

A type study of *Lactarius sakamotoi* and its presence in China

Xiang-Hua WANG & Pei-Gui LIU

*Key Laboratory of Biodiversity and Biogeography,
Kunming Institute of Botany, Chinese Academy of Sciences,
Kunming 650204, P. R. China*

*Tel.: 086-871-5223125 – Fax: 086-871-5150227
Email: xhwang@mail.kib.ac.cn, pglu@mail.kib.ac.cn*

Abstract – *Lactarius sakamotoi* (Russulaceae) is here reported from northeastern China. It is the second collection for this species, originally described from Japan. Our detailed study of the type collection revealed that the ornamentation of the basidiospores is not “echinulatis” as mentioned in the protologue, but consists of isolated ridges and warts in a zebroid pattern. This ornamentation, together with the ellipsoid form of the spores, the dark-coloured squamulose pileus, and the thick brown hyphae in the pileipellis delimit the species that is here considered a member of *Lactarius* subgen. *Piperites* sect. *Piperites*. Its counterparts in North America, Europe and tropical Asia are *L. purpureoechinatus*, *L. spinosulus*, and *L. strigosus* respectively.

***Lactarius* / taxonomy / Russulaceae / East Asia**

INTRODUCTION

Among the species originally described from East Asia, those described by S. Imai (1935) are poorly known (Nagasawa, 1998). The reason for this is that he just gave short and simple descriptions and that no further work has been done on the type specimens since their publication. This caused difficulties when trying to identify related Chinese collections.

During a field trip to northeastern China in 2006, a collection of small basidiocarps with a dark-coloured squamulose pileus led our attention to *L. sakamotoi* S. Imai, a species that has a “fibrilloso-squamoso” “subatroviridi” pileus. We here present a detailed study of this Chinese collection and compare it with the holotype of *L. sakamotoi* deposited in Hokkaido University Museum, Sapporo, Japan (SAPA).

MATERIALS AND METHODS

All morphological features of the type are based on our examination of the dry collection. The record of *L. sakamotoi* in China is based on a collection from Jilin Province, China, and deposited in Kunming Institute of Botany

Herbarium, Kunming, China (KUN). Basidiospores were observed in Melzer's reagent and measured in side view, excluding ornamentation and apiculus. Statistical citation of measures follows Yang (2000). 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 using a drawing tube installed on a Nikon E400 microscope. Colour codes are from Kornerup and Wanscher (1961).

RESULTS

Lactarius sakamotoi S. Imai, Bot. Mag. 49: 609 (1935)

Figs 1-2

Latin protologue: *Gregarius vel solitarius. Pileo 2-3 cm. lato, umbilicato, dein infundibuliformi, sicco, a fibrilloso-squamoso dense tecto, primo subatroviridi, dein pallescente, margine involuto, villosio; carne pallida, tenui, inmutabili; lacte albo, inmutabili, acri; lamellis decurrentibus, pallidis, dein fulvescentibus pruinescentibusque, bifidis, confertis; stipite 2-4.5 cm. longo, 3-4 mm. crasso, aequali vel apice leniter attenuato, fusco vel murino, glabro, cavo; sporis in cumulo ochraeis, late ellipsoideis vel subglobosis, echinulatis, 6-8 × 5-7 μ.*

Type study

In poor condition, composed of one almost complete basidiocarp and fragments of a second basidiocarp. Pileus 8-13 mm in diam., depressed at centre, with a central umbo, with erect to suberect squamules, margin hairy, greyish-brown (5F2-5F3). Lamellae 0.7-1.2 mm broad, crowded, decurrent, light yellow (3A4-4A4). Stipe 17 × 2.5 mm, cylindrical, equal, smooth, yellowish-brown (5F4); base with light yellow (4A4) tomentum.

Basidiospores 6.5-8(-8.5) × (5-)5.5-6.5 μm [Q = (1.17-)1.18-1.33(-1.43), Q = 1.26 ± 0.05] (80/2/1), ellipsoid; ornamentation 0.5-1.0(-1.2) μm high, composed of almost isolated ridges and warts arranged in a typical zebroid pattern; plage not amyloid, rarely completely amyloid. Basidia 35-40 × 9-12 μm, 4-spored, clavate. Pseudocystidia 3-4 μm in diam., narrowly cylindrical, common. Pleuromacrocytidia 45-65 × 7-9 μm, fusiform, sublanceolate, with very acute and thin apex, with dense contents, scarce to common. Lamellar edge sterile; cheilomacrocytidia 30-45 × 5-8 μm, fusiform, rarely cylindrical, with dense contents, scarce to common. Pileipellis between squamules a cutis; hyphae 5-10(-12) μm in diam., olivaceous-brown in distilled water, brownish in KOH; squamules composed of fascicles of erect to suberect hyphae 6-10 μm in diam. at basal part and 3-5 μm in diam. towards tips, olivaceous-brown in distilled water, brownish in KOH; hyphal incrustations absent. Stipitipellis a cutis; hyphae 3-5 μm in diam, compactly arranged, with brownish intracellular pigmentation. Trama of pileus and stipe with rosettes of sphaerocytes.

Holotype: JAPAN, Hokkaido, Prov. Ishikari, Mt. Sapporo, September 21, 1930, leg. M. Sakamoto (SAPA, Imai's collection no. 255).

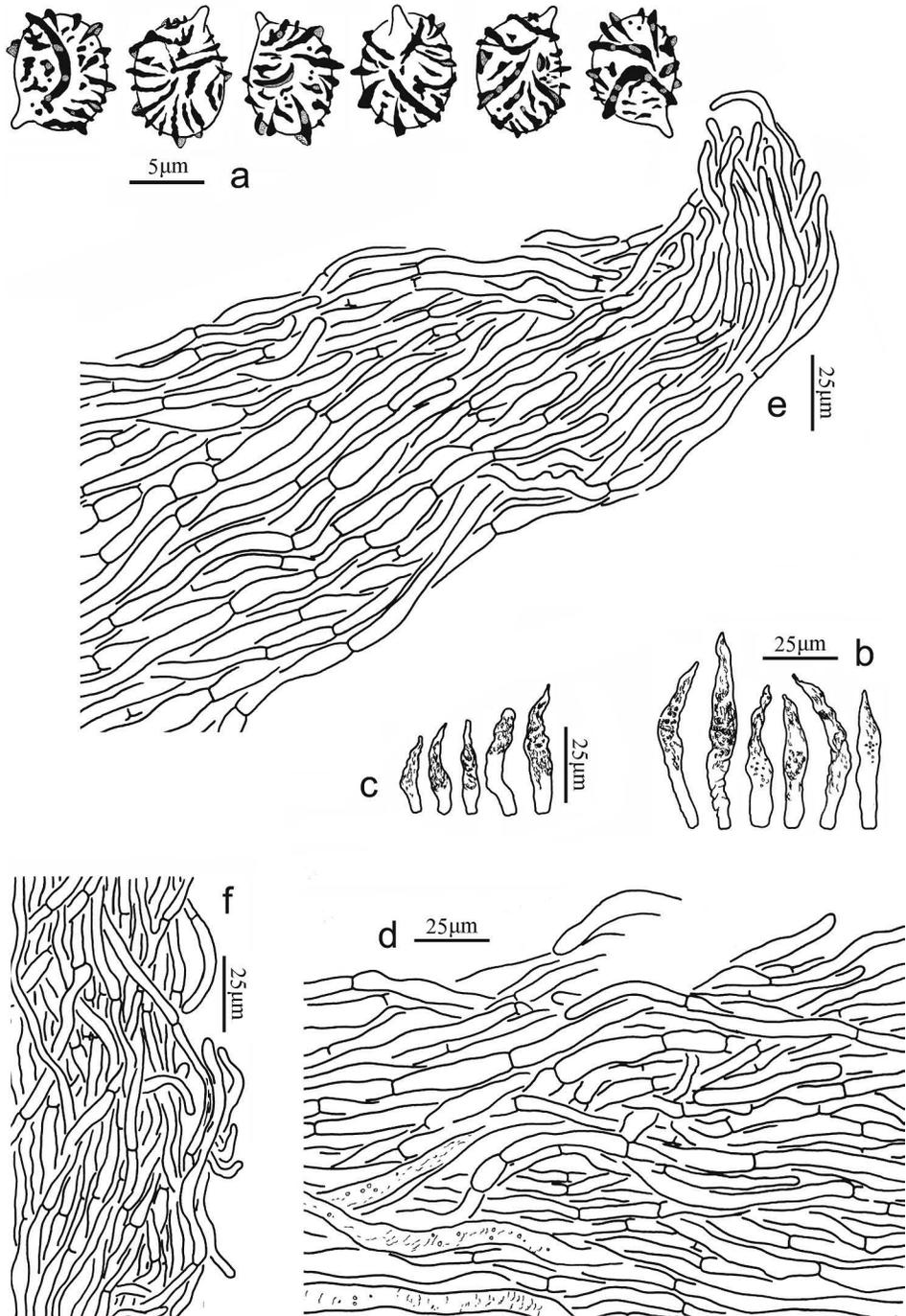


Fig. 1. *Lactarius sakamotoi* (holotype): **a.** basidiospores, **b.** pleuromacrocystidia, **c.** cheilomacrocystidia, **d.** pileipellis between squamules, **e.** structure of part of a squamule, **f.** stipitipellis.

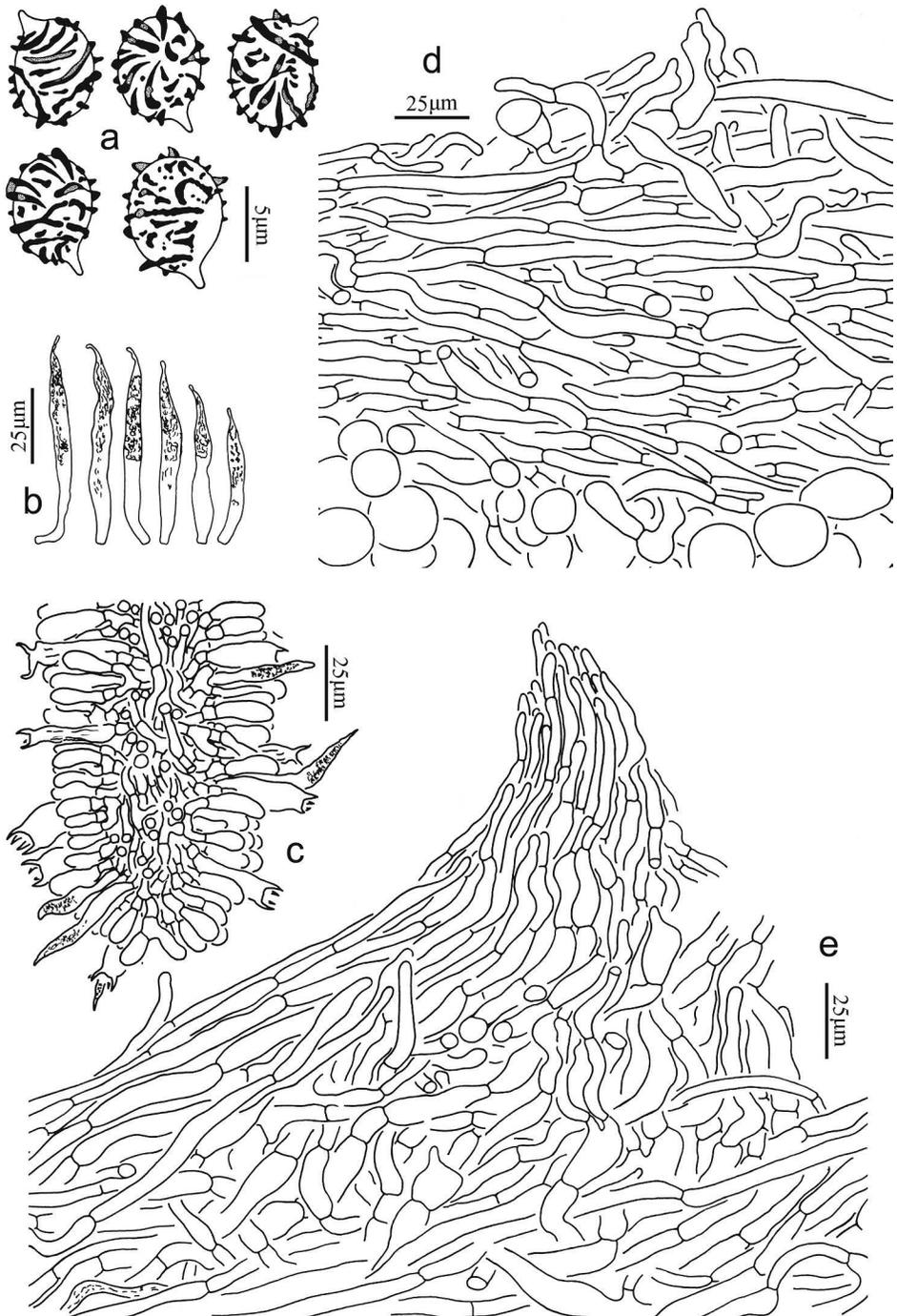


Fig. 2. *Lactarius sakamotoi* (KUN F51135): **a**, basidiospores, **b**, pleuromacrocystidia; **c**, lamellar edge, **d**, pileipellis between squamules, **e**, structure of part of a squamule.

Study of Chinese material

Pileus 15-30 mm in diam., concave at first, then infundibuliform, blackish when young, then greyish-black with dark bluish tinge, faintly zonate, darker at centre, covered with fine erect to suberect squamules. Context around 1 mm thick, smoky-grey. Lamellae 1-2 mm broad, crowded, decurrent, light yellow (4A4). Stipe 30-45 × 4-6 mm, tapering downwards or equal, often depressed, hollow, thin-fleshed, smooth, yellowish-brown (close to 5E5). Latex milky, soon watery, finally discoloring very pale yellowish on the lamellae, very hot.

Basidiospores 6-7.5(-8.5) × 5-6(-6.5) μm [Q = (1.15-)1.18-1.32(-1.36), Q = 1.23 ± 0.05] (40/2/1), ellipsoid; ornamentation 0.5-0.8(-1) μm high, composed of ridges and warts in a typical zebroid pattern; ridges rarely branching; plage not amyloid. Basidia 35-45 × 10-12 μm, clavate, 4-spored. Pseudocystidia 3-4 μm in diam., cylindrical, often forking or branching, uncommon. Pleuromacrocystidia (45-)50-70 × 6-8 μm, projecting, fusiform with an acute, μmoniliform apex, scarce. Lamellar edge sterile or fertile; cheilomacrocystidia scarce to common, similar to but smaller than pleuromacrocystidia. Pileipellis between squamules a cutis with some hyphal terminals projecting; hyphae 5-10(-15) μm in diam., with dark brownish intracellular pigmentation; squamules composed of fascicles of erect hyphae 5-15 μm in diam. at basal part and 3-5 μm in diam. towards tips; hyphal incrustations absent. Stipitipellis a cutis; hyphae 2-5 μm in diam., those at outermost layer brownish, compactly arranged. Trama of pileus and stipe with abundant rosettes.

Habit and habitat: Solitary, in forest dominated by *Pinus koraiensis* Sieb. et Zucc., *Betula platyphylla* Suk., *Populus* sp. and *Quercus* sp.

Specimen Examined: CHINA, Jilin Province, Fusong County, Lushuhe, in mixed forest, alt. 500 m, X.H. Wang 2097 (KUN F51135).

DISCUSSION

When *L. sakamotoi* was originally described from Japan, no collection was designated as the type (Imai, 1935). Since its publication was before January 1, 1958, *L. sakamotoi* is still a valid name based upon the Vienna Code (McNeill *et al.*, 2006). In SAPA, where S. Imai's collections are deposited, there is only one specimen under the name *L. sakamotoi*. It was collected by M. Sakamoto from Prov. Ishikari, Mt. Sapporo on September 21, 1930, coinciding with the time indicated in the protologue (Imai, 1935). This is apparently the material on which Imai's description was based and even though this specimen was not explicitly designated, it should be considered the holotype, as treated also by Hongo (1960). Most of the microscopic characters from the type could be studied. The spores revived well in Melzer's reagent and the ornamentation, which was described as "echinulatis" in the protologue, is in fact composed of isolated ridges and warts arranged in a zebroid pattern. Their shape is typically ellipsoid. Cheilomacrocystidia, not mentioned in the protologue, were found scattered along the entire lamellar edge, a feature that is consistent with the Chinese collection.

The Chinese specimen matches well with the type material, except that the pileus of *L. sakamotoi* is described as "primo subatroviridi, dein pallescente" by Imai whereas that of the Chinese specimen is greyish black tinged with some bluish tone.

The basidiospores ornamented with zebroid ridges and the dark-coloured pileus of *L. sakamotoi* are reminiscent of some other Chinese species in *Lactarius*. For *L. atosquamulosus* X. He, a species originally described from Jilin Province, northeastern China (He, 1996), the distinctive features are considered (He, pers. comm.) to be the pileus “purpureo nigricanti” and the basidiospores “globosae, subglobose vel late ellipsoideae”. However, since the type of *L. atosquamulosus* is missing (Wang, 2007), it is impossible to compare it with *L. sakamotoi*. Another morphologically similar species was recently described from southwestern China as *L. imbricatus* M.X. Zhou & H.A. Wen (Zhou & Wen, 2007), unfortunately an invalidly published name (McNeill *et al.*, 2006) since two specimens deposited in different herbaria were designated as the holotype. It has a greyish pileus lacking bluish or blackish green tinges.

Morphologically similar taxa to *L. sakamotoi* are also known from Europe, North America, and tropical Asia. In particular *L. spinosulus* Quéél., *L. purpureoechinatus* Hesler & A.H. Sm. and *L. strigosus* Verbeke & E. Horak all share the squamulose pileus and basidiospores with zebroid ornamentation. The pileus of the European *L. spinosulus* is lilac pinkish (Neuhoff, 1956; Heilmann-Clausen *et al.*, 1998; Basso, 1999). The subdistant to distant lamellae, the presence of hyphal incrustations in the pileipellis and the purple-drab pileus distinguish the American *L. purpureoechinatus* (Hesler & Smith, 1979), whereas *L. strigosus*, described from Papua New Guinea, has orange basidiocarps and a less zebroid spore ornamentation (Verbeke & Horak, 2000).

Hongo (1960) listed *L. sakamotoi* in *Lactarius* sect. *Russulares* Fr. based upon the system of Singer (1951). The small and slender basidiocarps of this species are indeed reminiscent of sect. *Russulares*. However, the features of the pileipellis and the spore ornamentation indicate closer affinities to *L. spinosulus*. We therefore propose that *L. sakamotoi* is placed in *Lactarius* subgen. *Piperites* sect. *Piperites* Fr. in the system of Heilmann-Clausen *et al.* (1998).

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REFERENCES

- BASSO M.T., 1999 — Fungi Europeai. *Lactarius* Pers. Alassio, Mycoflora.
 HE X., 1996 — *Lactarius atosquamulosus* X. He — a new species of *Lactarius*. *Acta Mycologica Sinica* 15: 17-20.
 HEILMANN-CLAUSEN J., VERBEKE A. & VESTERHOLT J., 1998 — *The Genus Lactarius* (Fungi of Northern Europe, Volume 2.). Mundelstrup, Danish Mycological Society.

- HESLER L.R. & SMITH A.H., 1979 — *North American species of Lactarius*. Ann Arbor, University of Michigan Press, 841p.
- HONGO T., 1960 — The Agaricales of Japan 1-3. Russulaceaeae. *Acta Phytotaxonomica et Geobotanica* 18: 129-146.
- IMAI S., 1935 — Studies on the Agaricaceae of Japan II *Lactarius* in Hokkaido. *The Botanical Magazine* 49: 603-610.
- KORNERUP A., WANSCHER J.H., 1961 — *Farver i Farver*. Copenhagen, Politikens Forlag.
- MCNEILL J., BARRIE F.R., BURDET H.M., DEMOULIN V., HAWKSWORTH D.L., MARHOLD K., NICOLSON D.H., PRADO J., SILVA P.C., SKOG J.E., WIERSEMA J.H. & TURLAND N.J. (eds.), 2006 — *International Code of Botanical Nomenclature (Vienna Code) adopted by the Seventeenth International Botanical Congress Vienna, Austria, July 2005*. Liechtenstein, A. R. G. Gantner Verlag.
- NAGASAWA E., 1998 — A preliminary checklist of the Japanese Agaricales. II. The suborder Russulineae. *Reports of the Tottori Mycological Institute* 36: 36-71.
- NEUHOFF W., 1956 — *Die Pilze Mitteleuropas. Band IIb. die Milchlinge (Lactarii)*. Julius Klinckhardt: Bad Heilbrunn Obb.
- SINGER R., 1951 — The “Agaricales” (mushrooms) in modern taxonomy. *Lilloa* 22: 1-832.
- VERBEKEN A. & HORAK E., 2000 — *Lactarius* (Basidiomycota) in Papua New Guinea. 2. Species in tropical-montane rainforest. *Australian Systematic Botany* 13: 649-707.
- WANG X.H., 2007 — Type studies of *Lactarius* species published from China. *Mycologia* 99: 253-268.
- YANG Z.L., 2000 — Type studies on agarics described by N. Patouillard (and his co-authors) from Vietnam. *Mycotaxon* 75: 431-476.
- ZHOU M.X. & WEN H.A., 2007 — Studies on the genus *Lactarius* from China III. A new species from Tibet. *Mycosystema* 26: 1-3.

