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AN UPDATED KEY TO COPROPHILOUS PEZIZALES AND THELEBOLALES IN ITALY

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Abstract

The author updates his previous key to coprophilous Pezizales and Thelebolales in Italy, according to recent systematic changes and new findings. He also describes, illustrates and remarks upon the species new to Italy, *Ascobolus reticulatus*, *Coprotus niveus*, T*helebolus caninus*, *Thelebolus crustaceus*, and records the substrate preference of all coprophilous species. He finally provides unpublished macro- and microscopic colour photos of some coprophilous discomycetes.

Key words: coprophilous discomycetes, new reports, substrate preference.

Introduction

Coprophily (from the Greek "*kópros*" = "dung" and "*philía*" = "love", "love for, consequently living on, dung") is a fairly common style of life and survival in mycobiota, also shared by several Pezizales Bessey and Thelebolales P.F. Cannon, which find, in dung and its derivatives, a rich, although strongly contested, substratum. In our monograph on basidiomycetes and ascomycetes living on faecal material in Italy (Doveri, 2004) we widely dealt with fungi belonging to these two orders, stressing that particularly the *Ascobolaceae* Boud. ex Sacc. and *Thelebolaceae* (Brumm.) Eckblad choose dung for their growth and reproduction, and that many genera in these families must be regarded as obligately coprophilous. Since then some other species have been added to the Italian coprophilous Ascomycota Berk., so our personal list of discomycetes is formed of 92 units at present. This work is born from the need to describe the species new to Italy and to insert them into an updated key. We also need to consider recent nomenclatural and systematic changes, usually resulting from molecular studies (Gernandt *et al*., 2001; de Hoog *et al*., 2005). The most important of these concerns the *Thelebolaceae*, which have been transferred from the Pezizales to the new order Thelebolales (Cannon in Kirk *et al*., 2001). Thelebolales were shown by de Hoog *et al*. (2005) to be closely related to Helotiales Nannf., a position accepted by Eriksson (2006) in Leotiomycetes O.E. Erikss. & Winka. We have not carried out any phylogenetic studies, so are not able to fully judge their results, but we continue, as before (Doveri, 2004), to follow Eriksson's (2006) systematics. In this article, however, we retain a connection to the past, dealing both with coprophilous Pezizales and Thelebolales, i.e. those discomycetes whose apothecioid, sometimes perithecioid or cleistothecioid, ascomata develop a hymenial surface exposed at maturity.

Materials and methods

The described species have been obtained from dried dung placed in a non-sterilised moist chamber, following the methods suggested by Richardson & Watling (1997) and Richardson (2001), slightly modified by Doveri (2004).

Key to coprophilous Discomycetes in Italy

1) Asci more or less cylindric, usually non-protruding at maturity above the general level of the hymenium, with a functional operculum. Spores uniseriate, exceptionally biseriate or irregularly arranged. Ascomata comparatively large, usually discoidal or cup-shaped, rarely pulvinate.

Pezizaceae Dumort. and ***Pyronemataceae*** Corda, ***p.p.***

N.B.: No new species belonging to these two families have been described, so see Doveri, 2004.

1*) Asci cylindric-claviform, clavate, saccate or subglobose, exceptionally cylindric, protruding at maturity, operculate or inoperculate. Spores biseriate to conglobate, rarely uniseriate. Ascomata usually minute, pulvinate to subglobose, with several intermediate forms, exceptionally discoidal. **2**

2) Asci amyloid, with a well outlined and functioning operculum. ***Ascobolaceae*** + ***Iodophanus*** Korf **3**

2*) Asci non-amyloid, operculate (with a functioning or, on the contrary, scarcely outlined and non-functioning operculum) or inoperculate. **17**

3) Hymenial surface dark papillate or dotted. Spores pigmented. **4**

3*) Hymenial surface more or less papillate or dotted but not dark. Spores colourless. **8**

4) Ascomata superficial or semi-immersed in the substratum, sessile or sometimes shortly stipitate, 0.2-10 (-30) mm diam., pyriform, turbinate, cup-shaped, exceptionally discoidal at maturity. Spores free inside the ascus.

Ascobolus Pers. **5**

4*) Ascomata superficial, sessile, 0.2-1 (-2) mm diam., discoidal, lenticular or pulvinate at maturity. Spores firmly united together in the ascus, and arranged according to well defined patterns. ***Saccobolus*** Boud.

N.B.: No new species belonging to this genus have been described, so see Doveri, 2004.

5) Ascomata very small, usually < 0.8 mm wide and high, perithecioid or cleistothecioid (pyriform, subglobose, turbinate), sometimes immersed. Hymenial surface exposed during a late phase only ("telohymenial" according to van Brummelen, 1967). Asci usually very broad, with a dome-shaped apex and a large operculum.

sect. ***Dasyobolus*** (Sacc.) Brumm.

N.B.: No new species belonging to this section have been described, so see Doveri, 2004.

5*) Ascomata larger, up to 10 mm, rarely less than 0.5 mm wide, superficial, sessile or pedunculate, globose or pyriform in the early phases only, usually cup-shaped, flattening at maturity. Hymenial surface precociously exposed ("prohymenial" or "mesohymenial" according to van Brummelen, 1967). **6**

6) Ascomata usually comparatively large. Asci cylindric-claviform, rather long. Spores ellipsoidal or fusiform, exceptionally globose (but then not warted). Episporium often ornamented with longitudinal or sometimes transverse striae, which can anastomose to make a more or less complete reticulum, rarely warted or dotted, exceptionally smooth. sect. ***Ascobolus***

N.B.: No new species belonging to this section have been described, so see Doveri, 2004.

6*) Ascomata less than 0.50 mm wide. Spores globose to broadly ellipsoidal. **7**

7) Asci strongly amyloid, narrowly cylindric to cylindric-claviform, dome-shaped at the apex. Spores globose, ornamented with rounded warts or truncate tubercles [sect. *Sphaeridiobolus* (Boud.) Brumm.], 11.5-13.1 µm diam. (10.5-13.5, van Brummelen, 1967). ***Ascobolus brassicae***

7*) Asci non-amyloid, broadly clavate, with a rounded apex (sect. *Pseudascodesmis* Brumm.), usually broadly ellipsoidal, with an almost complete reticulum, joining low tubercles, 15-18 x 13-14 µm (13-19.5 x 13-15.5, van Brummelen, 1967). ***Ascobolus reticulatus***

8) Imperfect state *Oedocephalum*-like. Episporic ornamentation resulting from the primary accumulation of epiplasmal material. Spores symmetrical, smooth (rarely) or punctate to finely or coarsely warted, exceptionally apiculate. Perisporium gelatinous, thin and often invisible. Asci 8-spored. Paraphyses containing carotenoid pigments. Ascomata globose in the early stages, soon pulvinate or discoidal, pinkish-orange, yellowish-brown, sometimes reddish or brick coloured (*Iodophanus*). Spores 17-26.2 x 10-14.7 µm (15-20 x 7.5-10.5, Kimbrough *et al*., 1969), regularly ornamented with warts, which usually are less than 0.8 µm high. Ascomata pale orange or flesh-coloured. ***Iodophanus carneus***

8*) Imperfect state rarely present, if so not *Oedocephalum*-like. Episporic ornamentation resulting from the condensation of secondary wall depositions. Spores sometimes asymmetrical, smooth or warted and/or apiculate. Perisporium gelatinous, usually rather thick. Asci 8-32-spored. Paraphyses lacking carotenoid pigments. Ascomata turbinate, subcylindric, truncate-conical, sometimes pulvinate or discoidal at maturity, often whitish but tending to brown. ***Thecotheus*** Boud. **9**

9) Asci 32-spored. Spores smooth, non-apiculate, (sub)fusiform, symmetrical, 34.6-42 x 17.3-19 µm (32-40 x 15-22, Aas, 1992). ***Thecotheus pelletieri***

9*) Asci 8-spored. **10**

10) Spores smooth. **11**

10*) Spores ornamented. **13**

11) Spores apiculate, symmetrical, narrowly ellipsoidal, 24.7-29 x 12.3-14 µm. Apiculi usually hemispherical. Paraphyses thin and hardly enlarged at the apex. ***Thecotheus neoapiculatus***

11*) Spores non-apiculate. **12**

12) Spores asymmetrical, ellipsoidal-subfusiform, 20-23.6 x 10-11 µm (19-23 x 8.5-10.5, Aas, 1992).
Thecotheus crustaceus

12*) Spores symmetrical, ellipsoidal or cylindric-ellipsoidal, 33.6-36.7 x 15.8-17.8 µm (32-41 x 14-18, Aas, 1992)
Thecotheus cinereus

13) Paraphyses uncinate. Asci strangulate. Spores non-apiculate, symmetrical, narrowly ellipsoidal, coarsely warted, 22.8-25.1 x 11.4-12.3 µm (22-26 x 11.5-16, AAS, 1992). ***Thecotheus strangulatus***

13a) Paraphyses non-uncinate. Asci non-strangulate. Spores apiculate. **14**

14) Spores narrowly ellipsoidal, mostly asymmetrical, dotted, 16.3-20 x 7.2-9 µm. **15**

14*) Spores larger, prevalently or exclusively symmetrical. **16**

15) Spores lacking collarettes. Far Eastern, on cattle dung. ***Thecotheus formosanus f. formosanus***

15*) Spores with collarettes. European, on equine dung. ***Thecotheus formosanus f. collariatus***

16) Ascomata with a whitish, blooming mycelial felt. Spores 26.2-30.4 x 12.6-14.1 µm (25-30 x 12.5-14.5, Aas, 1992), finely dotted, uniseriate. Asci cylindric. Paraphyses hyaline. ***Thecotheus lundqvistii***

16*) Ascomata lacking a mycelial felt. Spores 28-33 x 13.5-16.5 µm (29-38 x 14-18, AAS, 1992), warted, biseriate or irregularly arranged. Asci cylindric-clavate. Paraphyses often brownish and encrusted. ***Thecotheus holmskjoldii***

17) Ascomata lacking an excipulum, made up of a bundle of asci and paraphyses, and a receptacle reduced to a very thin layer of basal hyphae. Ontogenesis eugymnohymenial, i.e. hymenium exposed since the early stages (*Ascodesmidaceae* J. Schröt.). Asci operculate (operculum very large and functioning), clavate-sacciform, 8-spored. Spores pigmented at maturity, ornamented with spines and ridges. ***Ascodesmis*** Tiegh.

N.B.: No new species belonging to this genus have been described, so we refer to our previous key (DOVERI, 2004).

17*) Excipulum present even if often strongly reduced, usually with an outer layer of a textura globulosa-angularis. Ontogenesis eugymnohymenial and ascomata discoidal, lentiform, pulvinate, sometimes turbinate or subcylindric, or cleistohymenial (hymenium not exposed until the asci have matured) and then ascomata globose, pyriform, ovoid, never discoidal. Asci 1- to polyspored, inoperculate and dehiscing by an apical split or even operculate, but then operculum not always well outlined and functioning. Spores usually hyaline and smooth or pale and verruculose at most. ***Thelebolaceae*** + ***Chalazion*** Dissing & Sivertsen + ***Lasiobolus*** Sacc. **18**

18) Ascomata glabrous. Asci operculate or irregularly dehiscing. **19**

18*) Ascomata hairy. Asci operculate. **36**

19) Excipulum strongly cyanophilous. Asci clavate, 8-spored. Spores ellipsoidal, lacking de Bary bubbles, ornamented with coarse roundish warts (*Chalazion*), 14.1-17.3 x 10-12 µm. Ascomata whitish, pulvinate to discoidal, 75-100 µm diam. ***Chalazion erinaceum***

19*) Excipulum not strongly cyanophilous, except in a few *Coprotus* species. Spores smooth or finely warted at most. Ascomata often pigmented. **20**

20) Ascomata eugymnohymenial, apothecioid (lenticular or discoidal), 0.1-3.0 mm diam., but < 1.5 mm diam. on average, usually containing several asci. Spores smooth, (sub)ellipsoidal, exceptionally (sub)globose or subcylindric, with a gaseous de Bary bubble. Asci (broadly) cylindric to claviform, 8- to polyspored, dehiscing by a regular operculum, lacking a subapical ring. ***Coprotus*** Korf ex Korf & Kimbr. **21**

20*) Ascomata usually cleistohymenial, cleistothecioid (globose, ovoid, pyriform), rarely apothecioid, < 0.3 mm diam., almost always containing very few asci. Spores smooth or rarely verruculose, (oblong) ellipsoidal, lack-

ing de Bary bubbles. Asci polyspored and then broadly ovoid or subglobose, or exceptionally 8-spored and then cylindric-claviform, provided with a subapical ring, irregularly dehiscing, but operculate in the 8-spored species . ***Thelebolus*** Tode **31**

21) Ascomata yellowish or orange. Paraphyses containing granules or vacuoles of more or less the same colour. **22**

21*) Ascomata whitish, but sometimes yellowing on maturing or drying. Paraphyses usually non-pigmented. **25**

22) Ascomata bright orange, up to 0.4 mm diam. Paraphyses slightly uncinate but strongly enlarged at the apices. Asci cylindric or more often cylindric-claviform. Spores 12-12.6 x 7.3-7.8 µm (12-14 x 6-8.5, Kimbrough *et al*., 1972). ***Coprotus aurora***

22*) Ascomata yellowish, up to 0.8 mm diam. **23**

23) Spores 10.5-12 x 6.5-7 µm. Asci cylindric. Paraphyses strongly uncinate. ***Coprotus aff. luteus***

23*) Spores larger. Asci not cylindric, and paraphyses not strongly uncinate. **24**

24) Ascomata 0.35-0.45 mm diam. Spores subcylindric or suballantoid, 14.7-17.3 x 8.4-8.9 µm. Asci prevalently cylindric-claviform but sometimes cylindric, 84-100 µm long. Paraphyses curved but not uncinate, slightly enlarged at the apex. ***Coprotus subcylindrosporus***

24*) Ascomata up to 0.8 mm diam. Spores ellipsoidal, 16.2-19 x 10.5-12 µm. Asci cylindric-claviform to clavate, 100-117 µm long. Paraphyses straight or curved, slightly or strongly enlarged at the apex. ***Coprotus aff. ochraceus***

25) Asci 8-spored. **26**

25*) Asci more than 8-spored. **30**

26) Spores less than 10 µm long. Paraphyses slightly to strongly uncinate. **27**

26*) Spores more than 10 µm long. Paraphyses not- or slightly uncinate. **28**

27) Asci cylindric or more rarely cylindric-claviform, often less than 60 µm long. Spores ellipsoidal, 8.4-9.6 x 5.2-5.8 µm (7.5-9 x 4.5-5.5, Kimbrough *et al*., 1972), usually uniseriate. Paraphyses strongly uncinate. ***Coprotus glaucellus***

27*) Asci somewhat longer, cylindric-claviform. Spores broadly ellipsoidal, 9-9.5 x 6.6-7.1 µm (8-10 x 5-6.5, Kimbrough *et al*., 1972; 8-10.5 x 5.5-6.5, Aas, 1983), biseriate. Paraphyses somewhat curved at the apices. ***Coprotus lacteus***

28) Spores 17.3-18.3 x 10.5-11.5 µm (14-18 x 7.5-11.5, Kimbrough *et al*., 1972; 13-16.5 x 7-9.5, Aas, 1983). Asci cylindric-claviform. Paraphyses slightly enlarged and uncinate at the apex. ***Coprotus leucopocilum***

28*) Spores smaller. **29**

29) Spores 10.5-12 x 6-7.5 µm (9-15 x 6.5-9.5, Kimbrough *et al*., 1972; 11-14 x 6-8, Aas, 1983). Asci 35-55 x 16-17 µm, claviform or clavate-sacciform. Paraphyses strongly enlarged at the apex but not uncinate. ***Coprotus granuliformis***

29*) Spores 11.5-14 x 6.3-8.5 µm (12-13.5 x 5-8 , Kimbrough *et al*., 1972; 10-13 x 6.5-8.5, Aas, 1983). Asci cylindric. Paraphyses slightly uncinate and enlarged at the apex. ***Coprotus disculus***

30) Asci 16-spored. Spores 12-12.5 x 7-7.5 µm (11-16 x 8-10, Kimbrough *et al*., 1972; 12-14 x 7.5-9, Aas, 1983). ***Coprotus sexdecimsporus***

30*) Asci 64-spored. Spores 9.6-11.5 x 5.7-6.7 µm (8-12 x 4-7, Kimbrough *et al*., 1972). ***Coprotus niveus***

31) Ascomata superficial, containing more than 10 asci. Asci cylindric-claviform to claviform or clavate-saccate. **32**

31*) Ascomata immersed to superficial, ovoid or (sub)globose, containing less than 5 asci. Asci ovoid or subglobose. **35**

32) Ascomata discoidal or pulvinate at late maturity. Spores 8-9 x 3.8-4.2 µm, uni- or biseriate. Asci 8-spored, 62-80 x 11-15 µm. Paraphyses inflated at the tips up to 7 µm diam., with bright yellow pigments. ***Thelebolus microsporus***

32*) Ascomata discoidal-pulvinate or subglobose. Spores slightly smaller, conglobate. Asci more than 8-spored. Paraphyses less inflated at the tips, with very pale yellow pigments. **33**

33) Ascomata discoidal to pulvinate. Asci 32- or 64-spored. **34**

33*) Ascomata subglobose. Asci more than 200-spored, 87-100 x 25-33 µm. Spores 6.2-7.6 x 3.6-4.3 µm. ***Thelebolus dubius*** var**. *lagopi***

34) Ascomata usually not forming crusts. Asci 32-spored, 37-50 x 15-20 µm. Spores 6-7 x 3.5-4 µm. ***Thelebolus caninus***

34*) Ascomata tending to form crusts. Asci 64-spored, 50-70 x 20-30 µm. Spores 5.5-7 x 3.5-4.5 µm. ***Thelebolus crustaceus***

35) Ascomata with 1 ascus only. Spores 5.2-6.6 x 2.3-2.8 µm. Ascus 200-210 x 160-190 µm, more than 2000-spored. ***Thelebolus stercoreus***

35*) Ascomata with 3-5 asci. Spores 5.2-6.3 x 3.2-3.5 µm. Asci 45-80 x 33-53 µm, more than 200-spored. ***Thelebolus polysporus***

36) Margin of receptacles fringed with hyphoid hairs. Ascomata minute (< 0.5 mm diam.), eugymnohymenial, cylindric, turbinate, obconical. Spores often fusiform, lacking de Bary bubbles. Asci cigar-shaped, with an apical operculum and a subapical ring, dehiscing by a vertical bilabial split [*Ascozonus* (Renny) E.C. Hansen], 64-spored. Spores often asymmetrical, 12.6-14.7 x 4.7-5.7 µm. ***Ascozonus woolhopensis***

36*) Margin often not well differentiaded. Hairs seta-like, not arranged on the margin but arising from the outer surface of receptacles. Ascomata up to 1 mm diam., cleistohymenial. Spores more or less ellipsoidal or subglobose, rarely subfusiform. **37**

37) Ascomata turbinate, dome-shaped, obconical, rarely pulvinate at late maturity, containing several asci, exceptionally only one. Hymenium exposed in the late mesohymenial phase. Setae often with a bulbous base, usually non-septate. Spores with a de Bary bubble. Asci 8-spored, exceptionally polyspored. ***Lasiobolus***

N.B.: No new species belonging to this genus have been described, so see Doveri, 2004.

37*) Ascomata usually pyriform or ovoid, rarely differently shaped, containing one or several asci. Hymenium exposed in telohymenial phase. Setae septate, not bulbous. Spores with or without de Bary bubbles. Asci polyspored, rarely 8-spored. ***Trichobolus*** (Sacc.) Kimbr. & Cain

N.B.: No new species belonging to this genus have been described, so see Doveri , 2004.

Description of species new to Italy or only recorded so far

Ascobolus reticulatus Brumm., *Persoonia* suppl. 1: 153-154, 1967. Fig. 1a-g

Original diagnosis: Brummelen J. van, 1967. *Persoonia* supplement volume 1 : 153-154.

Apothecia sessilia, usque ad 0.5 mm diam. Receptaculum initio globulare, deinde lenticulare vel discoideum, lutescens vel lutescenti-brunneum, laeve vel imprimis ad basin dilatatam hyphis sat rigidis obtectum. Excipulum textura prismatica vel porrecta. Asci clavati, 75-90 x 25 µ, 8-spori, pariete iodo haud caerulescente. Ascosporae primum sphaericae, maturitate generaliter breviter ellipsoideae, 13-19.5 x 13-15.5 µ, reticulo pigmentoso irregulari ornatae. Paraphyses filiformes, c. 3 µ crassae, apice leviter incrassatae. In fimo camelopardali crescens. Typus: G.H. Wagner, Zoologischer Garten, Dresden, Germania (S-A478).

Materijal: Italy: 1) Livorno, Bibbona (La Pira farm holidays), 50 m, about ten solitary, superficial specimens, on goose dung in culture, F. Doveri, 21.5.06, 294.2-Bibbona, CLSM 004.06.

Description

Apothecia 150-200 µm diam., subglobose to pulvinate or discoidal, dirty whitish, membranous, more or less smooth, with some rhizoids at their base. **Margin** not differentiated. **Hymenial** surface slightly convex, dark dotted owing to the protruding asci. **Subhymenium** not differentiated from the medullary excipulum. **Medullary excipulum** a *textura angularis* of polygonal, hyaline, thin-walled cells, 5-11 µm diam. **Ectal excipulum** a *textura prismatica* of hyaline or pale yellow, thin-walled, rectangular cells, 5-10 µm diam., perpendicular to the hymenial surface. Some septate, thick-walled, hyphoid hairs, 2-4 µm diam., are observable at the apothecial base. **Paraphyses** exceeding the asci, cylindric-filiform, 2.5-4 µm diam., septate, sometimes branched, containing many hyaline vacuoles, usually curved and inflated at their tips, up to 8 µm diam. **Asci** 130-160 x 30-35 µm, 8-spored, inamyloid, broadly clavate, thick-walled, long-stalked, with a rounded apex. **Spores** 15-18 (-18.5) x (12.5-) 13-14 (-15) µm, rarely subglobose, usually broadly ellipsoidal, sometimes ellipsoidal (Q= 1.06-1.42; Q= 1.22), hyaline and smooth in the early stages, becoming brown, irregularly biseriate, surrounded by a gelatinous sheath, lacking oil drops, sometimes with gaseous bubbles, ornamented with a wide-meshed, almost complete reticulum, joining low tubercles, less than 0.5 µm high.

Observations

According to van Brummelen (1967) *A. reticulatus* belongs to sect. *Pseudascodesmis*

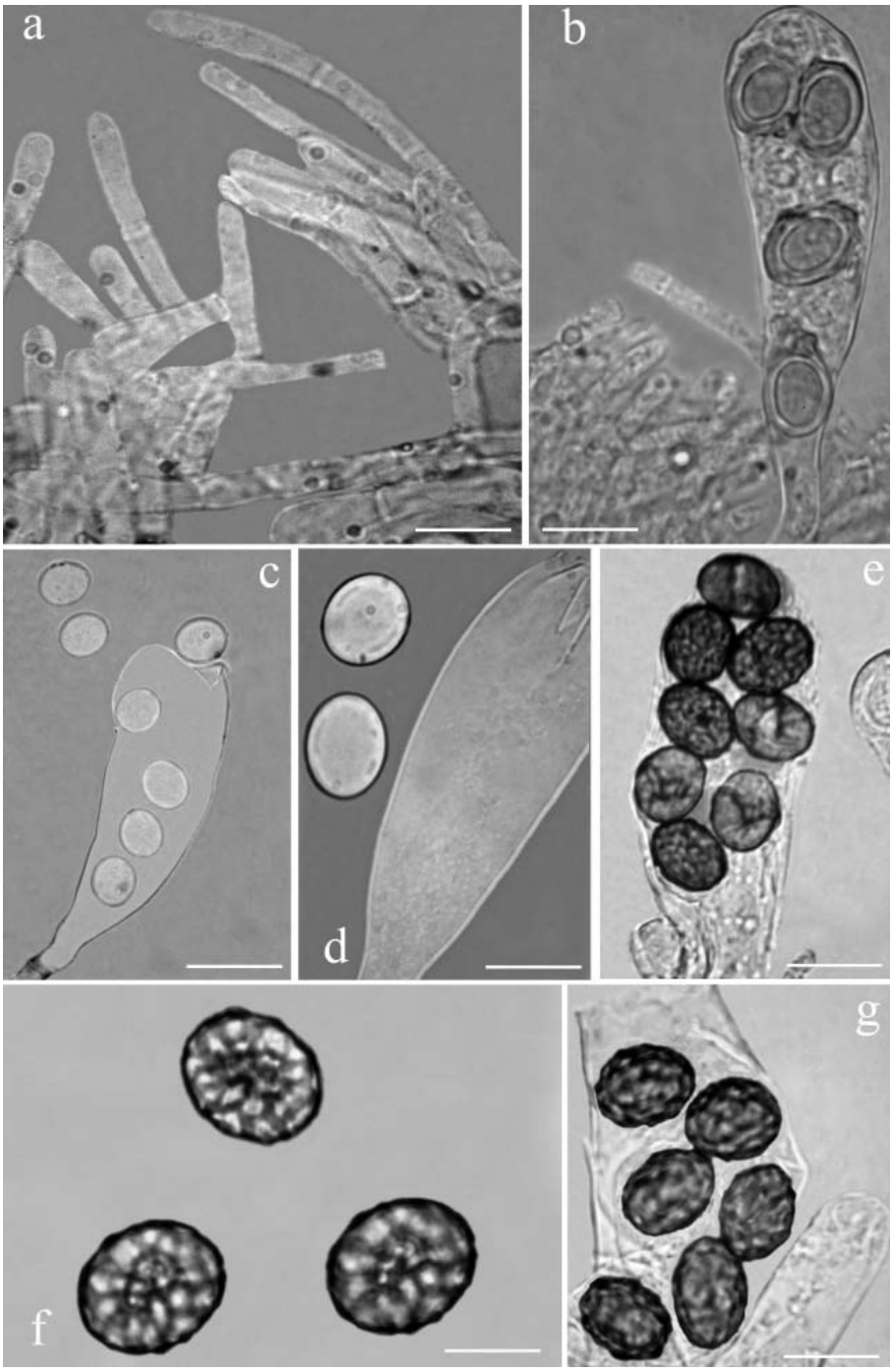

Fig. 1a-g *Ascobolus reticulatus*.
a. Paraphyses. b. An immature ascus and paraphyses. c-d. Immature asci and spores. e,g. Mature spores inside the asci. f. Mature spores. Scale bars : a,f = 10 µm ; b = 12 µm ; c = 23 µm ; d = 13 µm ; e = 19 µm ; g = 14 µm.

Brumm., which is very similar to *Ascodesmis* Tiegh. in growing on dung and having gymnohymenial apothecia, (sub)globose to broadly ellipsoidal, ornamented spores, broad and inamyloid asci. The two species of this section differ, however, from *Ascodesmis* in having a well developed excipulum and, according to our experience, in their trend to grow isolated rather than crowded. *A. perforatus* Brumm. differs from *A. reticulatus* in its globose to subglobose spores, 15-21 x 12-16 µm, with a granular episporium perforated by holes and pores: it was erected by van Brummelen (1981) based on *Ascodesmis canina* Jeng & Cain (1976), collected from dog dung in Venezuela; it was also reported by Abdullah & Alutbi (1993) on cow dung in Iraq.

A. reticulatus is very rare, with only three reports so far, i.e. by us in Italy, van Brummelen in the protologue (1967), referring to a collection from giraffe dung in Germany, and Wang (1996; 1999) in Taiwan from sheep and deer dung. Our description slightly differs from the original (van Brummelen, 1967) in having notably longer asci, but fully agrees with Wang (1996).

Coprotus niveus (Fuckel) Kimbr., Luck-Allen & Cain, *Can. J. Bot.* 50: 967, 1972. Fig. 2a-g
≡ *Ascobolus niveus* Fuckel, *Hedwigia* 5: 4, 1866.
≡ *Rhyparobius niveus* (Fuckel) Sacc., *Syll. Fung*. 8: 544, 1889.
≡ *Ascozonus niveus* (Fuckel) Boud., *Hist. Class. Discom. Eur.*: 79, 1907.

Original diagnosis : Fuckel K.W.G.L., 1866. Hedwigia 5 (1): 4, s.n. *Ascobolus niveus.*

Cupulis sparsis, punctiformibus, usque ad ½ lineam latis, planis, vix excavatis, hyalino-diaphanis, niveis, extus margineque pilis concoloribus subtilissime puberulis; ascis (a) stipatis, oblongo-ovatis, curvatis, 64 sporis, sporidiis farctis, demum operculo (b) magno rumpentibus; sporidiis (c) ellipticis, continuis, hyalinis; paraphysibus omnino deficientibus. - Ad fimum caninum putridum, rarissime. Hieme. In monte Rabenkopf.

Material: Italy: 1) Cuneo, Viola (loc. Il Colletto), 1100 m, one superficial specimen on cattle dung in culture, A. Bizzi, 14.9.05, 227.2-Pamparato, CLSM 016.05.

Description

Apothecium 180 µm diam., sessile, membranous, obconical in the early stages, flattening later and becoming almost discoidal, with a scarcely differentiated margin. Disc snow-white, finally pale yellowish, slightly convex, dotted at maturity due to the protruding asci. **Outer surface** smooth, the same colour. **Subhymenium** scarcely differentiated from the medullary excipulum. **Medullary** and **ectal excipulum** of a *textura globulosa-angularis*, made up of pale, polygonal or roundish cells, 7-12 x 4-7 µm, cylindric or claviform towards the margin of apothecium. **Paraphyses** filiform, exceeding the asci, 2-2.5 µm diam., septate, slightly narrowing at the septa, rarely simple, usually branched at some level, containing scarce, hyaline vacuoles, non- or hardly inflated (up to 4 µm diam.) at the tips. **Asci** 64-spored, 115-125 x 37-42 µm, clavate, with a dome-shaped operculum and a short stalk. **Spores** conglobate, 9.6-11.5 x 5.7-6.7 µm, ellipsoidal (Q= 1.42-1.84; Q= 1.66), roundish at the ends, smooth, hyaline, thick-walled, lacking oil drops, with de Bary's bubbles.

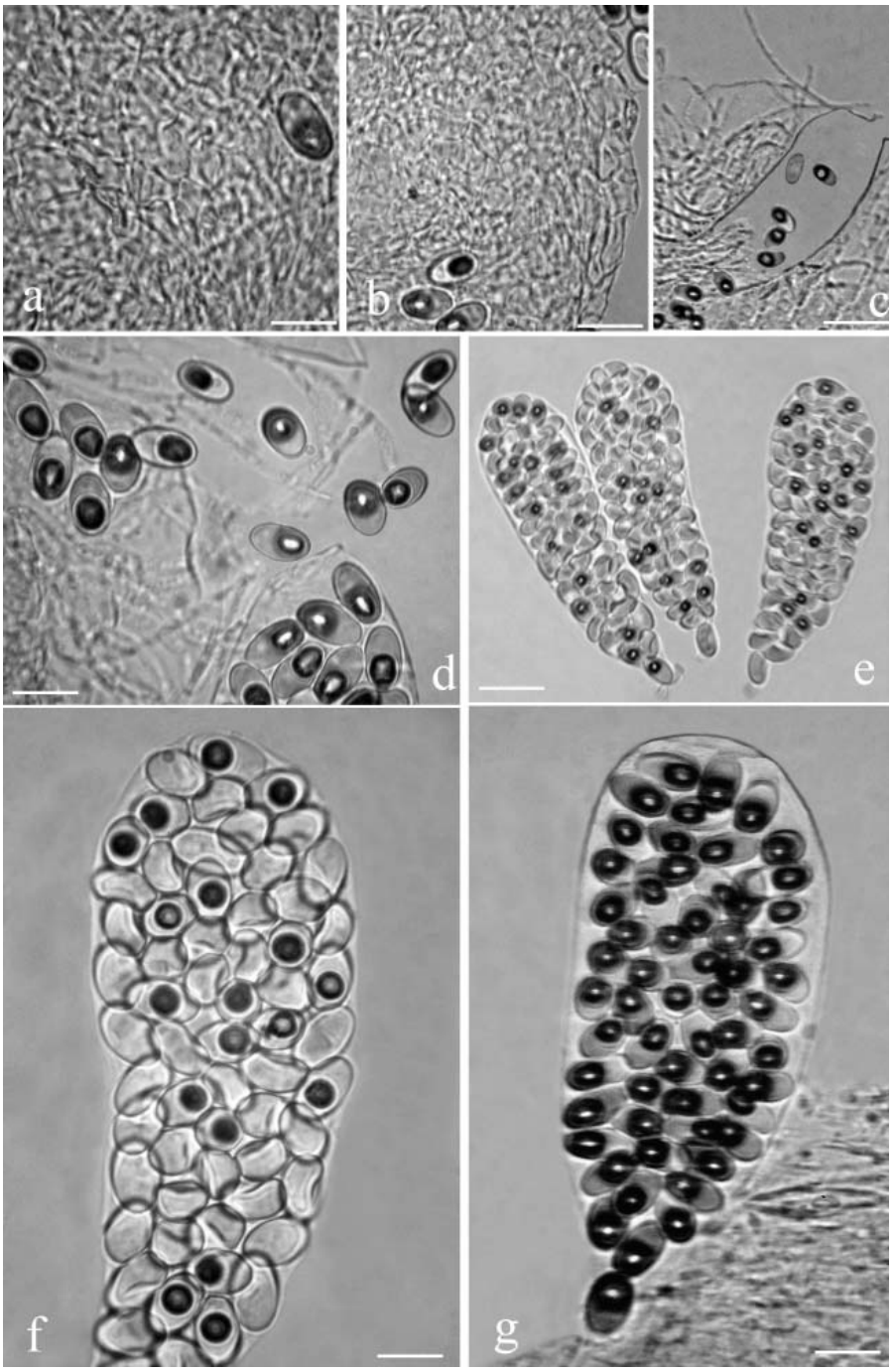

Fig. 2a-g. *Coprotus niveus*.
a-b. Excipulum. c. Ascus and paraphyses. d-g. Asci with spores.
Scale bars: a,f,g = 10 µm; b,d = 12 µm; c = 25 µm; e = 24 µm.

Observations

C. niveus is easily distinguishable from the other *Coprotus* spp. by its 64-spored asci, from similar species of *Thelebolus* Tode by having asci with a regular operculum. It is quite rare, although it has been frequently observed in Africa on eland, impala, hippopotamus, zebra, and zebu dung (Caretta *et al*., 1998). Elsewhere it has been reported on dung of several animals (Kimbrough *et al*., 1972), both herbivores (Valldosera & Guarro, 1988; Abdullah & Alutbi, 1994) and omnivores (Fuckel, 1866), although it prefers cattle dung (Wang, 1993, 1999; Piontelli & Grixolli, 1997).

Thelebolus caninus (Auersw.) Jeng & J.C. Krug, *Can. J. Bot.* 55: 2998. Fig. 3a-h

≡ *Ascobolus caninus* Auersw., *Hedwigia* 7: 51, 1868.

? = *Ryparobius brunneus* Boud., *Ann. Sci. Nat. V*, 10: 237, 1869.

= *Ascobolus crustaceus* Fuckel var. *myriadeus* P. Karst., *Monogr. Ascob. Fenniae*: 208, 1870, s. Saccardo.

≡ *Ryparobius caninus* (Auersw.) Sacc., *Syll. Fung*. 8: 539, 1889.

Original diagnosis: Auerswald B., 1868. *Hedwigia* 7 (4): 51.

A. microscopicus, depresso-globosus, fuscus v. brunneus, glaber, acute marginatus, disco pallidiore; ascis clavatis (44 micromillim. longis, 11 microm. circiter supra crassis), polysporis; sporis ovalibus, hyalinis, monoblastis, laevibus, 7-8 micromill. longis, 4 microm. latis, 24-32 in quovis asco.

Materijal: Italy: 1) Vicenza, Ponna, 600 m, about thirty gregarious, superficial specimens on roe deer dung in culture, A. Bizzi, 3.6.04, 102.1-Recoaro Terme, CLSM 001.05.

Description

Ascomata sessile, apothecioid, discoidal to pulvinate with a scarcely differentiated margin, membranous, snow to dirty white, 80-150 µm diam., containing more than 50 asci. Disc dotted at maturity due to the protruding asci. **Outer surface** the same colour, glabrous. **Excipulum** not differentiated into medullary and ectal layers, of a *textura angularis, globulosa-angularis* at intervals, of polygonal, sometimes roundish, uncoloured, fairly thin-walled cells, 3-8 x 3-5 µm. **Paraphyses** plentiful, exceeding the asci, cylindric, 1-2 µm diam., septate, diverticulate or branched at some level, apex included, filled with abundant, very pale yellowish pigment, curved or rarely hooked and usually inflated, up to 4 µm diam., at the tips. **Asci** claviform to broadly clavate, 37-50 x 15-20 µm, inoperculate, inamyloid, thick-walled, very short-stalked, roundish at the apex, 32-spored. conglobate, (5) 6-7 x 3.5-4 µm, smooth, hyaline, thin-walled, ovoid to ellipsoidal (Q=1.42-1.85; Q= 1.72), often slightly asymmetrical, somewhat pointed at one or both ends, lacking both oil drops and de Bary bubbles.

Observations

The main features of *T. caninus,* taken from literature (Auerswald, 1868; Rehm, 1887; Saccardo, 1889; Moser, 1963; Kimbrough & Korf, 1967; Jeng & Krug, 1977; Kimbrough, 1981; Spooner, 1981; van Brummelen, 1998, Prokhorov, 1998,

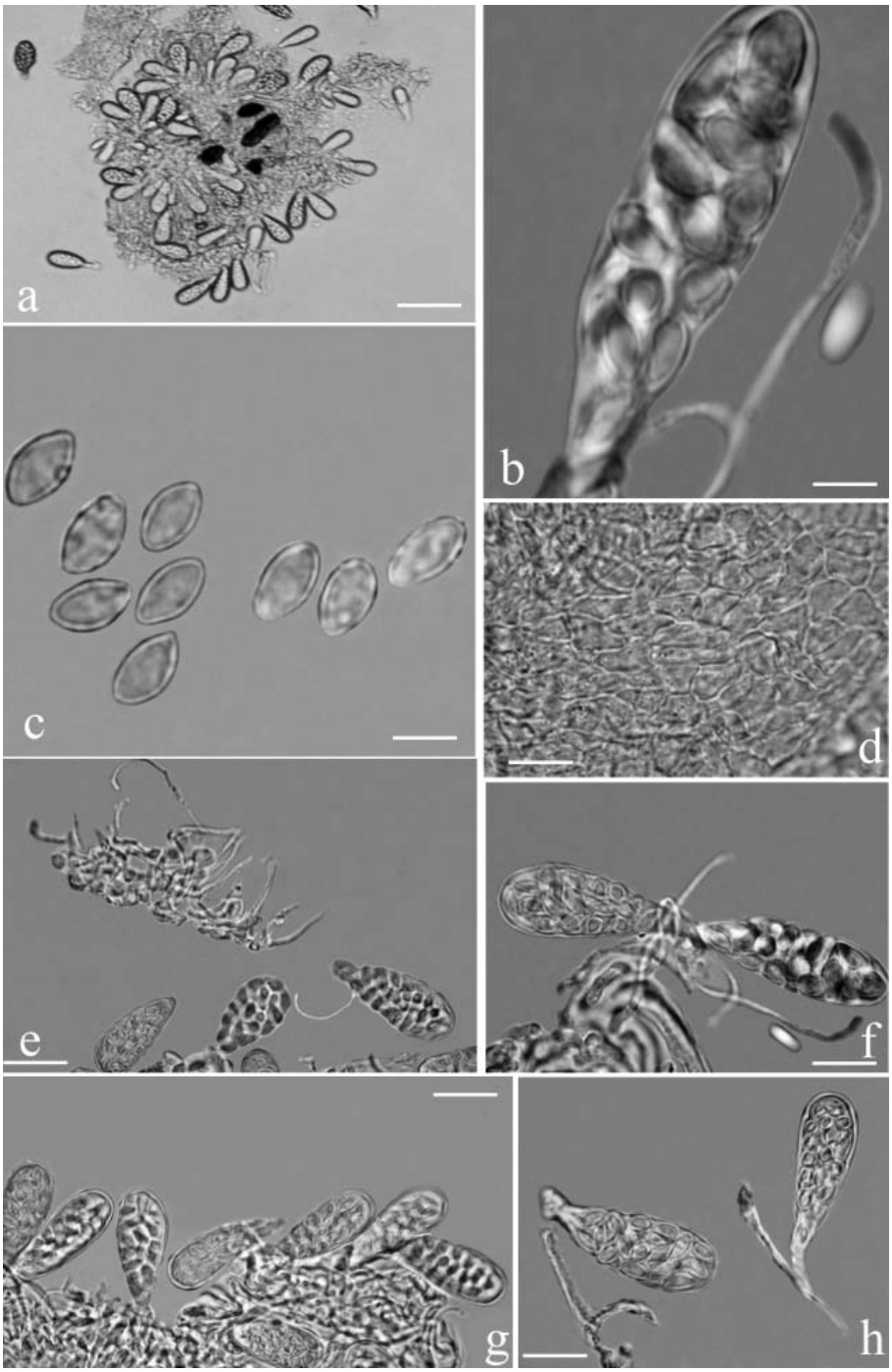

Fig. 3a-h. *Thelebolus caninus*.
a. Overall sight. b, e-h. Asci and paraphyses. c. Spores.
d. Excipulum. Scale bars: a = 70 µm; b = 6 µm; c = 4 µm; d = 9 µm; e = 23 µm;
f = 16 µm; g = 22 µm; h = 13 µm.

were described previously (Doveri, 2004), but the description above is the first from Italy, completely matching Jeng & Krug's (1977) from Venezuela, but slightly diverging from Spooner (1981), who described subglobose ascomata, and somewhat larger and verruculose spores from his British specimens from dog dung. Dog dung is also the substrate of the type material (Auerswald, 1868), and Malloch (in Brummelen, 1998) reported it on deer pellets in Ontario, Canada, and Kutorga (2000) from rabbit droppings in Lithuania.

The morphological differences between *T. caninus* and *T. crustaceus* are very small and correspond with those mentioned in our key. Judging by the numerous records in literature, *T. crustaceus* is widespread all over the world (North America: Seaver, 1928, Bergman & Shanor, 1957, Korf *et al*. in Kobayasi *et al*., 1967; South America: Spegazzini, 1924, Gamundí, 1975; Asia: Otani & Kanzawa, 1970, Ahmed *et al*., 1971; Africa: van Brummelen, 1998; Oceania: Bell, 1983), although it is commoner in Europe (Fuckel, 1866, Crouan & Crouan, 1867, Boudier, 1869, Karsten, 1870, 1871, Hansen, 1876, Spegazzini, 1878, Rehm, 1887, Heimerl, 1889, Saccardo, 1889, Schmidt, 1913, Grélet, 1932-1959, Velenovský, 1934, Svrček, 1962, Moser, 1963, Aas, 1978, Dennis, 1981, Prokhorov, 1989, 1991, 1998, Caretta & Piontelli, 1996, Jahn, 1997, De Meulder, 2000, Kutorga, 2000, Richardson, 2004). Our record from Italy follows Spegazzini (1878) and Caretta & Piontelli (1996). It particularly grows on carnivore or omnivore dung (Fuckel, 1866, Crouan & Crouan, 1867, Boudier, 1869, Karsten, 1870, 1871, Heimerl, 1889, Grélet, 1932-1959, Otani & Kanzawa, 1970, Gamundí, 1975, Dennis, 1981, van Brummelen, 1998), but also on dung of herbivores, and sometimes on soil and leaves.

Finally we must mention an important comparative, morphological and molecular, study (De Hoog *et al*., 2005) by which a single poly-spored (more than 8-spored asci), heterogeneous *Thelebolus* species has been recognised, s.n. *T. stercoreus* Tode: Fr., with an inconstant number of spores in the asci, even inside the same ascoma, including both *T. caninus* and *T. crustaceus*. The conclusion of this study is that, unlike the past, the spore number in an ascus "is of little value for the distinction of species", and that "*T. stercoreus* is the most variable species of the genus" with a regional variability of the DNA sequences. This prompts us to be cautious, to wait for further molecular studies that might confirm their conclusions, and to consider the poly-spored species independent meantime.

Thelebolus crustaceus (Fuckel) Kimbr. in Kobayasi *et al*., *Ann. Rept. Inst. Ferment. Osaka* 3: 49, 1967. Fig. 4a-e

≡ *Ascobolus crustaceus* Fuckel, *Hedwigia* 1: 4, 1866.

= *Ascobolus cookei* H. Crouan & P. Crouan, *Fl. Finist.* : 56, 1867.

= *Ryparobius cookei* (H. Crouan & P. Crouan) Boud., *Ann. Sci. Nat.* V, 10: 238, 1869.

? = *Ryparobius felinus* Boud., *Ann. Sci. Nat.* V, 10: 239, 1869.

= *Ascobolus crustaceus* var. *myriadeus* P. Karst., *Monogr. Ascob. Fenniae*: 208, 1870, s. Boudier.

≡ *Pezizula crustacea* (Fuckel) P. Karst., *Bidr. Känn. Finl. Nat. Folk* 19: 81, 1871.

≡ *Ryparobius crustaceus* (Fuckel) Rehm, *Ascom. exs.* n° 52 b, 1872.

= *Ryparobius crustaceus* var. *fuegiana* Speg., *Bol. Ac. Nac. Cienc. Cord*. 27: 387, 1924.

= *Streptotheca obscura* Seaver, *North Amer. Cup Fungi* (operc.): 143, 1928.

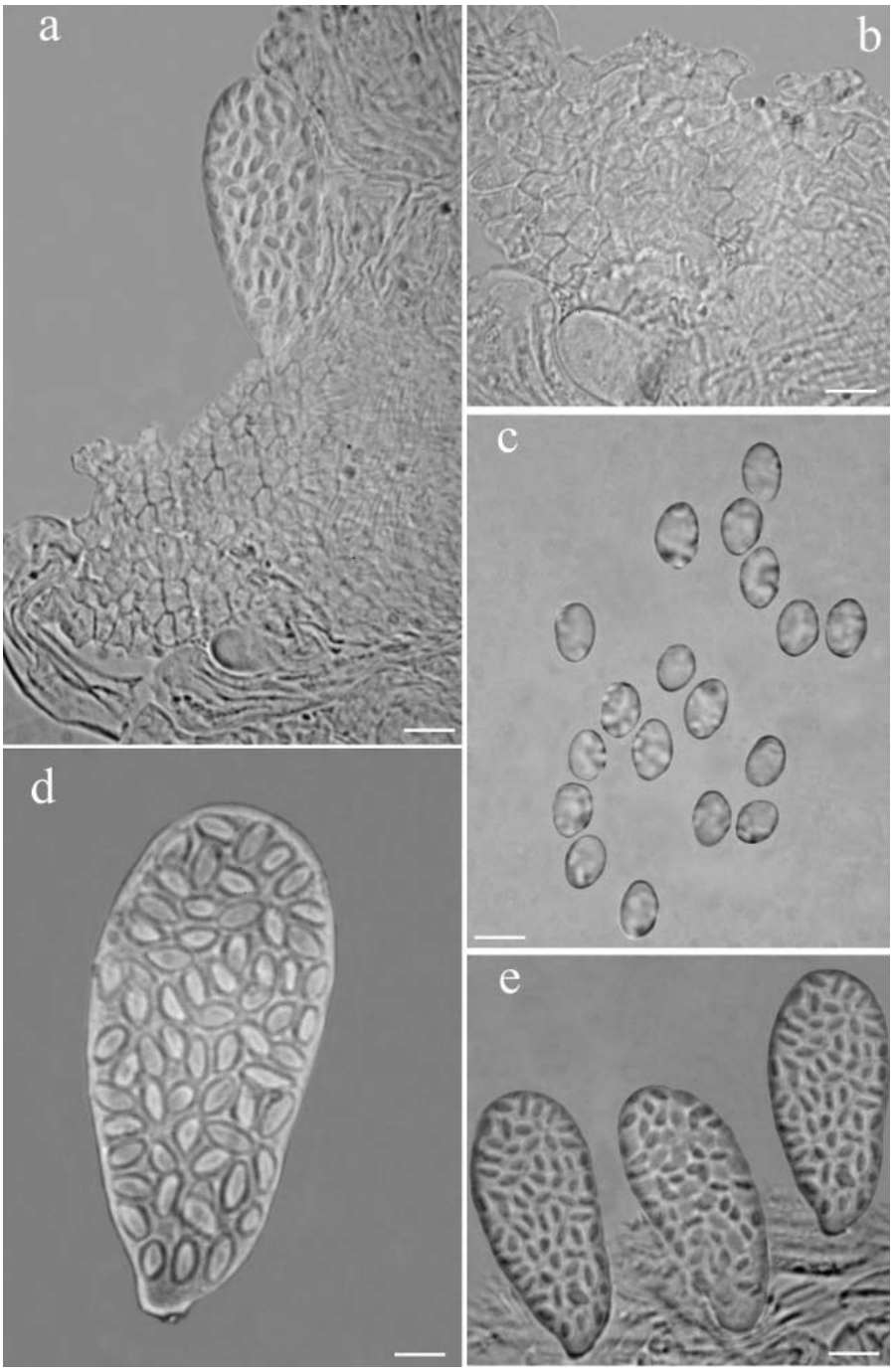

Fig. 4a-e. *Thelebolus crustaceus*.
a. Overall sight of excipulum, ascus with immature spores and paraphyses.
b. Detail of excipulum. c. Spores. d-e. Asci at different stages.
Scale bars: a = 12 µm; b = 8 µm; c = 5 µm; d = 6 µm; e = 10 µm.

= *Streptotheca psychrophila* P.S. Bergman *in* Bergman & Shanor, *Mycologia* 49: 879, 1957.
= *Thelebolus obscurus* (Seaver) Eckblad, *Nytt. Mag. Bot*. 15: 23, 1968.
=*Thelebolus psychrophilus* (P.S. Bergman) Eckblad, *Nytt. Mag. Bot.* 15: 23, 1968.
= *Ryparobius spegazzinii* Gamundí, *Fl. Crypt. Tierra Fuego* 10 (3): 162, 1975.

Original diagnosis: Fuckel K.W.G.L., 1866. *Hedwigia* 1 : 4.

Cupulis minutissimis, singulis oculo nudo vix conspicientibus, primo sparsis demum densissime dispositis, orbicularibus, planis, extus margineque fuscis, disco pallidiore; ascis (a) 64 sporis, farctis, fasciculatis, sessilibus, ovato-oblongis, basi paulo curvatis, operculum nondum vidi; paraphysibus (b) paucis, filiformibus, gracilibus; sporidiis (c) minutis, ovatis, continuis, hyalinis. Ad fimum caninum (Album graecum) putridum, rarissime. Hieme. Ca. Hortrichiam.

Material: Italy: 1) Cosenza, *Quercia rotonda*-Santa Sofia d'Epiro, 250 m, about one hundred superficial, gregarious specimens tending to form a crust, on porcupine dung in culture, C. Lavorato, 12.7.05, 552.4-S. Demetrio Corone, CLSM 003.06. 2) Livorno, S. Pietro in Palazzi, 0 m, on cattle dung in culture, F. Doveri, 30.4.06, 294.1-Cecina, CLSM 003.06 bis.

Description

Ascomata sessile, apothecioid, discoidal to pulvinate with a scarcely differentiated margin, membranous, snow to dirty white, 80-120 µm diam., containing more than 10 asci. Disc dotted at maturity due to the protruding asci. Outer surface the same colour, glabrous. **Excipulum** not differentiated in medullary and ectal layers, of a *textura angularis* of polygonal, uncoloured, fairly thin-walled cells, 5-7 x 3-4 µm. **Paraphyses** plentiful, exceeding the asci, cylindric-filiform, 1-2 µm diam., septate, branched at some level, filled with scarce, very pale yellowish pigment, curved or even hooked, slightly or not inflated at the tips. **Asci** claviform to clavate-saccate, 50-70 x 20-30 µm, inoperculate, anamyloid, thick-walled, very short-stalked or sessile, roundish at the apex, 64-spored. **Spores** conglobate, 5.5-7 x 3.5-4.5 µm, smooth, hyaline, thin-walled, ovoid to ellipsoidal (Q=1.37-2.00; Q= 1.63), often slightly asymmetrical, somewhat pointed at one end, lacking both oil drops and de Bary bubbles.

Observations

See under *Thelebolus caninus.*

Substrate prefferenze

For each species the total number of finds and the dung type on which they were found is given, e.g.: *Ascobolus albidus* H. Crouan & P. Crouan, *Ann. Sci. Nat. (Bot.)* IV 10: 193, 1858
Total 11: horse 6, goat 2, cattle 1, deer 1, wild pig 1.

Ascobolus albidus H. Crouan & P. Crouan, *Ann. Sci. Nat*. (Bot.) IV 10: 193, 1858 (fig. 5)
Total 12: horse 7, goat 2, cattle 1, deer 1, wild pig 1.

Ascobolus brassicae H. Crouan & P. Crouan, Ann. *Sci. Nat. (Bot.)* 4 (7): 174, 1857
Total 2: rat 1, wolf 1.

Ascobolus carletonii Boud., *Trans. Br. Mycol. Soc*. 4: 62, 1913

Total 1: tetraonid.

Ascobolus costantinii Rolland, *Bull. Soc. Mycol. Fr.* 4: 56, 1888

Total 1: unidentified animal.

Ascobolus crenulatus P. Karst., *Fungi Fenn. Exs.*: 763, 1868

Total 10: wild rabbit 2, bird 1, hedgehog 1, rabbit 1, rat 1, , unidentified carnivore 1, unidentified herbivore 1, weasel 1, wild pig 1.

Ascobolus elegans J. Klein, *Verh. zool.-bot. Ges. Wien* 20: 566, 1870

Total 5: all horse.

Ascobolus furfuraceus Pers.: *Fr., Syst. Mycol.* II: 163, 1823

Total 22: cattle 11, horse 3, roe deer 3, rock goat 2, deer 1, marten 1, sheep 1.

Ascobolus hawaiiensis Brumm., *Persoonia* suppl. 1: 87, 1967

Total 4: sheep 3, horse 1.

Ascobolus immersus Pers. ex Pers.: Fr., *Syst. Mycol.* II: 164, 1823 (fig. 6)

Total 103: sheep 33, cattle 16, horse 14, goat 8, roe deer 8, marmot 3, rock goat 3, deer 2, donkey 2, fallow deer 2, fox 2, hare 2, rabbit 2, wild pig 2, bird 1, pig 1, wild rabbit, wolf 1.

Ascobolus lineolatus Brumm., *Persoonia*, suppl. 1: 120, 1967

Total 1: fox.

Ascobolus mancus (Rehm) Brumm., *Persoonia*, Suppl. 1: 84, 1967

Total 5: horse 2, cattle 1, donkey 1, goat 1.

Ascobolus michaudii Boud., *Hist. Class. Discom. Eur*.: 71-72, 1907 (figs 7-8)

Total 13: sheep 5, horse 2, cattle 1, deer 1, donkey 1, fallow deer 1, ostrich 1, rabbit 1.

Ascobolus aff. ***pseudocainii*** Prokhorov, *Mikol. Fitopat.* 24 (5): 404, 1990

Total 2: deer 1, roe deer 1.

Ascobolus reticulatus Brumm., *Persoonia* suppl. 1: 153-154, 1967

Total 1: goose.

Ascobolus roseopurpurascens Rehm, *Rab. Krypt.-Fl., (Pilze)* 3: 1122, 1896

Total 1: unidentified herbivore.

Ascobolus stictoideus Speg., *Michelia* 1: 474, 1879

Total 4: horse 2, cattle 1, rat 1.

Ascodesmis microscopica (H. Crouan & P. Crouan) Seaver, *Mycologia* 8: 3, 1916

Total 3: hedgehog 1, sheep 1, wasp 1.

Ascodesmis nana Brumm., *Persoonia* 11 (3): 343, 1981

Total 1: bird.

Ascodesmis nigricans Tiegh., *Bull. Soc. Bot. Fr*. 23: 275, 1877

Total 8: beech marten 1, ostrich 1, pig 1, rabbit 1, rat 1, ring-dove 1, sparrow 1, toad 1.

Ascozonus woolhopensis (Renny) Boud., *Hist. Class. Discom. Europe*: 79, 1907

Total 1: unidentified herbivore.

Chalazion erinaceum Doveri, Y.-Z. Wang, Cacialli & Caroti, *RdM* 3: 204, 1998

Total 1: hedgehog.

Cheilymenia aurantiacorubra K.S. Thind & S.C. Kaushal, *Indian Phythopath*. 33 (3): 428, 1980

Total 3: cattle 2, unidentified herbivore 1.

Cheilymenia coprinaria (Cooke) Boud., *Icon. Mycol*. 2: 383, 1904

Total 3: cattle 2, horse 1.

Cheilymenia dennisii J. Moravec, *Libri Botanici* 21: 188, 2005

Total 1: unidentified animal.

Cheilymenia fraudans (P. Karst.) Boud., *Hist. Class. Discomyc. Eur*. : 63, 1907

Total 1: cattle.

Cheilymenia granulata (Bull.: Fr.) J. Moravec, *Mycotaxon* 38: 474, 1990

Total 7: cattle 6, goat 1.

Cheilymenia insignis (H. Crouan & P. Crouan) Boud., *Hist. Class. Disc. Eur*.: 63, 1907

Total 3: all cattle.

Cheilymenia pulcherrima (H. Crouan & P. Crouan) Boud., *Hist. Class. Discomyc. Europe* 63, 1907

Total 2: cattle.

Cheilymenia rubra (W. Phillips) Boud., *Hist. Class. Discomyc. Eur.*: 63, 1907

Total: 6: cattle 2, horse 2, mud of water softening 1, decaying bunches of grapes 1.

Cheilymenia stercorea (Pers.: Fr.) Boud., *Hist. classific. Discom. Europe* : 63, 1885 f. *stercorea*

Total 6: cattle 5, horse 1.

Cheilymenia theleboloides (Alb. & Schwein.: Fr.) Boud., *Hist. Class. Discom. Eur.* 62, 1907

Total 9: cattle 5, horse 2, man 1.

Coprotus aurora (H. Crouan & P. Crouan) Kimbr., Luck-Allen & Cain, *Can. J. Bot.* 50: 957-971, 1972

Total 3: cattle 2, wild rabbit 1.

Coprotus disculus Kimbr., Luck-Allen & Cain, *Can. J. Bot*. 50: 962, 1972.

Total 10: deer 2, wild rabbit 2, cattle 1, fallow deer 1, goat 1, rock goat 1, roe deer 1, wild pig 1.

Coprotus glaucellus (Rehm) Kimbr., *Am. J. Bot.* 54: 22, 1967

Total 5: roe deer 3, deer 2.

Coprotus granuliformis (H. Crouan & P. Crouan) Kimbr., *Am. J. Bot*. 54 (1): 22, 1967

Total 7: cattle 5, sheep 2.

Coprotus lacteus (Cooke & W. Phillips in Cooke) Kimbr., Luck-Allen & Cain, *Can. J. Bot.* 50: 965, 1972

Total 1: sheep.

Coprotus leucopocillum Kimbr., Luck-Allen & Cain, Can. J. Bot. 50: 965, 1972

Total 3: sheep 2, horse 1.

Coprotus aff. ***luteus*** Kimbr., Luck-Allen & Cain, *Can. J. Bot*. 50: 966, 1972

Total 3: cattle 2, horse 1.

Coprotus niveus (Fuckel) Kimbr., Luck-Allen & Cain , *Can. J. Bot*. 50: 967, 1972

Total 1: cattle.

Coprotus aff***. ochraceus*** (H. Crouan & P. Crouan) J. Moravec, *Česká Mykol*. 25: 155, 1971

Total 1: unidentified herbivore.

Coprotus sexdecimsporus (H. Crouan & P. Crouan) Kimbr. & Korf, *Am. J. Bot*. 54: 22, 1967 (fig. 9)

Total 31: horse 12, cattle 9, sheep 3, roe deer 3, fallow deer 1, rock goat 1, wild pig 1, wild rabbit 1.

Coprotus subcylindrosporus J. Moravec, *Česká Mykol.* 25 (3): 155, 1971.

Total 3: deer 1, horse 1, roe deer 1.

Iodophanus carneus (Pers.: Fr.) Korf in Kimbr. & Korf, *Amer. J. Bot*. 54 (1): 19, 1967

Total 81: cattle 23, sheep 17, roe deer 8, horse 7, goat 6, deer 3, rock goat 3, tortoise 2, ant 1, fallow deer 1, hare 1, hen 1, marmot 1, mouse 1, pigeon 1, rat 1, raven 1, snail 1, unidentified animal 1, wild rabbit 1.

Lasiobolus ciliatus (JC. Schmidt: Fr.) Boud., *Hist. Class. Discom. Eur*. 78, 1907

Total 17: horse 7, cattle 4, deer 1, goat 1, rock goat 1, roe deer 1, sheep 1, wild rabbit 1.

Lasiobolus cuniculi Velen., *Monogr. Discom. Bohem*. 1: 363, 1934

Total 65: sheep 18, horse 8, roe deer 7, cattle 5, goat 5, rock goat 5, deer 4, fallow deer 4, unidentified animal 2, wild pig 2, wild rabbit 2, hare 1, marmot 1, porcupine 1.

Lasiobolus diversisporus (Fuckel) Sacc., *Syll. Fung*. 8: 538, 1889

Total 3: cattle 2, rock goat 1.

Lasiobolus intermedius J.L. Bezerra & Kimbr., *Can. J. Bot*. 53: 1218, 1975

Total 3: donkey 1, roe deer 1, sheep 1.

Lasiobolus macrotrichus Rea, *Trans. Br. Mycol. Soc*. 16: 440, 1917

Total 5: goat 2, deer 1, marten 1, roe deer 1.

Lasiobolus microsporus J.L. Bezerra & Kimbr., *Can. J. Bot*. 53: 1221-1222, 1975

Total 4: wild pig 2, horse 1, wild goat 1.

Lasiobolus monascus Kimbr., *Mycologia* 66: 909, 1974

Total 2: fox 1, rat 1.

Lasiobolus ruber (Quél.) Sacc., *Syll. Fung*. 8: 537, 1889

Total 7: deer 3, roe deer 2, cattle 1, chamois 1.

Peziza fimeti (Fuckel) E.C. Hansen, *Vidensk. Meddel. Naturhist. Foren*.: 267, 1876

Total 6: horse 3, fallow deer 1, deer, 1, unidentified herbivore 1.

Peziza merdae Donadini, *Doc. Mycol*. 9 (36): 21, 1979

Total 1: man.

Peziza perdicina (Velen.) Svrček, *Česká Mykol*. 30: 139, 1976

Total 2: sheep 1, unidentified herbivore 1.

Peziza vesiculosa Bull.: Fr., *Syst. Mycol.* 2: 52, 1823

Total 6: horse 5, donkey 1.

Pseudombrophila bulbifera (E.J. Durand in Hotson) Brumm., *Libri Botanici* 14: 24, 1995

Total 1: rabbit.

Pseudombrophila cervaria (W. Phillips in J. Stev.) Brumm., *Libri Botanici* 14: 27, 1995

Total 5: roe deer 2, deer, 1, marten 1, sheep 1.

Pseudombrophila fuscolilacina (Grélet) Brumm., *Libri Botanici* 14: 36, 1995

Total 1: sheep.

Pseudombrophila merdaria (Fr.: Fr.) Brumm., *Libri Botanici* 14: 45, 1995

Total 5: cattle 3, rabbit 1, unidentified animal 1.

Pseudombrophila minuta Brumm., *Libri Bot*. 14: 50, 1995

Total 3: horse 1, goat 1, sheep 1.

Pseudombrophila theioleuca Rolland, *Bull. Soc. Mycol. Fr*. 4: 57, 1888

Total 3: roe deer 2, rock goat 1.

Saccobolus beckii Heimerl, Jahresb. K. K. *Ober-Realschule Bezirke Sechshaus Wien* 15: 18, 1889

Total 12: deer 6, roe deer 3, cattle 1, fallow deer 1, chamois 1.

Saccobolus caesariatus Renny *in* Phillips, *Brit. Discom*.: 297, 1887.

Total 7: wild rabbit 3, cattle 1, goat 1, rock goat 1, sheep 1.

Saccobolus citrinus Boud. & Torrend, *Bull. Soc. mycol. Fr*. 27: 131, 1911

Total 11: roe deer 3, cattle 2, deer 2, sheep 2, fallow deer 1, horse 1.

Saccobolus depauperatus (Berk. & Broome) E.C. Hansen, *Vidensk. Meddel. Nathurist. Foren*.: 87, 1876

Total 33: horse 16, sheep 5, roe deer 3, cattle 2, hare 2, deer 1, donkey 1, fallow deer 1, goat 1, marmot 1.

Saccobolus dilutellus (Fuckel) Sacc., *Syll. Fung*. 8: 526, 1889

Total 2: rat 1, wild rabbit 1.

Saccobolus glaber (Pers.: Fr.) Lambotte, *Fl. Mycol. Belg*., suppl.1: 284, 1887

Total 7: cattle 4, pig 1, sheep 1, unidentified herbivore 1.

Saccobolus minimus Velen., *Monogr. Discom. Boh*.: 370-371, 1934

Total 18: horse 5, sheep 4, fallow deer 2, cattle 1, deer 1, donkey 1, goat 1, rock goat 1, roe deer 1, wild pig 1.

Saccobolus saccoboloides (Seaver in Dodge & Seaver) Brumm., *Persoonia* suppl. 1: 168, 1967

Total 4: cattle 1, horse 1, roe deer 1, sheep 1.

Saccobolus succineus Brumm., *Persoonia* 5: 229, 1969

Total 5: cattle 4, horse 1.

Saccobolus truncatus Velen., *Monogr. Discom. Boh*. 1: 370, 1934

Total 9: cattle 4, horse 2, sheep 2, goat 1.

Saccobolus aff. ***verrucisporus*** Brumm., *Persoonia* suppl. 1: 198, 1967

Total 18: deer 8, roe deer 8, horse 1, sheep 1.

Saccobolus versicolor (P. Karst.) P. Karst., *Acta Soc. Fauna Fl. Fenn*. 2 (6): 123, 1885

Total 25: cattle 9, rock goat 3, wild rabbit 3, horse 2, rabbit 2, donkey 1, goat 1, hare 1, roe deer 1, sheep 1, wolf 1.

Scutellinia crinita (Bull: Fr.) Lambotte, *Fl. Mycol. Belge*, suppl. 1: 301, 1887

Total 1: unidentified herbivore.

Thecotheus cinereus (H. Crouan & P. Crouan) Chenant., *Bull. Soc. Mycol. Fr.* 34: 39, 1918

Total 2: cattle 1, unidentified animal 1.

Thecotheus crustaceus (Starbäck) Aas & N. Lundq. *in Aas, Univ. Bergen Bot. Inst., Thesis* 4: 70, 1992

Total 3: horse 2, pig 1.

Thecotheus formosanus Y.-Z. Wang f. ***collariatus*** Doveri & Coué, *Doc. Mycol* (in print).

Total 1: horse.

Thecotheus holmskjoldii (E.C. Hansen) Chenant., *Bull. Soc. Mycol. Fr.* 34: 39, 1918

Total 28: cattle 10, sheep 8, fallow deer 3, roe deer 3, deer 1, goat 1, rock goat 1, wild rabbit 1.

Thecotheus lundqvistii Aas, Thesis 4, *Univ. Bergen Bot. Inst*.: 127, 1992

Total 1: cattle.

Thecotheus neoapiculatus Doveri & Coué, *Doc. Mycol* (in print).

Total 2: cattle.

Thecotheus pelletieri (H. Crouan & P. Crouan) Boud., *Ann.. Sci. Nat. (Bot.)* 5 (10): 236, 1869

Total 9: horse 4, cattle 3, deer 1, sheep 1.

Thecotheus strangulatus (Velen.) Aas & N. Lundq. *in Aas, Univ. Bergen Bot. Inst., Thesis* 4: 170, 1992

Total 1: sheep.

Thelebolus caninus* (Auersw.) Jeng & J.C. Krug, *Can. J. Bot*. 55: 2998

Total 1: roe deer.

Thelebolus crustaceus* (Fuckel) Kimbr. in Kobayasi *et al*., *Ann. Rept. Inst. Ferment. Osaka* 3: 49, 1967

Total 2: cattle 1, porcupine 1.

Thelebolus dubius (Boud.) Doveri var. lagopi* (Rea) Doveri, *Fungi Fimicoli Italici*: 527, 2004

Total 2: hare 1, roe deer 1.

Thelebolus microsporus (Berk. & Broome) Kimbr. in Kobayasi *et al*., *Ann. Rept. Inst. Ferment. Osaka* 3: 50, 1967

Total 7: cattle 2, rock goat 2, sheep 2, roe deer 1.

Thelebolus polysporus* (P. Karst.) Y. Otani & Kanzawa, *Trans. Mycol. Soc. Japan* 11: 45, 1970

Total 11: sheep 3, roe deer 2, cattle 1, goat 1, horse 1, unidentified animal 1, wild pig 1, wild rabbit 1.

Thelebolus stercoreus Tode: Fr, *Syst. Mycol*. 2: 306, 1823

Total 12: roe deer 6, sheep 2, wild rabbit 2, bird 1, unidentified animal 1.

Trichobolus octosporus J.C. Krug, *Can. J. Bot*. 51: 1498, 1973

Total 1: wild rabbit.

Trichobolus sphaerosporus Kimbr. in Kimbr. & Korf, Amer. *J. Bot.* 54 (1): 21, 1967

Total 2: roe deer.

Trichobolus zukalii (Heimerl) Kimbr., *Amer. J. Bot.* 54: 21, 1967

Total 46: roe deer 10, goat 9, sheep 9, fallow deer 4, deer 3, cattle 2, chamois 1, hare 1, marmot 1, marten 1, rock goat 1, unidentified animal 1, wild goat 1, wild pig 1, wild rabbit 1.

Trichophaea gregaria (Rehm) Boud., *Hist. Class. Discom. Eur*.: 60, 1907

Total 1: unidentified herbivore.

* = ***Thelebolus stercoreus*** according to de Hoog *et al*. (2005).

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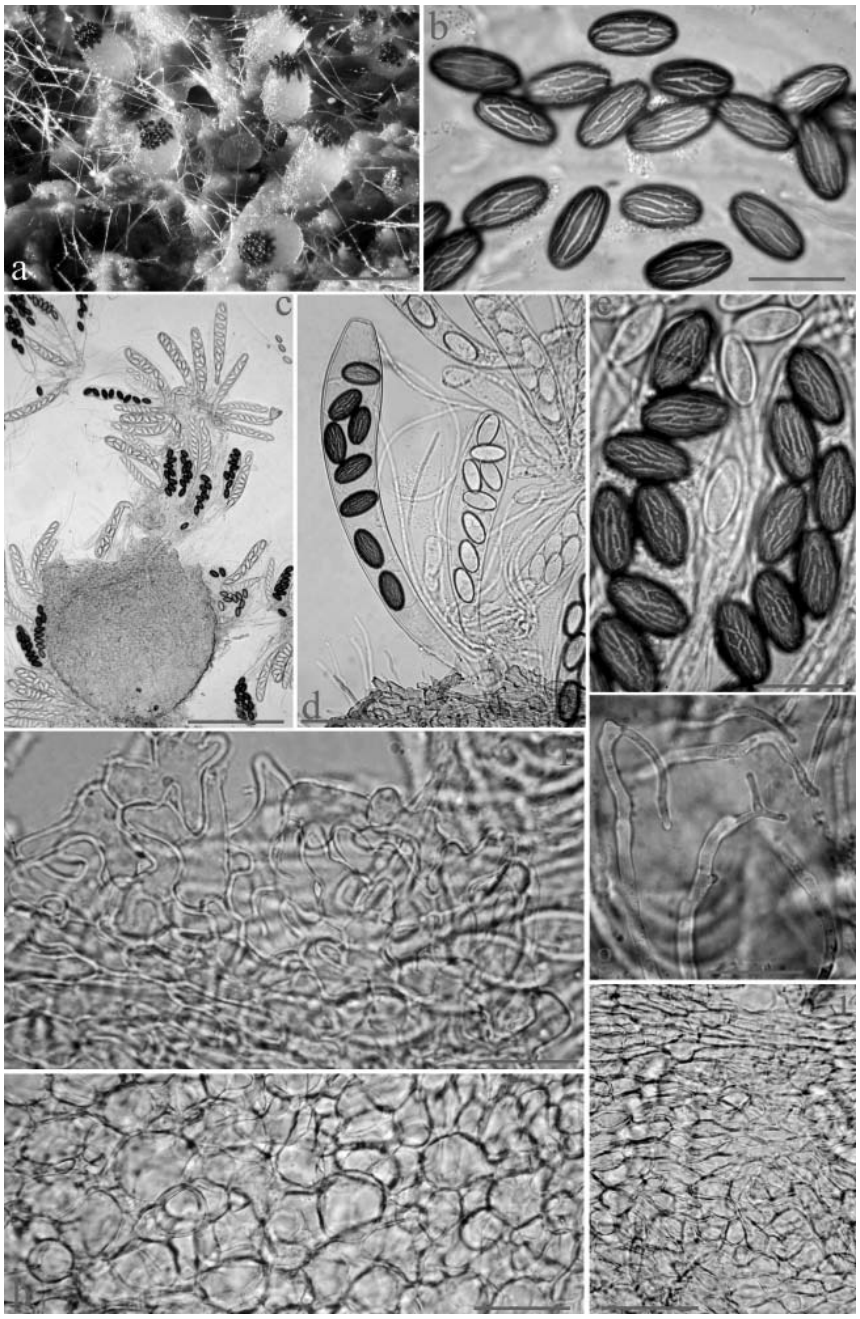

Fig. 5a-i. *Ascobolus albidus*.
a. Ascomata. b. Free spores. c. Longitudinal section of ascoma and asci with spores in different stages. d. Mature and immature asci with spores, and paraphyses. e. Irregularly biseriate spores inside asci. f. Medullary excipulum. g. Tips of paraphyses. h. Lower portion of ectal excipulum. i. Upper portion of ectal excipulum. Scale bars: a = 500 µm; b,e = 20 µm; c = 200 µm; d = 46 µm; f = 16 µm; g = 12 µm; h = 27 µm; i = 45 µm.

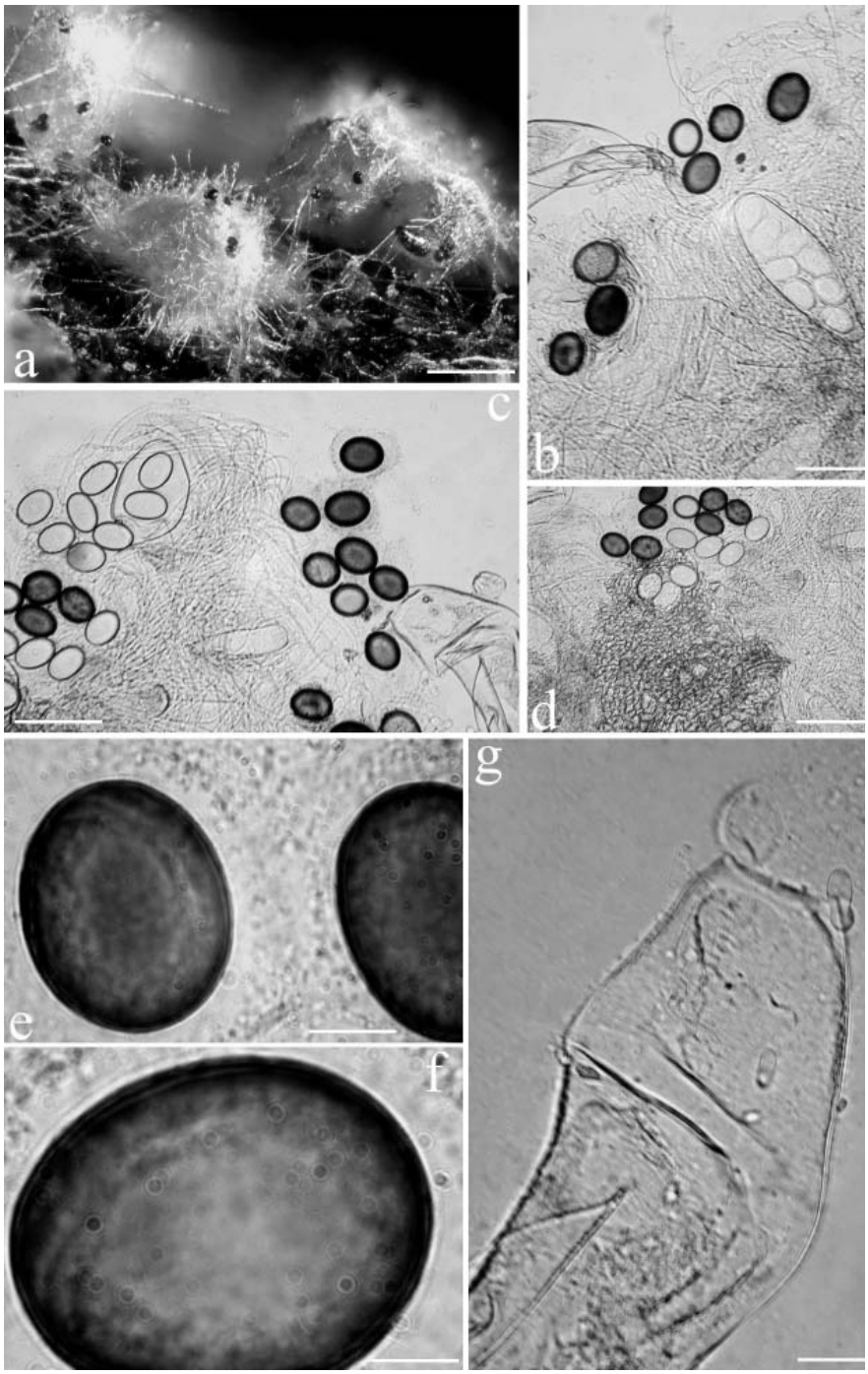

Fig. 6a-g. *Ascobolus immersus*.
a. Ascomata. b-c. Ascus with immature spores, paraphyses, and free spores surrounded by a gelatinous sheath. d. Excipular cells (in the middle). e-f. Spores. g. Empty operculate ascus.
Scale bars: a = 650 µm; b = 90 µm; c = 100 µm; d = 180 µm; e = 20 µm; f = 12 µm; g = 25 µm.

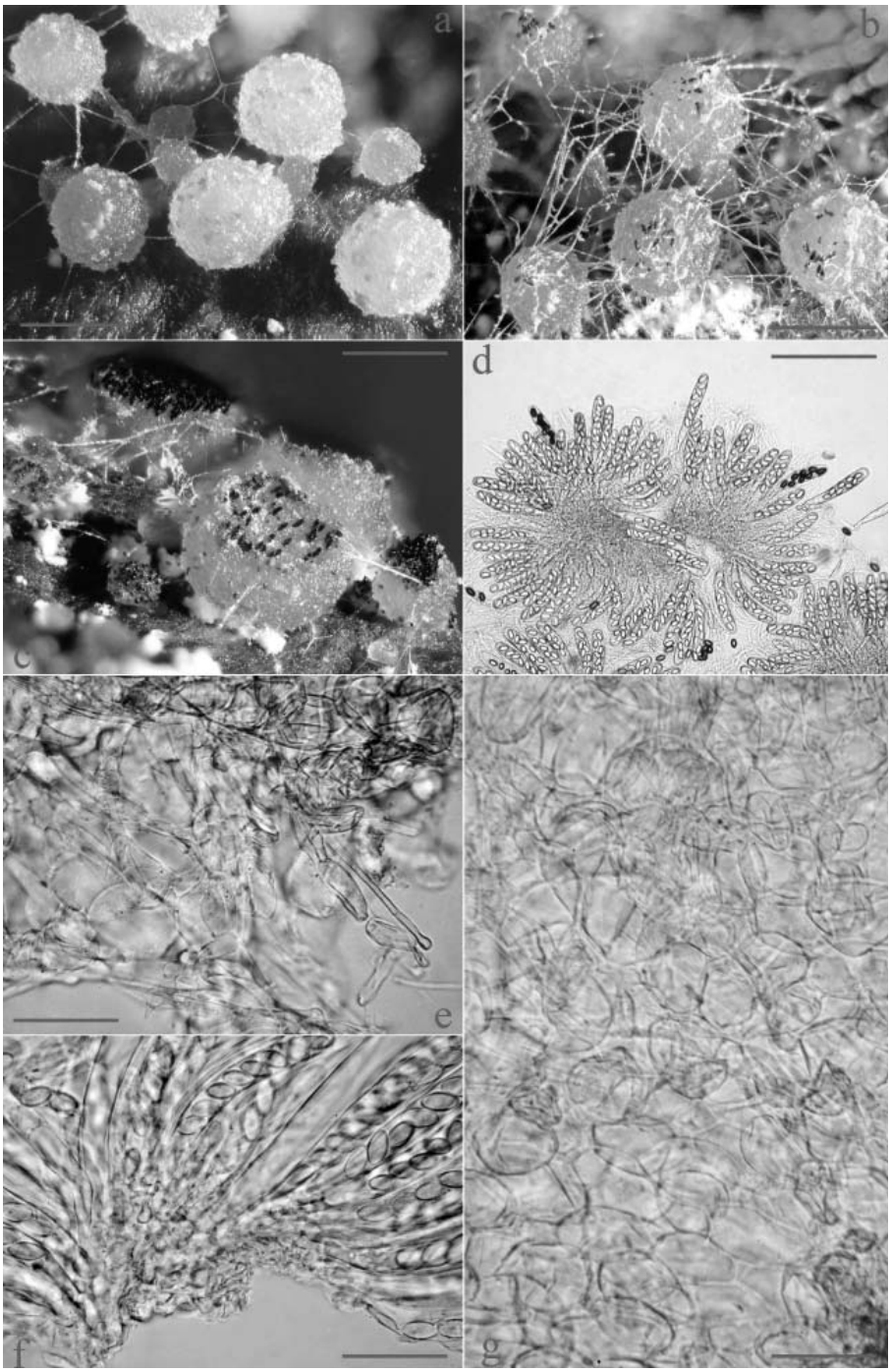

Fig. 7a-g. *Ascobolus michaudii*.
a-c Ascomata in different stages. d. Overall sight of hymenium. e. Detail of medullary excipulum (in the middle and below). f. Detail of hymenium (above) and subhymenium (below). g. Ectal excipulum. Scale bars: a-c = 1000 μm; d = 220 μm;

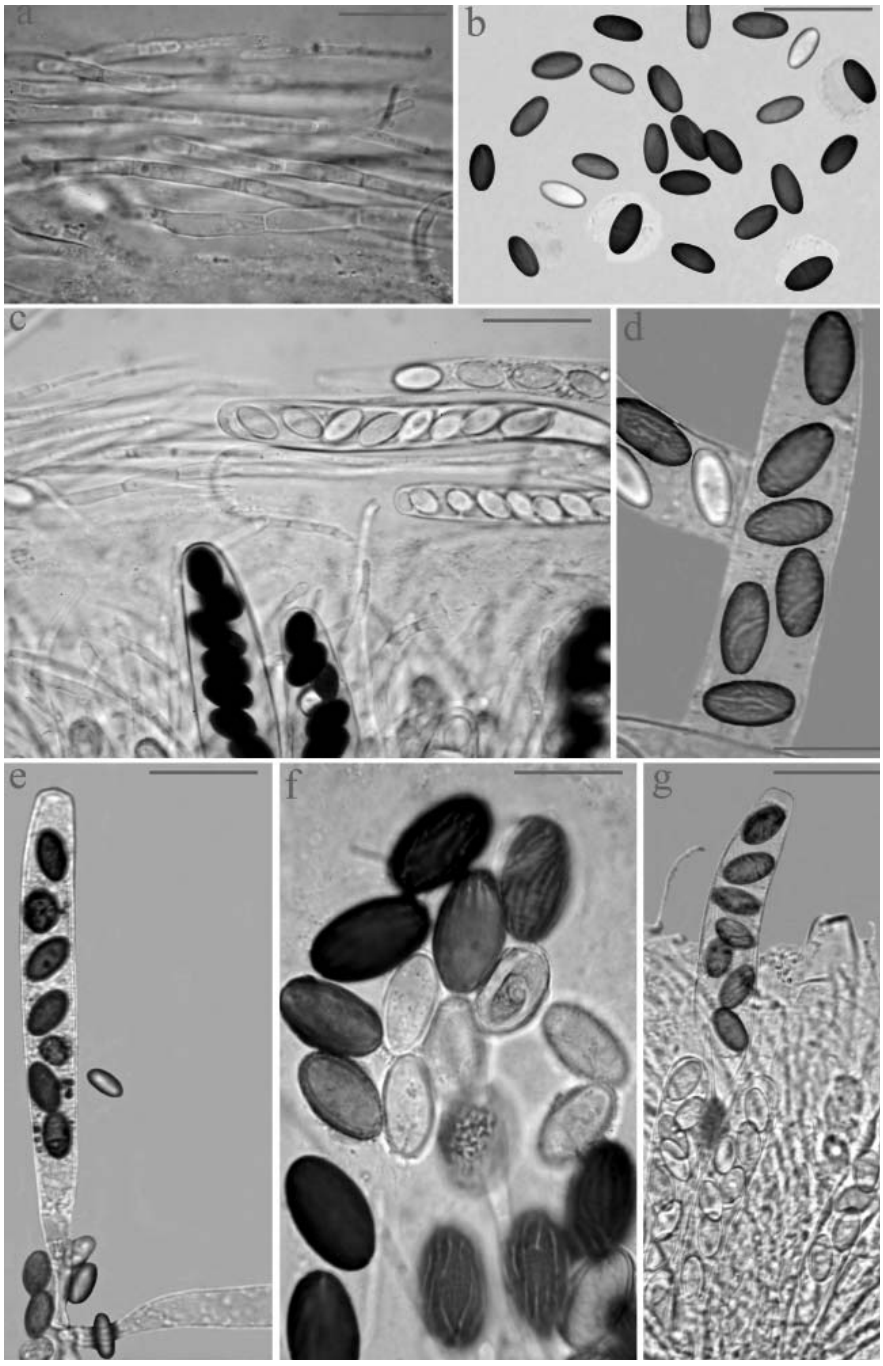

Fig. 8a-g. *Ascobolus michaudii.*
a. Tips of paraphyses embedded in a yellowish gelatinous material. b. Spores, some with a gelatinous sheath. c. Upper part of hymenium. d. Spores inside asci. e. Operculate ascus with spores. f. Mature and immature spores. g. Emerging ascus with mature spores.
Scale bars: a = 17 µm; b = 34 µm; c,e,g = 36 µm; d = 20 µm; f = 15 µm.

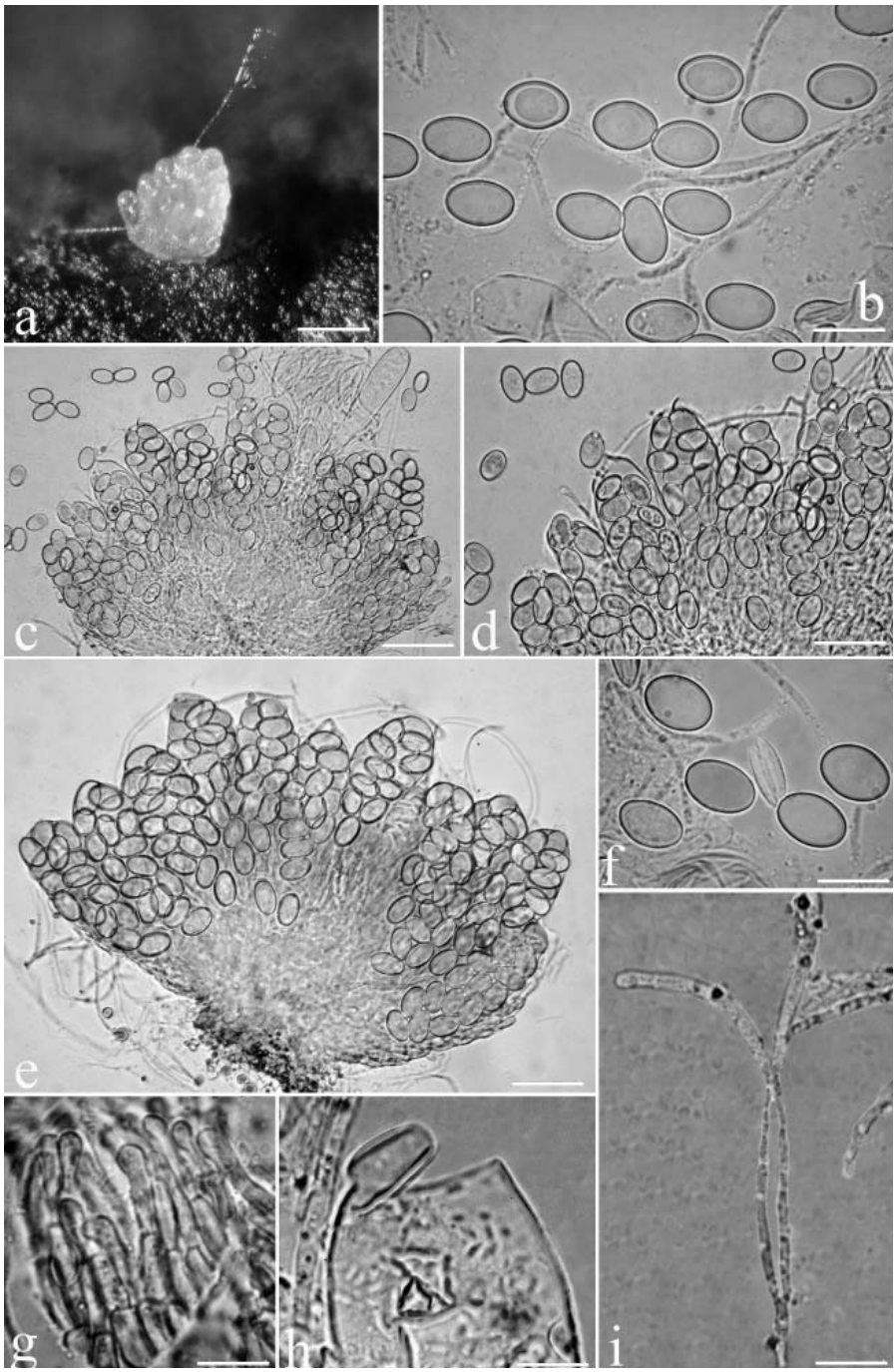

Fig. 9a-i. *Coprotus sexdecimsporus*.
a. Ascoma. b,f. Free spores. c,e. Longitudinal section of ascoma. d. Upper part of hymenium.
g. Cells of ectal excipulum near the disc. h. Apex of operculate ascus. i. Paraphyses.
Scale bars: a = 230 µm; b,f-g = 20 µm; c = 34 µm; d-e = 23 µm; h = 7 µm; i = 14 µm.

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