Chaetomium convolutum and *C. hexagonosporum* from Italy with a morphological revision of the group-*bostrychodes*

Francesco DOVERI

Ascomycete.org, 8 (5) : 185-198.
Novembre 2016
Mise en ligne le 3/11/2016

Abstract: *Chaetomium convolutum*, newly isolated from herbivore dung in a survey of coprophilous ascomycetes and basidiomycetes, is first described from Italy and compared with other species of the so called "group-*bostrychodes*". The taxonomic uncertainty, still present in this group despite a recent comparative, morphological and molecular study, led the author to revise all Italian collections of species related to *C. convolutum*, and to prove that also the very rare *C. hexagonosporum* is present in Italy. The morphological features of *C. hexagonosporum* are described in detail and particularly compared with those of *C. convolutum*. The results of this review confirm the existence of several intermediates in the group-*bostrychodes*, for which a much more extended revision is hoped.
Keywords: cellulose, *Chaetomiun bostrychodes*, *Chaetomium robustum*, coprophilous fungi, morphological study.

Riassunto: *Chaetomium convolutum*, isolato recentemente da escrementi di erbivori in un' indagine sugli ascomiceti e basidiomiceti coprofili, è descritto per la prima volta in Italia e messo a confronto con altre specie del cosiddetto "gruppo-*bostrychodes*". L'incertezza tassonomica, ancora presente in questo gruppo nonostante un recente studio comparativo, morfologico e molecolare, ha indotto l'autore a rivedere tutte le raccolte italiane correlate a *C. convolutum*, e a dimostrare che anche il molto raro *C. hexagonosporum* è presente in Italia. Le caratteristiche morfologiche di *C. hexagonosporum* sono dettagliatamente descritte e in modo particolare confrontate con quelle di *C. convolutum*. I risultati di questa revisione confermano l'esistenza di diverse forme intermedie nel gruppo-*bostrychodes*, del quale viene auspicata una revisione molto più estesa.
Parole chiave: cellulosa, *Chaetomiun bostrychodes*, *Chaetomium robustum*, funghi coprofili, studio morfologico.

Introduction

Since 1992, starting date of an ongoing survey of coprophilous fungi from Italy, I have isolated and described (Doveri, 2004, 2008, 2013, 2016) twenty-four *Chaetomium* spp. from herbivore and exceptionally from carnivore dung. It is well known (Ames, 1949; Mazzucchetti, 1965; Arx *et al*., 1986; Guarro *et al*., 2012) that several species of *Chaetomium* Kunze are highly cellulolytic and frequently occur on herbivore dung, a substrate usually rich in cellulose residues. I recently had the pleasure to develop in a damp chamber culture *Chaetomium convolutum* Chivers, a species previously recorded, but not described, from Italy (Dal Vesco *et al*., 1967), proved to be a scarce cellulose decomposer (Greathouse & Ames, 1945). The study of this isolate led me to go over again the literature of the genus *Chaetomium*, particularly over that (Carter, 1982; Arx *et al*., 1986; Rodríguez Morejón, 2003) of the so called "group-*bostrychodes*", to which *C. convolutum* belongs. The uncertain boundaries separating species within the group and the classification difficulties encountered by those who preceded me in this study suggested a revision of my numerous Italian collections of *C. bostrychodes* Zopf and *C. robustum* L.M. Ames. From that, interesting results emerged, firstly my misinterpretation of one collection labeled *C. bostrychodes*, resulted later to be *C. hexagonosporum*.

The aim of this paper is to describe *Chaetomium convolutum* in detail and the first Italian collections of *C. hexagonosporum*, and to provide a contribution to the knowledge of morphological characteristics of the group-*bostrychodes*.

Materials and methods

Chaetomium convolutum and *C. hexagonosporum* were obtained respectively from wild rabbit dung and from wild pig, roe deer and goat dung collected in different regions of Italy and placed in non-sterilised damp chambers, following the methods suggested by Richardson & Watling (1997) and Richardson (2001), slightly modified by Doveri (2004). Cultured materials, incubated at room temperature (18–25°C), under natural light, but not exposed to direct sunlight, were examined on alternate days using a stereomicroscope.

Microscopic examinations were carried out on specimens picked up from damp chambers and mounted in water and Melzer's reagent. Spore length and width were measured in water on ascospores discharged from mature ascomata.

Abbreviation: CLSM = author's personal herbarium.

Taxonomy

Chaetomium convolutum Chivers, *Proc. Amer. Acad. Arts & Sci*., 48: 85 (1912). Plates 1–4

= *Chaetomium hyderabadense* M.A. Salam & Nusrath, *J. Indian Bot. Soc*., 38: 543 (1959).

= *Chaetomium biapiculatum* Lodha, *J. Indian Bot. Soc*., 43: 126 (1964).

= *Chaetomium concinnum* Sörgel, *in* Seth, *Beih. Nova Hedwigia*, 37: 52 (1972).

= *Chaetomium montblancense* Guarro, Calvo & C. Ramírez, *Nova Hedwigia*, 32 (1): 207 (1980).

(*fide* Arx *et al*., 1986)

Perithecia subglobose to broadly obovoidal, 220–270 µm diam., dark grey at reflected light, brown at transmitted light, with a dark collar around the ostiole, membranous, wholly hairy, with denser terminal hairs. **Peridium** quite thin, pseudoparenchymatous, two-layered: endostratum of pale, comparatively thin-walled, polygonal cells, slightly larger than the exoperidial cells; exostratum a *textura angularis* of brown, thick-walled, polygonal cells, 8–13 × 7–10 µm, mostly more elongated and somewhat wavy, radiating in a petaloid pattern from a central cell, which subtends a hair base. **Terminal hairs** dense, particularly disposed around the ostiole, of two types, the former 5–7.5 µm diam., up to 10 µm at the flattened or slightly rounded base, fairly dark brown, paler towards the tips, coarsely warted, indistinctly septate, thick-walled, straight in the lower portion, loosely spirally coiled (usually more than 5 coils progressively narrowing towards the tips) in the upper portion, sometimes with a circinate apex; the latter type equal in width, but paler brown, straight, verrucose, pointed at the apex. **Lateral hairs** 230–400 × 4–5 µm (up to 7.5 µm at the base), sparse, warted, septate, thick-walled, brown but paler towards the tips, pointed, straight, somewhat

flexuose at the usually collapsed apices. **Basal hairs** 80–250 µm, similar to the lateral hairs but narrower. **Paraphyses** seemingly scarce, mixed with the asci, cylindric-moniliform and narrowing at the septa, 4–5 µm diam., tapering upwards. **Asci** 40–50 × 11–12 µm, clavate, 8-spored, lacking an apical ring, thin-walled, rather long-stalked. **Ascospores** dextrinoid in the early stages, biseriate or irregularly arranged inside the asci, (7.5–) 8 (–8.5) × 6–7 × 5–5.5 µm, broadly limoniform or subglobose (Q = 1.07–1.30; average Q = 1.19) in frontal view, bilaterally flattened and ellipsoidal in side view, pale grey at maturity, darker at the ends, smooth, thick-walled, slightly apiculate at both ends, with an indistinct apical germ pore and a pale halo at the opposite end.

Material examined: Italy, Cagliari, Santa Margherita di Pula-Is Molas, N 39°0'13" E 8°56'31", 0 m a.s.l., about ten gregarious, superficial specimens on wild rabbit (*Oryctolagus cuniculus*) dung in a damp chamber culture, C. Doveri, 3 Jun. 2016, CLSM 004.16.

Chaetomium hexagonosporum A. Carter & Malloch, *Can. J. Bot.*, 60: 1249 (1982). Plates 5–7

Perithecia ellipsoidal or obovoidal, 320–350 × 250–270 µm, brown at transmitted light, with a dark collar around the ostiole, membranous, wholly hairy, with denser terminal hairs. **Peridium** quite thin, pseudoparenchymatous, two-layered: endostratum of pale, comparatively thin-walled, polygonal cells, slightly larger than the exoperidial cells; exostratum a *textura angularis*, *globulosa* at intervals, of brown, thick-walled, polygonal or roundish cells, 10–16 × 7–15 µm, often more elongated and radiating in a petaloid pattern from a central cell, which subtends a hair base. **Terminal hairs** dense, particularly disposed around the ostiole, 4–6 µm diam., up to 8 µm at the flattened base, fairly dark brown, paler towards the tips, coarsely warted, indistinctly septate, thick-walled, straight in the lower portion, loosely spirally coiled in the upper portion, with coils progressively narrowing towards the tip, usually more than 5 in number. **Lateral hairs** 4–5 µm diam. (5–7 µm diam. at the base), sparse, warted, septate, thick-walled, pointed, straight to flexuose, brown, paler and usually collapsed at the apex. **Basal hairs** 50–120 µm long, straight or somewhat flexuose, pointed, very pale brown, paler at the apex, septate, thick-walled, verrucose. **Paraphyses** not seen. **Asci** 8-spored, clavate, collapsed. **Ascospores** dextrinoid in the early stages, biseriate or irregularly arranged inside the asci, 8–9 × (6–) 6.5–7.5 × 5–6 µm, indistinctly angular to irregularly angular or hexagonal (Q = 1.14–1.50; average Q = 1.26) in frontal view, bilaterally flattened and ellipsoidal to subfusiform in side view, pale grey at maturity, darker at the ends, smooth, thick-walled, slightly apiculate, with an indistinct apical germ pore.

Material examined: Italy, Livorno, Elba island, Campo nell'Elba, Pradazzo-loc. Valle Buia, N 42°44'41" E 10°10'15", 200 m a.s.l., on wild pig (*Sus scrofa*) dung in a damp chamber culture, A. Pierulivo, 9 Oct. 2010, CLSM 02197-LXXII; Venezia, Chioggia, Bosco Nordio, N 45°7'13" E 12°15'36", 0 m a.s.l., on roe deer (*Capreolus capreolus*) dung in a damp chamber culture, R. Cerello & G. Robich, 27 Apr. 2013, CLSM 02197-LXXIX; Grosseto, Montecristo island, N 42°20'19" E 10°17'65", 50 m a.s.l., on goat (*Capra hircus*) dung in a damp chamber culture, L. Moncini, 8 Apr. 2015, CLSM 02197-LXXXIX.

Discussion

Chaetomium convolutum is characterized by subglobose to ovoidal perithecia with long spirally coiled terminal hairs and a dark collar around the ostiole, a prevalent petaloid pattern of the peridial cells around the hair bases, eight-spored, claviform asci, dextrinoid young ascospores, and broadly limoniform, bilaterally flattened, biapiculate, pale grey mature ascospores. Based on this combination of features, it takes place in the so called «group-bostrychodes» (Rodríguez Morejón, 2003) or section *Bostrychode* A. Carter, which also encompasses *C. bostrychodes* (*inde nomen*), *C. hexagonosporum*, *C. quadrangulatum* Chivers, and *C. robustum*.

Several morphological intermediates were recorded in this group (Dreyfus, 1976; Arx *et al.*, 1986; Bell, 2005), particularly between *C. bostrychodes* and *C. convolutum* and between *C. bostrychodes* and *C. robustum*. Neither a combined, morphological and phylogenetic study (Rodríguez Morejón, 2003) could solve all taxonomic problems of specific independence inside the group. Only *C. quadrangulatum*

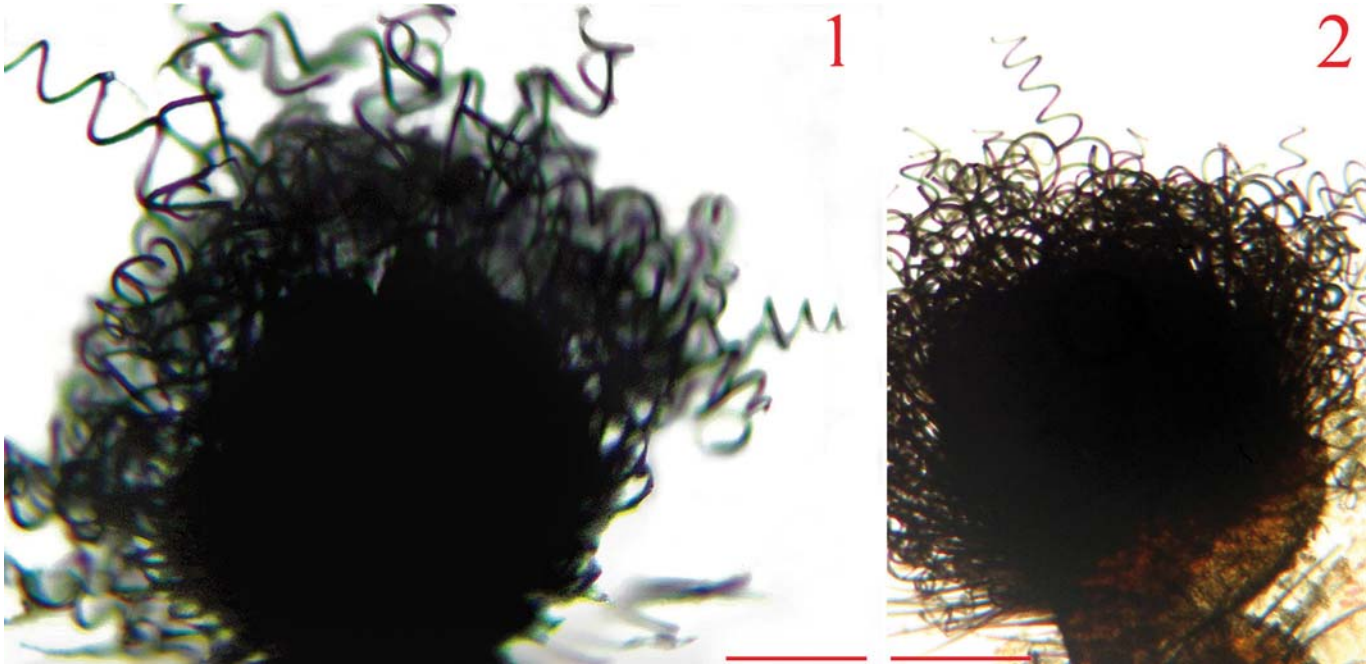

Plate 1 – *Chaetomium convolutum*
1. Perithecium in water. 2. Squashed perithecium in water. Scale bars: 1 = 80 µm; 2 = 100 µm.

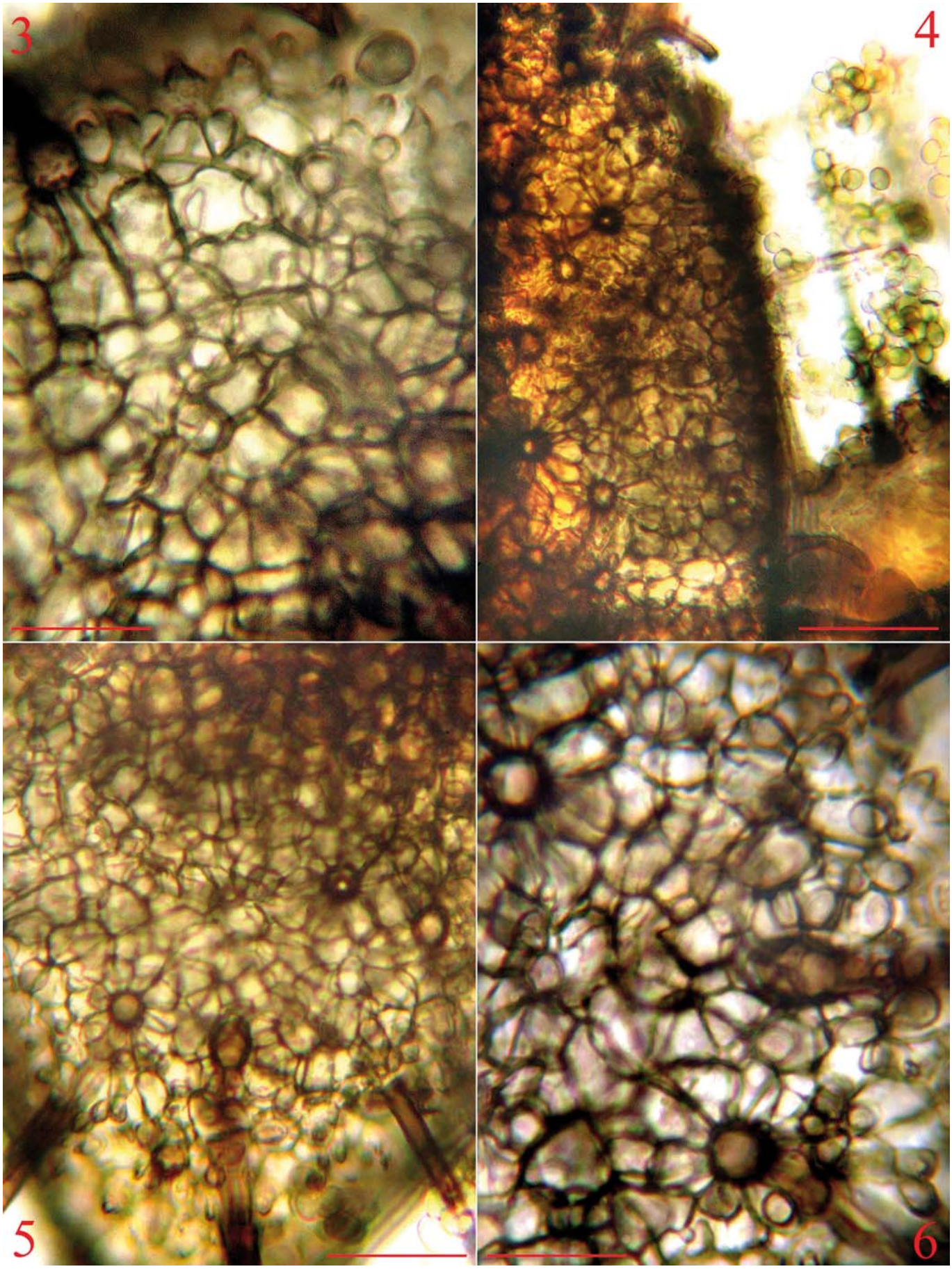

Plate 2 – *Chaetomium convolutum*
3. Detail of peridial *textura angularis*. 4–6. Petaloid patterns of *textura angularis*. Scale bars: 3, 6 = 20 µm; 4–5 = 40 µm.

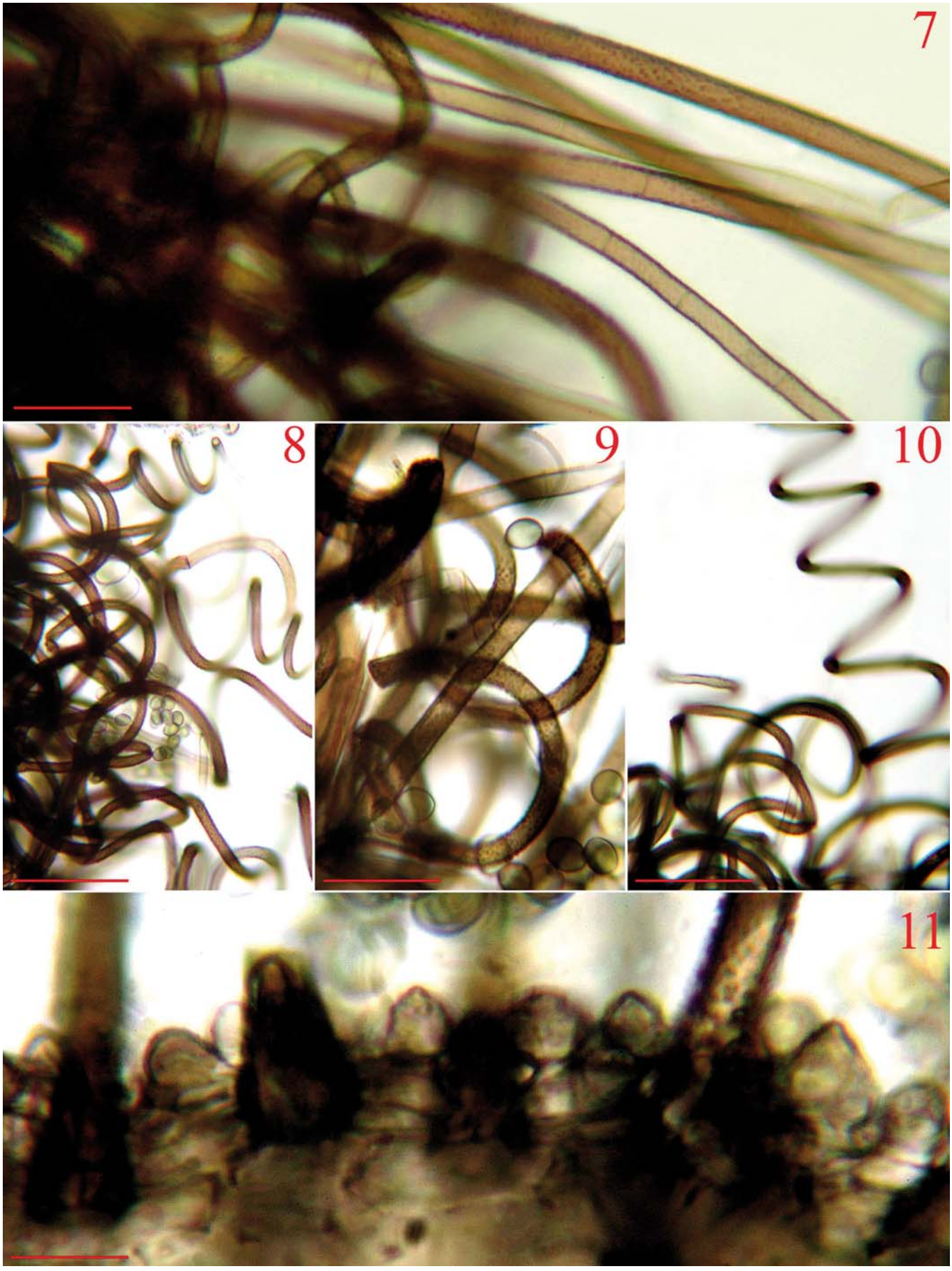

Plate 3 – *Chaetomium convolutum*

7. Middle part of lateral hairs. 8–10. Apices of terminal hairs. 11. Bases of terminal hairs. Scale bars: 7, 9 = 20 µm; 8, 10 = 40 µm; 11 = 10 µm.

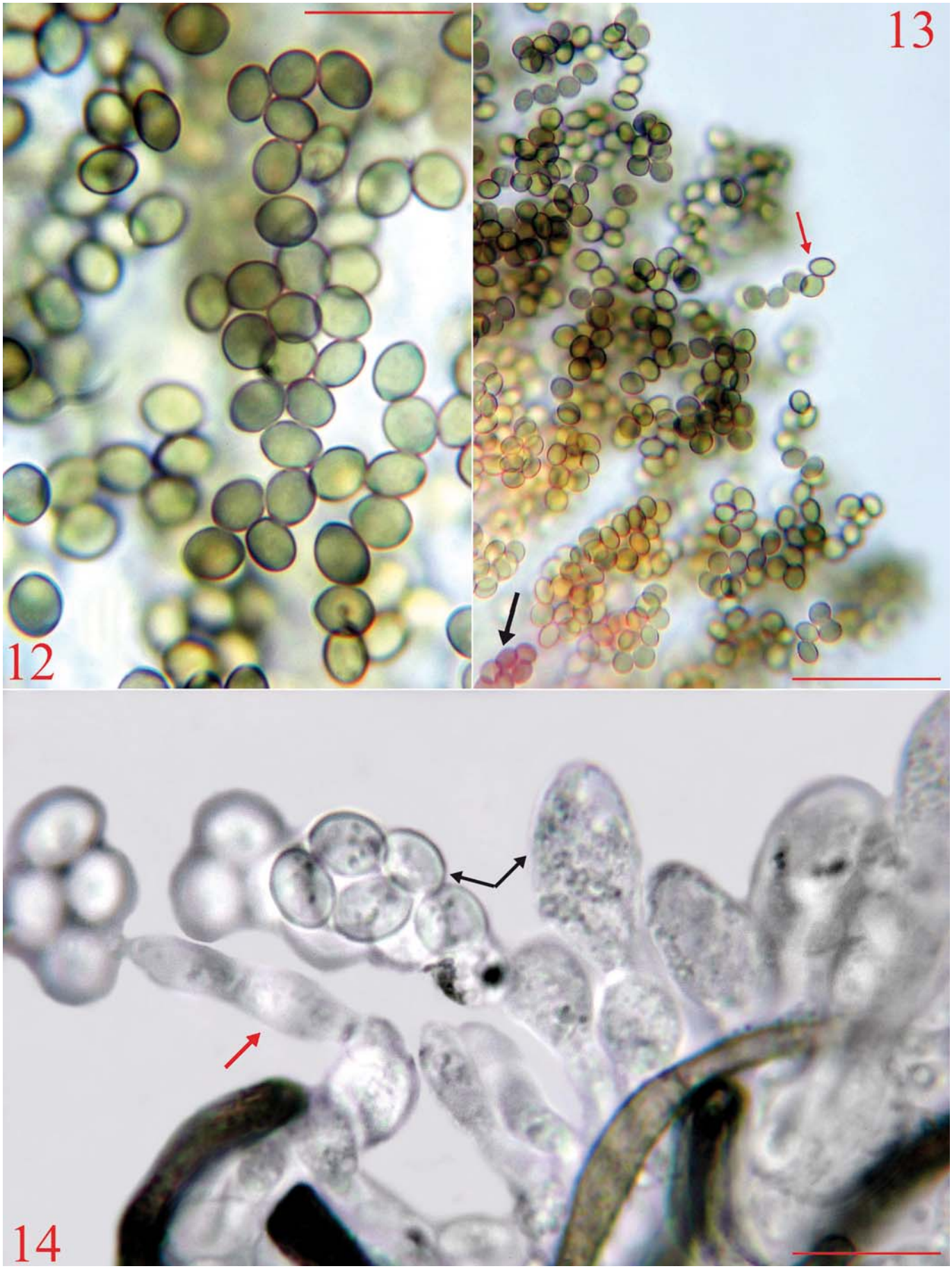

Plate 4 – *Chaetomium convolutum*

12. Free ascospores. 13. Free ascospores (red arrow) and dextrinoid young ascospores (black arrow). 14. Paraphyses (red arrow) and asci in different stages (black arrow). Scale bars: 12 = 20 µm; 13 = 40 µm; 14 = 15 µm.

has no intermediate forms and is fully defined by its spore shape, quadrangular in frontal view (Chivers, 1912, 1915; Skolko & Groves, 1953; Udagawa, 1960) with rounded ends (Arx *et al*., 1986).

Neither the petaloid pattern of peridial cells nor the darker grey colour of the spore ends are valuable distinguishing features, as they are common to most species of the group. The spore size is, on the contrary, a more stable and informative character to separate *C. hexagonosporum* and *C. convolutum* from *C. bostrychodes* and *C. robustum* (Rodríguez Morejón, 2003). *Chaetomium convolutum* in turn must be regarded as a morphological form of *C. hexagonosporum* having slightly smaller ascospores with roundish instead of (vaguely) angular walls (Rodríguez Morejón, 2003). The perithecial morphology is a useful feature to separate *C. robustum* from the other species of the group, as only in *C. robustum* are the ascomata ampulliform or obclavate (Plate 8, fig. 26) rather than subglobose or ovoidal: the narrower, apical part of the ampulliform perithecia shows a palisade of rectangular cells (Plate 8, fig. 24) disposed in several (four or more) overlapping rows (*textura prismatica*). A prismatic disposition can also develop in some forms of *C. bostrychodes* with narrowly ellipsoidal or narrowly ovoidal perithecia, but it is restricted to one, or two rows of rectangular cells just below the periostiolar dark collar (Rodríguez Morejón, 2003). Following this statement, I have revised all Italian collections of *C. bostrychodes* and *C. robustum* to verify my classification accuracy. The results are shown in Tables 1–2.

Chaetomium convolutum is a quite common, widespread species, isolated from soil (Guarro *et al*., 1980, s.n. *C. montblancense*; Coutinho *et al*., 2007), seeds (Skolko & Groves, 1953), particularly from herbivore (Dal Vesco *et al*., 1967; Bertault, 1982; Lorenzo, 1993; Caretta *et al*., 1998; Eriksson, 2009; Mungai *et al*., 2012) and rodent dung (Chivers, 1912; Ames, 1963; Lodha, 1964, s.n. *C. biapiculatum*; Carter, 1982), but also from carnivore (Valldosera & Guarro, 1992) and unspecified animal (Bell, 2005) dung.

Unlike *C. convolutum*, *C. hexagonosporum* is undoubtedly very rare as, besides the protologue (Carter & Malloch, 1982), I know the sole Arx *et al.* (1986) and Rodríguez Morejón (2003) descriptions of this species, both referring to the type from rat dung.

Table 1 – Revision of Italian collections originally identified as *Chaetomium bostrychodes*

Panel 1. *Chaetomium bostrychodes*						
CLSM	**dung source**	**perithecial shape**	***textura prismatica* (number of rows)**	**spore shape**	**spore size (µm)**	***Chaetomium* name after revision**
02197	wild rabbit	br. ellipsoid	0-3	br. limoniform	6–7 × 5–6	bostrychodes
bis	wild rabbit	ellipsoid	2	br. limoniform	5–6 × 5–5.5	bostrychodes
ter	badger	br. ellipsoid/ellipsoid	0-3	subglobose/br. limoniform	6–7 × 5.5–6	bostrychodes
quater	sheep	obovoidal	0-3	limoniform	6.5–7 × 5–5.5	bostrychodes
penta	toad	br. ellipsoid	1	limoniform	6.5–7 × 5.5–6	bostrychodes
esa	lizard	ellipsoid	2	br. limonif./limoniform	6–6.5 × 5.5	bostrychodes
epta	rabbit	ellipsoid	0-2	subglobose/br. limoniform	6–7 × 5–6	bostrychodes
ena	hedgehog	br. ellipsoid	1	br. limoniform	6.5–7 × 5–6	bostrychodes
deca	horse	br. ellipsoid	1	br. limoniform	6.5–7 × 5.5–6	bostrychodes
XI	pigeon	narr. ellipsoid	0	br. limonif./limoniform	6.5–7 × 5.5–6	bostrychodes
XIII	snail	obovoidal	0	br. limoniform	6.5–7 × 6	bostrychodes
XIV	hedgehog	ellipsoid	1	br. limoniform	6–6.5 × 5.5–6	bostrychodes
XV	sparrow	ellipsoid	0	br. limoniform	6.5–7 × 5.5–6	bostrychodes
XVI	hare	ellipsoid	2-3	limoniform	6–6.5 × 5.5	bostrychodes
XVIII	roe deer	ellipsoid	0	limoniform	6–7 × 5–5.5	bostrychodes
XX	hedgehog	narr. ellipsoid	2-3	br. limonif./limoniform	6–6.5 × 5.5	bostrychodes
XXI	sheep	subglobose	0	br. limonif./limoniform	6.5–7 × 6–6.5	bostrychodes
XXII	mouse	ellipsoid	2-3	limoniform	6.5 × 5.5–6	bostrychodes
XXIII	sheep	ellipsoid	2-3	br. limonif./limoniform	6–6.5 × 5.5–6	bostrychodes
XXIV	sheep	ellipsoid	1	br. limonif./limoniform	6–6.5 × 5.5–6	bostrychodes
XXVI	rat	subglobose	0	limoniform	6.5–7 × 5.5–6	bostrychodes
XXVII	sparrow	br. ellipsoid	0	br. limonif./limoniform	6.5–7 × 5.5–6	bostrychodes
XXVIII	wild rabbit	br. ellipsoid	1-2	br. limonif./limoniform	6.5–7 × 5.5–6	bostrychodes
XXX	wild rabbit	br. ellipsoid	1	br. limonif./limoniform	6.5–7 × 5.5–6	bostrychodes
XXXI	wild rabbit	ellipsoid	1	br. limonif./limoniform	6.5–7 × 6	bostrychodes
XXXII	toad	br. ellipsoid	0	br. limonif./limoniform	5.5–6 × 5.5	bostrychodes
XXXIII	rat	ovoidal	0	br. limoniform	6–6.5 × 5.5	bostrychodes
XXXIV	sheep	ellipsoid	2-3	br. limonif./limoniform	6–7 × 5.5–6	bostrychodes
XXXVI	lizard	ellipsoid	1	limoniform	6–7 × 5.5	bostrychodes
XXXVII	beech-marten	ellipsoid	0	limoniform	6.5–7 × 6	bostrychodes
XXXVIII	squirrel	ellipsoid	2	limoniform	6–6.5 × 5.5	bostrychodes
XXXIX	weasel	ovoidal	0	br. limoniform	6 × 5–5.5	bostrychodes
XL	sheep	br. ellipsoid	1	subglobose/br. limoniform	6.5–7 × 6–6.5	bostrychodes
XLI	goat	ellipsoid	2-3	br. limonif./limoniform	6.5–7 × 6	bostrychodes
XLII	sheep	ellipsoid	0-1	subglobose/br. limoniform	6–6.5 × 5.5	bostrychodes
XLIII	sheep	br. ellipsoid	0-1	limoniform	6.5–7 × 5.5–6	bostrychodes
XLVI	wild pig	ellipsoid	0-1	br. limonif./limoniform	6.5–7 × 5.5–6	bostrychodes
XLVIII	lizard	narr. ellipsoid	2	br. limonif./limoniform	7–7.5 × 6.5	bostrychodes

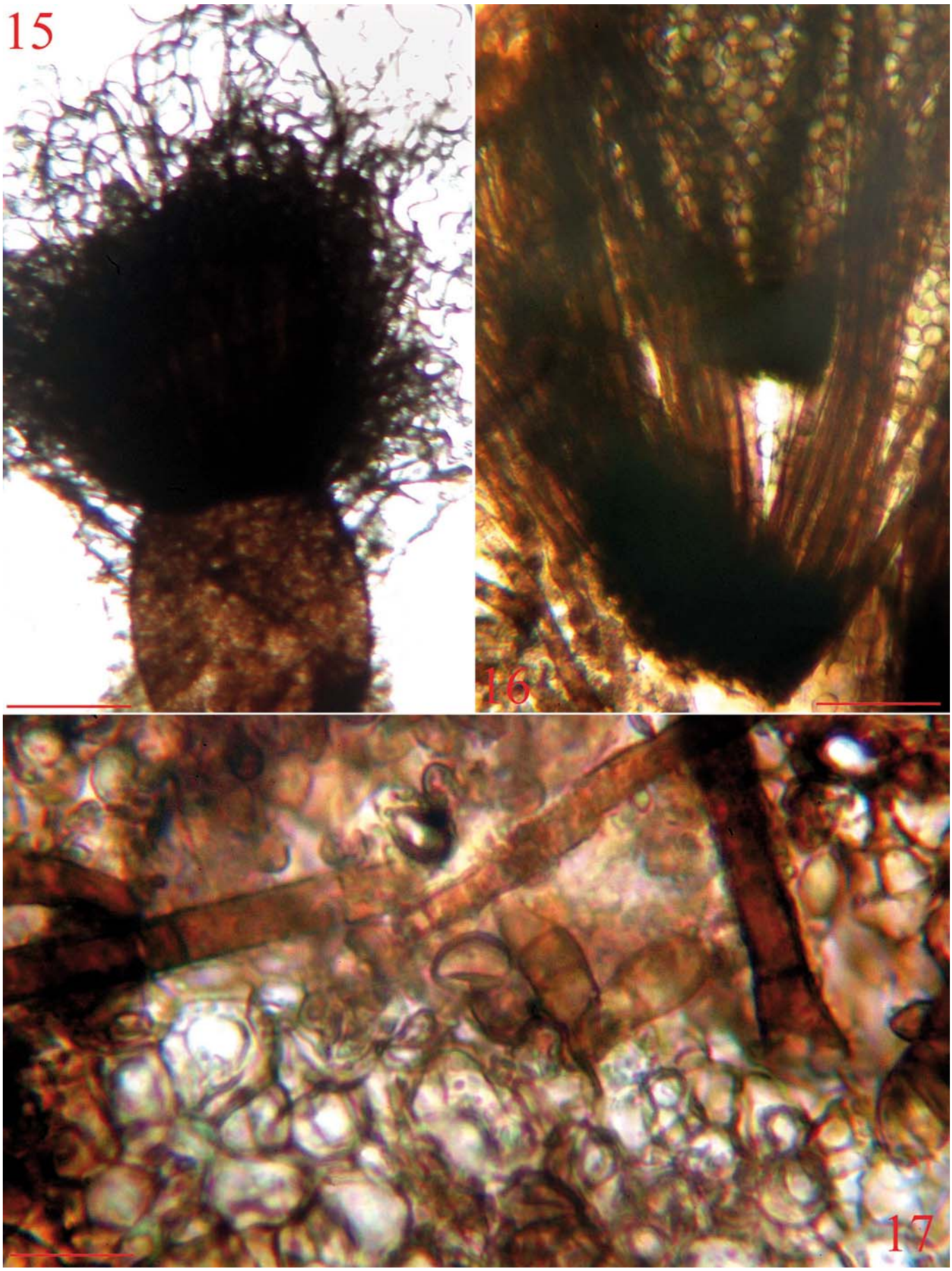

Plate 5 – *Chaetomium hexagonosporum*

15. Perithecium in water. 16. Middle and lower part of terminal hairs arising from a dark collar around the ostiole. 17. Bases of terminal hairs on cells of *textura angularis*. Scale bars: 15 = 125 µm; 16 = 20 µm; 17 = 15 µm.

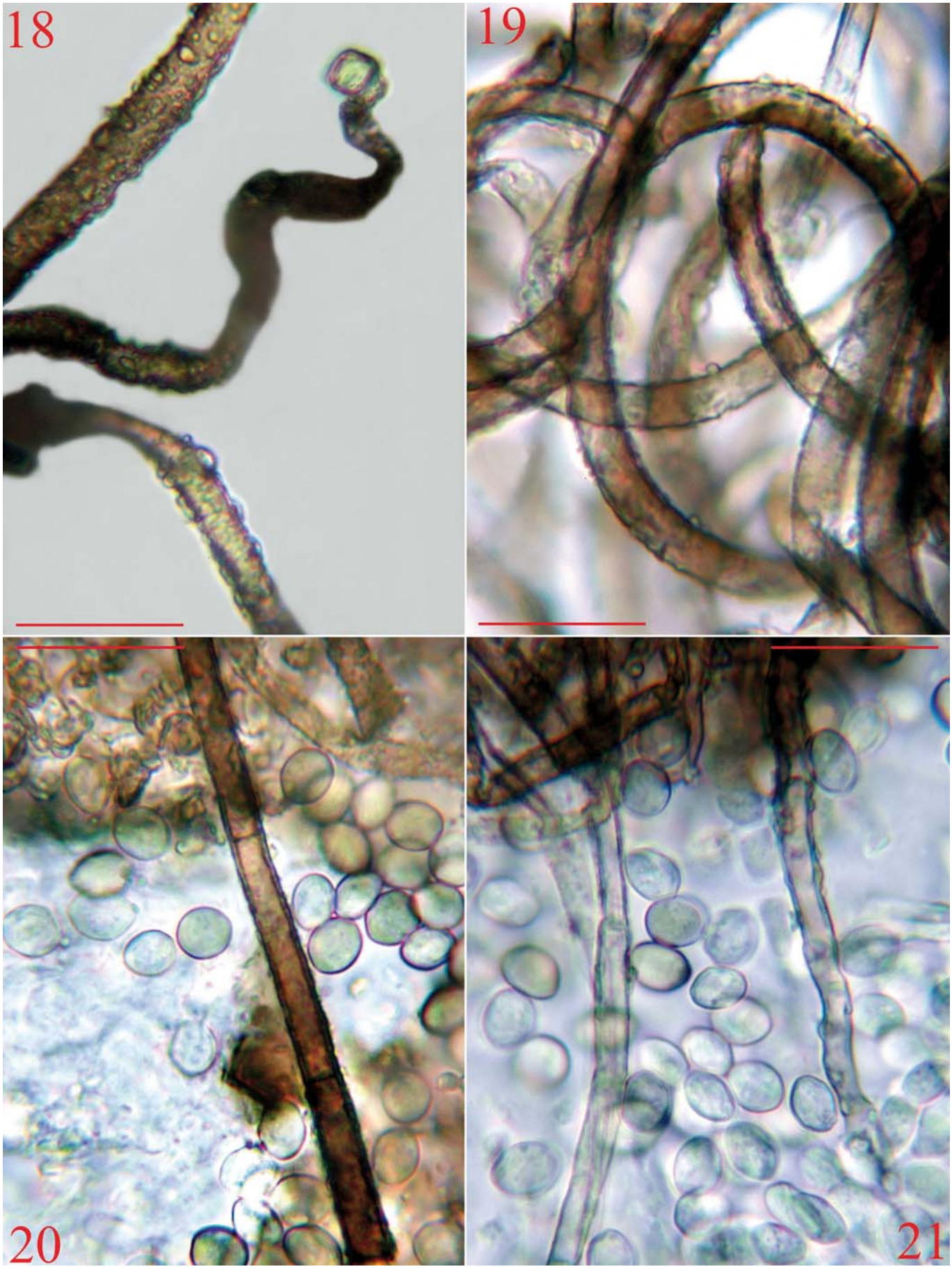

Plate 6 – *Chaetomium hexagonosporum*
18–19. Apices of terminal hairs. 20. Lateral hair and free ascospores. 21. Basal hairs and free ascospores. Scale bars: 18–21 = 20 µm.

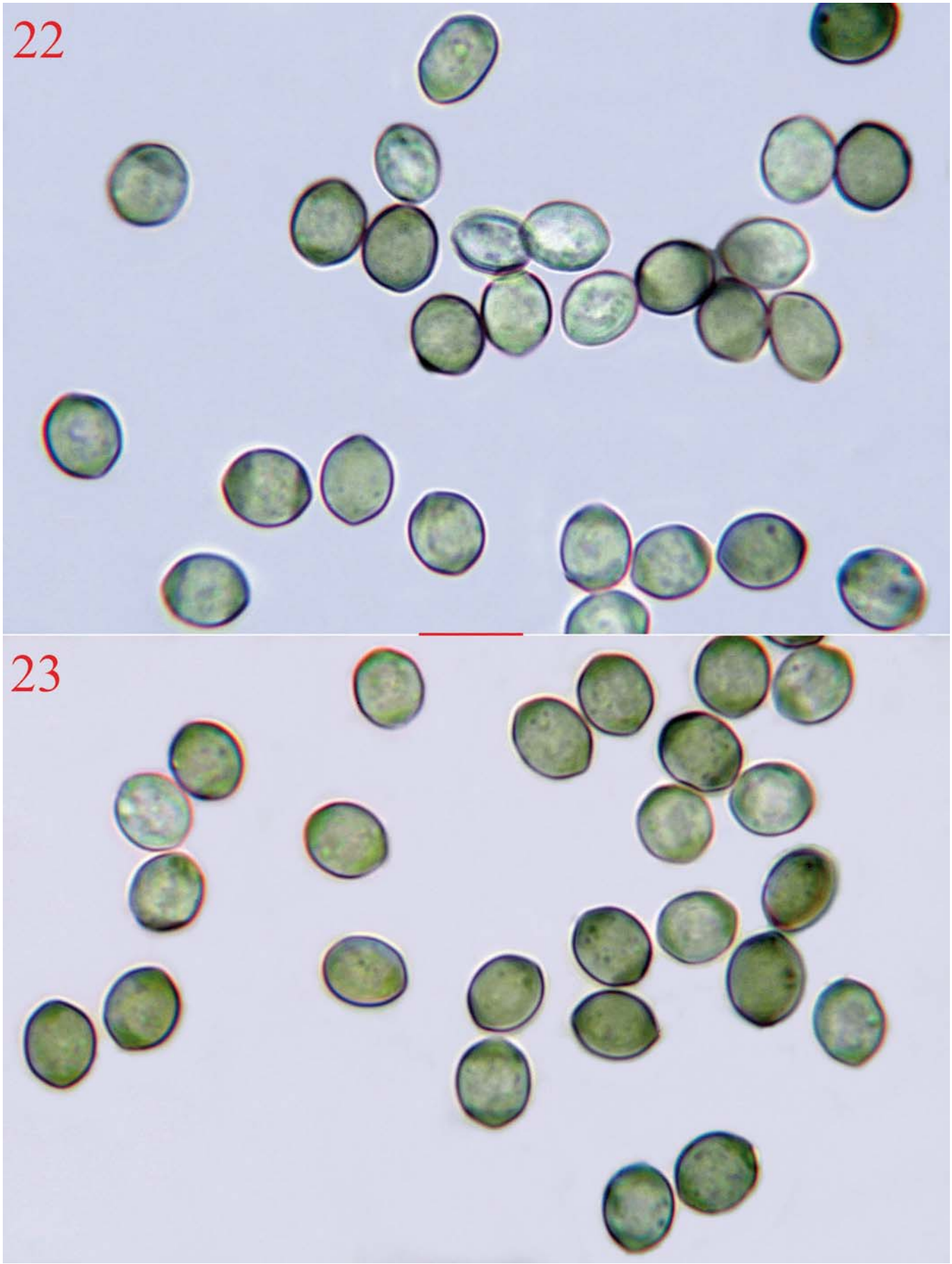

Plate 7 – *Chaetomium hexagonosporum*
22–23. Ascospores. Scale bar: 22–23 = 10 µm.

Panel 1 (continued) – *Chaetomium bostrychodes*						
CLSM	**dung source**	**perithecial shape**	***textura prismatica* (number of rows)**	**spore shape**	**spore size (µm)**	***Chaetomium* name after revision**
XLIX	pigeon	ellipsoid	2	limoniform	6.5–7 × 6	bostrychodes
L	hen	subglobose/br. ellipsoid	0-1	limoniform	7 × 5.5–6	bostrychodes
LIII	polecat	ellipsoid	0-1	br. limoniform	6–6.5 × 5–5.5	bostrychodes
LIV	beech-marten	ellipsoid	0-1	br. limoniform	6–6.5 × 5–5.5	bostrychodes
LV	tortoise	ellipsoid	0	br. limonif./limoniform	6.5–7 × 5.5–6	bostrychodes
LVI	hare	subglobose	0	br. limoniform	6–6.5 × 5.5–6	bostrychodes
LVII	roe deer	obovoid	0	limoniform	6.5–7 × 6	bostrychodes
LVIII	bird	ellipsoid	1-2	limoniform	6.5–7 × 5–5.5	bostrychodes
LIX	fallow deer	br. ellipsoid	0-1	limoniform	6–7 × 5.5–6	bostrychodes
LX	porcupine	ellipsoid	0	br. limonif./limoniform	6.5–7 × 6–6.5	bostrychodes
LXI	cattle	subglobose	0	limoniform	6–7 × 5.5–6	bostrychodes
LXIII	roe deer	ellipsoid	1	limoniform	6.5–7 × 5.5–6	bostrychodes
LXVI	horse	ellipsoid	0	br. limonif./limoniform	6.5–7 × 5.5–6	bostrychodes
LXVIII	dormouse	narr. ellipsoid	0	br. limoniform	6.5–7 × 5.5–6	bostrychodes
LXX	sheep	ellipsoid	0	subglobose/br. limoniform	6.5–7 × 5.5–6.5	bostrychodes
LXXI	rabbit	ellipsoid	1	limoniform	6.5–7 × 5.5–6	bostrychodes
LXXIII	rabbit	ellipsoid	0	limoniform	7–7.5 × 5.5–6.5	bostrychodes
LXXIV	roe deer	br. ellipsoid	0	limoniform	6.5 × 5–5.5	bostrychodes
LXXV	roe deer	?	0	subglobose/br. limoniform	5.5–6 × 5–5.5	bostrychodes
LXXVI	hare	narr. ovoidal	1	limoniform	6.5–7 × 5.5	bostrychodes
LXXVII	wild pig	ellipsoid	1	subglobose	6.5 × 6	bostrychodes
LXXX	hare	subglobose	0	limoniform	6.5–7.5 × 6	bostrychodes
LXXXI	sheep	br. obovoid	1	limoniform	6.5–7 × 5.5–6	bostrychodes
LXXXII	sheep	ovoidal	0	limoniform	6.5–7 × 5.5–6	bostrychodes
LXXXIII	wild rabbit	subglobose	0	limoniform	6.5–7 × 6	bostrychodes
LXXXIV	wild rabbit	br. ellipsoid	0	br. limonif./limoniform	6.5–7 × 6	bostrychodes
LXXXV	cattle	obovoid	0	br. limoniform	6–6.5 × 5.5–6	bostrychodes
LXXXVII	goat	ellipsoid	0-1	br. limonif./limoniform	6.5–7 (7.5) × 5.5–6.5	bostrychodes
LXXXVIII	goat	ellipsoid	2	br. limoniform	6.5–7 × 6	bostrychodes
XC	hare	narr. ellipsoid	0-1	br. limonif./limoniform	6–6.5 × 5.5	bostrychodes
XCI	hare	narr. obovoid	0-1	subglobose/br. limoniform	6–6.5 × 5.5–6	bostrychodes
XCII	goat	br. ellipsoid	1	limoniform	6.5–7 × 5.5–6	bostrychodes
XCIII	hare	br. ellipsoid	0	limoniform	7 × 6	bostrychodes
XCIV	wild rabbit	narr. ellipsoid	2	limoniform	6.5–7 × 5.5	bostrychodes
XCVI	porcupine	subglobose	0	br. limoniform	6.5–7 × 5.5–6	bostrychodes
CLSM = author's herbarium; br. = broadly; indist. = indistinctly; irreg. = irregularly; limonif. = limoniform; narr. = narrowly.						

Panel 2 – *Chaetomium robustum*						
CLSM	**dung source**	**perithecial shape**	***textura prismatica* (number of rows)**	**spore shape**	**spore size (µm)**	***Chaetomium* name after revision**
XXV	wild pig	narr. ovoidal	4-5	subglobose/br. limoniform	6 × 5.5	robustum
XXIX	horse	narr. ellipsoid	5-6	br. limonif./limoniform	6.5–7.5 × 5.5–6.5	robustum
XLV	fox	obclavate	4-5	br. limoniform	5.5–6 × 5–5.5	robustum
LXIX	hedgehog	doliform	6-7	subglobose/br. limoniform	5.5–6 × 5–5.5	robustum

Panel 3 – *Chaetomium hexagonosporum*						
CLSM	**dung source**	**perithecial shape**	***textura prismatica* (number of rows)**	**spore shape**	**spore size (µm)**	***Chaetomium* name after revision**
LXXII	wild pig	obovoidal	0	indist. angular/hexagonal	8.5–9 × 6.5–7	hexagonosporum
LXXIX	roe deer	ellipsoid	0	irreg. angular/hexagonal	8–9 × 6.5–7.5	hexagonosporum
LXXXIX	goat	ellipsoid	0	indist. angular to hexagonal	8–9 × 6–7	hexagonosporum

Panel 4 – *Chaetomium* intermediates						
CLSM	**dung source**	**perithecial shape**	***textura prismatica* (number of rows)**	**spore shape**	**spore size (µm)**	***Chaetomium* name after revision**
octa	wild pig	narr. ellipsoid	3-4	br. limoniform	5.5–6 × 5–5.5	bostrychodes/robustum
XIX	chamois	narr. obovoid	3	limoniform	6.5–7 × 6	bostrychodes/robustum
LI	hen	br. ellipsoid	0	limoniform	7–7.5 (8) × 6–6.5	bostrychodes/convolutum
LXXVIII	marten	ellipsoid	0	limoniform to indist. hexagonal	8–9 × 6.5–7	convolutum/hexagonosporum

Table 2 – Revision of Italian collections originally identified as *Chaetomium robustum*

Panel 1 – *Chaetomium robustum*						
CLSM	**dung source**	**perithecial shape**	***textura prismatica* (number of rows)**	**spore shape**	**spore size (µm)**	***Chaetomium* name after revision**
008.02	rabbit	narr. ellipsoid	3-4	br. limoniform	6–6.5 × 5.5–6	robustum
bis	lizard	obclavate	4-5	br. limoniform	5.5–6 × 5–5.5	robustum
ter	dormouse	narr. ellipsoid	3-4	br. limoniform	5.5–6 × 5–5.5	robustum
quater	rabbit	narr. ovoidal	4	br. limoniform	5.5–6 × 5–5.5	robustum
octa	badger	narr. ovoidal	3-4	br. limoniform	5.5–6 × 5–5.5	robustum
ena	snail	obclavate	5-6	br. limoniform	6 × 5–5.5	robustum
XI	hare	narr. obclavate	4-6	br. limoniform	6–6.5 × 5.5	robustum
XII	?	?	4-5	limoniform	6.5–7 × 5.5–6	robustum
XIII	hare	narr. ellipsoid	4-5	br. limoniform	5.5–6 × 5–5.5	robustum
XV	wild rabbit	narr. ellipsoid	4	br. limoniform	6.5–7 × 5.5–6	robustum
XVI	sheep	ampulliform	4	limoniform	6.5–7 × 6	robustum
XVIII	sheep	ampulliform	4-5	limoniform	6.5–7 × 5.5	robustum
XX	fallow deer	narr. ellipsoid	4-5	br. limoniform	5–6 × 5–5.5	robustum
XXV	sheep	ellipsoid/narr. ellipsoid	3-4	limoniform	6.5–7 × 5.5–6	robustum
XXVII	gecko	obclavate	4-6	br. limoniform/subglobose	5.5–6 × 5.5	robustum
XXVIII	wild rabbit	ampulliform	4-6	limoniform	6.5–7 × 5.5–6	robustum
CLSM = author's herbarium; br. = broadly; limonif. = limoniform; narr. = narrowly.						

Panel 2 – *Chaetomium bostrychodes*						
CLSM	**dung source**	**perithecial shape**	***textura prismatica* (number of rows)**	**spore shape**	**spore size (µm)**	***Chaetomium* name after revision**
esa	dormouse	br. ellipsoid	0-1	br. limoniform	6.5–7 × 6	bostrychodes
epta	badger	?	1-2	limoniform	6–7 × 5.5	bostrychodes
XIV	wild rabbit	ellipsoid	2	limoniform	6.5–7 × 5.5	bostrychodes
XVII	wild rabbit	ellipsoid	2	limoniform	6.5–7 × 6	bostrychodes
XIX	roe deer	ellipsoid	1-2	br. limoniform	6 × 5.5	bostrychodes
XXIII	hare	ellipsoid	1-2	limoniform	6–6.5 × 5–5.5	bostrychodes
XXIV	badger	narr. ovoidal	1-2	br. limoniform/limoniform	6.5–7 × 6–6.5	bostrychodes
XXVI	wild rabbit	narr. ovoidal	2	limoniform	6–6.5 × 5.5	bostrychodes

Panel 3 – *Chaetomium* intermediates						
CLSM	**dung source**	**perithecial shape**	***textura prismatica* (number of rows)**	**spore shape**	**spore size (µm)**	***Chaetomium* name after revision**
deca	dormouse	obclavate	2-3	br. limoniform	5.5–6 × 5	bostrychodes/robustum
XXI	hedgehog	narr. ovoidal	2-3	limoniform	6.5–7 × 5.5	bostrychodes/robustum

Results and conclusions

Based on my recent revision, I can state that *Chaetomium bostrychodes* and *C. robustu*m are much more frequent in Italy than *C. convolutum* and *C. hexagonosporum*.

In agreement with others (Ames, 1963; Arx *et al*., 1986; Rodríguez Morejón, 2003) the commonest perithecial forms of *C. robustum* are ampulliform or obclavate, but several narrowly ellipsoid and some narrowly ovoidal forms are known. In all Italian collections of *C. robustum*, these types of elongated ascomata correlate with a peridial *textura prismatica* of four rows at least of rectangular cells beneath the ostiole (Plate 8, fig. 24). The usually broadly limoniform (Q = 1.00–1.20) ascospores of *C. robustum* are also the smallest of the group and have very pronounced apiculi (Plate 8, fig. 25). I have noticed, however, some collections with limoniform (a higher Q) and slightly larger ascospores with less pronounced apiculi.

Chaetomium bostrychodes is quite variable in shape: perithecia are mostly ellipsoidal or broadly ellipsoid, but I also recorded stouter, subglobose or ovoidal, ascomata or, on the contrary, more slender, narrowly ellipsoid ascomata, the latter usually correlated with 1–2 rows of *textura prismatica* (Plate 9, fig. 28). The broadly limoniform or limoniform ascospores of *C. bostrychodes* are somewhat larger on average than those of *C. robustum* (Plate 9, fig. 27). In agreement with Rodríguez Morejón (2003), intermediate forms between *C. bostrychodes* and *C. robustum*, particularly concerning the extension of peridial *textura prismatica*, are not infrequent, so in my opinion *C. robustum* should be regarded as a morphological form of the older name *C. bostrychodes*.

I also have observed an Italian collection with intermediate characteristics between *C. bostrychodes* and *C. convolutum* and another intermediate between *C. convolutum* and *C. hexagonosporum*, the latter with ascospores slightly smaller than *typus* (Carter & Malloch, 1982).

According to Rodríguez Morejón (2003), *Chaetomium convolutum* and *C. hexagonosporum* should be regarded as morphological forms of the same taxon. In my opinion, *C. hexagonosporum* should be considered for the time being as an independent taxon from *C. convolutum* and the only Italian collection with intermediate characteristics of the two species must be interpreted as a morphological variant of *C. convolutum*.

Sequences of the 28S rDNA combined with a morphological study (Rodríguez Morejón, 2003) did not solve some taxonomic problems of the group-*bostrychodes*. I am confident that a future programme of type-studies, multigenic sequencing of the largest number of collections worldwide, and detailed morphological descriptions will shed full light on this complex.

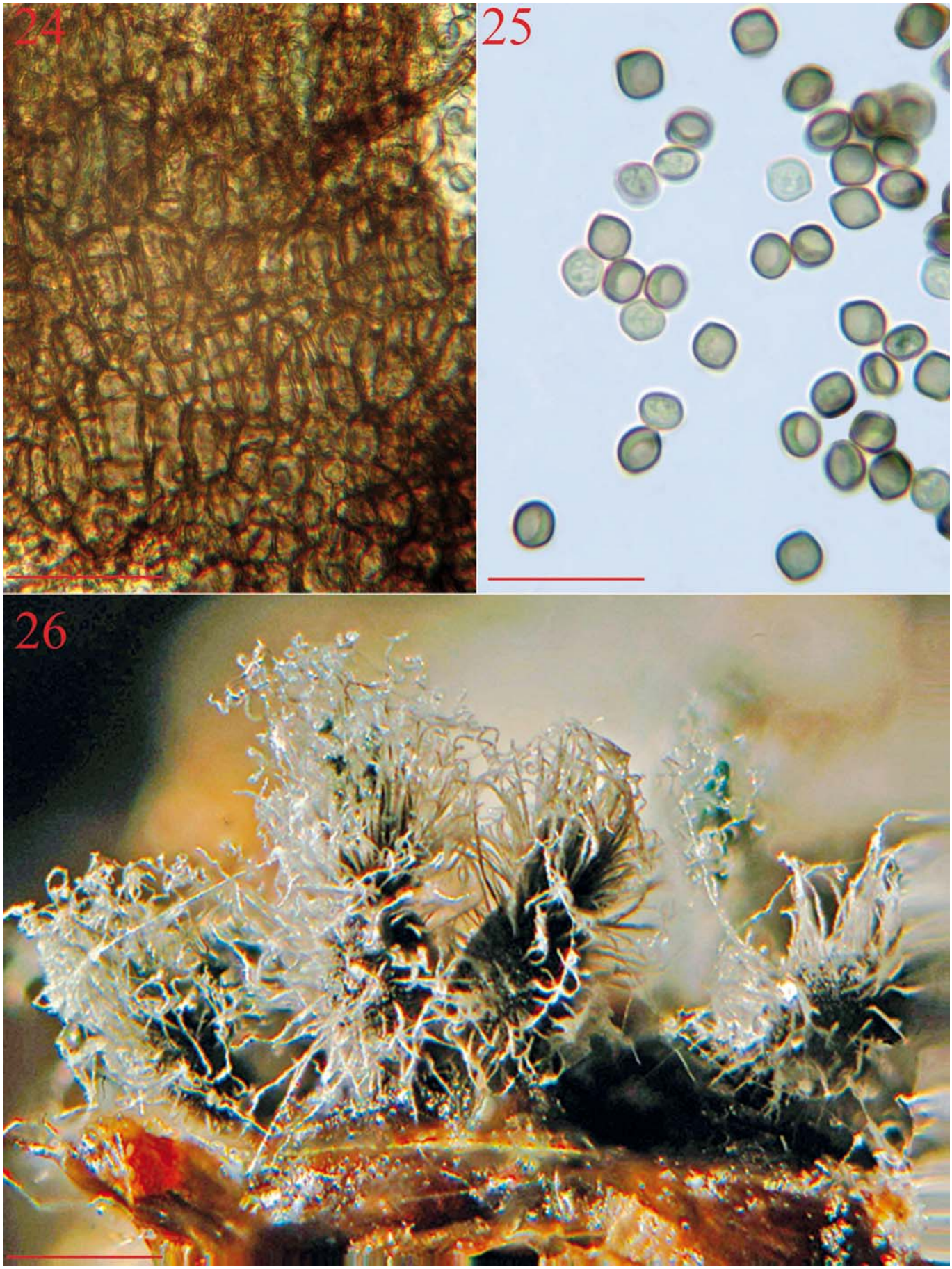

Plate 8 – *Chaetomium robustum*

24. *Textura prismatica* beneath the ostiole. 25. Broadly limoniform ascospores of some Italian collections. 26. Ascomata on dung. Scale bars: 24 = 25 µm; 25 = 20 µm; 26 = 300 µm.

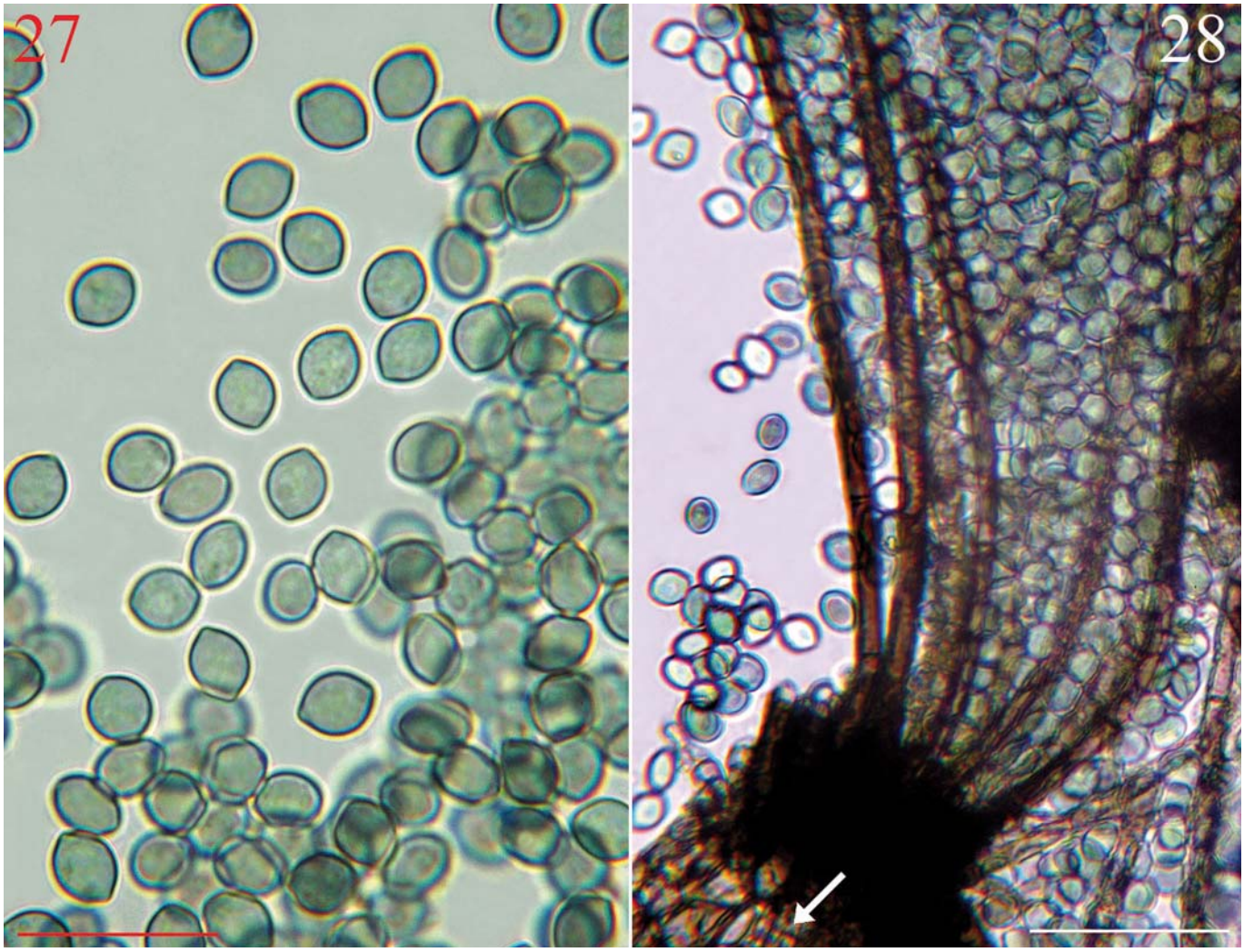

Plate 9 – *Chaetomium bostrychodes*

27. Limoniform ascospores. 28. Upper portion of perithecium with one row of *textura prismatica* (arrow) beneath the ostiole. Scale bars: 27 = 20 µm; 28 = 40.

Acknowledgements

The author is grateful to Adrian Carter for revising the text. He also thanks Cecilia Doveri for providing him with part of the material described in this article.

Bibliography

Ames L.M. 1949. — New cellulose destroying fungi isolated from military material and equipment. *Mycologia*, 41 (6): 637-648. doi: 10.2307/3755020

Ames L.M. 1963. — *A monograph of the Chaetomiaceae*. United States Army Research and Development series 2, 125 p.

Arx J.A. (von), Guarro J. & Figueras M.J. 1986. — The ascomycete genus *Chaetomium*. *Nova Hedwigia*, 84: 1-162.

Bell A. 2005. — *An illustrated guide to the coprophilous Ascomycetes of Australia*. CBS Biodiversity Series 3. Utrecht, Centraalbureau voor Schimmelcultures, 172 p., 115 pl.

Bertault R. 1982. — Contribution à la flore mycologique de la Catalogne. *Acta Botanica Barcinonensia*, 34: 1-35.

Caretta G., Piontelli E., Savino E. & Bulgheroni A. 1998. — Some coprophilous fungi from Kenya. *Mycopathologia*, 142 (3): 125-134. doi: 10.1023/A:1006995313657

Carter A. 1982. — *A taxonomic study of the ascomycete genus Chaetomium Kunze*. University of Toronto (Ph.D. thesis), 261 p.

Carter A. & Malloch D. 1982. — A novel taxonomic character for *Chaetomium* as illustrated by the new species *Chaetomium hexagonosporum*. *Canadian Journal of Botany*, 60 (7): 1249-1252. doi: 10.1139/b82-158

Chivers A.H. 1912. — Contributions from the cryptogamic laboratories of Harvard University. — No. LXVIII. Preliminary diagnoses of new species of *Chaetomium*. *Proceedings of the American Academy of Arts Sciences & Letters*, 48 (4): 83-88. doi: 10.2307/20022812

Chivers A.H. 1915. — A monograph of the genera *Chaetomium* and *Ascotricha*. *Memoirs of the Torrey Botanical Club*, 14 (3): 155-240. doi: 10.5962/bhl.title.97551

Coutinho F.P., Queiroz de Cavalcanti M.A. & Yano-Melo A.M. 2007. — New records of Ascomycota from Brazil. *Mycotaxon*, 101: 239-245.

Dal Vesco G., Peyronel B., Barge M.T. & Volpiano N. 1967. — Sulla micoflora dello sterco di coniglio ("*Oryctolagus cuniculus*"). *Allionia*, 13: 107-127.

Doveri F. 2004. — *Fungi Fimicoli Italici*. Trento, A.M.B, Fondazione Studi Micologici, 1104 p.

Doveri F. 2008. — Aggiornamento sul genere *Chaetomium* con descrizione di alcune specie coprofile, nuove per l'Italia — An update on the genus *Chaetomium* with descriptions of some coprophilous species, new to Italy. *Pagine di Micologia*, 29: 1-60.

Doveri F. 2013. — An additional update on the genus *Chaetomium* with descriptions of two coprophilous species, new to Italy. *Mycosphere*, 4 (4): 820-846. doi: 10.5943/mycosphere/4/4/17

Doveri F. 2016. — Description of *Chaetomium aureum*, *Corynascus sepedonium* and *Coniochaeta hansenii* newly recorded from Italy, and a key to coprophilous *Chaetomiaceae* and *Coniochaetaceae*. *Ascomycete.org*, 8 (1): 7-24.

Dreyfuss M. 1976. — Taxonomische Untersuchungen innerhalb der Gattung *Chaetomium*. *Sydowia*, 28: 50-133.

Eriksson O.E. 2009. — *The non-lichenized ascomycetes of Sweden*. KBC-tryckeriet, Umeå University, 461 p.

Greathouse G.A. & Ames L.M. 1945. — Fabric deterioration by thirteen described and three new species of *Chaetomium*. *Mycologia*, 37 (1): 138-155. doi: 10.2307/3754857

Guarro J., Calvo M.A. & Ramírez C. 1980. — Soil Ascomycetes (*Sphaeriales*) from Catalunya (Spain). I. *Nova Hedwigia*, 32: 199-216.

Guarro J., Gené J., Stchigel A.M. & Figueras M.J. 2012. — *Atlas of soil Ascomycetes*. Utrecht, CBS Biodiversity Series 10, 486 p.

Lodha B.C. 1964. — Studies on coprophilous fungi I. *Journal of Indian Botanical Society*, 43: 121-140.

Lorenzo L.E. 1993. — Especies coprófilas de la familia *Chaetomiaceae* en la Patagonia (Argentina). *Boletin de la Sociedad Argentina de Botanica*, 29 (3-4): 159-172.

Mazzucchetti G. 1965. — *Microfunghi della cellulosa e della carta attivita e inquadramento sistematico. Il genere Chaetomium*. Ente Nazionale per la Cellulosa e per la Carta. Roma, 364 p.

Mungai P.G., Chukeatirote E., Njogu J.G. & Hyde K.D. 2012. — Coprophilous ascomycetes in Kenya: *Chaetomium* species from wildlife dung. *Current Research in Environmental & Applied Mycology*, 2: 113-128.

Richardson M.J. 2001. — Diversity and occurrence of coprophilous fungi. *Mycological Research*, 105: 387-402. doi: 10.1017/S0953756201003884

Richardson M.J. & Watling R. 1997. — *Keys to fungi on dung*. British Mycological Society, 68 p.

Rodríguez Morejón K.C. 2003. — *Estudio taxonómico (morfológico y molecular) de especies del género Chaetomium y géneros afines*. Universitat Rovira i Virgili (Ph.D. thesis), 320 p.

Skolko A.J. & Groves J.W. 1953. — Notes on seed-borne Fungi. VII. *Chaetomium*. *Canadian Journal of Botany*, 31 (6): 779-809. doi: 10.1139/b53-060

Udagawa S. 1960. — A taxonomic study on the Japanese species of *Chaetomium*. *Journal of General and Applied Microbiology*, 6 (4): 223-251. doi: 10.2323/jgam.6.223

Valldosera M. & Guarro J. 1992. — Estudios sobre hongos coprófilos aislados en España. XVII. *Ascomycotina*. *Boletín de la Sociedad Micológica de Madrid*, 17: 19-37.

Francesco Doveri
Via dei Funaioli 22
57127 Livorno
Italy
f.doveri@sysnet.it