

The genus *Chlorophyllum* (Basidiomycetes) in China

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Abstract—Species of the genus *Chlorophyllum* (*Agaricaceae*) in China are described and illustrated with line drawings. Among them, *C. sphaerosporum* is new to science, and *C. hortense* is new to China. A key to the *Chlorophyllum* species in China is also provided.

Key words—*Agaricales*, new taxon, new record, taxonomy, distribution

Introduction

The genus *Chlorophyllum* Masee (*Agaricaceae*, *Agaricales*, Basidiomycetes) in its amended sense is characterized by a hymenidermal pileus covering, a smooth stipe, and basidiospores without a germ pore or with a germ pore but just caused by a depression in the epispodium. A hyaline covering on the germ pore is absent. The basidiospores may be white, green, brownish or brown in deposit, and the habit varies from agaricoid to secotioid (Vellinga 2001, 2002, 2003a, b; Vellinga & de Kok 2002; Vellinga et al. 2003). During our survey of the lepiotoid fungi in China, several species were identified, and one new species of the genus was encountered and thus described below. Differences between similar species are provided and discussed.

Material and methods

All material examined collected in China, and deposited in three Herbaria. Herbarium codes used follow Holmgren et al. (1990) with one exception: HKAS = Herbarium of Cryptogams, Kunming Institute of Botany, Chinese Academy of Sciences, which is not listed in the index or relevant publications. The descriptions of species will appear in alphabetical order by species epithet. In the description, macro-morphology is based on the field notes and color slides of the material; micro-morphology is based on observation of the material under microscope. In the descriptions of basidiospores, the abbreviation [*n/m/p*] shall mean *n* basidiospores measured from *m* fruit bodies of *p* collections in 5% KOH solution; Q is used to mean “length/width ratio” of a spore in

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side view; Q means average Q of all basidiospores \pm sample standard deviation; x means range of basidiospore length \times width.

Taxonomy

1. *Chlorophyllum agaricoides* (Czern.) Vellinga, Mycotaxon 83: 416, 2002 **FIGURE 1**
Endoptychum agaricoides Czern., Bull. Soc. Imp. nat. Moscou 18 (2): 148, 1845; *Secotium*
agaricoides (Czern.) Hollós, Természetrázi Füzetek 25: 93, 1902.

Fruit bodies (Fig. 1a) secotioid, 5-8 cm high, 3-7 cm across, cordate to obtusely conical, usually broader toward base; margin appressed to the stipe, usually lacerated when mature. **Peridium** 1-3 mm thick, fleshy and tender when young, becoming rather tough and fibrous upon drying; surface white, becoming straw colored on maturing and drying, covered with brownish to brown squamules. **Gleba** white when young, becoming yellow and finally brown; gleba chambers somewhat labyrinthiform, varying in width, up to 1 mm; tramal plates persisting in the mature and dried specimens, forming lamella-like folds; columella present, white, becoming reddish when bruised. **Stipe** short, 1-2 \times 0.8-1.5 cm, sub-conical, tapering downward into a thick cord, whitish, becoming yellowish on maturing.

Basidia 7-11.5 μm in diam., clavate, 4-spored. **Basidiospores** (Fig. 1b) [45/3/3] 7.5-8.5 (9.5) \times 6.0-7.0 (8.0) μm ($x = 8.3 \pm 0.41 \times 7.0 \pm 0.31 \mu\text{m}$), $Q = 1.13-1.21$ (1.25) ($Q = 1.18 \pm 0.04$), orthotropic, statismorphic, subglobose to broadly ellipsoid, rarely ovoid, yellowish brown to greenish brown, smooth, thick-walled, but becoming thinner towards the apex which is often slightly depressed; hilar appendix small but usually attached to a thin-walled sterigmatal appendage; young basidiospores dextrinoid, metachromatic in cresyl blue, becoming reddish in Congo Red. Clamps not observed in all tissues.

Habitat and known distribution in China: Solitary; scattered, or in groups on lawns and pastures, sometimes also on the ground in forest. Terrestrial; distributed in Inner Mongolia.

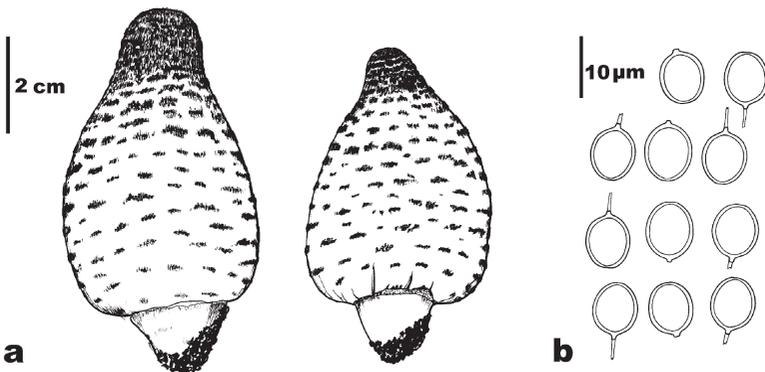


Fig. 1. *Chlorophyllum agaricoides* (HKAS 4408).

a. Fruit bodies. b. Basidiospores.

Material examined: China, Inner Mongolia, 15 Sept. 1978, Z. Y. Li & J. Z. Li 1465 (HKAS4408); Baotou City, 3 Aug. 1988, P. G. Liu 307 (HKAS 21432), alt. 1630 m; 31 Aug. 1988, P. G. Liu 260 (HKAS 21430a), P. G. Liu 571 (HKAS 21431), alt. 2100 m; Wumeng county, 2 Aug. 1990, P. G. Liu 627 (HKAS 23034), alt. 1590 m.

Note: *Chlorophyllum agaricoides* is characterized by its secotioid habit, labyrinthiform to sublamellate gleba, and yellowish brown to greenish brown, statismosporic, orthotropic, subglobose to broadly ellipsoid basidiospores with a slightly depressed apex. It has been formerly recorded as *Endoptychum agaricoides* from Inner Mongolia and Hebei Province of China by Liu (1984, 2005).

2. *Chlorophyllum hortense* (Murrill) Vellinga, Mycotaxon 83: 416, 2002 FIGURE 2

Lepiota hortensis Murrill, N. Amer. Fl. 10 (1): 59, 1914; *Leucoagaricus hortensis* (Murrill) Pegler, Kew Bull. Add. Ser. 9: 414, 1983.

Fruit bodies (Fig. 2a) agaricoid, small to medium. **Pileus** 4-7 cm in diam., convex, distinctly umbonate, white to cream-colored, covered with small patches of pale ochreous to yellowish brown squamules, margin of pileus finely short striate when dried. **Lamellae** free, crowded, whitish, becoming dirty white to pale ochreous, but never becoming darker when dried. **Stipe** 6-8 × 0.5-1 cm, subcylindrical, fibrillose, white to whitish, base not enlarged. **Annulus** present, persistent. **Context** white, becoming reddish when cut.

Basidia (Fig. 2e) 20-30 (32) × 7.5- 8.5(10.0) μm, clavate to narrowly clavate, hyaline, mostly 2-spored, occasionally 4-spored; sterigmata 3-5 μm long; clamps not observed on basal septa. **Basidiospores** (Fig. 2c) [85/5/2] (8.0) 8.5-10.0 (11.5) × (5.5) 6.0-7.0 (8.0) μm ($x = 9.0 \pm 0.61 \times 6.4 \pm 0.43 \mu\text{m}$), $Q = (1.23) 1.31-1.50 (1.57)$ ($Q = 1.42 \pm 0.06$), ellipsoid, sometimes broadly ellipsoid, thick walled, smooth, without germ pore, dextrinoid, metachromatic in cresyl blue, not or becoming reddish in Congo Red. **Pleurocystidia** absent. **Cheilocystidia** (Fig. 2d) (23) 30-40 (50) × (6) 8-10 (12) μm, crowded, forming a sterile edge, narrowly clavate to subcylindrical often with a round apex 6-8 μm, thin-walled, often with yellowish to brownish vacuolar pigments. **Pileipellis** (pileal squamules) (Fig. 2b) a hymeniderm made up of broadly clavate, sometimes subfusiform, colorless or nearly colorless, slightly thick walled ($\leq 0.5 \mu\text{m}$) terminal elements. **Stipitipellis** hardly differentiated, without caulocystidia, composed of filamentous hyphae with many anastomosing structures.

Habitat and known distribution in China: Solitary; Terrestrial; distributed in Guangdong and Yunnan Provinces. New to China.

Material examined: China, Guangdong Prov., Lianshan, 11 Sept. 1985, G. Y. Zheng 9175 (GDGM 9175, as *Chamaeota dextrinoidespora* by Bi & Li 1988), alt. 700-800 m. Yunnan Prov., Kunming, 21 Sept. 1991, Z. L. Yang 1709 (HKAS 23623), alt. 1900 m.

Note: The characters of the collections cited above agree well with the original and related descriptions (e.g. Akers & Sundberg 1997; Pegler 1983; Vellinga 2003a). Clamps in the Chinese collections were not observed, while Vellinga (2003a) stated that *C. hortense* is provided with clamps, and Akers & Sundberg (1997) found the clamps in the stipitipellis. Our observations show that there are many anastomosing structures on the hyphae of stipitipellis, which may be misinterpreted as clamps when they are on or near septa.

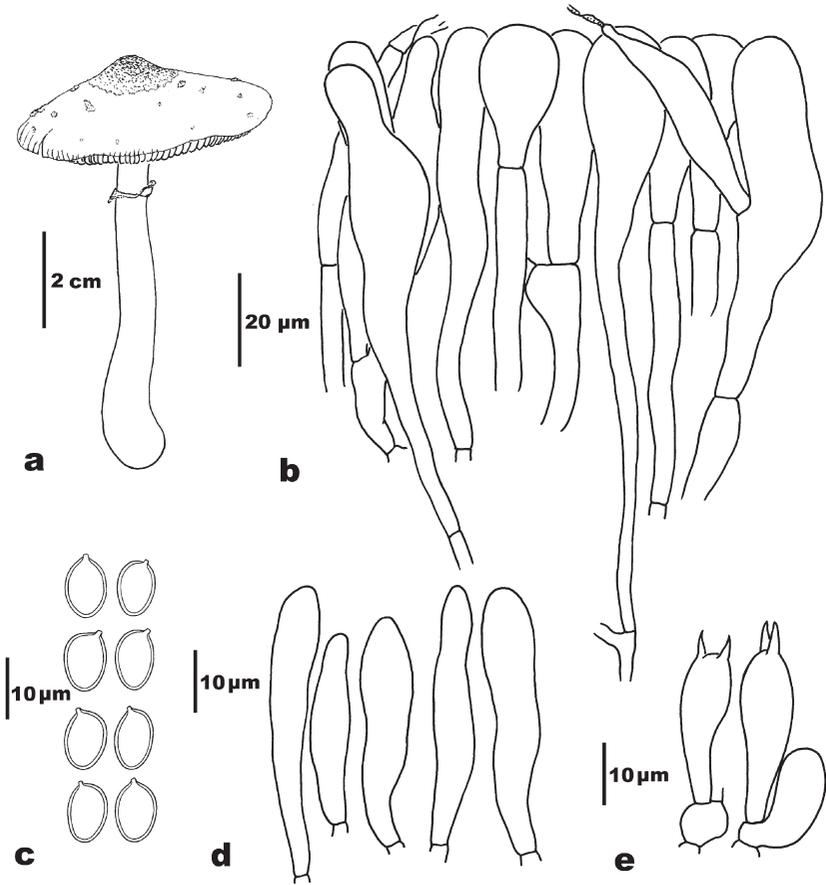


Fig. 2. *Chlorophyllum hortense* (GDGM 9175).
 a. Fruit bodies. b. Pileipellis (squamules on pileus).
 c. Basidiospores. d. Cheilocystidia. e. Basidia.

GDGM 9175 was previously regarded as *Chamaeota dextrinoidespora* Z.S. Bi (Bi & Li 1988). Reexamination of the type of *C. dextrinoidespora* shows that it bears basidiospores [(8.0) 8.5-11.5 (12) × (6.0) 6.5-8.5 µm] with a distinct germ pore, clavate to fusiform cheilocystidia (11-18 µm in diam.) often with a papilla or rostrate apical appendages; and a trichodermial pileipellis of narrowly clavate to subfusiform, sometimes lanceolate cells (13-20 µm in diam.) often with a rostrate apical appendage (data of authors unpublished).

3. *Chlorophyllum molybdites* (G. Mey.: Fr.) Massee, Kew Bull. 1898: 136, 1898

FIGURE 3

Agaricus molybdites G. Mey., Pr. Fl. Essequ.: 300, 1818: Fr., Syst. Mycol. 1: 308, 1821; *Mastocephalus molybdites* (G. Mey.: Fr.) Kuntze, Rev. Gen. Pl. 2: 860, 1891; *Lepiota molybdites* (G. Mey.: Fr.) Sacc., Syll. Fung. 5: 30, 1887; *Leucocoprinus molybdites* (G. Mey.: Fr.) Pat., Bull. Soc. Mycol. Fr. 29: 215, 1913; *Macrolepiota molybdites* (G. Mey.: Fr.) G. Moreno, Bañares & Heykoop, Mycotaxon 55: 467, 1995.

Fruit bodies (Fig. 3a) agaricoid, medium to large. **Pileus** 8-17 cm in width, nearly hemispherical when young, becoming convex to plano-convex with age, sometimes with a low umbo at disc, white to whitish, covered with brown squamules; disc smooth, brown. **Lamellae** free, crowded, whitish when young, then greenish to green when mature, bluish green to grayish green when dried. **Stipe** whitish, subcylindrical, 18 × 0.8-1.2 (1.5) cm, widening downwards, base enlarged. **Annulus** well developed, ascending, double crowned, upper surface whitish, lower surface brownish. **Context** whitish, becoming reddish brown when cut.

Basidiospores (Fig. 3c) [40/2/2] (8.5) 9.0-10.0 (10.5) × 6.5-8.0 μm ($x = 9.54 \pm 0.44 \times 7.18 \pm 0.37 \mu\text{m}$), $Q = (1.25) 1.27-1.43$ ($Q = 1.33 \pm 0.06$), broadly amygdaliform, thick-walled, smooth, light olive-green, dextrinoid, with a germ pore caused by a depression in the epispodium on the truncate apex. **Basidia** (Fig. 3e) 27-36 × (9.5) 11-14 (16) μm, clavate, hyaline, 4-spored; sterigmata 3-4.5 μm long. **Pleurocystidia** absent. **Cheilocystidia** (Fig. 3d) numerous, broadly clavate to sphaeropedunculate, 21-40 × (9) 13-21 μm, with brownish vacuolar pigment. **Pileipellis** (Fig. 3b) a palisade of hyphae with terminal elements clavate to subfusiform, 8-16 μm in diam., with brown to dark brown vacuolar pigment.

Habitat and known distribution in China: Terrestrial to saprotrophic; scattered to gregarious on the ground in broadleaf forest. Distributed in Guangdong, Hainan, Hunan, Sichuan and Yunnan.

Material examined: China, Guangdong Prov., Renhua, 1 Aug. 1985, A. H. Huang & G. Y. Zheng 9131 (GDGM 9131, as *Macrolepiota rachodes* by Bi et al. 1990, 1994); Baoting, 20 May 1988, T. H. Li 13868 (GDGM 13868, as *Macrolepiota rachodes* by Bi et al. 1997). Hainan Prov., Haikou, 20 Aug. 1994, X. L. Wu 7 (HKAS 29348); Qionghang, 2 Jun. 1988, GDGM 14911 (as *Macrolepiota rachodes* by Bi et al. 1997). Hunan Prov., Hengyang, 21 Jun. 2004, Z. H. Chen 30237 (HKAS 45051). Sichuan Prov., Xichang, 30 Jun. 1978, L. W. Xu 8 (HMAS 42516, as *Lepiota rachodes* by Ying et al. 1994), E 102.16, N 27.54. Yunnan Prov., Yuanmou, 4 July 2005, L. S. Wang 05-24866 (HKAS 49418).

Note: The Chinese specimens match closely with other descriptions of *C. molybdites* (e.g. Reid & Eicker 1991, Vellinga 2001). This species, often causing gastro-intestinal problems (e.g. Reid & Eicker 1991), was previously misidentified as *Macrolepiota rachodes* in some Chinese mycological literature (e.g. Bi et al. 1990, 1994, 1997). But the bluish green lamellae, the well developed complex annulus, the whitish context becoming reddish brown when cut, the greenish, broadly amygdaliform basidiospores with a truncate apex, and the broadly clavate to sphaero-pedunculate cheilocystidia clearly characterize the species.

Chlorolepiota mahabaleshwarensis Sathe & S.D. Deshp. is similar to *C. molybdites* on account of the greenish basidiospores. However, the basidiospores of the former are not

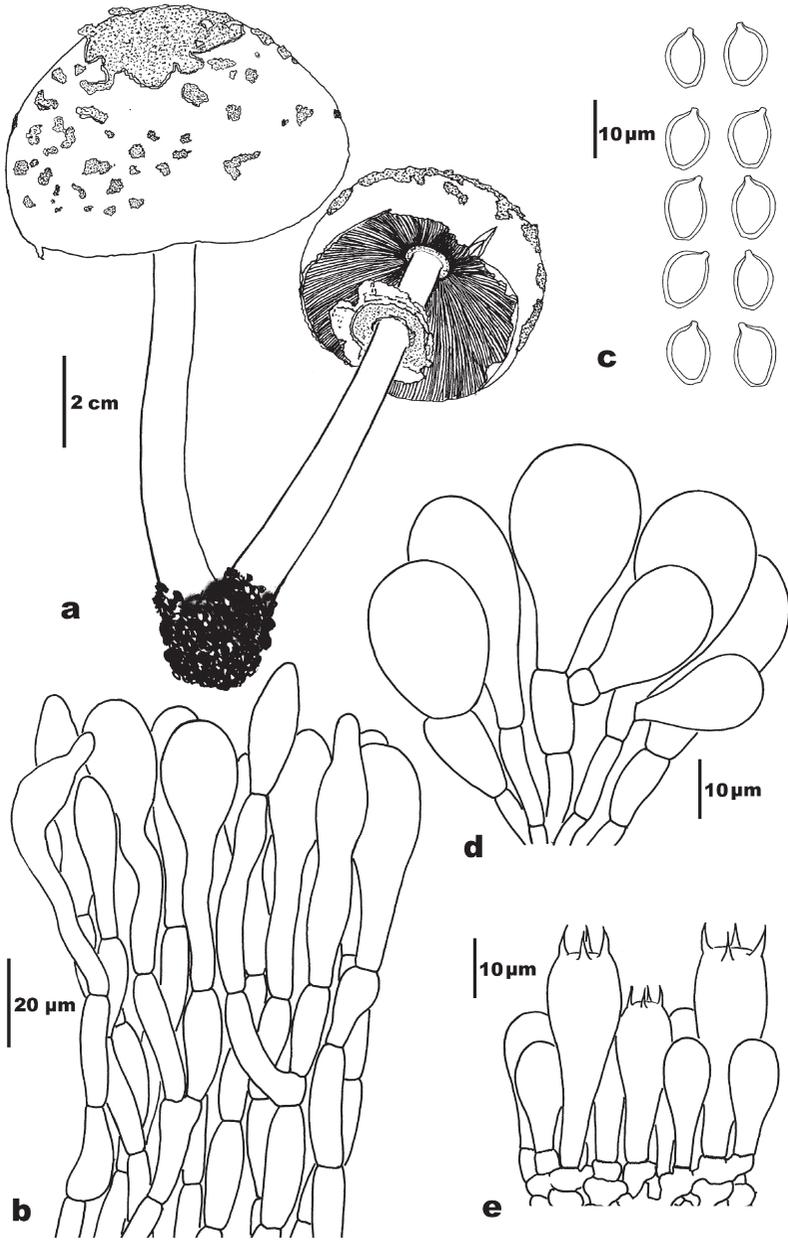


Fig. 3. *Chlorophyllum molybdites* (HKAS 45051).
a. Fruit bodies. b. Pileipellis. c. Basidiospores. d. Cheilocystidia. e. Basidia..

truncated, and bear a rudimentary germ pore with a poral plug (Sathe & Deshpande 1979).

4. *Chlorophyllum sphaerosporum* Z. W. Ge & Zhu L. Yang, sp. nov. **FIGURE 4**

Pileus 4.5-6.5 cm *latus*, *convexus*, *albus* vel *albidus*, *squamulis* *luteo-brunneis* vel *rubeolis brunneis*, *obtusis umbonatus*. *Lamellae liberae*, *albae*. *Stipes* 4.0-7.0 × 0.5-0.7 cm, *subcylindricus*, *subaequalis* vel *sursum attenuatus*, *albidus*, *non-dicolorans*, *basis incrassatus*. *Annulus membranaceus*, *albidus*. *Caro alba*. *Basidia* 24-32 × 9.5-12.5 μm, *clavata*, *hyalina*, *4-sporigera*. *Basidiosporae* (8.0) 9.0-10.0 (11.0) × 7.0- 9.0 (9.5) μm, *subgloboae* vel *lato-ellipsoideae*, *hyalinae*, *aporiae*, *dextrinoideae*, *congophilosae*, *metachromaticae*. *Pleurocystidia absentia*. *Cheilocystidia clavata* vel *latoclavata*, *hyalina*, (18) 25-32 (40) × (9) 11-13.5 μm. *Squamulae pilei hymenidermae*, *apicalis hyphis pallide brunneis clavatis*. *Fibulae praesentes*. *Habitatio: terrestris*.

Holotypus: "Mao Xiao-Lan M8040 (HMAS 66153), 15 August 1994, Inner Mongolia, China".

Etymology: the epithet refers to the shape of the basidiospores.

Fruit bodies (Fig. 3a) agaricoid, small to moderate. **Pileus** 4.5-6.5 cm in diam., convex, with a low umbo at the disc; surface white to whitish, covered with yellow brown to reddish brown squamules, continuous on disc, elsewhere disrupted; margin with faint short striations. **Lamellae** free, crowded, white, off-white to cream when dried. **Stipe** central, 4.0-7.0 × 0.5-0.7 cm, subcylindrical, slightly attenuate upward, surface whitish, not changing color when bruised, enlarged at the base. **Annulus** membranous, whitish, movable, compound. **Context** white, unchanging; taste mild.

Basidia (Fig. 4e) 24-32 × 9.5-12.5 μm, clavate, hyaline, thin-walled, 4-spored, occasionally 2-spored; sterigmata up to 4.5 μm long. **Basidiospores** (Fig. 4c) [105/6/2] (8.0) 9.0-10.0 (11.0) × 7.0-9.0 (9.5) μm ($x = 9.1 \pm 0.50 \times 8.0 \pm 0.51$ μm), $Q = (1.00) 1.12-1.21$ ($Q = 1.14 \pm 0.04$), subglobose, sometimes broadly ellipsoid, smooth, hyaline, thick-walled (about 0.5 μm thick), without germ pore, dextrinoid, congophilous, metachromatic in cresyl blue; apiculus 1-1.5 μm long. **Pleurocystidia** absent. **Cheilocystidia** (Fig. 4d) (18) 25-32 (40) × (9) 11-13.5 μm, clavate to broadly clavate, hyaline to very pale yellowish, thin-walled. **Lamellar trama** subregular to irregular, composed of colorless hyphae (2.5) 5-10 (12) μm in width. **Pileipellis** (Fig. 4b) a hymenidermal layer composed of brownish, slightly thick-walled, clavate to broadly clavate terminal elements 38-53 (80) × 12-25 (31) μm. **Clamp connections** occasionally observed at the base of young basidia and cheilocystidia.

Habitat and known distribution: Terrestrial in forests dominated by *Keteleeria* and *Xanthoceras*, so far only known from Inner Mongolia, China.

Additional material examined: China, Inner Mongolia, Qasuqi, 10 Aug. 1988, P. G. Liu 313b (HKAS 21185b), alt. 1200 m.

Note: *Chlorophyllum sphaerosporum* is characterized by its small, thick-walled, subglobose basidiospores without a germ pore, the unchanging context, and the hymenidermal pileipellis composed of brownish, slightly thick-walled clavate terminal elements. Based on these characters, especially the small subglobose basidiospores without a

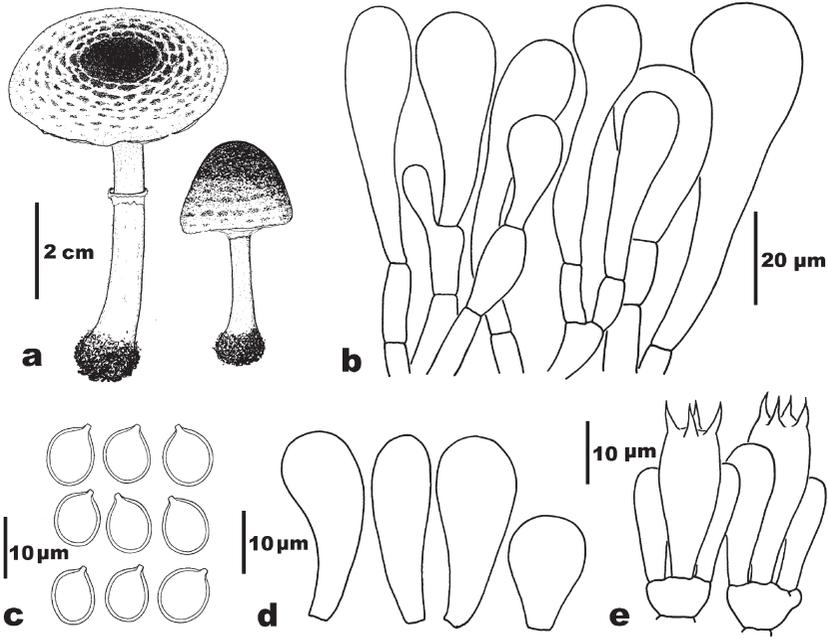


Fig. 4. *Chlorophyllum sphaerosporum* (from holotype).
 a. Fruit bodies. b. Pileipellis (squamules on pileus).
 c. Basidiospores. d. Cheilocystidia. e. Basidia.

germ pore, *C. sphaerosporum* can be easily keyed out in the genus *Chlorophyllum*. The present species is similar to *Chlorophyllum hortense*, in bearing basidiospores without a germ pore. However, *C. hortense* has 2-spored basidia, ellipsoid to broadly ellipsoid basidiospores, narrowly clavate to subcylindrical cheilocystidia, and the whitish context of the stipe becoming reddish when damaged (Akers & Sundberg 1997; Vellinga 2003a; see above).

Chlorophyllum sphaerosporum is also similar to *C. shimogaense* Sathe & S.M. Kulk. on account of the subglobose basidiospores. However, the latter, originally described from Shimoga, southwestern Indian, has much larger fruit bodies (pileus 8-10.5 cm in diam., stipe 13.5-15 × 0.7-7.1 cm) with a trichodermal palisade of much narrower hyphae (4.5-10.5 µm in diam.) in the pileal squamules, and possesses no clamp connections (Sathe et al. 1981). The basidiospores of *C. shimogaense* were described as having “indistinct germ pore or without germ pore”. *Chlorophyllum sphaerosporum* seems to be also similar to *C. bharatense* Sathe & S.M. Kulk. However, the latter, originally described from India, has a trichodermal palisade with much narrower terminal cells (43-108 × 11-13.5 µm) in the squamules on the pileus, and cream lamellae becoming reddish brown when dried, and no clamps. The basidiospores of *C. bharatense* were described as “without germ pore or with indistinct germ pore (Sathe et al. 1981). Type collections of the Indian species were requested twice on loan for comparison, but no response was received.

Taxon with uncertainty recorded from China

Chlorophyllum rachodes (Vittad.) Vellinga, Mycotaxon 83: 416, 2002

Agaricus rachodes Vittad., Descr. Funghi mang. Italia: 158, 1883 ('1835'); *Lepiota rachodes* (Vittad.) Quél., Mém. Soc. Émul. Montbéliard. Sér. II, 5: 70, 1872; *Leucocoprinus rachodes* (Vittad.) Pat., Ess. Tax. Hym.: 171, 1900; *Lepiotophyllum rachodes* (Vittad.) Locq., Bull. Mens. Soc. Linn. Lyon 11: 40, 1942 (as '*L. rhacodes*'); *Macrolepiota rachodes* (Vittad.) Singer, Lilloa 22: 417, 1951 ('1949').

Note: Macroscopically, *C. rachodes* is characterized by big fleshy fruit bodies, contrasting plate-like squamules on the pileus, a double-crowned annulus, and a bulbous stipe base. The stipe surface becomes orange-red first, then light brown when bruised. Microscopically, it is characterized by the ellipsoid spores with a germ pore caused by a depression in the episprium on the truncate to round apex, and the sphaeropedunculate to broadly clavate cheilocystidia (Candusso & Lanzoni 1990; Vellinga 2003b).

C. rachodes was previously recorded in China (as *Lepiota rachodes* or *Macrolepiota rachodes*) (Bi et al. 1990, 1994, 1997; Zang et al. 1996; Wang & Zang 1983; Mao, 1995; Ying & Zang 1994; Ying et al. 1994). However, according to our re-examination of the vouchers cited in the literature, some of the collections are *C. molybdites* (see above), while GDGM 11851 is *Macrolepiota procera* (Scop.: Fr.) Singer, and HKAS 5299, HMAS 30376 and 30499 are *Leucoagaricus nympharum* (Kalchbr.) Bon; HKAS 13214 is *Lepiota clypeolaria* (Bull.: Fr.) P. Kumm. HKAS 5630 consists of only one immature fruit-body, and looks like *M. procera*. HKAS 11749 can not be traced in the Herbarium. Thus, whether *C. rachodes* indeed occurs in China remains uncertain. For the convenience of use, this species is included in the following key.

Key to the *Chlorophyllum* species in China

- 1 Fruit bodies agaricoid, hymenophore lamellate, basidiospores heterotropic, ballistosporic, ellipsoid, subglobose to broadly amygdaliform, without sterigmal appendage 2
- 1 Fruit bodies secotiid, hymenophore (gleba) labyrinthiform to sub-lamellate, basidiospores orthotropic, statismosporic, broadly ellipsoid to subglobose, often with a short sterigmal appendage *C. agaricoides*
- 2 Fruit bodies small to large; lamellae white or brownish with age; spore print white or off-white, never green 3
- 2 Fruit bodies large; lamellae becoming greenish when mature; spore print green *C. molybdites*
- 3 Pileus and stipe discolored reddish or light brown when bruised or cut; basidiospores ellipsoid to broadly ellipsoid or broadly amygdaliform, with or without a germ pore 4
- 3 Pileus and stipe not changing color when bruised or cut; basidia 4-spored, basidiospores subglobose, without a germ pore *C. sphaerosporum*

- 4 Pileus with pale ochreous to yellowish brown patch-like squamules; stipe becoming reddish when bruised; annulus simple; stipe base without a bulb; basidia 2-spored, basidiospores without a germ pore, apex not truncate; cheilocystidia narrowly clavate to subcylindrical *C. hortense*
- 4 Pileus with brown plate-like squamules; stipe becoming light brown when bruised; annulus double crowned; stipe base bulbous; basidiospores with a germ pore caused by a depression in the episporium on the truncate to round apex; cheilocystidia clavate, broadly clavate to sphaeropedunculate *C. rachodes*

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