

Lepiotaceous fungi in California, U.S.A. – 1. *Leucoagaricus amanitoides* sp. nov.

ELSE C. VELLINGA^{1*} & R. MICHAEL DAVIS²

*vellinga@nature.berkeley.edu or ecvellinga@comcast.net

¹Department of Plant and Microbial Biology, University of California at Berkeley,
Berkeley, CA 94720-3102, U.S.A.

²Department of Plant Pathology, University of California at Davis,
Davis, CA 95616, U.S.A.

Abstract — A new, white *Leucoagaricus* species is described from central California. *Leucoagaricus amanitoides* is characterized by a volvate, short and bulbous stipe, long narrowly clavate cystidia and ellipsoid spores without a germ pore.

Key words — biodiversity, Agaricales, Central Valley

Introduction

The *Leucoagaricus/Leucocoprinus* clade in the *Agaricaceae* is represented by many species in California (Vellinga 2004a, b), with a considerable number still undescribed. A striking white species, resembling a short-stiped *Amanita* species, was discovered in Davis (Yolo Co.), and is here described as new in the genus *Leucoagaricus* Singer.

The genera *Leucoagaricus* Singer, *Leucocoprinus* Pat. and *Sericeomyces* Heinem. form one monophyletic clade within the family *Agaricaceae* (Vellinga 2004a). The molecular data on which this conclusion is based, support, though weakly, a monophyletic *Leucocoprinus*, embedded within *Leucoagaricus*, rendering that genus paraphyletic. *Sericeomyces* is polyphyletic. Preliminary data on protein coding gene sequences confirm that *Leucoagaricus* and *Leucocoprinus* form one, monophyletic, clade (non published results, ECV).

The type species of *Leucoagaricus*, *L. macrorrhizus* Locq. ex E. Horak, (synonym *L. barssii* (Zeller) Vellinga), does not have close relatives and is morphologically different from all other species analysed, so its position within the genus and the clade is not yet final (Vellinga 2004a).

Morphologically, *Leucoagaricus* is characterized by the following combination of characters: metachromatic spores, absence of clamp-connections, absence of pseudoparaphyses around the basidia, and a pileus which is not or hardly

plicate in the outer zone (Singer 1986; Vellinga 2001). *Leucocoprinus* shares the metachromatic spores and the absence of clamp-connections, but does have pseudoparaphyses around the trimorphic basidia, and a plicate pileus.

Despite these morphological differences between *Leucoagaricus* and *Leucocoprinus*, several species have been placed in both genera, e.g. *L. americanus* (Peck) Vellinga and the other reddening species like *L. badhamii* (Berk. & Broome) Singer (compare Reid 1990 and Vellinga 2001).

If the *Leucoagaricus/Leucocoprinus* clade were recognized as one genus, this would be an enormous genus and many new combinations would have to be made, since *Leucocoprinus* is the older name (Patouillard 1888; see e.g. Vellinga 2004a). This step may be premature, since it is likely that the clade can be split into smaller monophyletic and morphologically uniform groups which can be recognized at the genus level. The inclusion of further species from the large number in the tropics that are presently undescribed, combined with data from a wider range of genes, will surely clarify the division of the clade into distinct genera. Pending this research, a conservative approach is adopted here. The new species with characters in concordance with the old concept of *Leucoagaricus* will be accommodated in that genus.

The *Leucoagaricus* species described here was found under redwood (*Sequoia sempervirens*) and Valley oaks (*Quercus lobata*), pushing up through heavy clay, in the arboretum of the University of California at Davis. This arboretum is a half-natural area alongside a creek, where various California native trees and a number of exotics are planted among original Valley oaks. As the Davis campus lies in an area which is mycologically virtually unexplored, the vast Central Valley of California, the species could be a California native or an exotic brought in with plant material from elsewhere. The species fruits regularly in December/January.

Materials and methods

Standard methods for describing the basidiocarps were applied, using the terminology of Vellinga (2001). The notation [84, 5, 4] indicates that measurements were made on 84 spores in five samples in four collections. The following abbreviations are used: avl for average length, avw for average width, Q for quotient of length and width and avQ for average quotient.

Taxonomic description

Leucoagaricus amanitoides R.M. Davis & Vellinga sp. nov.

Figures 1-3

MYCOBANK MB 510369

Leucoagaricus amanitoides basidiocarpis albis, stipite volvato bulboso brevi, cheilocystidiis longis anguste clavatis, sporis inamyloideis sine poris, fibularum absentia designatus.

Holotypus: U.S.A., California, Yolo Co., Davis, University of California Davis Arboretum, 7 January 2006, R.M. Davis (coll. E.C. Vellinga 3456) (UC).



Fig. 1: *Leucoagaricus amanitoides*, basidiocarp from holotype (photo by R.M. Davis)

Etymology: amanitoides is derived from the Greek ‘αμανιτοειδης’ = ‘looking like an *Amanita*’, because of the striking resemblance to some members of that genus.

Basidiocarp when young with a small hemispherical pileus sitting on top of a turbinate stipe.

Pileus 35 mm when young, expanding to 85 mm, when young hemispherical with flat top, later expanding to plano-convex, wavy applanate with low wide umbo or with applanate centre, white in all stages, but when old with brown patches, dry, slightly radially squamose-fibrillose with short fibrils, when young with thick involute margin, later straightening out, but still exceeding lamellae. **Lamellae**, L = about 105, l = 0 or 1, free, rather crowded, not or slightly ventricose, segmentiform, up to 9 mm wide, in some specimens

lamellulae anastomosing with lamellae, slightly cream to cream coloured when seen from aside, with distinctly white cystidiose, irregular or even scalloped edge. **Stipe** 32-90 x 11-20 mm, with amorphous bulbous base with turbinate or rounded bottom, up to 35 mm wide in young specimens, 30 mm in mature specimens, white-cream, smooth and shiny with up to 3 bands of guirlandes of white velar material on the stipe, with some white velar remnants at top of bulb, solid, or narrowly hollow. **Annulus** small and triangular in cross-section, white. Velum universale soft and white. **Context** in pileus very thick, white and dull, not changing colour; in stipe white, slightly glassy in outer part. **Smell** (of cut specimen) sweet and pleasantly fungoid, but slightly astringent at back of throat. **Taste** indistinctly fungoid.

Basidiospores [84, 5, 4] in side view 6.1-8.3 (8.8) x 4.1-5.4 μm , $\text{avl} \times \text{avw} = 6.7\text{-}7.5 \times 4.6\text{-}5.0 \mu\text{m}$, $Q = 1.27\text{-}1.79$, $\text{av}Q = 1.43\text{-}1.51$, most ellipsoid, some oblong, some slightly amygdaloid in side-view, in frontal view ellipsoid or slightly oblong, not-coloured, thick-walled, without germ pore, with oil drop, congophilous but variable, either only the young ones, or all, dextrinoid, and vaguely metachromatic in Cresyl blue. **Basidia** 30-39 x 8.5-10 μm , 4 spored, without basal clamp connection. **Lamella edge** sterile. **Cheilocystidia** 29-75 x (6-)8-15 μm , narrowly clavate, often slightly capitate, rarely moniliform or narrowly lageniform, not-coloured, and slightly thick-walled. **Pleurocystidia** not observed. **Pileus covering** a loosely arranged cutis of cylindrical, colourless hyphae, 3-7 μm in diameter, with terminal elements slightly inflated and up to 12 μm wide. **Lamella trama** regular. **Stipe covering** a cutis of loosely arranged slightly inflated to cylindrical colourless hyphae, around 5-10 μm wide. **Clamp connections** absent.

Habitat and distribution – Solitary to gregarious, under planted *Sequoia sempervirens*, other conifers and *Quercus lobata* on heavy clay, December-beginning of January, only known from the type locality, an arboretum, in Davis, California (U.S.A.).

Collections examined — U.S.A., CALIFORNIA: Yolo Co., DAVIS, UNIVERSITY OF CALIFORNIA AT DAVIS ARBORETUM, 3.I.2003, R.M. Davis 03001 (herb. R.M. Davis) (Genbank nrITS EF080870; nrLSU EF080872); *ibidem*, 17.XII.2004, E.C. Vellinga 3331 (UC) (Genbank nrITS EF080869; nrLSU EF080873); *ibidem*, 19 Dec. 2004, R.M. Davis (herb. R.M. Davis) (Genbank nrITS EF080871); *ibidem*, 7.I.2006, R.M. Davis (coll. E.C. Vellinga 3456; HOLOTYPE UC).

Comments — In the field the species resembles most closely an *Amanita* species, but the spores are dextrinoid and not amyloid, and the hymenophoral trama is regular, not divergent.

The closest relatives to this new species are, according to phylogenetic analyses of nrITS and nrLSU sequences (see examined collections for GenBank accession numbers), species cultivated by attine ants in cultivar clade 1 in the

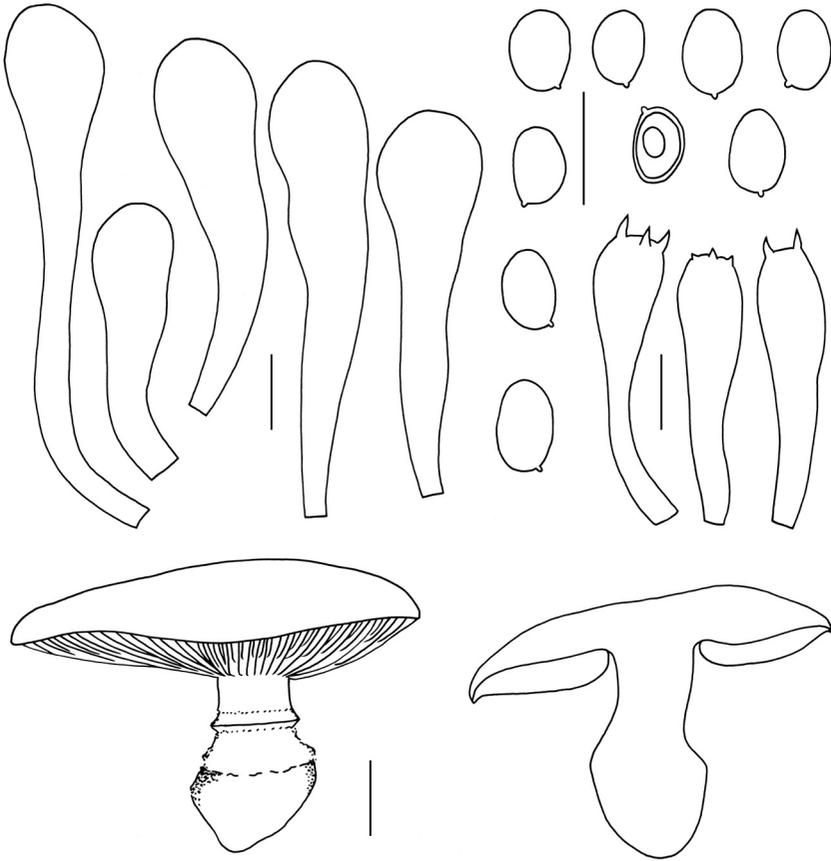


Fig. 2: *Leucoagaricus amanitoides*, basidiocarp (ecv3331), spores (ecv3456), basidia (rmd03001) and cheilocystidia (ecv3456). Scale bar is 1 cm for basidiocarp and 10 μ m for microscopic features.

analyses by Mueller et al. (1998). *Leucoagaricus amanitoides* has a combination of striking characters: it is completely white, has a volva, and a bulbous stipe base, and microscopically, the spores lack a germ pore, cheilocystidia are narrowly clavate and long, and pleurocystidia are lacking. We compared our species with others from the literature which either share the presence of a volva, are white and fleshy, or in other respects resemble *Amanita* species. A short discussion of those species follows.

The two white European volvate species, *Leucoagaricus subvolvatus* (Malençon & Bertault) Bon and *Leucoagaricus volvatus* Bon & A. Caball. belong to sect. *Rubrotincti* Singer. The former has been included in molecular

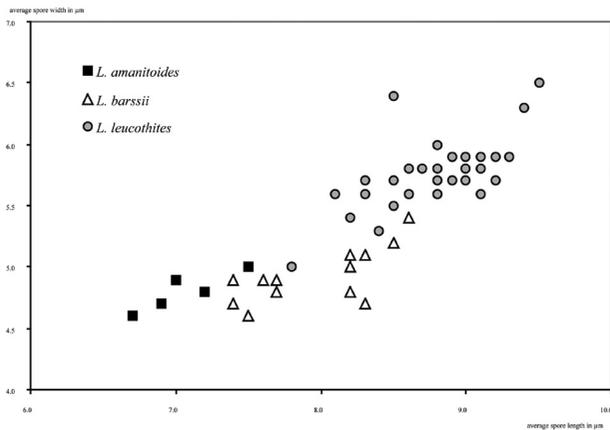


Fig. 3: Scatter diagram of average spore sizes for *Leucoagaricus amanitoides*, *L. barssii* and *L. leucothites*. The measurements for *L. barssii* are based on 14 collections from Europe, western North America (including the type collection) and Australia; those for *L. leucothites* are based on 33 collections from Europe, North America and Australia. Average spore length on the X-axis, average spore width on the Y-axis.

phylogenetic studies (Vellinga 2004a) and is close to *Leucoagaricus crystallifer* Vellinga and *L. menieri* (Sacc.) Singer, and other white species with crystals on top of the cheilocystidia. *Leucoagaricus volvatus* has some olivaceous tinges in the pileus, but also has crystals on the cystidia and a slightly gelatinized pileus covering.

Two other volvate species are *Leucoagaricus bivelatus* B.P. Akers & Ovrebo from Panama and *Lepiota volvatula* Pegler from the Caribbean island of Martinique. The former has slender basidiocarps with a sheathing volva, and a bluish black pileus; the spores are ellipsoid, lacking a germ pore, and the cheilocystidia are relatively short and narrowly clavate (Akers & Ovrebo 2005). The latter is a small species (pileus 2.5-3 cm), with a thin and fragile, brownish pileus, which is sulcate-plicate; the spores are 5.5-7.2 x 3.5-4.5 µm (Pegler 1983).

Fleshy white or whitish species that show some resemblance to the new species are *Leucoagaricus leucothites* (Vittad.) Wasser and *L. barssii*. *Leucoagaricus leucothites* is a common species of open man-made habitats, such as lawns and fields. There is no volva at the base of the stipe, the spores have a germ pore and the pileus covering is a trichoderm. The spores are bigger than those of *L. amanitoides* (Fig. 3). *Leucoagaricus leucothites* is widespread and has been recorded from Europe, Asia, North America, Africa and Australia (see Vellinga 2004b and references therein).

Leucoagaricus barssii also occurs in man-made habitats, but has a radially fibrillose, white to greyish pileus covering, and a tapering stipe. The ellipsoid spores lack a germ pore, and pleurocystidia are present close to the lamella edge (Vellinga 2000, 2001). The spore sizes overlap with those of *L. amanitoides* (Fig. 3). This species is widespread and known from Europe, North America and Australia (e.g. Vellinga 2000, 2001, and personal observations).

Leucoagaricus gaillardii Bon & Boiffard resembles *L. amanitoides* in its sturdiness; it is a species with a pinkish pileus, a distinctly bulbous stipe, which can be volvate. The spores measure 7-9(-10) x 5-6(-7) μm . The cheilocystidia are narrowly lageniform to cylindrical and wavy, and not narrowly clavate as in *L. amanitoides*, but they are of the same length (Bon & Boiffard 1975). *Leucoagaricus gaillardii* grows in sandy habitats in south-western Europe. Its phylogenetic position is not quite clear; it has been originally described in section *Rubrotincti* (Bon & Boiffard 1975), but on account of the reddening of the pileus centre when touched, and the green reaction in ammonia it was placed in sect. *Piloselli* (Kühner) Singer (Priou et al. 1995). One of us (ECV) has examined one collection from France, and its nrITS1 sequence groups with those of species in section *Rubrotincti* (data not shown).

Several other species resemble *Amanita* species, but differ from *L. amanitoides* in the colours of the basidiocarps; these are discussed here briefly in alphabetical order.

Lepiota amanitifformis Murrill was described from conservatories of the New York Botanical Garden. Its pileus surface is dry, and reddish brown, the stipe very short and thick, usually tapering upward from an abrupt, globose bulb at the base, white or tinged with reddish-brown (Murrill, 1914).

Lepiota amanitoides Beeli, with dingy white pileus with yellowish stains, and a bulbous stipe base, turned out to be an *Amanita* species (Bas 1969).

Lepiota subamanitifformis S. Imai from Hokkaido (Japan) has a red-brown pileus, and the margin of the annulus is given as 'incarnate' (Imai 1938).

Lepiota subamanitifformis Dennis is characterized by a pale brown pileus with darker umbo, and was described from Trinidad (Dennis 1952).

Acknowledgements

Jan Frits Veldkamp was so kind as to correct the Latin description. John Lennie edited the text and ECV's work was in part funded by NSF grant DEB 0618293. Comments by Dr Brian A. Perry and Prof. Zhu-liang Yang greatly improved the text.

Literature cited

- Akers BP, Ovrebo CL. 2005. *Leucoagaricus bivelatus*, a new volvate lepiotoid species. *Mycotaxon* 91: 303-308.
- Bas C. 1969. Morphology and subdivision of *Amanita* and a monograph on its section *Lepidella*. *Persoonia* 5: 285-579.

- Bon M, Boiffard J. ('1974') 1975. Lépiotes de Vendée et de la Côte atlantique française (1). Bull. trim. Soc. mycol. France 90: 287-306.
- Bon M, Caballero A. 1995. Une nouvelle espèce 'amanitoïde' de *Lepiotaceae*. *Leucoagaricus volvatus* sp. nov. Docum. mycol. 24 (96): 9-12, 77.
- Dennis RWG. 1952. *Lepiota* and allied genera in Trinidad, British West Indies. Kew Bulletin 7: 459-499.
- Guinberteau J, Callac P, Boisselet P. 1998. Inventaire des communautés fongiques liées au *Cupressus macrocarpa* en zone littorale atlantique et données récentes sur les populations sauvages d'*Agaricus bisporus*. Bull. trim. Soc. mycol. France 114 (2): 19-38. 1998.
- Imai S. 1938. Studies on the *Agaricaceae* of Hokkaido. I. Journal of the faculty of Agriculture Hokkaido Imperial University 43: 1-378.
- Malençon G, Bertault R. 1971. Champignons de la péninsule ibérique. Acta phytotax. barcin. 8: 1-97.
- Mueller UG, Rehner SA, Schultz TR 1998. The evolution of agriculture in ants. Science 281: 2034-2039.
- Murrill WA. 1914. *Agaricaceae*. North American Flora 10 (1): 41-65.
- Patouillard NT. 1888. Quelques points de la classifications des Agaricinées. J. Bot., Paris 2: 12-16.
- Pegler DN. 1983. Agaric flora of the Lesser Antilles. Kew Bulletin additional Series IX: 1-668.
- Priou JP, Bodin M, Guinberteau J. 1995. Une espèce méconnue: *Leucoagaricus gaillardii* Bon & Boiffard - nouvelles données morphologiques, écologiques, chorologiques. Docum. mycol. 25 (98-100): 349-358.
- Reid DA. 1990. The *Leucocoprinus badhamii* complex in Europe: species which redden on bruising or become green in ammonia fumes. Mycol. Res. 94: 641-670.
- Singer R. 1986. The *Agaricales* in modern taxonomy. Ed. 4. Koenigstein, Koeltz Scientific Books.
- Vellinga EC. 2000. Notes on *Lepiota* and *Leucoagaricus*. Type studies on *Lepiota magnispora*, *Lepiota barssii*, and *Agaricus americanus*. Mycotaxon 76: 429-438.
- Vellinga EC. 2001. *Leucoagaricus*. In ME Noordeloos, ThW Kuyper, EC Vellinga (eds). Flora agaricina neerlandica 5: 85-108. Lisse/Abingdon/Exton (PA)/Tokyo, A.A. Balkema Publishers.
- Vellinga EC. 2004a. Genera in the family *Agaricaceae* – Evidence from nrITS and nrLSU sequences. Mycol. Res. 108: 354-377.
- Vellinga EC. 2004b. Ecology and distribution of lepiotaceous fungi – a review. Nova Hedwigia 78: 273-299.
- Zeller SM. 1934. A new species of *Lepiota*. Mycologia 26: 210-211.