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The genus *Omphalotus* (Omphalotaceae) in China

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Abstract: Specimens of *Omphalotus* (including *Lampteromyces*) in China were studied and four species, viz. *O. flagelliformis* sp. nov., *O. guepiniformis*, *O. mangensis* and *Lampteromyces luminescens*, were reported. Based on holotype observation, it is found that *L. luminescens* is very close to *O. guepiniformis* (*O. japonicus*) if they are not conspecific. Because no additional materials of *L. luminescens* from the type locality or its adjacent areas are available for morphological or molecular phylogenetic comparison, we keep *L. luminescens* as distinct for the time being. The transfer of *L. luminescens* to *Omphalotus* requires further investigation. Microscopic characters of *O. guepiniformis* from newly collected materials in northeastern China showed that crassospores were as common in *O. guepiniformis* as in *O. mangensis* and *L. luminescens*. Surfaces of crassospores are finely rough to uneven under microscope, which is probably due to the non-uniform density of the spore wall. *Paxillus yunnanensis* was also considered as a species of *Omphalotus*. Reexamination of the holotype of *P. yunnanensis* indicated, however, that it is likely congeneric with *Tricholomopsis*, with prominently large cheilocystidia.

Key words: *Omphalotus*, *Lampteromyces*, new taxon, phylogeny, taxonomy

中国类脐菇属（类脐菇科）的分类

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摘 要：作者对国产类脐菇属 *Omphalotus*（含亮菌属 *Lampteromyces*）标本进行了研究，报道 4 种，即鞭囊类脐菇 *O. flagelliformis*、日本类脐菇 *O. guepiniformis*、莽山类脐菇 *O. mangensis* 和亮耳菌 *Lampteromyces luminescens*，其中鞭囊类脐菇为新种。作者对亮耳菌的模式标本进行了研究，发现它与日本类脐菇即使不是同一物种也是很近缘的，但由于没有亮耳菌模式产地或其附近地区的更多标本用于形态和分子系统发育的比较，故不对其进行分类处理。利用新近采自我国东北的标本，作者对日本类脐菇的显微特征进行了较为详细地研究，发现日本类脐菇、莽山类脐菇和亮耳菌都具有厚壁担孢子，厚壁担孢子的孢子壁外表在显微镜下看上去粗糙至不平滑，这可能是因为孢子壁不同

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区域的密度不同所致。云南桩菇 *Paxillus yunnanensis* 曾被猜测为类脐菇属的物种，作者对该种的模式标本进行了研究，发现模式标本具有巨大的褶缘囊状体，应是假白蘑属 *Tricholomopsis* 的成员。

关键词：类脐菇属，亮耳菌属，新种，系统发育，分类

INTRODUCTION

Species of the genus *Omphalotus* Fayod (Omphalotaceae) have received much attention for their luminescent ability, poisonous and nematotoxin-producing features (Kämmerer *et al*. 1985; Miller 1994; Hughes & Petersen 1998; Petersen & Hughes 1998; Mo *et al*. 2000; Kirchmair *et al*. 2002, 2004; Desjardin *et al*. 2008). Recent studies suggested that *Lampteromyces* Singer is a synonym of *Omphalotus* and that consequently species of *Lampteromycs* should be combined into *Omphalotus* that thereby possesses nearly ten species worldwide (Kirchmair & Pöder 2002). Two species of *Lampteromyces*, *L. mangensis* Jian Z. Li & X.W. Hu and *L. luminescens* M. Zang, were described from China and they are rarely known outside of China. *Lampteromyces mangensis* was moved to *Omphalotus* by Kirchmair & Pöder (2002) without assessing the type collection or other materials of the fungus. Besides, Kirchmair *et al*. (2002) suggested that *L. luminescens* belongs likely to the genus *Lentinellus* P. Karst. and the taxonomic status of the species is, thus, unsettled. Probably based on the protologue of a study on the family Paxillaceae in China, Singer (1981) alleged that "a Chinese species of what is obviously an *Omphalotus* has recently been described as *Paxillus* Fr. (Zang & Zeng 1978)". In order to characterize *Omphalotus* and its species in China, it is necessary to restudy the types and additional materials by means of both morphological and molecular phylogenetic analysis.

In this study, we reexamined the holotypes of *L. luminescens*, and the two *Paxillus* species described by Zang & Zeng (1978) and additional materials of *Omphalotus* and characterized a new species of *Omphalotus* using morphology and molecular data.

1 MATERIALS AND METHODS

1.1 Specimens and morphological descriptions

Morphological descriptions of the basidiomata are based on field notes and laboratory observations with color codes of the form "ABC", indicating the plate (A), row (B), and color block (C), are from Kornerup & Wanscher (1981). Specimens were deposited in the Herbarium of Cryptogams, Kunming Institute of Botany of the Chinese Academy of Sciences (HKAS), the Mycological Herbarium of Hunan Normal University (MHHNU) and the Mycological Herbarium of Institute of Microbiology of the Chinese Academy of Sciences (HMAS). For microscopic observation, the dried materials were sectioned and mounted in 5% KOH solution, while fresh materials were analyzed in distilled H_2O. In the descriptions of basidiospores, the abbreviation [*n*/*m*/*p*] means *n* basidiospores measured from *m* basidiomata of *p* collections; *Q* is used to mean "length/width ratio" of a spore in side view; **Q** means average Q of all basidiospores ± sample standard deviation.

1.2 DNA extraction, PCR and sequencing

Total DNA was isolated from silica-gel dried materials using the CTAB method (Doyle & Doyle 1987). The internal transcribed spacer (ITS) region was amplified with primer pair ITS5/ITS4 (White *et al*. 1990) in an ABI 2720 thermal cycler (Applied

Biosystems, Foster City, CA, USA). The PCR program was as follows: pre-denaturation at 95℃ for 3min; then followed by 35 cycles of denaturation at 94℃ for 30s, annealing at 50℃ for 50s, elongation at 72℃ for 90s; afterwards, a final elongation at 72℃ for 8min was included. PCR products were depurated with the Gel Extraction & PCR Purification Combo Kit (Spin-column, Bioteke, Beijing, China), and then sequenced on an ABI-3730-XL sequence analyzer (Applied Biosystems, Foster City, CA, USA) using primer ITS4. Three sequences generated in this study have been deposited in the GenBank sequence database (accession numbers: KC333363–KC333365).

1.3 Phylogenetic analyses

Additional ITS sequences of genus *Omphalotus* were retrieved using genus search tool implemented in emerencia (http://andromeda.botany.gu.se/emerencia.html) and were combined with the three sequences generated in this study to form a dataset. Sequences of representatives of other genera in Omphalotaceae were also included in the dataset. *Marasmius scorodonius* and *Marasmiellus opacus* were chosen as outgroups as inferred by Vydryakova *et al*. (2012). The dataset was then aligned using Opal v2.0.0 (Wheeler & Kececioglu 2007) and manually optimized on Bioedit v7.0.9 (Hall 1999).

Maximum Likelihood (ML) and Bayesian Inference (BI) analyses were applied using RAxML (Stamatakis 2008) and MrBayes (Ronquist & Huelsenbeck 2003), respectively. For phylogenetic analysis, HKY+G was chosen as the best fit model for the dataset by using Mrmodeltest 2.3 (Nylander 2004). As GTR is the only model available in RAxML, we thus used GTRGAMMA with the default setting in ML analysis. Statistic supports were calculated using nonparametric bootstrapping with 1,000 replicates. For BI analysis, HKY+G model was used with the default setting. We set the generations to 5 million and used the stoprul command with the value of stopval set to 0.001. Trees were sampled every 1,000 generation. Statistic supports were obtained by the using sumt command implemented in MrBayes by discarding the first 10% of generations as burn-ins.

2 RESULTS

2.1 Molecular phylogeny

Omphalotus formed a monophyletic group with high statistical supports in the phylogenetic trees generated from ITS dataset using both ML and BI analyses (Fig. 1). Our proposed new species, *O. flagelliformis*, was clustered with *O. illudens* and *O. mexicanus* with high statistical supports (Bootstrap values 100%, and Bayesian posterior probabilities 1) (Fig. 1). Two sequences generated from basidiomata of *O. guepiniformis* (*O. japonicus*) collected from northeastern China were clustered to the sequences generated from the same species collected from Japan and South Korea. The identities of the ITS sequences of *O. guepiniformis* are 98.8%–99.6%.

2.2 Taxonomy

1. *Omphalotus flagelliformis* Zhu L. Yang & B. Feng, sp. nov. Figs. 2, 3

MycoBank MB802884

Etymology: the epithet refers to the flagelliform to rostrate appendages of cheilocystidia.

Holotypus: CHINA, Yunnan Province, Kunming, Kunming Botanical Garden, alt. 1,980m, in caespitose around the base of a trunk of a living fagaceous plant, 4 October 2012, Z.L. Yang 5639 (HKAS 76645; ITS sequence generated from the holotype: KC333363).

Pileus 4–8cm latus, convexus vel infundibuliformis, interdum umbonatus vel papillatus, obscure rufo-brunneus vel brunneus. Lamellae pallide aurantiacae vel flavido-aurantiacae.

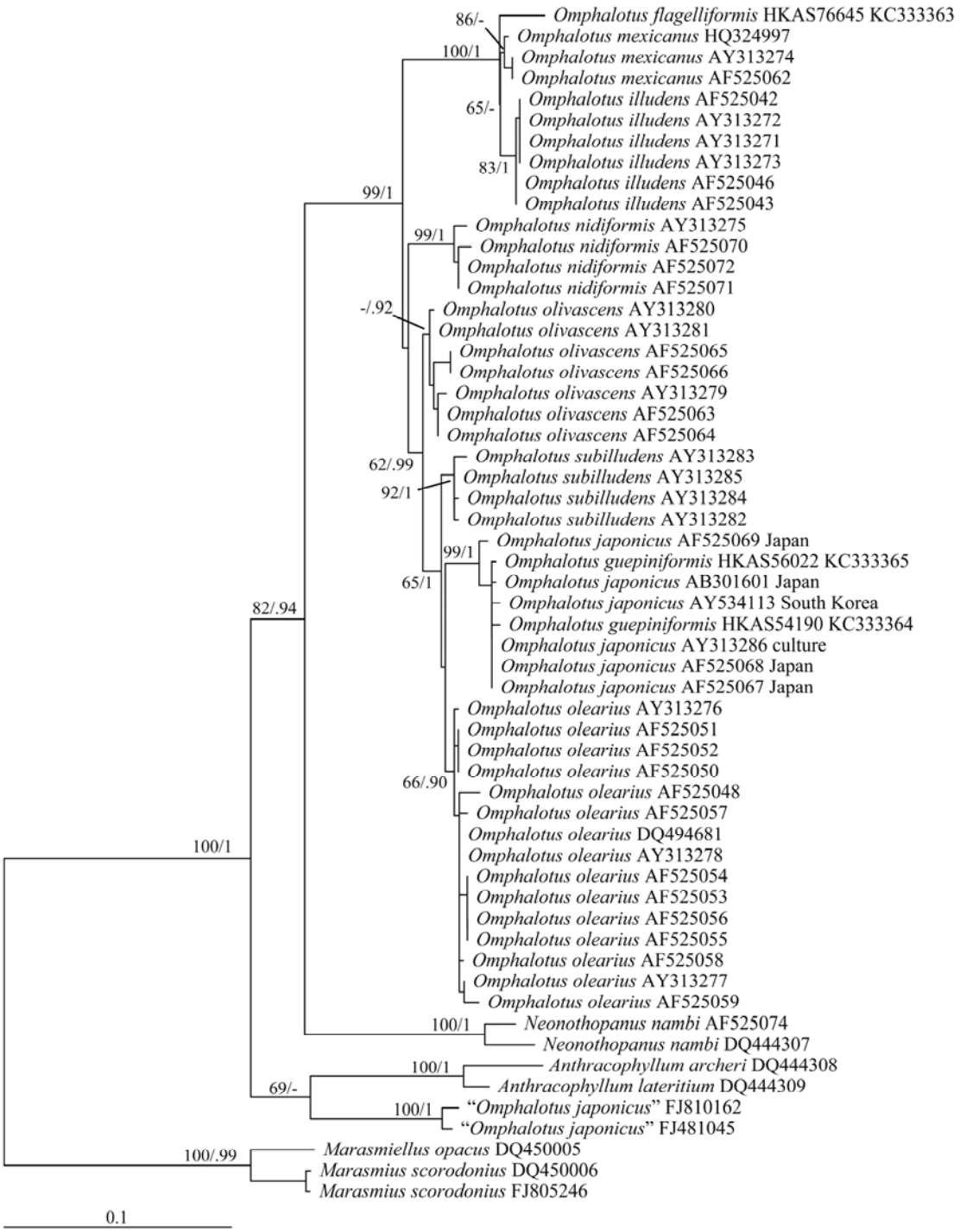

Fig. 1 Phylogenetic position of *Omphalotus flagelliformis* inferred from Maximum Likelihood (ML) analysis of ITS sequences. Bootstrap values (ML, >50%)/Bayesian posterior probabilities (BI, >0.90) are shown above or beneath individual branches.

Fig. 2 Basidiomata of *Omphalotus flagelliformis* (HKAS 76645, holotype).

Stipes 5–12×1–2.5cm, pallide aurantiacus vel flavido-aurantiacus. Basidiosporae 4–5.5×3.5–4.5µm. Basidia 20–30×6–7µm, 4-sporigera. Cheilocystidia clavata vel subfusiformia, saepe flagelliformia vel rostrata, 10–25×5–7µm. Fibulae praesentes.

Basidiomata medium-sized to large, caespitose or in clusters. Pileus 4–8(–12)cm in diam., convex then soon flattened and then infundibuliform, sometimes umbonate or papillate; surface dark reddish brown to brown (7D5, 7D6, 7D8, 7E5, 7E6, 7E8), glabrous, smooth, innately fine fibrillose, dry; margin incurved or not; context orange-yellow, unchanging, relatively thin (up to 5mm in thickness). Lamellae decurrent, subdistant, narrow (up to 3mm broad), pale orange to orange-yellow (5A6, 5A7, 5A8, 5B6, 5B7, 5B8, 6A6, 6A7, 6A8, 6B6, 6B7, 6B8); edge even; lamellulae 2–3 tiers. Stipe more or less excentric, 5–12×1–2.5(–4)cm, subcylindric or slightly attenuate upwards and downwards; surface glabrous, pale orange to orange-yellow (slightly paler than lamellae); context pale yellow to pale orange-yellow. Odour fish-like smell; taste mild.

Basidiospores [60/4/2] 4–5.5(–6)×3.5–4.5(–5)µm, Q=(1.04–)1.05–1.25(–1.33) (**Q**=1.14±0.07), globose, subglobose to broadly ellipsoid, nearly colorless and hyaline, occasionally with brownish yellow contents, thin-walled to slightly thick-walled (≤0.5µm thick), smooth, non-amyloid, non-dextrinoid. Basidia 20–30(–35)×6–7(–8)µm, clavate, hyaline, thin-walled, 4-spored; sterigmata 4–6µm long. Cheilocystidia abundant, clavate to subfusiform, 10–25×5–7µm (apical outgrowths excluded), colorless and hyaline or with yellowish to brownish contents, thin-walled, often with flagelliform, rostrate to mucronate apical outgrowths 10–40× 1–1.5(–2)µm. Pleurocystidia absent. Lamellar trama composed of ± regularly arranged thin- to slightly thick-walled (≤0.5µm thick) filamentous hyphae 3–12m wide. Pileipellis a 100–150µm thick cutis composed of repent, radially arranged, 3–7µm wide filamentous hyphae incrusted with brown to yellow-brown pigments which become green to olivaceous green when in KOH; refractive hyphae rare, 2–8µm wide; outer surface of pileipellis covered with scattered brown to yellow-brown amorphous substances and scattered lanceolate to subcylindric cystidia-like terminal cells (15–50× 3–4µm) often with an attenuate apex 1.5–2µm wide. Stipitipellis composed of vertically arranged, branching and sometimes anastomosing hyphae 3–15µm wide. Caulocystidia often caespitose, lanceolate to subcylindrical (20–60×2–9µm), occasionally broadly clavate (20–25×7–10µm), often with yellowish contents; surface of stipitipellis often covered with brown to yellow-brown amorphous substances. Clamp connections abundant in all tissues.

Additional specimen of *O. flagelliformis* examined: CHINA, Yunnan Province, Kunming City, Kunming Botanical Garden, alt. 1,980m, in caespitose or clusters at the bases of a trunk of a living fagaceous plant, 14 October 2012, Z.L. Yang 5657 (HKAS 76654).

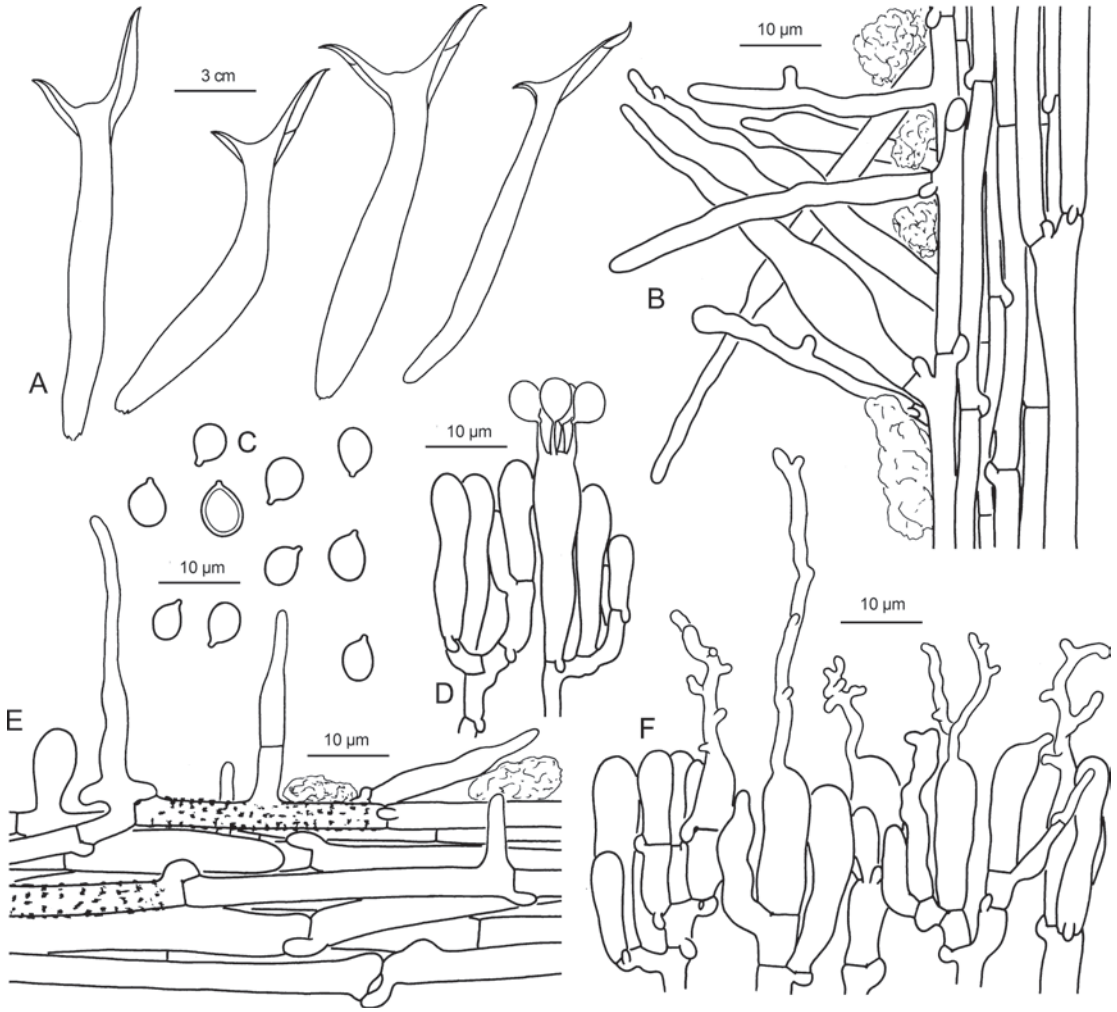

Fig. 3 *Omphalotus flagelliformis* (HKAS 76645, holotype). A: Longitudinal sections of basidiomata; B: Stipitipellis and caulocystidia; C: Basidiospores; D: Basidia; E: Radial-vertical section of pileipellis; F: Cheilocystidia.

Specimen of *O. illudens* examined: USA, Tennessee: Great Smoky Mts., on decaying trunk of *Tsuga canadensis*, 13 July 1987, M. Zang 11001 (HKAS 19085).

Notes: Morphologically, the umbonate or papillate pileus of *O. flagelliformis* resembles that of *O. illudens* (Schwein.) Bresinsky et Besl. In fact, *O. flagelliformis* was clustered to *O. illudens* and *O. mexicanus* Guzmán & V. Mora with a high support in the phylogenetic analysis (Fig. 1). However, *O. illudens*, originally described from Carolina, USA (Schweinitz 1822), differs from *O. flagelliformis* by its deep yellow to yellowish orange pileus, slightly larger basidiospores, and the common presence of numerous refractive hyphae in the pileipellis. In addition, *O. flagelliformis* smells like fish, but *O. illudens* doesn't (Kuyper 1995; Kirchmair & Pöder 2002; Kirchmair *et al*. 2002; Phillips 2005). Kuyper (1995) stated that the cheilocystidia are absent in *O. illudens*, and neither in Kirchmair & Pöder (2002)

nor in Kirchmair *et al*. (2002) were cheilocystidia mentioned in *O. illudens*. The US collection of *O. illudens* examined in this study produces basidiospores of 4.5–6×4–4.5(–5)µm in size, and the cheilocystidia that are similar to those of *O. flagelliformis* in size and form. *Omphalotus mexicanus* differs from *O. flagelliformis* by its entire bluish black to blackish basidioma with a blue-violet context, larger basidiospores and violet incrusting pigment in the pileipellis (Mora & Guzmán 1983; Kirchmair *et al*. 2002).

Omphalotus flagelliformis is very similar to *O. olearius* (DC.: Fr.) Singer in coloration of basidioma. However, for the European *O. olearius*, the pileus is neither umbonate nor papillate and the basidiospores are considerably larger (Kirchmair & Pöder 2002; Kirchmair *et al*. 2002). Although it was reported that there was no cheilo- and caulocystidium in *O. olearius* (Horak 1968), this needs to be verified with living or well dried materials.

2. *Omphalotus guepiniformis* (Berk.) Neda, Mycoscience 45: 183, 2004. [“*Omphalotus guepiniforimis*”] —— *Agaricus guepiniformis* Berk., Linn. Soc. Journ. Bot. 16: 50, 1878; *Pleurotus guepiniformis* (Berk.) Sacc., Syll. Fung. 5: 382, 1887. Fig. 4

Synonyms: *Pleurotus japonicus* Kawam., Journal Coll. Sci., Imp. Univ. Japan 35(3): 2, 1915; *Lampteromyces japonicus* (Kawam.) Singer, Mycologia 39: 80, 1947; *Omphalotus japonicus* (Kawam.) Kirchm. & O.K. Mill., Persoonia 17: 597, 2002 [For further synonyms, see Neda 2004].

Basidioma pleurotoid to fan-shaped. Pileus 5–10cm in radius, 5–15cm broad; surface red-brown, but becoming dark brown to blackish towards the base; context grayish, but becoming yellow-brown towards the base. Lamellae up to 1.5cm broad, cream, dense. Stipe short, 0.5–1cm long, 1–2cm in diam., brownish to brownish yellow; annulus brownish yellow.

Basidiospores [70/5/5] (9–)10–15.5(–16.5)× (8.5–)9.5–14.5(–15)µm, Q=1.0–1.11(–1.17) (**Q**= 1.07±0.04), globose to subglobose, rarely broadly ellipsoid, nearly colorless and hyaline or yellowish to brownish, thin- to thick-walled (≤2µm thick), non-amyloid, non-dextrinoid; surface smooth when thin-walled, finely rough to verrucous when thick-walled. Basidia 50–67×12–17µm, thin- to thick-walled, 4-spored, sometimes 1- or 2-spored; sterigmata up to 10µm long; basal clamps present. Pleurocystidia absent. Cheilocystidia crowded, fusiform, clavate to subcylindric, 30–60×3–10µm, often with flagelliform, nodulose to sinuous apical outgrowths 1.5–3µm in diam. Pileipellis a cutis composed of repent, radially arranged, 3–20µm wide filamentous hyphae incrusted with violaceous pigments which become olivaceous green when in KOH. Clamp connections abundant in all tissues.

Specimens examined: CHINA, Jilin Province, Xifeng County, Chibei, alt. 860m, 2 August 2008, Z.L. Yang 5094 (HKAS 54190); same location, 2 August 2008, Y.C. Li 1168 (HKAS 56022); Guizhou Province, Suiyang County, Kuankuoshui Nature Reserve, on trunk base of *Quercus* sp., 2 November 1998, M.H. Mo 112 (HKAS 34547). JAPAN: Fukushima Prefecture, Mt. Tashiro-yama, on decaying wood of *Fagus crenata*, 28 September 1980, Y. Doi s.n. (HKAS 35330); Tokyo, Meguro, on decaying wood of *Fagus crenata*, 20 October 1956, R. Imazeki s.n. (HKAS 4826).

Notes: The macro-morphology description of *O. guepiniformis* is based on the Chinese collections. The name *L. japonicus* or *O. japonicus* was used for a long time until Neda (2004) pointed out that this taxon is a later synonym of *O. guepiniformis*. Our

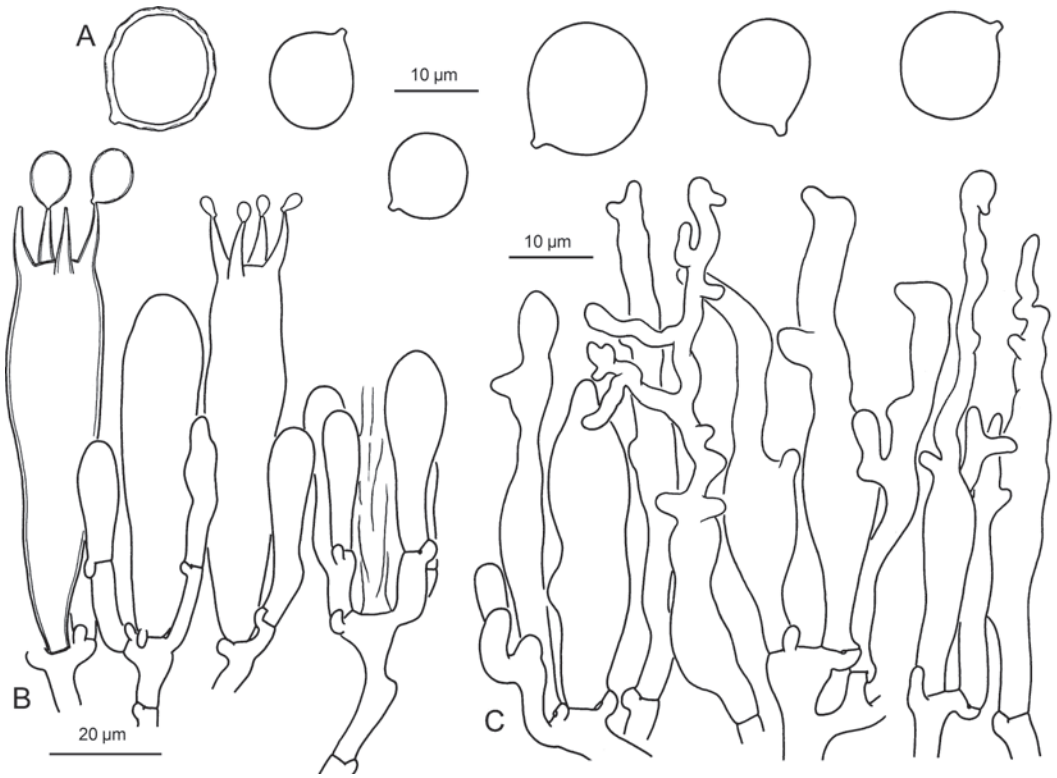

Fig. 4 Microscopic characters of *Omphalotus guepiniformis* (HKAS 54190). A: Basidiospores; B: Basidia; C: Cheilocystidia.

molecular analysis showed that materials from China are clustered with those collected from Japan and South Korea under the name of *O. japonicus* (Fig. 1), and the sequence identities among these samples are very high (98.8%–99.6%), indicating that samples from northeastern China, Japan and South Korea are conspecific. In the literature, the basidiospores of *O. guepiniformis* (or *O. japonicus*) were usually described as smooth (Imazeki & Hongo 1979; Neda 2004). In fact, collections from both China and Japan possess abundant thick-walled basidiospores (crassospores), whose surfaces are finely rough or uneven (Fig. 4). The presence of cheilocystidia in *O. guepiniformis* is evidenced here for the first time.

3. *Omphalotus mangensis* (Jian Z. Li & X.W. Hu) Kirchm. & O.K. Mill., Persoonia 17: 597, 2002. Fig. 5-A

Basionym: *Lampteromyces mangensis* Jian Z. Li & X.W. Hu, Acta Scient. Natur. Univers. Normal Hunan. 16(2): 188, 1993.

Basidiospores [40/2/2] (10–)11–16×(9.5–)10–15(–16)μm, Q=1.0–1.15(–1.23) (**Q**=1.08±0.08), globose to subglobose, rarely broadly ellipsoid, nearly colorless and hyaline or yellowish, thin- to thick-walled (≤2μm thick), non-amyloid, non-dextrinoid; surface smooth when thin-walled, finely rough to verrucous when thick-walled. Basidia, cheilocystidia and pileipellis not recovered.

Specimens examined: CHINA, Hunan Province, Mangshan, on rotten wood of *Schima* sp., 29 April 1974, collector unknown (MHHNU 860, holotype); the same location, on rotten wood of *Schima* sp., 22 April 1975, collector unknown (MHHNU 1696).

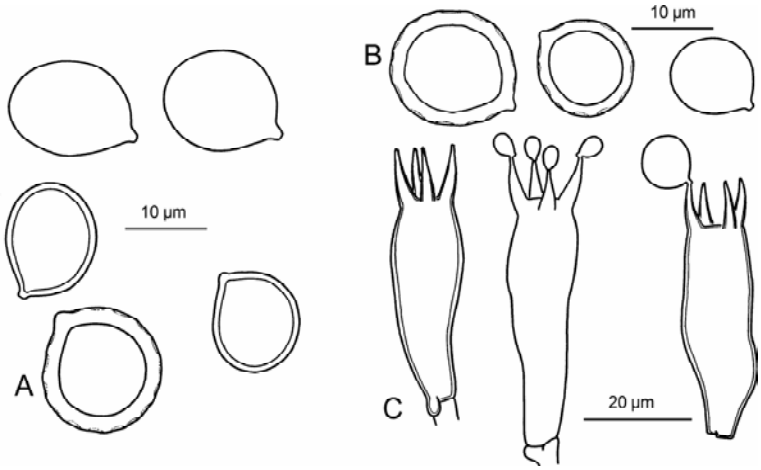

Fig. 5 Microscopic characters. A: Basidiospores of *Omphalotus mangensis* (MHHNU 860, holotype); B and C: Basidiospors and basidia of *Lampteromyces luminescens* (HKAS 5675, holotype), respectively.

Notes: The collections studied are not in good condition, and, thus, only spores were carefully examined (Fig. 5-A). Based on the protologue (Liu & Hu 1993), *O. mangensis* differs from *O. guepiniformis* mainly by its whitish colored basidioma. This species is also very similar to the Malaysian *Pleurotus olivascens* Corner (Corner 1981; Singer 1986; Kirchmair *et al*. 2002). Unfortunately, no recent material of *O. mangensis* is available for both morphological and molecular phylogenetic analyses, and, thus, the taxonomic status of *O. mangensis* is still an open question.

4. *Lampteromyces luminescens* M. Zang, Acta Bot. Yunn. 1: 102, 1979. Fig. 5-B–C

Basidiospores [10/1/1] 10–15×9.5–14.5μm, Q=(1.0–)1.03–1.09 (**Q**=1.05±0.02), globose to subglobose, nearly colorless and hyaline or yellowish, thin- to thick-walled (≤2.5μm thick), non-amyloid, non-dextrinoid; surface smooth to finely rough or verrucous. Basidia 35–50×12–14μm, thin- to thick-walled, 4-spored, sometimes 1- or 2-spored; sterigmata up to 10μm long; basal clamps present. Cheilocystidia not recovered. Pileipellis a cutis composed of repent, 3–8μm wide filamentous hyphae incrusted with violaceous pigments which become olivaceous green when in KOH. Clamp connections present.

Specimen examined: CHINA, Xizang (Tibet) Autonomous Region, Chayu County, Xiachayu, on rotten wood, 1 September 1976, M. Zang 675 (HKAS 5675, holotype).

Notes: This species was erected mainly based on the rough basidiospores (Zang 1979). It is true that thick-walled basidiospores seem to be rough or finely verrucous (see section discussion below). However, rough basidiospores can also be found in the collections of *O. guepiniformis* and *O. mangensis* (Figs. 4-A, 5-A). Thus, the separation of *L. luminescens* from *O. guepiniformis* based on spores morphology is not well justified. It is worth to note that the pileus of *L. luminescens* becomes cyaneous when injured, a phenomenon not common for *Omphalotus* species (Zang 1979). Because no additional materials from the type locality or its adjacent areas are available for morphological or molecular phylogenetic comparison, we keep *L. luminescens* as distinct from *O. guepiniformis*, *O.*

mangensis and *Pleurotus olivascens* for the time being, and the transfer of *L. luminescens* to *Omphalotus* requires further investigation.

2.3 Taxa not well known or excluded

1. ***Omphalotus*** sp.

Basidiospores [60/2/2] 5.5–7.5(8.5)×3.5–4.5(5)μm, Q=(1.30–)1.40–1.89(2.14), (**Q**=1.63±0.17), ellipsoid, occasionally long ellipsoid, thin-walled, colorless and hyaline, non-amyloid, non-dextrinoid; surface smooth. Basidia 35–45×6–7μm, clavate, thin-walled, 4-spored; sterigmata about 5μm long; basal clamps present. Pleurocystidia absent. Cheilocystidia uncovered.

Specimens examined: CHINA, Hubei Province, Shennongjia, on rotten wood, July 1982, anonymous (HMAS 57648, identified as *O. olearius* by X.L. Mao); Xizang (Tibet) Autonomous Region, Medog County, Gandeng, on rotten wood, 19 November 1982, Y.G. Su 2516 [HKAS 13077, regarded as *O. olearius* by Zang (1996)].

2. ***Paxillus rhytidophyllus*** M. Zang, Acta Microbiol. Sin. 18(4): 282, 1978.

Basidiospores [20/1/1] (8.5)9.0–11.5×(6)6.5–8μm, Q=(1.30–)1.38–1.62(–1.67) (**Q**=1.46±0.09), ellipsoid, yellow-brown to brown, smooth, slightly thick-walled (≤1μm thick). Clamp connections present.

Specimen examined: CHINA, Yunnan Province, Mengla County, Menglun, on soil, 2 September 1974, M. Zang 1030 (HKAS 28975).

3. ***Paxillus yunnanensis*** M. Zang, Acta Microbiol. Sin. 18(4): 281, 1978.

Basidiospores not found. Pleurocystidia 30–60×4.5–6μm, narrowly clavate to subcylindric, with yellow contents or light-refractive substances. Cheilocystidia 75–220×12–30μm, crowded, subfusiform, with yellow to yellowish contents.

Specimen examined: CHINA, Yunnan Province, Kunming City, Heilongtan, on soil or on rotten wood with soil (?), alt. 1,900m, under trees of *Pinus yunnanensis*, 8 August 1974, W.Q. Yin 931 [HKAS 28976, holotype; cited as "7. VII. 1974. W.Q. Yin 101 (Typus HKAS 931)" in Zang & Zeng 1978].

3 DISCUSSION

The basidiospores of *O. guepiniformis* (*O. japonicus*) and *O. mangensis* were usually described as "smooth" in the literature. Our observation indicates that the spore walls of *O. guepiniformis* and *O. mangensis* are usually thin-walled and smooth when the spores are just mature, but they are finely rough to verrucous or uneven under light microscope when the spores are old and thick-walled (Figs. 4-A, 5-A, 5-B). Such rough to verrucous appearance is probably due to the non-uniform density of the spore wall, somewhat similar to that observed in species of *Amanita* Pers. (Tulloss & Halling 1997).

Singer (1981) stated that "a Chinese species of what is obviously an *Omphalotus* has recently been described as *Paxillus* (Zang & Zeng 1978)". There were only two new species of *Paxillus*, *P. rhytidophyllus* and *P. yunnanensis* described in the paper of Zang & Zeng (1978). *Paxillus rhytidophyllus* was described to produce a poroid hymenophore, clearly indicating no relationship between this fungus and species of *Omphalotus*. The holotype of *P. rhytidophyllus* has a typical poroid hymenophore bearing yellow-brown to brown basidiospores, typical for a species of Boletales. The purplish red to red-brown pileus, the paler-colored stipe, the minute basidiospores ("2.5–3×3.8–4.5μm") and the vividly colored plate of basidiomata of *P. yunnanensis* might have lead Singer (1981) to conclude that *P. yunnanensis* is a member of

Omphalotus. We also examined the holotype of *P. yunnanensis*. The holotype of *P. yunnanensis* contains only immature basidiomata, and the fungus produces prominently large cheilocystidia, implying a likely classification in *Tricholomopsis*.

Kirchmair *et al*. (2002) supposed that *L. luminescens* belongs likely to *Lentinellus*. The type of *L. luminescens* is a single basidioma in a relatively good condition, and a rudimental annulus on the stipe could clearly be traced and the basidiospores are neither amyloid nor dextrinoid. Such characters indicate that *L. luminescens* must be very close to *O. guepiniformis* if they are not conspecific. The possibility that *L. luminescens* is a member of *Lentinellus*, a genus with amyloid basidiospores (Singer 1986; Petersen & Hughes 2004), can be excluded.

Tai (1979), Mao (1987, 1998, 2000) and Zang (1996) reported *O. olearius* from China. We found two Chinese collections, each with only one basidioma, under the name of *O. olearius* in Chinese mycological herbaria, viz. HMAS 57648 and HKAS 13077. The basidiospores of HMAS 57648 are (5.5)6–8(8.5)×3.5–4.5(5)μm, while the basidiospores of HKAS 13077 are 5.5–7(7.5)×(3.5)4–4.5μm. The sizes of the basidiospores of the two collections are almost the same, which indicates that the both collection probably represent a single species. However, the basidiospores of the Chinese collections are much narrower than those of the European *O. olearius* (Horak 1968; Kirchmair & Pöder 2002; Kirchmair *et al*. 2002). Additional collections of the Chinese fungus will shed light on its taxonomy.

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