

臺灣靈芝科（多孔菌目）三種新紀錄

Three species of Ganodermataceae (Polyporales) new to Taiwan

魏佳玲¹ 陳哲志² 吳聲華^{1*}

Chia-Ling Wei Che-Chih Chen and Sheng-Hua Wu*

¹ 國立自然科學博物館生物學組 40453 台中市北區館前路 1 號

² 中央研究院生物多樣性研究中心 11529 台北市南港區研究院路二段 128 號

¹ Department of Biology, National Museum of Natural Science, Taichung City, North District, Taiwan

Biodiversity Research Center Academia Sinica Taipei City, Nangang District, Taiwan

*Corresponding author: shwu@mail.nmns.edu.tw

* 通訊作者：shwu@mail.nmns.edu.tw

Abstract

Ganodermataceae is a large family of polyporoid fungi, characterized by having double-walled and pigmented basidiospores. In the present study, *Ganoderma gibbosum*, *G. lingzhi* and *Haddowia longipes* are reported as newly recorded from Taiwan. Descriptions, illustrations and photos of these three species are provided.

Key words: Basidiomycota, Ganoderma, Haddowia, taxonomy

摘要

靈芝科 (Ganodermataceae) 是孔狀擔子菌中的一大科，靈芝科獨特之處在於其成員的擔孢子具有雙層壁且有顏色。本研究提出台灣產靈芝科三個新紀錄種：有柄靈芝 (*Ganoderma gibbosum*)、赤芝 (*G. lingzhi*) 和長柄雞冠孢芝 (*Haddowia longipes*)，並提供這些物種的描述、繪圖和照片。

關鍵字：擔子菌門、靈芝屬、雞冠孢芝屬、分類學

Introduction

Ganodermataceae (Donk) Donk is a large family of polyporoid basidiomycetes. Its members are widespread in tropical to temperate regions; and is morphologically characterized by having laccate or non-laccate pileal surface, mostly trimitic hyphal system, and pigmented double-walled basidiospores. In Taiwan, the first report of Ganodermataceae species is *Ganoderma australe* (Fr.) Pat. (Murrill 1909, as *Elfvigia tornata* (Pers.) Murrill), which was collected by a Japanese K. Miyake. Since then, several early records were made by Japanese mycologists. They are *Ganoderma lucidum* (Curtis) P. Karst. (Kanehira 1918a, as *Polyporus lucidus* (Curtis) Fr.), *Ganoderma applanatum* (Pers.) Pat. (Kanehira 1918b, as *Fomes leucophaeus* (Mont.) Cooke), *Ganoderma dimidiatum* (Thunb.) V. Papp (Sawada 1931, as *Ganoderma japonicum* (Fr.) Sawada), *Ganoderma orbiforme* (Fr.) Ryvar den (Sawada 1942, as *Ganoderma fornicatum* (Fr.) Pat.), *Ganoderma tropicum* (Jungh.) Bres. (Sawada 1942), *Sanguinoderma rugosum* (Blume & T. Nees) Y.F. Sun, D.H. Costa & B.K. Cui (Sawada 1942, as *Ganoderma rugosum* (Blume & T. Nees) Pat.) and *Trachyderma tsunodae* (Yasuda ex Lloyd) Imazeki (Sawada 1942, as *Ganoderma tsunodae* (Yasuda ex Lloyd)). Among them, *G. applanatum* and *G. lucidum* were supposed to be misidentified (Yeh and Chen 1990; Moncalvo et al. 1995), and have not been found occurring in Taiwan.

Subsequently new records were added by Taiwanese mycologists, namely *Amauroderma exile* (Berk.) Torrend (Chang et al.

2001), *Ganoderma applanatum* var. *laevisporum* Humphrey & Leus-Palo (Chang 1994), *Ganoderma calidophilum* J.D. Zhao, L.W. Hsu & X.Q. Zhang (Chou and Chang, 2005), *Ganoderma flexipes* Pat. (Wang and Wu 2007), *Ganoderma multiplicatum* (Mont.) Pat. (Wang and Wu 2007), *G. orbiforme* (Chang 1992, as *Ganoderma boninense* Pat.; Chang 1992 as *Ganoderma limushanense* J.D. Zhao & X.Q. Zhang; Wu and Zhang 2003, as *Ganoderma densizonatum* J.D. Zhao & X.Q. Zhang), *Ganoderma rotundatum* J.D. Zhao, L.W. Hsu & X.Q. Zhang (Wu and Zhang 2003), *Magoderna subresinosum* (Murrill) Steyaert (Chang 1996) and *Tomophagus colossus* (Fr.) Murrill (Wu and Zhang 2003).

Four new species have been proposed by domestic mycologists. There were *Ganoderma multipileum* Ding Hou (Hou 1950), which was collected from the lowlands in Taichung, *Ganoderma formosanum* T.T. Chang & T. Chen (Chang and Chen 1984), which was synonymized under *Ganoderma sinense* J.D. Zhao, L.W. Hsu & X.Q. Zhang (Moncalvo et al. 1995; Moncalvo and Ryvar den 1997), and *Ganoderma microsporium* R.S. Hseu (Hseu et al. 1989), which was synonymized under *Ganoderma weberianum* (Bres. & Henn. ex Sacc.) Steyaert (Wang 2005; Wang et al. 2005), and *Ganoderma bambusicola* Sheng H. Wu, C.L. Chern & T. Hatt., which was misidentified as *Ganoderma neojaponicum* Imazeki from Taiwan for thirty years (Hseu 1990). Totally there have been 18 species of Ganodermataceae species known in Taiwan.

In the present study, we report three

new records of Ganodermataceae from Taiwan: *Ganoderma gibbosum*, *Ganoderma lingzhi* and *Haddowia longipes*, which were collected during 2015-2020.

Materials and methods

Morphological studies

All studied specimens are deposited at the herbarium of National Museum of Natural Science (TNM). Descriptions and illustrations are based on dried specimens. Freehand thin sections are mounted in 5% KOH for observations and measurements. Melzer's reagent (IKI) are applied to detect amyloidity and dextrinoidity.

DNA extraction, PCR and sequencing

Dried specimens were prepared for DNA extraction using the Plant Genomic DNA Extraction Miniprep System (Viogene Biotek corporation, New Taipei City, Taiwan), following the manufacturer's protocol. Primer pairs ITS1/ITS4 were used to amplify ITS regions (White et al. 1990). PCR products were purified and sequenced by MB Mission Biotech company (Taipei City, Taiwan). BioEdit v7.2.5 was used to assemble new sequences (Hall 1999). Finally, the newly generated sequences were submitted to GenBank.

Phylogenetic analyses

The dataset of ITS sequences was used to construct the phylogenetic tree. MAFFT v.7. was used to align the sequences. Phylogenetic analyses were carried out for the dataset based on maximum likelihood (ML), using RaxML Black Box (Stamatakis 2014) at the CIPRES Science Gateway. The statistical

supports were shown above branches of ML tree when bootstrap values (BS) ≥ 70 .

The ITS ML tree (Fig. 1) consisted of 26 species and 39 sequences. Twenty-four species from ingroups; two species from outgroups (*Perenniporiella chaquenia* Robledo & Decock and *P. pendula* Decock & Ryvarden), Ingroups contain the members of 8 genera of the Ganodermataceae: *Amauroderma* Murrill, *Ganoderma* P. Karst., *Haddowia* Steyaert, *Humphreya* Steyaert, *Magoderna* Steyaert, *Sanguinoderma* Y.F. Sun, D.H. Costa & B.K. Cui, *Tomophagus* Murrill and *Trachyderma* (Imazeki) Imazeki.

Results

Phylogeny

The final alignment of 39 sequences had 684 sites including gaps, of which 129 sites were parsimony informative. Our new generated *Ganoderma gibbosum* strains (MW887921, MW887922, MW887927, MW888212 and MW888213), *G. lingzhi* (MW888214, MW888223, MW888224 and MW888225) and *Haddowia longiceps* (MW888226) were clustered with *G. gibbosum* strains [AY593856 (Wang and Yao 2005) and KY364271 (Jargalmaa et al. 2017)] *G. lingzhi* holotype strain (JQ781858) and *H. longiceps* strain [MK345423 (Hapuarachchi et al. 2019)], respectively, and with strong support values (BS = 100%). Therefore, phylogenetical analysis supports identification of these three species.

Taxonomy

Ganoderma gibbosum (Blume & T. Nees) Pat., Annales du Jardin Botanique de Buiten-

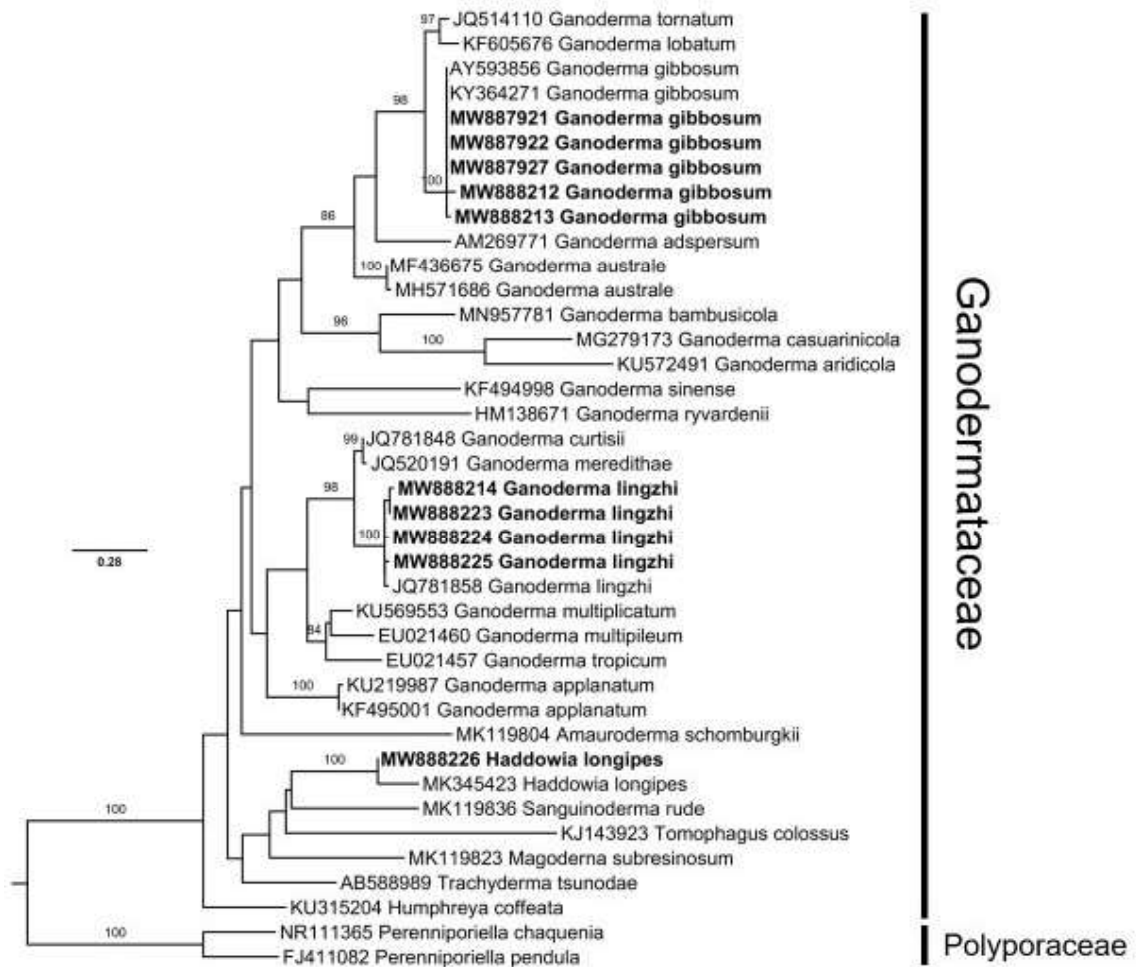


Fig. 1. The phylogram of Ganodermataceae inferred from ML analysis using the ITS dataset. The result presented the position of the three newly recorded species (shown in bold).

zorg Suppl. 1: 114 (1897)

Fig. 2A and Fig. 3

Description. Basidiomata perennial, solitary or scattered. Pileus semicircular, applanate, projecting 3.5–9.5 cm, 6–16 cm broad and 2–6.5 cm thick, sessile or laterally substipitate, woody hard. Pileal surface non-laccate, light brown to brown, with concentric sulci, sometimes irregularly swollen. Pore surface cream to light yellowish, brownish in old specimens; pores circular, 4–5 per mm,

120–160 μm diam, dissepiments entire, 60–100 μm diam. Context layer dark brown, 1–3 cm thick. Tube layer concolorous or slightly paler than context layer, 2–4 cm thick. Hyphal system trimitic. Pileipellis of a cutis, 0.4–1.4 mm thick, blackish brown, anamixoderm, composed of compacted interwoven skeleto-binding hyphae, terminal branched, main stems brownish to brown 4–5 μm diam, walls subsolid, lateral branches brownish to subcolorless, 1–2.5 μm diam,



Fig. 2. Photos of basidiomata in situ. A. *Ganoderma gibbosum*. B. *Ganoderma lingzhi*. C. *Haddowia longipes*.

walls subsolid. Context mainly composed of skeleto-binding hyphae, fairly straight, usually over 300 μm long, terminal branched, main stems brownish to brown, 3.5–6 μm diam, walls subsolid, lateral branches yellowish brown, 2–3 μm diam, walls subsolid; generative hyphae not observed. Tube mainly composed of binding hyphae, richly branched, main stems brownish to brown, 3–4.5 μm diam, with 0.8–1.5 thick walls or subsolid, lateral branches brownish to subcolorless, 1–2 μm diam, walls or subsolid; generative hyphae with clamp connections, 2–2.5 μm diam, thin-walled. Basidia not observed. Basidiospores double-walled, ellipsoid to narrowly ellipsoid, exospore smooth and colorless, endospore echinulate and brownish, IKI —, CB —, 8.2–11 \times 5.2–7

μm (with myxosporium), 7–9 \times 4.8–5.8 μm (without outer myxosporium).

Specimen examined. TAIWAN. Nantou County, Jenai Township, Aowanda National Forest Recreation Area, 121°11'E, 23°57'N, alt. 1250 m, on fallen angiosperm trunk, 3 Oct 2016, C.-C. Chen & C.-L. Wei, WEI 16-460 (TNM F31102, GenBank MW888213); 121°10'E, 23°57'N, alt. 1200 m, on fallen angiosperm trunk, 28 Aug 2017, C.-C. Chen, GC 1708-345 (TNM F33086, GenBank MW887927); Wulingshan Trail, 121°10'E, 24°01'E, alt. 1170 m, on fallen angiosperm trunk, 2 Mar 2020, C.-L. Wei, WEI 20-020 (TNM F34691, GenBank MW887921); Y.-C. Lin, L-2003-04 (TNM F34692); New Taipei City, Chinshan District, Shihtoushan Park, 121°38' E, 25°13' N, alt. 12 m, on liv-

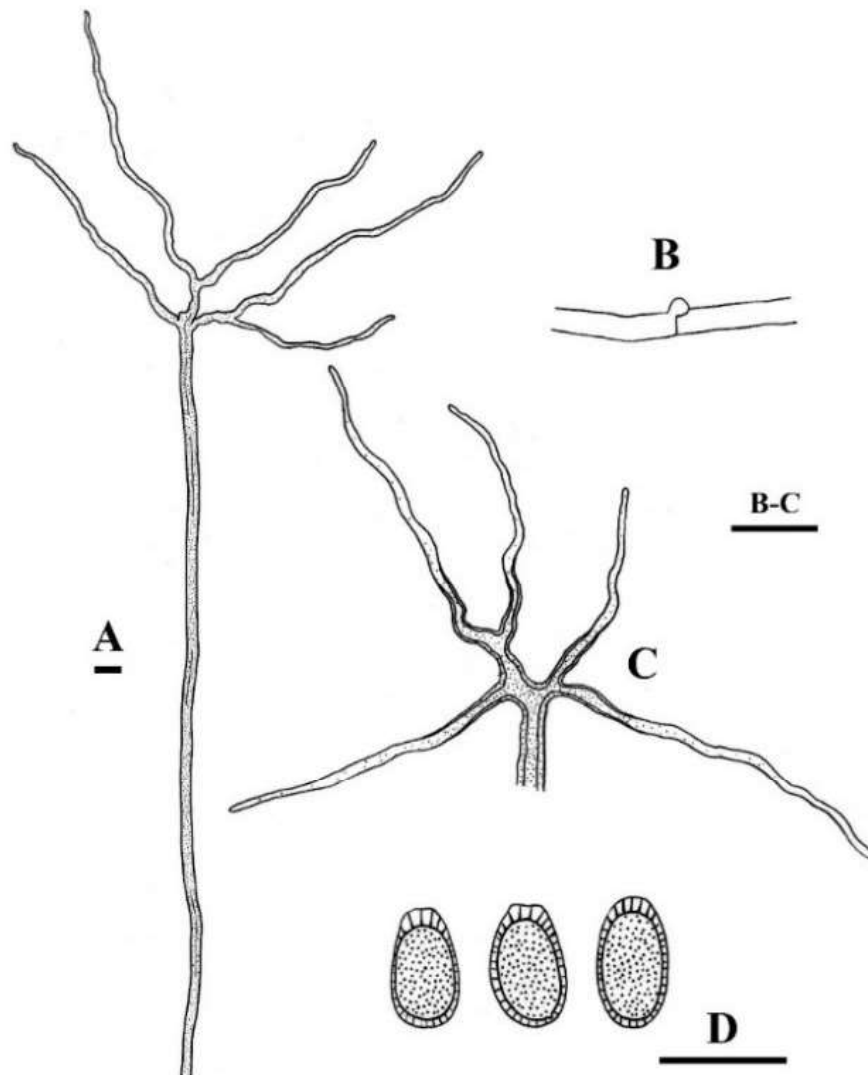


Fig. 3. Micromorphological of *Ganoderma gibbosum*. A. Skeletal-binding hyphae from context. B. Generative hyphae from tube. C. Binding hyphae from tube. D. Basidiospores. Bars = 10 μ m.

ing trunk base of *Casuarina equisetifolia*, 26 Aug 2015, C.-C. Chen, C.-L. Wei, W.-C. Chen & S. Lim, GC 1508-86 (TNM F33086); Taichung City, Hoping District, Hengling-shan Trail, 120°55'E, 24°14'N, alt. 990 m, on standing angiosperm trunk, 8 Aug 2017, C.-L. Wei & Y.-L. Huang, WEI 17-602 (TNM F32608); WEI 17-603 (TNM F32609, GenBank MW888212); Taiwan Endemic Species

Research Institute, Low Altitude Experimental Station, 120°57'E, 24°16'N, alt. 1000 m, on standing angiosperm trunk, 7 Aug 2017, C.-L. Wei & Y.-L. Huang, WEI 17-568 (TNM F32583, GenBank MW887922).

Habitat. On dead angiosperm trunks.

Distribution. China, Laos, Myanmar, Thailand and Vietnam (Hapuarachchi et al. 2019; Parmasto 1986; Zhao et al. 1983), and Tai-

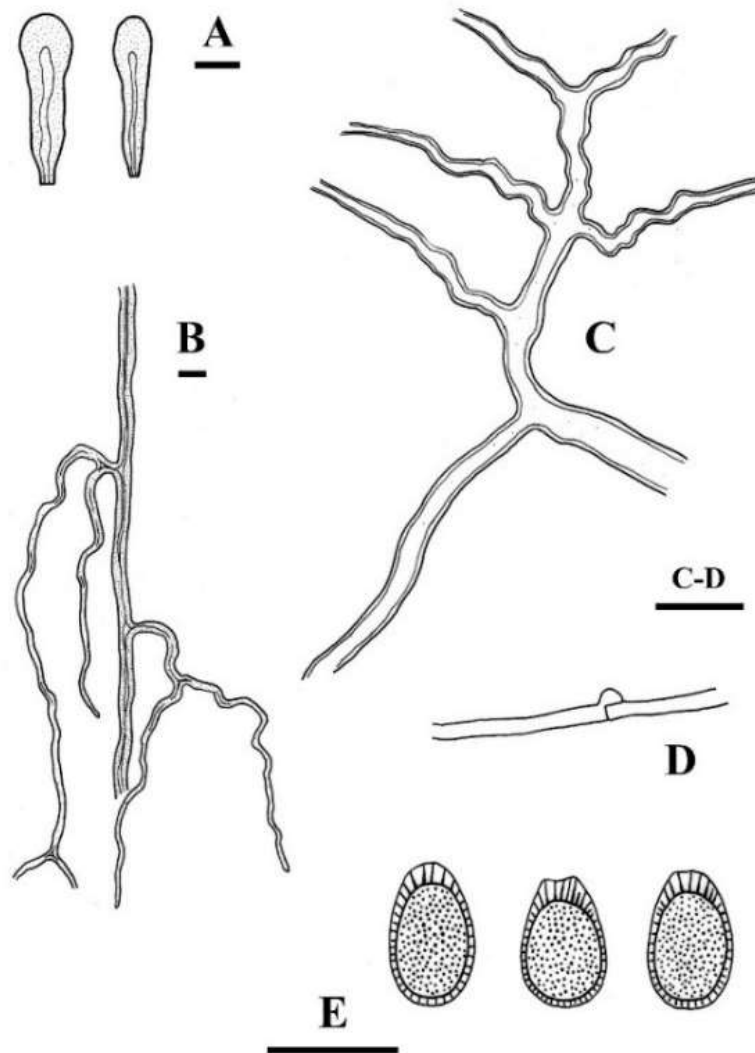


Fig. 4. Micromorphological of *Ganoderma lingzhi*. A. Pileipellis. B. Skeletal-binding hyphae from context. C. Binding hyphae from tube. D. Generative hyphae from tube. E. Basidiospores. Bars = 10 μ m.

wan (this study).

Notes. *Ganoderma gibbosum* is characterized by sessile to laterally substipitate basidiomata, non-laccate pileal surface, pores 4–5 per mm, context skeleto-binding hyphae with terminal branched and ellipsoid to narrowly ellipsoid basidiospore. *Ganoderma australe* (Fr.) Pat. is similar in having

non-laccate pileal surface and same pores size. However, it differs from *G. gibbosum* in having consistently sessile basidiocarps and slightly smaller basidiospores [5.3–7.9 \times 3.4–5.1 μ m (without outer myxosporium) (Hapuarachchi et al. 2019)] Taiwanese collection fits description of Luangharn et al. (2020) in all aspects.

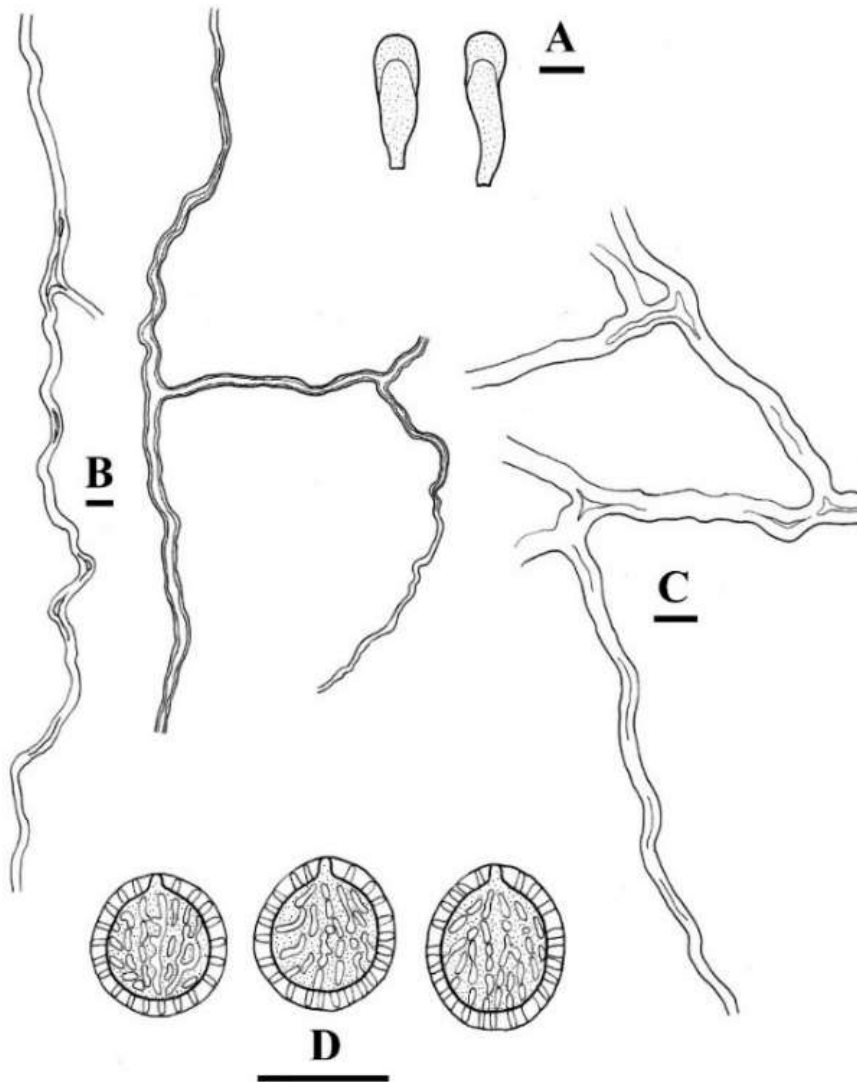


Fig. 5. Micromorphological of *Haddowia longipes*. A. Pileipellis. B. Skeletal-binding hyphae from context. C. Binding hyphae from tube. D. Basidiospores. Bars = 10 μ m.

Ganoderma lingzhi Sheng H. Wu, Y. Cao & Y.C. Dai, Fungal Diversity 56 (1): 54 (2012) Fig. 2B and Fig. 4

Description. Basidiomata annual, solitary or scattered, stipitate. Pileus reniform, semi-circular to flabelliform, projecting 4–7 cm, 5–12 cm broad and 1.5–2.5 cm thick, hard corky to corky. Stipe lateral, subcylindrical, laccate, dark reddish brown to dark purplish

brown, up to 27 cm long and 1.5–3 cm thick. Pileal surface laccate, orange brown, reddish brown to dark reddish brown. Pore surface cream to yellow, yellowish brownish in old specimens; pores circular, 5–6 per mm, 100–180 μ m diam, dissepiments entire, 50–100 μ m diam. Context layer rather homogeneous, buff to brownish, about 0.5 cm thick. Tube layer concolorous with context layer,

up to 2 cm thick. Hyphal system trimitic. Pileipellis of a cutis, hymeniderm, composed of clavate hyphal elements, brown, 30–50 × 8–10 μm, with narrow lumens, more or less amyloid. Context mainly composed of skeleto-binding hyphae, intercalary, main stems brownish to brown, 4–6 μm diam, with 1–2 μm thick walls or subsolid, lateral branches brownish, 1.5–3 μm diam, walls subsolid; generative hyphae rarely, 2.5–3 μm diam, thin-walled. Tube mainly composed of binding hyphae, richly branched, main stems subcolorless, 4–6 μm diam, with 0.5–1 μm thick walls, lateral branches colorless, 1.5–3 μm diam, with 0.5 μm thick walls; generative hyphae with clamp connections, 2–3 μm diam, thin-walled. Basidia not observed. Basidiospores double-walled, ellipsoid to ovoid, exospore smooth and colorless, endospore echinulate and brownish, IKI – , CB – , 9.5–11.5 × 6.2–7.2 μm (with myxosporium), 7.5–9 × 5.5–6.5 μm (without outer myxosporium).

Specimen examined. TAIWAN. Nantou County, Jenai Township, Aowanda National Forest Recreation Area, 121°10'E, 23°57'N, alt. 1200 m, on the ground, 12 Aug 2015, C.–C. Chen, GC 1508-3 (TNM F29033); 8 Sep 2016, K.-Y. Lin, GC 1609-38 (TNM F31387); GC 1609-39 (TNM F31388); 27 Sep 2016, N.A., GC 1609-47 (TNM F31394); GC 1609-48 (TNM F31395); 28 Aug 2017, C.–C. Chen, GC 1708-346 (TNM F33087); 12 Sep 2018, C.–C. Chen & C.–C. Chang, GC 1809-43 (TNM F33756, GenBank MW888225); 14 Jun 2020, C.–C. Chen, GC 2006-1 (TNM F34693); 121°11'E, 23°57'N, alt. 1250 m, on

the ground, 3 Oct 2016, C.–C. Chen & C.–L. Wei, WEI 16-418 (TNM F31078); 21 Aug 2017, C.–C. Chen & C.–L. Wei, WEI 17-606 (TNM F34297); WEI 17-607 (TNM F32614); 28 Aug 2017, S.–H. Wu, Wu 1708-309 (TNM F31664), Wu 1708-313 (TNM F31668), Wu 1708-314 (TNM F31669), Wu 1708-315 (TNM F31670); 28 Apr 2018, C.–L. Wei, WEI 18-017 (TNM F33181); 12 Sep 2018, C.–L. Wei, WEI 18-403 (TNM F34461); WEI 18-409 (TNM F34224); Yuchih Township, Lienhuachih, 120°53'E, 23°56'N, alt. 700 m, on the ground, 30 Aug 2006, S.–Z. Chen, Chen 1562, (TNM F25901); on rotten trunk base, 2 Jun 2018, S.–Z. Chen, Chen 3968 (TNM F34511, GenBank MW888224); on the ground, Chen 3969 (TNM F34512); Chen 3970 (TNM F 34513); Taichung City, Hoping District, 3.5 km of Tungmaoshan Trail, 120°57'E, 24°11'N, alt. 1200 m, on standing dead trunk, 27 May 2018, C.–L. Wei & C.–P. Huang, WEI 18-127 (TNM F33559, GenBank MW888214); Hsinshue District, Takeng Walking Road No. 4, 120°48'E, 24°11'N, alt. 780 m, on the ground, 10 Jun 2018, C.–L. Wei & C.–P. Huang, WEI 18-378 (TNM F34444, GenBank MW888223).

Habitat. Usually on the ground near angiosperm tree, rarely on trunk.

Distribution. China, Japan and Korea (Cao et al. 2012), and Taiwan (this study).

Notes. *Ganoderma lingzhi* is a famous medicinal fungus in China for more than two thousand years (Cao et al. 2012). It is characterized by having laccate pileus, yellow pore surface, skeleto-binding hyphae with intercalary branch and ellipsoid to ovoid

basidiospore. *Ganoderma lucidum* (Curtis) P. Karst. shares similar pileal surface and basidiospores sized with *G. lingzhi*. However, it differs from *G. lingzhi* in having white pore surface and longer cuticle cells (47–70 μm). Besides, Moncalvo et al. (1995) indicated that *G. lucidum* have not been distributed in Taiwan, here we follow their opinions. In Taiwan, *G. lingzhi* occurs at the elevation of 700–1200 meters, usually grow under trees of Fagaceae spp. This observation corresponds with Cao et al. (2012). Morphological features of Taiwanese collections fit description of Cao et al. (2012) for this species.

Haddowia longipes (Lév.) Steyaert, Persoonia 7 (1): 109 (1972) Fig. 2C and Fig. 5

Description. Basidiomata annual, solitary, stipitate, light in weight. Pileus reniform, projecting 4 cm, 4.5 cm broad and about 1.2 cm thick, soft corky. Stipe eccentric, cylindrical, laccate, black, 12 cm long and about 0.7 cm thick. Pileal surface weakly laccate, orange brown, with concentric shallow sulci. Pore surface cream; pores subcircular to subangular, 1.5–2.5 per mm, 300–500 μm diam, dissepiments entire, 100–140 μm diam. Context layer buff, 0.2–0.3 cm thick. Tube layer concolorous with context layer, 0.7–0.9 cm thick. Hyphal system trimitic. Pileipellis of a cutis, hymeniderm, composed of clavate hyphal elements, yellowish brown, 25–35 \times 9–11 μm , with wide lumens, swollen in KOH. Context mainly composed of skeleto-binding hyphae, intercalary, main stems colorless, 3.5–6 μm diam, with 1–1.5 μm thick walls or subsolid, lateral branches

colorless, 1.5–3 μm diam, walls up to 1 μm thick or subsolid; generative hyphae not observed. Tube mainly composed of binding hyphae, richly branched, main stems colorless, 3–5 μm diam, walls up to 1.5 μm thick or subsolid, lateral branches colorless, 1.5–3 μm diam, walls up to 1 μm thick; generative hyphae 3–4 μm diam, thin-walled. Basidia not observed. Basidiospores broadly ellipsoid to subglobose, double-walled, exospore with longitudinal ridges partly connected with short transverse walls, colorless, endospore smooth, brownish, IKI —, CB —, 10–13 \times 9–11.5 μm (with myxosporium), 9–11 \times 8.5–9.5 μm (without outer myxosporium).

Specimen examined. TAIWAN. Pingtung County, Mudan Township, Shimen Village, 120°45'E, 22°09'N, alt. 240 m, on the ground near *Melia azedarach*, 11 Nov 2020, S.-H. Wu, S.-Z. Chen & C.-L. Wei, Wu 2011–62 (TNM F34694, GenBank MW888226).

Habitat. On the ground near angiosperm tree.

Distribution. Africa—Angola and Kenya, Asia—China, India, Laos and Philippines, South America—Brazil, Costa Rica and French Guiana (Corner 1983; Hapuarachchi et al. 2019; Ryvarden and Johansen 1980; Zhao 1989; Zhao and Zhang 2000) and Taiwan (this study).

Notes. *Haddowia longipes* was initially collected from South America (French Guiana) and subsequently reported to widespread in other tropical regions (Zhao and Zhang 2000). This species is characterized by having weakly to strongly laccate pileus, large pores (1.5–2.5 per mm), skeleto-binding

hyphae with intercalary branch and broadly ellipsoid to subglobose basidiospores with crest-like ornamentations. Taiwanese collection fits description of Ryvarden and Johansen (1980) in all aspects, except for the slightly smaller basidiospores, i.e., 10–13 × 9–11.5 μm (with myxosporium) in this study vs. 12–17 × 10–14 μm (with myxosporium) in Ryvarden and Johansen (1980). The ITS sequence derived from *Wu 2011-62* (GenBank MW888226) has a 99% similarity with the strain *LPDR17072709*, (GenBank MK345423 (Hapuarachchi et al. 2019) of this species.

Acknowledgments

This study was supported by a Grant-in-Aid for Scientific Research (no. 110-08.1-SB-18) from Council of Agriculture, Executive Yuan, ROC. We are grateful to Dr. Che-Chih Chen (陳哲志) for providing photos of *Ganoderma gibbosum* and Miss Siou-Zhen Chen (陳秀珍) for managing studied specimens.

Literature Cited

- Cao, Y., Wu, S. H., and Dai, Y. C. 2012. Species clarification of the prize medicinal *Ganoderma* mushroom “Lingzhi”. *Fungal Diversity* 56: 49-62.
- Chang, T. T. 1992. One terrestrial and some lignicolous Aphyllophorales (Basidiomycotina) from Taiwan. *Botanical Bulletin of Academia Sinica* 33: 327-334.
- Chang, T. T. 1994. Some new Taiwan polypores (Basidiomycotina). *Transactions of the Mycological Society of Republic of China* 9: 111-122.
- Chang, T. T. 1996. Nine Species of Polypores New to Taiwan. *Fungal Science* 11: 31-38.
- Chang, T. T. and Chen, T. 1984. *Ganoderma formosanum* sp. nov. on Formosan sweet gum in Taiwan. *Transactions of the British Mycological Society* 82: 731-733.
- Chang, T. T., Chou, W. N., Wang, Y. Z. and Ju, Y. M. 2001. *Macrofungi of Taiwan*, Taipei. (in Chinese)
- Chou, W. N. and Chang, T. T. 2005. *Mushrooms of Taiwan*, Taipei. (in Chinese)
- Chen, Z. C. 1976. Notes on new Formosan forest fungi V. A list of Polyporaceae found in Taiwan. *Taiwania* 21: 128-133.
- Corner, E. J. H. 1983. Ad Polyporaceas I, *Amuroderma* and *Ganoderma*. *Beihefte zur Nova Hedwigia* 75: 1-182.
- Hall, T. A. 1999. BioEdit: a user-friendly biological sequence alignment editor and analysis program for windows 95/98/NT. *Nucleic Acids Symposium Series* 41: 95-98.
- Hapuarachchi, K. K., Karunarathna, S. C., Phengsintham, P., Yang, H. D., Kakumyan, P., Hyde, K. D. and Wen, T. C. 2019. *Ganodermataceae (Polyporales): Diversity in Greater Mekong Subregion countries (China, Laos, Myanmar, Thailand and Vietnam)*. *Mycosphere* 10: 221-309.
- Hseu, R. S. 1990. An identification system for cultures of *Ganoderma* species. PhD thesis. National Taiwan University. Taipei. (in Chinese)

- Hseu, R. S., Chen, Z. C. and Wang, H. H. 1989. *Ganoderma microsporium*, a new species on weeping willow in Taiwan. Mycotaxon 35: 35-40.
- Jargalmaa, S., Eimes, J. A., Park, M. S., Park, J. Y., Oh, S. Y. and Lim, Y. W. 2017. Taxonomic evaluation of selected *Ganoderma* species and database sequence validation. PeerJ 5: e3596.
- Kanehira, R. 1918a. Fungi collected in Niitakayama. Transactions, Natural History Society of Formosa 8: 88. (in Japanese)
- Kanehira, R. 1918b. Fungi collected in Tentana, Hsinchu. Transactions, Natural History Society of Formosa 8: 88. (in Japanese)
- Kanehira, R. 1923. Mushroom of Taiwan (3). Transactions, Natural History Society of Formosa 13: 15-16. (in Japanese)
- Luangharn, T., Karunarathna, S. C., Mortimer, P. E., Hyde, K. D. and Xu, J. 2020. Morphology, Phylogeny and Culture Characteristics of *Ganoderma gibbosum* Collected from Kunming, Yunnan Province, China. Phytotaxa 456: 743-764.
- Moncalvo, J. M. and Ryvarden, L. 1997. A nomenclatural study of the Ganodermataceae Donk. Fungiflora, Oslo.
- Moncalvo, J. M., Wang, H. F. and Hseu, R. S. 1995. Gene phylogeny of the *Ganoderma lucidum* complex based on ribosomal DNA sequences. Comparison with traditional taxonomic characters. Mycological research 99: 1,489-1,499.
- Moncalvo, J. M., Wang, H. H. and Hseu, R. S. 1995. Phylogenetic relationships in *Ganoderma* inferred from the internal transcribed spacers and 25S ribosomal DNA sequences. Mycologia 87: 223-238.
- a. Mycotaxon 108: 35-40.
- Wang, D. M., Wu, S. H. and Yao, Y. J. 2014. Clarification of the concept of *Ganoderma orbiforme* with high morphological plasticity. PLoS One 9: e98733.
- Wang, D. M., Zhang, X. Q. and Yao, Y. J. 2005. Type studies of some *Ganoderma* species from China. Mycotaxon 93: 61-70.
- White, T. J., Bruns, T., Lee, S. J. W. T. and Taylor, J. 1990. Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. PCR protocols: a guide to methods and applications 18: 315-322.
- Wu, S. H., Chern, C. L., Wei, C. L., Chen, Y. P., Akiba, M. and Hattori, T. 2020. *Ganoderma bambusicola* sp. nov. (Polyporales, Basidiomycota) from southern Asia. Phytotaxa 456: 75-85.
- Wu, S. H. and Zhang, X. 2003. The finding of three Ganodermataceae species in Taiwan. Collection and Research 16: 61-66.
- Yeh, Z. Y. and Chen Z. C. 1990. Preliminary Investigations of *Ganoderma australe* (Subgen. *Elfvigia*) in Taiwan. Taiwania 35: 127-141.
- Zhao, J. D. 1989. The Ganodermataceae in China. J. Cramer, Berlin.
- Zhao, J. D. and Zhang X. Q. 2000. Flora Fungorum Sinicorum 18: Ganodermataceae. Science Press, Beijing. (in Chinese)