

## Research Article

# Four New Species Records of *Umbelopsis* (Mucoromycotina) from China

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Four species of *Umbelopsis* newly found in China, that is, *U. angularis*, *U. dimorpha*, *U. nana*, and *U. versiformis*, are reported in this paper. Descriptions and illustrations are provided for each of them.

## 1. Introduction

The genus *Umbelopsis* Amos and H. L. Barnett, typified by *U. versiformis* Amos and H. L. Barnett, was placed in Deuteromycetes by Amos and Barnett in 1966 [1]. Von Arx [2] proposed that this genus should be classified in Zygomycetes in 1982. Meyer and Gams [3] erected the family Umbelopsidaceae of Mucorales to accommodate it in 2003. This family occupies a basal phylogenetic position within the Mucorales [4]. Members of this genus grow slowly and form a velvety layer; sporangiophores typically arise from vesicles on substrates, cymosely or umbellately branched; sporangia are uni- and/or multispored and ochraceous, reddish, or hyaline; columellae are usually small or absent; sporangiospores are variously shaped and have the same color as the sporangia; chlamydospores, if present, are often abundant and mostly intercalary on mycelia [3, 5–8]. So far, 15 species have been described in this genus, 13 of which are accepted by Meyer and Gams [3] and Mahoney et al. [8]. Three species have been recorded from China by Chen [9]: *U. isabellina* (Oudem.) W. Gams (as *Mortierella isabellina* Oudem.), *U. ramanniana* (Möller) W. Gams (as *M. ramanniana* (Möller) Linnem.), and *U. vinacea* (Dixon-Stew.) Arx (as *M. vinacea* Dixon-Stew.). In this paper, four species newly recorded from soil and plant residues in China are described and illustrated.

## 2. Materials and Methods

Details of materials studied are presented under the description of each taxon. Strains found in China were isolated using the method of Zheng et al. [10]. For morphological observations, fungi grew at 20°C or 25°C for 6–10 days under natural light on malt extract agar ((MEA) 2% malt extract, 2% glucose, 0.1% peptone, and 2% agar), cornmeal agar ((CMA) 2% cornmeal and 2% agar), and potato dextrose agar ((PDA) 20% potato, 2% glucose, and 2% agar). Maximum growth temperatures were tested twice on PDA. For inducing the formation of zygospores, 0.1% lecithin was added to PDA [10]. Capitalized color designations refer to the Color Standards and Color Nomenclature published by Ridgway [11].

## 3. Taxonomy

*3.1. Umbelopsis angularis.* W. Gams & M. Sugiy., in Sugiyama et al., *Mycoscience* 44: 221, 2003. (Figure 1).

Colonies on MEA after 5 days reaching 42 mm diam. at 20°C, 1–2 mm high, flat, etruscan red to prussian red (Ridgway, Pl. XXVII), velvety, zonate; on CMA after 5 days reaching 35 mm diam. at 20°C, low, hyaline to slightly vinaceous, sparser than on MEA. *Sporangiophores* often arising from swollen stalk on substrate mycelia, cymosely

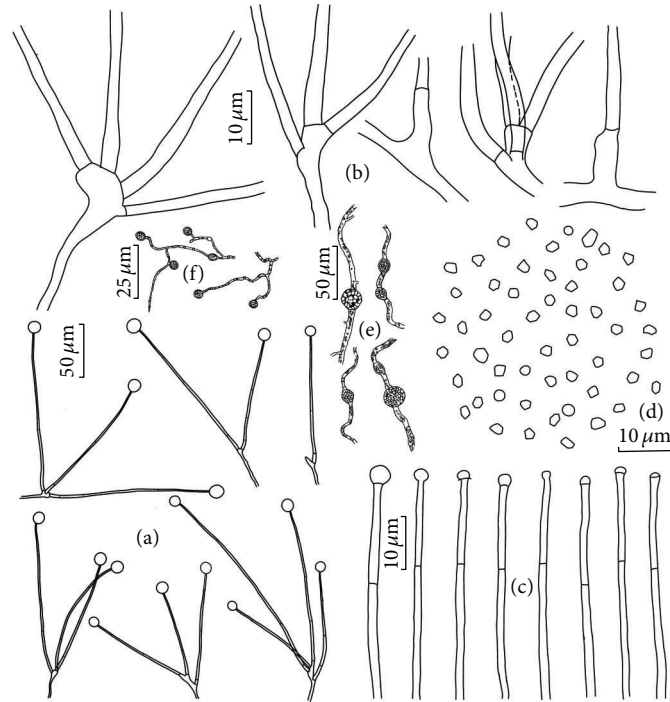


FIGURE 1: *Umbelopsis angularis*. (a) Sporangiophores with various types of branching. (b) Branching pattern of lower parts of sporangiophores. (c) Sporangiophores with different sizes and shapes of columellae at their tips after the sporangia have been dissolved or detached; also note that the position of the uppermost septa is often quite uniform. (d) Sporangiospores. (e) Macrochlamydospores. (f) Microchlamydospores.

branched, 174–379 (–442)  $\mu\text{m}$  long, 2.5–5.2 (–6.9)  $\mu\text{m}$  wide near the base, and 2.0–3.0  $\mu\text{m}$  near the tip, 2–5 septate, with one near the base and the uppermost one at 18–30  $\mu\text{m}$  below the columella. *Sporangia* globose to subglobose, (10–) 12–25 (–27)  $\mu\text{m}$  diam., reddish or reddish-brown, multispored; walls deliquescent, leaving no or small collars. *Columellae* globose or depressed globose, 2.0–6.1  $\mu\text{m}$  diam. *Sporangiospores* angular, 2.5–5.0  $\mu\text{m}$  diam., reddish in mass. *Chlamydospores* abundant, containing oil droplets, of one or two types: macrochlamydospores 11–26  $\mu\text{m}$  diam., usually intercalary; microchlamydospores 5–8  $\mu\text{m}$  diam., often terminal. *Zygospor*es unknown.

Maximum growth temperature: (35–) 36–38°C.

Distribution: China, Germany, and The Netherlands.

Materials examined: Um-1 (=CGMCC 3.6640, ITS rDNA GenBank KC489475) was isolated from *Ligusticum chuanxiong*, Shennongjia, Hubei, August 7, 1984, Hua-zhong Kong, 401; Um-2 (=CGMCC 3.6639, ITS rDNA GenBank KC815992) and Um-9 (=CGMCC 3.16326, ITS rDNA GenBank KC815994) were isolated from broad-leaved forest soil, Shennongjia, Hubei, September 4, 1984, Hua-zhong Kong, 601; Um-80 (=CGMCC 3.16342, ITS rDNA GenBank KC816010) was isolated from soil, Temple of Soul's Retreat, Hangzhou, Zhejiang, October 14, 2000, Long Wang, 9683; Um-30 (=CGMCC 3.16335, ITS rDNA GenBank KC816003), Um-39 (=CGMCC 3.16336, ITS rDNA GenBank KC816004), Um-41 (=CGMCC 3.16337, ITS rDNA GenBank KC816005), Um-42 (=CGMCC 3.16338, ITS rDNA GenBank KC816006), Um-43 (=CGMCC 3.16339, ITS rDNA GenBank KC816007),

Um-44 (=CGMCC 3.16340, ITS rDNA GenBank KC816008), Um-50 (=CGMCC 3.16341, ITS rDNA GenBank KC816009), and Um-83 (=CGMCC 3.16344, ITS rDNA GenBank KC816012) were isolated from mixed forest soil, 42°10'548"–44°02'274" N, 126°35'399"–128°55'815" E, alt. 360–2654 m, Changbai Mountain, Jilin, July 2011, Xiao-yong Liu, 12447.

*Note.* This species is different from the other *Umbelopsis* species in possessing distinct columellae and angular sporangiospores. *U. ramanniana* is morphologically most similar to this species, except for the shape of sporangiospores which is subglobose to ellipsoid in *U. ramanniana* [5, 12] but angular in *U. angularis*. There are two more species having angular sporangiospores, *U. dimorpha* Mahoney and W. Gams and *U. vinacea* (Dixon-Stew.) Arx. The former is different from *U. angularis* in possessing two types of each of the sporangiophores, sporangia, and sporangiospores as described in Section 3.2 and the latter in lacking distinct columellae [7].

3.2. *Umbelopsis dimorpha*. Mahoney & W. Gams, in Mahoney *et al.*, *Mycol. Res.* 108 (1): 109, 2004. (Figure 2).

*Colonies* on MEA after 5 days reaching 40 mm diam. at 25°C, 1–3 mm high, flat or high in the center and low at the edge, pinkish vinaceous (Ridgway, Pl. XXVII), often with white sectors, velvety; on CMA after 5 days reaching 25 mm diam. at 25°C, low, hyaline to white or slightly pinkish, sparser than on MEA. *Sporangiophores* having two kinds, short and long: short sporangiophores often present on

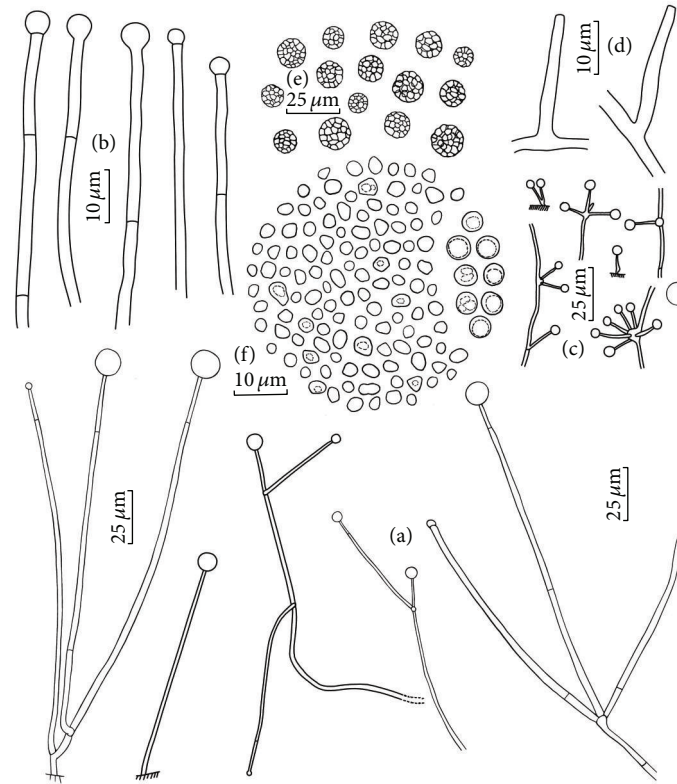


FIGURE 2: *Umbelopsis dimorpha*. (a) Sporangiophores with various types of branching. (b) Long sporangiophores with columellae. (c) Short sporangiophores with different types of branching and one-spored sporangia. (d) Short sporangiophores without columellae. (e) Multispored sporangia. (f) Sporangiospores, note that the smaller angular ones are from multispored sporangia, and the larger globose ones are from one-spored sporangia.

CMA, arising from distinct vesicles on agar surface or aerial hyphae, simple or cymosely branched, 8–26  $\mu\text{m}$  long, 1.8–2.2  $\mu\text{m}$  wide near the base and 1.2–1.6  $\mu\text{m}$  near the tip; long sporangiophores abundant on MEA, arising from indistinct vesicles or widened hyphae, variously branched, (95–) 197–537  $\mu\text{m}$  long, 2.2–3.0 (–4.0)  $\mu\text{m}$  wide near the base, and 1.6–2.4 (–3.2)  $\mu\text{m}$  near the tip, septate, with one septum near the base and one or none near the columella. *Sporangiola* on short sporangiophores, globose, 5–8  $\mu\text{m}$  diam., hyaline, one-spored; *sporangia* on long sporangiophores, globose, 9.5–17.4  $\mu\text{m}$  diam., reddish, multispored; walls slowly deliquescent, leaving no collar. *Columellae* absent on short sporangiophores, present on long sporangiophores, subglobose, and 2.5–5.2  $\times$  2.5–6.1  $\mu\text{m}$ . *Sporangiospores* having two kinds: globose and hyaline in one-spored sporangia on short sporangiophores, 4.5–7.5  $\mu\text{m}$  diam.; angular in multispored sporangia on long sporangiophores, 2.2–4  $\mu\text{m}$  diam., reddish in mass. *Chlamydospores* scarce, globose to subglobose, 6–9  $\times$  4–9  $\mu\text{m}$ , often intercalary. *Zygosporae* unknown.

Maximum growth temperature: 39°C.

Distribution: China and New Zealand.

Materials examined: Um-3 (=CGMCC 3.6641, ITS rDNA GenBank KC489477) without substrate information was isolated more than 20 years ago under the name *Umbelopsis vinacea* and renamed as *U. dimorpha* in this study; Um-8

(=CGMCC 3.16325, ITS rDNA GenBank KC815993) was isolated from broad-leaved forest soil, Shennongjia, Hubei, September 4, 1984, Hua-zhong Kong, 601; Um-20 (=CGMCC 3.16329, ITS rDNA GenBank KC815997), Um-21 (=CGMCC 3.16330, ITS rDNA GenBank KC815998), Um-22 (=CGMCC 3.16331, ITS rDNA GenBank KC815999), Um-23 (=CGMCC 3.16332, ITS rDNA GenBank KC816000), Um-24 (=CGMCC 3.16333, ITS rDNA GenBank KC816001), and Um-25 (=CGMCC 3.16334, ITS rDNA GenBank KC816002) were isolated from mixed forest soil, 42°10'548"–44°02'274" N, 126°35'399"–128°55'815" E, alt. 360–2654 m, Changbai Mountain, Jilin, July 2011, Xiao-yong Liu, 12447.

*Note.* This species is distinct from the other *Umbelopsis* species by having two kinds of each of the sporangiophores, sporangia and sporangiospores. It produces mainly multispored sporangia on MEA as *U. vinacea* does, while on CMA a number of unispored sporangia similar to those in *U. versiformis* are abundantly formed [1, 3, 7]. The number of sporangiospores in sporangia on CMA tends to decrease due to hypotrophy, sometimes containing only three.

3.3. *Umbelopsis nana*. (Linnem.) Arx, *Sydowia* 35: 20, 1982. (Figure 3).

= *Mortierella nana* Linnem., *Pflanzenforschung* 23: 16, 1941 (basionym).



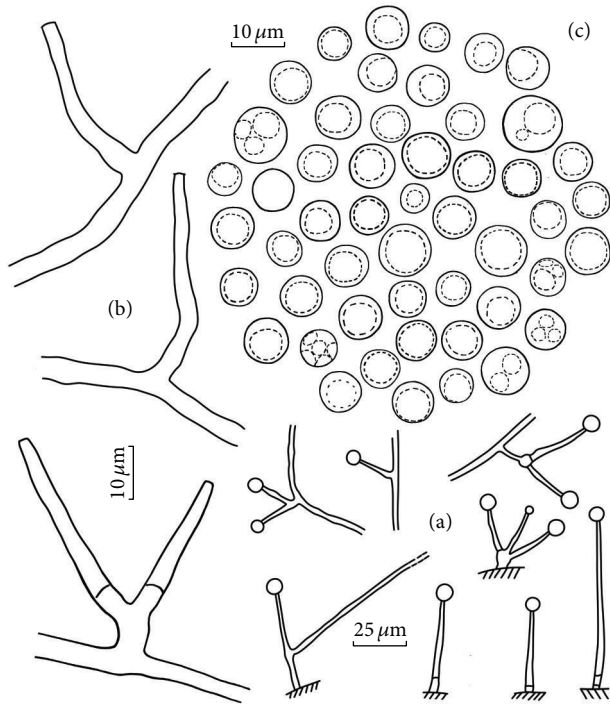


FIGURE 3: *Umbelopsis nana*. (a) Sporangiophores with different branching types and one-spored sporangia. (b) Sporangiophores. (c) Sporangiospores.

= *M. alba* Mańka & Gierczak, *Práce Komisji Nauk Rolniczych i Komisji Nauk Leśnych* 9: 17, 1961.

Colonies on MEA after 5 days reaching 42 mm diam. at 25°C, 2–3 mm high, high in the center and low at the edge, white, velvety, obscurely zonate; on CMA after 5 days reaching 28 mm diam. at 25°C, low, hyaline, sparser than on MEA. *Sporangiophores* often umbellately branched from distinct vesicles on agar surface or simply branched on aerial hyphae, (12–) 15–50 (–55) μm long, 2.4–3.6 μm wide near the base, and 1.6–2.2 μm near the tip, with one septum near the base. *Sporangia* globose or subglobose, 4.9–7.9 μm diam., hyaline, one-spored, containing oil droplets. *Collars* absent or small. *Columellae* absent. *Sporangiospores* globose, 4.5–7.5 μm diam., hyaline, containing oil droplets. *Chlamydo*spores scarce to absent, 4–9 × 6–9 μm. *Zygo*spores unknown.

Maximum growth temperature: 37°C.

Distribution: Belgium, Britain, Canada, China, Denmark, Germany, Japan, Poland, Russia, Sweden, The Netherlands, Ukraine, and USA.

Material examined: Um-82 (=CGMCC 3.16343, ITS rDNA GenBank KC816011) was isolated from soil under herbaceous ferns, Nanyigou, Milin, Tibet, August 4, 2009, Xue-wei Wang, 12608.

*Note.* This species is distinct from the other *Umbelopsis* species by white colonies and unispored sporangia. It is morphologically similar to *U. versiformis*, and the difference between them will be discussed in the following section.

3.4. *Umbelopsis versiformis*. Amos & H. L. Barnett, *Mycologia* 58(5): 807, 1966. (Figure 4).

= *Mortierella roseonana* W. Gams & Gleeson, in Gams, *Persoonia* 9: 112, 1976.

≡ *U. roseonana* (W. Gams & Gleeson) Arx, *Sydowia* 35: 19, 1982.

Colonies on MEA after 5 days reaching 45 mm diam. at 25°C, 1–2 mm high, flat, at first white and then pale vinaceous (Ridgway, Pl. XXVII), velvety, obviously zonate; on CMA after 5 days reaching 26 mm diam. at 25°C, low, hyaline, sparser than on MEA. *Sporangiophores* often arising from distinct vesicles on agar surface or aerial hyphae, simple to successively umbellately branched, (10–) 15–35 (–45) μm long, 1.8–3.0 μm wide near the base, and 1.6–2.2 μm near the tip, with one septum near the base. *Sporangia* globose or subglobose, 4.7–7.9 μm diam., hyaline, one-spored, containing oil droplets. *Collars* absent or small. *Columellae* absent. *Sporangiospores* globose, 4.3–7.5 μm diam., hyaline, containing oil droplets. *Chlamydo*spores not abundant, subglobose, 6 μm diam. *Zygo*spores unknown.

Maximum growth temperature: 38°C.

Distribution: Australia, China, and USA.

Materials examined: CBS 150.81 (ITS rDNA GenBank KC489496), roots of a red oak tree (*Quercus borealis* Michx.), Pendleton County, WV, USA; Um-11 (=CGMCC 3.16327, ITS rDNA GenBank KC815995) and Um-19 (=CGMCC 3.16328, ITS rDNA GenBank KC815996) were isolated from mixed forest soil, 42°10'548"–44°02'274" N, 126°35'399"–128°55'815" E, alt. 360–2654 m, Changbai Mountain, Jilin, July 2011, Xiao-yong Liu, 12447.

*Note.* The color of colonies is white in the original description of *Umbelopsis versiformis* [1]. However, the extype strain CBS 150.81 is really white at first but then changes to pale vinaceous when it is reexamined on MEA medium in this study. Meyer and Gams [3] also noticed the pale pink pigmentation of CBS 150.81. The colonial color of the two Chinese isolates of *U. versiformis*, Um-11 and Um-19, is a little lighter than that of CBS 150.81, which might reflect the geographic differences within the circumscription of a species. A few chlamydospores are found in both the extype strain CBS 150.81 and the two Chinese isolates, though the original description did not mention this trait [1].

*Umbelopsis versiformis* is close to *U. nana*, and the most remarkable shared characteristic is the one-spored sporangia. Furthermore, the colony color of *U. nana* is always white and similar to that of *U. versiformis* in its protologue [1]. Maybe for these reasons, they were synonymized by von Arx [2]. However, the different color of old colonies, white in *U. nana* and vinaceous or pinkish in *U. versiformis*, was discovered in this study and also by Meyer and Gams [3]. Besides, they disclosed that *U. nana* is different from *U. versiformis* in ITS rDNA sequences and RFLP data. Based on all these differences, this study agrees with the treatment of Meyer and Gams [3] to retain them as different species.

#### 4. Conclusions

Four species were recorded in the present study, raising the number of *Umbelopsis* species in China to seven. More than

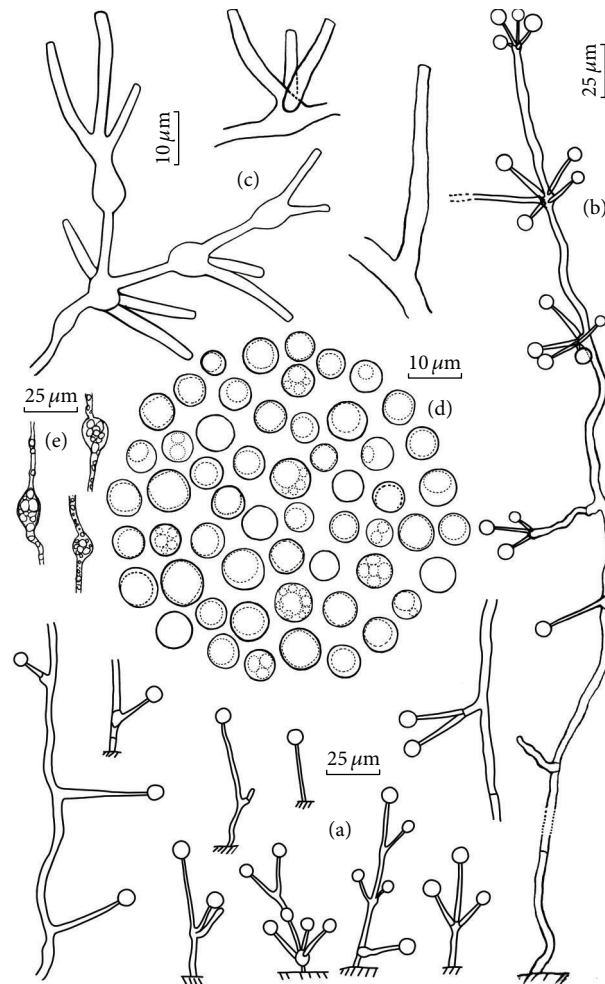


FIGURE 4: *Umbelopsis versiformis*. (a), (b) Sporangiophores showing branching types and one-spored sporangia. (c) Sporangiophores. (d) Sporangiospores. (e) Chlamydo-spores.

half of the total number of *Umbelopsis* species worldwide could be proven to exist in China so far.

## Acknowledgments

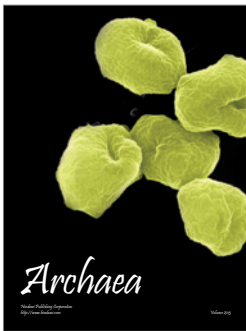
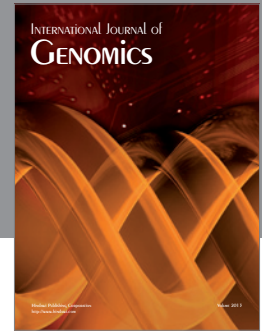
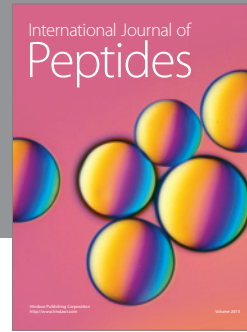
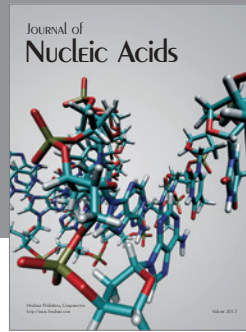
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