

TYPE STUDIES IN THE GENUS *COPRINUS*  
(COPRINACEAE, AGARICALES)  
COPRINUS XEROPHILUS A NEW RECORD IN EUROPE

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In the present study a comparison of the holotypes of *Coprinus calyptratus*, *C. vosoustii*, *C. asterophorus* and *C. asterophoroides* has been carried out. As a conclusion of the latter we can state that all of them are conspecific, the correct name of this taxon being *C. calyptratus*. On the other hand the study of the type of *Coprinus xerophilus*, a vernal species which occurs in xerothermic plant communities on calcareous and gypsiferous soils, shows that this taxon is very close to *C. calyptratus*. Finally, we have studied the type of *C. arenarius*, a species which shares the same habitat as both *C. calyptratus* and *C. xerophilus*, and conclude that the former is different, being a species in its own right, known only from Africa. *Coprinus xerophilus* is a new record for the European mycobiota.

The xerothermic plant communities which thrive on calcareous and gypsiferous soils in the Iberian Peninsula are of great biological interest since they are composed of very selective and endemic species. The extreme environmental conditions such as drought, saline soils and high evaporation rates, characterize them as unfavourable habitats for a great majority of organisms. Therefore, only a small number of specifically adapted plants (such as mosses) and fungi (including some basidiomycetes and lichens) are able to colonize these ecologically harsh habitats. It is interesting to note that in the last few years several new fungi have been described in these habitats. In this respect we may quote the description of four new species in such different taxonomic groups as *Simocybe iberica* G. Moreno & Esteve-Rav. (Moreno & Esteve-Raventós, 1991), *Tulostoma pseudopolchellum* G. Moreno, Altés & Wright (Moreno et al., 1992), *Phaeomarasmius gypsophilus* Esteve-Rav., Villarreal, Heykoop & Horak (Esteve-Raventós et al., 1998) and *Marasmius celtibericus* G. Moreno & Raitviir (Moreno & Raitviir, 1998).

In this new contribution we describe a species of the genus *Coprinus*, *C. xerophilus*, which we already knew for sixteen years but which, due to its vernal fructification united to the great drought of the last years, could not be collected again until now. On the other hand, after having carried out a thorough bibliographic study in order to confirm or rule out the presence of this species in other areas, we became aware that several other species of *Coprinus* such as *C. calyptratus* Peck, *C. vosoustii* Pilát, *C. asterophorus* Long & Miller, *C. asterophoroides* Bogart and *C. arenarius* Pat. have been described from similar habitats. Therefore, and after having observed numerous similarities in their original descriptions we decided to compare their holotypes to elucidate the exact taxonomic status of all these taxa.

## MATERIALS AND METHODS

The microscopical examinations have been carried out in  $\text{NH}_4\text{OH}$  5% and Congo red. The microphotographs were made under a Nikon microscope, model Optiphot, with an incorporated system of automatic photography. The film used is Kodak Plus X Pan 125 ASA. The SEM photographs were made with a Zeiss DSM-950 microscope using the following technique: gills and spores were rehydrated with concentrated ammonium hydroxide (28–30%) for 30 min., dehydrated in aqueous ethanol (70%) for 1–1.5 hours, and, after fixing for 2 hours in pure ethylene glycol dimethyl ether (= 1,2-dimethoxymethane), immersed in pure acetone for at least 2 hours followed by critical point drying and sputtering with gold-palladium.

The abbreviations AH and FVDB refer respectively to the Herbarium of the University of Alcalá and the private Herbarium of Fred van de Bogart (deposited in WTU).

***Coprinus calyptratus* Peck — Figs. 1–24**

*Coprinus calyptratus* Peck, Bull. Torrey. bot. Club 22 (1895) 205–206.

*Coprinus vosoustii* Pilát, Stud. Bot. Cech. 5 (1942) 207.

*Coprinus asterophorus* Long & Miller, Mycologia 37 (1945) 120.

*Coprinus asterophoroides* Bogart, Mycotaxon 4 (1976) 252–254.

Pileus at first ovoid, then flat, 2–4 cm diam., 3–5 cm in height, white, covered with an ochraceous thick and persisting (not deliquescent) star-shaped universal veil. Margin fibrous and sulcate. Gills free, ascending, deliquescent, at first white, then turning pink, and finally blackish at maturity. Stipe 4.5–13 × 0.2–0.5 cm, white, cylindrical, hollow, fragile, somewhat bulbous (0.5–0.9 cm diam.) and slightly rooting. Taste and smell not distinctive.

Spores 17–20(–23) × 10–12(–14)  $\mu\text{m}$ , ellipsoid, smooth, dark brown to blackish, with eccentric germ-pore located on the abaxial side. Basidia 4-spored, clavate, 35–50 × 22–26  $\mu\text{m}$ , with strong brown parietal pigment, especially towards the apex. Cheilocystidia almost always collapsed (due to deliquescence), but when present globose to ellipsoid. Pleurocystidia not observed. Clamp-connections present. Universal veil consisting of branched densely packed hyphae, very variable in shape and size, dissociating with difficulty when mounted under the microscope.

*Collections examined*

Collections labelled as *Coprinus calyptratus*. — NORTH AMERICA: Rockport, Kansas, open cultivated ground, Aug., *F. Bartholomew* (typus, FH).

Collections labelled as *Coprinus vosoustii*. — CZECH REPUBLIC: Bohemia centralis, Bohnice prope Pragam, May 1942, *Bedrich Vosoust* (typus, PRM 626858). — MEXICO: Baja California, Sierra de San Pedro Mártir, in strongly manured grassland, 31.VI.1986, *N. Ayala* (BCMEX 4359); Baja California, in the campus of the Universidad Autónoma de Baja California, Unidad Ensenada, in urban garden, 2.IV.1992, *M. Lizárraga* (BCMEX 4791); *ibid.*, 16.II.1993, *Medina* (BCMEX 4787). — SPAIN: Madrid, Facultad de Farmacia y Medicina, Universidad Complutense, in manured gardens, on acid soils, 13.V.1976, *K. Tabba* (AH 556); *ibid.*, 19.V.1976, *G. Moreno* (AH 1218); *ibid.*, 8.V.1977, *G. Moreno* (AH 1284); *ibid.*, 1.X.1977, *G. Moreno* (AH 11584).

Collections labelled as *Coprinus asterophorus*. — NORTH AMERICA: New Mexico, four miles north of Albuquerque on Guadalupe Trail on the west end of the Denton Addition, on sandy soil, 12.VI.1941, *W.H. Long* (type *W.H. Long* 9354, UC); Bernadillo County, in an old cow pasture 2 miles south of the Alameda Bridge on the west side of the Río Grande river, elevation 5000 feet, 7.III.1941, *W.H. Long*; *ibid.*, *W.H. Long* 9305 (labelled as 'Co-type', UC; misidentified, it corresponds to *C. xerophilus*).

Collection labelled as *Coprinus asterophoroides*. — NORTH AMERICA: Beverly, comitato Grant, pago Washingtonis, in solo arenario in deserto, 5.VIII.1974, *J. Ebenal* (FVDB 3333, typus in WTU).

### *Results of the type studies*

(1) The type material of *Coprinus calyptratus* (Figs. 1–5) consists of one well-preserved basidioma with the following characters: pileus 4 cm diam., universal veil forming a thick ochraceous star-shaped layer (with six arms). Stipe 10.5 × 0.5 cm, whitish, hollow, cylindrical with bulbous base (0.8 cm diam.). Microscopically the universal veil is formed by ellipsoid to sometimes subglobose cells, very variable in size, densely packed and dissociating with difficulty when mounted under the microscope. Spores 18–20 × 10–12 μm, ellipsoid, dark brown, with eccentric germ-pore on the abaxial side.

(2) The type material of *Coprinus vosoustii* (Figs. 6–10) consists of nine basidiomata, some of them strongly fragmented, with the following characters: pileus 2–3 cm diam., universal veil ochraceous and well-developed, forming a thick layer which breaks up radially into a star-shaped structure. Stipe 4.5–7 × 0.2–0.5 cm, hollow, cylindrical, with bulbous and whitish base (0.5–0.9 mm diam.). Universal veil formed by cells very variable in shape and size, dissociating with difficulty when mounted under the microscope. Spores 17–19 × 11–12 μm, ellipsoid, dark brown, with eccentric germ-pore on the abaxial side.

(3) The type material of *Coprinus asterophorus* (Figs. 11–19) consists of two basidiomata in which the typical radially arranged structure of the veil on the pileus is well preserved, whereas the gills are completely collapsed making it difficult to study them under the microscope. The following characters were nevertheless observed: spores 17–19 × 11–12 μm, ellipsoid, dark brown, with eccentric germ-pore on the abaxial side. Universal veil formed by branched hyphae, very variable in shape and width, dissociating with difficulty when mounted under the microscope. The material labelled as 'Co-type' has been misidentified by Long & Miller and corresponds to *C. xerophilus* (see comments on this species).

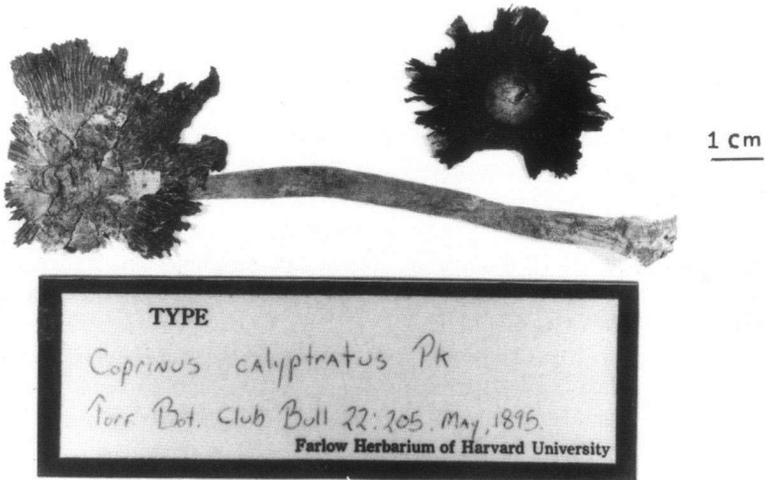
(4) The type material of *Coprinus asterophoroides* (Figs. 20–24) consists of five basidiomata, two of them strongly fragmented, with the typical star-shaped universal veil (with six arms). The following characters were observed: stipe cylindrical, hollow, the base not preserved in any of the specimens. Spores 18–19 × 10–12 μm, ellipsoid, dark brown, with eccentric germ-pore on the abaxial side. Universal veil formed by densely packed cells, very variable in shape and size, dissociating with difficulty when mounted under the microscope.

After comparing their respective holotypes we must conclude that *Coprinus calyptratus*, *C. asterophorus*, and *C. asterophoroides*, described from America, are conspecific with the European species known as *C. vosoustii*. According to art. 11.4 of the International Code of Botanical Nomenclature (Greuter et al., 1994) the correct name must be *Coprinus calyptratus* Peck, introduced by this author (Peck, 1895) when he described this taxon for the first time.

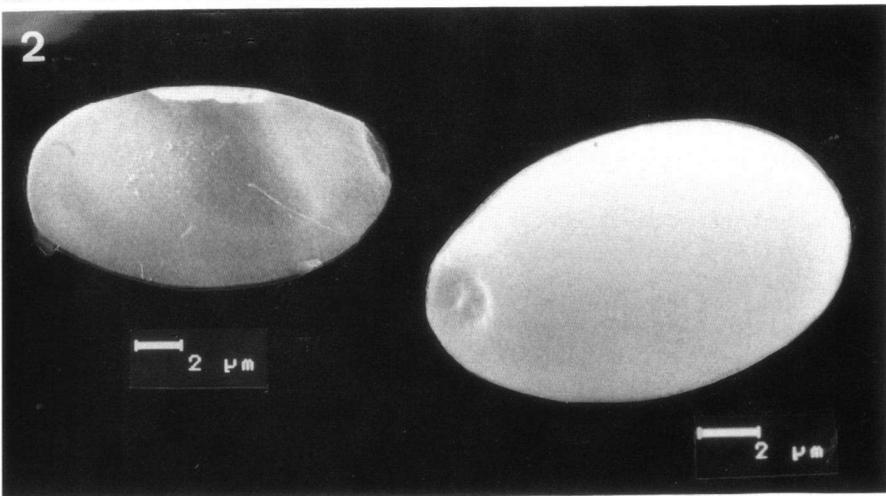
The most striking features of this species are its habit similar to small forms of *Coprinus comatus*, the persistence, even in dried herbarium material, of the star-shaped universal veil and its spores with eccentric germ-pore located on the abaxial side. We must indicate that Smith (1948) was the first author who considered both *Coprinus calyptratus* and *C. asterophorus* as synonyms, a statement on which we fully agree. Besides, Donelli & Simonini (1989) when describing *Coprinus vosoustii* as new to Italy made a very clever observation: "La specie de Pilát sembra molto vicina a due specie americane delle quali la specie europea sembra essere – il trait d'union –, *Coprinus asterophorus* Long & Miller e *Coprinus asterophoroides* Van de Bogart". However, this hypothesis was never tested satisfactorily.

For the diagnostic criteria by which *Coprinus calyptratus* and *C. xerophilus* can be distinguished see observations on the latter.

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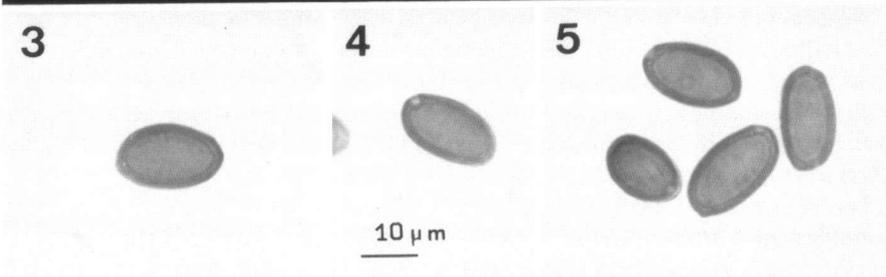
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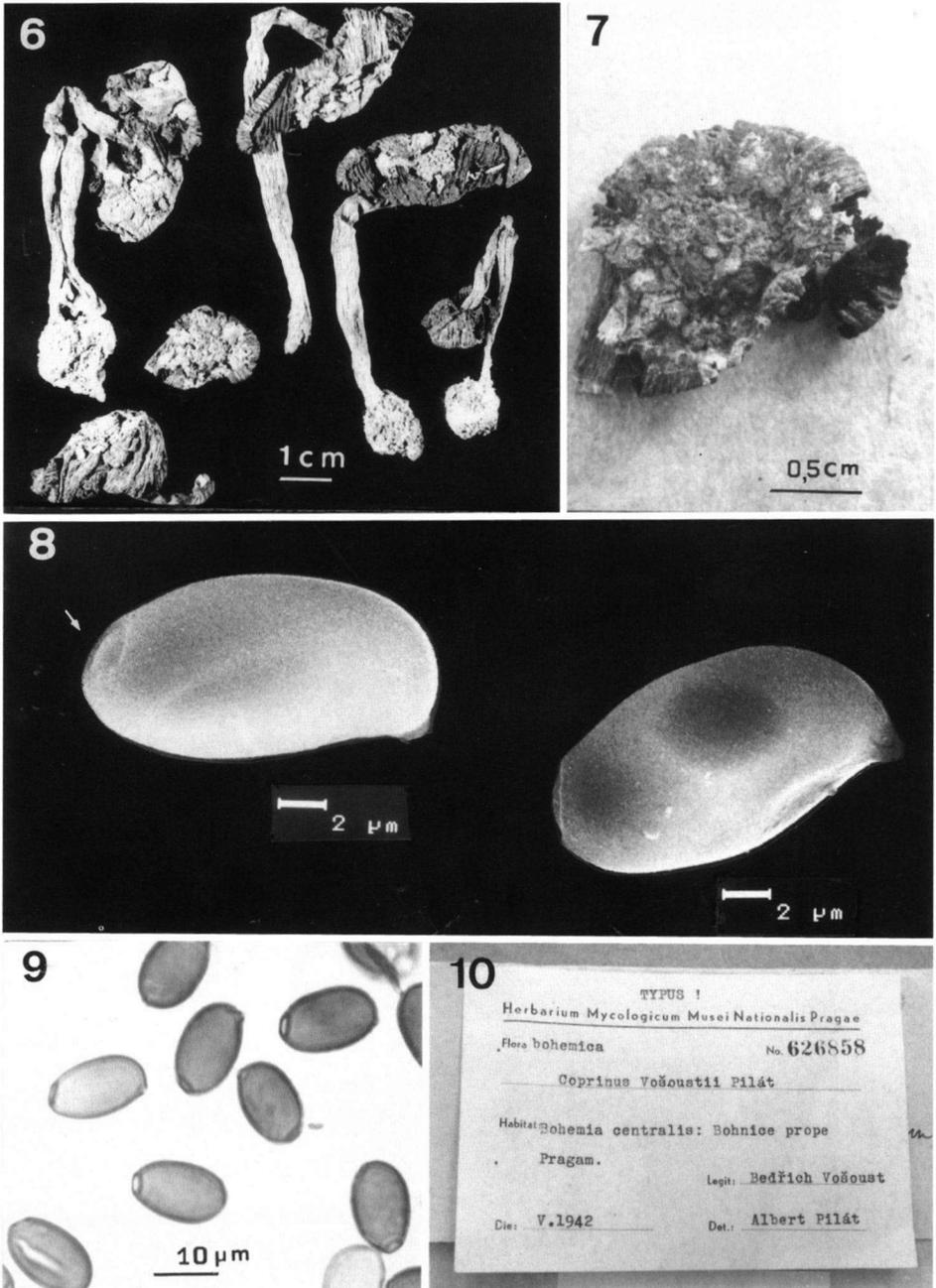
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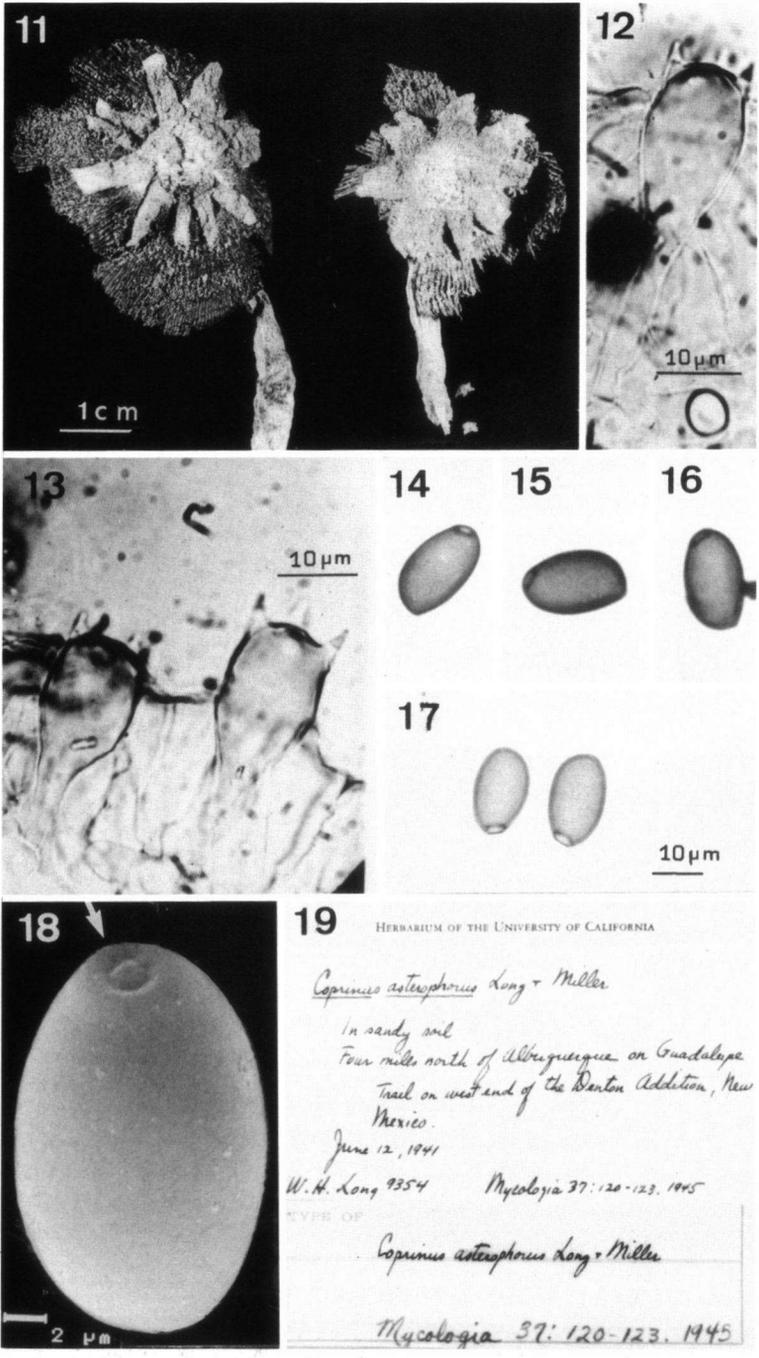
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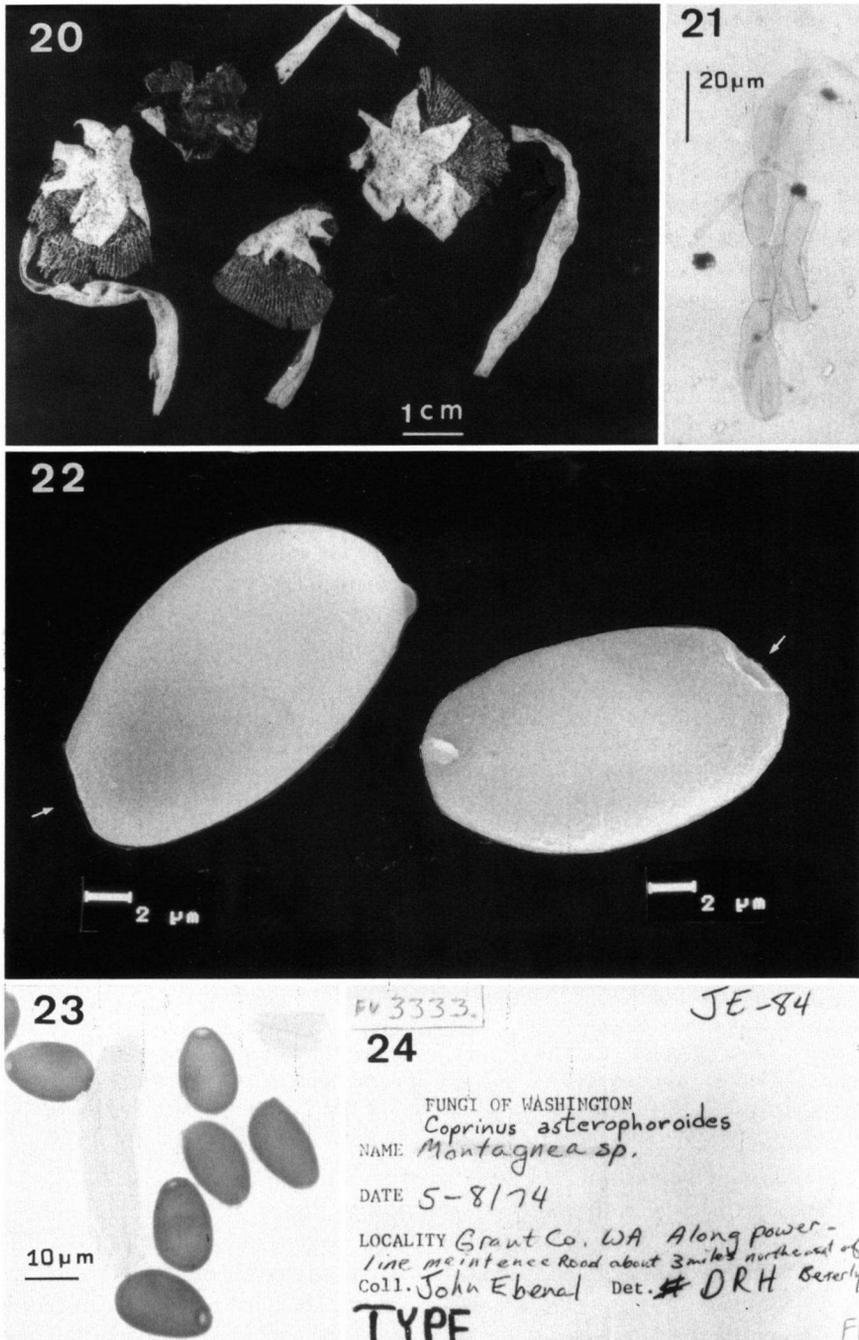
Figs. 1–5. *Coprinus calyptratus* (holotype). 1. Basidiomata; 2. spores with germ-pore on the abaxial side under SEM; 3–5. spores with germ-pore on the abaxial side under light microscope.



Figs. 6–10. *Coprinus vosoustii* (holotype). 6. Basidiomata; 7. detail of the apex of pileus; 8. spores with germ-pore on the abaxial side under SEM; 9. spores with germ-pore on the abaxial side under light microscope; 10. original herbarium label.



Figs. 11–19. *Coprinus asterophorus* (holotype). 11. Basidiomata; 12–13. basidia; 14–17. spores with germ-pore on the abaxial side under light microscope; 18. spore with germ-pore on the abaxial side under SEM; 19. original herbarium label.



Figs. 20–24. *Coprinus asterophoroides* (holotype). 20. Basidiomata; 21. hyphae of the universal veil; 22. spores with germ-pore on the abaxial side under SEM; 23. spores with germ-pore on the abaxial side under light microscope; 24. original herbarium label.

**Coprinus xerophilus** Bogart — Figs. 25–53

*Coprinus xerophilus* Bogart, Mycotaxon 4 (1976) 255–256.

Pileus conical to campanulate, 1.8–2.5 cm in height, 1.8–3.5 cm wide, pure white, covered with a large universal veil, white to cream-whitish, very patent towards the centre of pileus, showing a typical imbricate pattern and breaking up into thick scales which recall the cap of *Strobilomyces strobilaceus*. Margin sulcate, incurved when dry. Gills barely deliquescent, free, close, separate from the stem apex by a distinct collar which recalls *Coprinus plicatilis*. Stipe cylindrical, white, smooth, 3–5.7 × 0.2–0.3 cm, with marginate basal bulb, 0.6–0.9 cm in diam., often with white mycelial cords at the base. Taste and smell not distinctive.

Spores very dark black, (14–)17–20 × 11–13 (frontal view) × 8.5–10 μm (lateral view), smooth, ellipsoid, sometimes with somewhat enlarged base, germ-pore patent (up to 2 μm in diam.) and eccentric on the abaxial side. Basidia tetrasporic, with strong brown parietal pigment, especially towards the apex; walls refringent and somewhat thickened (e.g. 74 × 22 μm). Pleurocystidia not observed. Cheilocystidia probably present in young specimens, but the material studied was always very mature, with the gill-edge completely deliquesced. Clamp-connections absent or very rare. Universal veil consisting of hyaline radially arranged cylindrical hyphae, constricted at the septa and dissociating easily when mounted under the microscope; velar cells variable in shape and size, varying from nearly globose to more or less cylindrical (the last cell measuring for instance 95 × 20 μm).

*Collections examined*

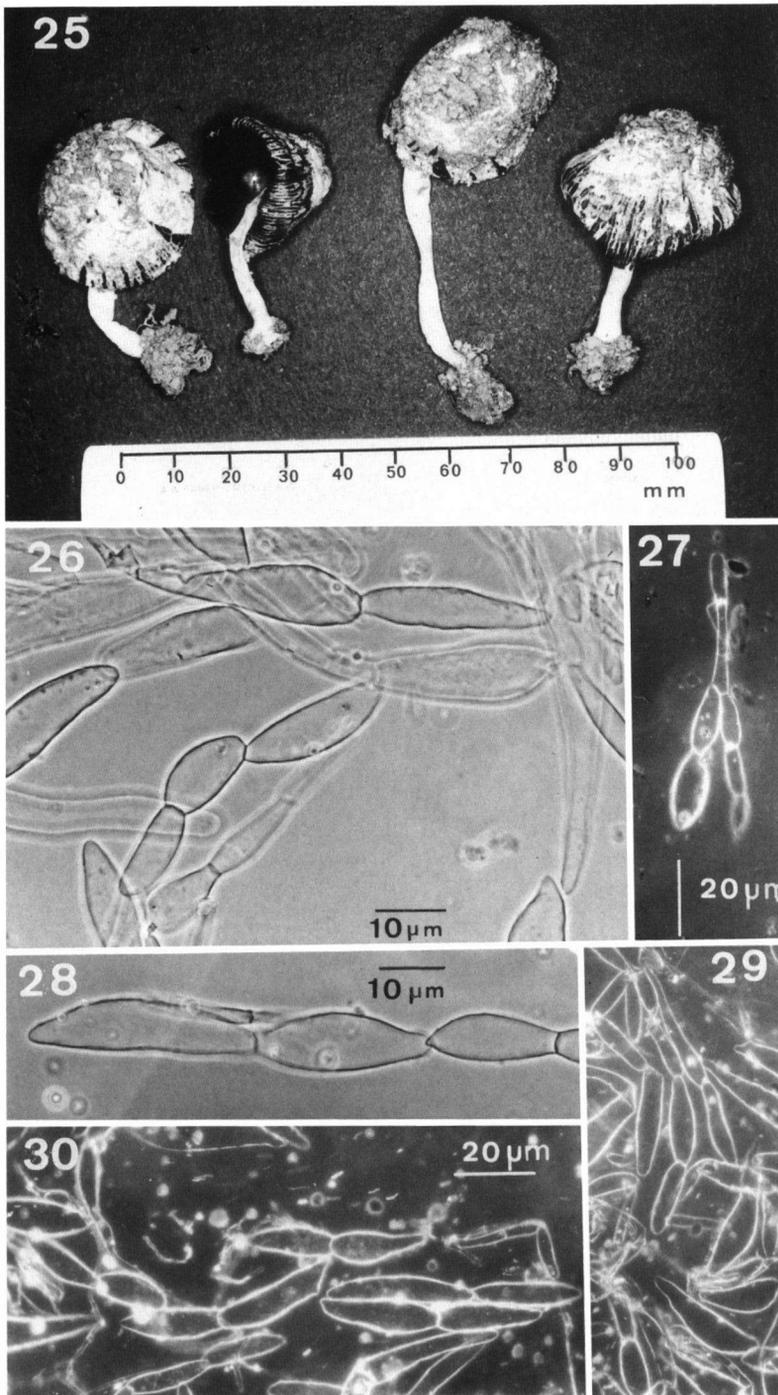
NORTH AMERICA: Nephi, comitato Juab, pago Utah, terrestriis, in solo arenario vel glareosa locorum, 15.VI.1975, S. G. Beougtt (FVDB 2159, typus in WTU); near Pateros, Wn., 1941 (FVDB 2155, paratypus in WTU). — SPAIN: Prov. Madrid, between Aranjuez and Ontigola, in grassland on gypsiferous soil, among *Teucrium gnaphalodes* L'Hér., *Stipa pennata* L., *Phlomis lychnitis* L., 17.V.1980, C. Lado & G. Moreno (AH 14860); Prov. Madrid, Villar del Olmo, in calcareous grassland, among *Thymus zygis* L., 10.VI.1984, J. L. Manjón (AH 14861); Prov. Zaragoza, between Retuerta de Pina and Pina de Ebro, solitary on gypsiferous soil, in a ploughed field with *Juniperus thurifera* L., 23.VI.1989, J. Blasco (AH 18386); Prov. Guadalajara, between Lupiana and Brihuega, in calcareous grassland, among *Convolvulus lineatus* L., *Thymus zygis* L., *Eryngium campestre* L., 19.VI.1992, A. Altés & G. Moreno (AH 14862); Prov. Madrid, Aranjuez, on gypsiferous soil among *Salsola vermiculata* L., 5.VI.93, J. Rejos (AH 21051).

*Other collections examined*

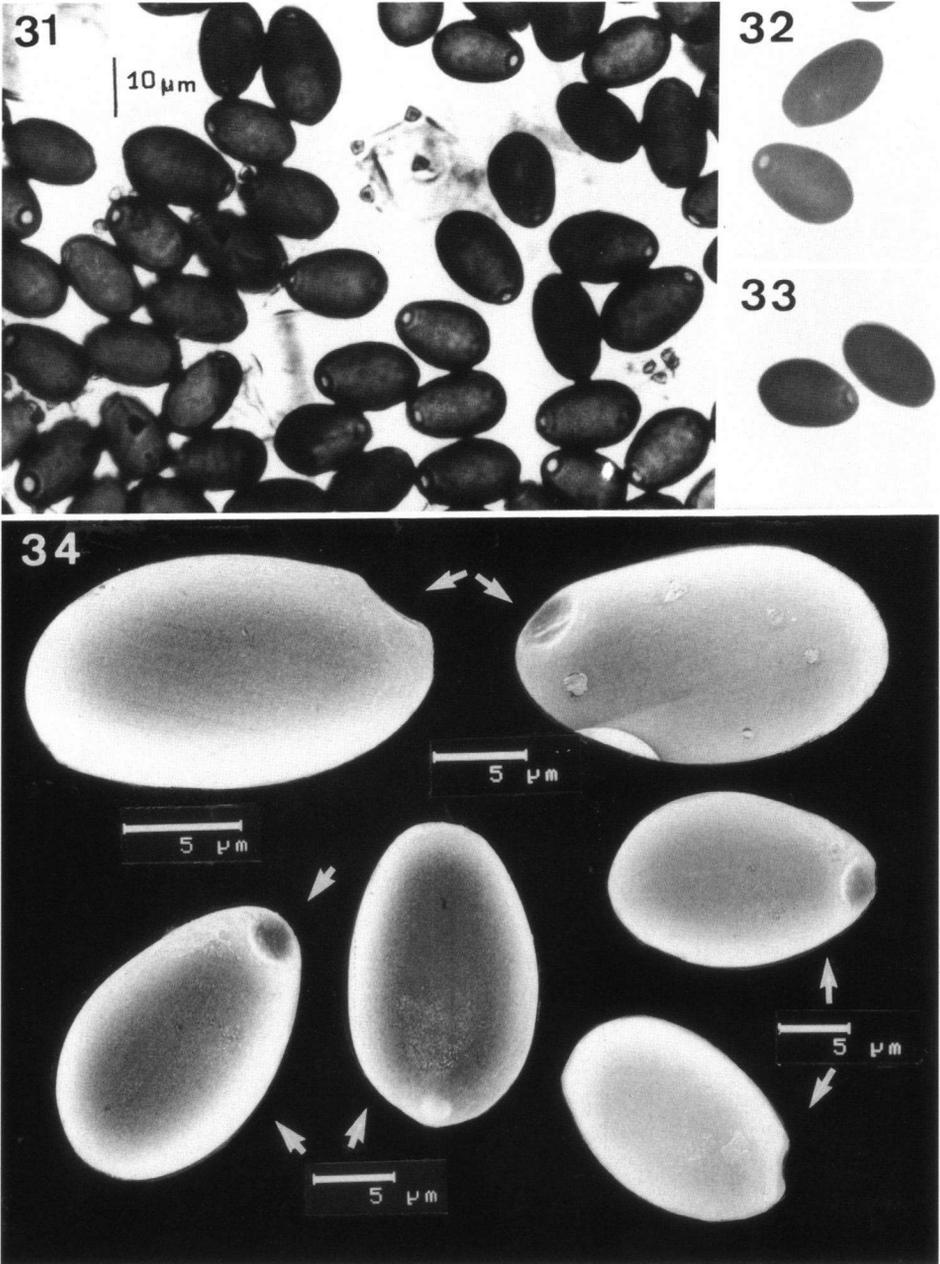
NORTH AMERICA: New Mexico, Bernadillo County, in an old cow pasture 2 miles south of the Alameda Bridge on the west side of the Río Grande river, elevation 5000 feet, 7.III.1941, W. H. Long (material identified and labelled as *Coprinus asterophorus* by Long & Miller (1945); labelled as 'Co-type' W. H. Long 9305, UC). — TUNISIA: Between Bir-Sidi and Bir-Medkidès, partly burried in the sand, 20.III.1891, N. Patouillard (type of *Coprinus arenarius*; Herb. Patouillard 93, FH).

*Results of the type studies*

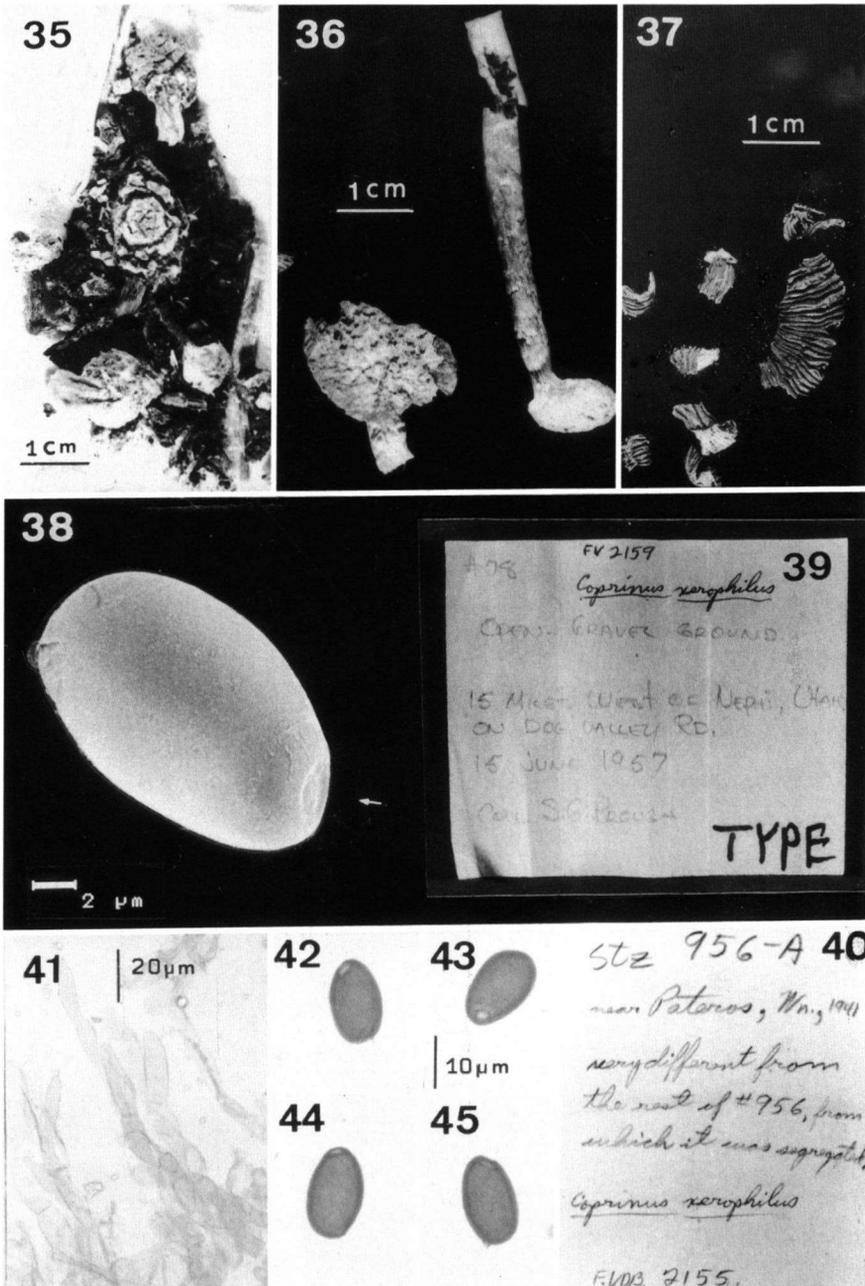
(1) The type material of *Coprinus xerophilus* (Figs. 35, 38, 40 and 41) is strongly fragmented. Nevertheless, it has been possible to observe four bulbous stipes (0.4–0.7 mm diam.) as well as the typical imbricate pattern of the universal veil which breaks up into thick scales, similar to that of the Spanish specimens collected by us. The universal veil dissociates easily when mounted under the microscope and consists of septate branched hyphae, which are formed by extended cells, constricted at the septa, clamped, and variable in shape and width (× 12–35 μm diam.). Spores 18–19 × 10–12 μm, ellipsoid, dark brown, with eccentric germ-pore on the abaxial side.



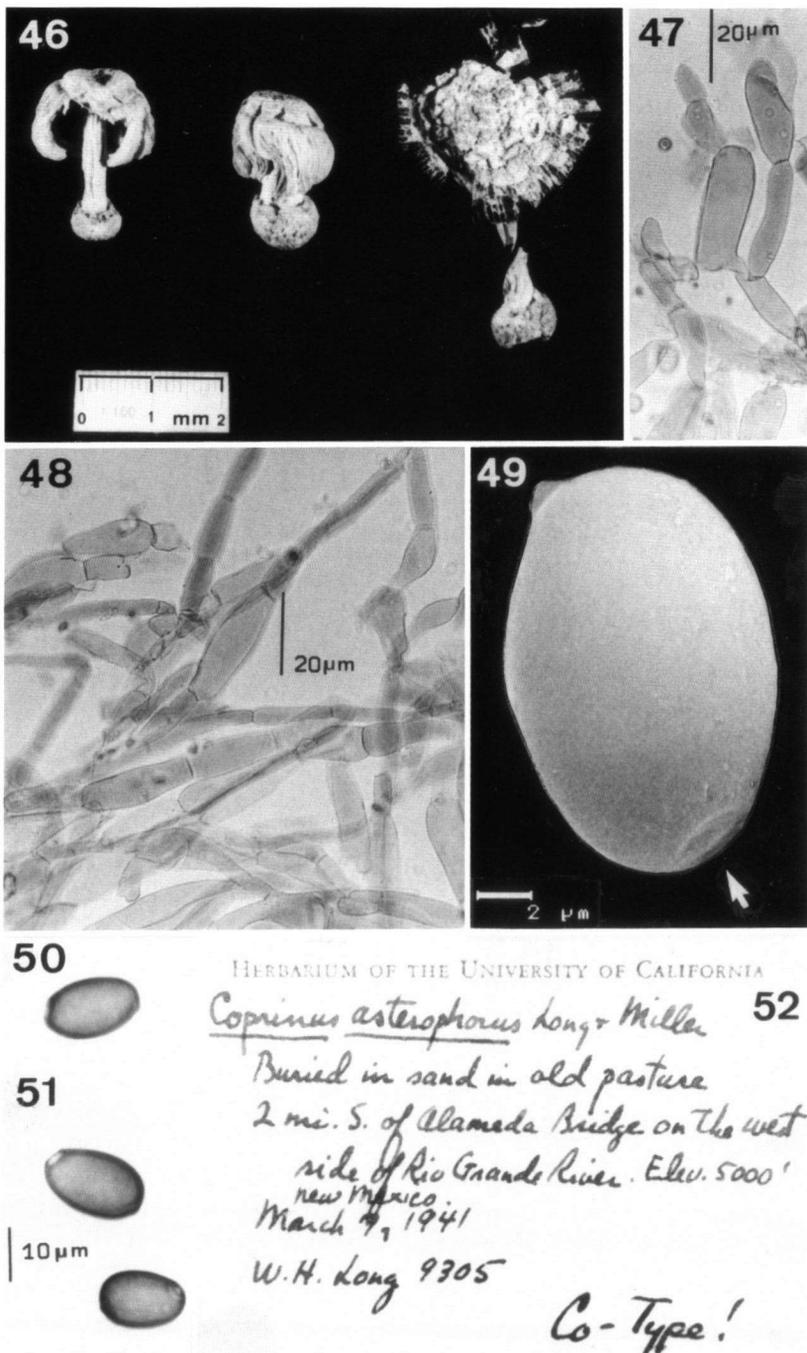
Figs. 25–30. *Coprinus xerophilus* (AH 14862). 25. Basidiomata; 26–30. hyphae of the universal veil.



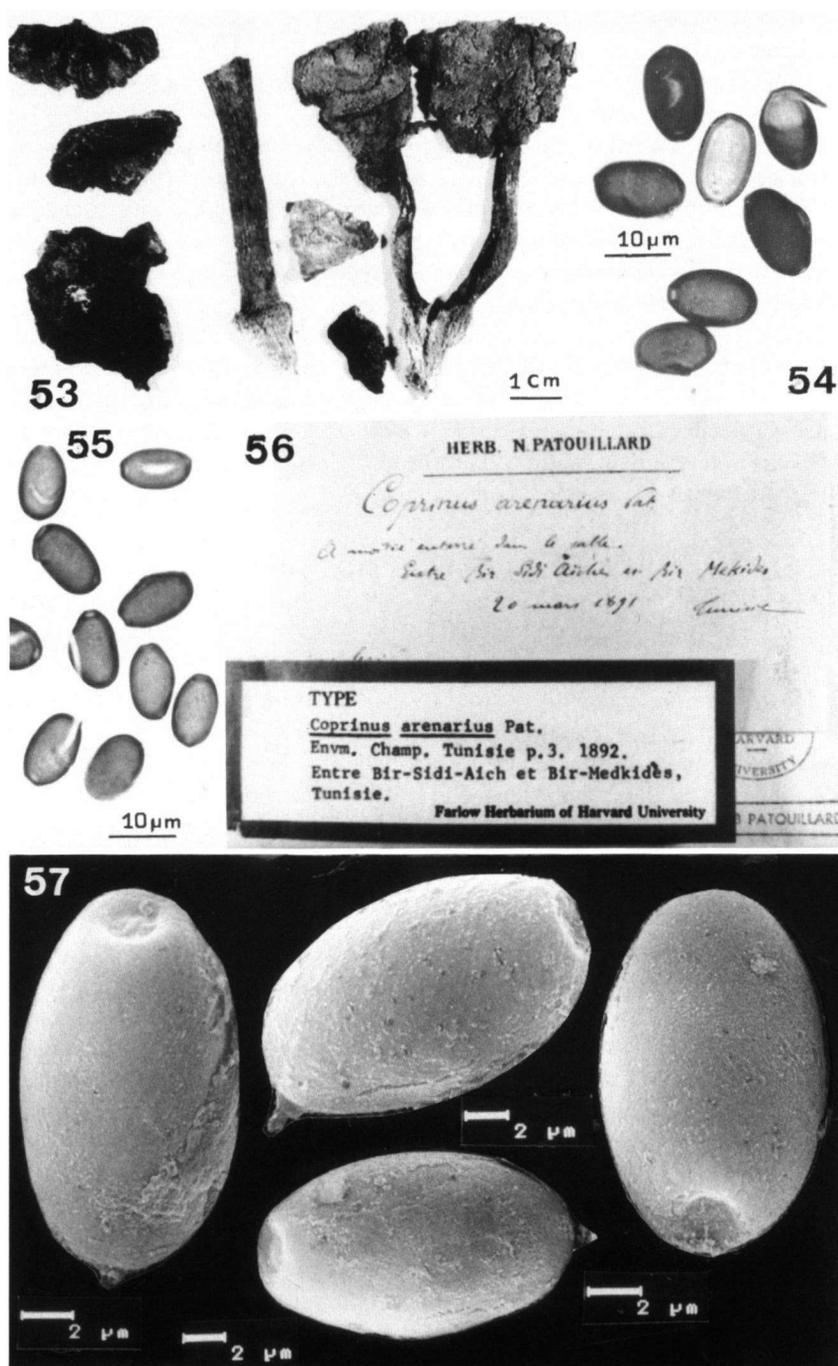
Figs. 31–34. *Coprinus xerophilus* (AH 14862). 31–33. Spores with germ-pore on the abaxial side under light microscope; 34. spores with germ-pore on the abaxial side under SEM.



Figs. 35, 38, 39, 41–43. *Coprinus xerophilus* (holotype). 35. Detail of the pileus surface; 38. spore with germ-pore on the abaxial side under SEM; 39. original herbarium label; 41. hyphae of the universal veil; 42 & 43. spores with germ-pore on the abaxial side under light microscope. — Figs. 36, 37, 40, 44, 45. *Coprinus xerophilus* (paratype). 36. Basidioma; 37. remains of gills; 40. original herbarium label; 44 & 45. spores with germ-pore on the abaxial side under light microscope.



Figs. 46–52. *Coprinus asterophorus* (co-type). 46. Basidiomata; 47 & 48. hyphae of the universal veil; 49. spore with germ-pore on the abaxial side under SEM; 50 & 51. spores with germ-pore on the abaxial side under light microscope; 52. original herbarium label.



Figs. 53–57. *Coprinus arenarius* (holotype). 53. Basidiomata; 54 & 55. spores under light microscope; 56. original herbarium label; 57. spores with apical germ-pore under SEM.

(2) The paratype of *Coprinus xerophilus* (Figs. 36, 37, 44–46) consists of one mature, though somewhat fragmented, basidioma in which the following characters have been observed: universal veil imbricate breaking up into thick scales, stipe  $7 \times 0.4$  cm, cylindrical, hollow, with whitish and bulbous base (1 cm diam.).

(3) The material labelled as 'Co-type' of *Coprinus asterophorus* (Figs. 47–53) consists of one small basidioma. It shows the typical imbricate universal veil breaking up into thick scales. The latter is formed by septate, branched and clampless hyphae with extended cells, constricted at the septa dissociating easily when mounted under the microscope. Spores ellipsoid, dark brown, with eccentric germ-pore on the abaxial side.

(4) The type material of *Coprinus arenarius* (Figs. 54–58), a species which shares a similar habitat, consists of three basidiomata, two of which are complete and one fragmented, pressed and fixed on a thin cardboard. The gills of these specimens are very poorly preserved but, nevertheless, we can assert that *C. arenarius* Pat. is different from *C. xerophilus* because of its fairly narrower ellipsoid spores ( $15\text{--}17 \times 8.5\text{--}10.5$   $\mu\text{m}$ ) with apical germ-pore. *Coprinus arenarius* is very similar, macroscopically, to *C. comatus* (Mull.: Fr.) Pers.; it differs, however, from the latter in having broader spores.

*Coprinus xerophilus* is characterized by its very thick and patently imbricate universal veil, and by its large spores with eccentric germ-pore on the abaxial side. Because of the radially arranged structure of the universal veil, consisting of hyphae formed by cylindrical to globose cells, which remains on the pileus as a hood, this species belongs to section *Coprinus* Pers.: S.F. Gray (= *Comati* Fr. emend. Lange).

*Coprinus xerophilus* apparently is a vernal species, fruiting with the first rainfalls and after several moderately warm days ( $15\text{--}20^\circ\text{C}$ ). We know it from the provinces of Madrid and Guadalajara, but its distribution is probably much wider and it will certainly be found in other similar gypsiferous and calcareous areas of the Iberian Peninsula. We have not been able to observe neither the presence of cheilocystidia nor pleurocystidia, and so these characteres should be confirmed in further collections. Nevertheless, the absence of cystidia was also indicated in the original description of van de Bogart (1976).

*Coprinus flocculosus* D.C.: Fr. is similar to *C. xerophilus* in having spores with a germ-pore located on the abaxial side, but the latter are smaller ( $11.5\text{--}16.5 \times 6\text{--}9.5$   $\mu\text{m}$ ); besides, the universal veil is floccose and neither thick nor imbricate.

*Coprinus calyptratus* fruits in similar habitats as *Coprinus xerophilus*. However, it differs macroscopically from the latter because of its habit which recalls small fruit-bodies of *C. comatus*, and by its typically star-shaped instead of imbricate universal veil. Furthermore, the veil of *C. xerophilus* when mounted under the microscope is filamentous, formed by branched hyphae and dissociates easily, whereas that of *C. calyptratus* is more densely packed and dissociates with great difficulty. Finally, the features of the spores such as shape, size and germ-pore are similar in both species. On the basis of their microscopic and ecological similarities we can conclude that both species, though clearly different, are closely related. We think this was precisely the reason why Long & Miller (1945) mixed them up when they described *Coprinus asterophorus* as new to science from America, designating a specimen with the typical star-shaped veil (which characterizes *C. calyptratus*) as the holotype and a specimen with imbricate veil easily dissociating when mounted under the microscope as 'co-type' (which corresponds to *C. xerophilus*).

Until now *Coprinus xerophilus* was known only from North America, and exclusively from its original description (van de Bogart, 1976), representing therefore a new record for the European mycobiota<sup>1</sup>.

#### ACKNOWLEDGEMENTS

We wish to express our gratitude to Prof. H. Romagnesi (Paris) for his valuable comments. We also thank the curators of the herbaria FH, PRM, UC, WTU, and AH, for the loan of the specimens mentioned in the text. We especially thank J.A. Pérez and A. Priego for their invaluable assistance with the SEM. This paper has been partially funded by the research project DGICYT PB 95-0129 and by the 'Programa de Cooperación con Iberoamérica' of the Ministry of Education and Science, Spain.

#### REFERENCES

- Bogart, F. van de. 1976. The genus *Coprinus* in western North America, part. I: Section *Coprinus*. *Mycotaxon* 4: 233–275.
- Donelli, G. & G. Simonini. 1989. *Coprinus vosoustii* Pilát e *Coprinus phlyctidosporus* Romagn. var. *monobisporus* Donelli et Simonini. XIII Mostra Reggiana del Fungo 1, 2 et 3 Ottobre 1988. Assoc. Micol. Bresadola. Gruppo 'R. Franchi': 11–21. Reggio Emilia.
- Esteve-Raventós, F., M. Villarreal, M. Heykoop & E. Horak. 1998. *Phaeomarasmium gypsophilus*, a new species from gypsiferous plant communities in Central Spain. *Mycologia* 90: 151–154.
- Greuter, W., F.R. Barrie, H.M. Burdet, W.G. Chaloner, V. Demoulin, D.L. Hawksworth, P.M. Jorgensen, D.H. Nicolson, P.C. Silva, P. Trehane & J. McNeill (Eds.). 1994. International Code of Botanical Nomenclature (Tokyo Code). Koeltz Scientific Books. Königstein, Germany.
- Long, W.H. & V.M. Miller. 1945. A new desert *Coprinus*. *Mycologia* 37: 120–123.
- Moreno, G., A. Altés & J.E. Wright. 1992. *Tulostoma pseudopulchellum* sp. nov. (*Tulostomatales*, *Gasteromycetes*) and allied species. *Mycotaxon* 43: 479–486.
- Moreno, G. & F. Esteve-Raventós. 1991. *Gymnopilus microsporus* (Sing.) Sing. y *Simocybe iberica* sp. nov., en España peninsular. *Rivista di Micol.* 3: 287–292.
- Moreno, G. & A. Raitviir. 1998. *Marasmius celtibericus* sp. nov. (*Tricholomataceae*, *Agaricales*) from Spain. *Persoonia* 16: 541–544.
- Peck, C.H. 1895. New species of fungi. *Bull. Torrey bot. Club* 22: 198–211.
- Pilat, A. 1942. *Coprinus vosoustii* sp. n. *bohemia sectionis* Volvati. *Stud. Bot. Cech.* 5: 207–211.
- Smith, A.H. 1948. Studies in the dark-spored agarics. *Mycologia* 40: 669–707.
- Vila, J., A. Rocabrana, M. Tabarès & X. Llimona. 1997. Algunos hongos nuevos o interesantes de la Península Ibérica. *Revista Catalana Micol.* 20: 169–176.

1) When this paper was in the press we became aware of the recent publication of a record of *Coprinus xerophilus* from Valladolid (Spain) in a similar habitat as where we collected our material (Vila et al., 1997). Therefore, the material studied by us represents the second for Spain and Europe. It can, nevertheless, be considered a very rare species.