

## ***Multifurca* (Russulales), a genus new to China**

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**Abstract** – The genus *Multifurca* was newly established to accommodate a phylogenetic clade based on *Russula* subsect. *Ochricompactae*. Two species of the genus, *M. furcata* and *M. zonaria*, which were originally described from United States and Thailand respectively, were found to exist in subtropical-tropical China. Morphological analysis showed that the Chinese collections named as *M. furcata* meet all of the key characters of *M. furcata*, which circumscribed an Asia-American distribution pattern of *M. furcata*. Compared with Thai material of *M. zonaria*, more differentiated pileipellis and presence of hymenial macrocystidia were found in the Chinese specimens. This report broadens our understanding on the morphology, geographic distribution, and habitat of the two species, as well as the whole genus.

tropical / *Lactarius* / *Russula* / taxonomy / biogeography

### **INTRODUCTION**

As a result of molecular phylogenetic studies, the last decade has seen a series of changes in the understanding of many groups in Russulaceae. The changes are not only related to genera with a gasteroid or secotioid habit, such as *Arcangiella*, *Gymnomyces*, *Macowanites*, and *Zelleromyces*, but also involve two most famous agaricoid genera *Russula* and *Lactarius* (Miller *et al.*, 2006; Buyck *et al.*, 2008). The morphological delimitation between *Russula* and *Lactarius*, such as presence/absence of latex exudation and hymenial pseudocystidia, abundance of sphaerocytes, and habit of sporocarps became obscure with some members found from tropical regions (Buyck, 1995; Henkel *et al.*, 2000; Buyck & Desjardin, 2003). With the exception of Eberhardt & Verbeken (2004), the monophyly of *Russula* and *Lactarius* is under suspicion for long time (Henkel *et al.*, 2000; Miller *et al.*, 2001; Shimono *et al.*, 2004; Miller *et al.*, 2006). The description of a new genus *Multifurca* Buyck & V. Hofst. was proposed as the best option to minimize the phylogenetic and overwhelming nomenclatural problems with *Russula* and *Lactarius* (Buyck *et al.*, 2008, 2010).

*Multifurca* was described to accommodate a well-supported monophyletic clade comprising species of *Russula* subsect. *Ochricompactae* Bills & O.K. Mill. and one *Lactarius*, *L. furcatus* Coker. Mainly based on *Russula* subsect. *Ochricompactae* and sharing the same type with the subsection, as a “hybrid” of the two genera, the small genus can nevertheless easily be recognized by a combination of various characters: concentrically zonate pale-colored pileus, regularly forked gills that are yellow to salmon at maturity, zonate context, dark-

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colored spore print, and very small and faintly ornamented spores. The now known geographic distribution ranges from southeastern North America, Central America (Costa Rica), Oceania (New Caledonia), and Southeast and South Asia (Thailand and India) (Buyck *et al.*, 2008). In our framework of the taxonomy of the genus *Lactarius* in southwestern China, a few *Multifurca* collections from subtropical-tropical evergreen forests were found. Morphological analysis suggests the conspecificity of the Chinese collections with the American collections of *M. furcata* (Coker) Buyck & V. Hofst. and with the Thai collections of *M. zonaria* (Buyck & Desjardin) Buyck & V. Hofst. respectively. The results presented in this paper, while broadening the present knowledge of the distribution of the genus, address further the biogeography of the genus.

## MATERIALS AND METHODS

The macroscopical descriptions of sporocarps are from fresh material and micromorphological study on dried material. Basidiospores were observed and measured in Melzer's reagent in sideview, excluding ornamentation and apiculus. All other micromorphological structures were revived in 5% KOH then mounted with Congo-red (aqueous reagent). Presence or absence of hyphal incrustations was checked using distilled water. All drawings except those of the basidiospores were made under a drawing tube installed in Nikon E400 microscope. Colour codes are from Kornerup & Wanscher (1961). For further explanation of basidiospores data, see Yang (2000).

## RESULTS

*Multifurca furcata* (Coker) Buyck & V. Hofst., Fungal Diversity 28: 37 (2008) Fig. 1  
 = *Lactarius furcatus* Coker, J. Elisha Mitchell Sci. Soc. 34(1): 18 (1918)

**Sporocarps** medium-sized, robust, hard, compact. **Pileus** 30-70 mm in diam., depressed at center, infundibuliform, undulate, sometimes divided into two lobes; margin strongly involute when young; surface greasy, smooth, pale yellowish, clearly and densely zonate. **Context** 2-3 mm thick, subwhitish, sharp. **Lamellae** as cantharelloid veins when young, 1-1.5 mm high, forking, subcrowded to subdistant, decurrent, subconcolorous with the pileus. **Stipe** 20-30 × 6-10 mm, equal, cylindrical, solid, often eccentric; surface whitish, smooth, irregularly scrobiculate. **Latex** white, sharp. **Spore print** unknown.

**Basidiospores** (80/4/2) (4.0) 4.5-5.5 (6.0) × 3.5-4.5 μm [ $Q = (1.13) 1.16-1.38 (1.43)$ ,  $Q = 1.26 \pm 0.07$ ], subglobose to ellipsoid; ornamentation very faint, up to 0.2 μm high, composed of short ridges and irregular warts, rarely arranged in a zebroid pattern, not forming a reticulum; plage obscure or not amyloid. **Basidia** 35-50 × 5-9 μm, subcylindrical, 4-spored. **Macrocystidia** absent. **Pseudocystidia** abundant, (6) 8-14 μm thick, robust, emergent, unforking, with a blunt and swollen apex, with dense contents, buried or shortly projecting beyond the basidia. **Lamellar edge** sterile. **Pileipellis** an ixocutis, 120-150 μm thick; hyphae (3) 4-6 μm in diam., often shriveled, not gelatinized. **Stipitipellis** an ixocutis or cutis;

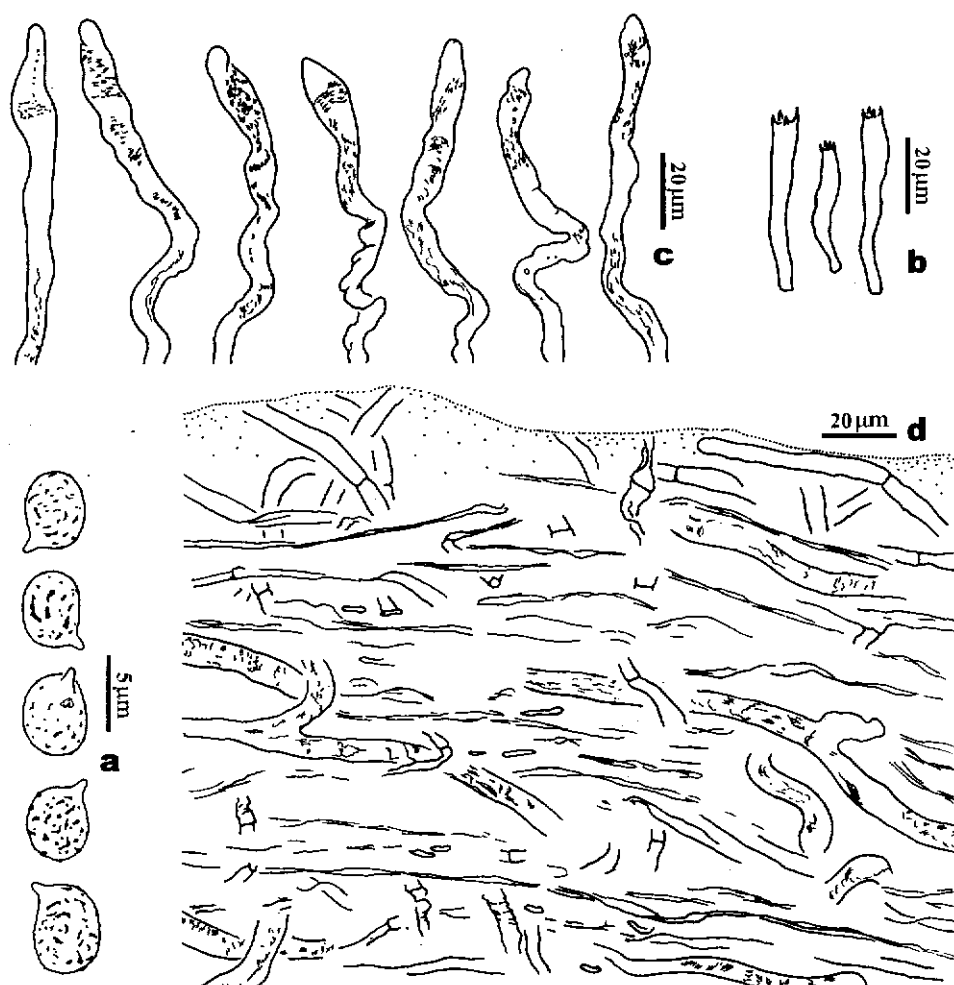


Fig. 1. *Multifurca furcata* (KUN F41904): a. basidiospores; b. basidia; c. pseudocystidia; d. pileipellis.

hyphae 3-4 (6)  $\mu\text{m}$  in diam., often shriveled, compactly arranged. **Trama** in pileus and lamellae with abundant robust lactiferous hyphae filled with rich golden yellow contents, lacking sphaerocytes, in stipe with typical rosettes. **Hyphal incrustations** absent from all tissues.

**Habitat and distribution:** in forest of *Pinus kesiya* var. *langbianensis* (A. Chev.) Gaussen + fagaceous trees. China (subtropical-tropical Yunnan), Costa Rica, Mexico, and USA.

**Specimens examined:** CHINA, Yunnan Prov.: Lancang County, Qianmai, Longshan Village, alt. 950 m, July 18, 2002, F.Q. Yu 775 (KUN F41904); Mengla, Longmen, Nanman Mt., alt. 850-900 m, September 27, 1974, M. Zang 1868 (KUN F1868); Simao, Caiyang River, Tianbi, alt. 1550 m, July 6, 2000, M. Zang 13589 (KUN F36369).

*Note:* According to Coker (1918) and Montoya *et al.* (2003), the latex of the species discolors grayish green. Though the discoloration of the latex of the Yunnan specimens is unknown due to lack of field notes, the strong similarity to the American collections is still very obvious: the clearly densely zonate and pale-colored pileus, the small spores with very faint ornamentation, an ixocutis as the pileipellis, and the robust hymenial pseudocystidia in contrast with the slender basidia. No notable differences were found between the Chinese material and descriptions based on American material (Coker, 1918; Hesler & Smith, 1979; Montoya *et al.*, 2003).

This is the only species that exudes latex in *Multifurca*. It is because of this that when described, it was regarded as a typical *Lactarius* (Coker, 1918). Hesler & Smith (1979) and Montoya *et al.* (2003) all placed this species in *Lactarius* subgen. *Piperites* (Fr.) Kauffman. The characteristics of the species strongly argue for a position in *Lactarius* subsect. *Zonarii* (Quél.) Basso. The molecular data, however, definitely clustered this species with two species of *Russula* in a small but basal clade separate from other *Lactarius* and *Russula* (Buyck *et al.*, 2008).

The potential hosts of the Yunnan specimens are *Pinus kesiya* var. *langbianensis* or fagaceous trees (probably *Castanopsis*). This is partly similar to those in Mexico and Costa Rica (Montoya *et al.*, 2003). Like in America, this species is also very rare in southwestern China: among more than 2000 *Lactarius* specimens deposited in the fungal herbarium of KUN collected for over 30 years, only 3 specimens were found. The resulting larger geographic distribution tentatively suggests an Asia-American disjunct distribution pattern for *M. furcata*. Given that the whole genus *Multifurca* is ancient, as concluded by Buyck *et al.* (2008), the present distribution could be explained more likely as a result of vicariance from a common ancestor that already existed in Pangaea. Molecular data on more specimens are needed to investigate the phylogenetic diversity inside this morphological species group.

***Multifurca zonaria*** (Buyck & Desjardin) Buyck & V. Hofst., Fungal Diversity 28: 37 (2008)

Figs 2, 3 & 4

≡ *Russula zonaria* Buyck & Desjardin, Cryptogamie Mycologie 24(2): 112 (2003)

**Sporocarps** small to medium-sized, robust, hard, compact. **Pileus** 20–50 mm in diam., depressed at center with involute margin, pale yellow or pale orange; margin whitish, with a tendency to forming a cottony roll; surface subglabrous, azonate or subzonate. **Context** 3–4 mm, whitish, concentrically zonate. **Lamellae** as cantharelloid veins, 1 mm high, forking, subcrowded, decurrent, cream or pale yellow (3A3) at first, pale yellow (3A3) when mature. **Stipe** 12–15 × 10–20 mm, equal or tapering downwards, cylindrical, hollow, central, rarely eccentric; surface whitish, subtomentose, locally scrobiculate. **Odor** unpleasant. **Spore print** unknown.

**Basidiospores** (60/3/2) 5.0–6.0 (6.5) × (4.0) 4.5–5.0 (5.5)  $\mu\text{m}$  [ $Q = (1.10) 1.14\text{--}1.28$  (1.33),  $Q = 1.21 \pm 0.05$ ], subglobose to ellipsoid; ornamentation composed of clear, strong amyloid warts and ridges sometimes forming a partial reticulum, up to 0.5  $\mu\text{m}$  high; plage not amyloid. **Basidia** (30) 35–45 × 8–10  $\mu\text{m}$ , clavate, 4-spored. **Pleuromacroscystidia** very rare, scattered, subcylindrical with slightly ventricose middle parts, with sparse granular refractive contents; base imbedded in sybhyemium or even trama. **Pseudocystidia** common, 4–6  $\mu\text{m}$  in diam., projecting 10–30  $\mu\text{m}$  beyond basidia, with refractive contents, sometimes forking, with a blunt apex. **Lamellar edge** sterile; cheilomacroscystidia absent.

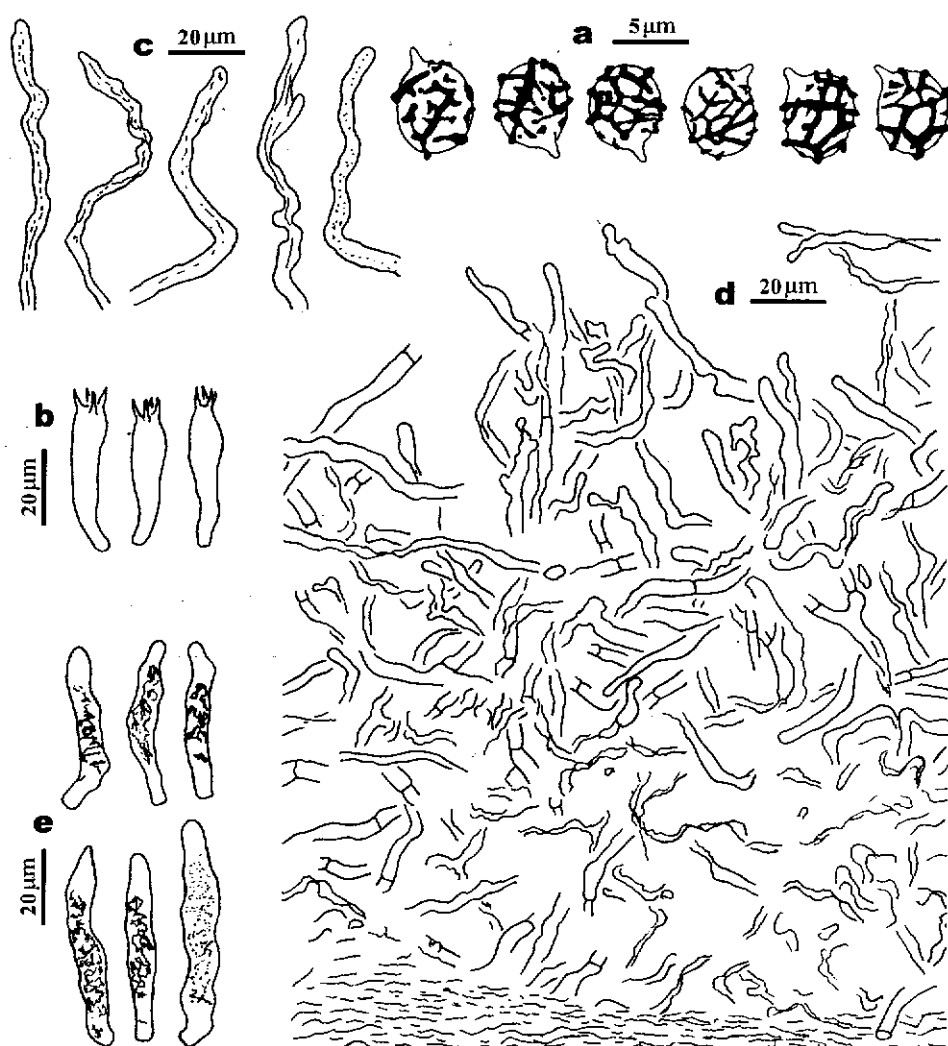


Fig. 2. *Multifurca zonaria* (KUN F51464): a. basidiospores; b. basidia; c. pseudocystidia; d. pileipellis. KUN F47712: e. pleuromacrocystidia.

**Pileipellis** a lattice, obviously differentiated from context, 120-180 µm thick, composed of very loosely interwoven hyphae, rarely with terminals of lactiferous hyphae; hyphae 3-5 µm in diam., those at inner part often shriveled, not or slightly gelatinized; dermatocystidia absent. **Stipitipellis** ill-defined; outermost layer as irregularly scattered repent fascicles of thin-walled hyphae, hyphae 3-5 µm in diam.; layer under the hyphal fascicles composed of compacted hyphae which are similar to those under the pileipellis. **Trama** of pileus and stipe composed of compacted, thin-walled hyphae, lacking sphaerocytes, in lamellae composed of cylindrical, generative hyphae and oleiferous hyphae, lacking sphaerocytes. **Hyphal incrustations** absent from all tissues.



Fig. 3. *Multifurca zonaria* (KUN F51464).

*Habitat and distribution:* in *Castanopsis* sp. forests. China (tropical Yunnan) and Thailand.

*Specimens examined:* CHINA, Yunnan Prov. Jinghong, Dadugang, August 30, 2004, X.H. Wang 1790 (KUN F47712); Jinghong, Jinduoshan, alt. 1000 m, July 9, 2006, X.H. Wang 1984 (KUN F51464).

*Note:* The tropical Chinese collections essentially meet the characters in *M. zonaria* from Chiang Mai, Thailand given by Buyck & Desjardin (2003): the *Lactarius*-like sporocarps, absence of latex, presence of hymenial pseudocystidia, concentrically zonate context, and ornamentation of spores. The macrocystidia, which were described as “not observed and either extremely rare or absent” by Buyck & Desjardin (2003), were found to be very rare and atypical in our Chinese collections. They are somewhat similar to big sterile basidioles, however, the apex, the deeper position, and denser contents inside tend to suggest that they represent macrocystidia. The cystidia are difficult to be found in materials not preserved well. The pileipellis in the Yunnan materials is well-developed and better differentiated from the underlying context, giving a pattern of lattice.

It is worthwhile to mention that the two Chinese specimens were collected from fagaceous forests, while the Thai ones are from dipterocarp forest (Buyck & Desjardin, 2003; Buyck *et al.*, 2008). The Chinese collections broaden our understanding of the distribution and habitat of *M. zonaria*. Taking both the similar climate and biogeographic background between tropical China and



Fig. 4. *Multifurca zonaria* (KUN F47712).

Southeast Asia into account, it is not surprising to see some Thai species in tropical China (Yang & Zang, 2003). Our work on the genus *Lactarius* in tropical southwestern China has convinced that tropical China shares a quite number of species with tropical Asia, such as *L. austrozonarius* H.T. Le & Verbeken, *L. sulphureus* Verbeken & E. Horak, and *L. liliputianus* Verbeken & E. Horak etc. (results unpublished).

**Acknowledgements.** The authors thank Dr. B. Buyck, Muséum National d'Histoire Naturelle, Paris, France, Dr. L. Montoya, Instituto de Ecología, Xalapa, México, and Dr. Z.L. Yang, Kunming Institute of Botany, Chinese Academy of Sciences, Kunming, China for critically reviewing and improving the manuscript. Prof. M. Zang, Kunming Institute of Botany, Chinese Academy of Sciences helped to recheck the information on the localities. The work was supported by the National Natural Science Foundation of China (NSFC 30970020, 30300002, 30770007), the Innovation Program of the Chinese Academy of Sciences (No. KSCX2-YW-Z-0926), the Ministry of Science and Technology of China (2008FY110300), and the Yunnan Provincial Science Foundation (2009CD115).

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