–1.3, with myxosporium) (8.8)10.0–*10.9*–11.8(12.8) × (7.7)8.7–*9.5*–10.3(10.5) µm (Q_m = 1.2, Q = 1.0–1.4, without myxosporium), sub globose to broadly ellipsoid, brown (6E8) to dark brown (6F8), with a yellowish orange (4B7) eusporium bearing thick echinulae, overlaid by a hyaline myxosporium, with longitudinal double crests partly connected with short transverse walls. *Pileipellis* a hymeniderm, pale yellow (4A3) streaks the cutis, a closely-packed palisade, yellowish white (4A2), club shaped terminal elements. *Context* trimitic; generative hyphae (n = 25) (1.1–*1.3*–1.6) µm in width, colorless, thin-walled; skeletal hyphae (n = 25) (2.4–*3.1*–4.1), thick walled, sometimes branched, grey (4B1), dextrinoid; binding hyphae (n = 25) (2.6–*3.5*–4.4) µm in width, grey (4B1), branched.

Habitat – Rotten wood, dry root area, in dry dipterocarp forest and in upper mixed deciduous forest and growing up from soil.

Specimens examined – LAOS, Xiengkhouang Province, Phoukoud District, Yai village, Evergreen forest, 19º58′N–103º00′Eº, elev. 1120 m, 27 July 2017, P. Phengsintham (GACP17072708, GACP17072710).

Notes – *Haddowia longipes* was introduced as *Polyporus longipes* (Steyaert 1972). Torrend (1920b) transferred this species into *Amauroderma* based on morphology: spherical stalk, distinct thorns and longitudinally parallel strips with crested basidiospores with the size of (12.0–14.0) µm. Microscopically the species should be easy to recognize because of the crested spores and the basidiome reminds of a *Ganoderma* species (Ryvarden & Johansen (1980).Steyaert (1972) combined this species into the genus *Haddowia* describing the ellipsoid basidiospores: (12.0–*15.3*–19.0 × 10.0–*12.0*–14.5) µm. Ryvarden & Johansen (1980) mentioned the basidiospore size as (12.0–*17.0*–19.0 × 10.0–*14.0*–15.0) µm. Furtado (1981) observed oval shape basidiospores with the size of (12.0–14.0 × 10.0–12.0) µm. In our study, we observed crested basidiospores with the size of (12.0–14.0 × 10.0–12.0) µm. Combined molecular data of ITS, nrLSU and nrSSU clearly make *Haddowia* as an independent clade from *Ganoderma* and *Amauroderma*. This species is reported from Africa and Neotropical countries (Steyaert 1972, Ryvarden & Johansen 1980, Corner 1983), Australia's overseas territory, Christmas Island, Angola, French Guiana, Costa Rica, Kenya

Figure 22 – *Amauroderma rude* (GACP18011905). a, b Upper surface. c Lower surface. d Pores in the lower surface (5×). e Section of pileus. f–i Spores (100×). j Generative hyphae (100×). k Binding hyphae (100×). **i** Skeletal hyphae (100×). Scale bars: f–i= 10 µm, j–l= 5 µm.

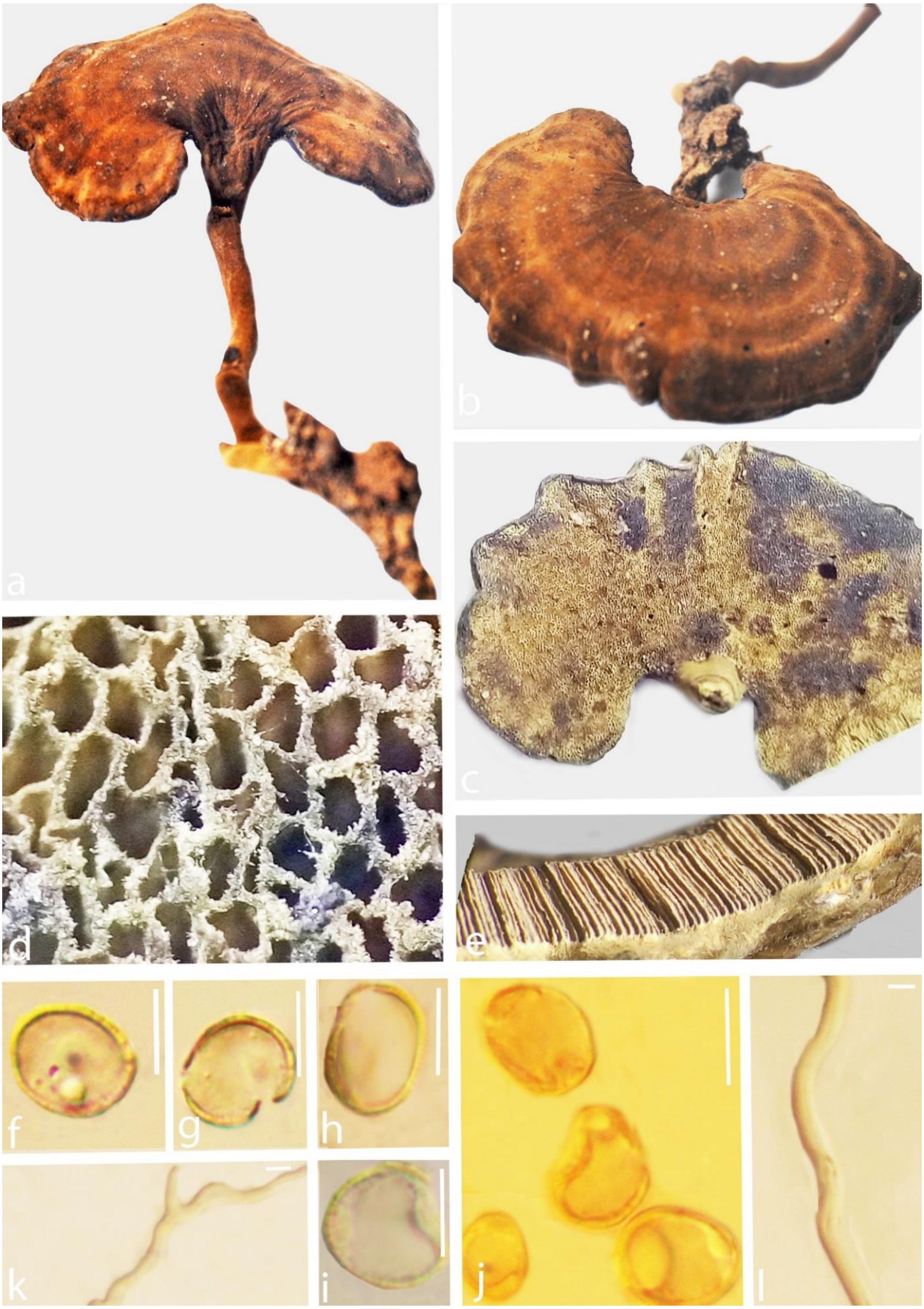


Figure 23 – *Amauroderma schomburgkii* (GACP16072833). a,b Upper surface. c Lower surface. d Pores in the lower surface (5×). e Section of pileus. f–j Spores (100×). k Binding hyphae (40×). i Skeletal hyphae (40×). Scale bars: f–j = 10 µm, k–l = 5 µm.

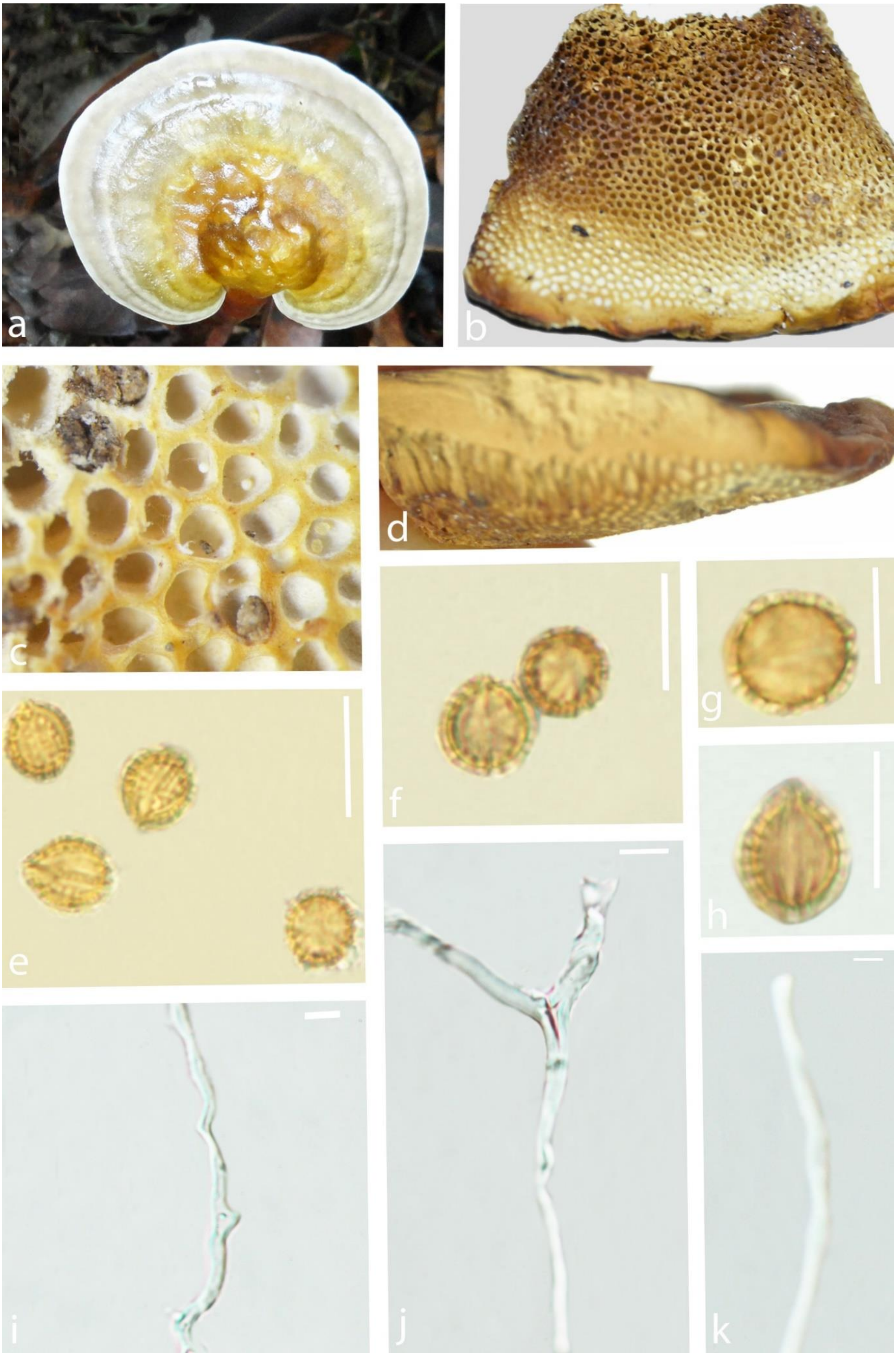


Figure 24 – *Haddowia longipes* (GACP17072708). a Upper surface. b Lower surface. c Pores in the lower surface (5×). d Section of pileus. e–h Spores (100×). i Skeletal hyphae (100×). j Binding hyphae (100×). k Generative hyphae (100×). Scale bars: e–h = 10 µm, i–k = 5 µm.

(Furtado 1981), China (Teng 1963, Tai 1979, Zhao 1989, Zhao & Zhang 2000, Zhang et al. 2015), India, Philippines (Ryvarden & Johansen 1980) and Laos (This study).concept of *Humphreya* may represent a genus independent of *Ganoderma* (Costa-Rezende et al. 2017). However, *Humphreya*'s position at genus level is still uncertain given the lack of sufficient DNA sequence data analyses (Costa-Rezende et al. 2017). Currently there are four species, i.e. *H. coffeata*, *H. eminii*, *H. endertii* and *H. lloydii* described under this genus according to Index Fungorum (www.indexfungorum.org, accessed 22 March 2019).

Humphreya Steyaert, Persoonia 7(1): 98 (1972)

See the description at Steyaert (1972)

Basidiome stipitate, pileus dull to glossy, yellow to dark brown, shiny to dull, pores small to medium, context ochraceous. Hyphal system di-trimitic, generative hyphae with clamps, hyaline, skeletal hyphae arboriform with long unbranched lower segments, moderately to richly-branched, in the top, hyaline to pale-yellowish, cuticle a palisade of clavaroid elements arising from generative hyphae, with age becoming thickened and brown at the apex. Cystidia none. Spores large, 10–35 µm long, truncate and ornamented with a reticulate pattern of ridges, covered with a thin hyaline episporium, usually collapsed in dry specimens.

Type species – *Humphreya lloydii* (Pat. & Har.) Steyaer

Notes – Steyaert (1972) proposed the genus *Humphreya* to accommodate *Amauroderma lloydii*, *Polyporous coffeatus* and *Humphreya endertii* due to their hyphal disposition and basidiospore ornamentation. *Humphreya* species has pale context and basidiospores with truncate apex and the endosporium ornamented by typical longitudinal ridges (Costa-Rezende et al. 2017). However, *Ganoderma coffeatum* has typical basidiospores with endosporic ornamentation as predominantly longitudinal ridges and with a known distribution in South and Central America (Decock & Herrera-Figueroa 2007). Hence, latter authors declined the combination of Steyaert (1972) since the vicinity of *G. coffeatum* and *H. lloydii* is uncertain. Later, it was concluded that the *G. coffeatum* clustered in an independent clade from the typical *Ganoderma* species and the

Foraminispora Robledo, Costa-Rezende & Drechsler-Santos, Persoonia 39, 254–269 (2017)

See the description at Costa-Rezende et al. (2017)

Basidiomata annual, stipe pleuropodal to pseudomesopodal, pileus circular to spathulate. Pilear surface glabrous, greyish brown to dark brown, concentrically zonate with thin blackish bands, radially rugose. Context white, homogenous, in section with a shiny black cuticle. *Tubes* slightly darker than context. Pore surface whitish to vivid orange. Pores regular, circular to angular. Dissepiments thick, entire. *Stipe* cylindrical, pale to dark brown, finely tomentose, solid to hollow, context homogeneous, whitish, in section with a shiny dark cuticle. Hyphal system dimitic, generative hyphae clamped, arboriform and skeleto-binding hyphae almost hyaline, dextrinoid. Cystidia and cystidioles absent. Basidia clavate, with four sterigmata. Basidiospores subglobose, hyaline to pale brown, double walled, with conspicuous ornamentation as endosporic projections column-like, some of them with a hole, that persists up to the exospore, IKI-.

Type species – *Foraminispora rugosa* (Berk.) Costa-Rezende, Drechsler-Santos & Robledo

Notes – *Foraminispora* was introduced to accommodate *Porothelium rugosum* Berk. (= *Amauroderma sprucei*) and is characterized by stipitate basidiomata, dull pilear surface, whitish context, a dimitic hyphal system, skeleto-binding hyphae with lateral and apical branches and arboriform skeletal hyphae, both dextrinoid, and globose to subglobose, hyaline to pale brown spores, with conspicuous endosporic projections. These columnar endosporic projections are hollow and these holes persist until the exospore wall. This feature is unique for this genus (Costa-Rezende et al. 2017). *Foraminispora* belongs to Ganodermataceae because it has clamped generative and arboriform skeletal hyphae, the double-walled basidiospores, with the inner layer ornamented (Costa-Rezende et al. 2017). Macro- and microscopic features of *Foraminispora* are similar with *Amauroderma*, however, perforated columns in basidiospores are absent in this genus (Furtado 1962, 1981, Ryvarden & Johansen 1980, Corner 1983, Ryvarden 2004a). *Ganoderma* also presents species with pale context and double-walled spores with endosporic ornamentation

(Ryvarden & Johansen 1980, Corner 1983, Ryvarden 2004b, Torres-Torres & Guzmán-Dávalos 2012), but absence of hollow columns (some species) and the truncate apex of basidiospores clearly distinguish *Ganoderma* from *Foraminispora* (Costa-Rezende et al. 2017). *Haddowia* and *Humphreya* differ from this genus by having double-walled spores with endosporic ornamentation formed by ridges (Costa-Rezende et al. 2017). *Tomophagus* mainly differs from *Foraminispora* by its laccate and soft pileus and truncate basidiospores (Murrill 1905c, Steyaert 1972, Ryvarden 2004b, Le et al. 2012).

39. *Foraminispora rugosa* (Berk.) Costa-Rezende, Drechsler-Santos & Robledo (2017)

= *Porothelium rugosum* Berk., Hooker's J. Bot. Kew Gard. Misc. 8: 237. (1856)

See the description and illustration at Decock & Herrera-Figueroa (2005) as *Amauroderma sprucei*.

Notes – This species is characterized by the predominantly subglobose basidiospores with conspicuous hollow columnar ornamentation, di-trimitic hyphal system and the strongly dextrinoid skeletal hyphae (Decock & Herrera-Figueroa 2005, Costa-Rezende et al. 2017). When *Porothelium rugosum* was combined in *Ganoderma* the epithet 'rugosum' was already occupied by *Ganoderma rugosum*, hence, the name *Ganoderma sprucei* was proposed. Torrend (1920b) continued to use 'sprucei', the earliest epithet available in *Amauroderma* (as *A. sprucei*). Considering the combination of *Porothelium rugosum* in *Foraminispora* the epithet is available (Costa-Rezende et al. 2017). Specimens growing on the ground or on decayed angiosperm wood in Brazil, Venezuela, French Guiana, Costa Rica and Cuba (Decock & Herrera-Figueroa 2005).

Furtadoa Costa-Rezende, Robledo & Drechsler-Santos, in Costa-Rezende, Robledo, Góes-Neto, Reck, Crespo & Drechsler-Santos, Persoonia 39: 263 (2017)

See the description at Costa-Rezende et al. (2017)

Basidiomata annual, stipe pleuropodal to pseudomesopodal, soft when fresh, light and fragile when dried, pileus circular to almost flabelliform or funnel-shaped. Pilear surface dull, glabrous, greyish brown, azonate. Context white to pale brown, homogenous. *Tubes* slightly darker than context. Pore surface pale brown. Pores angular, sometimes radially elongated. Dissepiments thin, entire to lacerate. Stipe yellowish brown, finely tomentose, solid to hollow, context homogeneous, pale brown. Hyphal system dimitic. Context composed of clamped to simple septate generative hyphae, thin to slightly thick-walled, some distinctly wider, with a swollen apex. Trama of tubes composed of clamped generative and arboriform skeletal hyphae. Cystidia and cystidioles not seen. Basidia clavate, with four sterigmata. Basidiospores subglobose to ellipsoid, hyaline, double walled, with ornamentation as endosporic projections column-like, IKI-.

Type species: *Furtadoa biseptata* Costa-Rezende, Drechsler-Santos & Reck

Notes – *Furtadoa* was introduced to accommodate *Furtadoa biseptata*, *F. brasiliensis* (= *Amauroderma brasiliensis*), *F. corneri* (= *A. corneri*) and is characterized by a stipitate basidiomata, soft when fresh, dull pilear surface, pale context, a dimitic hyphal system, with a monomitic context, composed of both clamped and simple-septate generative hyphae, thin to slightly thick-walled and dimitic trama of tubes, composed of clamped generative hyphae and arboriform skeletal hyphae and double-walled, ornamented basidiospores (Costa-Rezende et al. 2017). *Furtadoa* is considered as member of Ganodermataceae due to its double-walled basidiospores with ornamented inner layer. Macro- and microscopic features of *Furtadoa* are similar to *Amauroderma*, however the monomitic context with simple-septate generative hyphae is exclusive of this new genus (Costa-Rezende et al. 2017).

40. *Furtadoa biseptata* Costa-Rezende, Drechsler-Santos & Reck, in Costa-Rezende, Robledo, Góes-Neto, Reck, Crespo & Drechsler-Santos, Persoonia 39: 265 (2017).

See the description and illustration at Costa-Rezende et al. (2017)

Notes — *Furtadoa* was typified by *F. biseptata* and this species differs from *Furtadoa brasiliensis* by its thinner basidiomata, darker context, and the presence of simple septate generative hyphae in the context. *F. corneri* differs from *F. biseptata* by the funnel-shaped basidiomata and the thinner pileus, and slightly larger basidiospores. This species grows on the ground or on decayed angiosperm wood and found rarely in the field (Costa-Rezende et al. 2017).

41. *Furtadoa brasiliensis* (Singer) Costa-Rezende, Drechsler- Santos & Robledo, in Costa-Rezende, Robledo, Góes-Neto, Reck, Crespo & Drechsler-Santos, Persoonia 39: 265 (2017).

= *Scutiger brasiliensis* Singer, Nova Hedwigia, Beih. 77: 22, 1983.

= *Amauroderma brasiliense* (Singer) Ryvarden, Syn. Fungorum 19: 44, 2004 'as *A. brasilensis*'.

See the description and illustration at Singer et al. (1983) 22, 'as *Scutiger brasiliensis*'

Notes – This species was introduced as *Scutiger brasiliense* from Brazil with stipitate basidiomata with a white and soft-flesh context, monomitic hyphal system and inamyloid and ellipsoid to almost subglobose spores (Singer et al. 1983). Then, it was transferred to *Amauroderma* (as *A. corneri*) based on *Amauroderma*-like basidiospores by observing a specimen from Atlantic Rain Forest in Brazil (Gulaid & Ryvarden 1998). The species was later considered as a synonymy of *A. brasiliense* (Ryvarden 2004b, Coelho et al. 2007, Gomes-Silva et al. 2015). However, based on morphological differences and high genetic divergence between the taxa Costa-Rezende et al. (2017) decided to maintain both *A. brasiliense* and *A. corneri* as independent species. Furthermore, the latter authors suggested a separate genus; *Furtadoa* to accommodate *A. brasiliense* and *A. corneri* based on monomitic context with simple-septate generative hyphae. *Furtadoa brasiliensis* is growing on the ground or on decayed angiosperm wood (Costa-Rezende et al. 2017).

42. ***Furtadoa corneri*** (Gulaid & Ryvarden) Robledo & Costa- Rezende in Costa-Rezende, Robledo, Góes-Neto, Reck, Crespo & Drechsler-Santos, Persoonia 39: 265 (2017).

= *Amauroderma corneri* Gulaid & Ryvarden, Mycol. Helv. 10 (1): 28. 1998.

See the description and illustration at Gulaid & Ryvarden (1998) 28, as '*A. corneri* '

Notes – *Furtadoa corneri* is characterized by a thin, funnel-to fan-shaped pileus, monomitic context and subglobose to ellipsoid basidiospores. This species is growing on the ground or on decayed angiosperm wood (Costa-Rezende et al. 2017).

Polyporopsis Mycotaxon 111: 447 (2010)

Type species: *Polyporopsis mexicanus* (Laferr. & Gilb.) Audet

43. *Polyporopsis mexicanus* (Laferr. & Gilb.) Audet, Mycotaxon 111: 447 (2010)

See the description Audet (2010)

Notes – *Polyporopsis* was introduced to accommodate *Albatrellus mexicanus* (Laferr. & Gilb.) and this genus is characterized by circular pileus, dimitic hyphal system and ellipsoidal basidiospores with oily drops. Laferrière & Gilbertson (1990) have classified this species as *Albatrellus* without considering the double wall of the spores or the hyphal system. Microscopic characters of *P. mexicanus* are close to *Amauroderma* but some microscopic features do not correspond to this genus and the morphology of the basidiome is very distinct according to Ryvarden (1991). Furthermore, Zheng & Liu (2006) synonymized this species with *Polyporoletus sublividus* without examining the dimitic hyphal system or other characters of *Polyporoletus* (Audet 2010). However, *P. sublividus* is a species with gray pores, with a trichodermic coating, and larger spores, while *Polyporopsis mexicanus* is a yellow-brown species with resinous brown pores in the lower surface and non-aborted tubes on the stipe, with an indeterminate coating, and a dimitic hyphal system and with smaller spores (Audet 2010).

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