

## ***Russula zhejiangensis* sp. nov. from East China**

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**Abstract** – As a result of a study of *Russula* in East China, *Russula zhejiangensis* sp. nov., a member of *Russula* subgen. *Tenellula* sect. *Laricinae*, is described. It is characterized by the small-sized basidiomata with bright red, glabrous pileus, yellowish context, cream to ochre spore print, subglobose to ellipsoid basidiospores with isolated obtuse warts, and the pileipellis with septate dermatocystidia. It strongly resembles the Chinese *R. minutula* var. *minor*, but the latter has a yellow tinged pileus edge, white spore print, longer, lanceolate cystidia with acute apex and longer cells for the hyphal extremities in the pileipellis.

***Russulaceae* / taxonomy / morphology / Basidiomycota**

### INTRODUCTION

East China includes Shandong, Jiangsu, Anhui, Jiangxi, Zhejiang, Fujian, Taiwan provinces and Shanghai city, covering 25°40'N-33°N, 111°15'E-123°E. Influenced by the monsoon and adjacent ocean, the region is characterized by a relatively moist and warm climate, rather diverse coniferous and broad-leaved forests, which are dominated by pine and fagaceous trees (Zheng & Jin 2008; Zhou & Meng 1996). These putative ectomycorrhizal partners explain the fructification of many ectomycorrhizal fungi in summer time, among which the species of *Russula* are very common (Gan et al, 2005).

The Chinese mycologist S. C. Teng was the first to collect *Russula* specimens in East China between 1932 and 1963 in Jiangsu, Zhejiang, Anhui and Fujian provinces (Tai 1979). In the Mycological Herbarium, Institute of Microbiology, Chinese Academy of Sciences (HMAS), there are 52 specimens collected by Teng in East China during that period. Subsequently more *Russula* species were reported from East China (Chou & Wang 2005; Huang 1998; Mao 1998, 2000; Sawada 1942, 1943, 1959; Ying et al 1982, 1987; Wang et al 1999, 2009; Wang & Liu 2010), resulting in a total number of 72 recorded taxa (Song et al. 2007; Li & Wen 2009; Wang et al 2009) some of which may have a broader distribution (Das et al. 2011). Due to the notorious taxonomic difficulty of the genus and due to the shortage of intensive taxonomic studies in China (Singer 1962; Wang et al 2009), most Chinese russulas were passed under European or American names, which might blur the real diversity of the genus in China in the same way it does in North America for example (Adamcik & Buyck 2010, 2011; Buyck & Hofstetter, 2011). While studying the collections from East China, one new species was discovered and is described herein.

## MATERIALS AND METHODS

Fresh characteristics were recorded in detail soon after the basidiocarps were collected. Color names and codes are based on Ridgway (1912). Descriptions of the spore color refer to Romagnesi (1967). Specimens were air-dried at 55°C. Microscopic characteristics were examined and observed in 5% KOH solution, Congo Red aqueous solution, Melzer's reagent (for spores only) and solutions of sulphovanillin (SV) using the methods of Romagnesi (1967) and Singer (1986) with a Nikon Eclipse 80i microscope. Scanning electron photos were taken with an FEI Quanta 200 microscope. Spore dimensions exclude ornamentations and descriptions of spores follow Yang (2000). Specimens cited are deposited in HMAS and the Herbarium of Guangdong Institute of Microbiology (HMIGD).

## RESULTS

*Russula zhejiangensis* G. J. Li & H. A. Wen, **sp. nov.**

Figs 3-6

*Mycobank*: MB 561582

*Etymology*: named after Zhejiang Province, the name of its type locality.

*Pileus* 0.8-3.3 cm *latus*, *convexus*, *juventute hemisphaericus*, *maturitate parum plano-depressus in centro*, *primum plus minusve tomentulosus et viscidus*, *mox glaber*, *cutis separabilis usque 1/3 ad radium*; *marginem aequus*, *centripete pallidus striatus* 4-9 mm, *interdum rimosus*; *scarlatinus vel persicinus*, *marginem decolor centripete et pallide roseus*; *trama alba, tenuis, fragilis, prope stipitem* 5-10 mm *crassa, non discolorata ubi contusa*; *sapor et odor indistinctus*. *Lamellae* 1-3 mm *latae ad mid-radium, adnexae, albae, aliquando furcatae prope stipitem, lamellulae viscae, fragiles, non discoloratae ubi contusae, maturitate cremeae*. *Stipes* 0.6-4 cm *longus, 0.6-1.5 cm crassus, albus, glaber, cylindricus vel claviformis, basim versus paulatim inflatus, primum solidus, deinde cavus, color tactu non mutatus*. *Basidiosporae in cumulo saturate cremeae vel ochraceae (II-d-IIIa in Romagnesi 1967)*, (5.5) 6.0-8.0 × 5.0-6.5 μm, *globosae vel subglobosae, verrucis vel spinis amyloideis*, (0.3) 0.5-1.0 (1.2) μm *altis, conicis vel cylindricis, segregatis interdum paucis lineis interconnectis, ornatae, haud reticulatae*. *Basidia* (28) 29-40 × (10) 11-14 μm, *clavata vel subclavata*, (2-) 4-spora, *hyalina, sterigmata* 2-4 μm *alta*. *Pleurocystidia* 35-74 × 6-11 μm, *pauca, clavata vel anguste fusiformia, cava, interdum contento refracto vel granulato repleta, rotundata vel papillata, 10-30 μm emergentia*. *Pileipellis hyphae* 2-5 μm *lata, septata, hyalina, apice interdum parum ventricosa, pileocystidia* 6-9 (10) μm *crassa, contenta refractiva vel granulata*.

*Holotypus*: Gutianshan mons, Kaihua urbs, Zhejiang provincia, China. *Ad terram in silvis mistis*, 29°20' N, 118°14' E, alt. 360 m, 17 VII 2008, Li Guo-Jie et Yang Xiao-Li 08094, HMAS 187071.

**Basidiomata** (Fig. 1) small, solitary or dispersed, terrestrial. **Pileus** 0.8-3.3 cm broad, convex, hemispherical when young, then slightly plano-depressed at centre when mature, initially a little pruinose and viscid, soon glabrous, concentrically rugose when dry, forming melanocratic homocentric rings around margin when dry, cuticle peeling 1/3 to the radius; margin even, obtuse, not striate when young, very slightly striate 4-9 mm inward in age, sometimes cracked (up to 5 mm); Scarlet (I5) to Peach Red (I3) first, then fade from the edge to the



Fig. 1. *Russula zhejiangensis* sp. nov. (Holotype HMAS187071) Basidiocarps. Scale bar = 10 mm.

mid-radius to Shrimp Pink (I5f), La France Pink (I3f) and Hermosa Pink (I1f) in age, centre Corinthian Red (XXVII3'') to Deep Corinthian Red (XXVII3'i), margin Japan Rose (XXVIII9'b), Congo Pink (XXVIII7'b) to Vinaceous-Pink (XXVIII9'd) when dry. **Context** 5-10 mm from stipe top to pileus surface, fragile, white (LIII), Marguerite Yellow (XXX23f) when mature, Capucine Buff (III13f) when dry, no discoloring when injured, mild, odor none. **Lamellae** 1-3 mm broad at mid-radius, rounded in front, adnate to adnexed, sometimes slightly forked near the base, equal, brittle, first white, soon with cream color (XVI19f) tinge, finally Pale Yellow-Orange (III15f) when dry or fully matured, unchanging when cut, densely spaced (12-16 /cm at the cap edge). **Stipe** 0.6-4.0 cm long, 0.6-1.5 mm broad, central or slightly eccentric, whitish (LIII), Baryta Yellow (IV21f) when dry, unchanging when bruised, glabrous, cylindrical, without annulus, clavate, often slightly enlarged towards the base, solid at first, then spongy to hollow. **Spore print** dark cream to ochre-colored (IIId-IIIa).

**Basidiospores** (Fig. 2) (5.5) 6.3-7.8 (8.0)  $\times$  (5.0) 5.6- 6.4 (6.5)  $\mu\text{m}$ , average  $7.2 \times 6.0 \mu\text{m}$ , subglobose to broadly ellipsoid, sometimes ellipsoid [ $Q = (1.02) 1.04-1.30 (1.52)$ ,  $Q = 1.19 \pm 0.09$ ] (80/4/3); ornamentation amyloid, composed of isolated, conical spines to obtuse warts of different size, (0.3) 0.5-1.0 (1.2)  $\mu\text{m}$  high; suprahilar plage large, amyloid. **Basidia** (Fig. 3) (28) 29-40  $\times$  (10) 11-14  $\mu\text{m}$  (sterigmata excluded), projecting 10-20  $\mu\text{m}$  beyond hymenium, clavate to subclavate, broadly tapered near base, (2-) 4-spored, hyaline in KOH, sometimes with oily contents and several droplets; sterigmata, 4-5  $\times$  1-2  $\mu\text{m}$ . **Pleurocystidia** (Fig. 4) 35-74  $\times$  6-11  $\mu\text{m}$ , uncommon, slightly turning grey in SV, usually clavate or narrowly-fusoid, tapering towards the base, thin-walled, emergent, projecting 10-30  $\mu\text{m}$  beyond hymenium, sometimes with refractive, granular to banded sparse contents; apices round, at times with a moniliform appendage. **Cheilocystidia** not

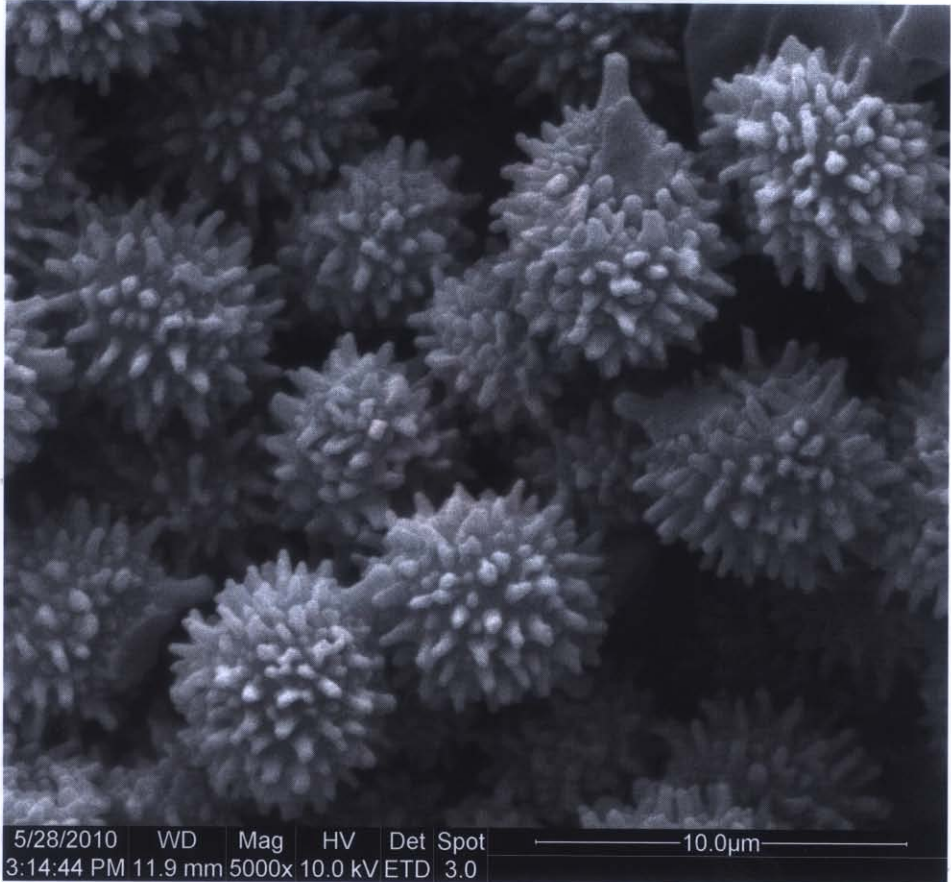
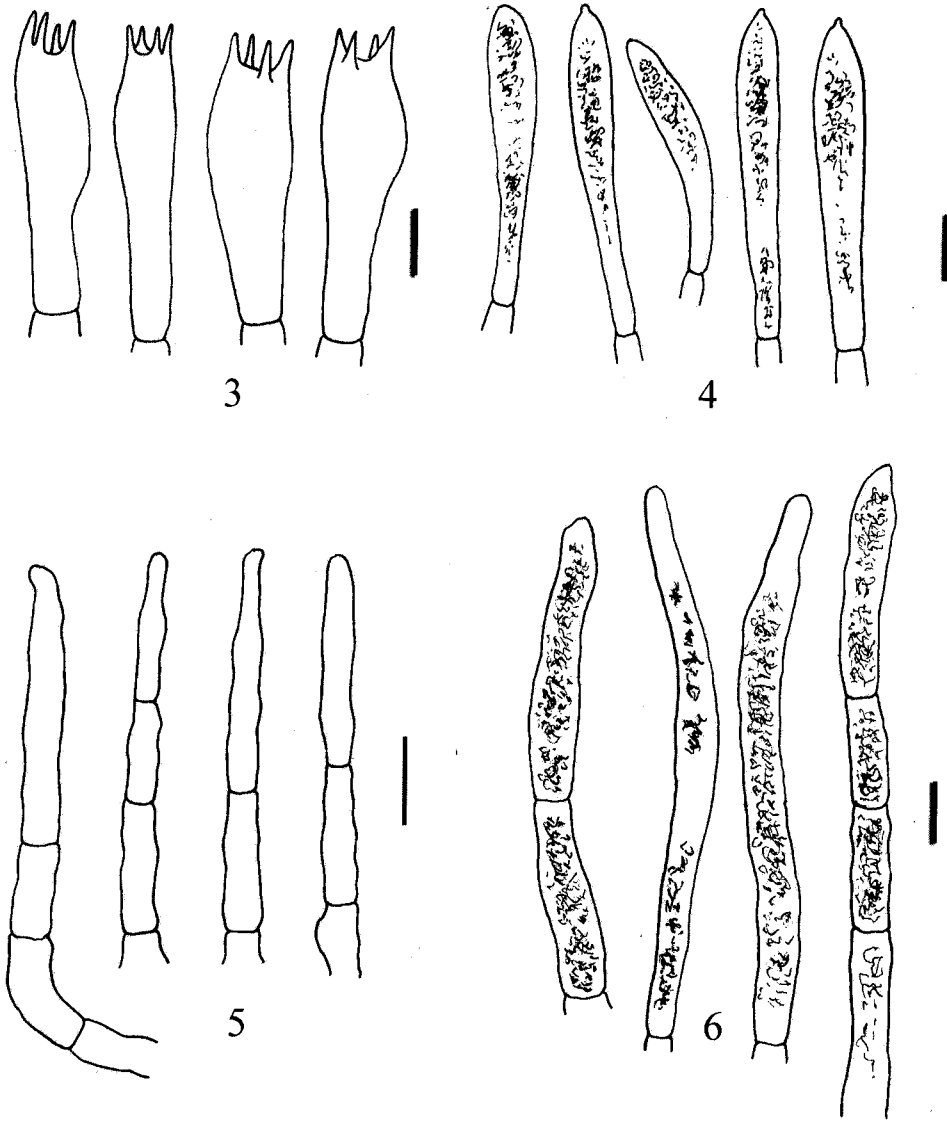


Fig. 2. *Russula zhejiangensis* sp. nov. (Holotype HMAS187071). Scanning electron microscope (SEM) photo of basidiospores. Scale bar = 10  $\mu$ m.

found, lamellar edge sterile. **Subhymenium** 15-20 (25)  $\mu$ m thick, cellular, composed of cylindrical cells under basidia and inflated cells next to trama. **Trama** bright carmine in SV, composed of vascular hyphae and sphaerocytes ("rosettes"). **Pileipellis** 150-200  $\mu$ m thick, two-layered; suprapellis a trichoderm, hyphae (Fig. 5) 2-5  $\mu$ m broad, scattered, hyaline, a little ventricose at the apices, erect to suberect, terminal cells thin-walled, cylindrical to narrowly clavate, hyaline, rarely with some interstitial brownish pigmentation, pileocystidia (Fig. 6) 6-9 (10)  $\mu$ m broad, dispersed, only at the surface, cylindrical to clavate, with 0-3 septa, contents granular, dark gray in SV; subpellis composed of a few 15-30  $\mu$ m large, global to angular thin-walled sphaerocytes, forming a thin pseudoparenchymatic layer. **Stipitipellis** composed of filamentous, repent, branched hyphae measuring 2-5  $\mu$ m in diam., some light yellowish brown, intermixed with several rosettes; no caulocystidia observed. **Clamps** absent in all tissues.

**Habit and habitat:** solitary or in small groups on thin soil on rock surface or on ground, in forest dominated by *Pinus massoniana* Lamb. and *Castanopsis eyrei* Tutch., on soil. Only known from the type locality. July to August.



Figs 3-6. *Russula zhejiangensis* sp. nov. (Holotype HMAS187071) 3. Basidia. 4. Pleurocystidia. 5. Hyphal ends of suprapellis in pileipellis. 6. Pileocystidia. Scale bars = 10  $\mu$ m.

**Specimens examined:** CHINA, Zhejiang Province, Kaihua County, Suzhuang Town, Maotan Village, Gutianshan Mountains, 29°20' N, 118°14' E, alt. 360 m, in mixed forest dominated by *Pinus massoniana* Lamb. and *Castanopsis eyrei* Tutch., 17 July 2008, G. J. Li & X. L. Yang 08094 (HMAS 187071, Holotype), G. J. Li & X. L. Yang 08170, HMAS (187070), G. J. Li & X. L. Yang 08191 (HMAS 187072), *ibid.*, alt. 400 m, 11 July 2008, G. J. Li & X. L. Yang 08118 (HMAS 187069), G. J. Li & X. L. Yang 08118 (HMAS 187069); *ibid.*, alt. 360 m,

20 July 2008, G. J. Li & X. L. Yang 08169 (HMAS 187099); *ibid.*, alt. 360 m, 22 July 2008, G. J. Li & X. L. Yang 08191 (HMAS 187100).

**Observations:** *Russula zhejiangensis* can be easily neglected in the field because of the small basidiocarps when there is no moss around. The small size and yellowish context of the basidiocarps are rather stable and distinctive features in the genus *Russula*. When the system of Romagnesi (1967, 1985, 1987) is followed, this species can be assigned to subgenus *Tenellula* Romagn. section *Laricinae* Romagn. It is similar to the European species *R. cessans* A. Pearson, *R. laricina* Velen, *R. nauseosa* (Pers.) Fr., *R. velenovskyi* Melzer & Zvára and *R. paludosa* Britzelm. because of the following characteristics: dark cream to pale ochre spore print, the non-acrid lamellae and the trama turning pale yellowish when old or bruised. *R. velenovskyi* has a red to pink-tinged stipe, longer basidia, up to 53  $\mu\text{m}$ , and spore ornamentations lower than 0.75  $\mu\text{m}$ , *R. paludosa* is a large species which has much larger basidiospores, 8-10.5 (11.5)  $\times$  6.7-7.7 (8)  $\mu\text{m}$ , and warts linked with ridges forming a subreticulate network (Romagnesi 1967). Compared with the other members of section *Laricinae*, as well as the very small, mostly 1-2 cm diam. pileus, the distinct macroscopic difference is that the color of the central part of the pileus of *R. zhejiangensis* is always salmon or cardinal, but never with typically purple, violet or olive colors as the other members of the subsection (Singer 1957; Romagnesi 1967). The spore ornamentation of *R. cessans* consists of warts that are often linked with fine lines (Romagnesi 1967). The context of *R. ruberrima* Romagn. often slightly turns gray (Romagnesi 1967). The peppery tasted gills, the large basidia and the slender cystidium appendix distinguish *R. nauseosa* (Miller & Buyck 2002; Romagnesi 1967), whereas *R. laricina* has more wide lamellae (Velenovský 1920).

Another Asian taxon *R. minutula* var. *minor* Bi, described in Guangdong Province of South China, also can be easily mistaken for *R. zhejiangensis* because of the very small fruiting bodies, red pileus, white to yellowish gills, red-colored reactions to SV and similar spores. However, our observations on the holotype of *R. minutula* var. *minor* (HMIGD 4372) shows that *R. minutula* var. *minor* has much shorter pleurocystidia and shorter terminal cells in the pileipellis compared to *R. zhejiangensis*. Moreover, *R. minutula* var. *minor* has a white spore print, yellow tinged pileus margin and lanceolate cystidia with acute apex (Bi & Li 1986).

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## REFERENCES

- ADAMČÍK S. & BUYCK B., 2010 — Reinstatement of *Russula levyana* as a good and distinct species of *Russula* section *Xerampelinae* in America. *Cryptogamie, Mycologie*: 31(2): 119-135.  
 ADAMČÍK S. & BUYCK B., 2011. — The species of *Russula* subsection *Xerampelinae* described by C.H. Peck and Miss G.S. Burlingham. *Cryptogamie, Mycologie* 32(1): 63-81.

- BI Z.S. & LI T.H., 1986 — A Preliminary Note on *Russula* species from Guangdong, with a new species and a new variety. *Guihaia* 6 (3): 193-199.
- BUYCK B. & HOFSTETTER V., 2011 — The contribution of tef-1 sequences for species delimitation in the *Cantharellus cibarius* complex in the southeastern USA. *Fungal Diversity* DOI: 10.1007/s13225-011-0095-zOnline First™
- CHOU W.N. & WANG Y.Z., 2005 — Nine species of *Russula* (Basidiomycotina) new to Taiwan. *Taiwania* 50 (2): 93-100.
- DAS K., VAN DE PUTTE K. & BUYCK B., 2011(2010) — New or interesting *Russula* from Sikkim Himalaya (India). *Cryptogamie, Mycologie* 31 (4): 373-387.
- GAN Y.K., ZHAO L.F., DAI L., CHEN X.J., PANG R.Y., FENG H.Q. & ZHANG H., 2005 — A review of wild *Russula* research. *Journal of Yulin Teacher's College (Natural Science)* 26 (3):70-74.
- HUANG N.L., 1998 — *Colored illustrations of macrofungi (mushrooms) of China*. China Agricultural Press, Beijing. 293 p.
- LI G.J. & WEN H.A., 2009 — Research of prospects on taxonomy of the *Russula* in China. *Mycosystema* 28 (2):303-309.
- MAO X.L., 1998 — *Economic fungi of China*. Science Press, Beijing. 762 p.
- MAO X.L., 2000 — *The macrofungi in China*. Henan Science and Technology Press, Zhengzhou. 719 p.
- MILLER S.L. & BUYCK B., 2002 — Molecular phylogeny of the genus *Russula* in Europe with a comparison of modern infrageneric classifications. *Mycological Research* 106 (3): 259-276.
- RIDGWAY R., 1912 — *Color Standards and Color Nomenclature*. Robert Ridgway, Washington. 161 p.
- ROMAGNESI H., 1967 — *Les Russules d'Europe et d'Afrique du Nord*. Bordas, Paris. 998 p.
- ROMAGNESI H., 1985 — *Les Russules d'Europe et d'Afrique du Nord*. Reprint with supplement. J. Cramer, Lehre. 32 p.
- ROMAGNESI H., 1987 — Statuts et noms nouveaux pour les taxa infragénériques dans le genre *Russula*. *Documentation Mycologique* 18 : 39-40.
- SAWADA K., 1942 — *Descriptive catalogue of Formosan fungi VII*. Report Government Research Institute, Department of Agriculture Formosa, 83: 1-159.
- SAWADA K., 1943 — *Descriptive catalogue of Formosan fungi VIII*. Report Government Research Institute, Department of Agriculture Formosa 85: 1-131.
- SAWADA K., 1959 — *Descriptive catalogue of Taiwan Fungi. Part XI*. Edited by Imazeki R, Hiratsuka N, Asuyama H. Special Publication no. 8, College of Agriculture, National Taiwan University, Taipei. 268 p.
- SINGER R., 1957 — New and interesting species of Basidiomycetes V. Descriptions of *Russulae*. *Sydowia* 11: 141-272.
- SINGER R., 1962 — *The Agaricales in Modern Taxonomy*. 2nd ed. J. Cramer, Weinheim. 915 p.
- SINGER R., 1986 — *The Agaricales in Modern Taxonomy*. 4th ed. Koeltz Scientific Books, Koenigstein. 981 p.
- SONG B., LI T.H., WU X.L., LI J.J., SHEN Y.H. & LIN Q.Y., 2007 — Known Species of *Russula* from China and Their Distribution. *Journal of Fungal Research* 5 (1): 20-42.
- TAI F.L., 1979 — *Sylloge fungorum Sinicorum*. Science Press, Beijing. 1527 p.
- TENG S.C., 1964 — *Fungi of China*. Science Press, Beijing. 808 p.
- VELENOVSKÝ J., 1920 — *Ceské Houby*. Praha: České Botanické Spolecnosti. 200 p.
- WANG Y.Z., WU S.H., CHOU W.N., CHANG T.T., CHEN C.H., CHEN S.F., CHEN C.L., TZEAN S.S., LIU J.H., HSIEH, W.H., HSIEH H.R., CHONG C.H. & CHIEN C.Y., 1999 — *List of the Fungi in Taiwan*. Committee of Agriculture, Taipei. 289 p.
- WANG X.H. & LIU P.G., 2010 — *Multifurca* (Russulales), a genus new to China. *Cryptogamie, Mycologie* 31 (1): 9-16.
- WANG X.H., YANG Z.L., LI Y.C., KNUDSEN H. & LIU P.G., 2009 — *Russula griseocarnosa* sp. nov. (Russulaceae, Russulales), a commercially important edible mushroom in tropical China: mycorrhiza, phylogenetic position, and taxonomy. *Nova Hedwigia* 88 (1-2): 269-282.
- YANG Z.L., 2000 — Type studies on Agarics described by N. Patouillard (and his co-authors) from Vietnam. *Mycotaxon* 75: 431-476.
- YING J.Z., ZHAO J.D., MAO X.L., MA Q.M., XU L.W. & ZONG Y.C., 1982 — *Edible mushrooms*, Beijing. 255 p.
- YING J.Z., MAO X.L., MA Q.M., ZONG Y.C. & WEN H.A., 1987 — *Icons of medicinal fungi from China*. Science Press, Beijing. 575 p.
- ZHENG C.Z. & JIN X.F., 2008 — Study on the Chinese endemic genera of seed plants distributed in the region of East China. *Journal of Zhejiang University Science Edition* 35 (6): 668-673.
- ZHOU Z.Z. & MENG R.X., 1996 — The General Conditions of Vegetations in Eastern China. *Journal of Anhui University Natural Science Edition* 20 (4): 62-68.