RMR Boll. AMER n. 122, Anno XL, 2024 (2): 3-31
https://doi.org/10.57624/AMER.2024.4

EDMONDO GRILLI, FABRIZIO BOCCARDO, ALESSANDRO FELLIN

ADDENDA TO THE *HEBELOMA FUNGA* OF ITALY. 2
HEBELOMA SORDESCENS, *H. CATALAUNICUM*, *H. LINDAE* AND *H. NANUM*

Abstract

Second contribution to the "Addenda" series documenting the first molecularly confirmed Italian record of Hebeloma sordescens and additional records of the rare H. catalaunicum, H. lindae and H. nanum, so far known only from Calabria and Sardinia, Sicily and Piedmont respectively. Each of the species is exhaustively described, annotated and illustrated with colour photographs of basidiomes in habitat and photographs and camera lucida micrographs of spores and cheilocystidia.

Riassunto

Questo secondo contributo ad "Addenda alle specie del genere Hebeloma in Italia" documenta il primo ritrovamento molecolarmente confermato di Hebeloma sordescens e raccolte aggiuntive di H. catalaunicum, H. lindae e H. nanum, specie rare finora note per raccolte fatte rispettivamente in Calabria e Sardegna, Sicilia e Piemonte. Ciascuna specie è esaurientemente descritta ed illustrata con fotografie dei basidiomi in habitat e fotografie e disegni alla camera lucida di spore e cheilocistidi.

Key words *Hymenogastraceae*, *Hebeloma*, *H. sordescens*, *H. catalaunicum*, *H. nanum*, *H. lindae.*

Introduction

Following Grilli & Fellin (2024), this second contribution provides new additions to occurrence and distribution of the *Hebeloma* funga in Italy (Grilli *et al*. 2020). To avoid repetitions, for the general information about, and the rationale behind, this series of papers the reader is referred to the above-cited works.

The present study zooms in on *Hebeloma sordescens* Vesterh. (Vesterholt 1989), a species apparently very rare in Italy. This is a typical member of *Hebeloma* sect. *Hebeloma* subsect. *"subsect1"*, the velar remnants of which can at times be fugacious, sharing misleading microanatomical similarities (spore features and shape of cheilocystidia) with members of the *H. quercetorum* complex (*Hebeloma* sect. *Velutipes*): *H. quercetorum* Quadr. and *H. celatum* Grilli, U. Eberh. & Beker in particular. Therefore, it can happen that when in the latter two species, the lack of velar remnants is downplayed and the occurrence of caulocystidia well below the stipe apex is overlooked, they can be misidentified as *H. sordescens.* The collection presented is the first confirmed record, both morphologically and molecularly, for Italy. What is meant with "confirmed" was expounded in both the Supplement (Grilli *et al.* 2020) and Grilli & Fellin (2024).

Secondarily, we provide additional collections of the somewhat rare *Hebeloma catalaunicum* Beker, U. Eberh., Grilli & Vila and *H. nanum* Velen., both members of *Hebeloma* sect. *Naviculospora*, and the likewise uncommon *H. lindae* Beker & U. Eberh. belonging in *Hebeloma* sect. *Scabrispora*. Each species is exhaustively described and illustrated based on material collected in Liguria. Regarding *H. catalaunicum*, data and micrograph plates of the holotype and of an additional collection from Sardinia are also provided, while of *H. nanum* is described and illustrated also an additional collection from Lombardy. All three taxa were already treated in the Supplement based on collections from Sardinia and Calabria, Piedmont and Sicily respectively.

Materials and methods

The collections related to the species object of the present work were first identified morphologically then samples were sent to U. Eberhardt and H.J. Beker, who after obtaining sequences from them, assessed the molecular congruence of the identifications, or dispelled the doubts arising from one of them.

The Monograph (Beker *et al*. 2016) and, to a lesser extent, the Supplement provide all the necessary information on the genus *Hebeloma* and a detailed analysis of all the characters currently utilized in species delimitation. The format of species description follows that adopted in the Supplement. Likewise, the microscopic description is limited to the core characters of spores and cheilocystidia and, when present, pleurocystidia, that is to say only the characters providing diagnostic information. Habitat data, however, now also include specifications from the IUCN Habitats Classification Scheme and Terrestrial Ecoregions of Italy (Blasi *et al*. 2018). The observational protocol, descriptive terminology and coding conventions follow what specified and used in the previous two works and the contributions published by H.J. Beker's *Hebeloma* team. It is worth remembering, however, that the average spore values were determined by measuring at least 50 fully ripe spores with normally developed ornamentation from each collection. When spore prints were not available, measures were taken from a lamellar squash of exsiccate material, but an assessment of the diagnostic spore features in naturally shed (mature) spores was preliminarily made observing a mount from the stipe apex. The presentation of quantitative data of spores and cheilocystidia follows Grilli *et al.* (2016). It has the form (a) b c d (e), in which the values between parentheses are the smallest and the highest values recorded (but excluding those that are clearly not representative, exceptionally large or small), b and d the 5% and 95% percentiles and c the average. For spores the format is length × width, followed by Q value; for cheilocystidia the format is L × A × M × B.

Noticing and coding the dextrinoid colour change of spores, an important diagnostic character, follows the agreed observational protocol (Vesterholt 2005). In an attempt to reduce subjectivity in the degree of spore dextrinoidity (D0; D1; D2; D3; D4), the codes in the descriptions are correlated to colours from Kornerup & Wanscher (1978). Given its diagnostic value, the average width of the apex (A) of cheilocystidia was assessed based on at least 100 cheilocystidia from unsquashed mounts of lamellar sections, unselectively measuring all apices properly in focus within a field. The average measures of the other cheilocystidium features (L, M and B) were obtained by measuring in excess of 30 entire cheilocystidia from squashed mounts. They were chosen to provide an acceptably accurate picture of the relative percentages of cheilocystidium types observed, L, A, M and B being the initial letters of *length*, *apex width*, *median width* (approximately the narrowest median point, but see below) and *basal width* (width of base or, if present, basal swelling), respectively. Three of these measures (A, M and B) are also used to calculate the A/M, A/B and B/M ratios, which are considered useful to make the most of cheilocystidium shape. Since where to measure the median width (M) might be controversial, in Grilli & Fellin (2024) was cited a long excerpt from the Supplement and republished a drawing (reproduced from Eberhardt *et al*. 2022a) showing where the measures should be taken.

The standardized terms used in the description of lamellar density (L = number of full-length lamellae) follow Grilli *et al.* (2016): distant (L < 32), subdistant (L < 40), close (L 40-59), subcrowded (L 60-80), and crowded (L > 80).

The Database referred to in the present paper and elsewhere is the one that has been built by H.J. Beker's *Hebeloma* team over the last 20 years. On the Database, hosted on version 12 BioloMICS from Bioaware SA NV, are stored all the data (morphological and molecular alike, as well as images) on some 10.000 collections (including all types worldwide that could be located and loaned) related to the 135 *Hebeloma* species at present regarded as current. This huge mass of data can be accessed on the website, https:// hebeloma.org. The website offers exhaustive up-to-date species descriptions, accurate information about every *Hebeloma*

name published to date, and tools for the comparisons of species, species parameters, species geography and habitats, as well as a species Identifier based on AI machine learning. (Bartlett *et al.* 2021; Bartlett *et al.* 2022a; Bartlett *et al.* 2022b).

Regrettably, the number of full-length lamellae were not included when the data on gross morphology of the collections presented were recorded. Anyway, a reasonable estimate was possible judging by the photographs and an attentive observation of exsiccata. The abbreviation "*ca.*" (circa) preceding the values of L (lamellar density) is a reminder that such values are only an approximate estimate.

The voucher material of the collections presented are stored at GDOR and in the first author's and H.J. Beker's fungaria.

TAXONOMY

Hebeloma sect. *Hebeloma* subsect. *"subsect1"**

*This is a provisional solution adopted in Hebeloma.org, mostly for convenience sake, to separate the group of species with predominantly amygdaloid and dextrinoid spores from that of species with ellipsoid and indextrinoid spores. Naming this subsection is, in fact, nomenclaturally problematic due to two competing subsectional names: *Hebeloma* subsect. *Testacea* Quadr. 1984 [type *H. testaceum* (Batsch: Fr.) Quél.] and *Hebeloma* subsect. *Amygdalina* Vesterh. 1989 (type *H. sordescens* Vesterh. = *H. testaceum* ss Lange), with the apparently obvious choice between the two complicated by the status of *H. testaceum*, the problems of which were addressed by Grilli *et al*. (2015). Additionally, there are unresolved problems also with *H. sordescens*, which phylogenetically appears to be the ancestor of both groups (H.J. Beker pers. comm.).

Hebeloma sordescens Vesterh. *Nord. J. Bot.* **9** (3): 307 (1989)

Types: DENMARK: NEZ, Kongelunden, Amager UTM UB 47,61 TBU 46 (approx. N55.57, E12.57, alt. approx. 0 m a.s.l.) on soil under *Betula* sp., *Corylus* sp. and *Quercus* sp., Sep. 29 1984, J. Vesterholt (84-1371) (Holotype. herbarium acc. no. C JV-84-1371).

English translation of the original diagnosis

Pileus hemispherical at first then convex to applanate, 20-50 mm broad, surface slightly viscid, cinnamon to orange-brown, paler at margin to almost white. Velum very ephemerous. Lamellae emarginate. Stipe 25-90 × 4-8 mm, clavate towards base, up to 13 mm thick. Spores amygdaloid and sublimoniform, 10-11 × 5-6.5 μm, roughened, distinctly dextrinoid. Cheilocystidia cylindrical, widened towards base. Terrestrial under Betula, Quercus and Corylus.

Macroscopic description (EG170913.01; HJB20663) (Figure 1.0)

Pileus 30-32 mm in diameter, broadly campanulate to convex, orbicular to slightly lobate, margin long inflexed, smooth, with white, thin remnants from the universal veil. Surface smooth, tacky when moist, bicolorous, a warm orange to reddish-yellow (6B5; 5YR7/6) over a broad discal area, fading into pale orange or pinkish (6B3; 5YR7/4) towards the marginal area where the ground colour is superimposed by the white velar covering.

Lamellae emarginate, segmentiform to subventricose, 3-4 mm broad, density in the close range (L *ca.* 48-50); edge whitish, fimbriate, dry.

Stipe 60-90 × 6-9 mm, cylindraceous, slightly clavate at base, whitish, discolouring dark brown towards the base, pruinose at the apex, more or less fibrillose downwards; stuffed to fistulose. With cortinate velar remnants.

Context firm, dingy whitish in the pileus, dark brown in stipe base; smell raphanoid, taste not recorded.

Exsiccata blackening, especially parts of the pileus and stipe.

Microscopic description (Figures 1.1, 1.2, 1.3, 1.4 and 1.5)

Spores (9.4) 9.6 10.7 12.4 (13.2) × (5.2) 5.4 5.8 6.4 (6.6) µm; Q = (1.62) 1.65 1.84 2.04 (2.17), shape mostly amygdaloid to citriform, occasionally subellipsoid. Ornamentation mostly subdistinct, much less frequently distinct. Myxosporium mostly undilating to rugulose, occasionally scantily vesiculate. Dextrinoidity strong (6C/D6; 7C3-4). Apical modifications of spore walls: occasionally papillate, but mostly the expansion of the coriotunica is very weak. Colour in KOH (5% aqueous solution): pale greenish (30A/B2). Spore Code: **O2; P0 P1; D3**.

Basidia 22-32 × 7.2-9.0 µm, avg. Q = 3.2, clavate, four-spored.

Cheilocystidia 32 44 63 (65) × (3.4) 3.8 4.7 5.6 (6.0) × 3.2 4.1 5.0 (5.2) × (5.6) 6.3 8.5 12.3 (13.6) µm, lamellar edge sterile. Shape mostly lageniform, less frequently ventricose. Occurrence of special features: refringent wall thickening, sometimes apical; sometimes septate-clamped. Cheilocystidium Ratios: **A/M = 1.14**; **A/B = 0.58**; **B/M = 2.09**.

Pleurocystidia none noted.

Habit and habitat gregarious on mossy, calcareous soil in a coniferous forest of *Picea abies* (L.) H. Karst. **IUCN**. **Habitat:** 1. Forest & Woodland; 1.4 Temperate Forest. **Italian Ecoregion**: 1 Temperate Division; 1A Alpine Province; 1A1 Western Alps Section; 1A1b North-western Alps Subsection.

ITALY: Val d'Aosta, Champ Premier, Fenis (AO), (N45.717805, E 7.480444, alt. 1311 m a.s.l.), *Picea abies*, Sept. 13 2017, D. Tamone (GDOR FB4099; EG170913.01; HJB20663).

Additional collections cited: Tuscany, Monte Cetona, Sarteano (SI), (Approx. N42.924055, E11.87775, alt. 1000 m a.s.l.), summit grassland with *Ophryis bertoloni* Moretti, *Orchis pauciflora* Ten. and *O. tridentata* Scop., surrounded by a forest with *Acer* sp., *Fagus* sp., *Fraxinus* sp., *Ostrya* sp. and *Quercus* sp., Nov. 08 2007, L. Pecoraro (MSIENA-908311; EG071108.01). Most likely,

Fig. 1.0. *Hebeloma sordescens* (EG170913.01). Photo credit: Fabrizio Boccardo

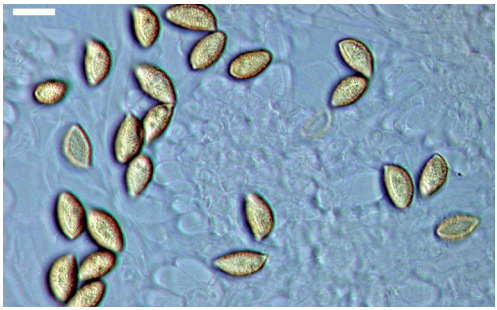

Fig. 1.1. *H. sordescens* (EG170913.01). Spore ornamentation. Scale bar 10 μm. Photo credit: Alessandro Fellin

Fig. 1.2. *H. sordescens* (EG170913.01). Spores in Melzer's. Scale bar 10 μm. Photo credit: Alessandro Fellin

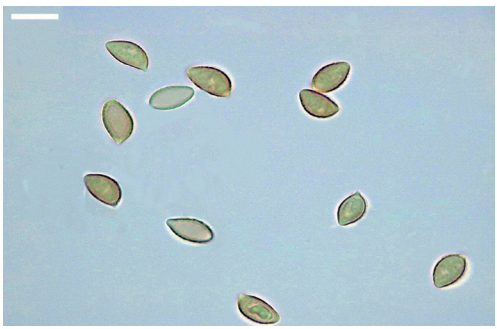

Fig. 1.3. *H. sordescens* (EG170913.01). Spores in KOH. Scale bar 10 μm. Photo credit: Alessandro Fellin

this is *H. pseudofragilipes* Beker, Vesterh. & U. Eberh. **Tuscany,** Nature Reserve Forest of Berignone and forest of Tatti, Volterra (PI), (approx. N43.335833, E10.9425, alt. 420 m a.s.l.), deciduous woodland with *Quercus* sp., Oct. 10 1994, A. Laganà & E. Salerni (SIENA-3921; EG941010.01). This is *H. celatum.* **Tuscany,** Monte Morio, Siena (SI), (N43.342222, E11.221833, alt. 490 m a.s.l.), deciduous broadleaf woodland with *Quercus* sp., Nov. 15 1994, C. Barluzzi & C. Perini (MSIENA-392211; EG941115.01). This is *H. celatum.*

Fig. 1.4. *H. sordescens* (EG170913.01). Cheilocystidia. Scale bar 10 μm. Photo credit: Alessandro Fellin

Notes and comments

The obvious velar remnants on both pileus margin and stipe apex, the amygdaloid, strongly dextrinoid spores and the typical lageniform or ventricose cheilocystidia qualify, unmistakably, this material as a member of *H.* sect. *Hebeloma* subsect. *"subsect.1".* At present, the subsection includes 10 species: *Hebeloma cistophilum* Maire, *H. discomorbidum* (Peck) Peck (= *H. clavulipes*, *H. oreophilum*), *H. fuscatum* Beker & U. Eberh., *H. grandisporum* Beker, U. Eberh. & A. Ronikier, *H. monticola* Vesterh., *H. nigellum* Bruchet, *H. paludicola* Murrill (= *H. hygrophilum*), *H. praeolidum* A.H. Sm., V.S. Evenson & Mitchel, *H. spetsbergense* Beker & U. Eberh. and *H. sordescens.* Regarding the above synonymies, see Eberhardt *et al.* (2022), Eberhardt *et al.* (2023a) and Grilli & Fellin (2024).

Hebeloma praeolidum, originally described from the United States (Smith 1983; Eberhardt *et al.* 2023b), and *H. spetsbergense* (Monograph: 180) first reported from the Svalbard archipelago,

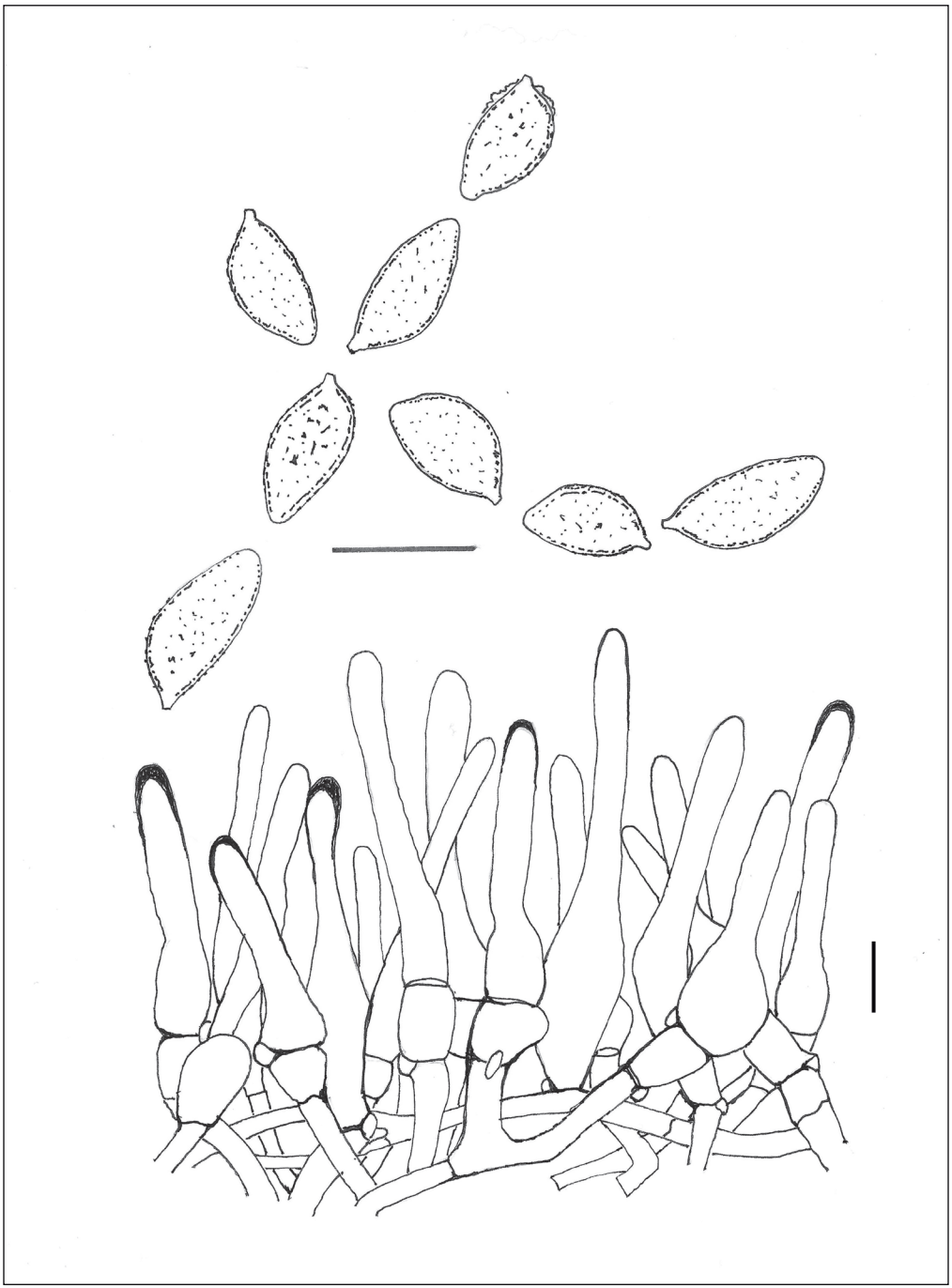

Fig. 1.5. *Hebeloma sordescens* (EG170913.01). Spores and cheilocystidia. Scale bars 10 µm. Plate credit: Edmondo Grilli

can be left out of consideration. The first, based on present knowledge, has been recorded only from Canada and the United States, while the second, occurring also in Canada, Greenland, Russian Federation and United States, in Europe has been reported only from the arctic tundra or the alpine shrubland of Norway.

Hebeloma cistophilum can also be excluded at least because of the nil to very weak dextrinoidity (D0 D1) and the peculiar variability of its spore shape (usually ellipsoid, but also amygdaloid and ovoid). Further, *H. fuscatum* and *H. nigellum* can be ruled out on the lower lamellar density (L 20-36) and avg. spore width (≥ 7.0 μm). Likewise, *H. paludicola* differs in lamellar density (23-36) and avg. spore size (≥ 11 μm in length and ≥ 6.2 μm in width) and *H. grandisporum*, in the much lower lamellar density (L 10-18) and exceedingly larger spores (≥ 14.2 × 8.8 μm) (See **Tables 1**, below). There remain *H. discomorbidum, H. monticola* and *H. sordescens*, which are rather close regarding lamellar density and avg. spore size. Overall, the avg. spore width (< 6.0 μm), the warm pileal colours of the above-described material and the partly blackening basidiomes in exsiccata appear to be more typical of Vesterholt's species and a comparison of all quantitative data reveals a perfect match, but for a negligible difference in the A/M ratio. The growth on mossy soil in coniferous forests of *Picea* is also the one most often recorded (44%) for *H. sordescens*. Other, if less frequent, hosts are *Betula* (33%), and much more rarely *Alnus* sp., *Corylus* sp., *Fagus* sp. and *Populus* sp.

The morphological identification has received the full support of molecular sequence data. *Hebeloma sordescens* is recovered as monophyletic and with good bootstrap support by all nuclear loci, including ITS, but it is paraphyletic in the results of the mitochondrial loci (V6 and V9) as most of its cosectional members (Monograph: 179).

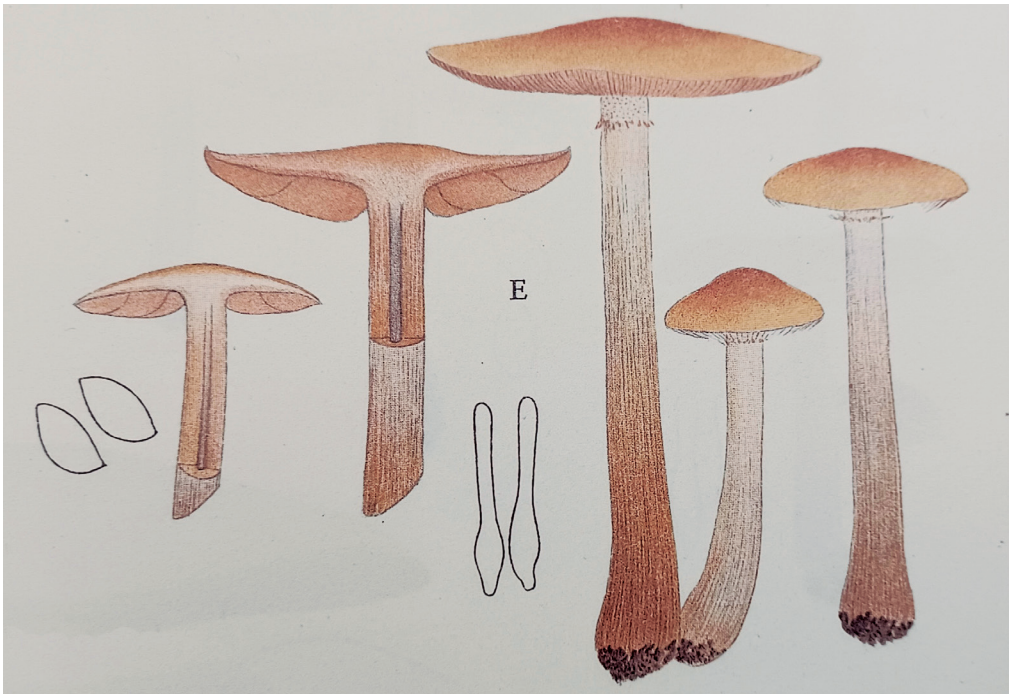

Fig. 2. *Hebeloma testaceum* ss Lange. Reproduced from plate 118E in *Flora Agaricina Danica V*. Society for the Advancement of Mycology in Denmark and Danish Botanical Society, Copenhagen: 4 (1940)

Hebeloma sordescens is a replacement name proposed by Vesterholt (1989) as an explicit substitute for *H. testaceum* in the sense of Lange. Lange (1938) was, in fact, the first author to provide an unequivocal characterization of the species as a member of *Hebeloma* sect. *Hebeloma*, describing and illustrating the species as being cortinate, amygdaloid-spored and with ventricose cheilocystidia (see **Figure 2**). The thorny interpretative problems arising from *Agaricus subtestaceus* Batsch (Batsch 1789) and *A. testaceus* Fr. (Fries 1836-1838), a superfluous name change and a misinterpretation of the former, were analysed and discussed in Grilli *et al.* (2015), from which the concluding remark is reported *in extenso*:

"*In summary, with a view to preserving nomenclatural stability, the only satisfactory solution is to designate Batsch's figure 198 as lectotype of A. subtestaceus Batsch and A. testaceus Fr., which conforms with both protologues and to regard Batsch's name as doubtful and use for each of the taxa that this might represent a modern name for which there is a type specimen, a complete description and also a molecular characterization.*"

According to the records on the Database, the species is mostly confined to Europe (97.5%), occasional finds, in fact, have been reported only from Temperate Asia (Russian Federation) (2.5%). Within Europe, the records are from Austria, Denmark, England, France, Germany, Iceland, Italy, Norway, Poland, Scotland and Sweden.

Based on present knowledge, this collection from Val d'Aosta is the first confirmed record of *Hebeloma sordescens* for the Italian territory.

De facto, in Italy, *Hebeloma sordescens* has already been reported by various authors. In particular, Salerni *et al*. 1998, Zotti & Orsino, 2001 and, more recently, Pecoraro *et al*. 2021 and Clericuzio *et al*. 2022. However, as it often happens with checklists, Salerni *et al* (1998) and Zotti & Orsino (2001) report on a collection of *H. sordescens* from Tuscany, and three collections of *H. testaceum* from Liguria respectively, without any indications of exsiccata, accession numbers and fungaria where they might be deposited. Luckily, in Pecoraro *et al.* (2021) it was indicated that specimens of the species listed in the work were deposited at SIENA and so it was possible to loan and study the related voucher material (MSIENA-908311), which is the same material also cited in Clericuzio *et al.* (2022).

Three Tuscan collections held at SIMUS previously identified as *Hebeloma sordescens*

Tuscany: Monte Cetona, Sarteano (SI), (Approx. N42.924055, E11.87775, alt. 1000 m a.s.l.), summit grassland with *Ophryis bertoloni*, *Orchis pauciflora* and *O. tridentata*, surrounded by a forest with *Acer* sp., *Fagus* sp., *Fraxinus* sp., *Ostrya* sp. and *Quercus* sp., Nov. 08 2007, L. Pecoraro (**MSIENA-908311**; EG071108.01). Nature Reserve Forest of Berignone and forest of Tatti, Volterra (PI), (approx. N43.335833, E10.9425, alt. 420 m a.s.l.), deciduous woodland with *Quercus* sp., Oct. 10 1994, A. Laganà & E. Salerni (**SIENA-3921**; EG941010.01). Monte Morio, Siena (SI), (N43.342222, E11.221833, alt. 490 m a.s.l.), deciduous broadleaf woodland with *Quercus* sp., Nov. 15 1994, C. Barluzzi & C. Perini (**MSIENA-392211**; EG941115.01).

Notes and comments

MSIENA-908311. The clavate-lageniform main shape of cheilocystidia rules out the possibility that this material is a member of *Hebeloma* sect. *Hebeloma* s.l. In particular, such a shape is typically observable in members of *H.* sect. *Denudata* subsect. *Clepsydroida* or subsect. *Hiemalia*. The very pale, cream colour of the pileus in the exsiccata and the rough estimate of lamellar density by the exsiccata, plus the weak spore dextrinoidity and the quantitative microanatomical data suggest that, morphologically, this material is to be attributed to *Hebeloma pseudofragilipes*, a species that is rather common and widespread in Italy.

SIENA-3921. Microanatomical data, in particular the shape of cheilocystidia, mostly clavate-ventricose, less frequently ventricose, occasionally gently clavate, together with sporal data and

parameters, provide sufficient morphological evidence that this material is to be attributed to *Hebeloma celatum* (*H.* sect. *Velutipes*).

MSIENA-392211. The strong to very strong spore dextrinoidity (D3 D4) and the shape of cheilocystidia, mostly clavate-ventricose, less frequently ventricose and at times gently clavate, provide sufficient morphological evidence that also this material is to be attributed to *Hebeloma celatum* (*H.* sect. *Velutipes*).

Tables 1. Comparison of *Hebeloma sordescens*

	Sp. Length	Sp. Width	Sp. Q	Ch. L	Ch. A	Ch. M	Ch. B
H. discomorbidum	10-12.2	5.8-7.5	1.51-2.10	34-60	4.1-6.5	3.8-6.3	6.5-12.2
H. fuscatum	11.5-13.6	7.1-7.5	1.58-1.89	36-54	4.2-6.3	4.1-6.1	7.9-13.3
H. grandisporum	14.2-16	8.8-9.3	1.57-1.80	41-70	5.3-6.3	4.5-5.6	8.2-10.5
H. monticola	10.5-11.5	6.2-6.9	1.56-1.78	37-56	4.3-6.4	4.1-5.4	7.1-11.1
H. nigellum	11.1-13.4	7.0-7.4	1.56-1.86	44-65	4.4-6.5	4.0-6.1	6.4-10.9
H. paludicola	11-13.2	6.2-7.0	1.62-2.0	41-64	4.4-6.3	4.0-6.0	6.9-11.4
H. sordescens	10-12.2	5.5-6.8	1.60-1.93	41-69	4.0-5.0	3.9-4.9	6.6-9.4
EG170913.01	10.7	5.8	1.84	44	4.7	4.1	8.5

	Lam.	Spore Codes			Cheilocystidium Ratios		
	L	O	P	D	A/M	A/B	B/M
H. discomorbidum	42-60	(O1) O2	P0 (P1)	D2 D3	0.87-1.46	0.42-0.81	1.49-2.40
H. fuscatum	24-32	O1 O2	P0 (P1)	D2 D3	0.90-1.17	0.46-0.67	1.75-2.56
H. grandisporum	10-18	O1 O2	P0	D2 D3	1.02-1.44	0.53-0.75	1.48-2.03
H. monticola	50-64	O2 O3	P0 P1	D2 D3	1.01-1.25	0.50-0.89	1.42-2.21
H. nigellum	20-36	O1 O2	P0	D2 D3	0.92-1.41	0.45-0.89	1.45-2.30
H. paludicola	23-36	(O1) O2	P0 P1	D3 D3	0.89-1.24	0.36-0.71	1.54-2.52
H. sordescens	42-60	O2	P0 P1	D3	0.83-1.13	0.40-0.70	1.59-2.27
EG170913.01	48-50	O2	P0 P1	D3	**1.14**	0.58	2.09

Here and below, the quantitative data of all species in the tables are from the Database, repeatedly accessed during the drafting of the work. Since the ranges are subject to variation with the addition of new collections, a final check was made shortly before submission for publication. To give an idea of the reliability of the comparative data, there follows the number of collections, all checked molecularly, from which they are derived: *H. sordescens* 43, *H. discomorbidum* 141, *H. fuscatum* 29, *H. grandisporum* 5, *H. monticola* 42, *H. nigellum* 72, *H. paludicola* 51.

Hebeloma* sect. *Naviculospora Beker & U. Eberh.

Hebeloma catalaunicum Beker, U. Eberh., Grilli & Vila in *Hebeloma* (Fr.) P. Kumm.: 411 (2016)

Types: SPAIN: Girona, Mas Roures, Llagostera (Girona) (approx. N41.82, E2.89, alt. approx. 140 m a.s.l.) under *Eucalyptus* sp., Dec. 30 1997, X. Llimona, J. Vila (JV-JVG971230A).

Original diagnosis

Hebeloma catalaunicum is morphologically similar to H. nanum and H. naviculosporum. The cheilocystidia of H. catalaunicum are as diversely and irregularly shaped as is typical for H. sect. Naviculospora with average apex width greater than 5 µm and average basal width greater than 6 µm. The spores are weakly ornamented and distinctly to strongly dextrinoid, with the perispore distinctly but not constantly loosening, average length at most 11 µm and average width at least 5.7 µm. Molecular data support H. catalaunicum as an independent species related to the above named species. To date, H. catalaunicum has only been found in the Mediterranean region.

Macroscopic description (EG121124.02; HJB20684) (Figure 3.0)

Pileus 25-60 mm in diameter, subglobular to convex, then subapplanate, often lobate, margin subinvolute, shortly ribbed, bearing no universal veil remnants. Surface smooth, tacky when moist, mostly bicoloured, shades of brownish-orange (7C4; 7B3) on the discal area, gradually fading into shades of pale orangish-brown (5B/C4) towards the margin, where the ground colours are masked by a more or less thick, frosted overlay.

Lamellae emarginate, subventricose, 4-5 mm broad, density in the subcrowded range (L *ca.* 70-74); edge whitish, finely fimbriate, uneven, dry.

Stipe 20-42 × 7-11 mm, cylindraceous, with slightly enlarged base and/or flaring upwards, white tending to discolour brown on handling or with age, pruinose-flocculose; stuffed to fistulose. No cortinate velar remnants.

Context firm, whitish in the pileus, whitish to brownish especially in the cortical layers of stipe base; smell faintly raphanoid, taste not recorded.

Microscopic description (Figures 3.1, 3.2, 3.3, 3.4, 3.5 and 3.6)

Spores (8.8) 9.0 10.1 11.2 (12) × (5.0) 5.4 6.0 6.6 µm, Q = (1.55) 1.60 1.70 1.84 (1.89), broadly amygdaloid, often with a slight suprahilar flattening of the abaxial side. Ornamentation subdistinct. Myxosporium undilating to rugulose, occasionally sparingly vesiculate. Dextrinoidity weak (4B3; 4B4). Spore Code: **O2; P0 P1; D2**.

Basidia 22-34 × 6.4-9.0 µm, avg. Q = 3.4, mostly clavate, four-spored.

Cheilocystidia (30) 32 41 52 (55) × (4.0) 4.8 7.4 9.6 (12) × (3.2) 3.8 4.5 5.6 (6.0) × (2.4) 5.6 6.9 8.8 (9.6) µm, lamellar edge not entirely sterile. Shape clavate-lageniform or clavate-ventricose, often irregular, at times ventricose or clavate-stipitate. Occurrence of special features: refringent wall thickening at times apical or median-ventral; apex occasionally bifid; rarely septate. Cheilocystidium Ratios: **A/M = 1.63; A/B = 1.11; B/M = 1.56**.

Pleurocystidia none noted.

Habit and habitat gregarious to caespitose on calcareous soil, in leaf litter under *Cistus salvifolius* L. in mixed Mediterranean woodland with also *C. albidus* L. and sparse *Pinus pinaster* Aiton and *Quercus ilex* L. **IUCN. Habitat**: 1. Forests & Woodland; 1.4 Temperate Forest (Includes Mediterranean forests). **Italian Ecoregion:** 2 Mediterranean Division; 2A Italian Part of Ligurian-Provencal Province.

ITALY: Liguria, Punta Baffe, Sestri Levante (GE), (N44.252305, E9.437611; alt. 160 m a.s.l.), *Cistus salvifolius*, *C. albidus*, *Pinus pinaster* and *Quercus ilex*, Nov. 24 2012, F. Boccardo (GDOR FB2892; EG121124.02; HJB20684).

Additional collections cited: Sardinia, Campidano, Serramanna (CA), (approx. N39.422514, E8.921749, alt. 40 m a.s.l.), *Eucalyptus camaldulensis* Dehnh. and *Eucalyptus* sp., Dec. 05 1992, M. Contu (EG921205.01; HJB14627). **SPAIN:** Girona, Mas Roures, Llagostera (Girona) (approx. N41.82, E2.89, alt. approx. 140 m a.s.l.) under *Eucalyptus* sp., Dec. 30 1997, X. Llimona, J. Vila (JV-JVG971230A). This is the type of *Hebeloma catalaunicum.*

Fig. 3.0. *Hebeloma catalaunicum* (EG121124.02). Photo credit: Fabrizio Boccardo

Fig. 3.1. *H. catalaunicum* (EG121124.02). Spore ornamentation. Scale bar 10 µm. Photo credit: Alessandro Fellin

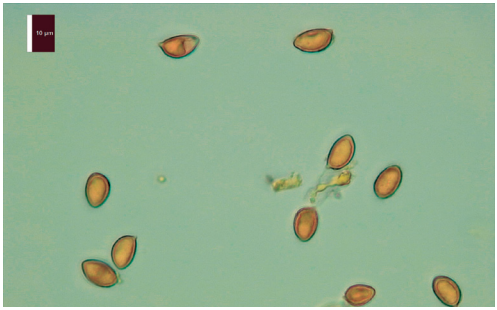

Fig. 3.2. *H. catalaunicum* (EG121124.02). Spores in Melzer's. Scale bar 10 µm. Photo credit: Alessandro Fellin

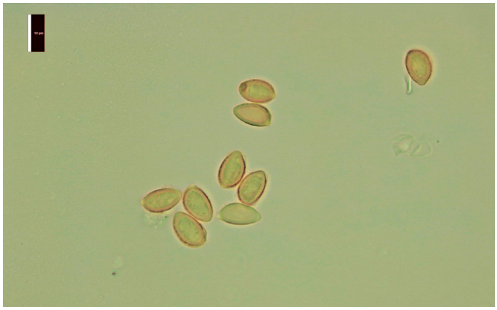

Fig. 3.3. *H. catalaunicum* (EG121124.02). Spores in KOH. Scale bar 10 µm. Photo credit: Alessandro Fellin

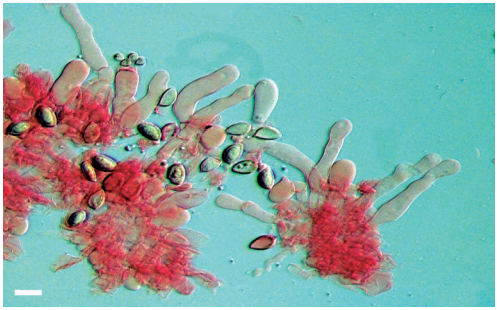

Fig. 3.4. *H. catalaunicum* (EG121124.02). Cheilocystidia. Scale bar 10 µm. Photo credit: Alessandro Fellin

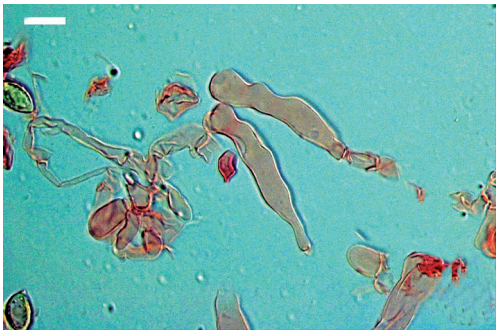

Fig. 3.5. *H. catalaunicum* (EG121124.02). Cheilocystidia. Scale bar 10 µm. Photo credit: Alessandro Fellin

Notes and comments

Pileus colours and the often irregular, clavate-ventricose shape of cheilocystidia, along with the subdistinct ornamentation and the weak but distinct dextrinoidity of the spores, provided substantial evidence suggesting that a likely placement of this collection was in *Hebeloma* sect. *Naviculospora*. However, its identification to species remained doubtful, because of a significant discrepancy in the average width of cheilocystidium apex, when compared with that of all members of the section, to become certain only after the outcome of the phylogenetic analysis.

Until a few months ago, the section included a rather limited number of taxa: *Hebeloma naviculosporum* Heykoop, G. Moreno & Esteve-Rav., type species of the group, *H. catalaunicum* and *H. nanum* all of them described from Europe. Recently, three more have been added from North America: *H. subfastibile* Murrill 1945, *H. subaustrale* Murrill 1946 and *H. pungens* A.H. Sm., V.S. Evenson & Mitchel 1983 (Eberhardt *et al*. 2023a, Eberhardt *et al*. 2023b), while *H. islandicum* Beker & U. Eberh., at first also placed in this section, has informally been transferred into a section of its own *H.* sect. *"Islandica"* (Hebeloma.org).

Based on present knowledge, the average spore width of the above-described collection suggested ruling out *H. naviculosporum* and *H. nanum*, both of which have narrower spores, and considering a likely identification as *H. catalaunicum.* However, if the quantitative and qualitative sporal data are perfectly comparable, the average width of the apex of cheilocystidia, often a crucial character in the genus, is significantly higher than in both *H. catalaunicum* and, for that matter, the other two European taxa (see **Tables 2**, below). Moreover, a further comparison with the data of the additional, three North American taxa did not reveal any potential match worth considering.

It was then weighed a possible affinity with members of *H.* sect. *Theobromina*, most of which share similar spore and cheilocystidium features and, additionally, often associate with *Cistus* in Mediterranean environment. Within the section, the rather conspicuous average width of the apex of cheilocystidia, together with the pileal colours (very similar to those of the specimens in the photograph of the holotype, (Eberhardt *et al*. 2009) and the congruity of almost all other quantitative data, appeared to offer enough evidence that *Hebeloma plesiocistum* Beker, U. Eberh. & Vila might be the species name befitting this collection. Yet, its higher lamellar density and weaker spore dextrinoidity kept arousing nagging doubts.

Therefore, it did not come as an utter surprise when sequence data revealed that this material after all does belong in *Hebeloma.* sect. *Naviculospora* and is phylogenetically resolved in the *Hebeloma catalaunicum* clade, despite the more voluminous apex of cheilocystidia, significantly exceeding the upper limit of the range so far assessed for this species. It is to be considered, however, that the number of collections of *H. catalaunicum* studied to date is still rather limited (8) and that the morphological quantitative delimitation of any species is a hypothesis based on an inductive generalization. The higher the number of observational data on which it is based, the more numerous the cases in which the hypothesis will be corroborated, but eventually it is destined to be falsified. This appears to be a case in point, because the average apex width of cheilocystidia was double-checked in the same sample, but the quantitative result was almost the same. A further check by A.F., using a different sample from the same collection and a different method of taking measures

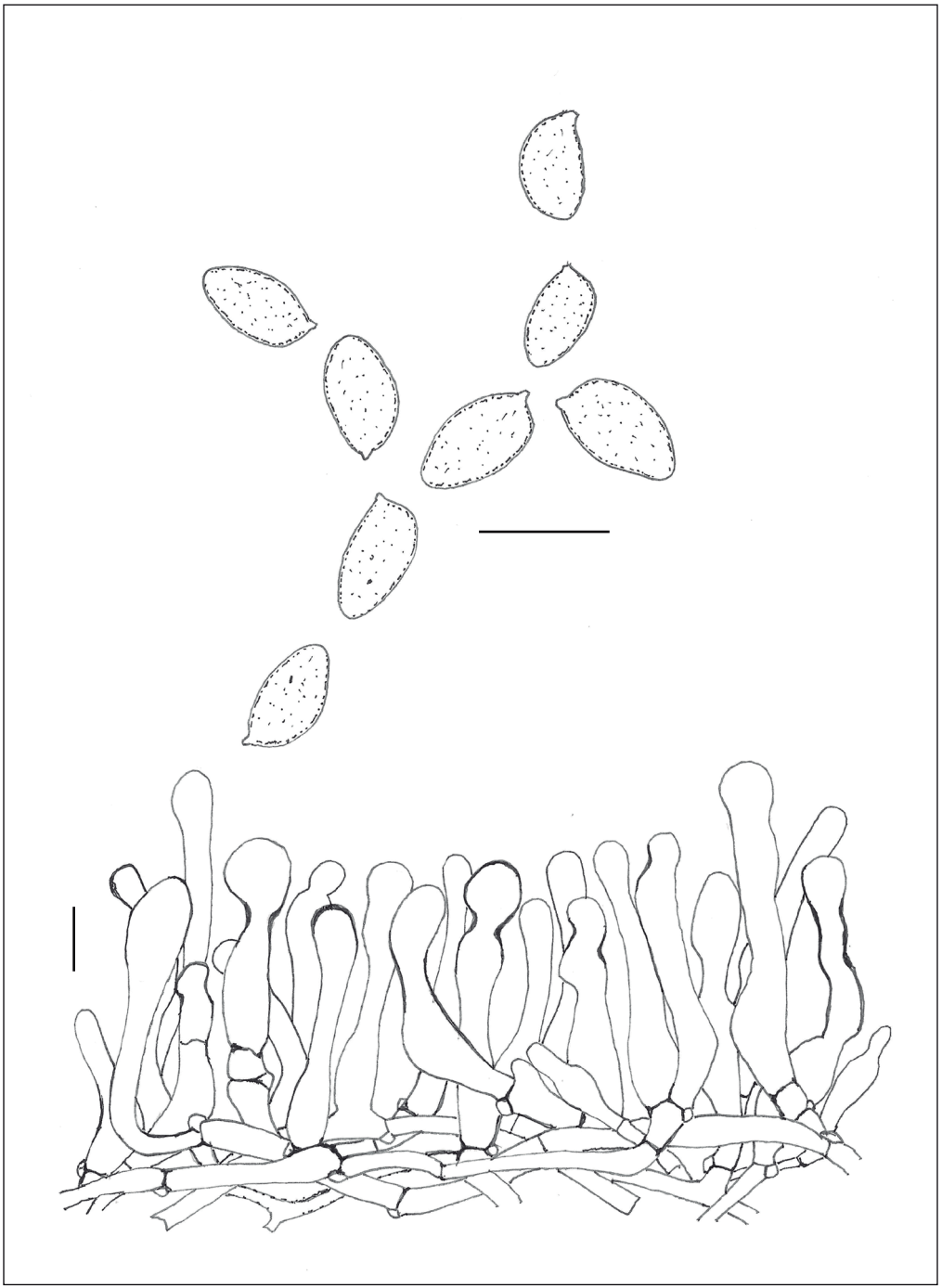

Fig. 3.6. *Hebeloma catalaunicum* (EG121124.02). Spores and cheilocystidia. Scale bars 10 μm. Plate credit. Edmondo Grilli

(software instead of a micrometer), gave an even higher avg. width (7.8 μm). In the additional collection from Sardinia (EG921205.01; HJB14627) - regrettably, lacking any photographic illustration - the average width of cheilocystidia falls within the range recorded in the Database and, obviously, so does that of the holotype (see **Tables 2** below and **Figures 3.7, 3.8**).

Molecularly, *Hebeloma catalaunicum* is resolved in a distinct clade by any of the nuclear loci (ITS, *RPB2*, *Tef1a*), but the mitochondrial loci (V6, V9) do not separate it from *H. nanum* (Monograph: 413; Hebeloma.org).

Given the limited number of collections available, it is difficult to hold an informed opinion on the habitat preferences of this species. It most commonly associates with *Eucalyptus* (75%) and *Pinus* (25%), when the host is a single species, but when a number of associates is possible, on the Database are also recorded putative associations with *Arbutus*, *Cedrus*, *Cistus* and *Quercus.*

Hebeloma catalaunicum appears to occur only in Europe, where it has been reported from Italy, Portugal and Spain, always in Mediterranean habitats. In Italy, one confirmed record is from Calabria, two from Sardinia and now one from Liguria.

Tables 2. Comparison of *Hebeloma catalaunicum*

	Sp. length	Sp. width	Sp. Q	Ch. L	Ch. A	Ch. M	Ch. B
H. plesiocistum	9.4-11.9	6.0-6.4	1.58-1.85	36-46	6.7-8.1	3.9-4.7	5.3-7.1
H. subaustrale	8.6-9.9	4.6-5.3	1.73-2.09	29-43	4.5-6.3	4.1-5.1	4.9-6.8
H. subfastibile	10.5-11.3	5.1-5.7	2.0-2.08	27-34	3.6-6.3	3.5-5.9	3.8-5.0
H. pungens	10.5-11	5.6-5.8	1.81-1.99	28-40	5.2-6.6	4.6-4.7	4.9
H. naviculosporum	10.2-11.6	4.6-5.5	2.01-2.40	23-44	4.7-6.4	3.9-5.5	4.1-6.1
H. nanum	7.9-10	4.2-5.0	1.64-2.03	19-39	4.4-5.8	3.8-5.2	3.6-5.3
H. catalaunicum	9.6-11.2	5.7-7.2	1.55-1.73	27-41	5.3-6.6	3.9-4.9	5.1-7.0
JV-JVG971230A	10.2	6.1	1.68	38	5.6	4.3	6.8
EG921205.01	10.3	6.3	1.64	42	6.4	4.8	6.3
EG121124.02	10.1	6.0	1.70	41	**7.4-7.8**	4.5	6.9

	Lam.	Spore Codes			Cheilocystidium Ratios		
	L	O	P	D	A/M	A/B	B/M
H. plesiocistum	52-60	O1 O2	P0 (P1)	D3 D4	1.52-1.85	1.0-1.28	1.37-1.57
H. subaustrale	80-92	O1 O2	(P0) P1(P2)	D2 D3	1.04-1.48	0.84-1.31	1.20-1.36
H. subfastbile	52-64	O1 O2	P0 (P1)	D1 D2	1.02-1.57	0.90-1.45	0.89-1.28
H. pungens	68-72	O1 O2	P0P1P2	D3 D4	1.12-1.68	1.05-1.63	1.08-1.14
H. naviculosporum	60-88	O2 O3	P1 P2	(D2) D3	1.07-1.41	0.98-1.38	0.85-1.17
H. nanum	48-108	O1 O2	P0P1(P2)	D1D2D3	0.89-1.38	0.95-1.54	0.83-1.19
H. catalaunicum	70-120	O2	P0 P1	(D2) D3	1.15-1.69	0.82-1.13	1.25-1.78
JV-JVG971230A	80	O2	P0 P1	D2 D3	1.33	0.85	1.60
EG921205.01	80	O1 O2	P0 P1	D2 D3	1.38	1.13	1.37
EG121124.02	70-74	O2	P0 P1	D2	1.63	1.11	1.56

Number of collections in the Database: *Hebeloma plesiocistum* 7, *H. naviculosporum* 13, *H. nanum* 44, *H. catalaunicum* 9, *H. subaustrale* 8, *H. subfastibile* 4, *H. pungens* 2.

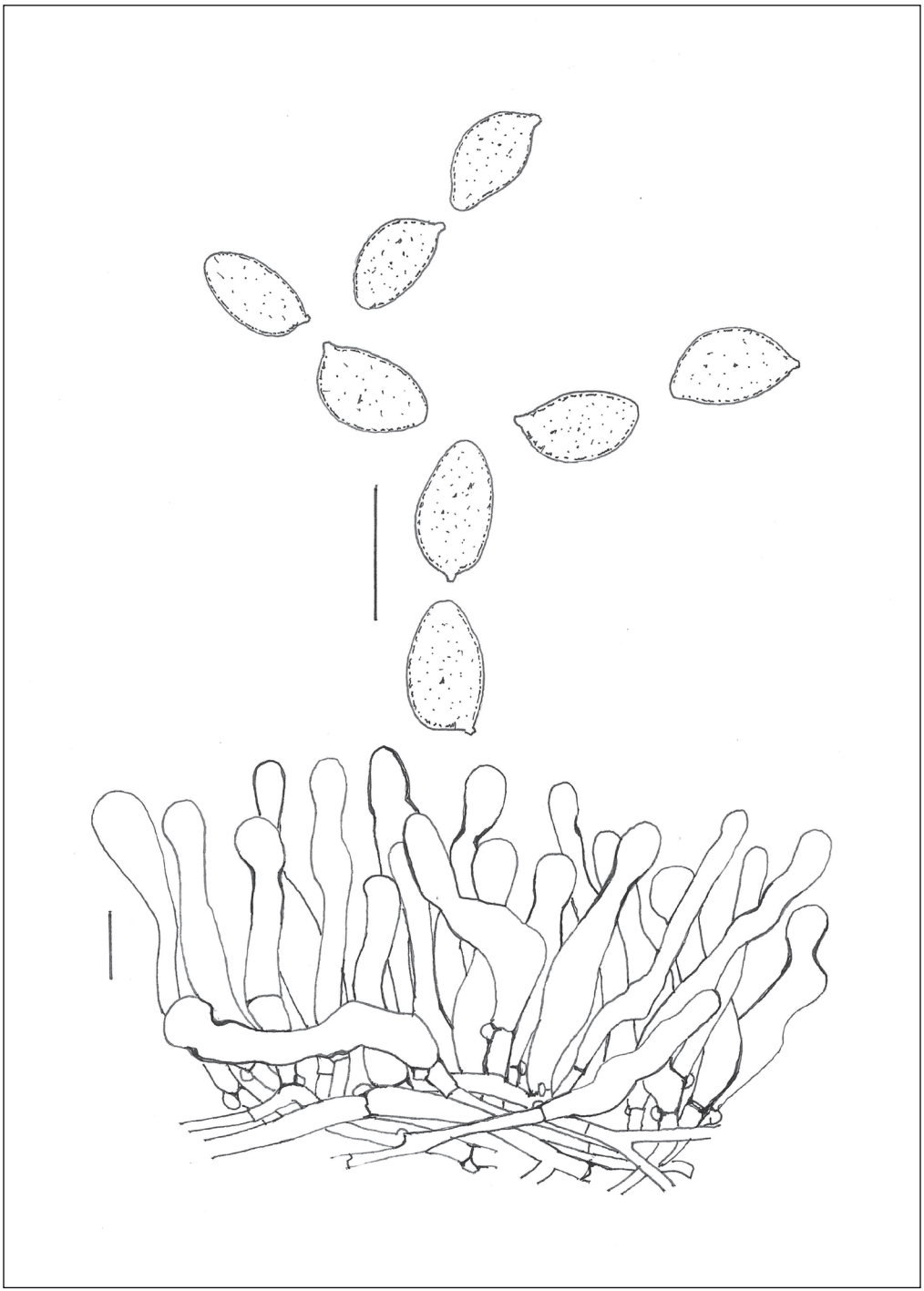

Fig. 3.7. *Hebeloma catalaunicum* (EG921205.01). Spores and cheilocystidia. Scale bars 10 μm. Plate credit: Edmondo Grilli

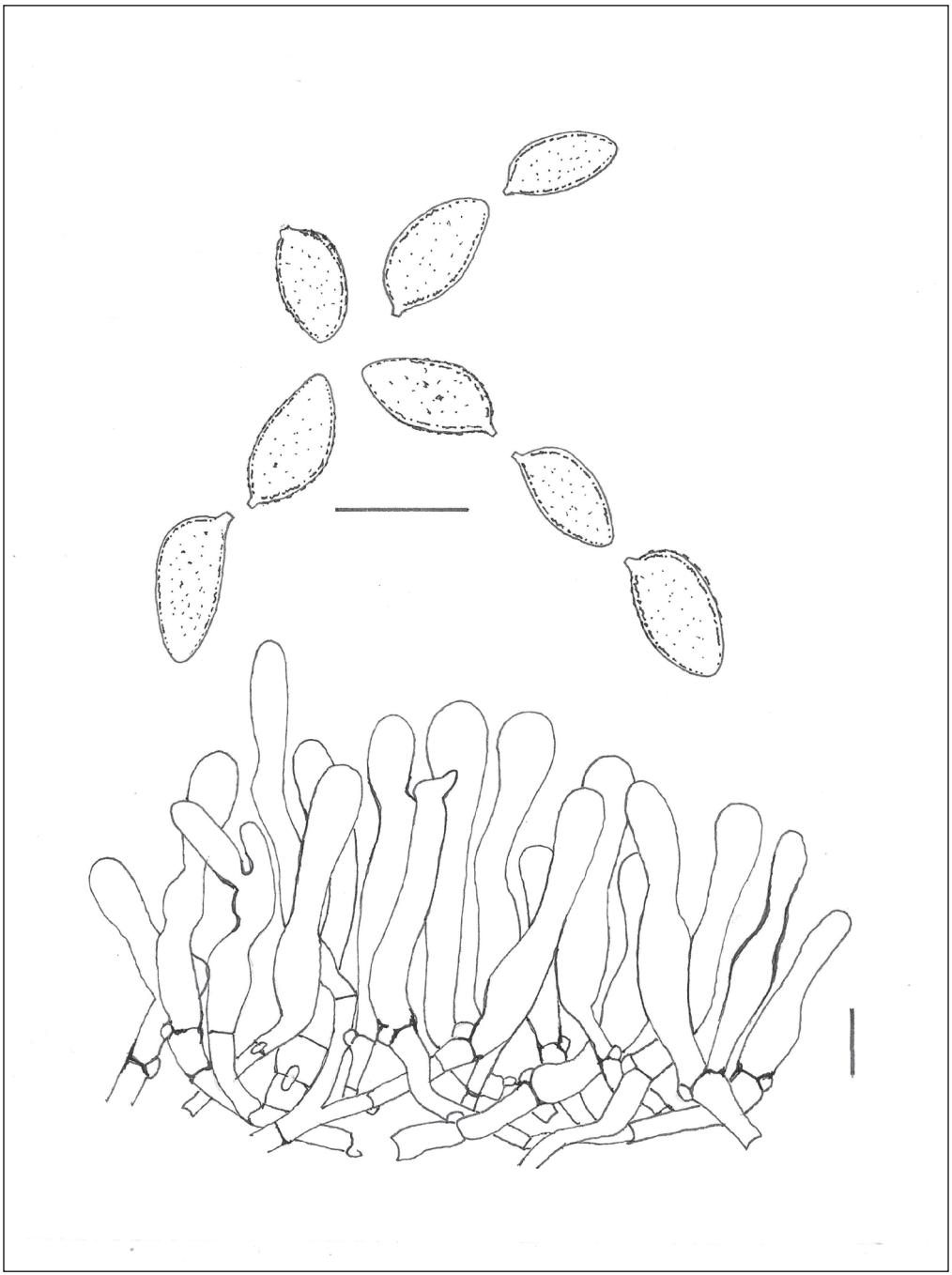

Fig. 3.8. *Hebeloma catalaunicum* (JV-JVG971230A). This is the type. Spores and cheilocystidia. Scale bars 10 μm.
Plate credit: Edmondo Grilli

Hebeloma nanum Velen., *Nov. Mycol.* L. Soucek, Prague: 117 (1939)

Types: CZECH REPUBLIC: Bohemia, SE of Prague, Mirosovice, Mnichovice (approx. N49.9349, E14.7097, alt. approx. 355 m a.s.l.) in dry woodland under *Picea* sp., 20 Jun. 1936, J. Velenovsky (Holotype. herbarium acc. no. PRM153761).

Heterotypic synonyms: *H. crustuliniforme* f. *microspermum* Hongo, *J. Jap. Bot.* **41** (6): 169 (1966); *Hebeloma sordidum* var. *microsporum* Saini & Atri, *Geobios New Reports* **4**: 2 (1985).

English translation of the original diagnosis

Hebeloma nanum sp. nov. Fasciculate, 3-5 together. Fleshy, pileus 3-4 cm, quickly expanding, bluntly and slightly umbonate, shiny, viscous when moist, not hygrophanous, sordid, pallescent, ochraceous at centre. Stipe equal, 8-10 mm broad, stiff, solid, purely white, entirely granulose-squamulose. Lamellae crowded, narrow, attenuate towards end, clay-coloured. Spores fusiform, pale yellow, 6-9 μm. Cystidia filiform, straight, blunt, septate, 25 μm. Context with unpleasant smell. In dry Picea forest near Mnichovice, June 1926. Close to the former species (H. octavii), equally vernal. Distinguished by the short, hard stipe.

Given the paucity of Italian collections of this taxon, the two new collections are fully described separately.

Macroscopic description (EG151229.01; HJB20682) (Figure 4.0)

Pileus 20-60 mm in diameter, plano-convex, subapplanate to applanate-depressed, lobate, margin inflexed to straight, shortly ribbed, then smooth, without any remnants from the universal veil. Surface smooth, tacky when moist, occasionally with darker hygrophanous zones, mostly bicoloured, but colours slightly contrasting, pale reddish-brown (5YR6/4) on the disc, shades of pinkish-yellow (7.5YR7.5/4; 8/4) on the peridiscal area and much paler towards the margin where the ground colour is masked by a pinkish-white frosted overlay, or of a uniform pinkish-yellow colour excepting the frosted marginal area.

Lamellae emarginate, subventricose to ventricose, 2-4 (6) mm broad, occasionally intervenose, density in the close to subcrowded ranges (L *ca.* 50-60); edge paler, fimbriate, dry.

Stipe 20-45 × 4.0-8.0 mm, cylindraceous, mostly clavate at base, white at first, then dingy whitish to brownish, pruinose-floccose over the upper third, fibrillose elsewhere; stuffed to fistulose. No cortinate velar remnants.

Context firm, dingy whitish; smell faintly raphanoid, taste not recorded.

Microscopic description (Figures 4.1, 4.2, 4.3, 4.4 and 4.5)

Spores (8.4) 9.6 10.3 11.8 (12) × (4.2) 4.6 4.9 5.5 (5.6) μm, Q = (1.85) 1.90 2.08 2.24 (2.40), shape mostly fusoid, less frequently amygdaloid. Ornamentation hypo- to subdistinct. Myxosporium undilating to rugulose, less frequently more or less scantily vesiculate. Dextrinoidity strong, slowly very strong (6B/C4; 7B/C4; 7C5). Spore Code: **O1 O2; P1 P2; D3**.

Basidia 20-30 × 6.4-8.0 μm, avg. Q = 3.6, clavate to clavate-constricted, four-spored.

Cheilocystidia (20) 23 31 41 (42) × (3.8) 4.3 5.3 6.2 (6.6) × (3.0) 3.2 3.9 4.6 × (2.2) 2.4 5.1 6.4 (7.2) μm, lamellar edge sterile. Somewhat small, shape mostly clavate-lageniform or clavate-ventricose, but often irregularly so, less frequently cylindroid, lageniform or gently clavate. Occurrence of special features: apex at times mucronate; often sinuous. Cheilocystidium Ratios: **A/M = 1.36; A/B = 1.17; B/M = 1.29**.

Pleurocystidia none noted.

Fig. 4.0. *Hebeloma nanum* (EG151229.01). Photo credit: Fabrizio Boccardo

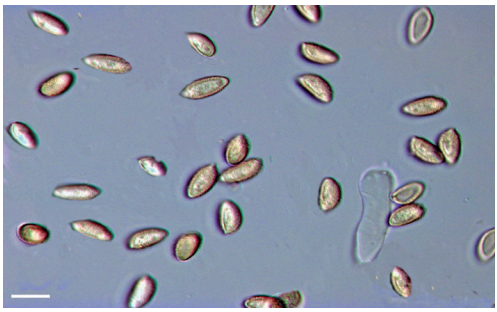

Fig. 4.1. *H. nanum* (EG151229.01). Spore ornamentation, Scale bar 10 μm. Photo credit: Alessandro Fellin

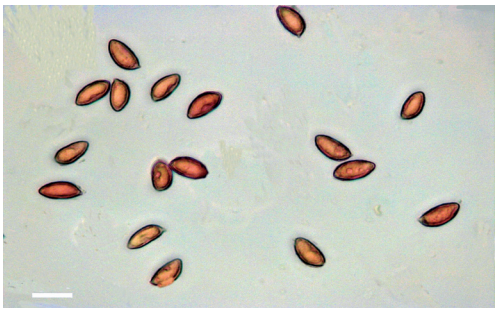

Fig. 4.2. *H. nanum* (EG151229.01). Spores in Melzer's. Scale bar 10 μm. Photo credit: Alessandro Fellin

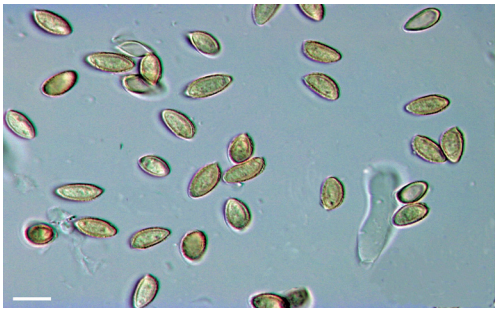

Fig. 4.3. *H. nanum* (EG151229.01). Spores in KOH. Scale bar 10 μm. Photo credit: Alessandro Fellin

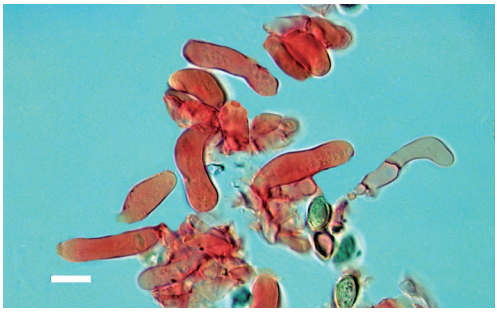

Fig. 4.4. *H. nanum* (EG151229.01).). Cheilocystidia. Scale bar 10 μm. Photo credit: Alessandro Fellin

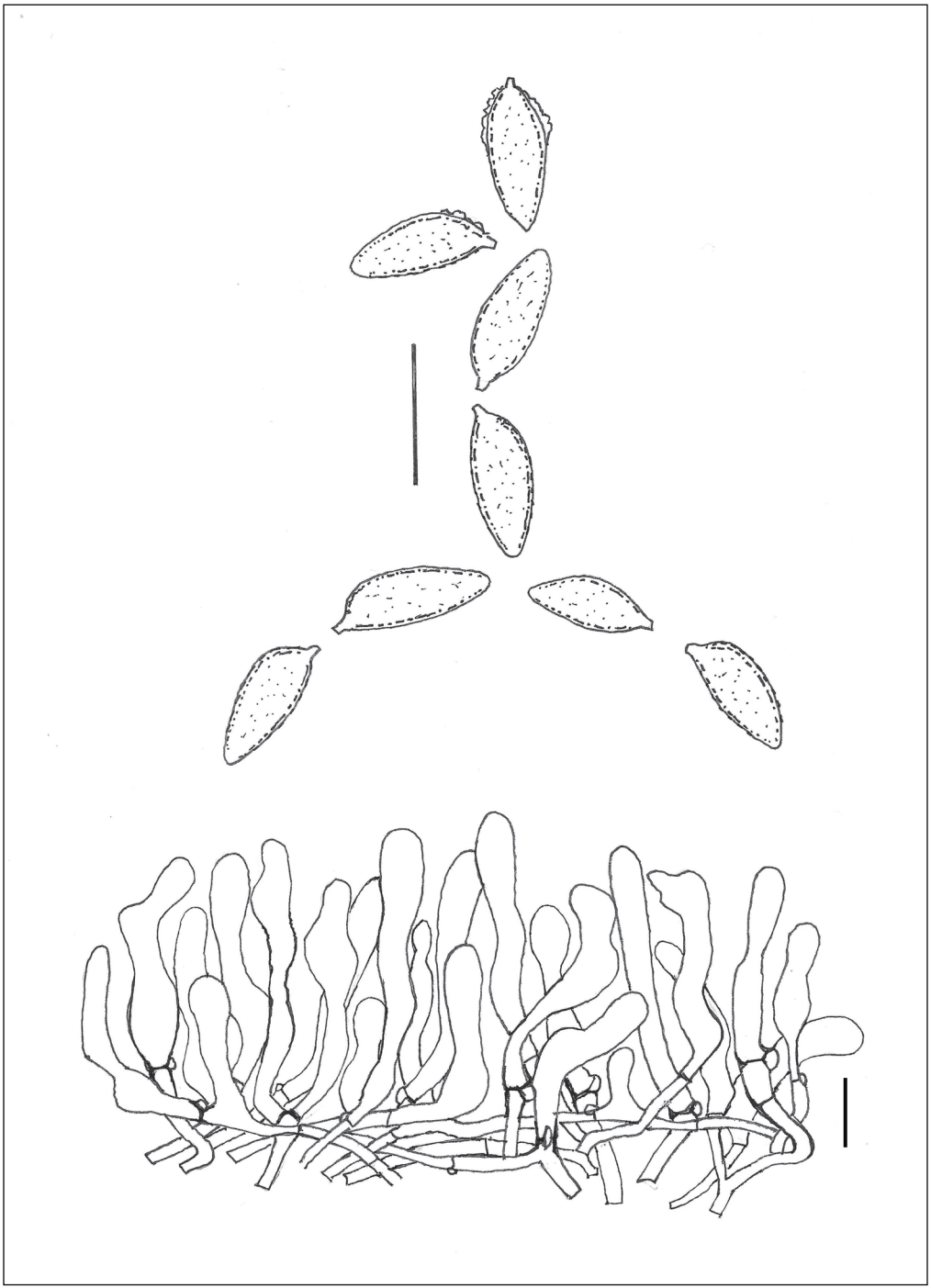

Fig. 4.5. *Hebeloma nanum* (EG151229.01). Spores and cheilocystidia. Scale bars 10 µm. Plate credit: Edmondo Grilli

Habit and habitat gregarious to caespitose on calcareous, sandy soil, among vegetal debris, in association with *Cistus salvifolius*, in Mediterranean woodland with *C. albidus* and sparse *Pinus pinaster* and *Quercus ilex*. **IUCN Habitat**: 1. Forests & Woodland; 1.4 Temperate Forest (Includes Mediterranean forests). **Italian Ecoregion**: 2 Mediterranean Division; 2A1a Italian Part of Ligurian-Provencal Province.

ITALY: Liguria. Punta Baffe, Sestri Levante (GE), (N44.252305, E9.437611, alt. 160 m a.s.l.), *Cistus salvifolius*, *C. albidus*, *Pinus pinaster* and *Quercus ilex*. Dec. 29 2015, F. Boccardo (GDOR FB3801; EG151229.01; HJB20682).

Macroscopic description (EG980924.01; HJB20680) (Figure 4.6)

Pileus 20-40 mm, convex to plano-convex, at times umbonate, suborbicular or lobate, margin inflexed, smooth, showing no universal veil remnants. Surface slightly viscid when moist, smooth, bicoloured, shades of reddish-brown (2.5YR5/4) or pinkish (5YR7/4; 8/5) to reddish-yellow (5YR7/6) on the disc, fading into whitish towards the margin where is present a shiny white frosted overlay.

Lamellae emarginate to narrowly adnate, subventricose, relatively narrow, 3-4 mm broad, subcrowded (L *ca.* 64); edge subconcolorous, finely fimbriate, dry.

Stipe 30-60 × 3-6 mm, cylindraceous, at times slightly tapered downwards, whitish, showing no noteworthy brown discolouration, flocculose on the upper third; stuffed. No cortinate velar remnants.

Context hardly fleshy, whitish, firm; smell complex sweetish-aromatic mixed with an unpleasant component, calling to mind *H. saccharioleus* and *Hygrophorus cossus*, taste bitterish.

Microscopic description (Figure 4.7)

Spores (8.0) 8.2 9.5 10.5 (11) × (4.4) 4.6 5.0 5.4 (5.5) µm; Q = (1.71) 1.74 1.91 2.12 (2.20), mostly amygdaloid, less frequently subcitriform. Ornamentation hypodistinct to subdistinct. Myxosporium mostly rugulose to scantily vesiculate. Dextrinoidity soon weak to strong (5D8; 6D5-6; 7D5), even very strong (9C3; 9D5) after some time. Spore Codes: **O1 O2; P1 P2; D2 D3**.

Basidia 16-24 × 6.0-8.0 µm, avg. Q = 3.1, mostly clavate, four-spored, rarely two-spored.

Cheilocystidia (17) 19 29 40 (45) × (3.8) 4.4 5.2 6.3 (6.4) × 3.2 4.2 5.4 (5.6) × 2.0 3.8 6.0 (6.3) µm, lamellar edge substerile. Small, versiform, often obscurely clavate, subcylindraceous or clavate-lageniform, less frequently utriform, lageniform or irregular. Occurrence of special features: apex at times rostrate. Cheilocystidium Ratios: **A/M = 1.27; A/B = 1.58; B/M = 0.94**.

Habit and habitat gregarious on grassy ground in mixed broadleaf woodland under *Betula* sp. **IUCN Habitat:** 1. Forest & Woodland; 1.4 Temperate Forest. **Italian Ecoregion:** 1 Temperate Division; 1A Alpine Province; 1A2 Central and Eastern Alps Section; 1A2c Northeastern Alps subsection.

ITALY: Lombardy, Valtellina, Albosaggia (SO), (approx. N46.147222; E9.8475; approx. alt. 505 m a.s.l.), *Betula* sp., Sept. 24 1998, L. La Chiusa (EG980924.01; HJB20680).

Notes and comments

The two collections of *Hebeloma nanum* presented are rather typical in pileus colours and microanatomy (sporal and cystidial characters). The low sporal ornamentation (O1 O2), together with the strong dextrinoidity (D3), rather irregular shape of the cheilocystidia, fusoid spores shape and relative frequency of vesiculate spores provide obvious clues to *H.* sect. *Naviculospora*.

The second (EG980924.01) is perfectly congruent in quantitative values, but for a slight mismatch in A/B Ratio (1.58 vs 0.95 -1.54), and host association. The first, by contrast, is somewhat peculiar in both quantitative data and mycorrhizal partnership. Sequence data,

Fig. 4.6. *Hebeloma nanum* (EG980924.01). Photo credit: Lillo La Chiusa

unmistakably, resolve this Ligurian material in the *Naviculospora* clade and identify it as *Hebeloma nanum* and, as already noted, its gross morphology fits in with the species. However, not all microanatomical features are perfectly congruent with the current quantitative delimitation of the species. Both the avg. spore length and Q ratio do, in fact slightly exceed, the upper limit of the related ranges so far known for the species (see **Tables 3** below). As in the case of *H. catalaunicum* above, the circumstance advised double-checking the spore quantitative data, taking a new set of measures, which, however, yielded the same results for what concerns spore length and width, with only a slight reduction in the Q ratio. An additional check by A.F., using a different sample from the same collection and a different method of taking measures (software instead of a micrometer), gave an even higher avg. length (10.5 μm), but also a higher avg. width (5.3 μm) and a definitely lower Q ratio (1.98).

Since the molecular identification is unambiguous, despite the no small number of collections (44) on the Database, it is worth stressing that such quantitative mismatches widen the variability ranges of spore length, width and Q ratio so far known and, concurrently, reduce the quantitative gap with *H. naviculosporum*. *Hebeloma nanum* is well supported as monophyletic by all nuclear loci, ITS included, but the phylogenetic resolution of the mitochondrial loci V6 and V9 is ambiguous (Monograph: 419).

Regarding habitat, coniferous woodland appears to be the favoured habitat of *Hebeloma nanum*. According to the recordings on the Database, it most frequently associates with *Pinaceae* (*Pinus* 68.2%, *Picea* 9.1% and *Cedrus* 9.1%), but there are also some records of broadleaf partnership (*Betula* 9.1% and *Castanea* 4.5%). When it grows in mixed woodland, the host spectrum widens to include *Populus* (7.3%), *Quercus* (4.9%), *Arctostaphylos* (2.4%), *Larix* (2.4%), *Salix* (2.4%) and *Eucalyptus* (2.4%), but, in such cases, the real mycorrhizal partnership remains highly speculative.

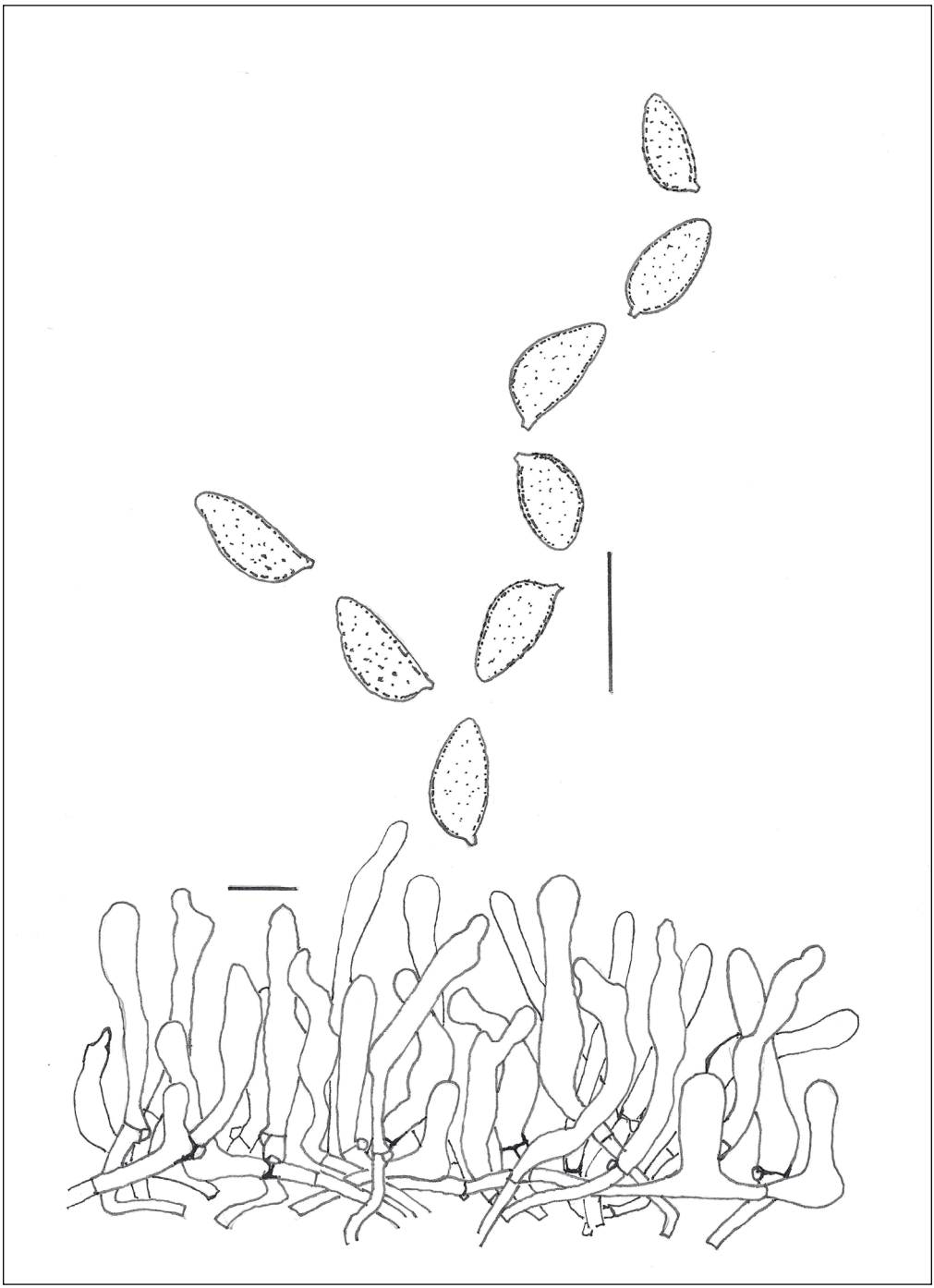

Fig. 4.7. *Hebeloma nanum* (EG980924.01). Spores and cheilocystidia. Scale bars 10 µm. Plate credit: Edmondo Grilli

The area of Punta Baffe, where this material was gathered, was interested by wildfire in 2004. The fire destroyed almost completely the pinewood covering most of the area and, in subsequent years, the postfire recovery of the ecosystem saw the extensive growth of *Cistus* colonies and the survival of sparse *Pinus halepensis* and *Quercus ilex*. Given the situation and the fact that the specimens were collected within one such colony, it would be safe to conclude that the photobiont associate of this collection of *Hebeloma nanum* is *Cistus*. However, lacking any experimental evidence, the association with *Cistus*, so far unrecorded, remains putative because scattered pine trees and oaks were also present.

According to the data available, *Hebeloma nanum* is present in North America (Canada and United States), Europe, temperate Asia (Japan and China) and tropical Asia (India). Within Europe, the species has been recorded from the Czech Republic, England, Finland, Germany, Italy, Poland, Scotland and Spain. In Italy, the species is to date known only from Liguria, Lombardy and Piedmont.

Tables 3. Comparison of *Hebeloma nanum*

	Sp. length	Sp. width	Sp. Q	Ch. L	Ch. A	Ch. M	Ch. B
H. naviculosporum	10.2-11.6	4.6-5.5	2.01-2.40	23-44	4.7-6.4	3.9-5.5	4.1-6.1
H. catalaunicum	9.6-11.2	5.7-7.2	1.55-1.73	27-41	5.3-6.6	3.9-4.9	5.1-7.0
H. nanum	7.9-10	4.2-5.0	1.64-2.03	19-39	4.4-5.8	3.8-5.2	3.6-5.3
EG980924.01	9.5	5.0	1.91	29	5.2	4.2	3.8
EG151229.01	**10.3-10.5**	4.9-**5.3**	1.98-**2.08**	31	5.3	3.9	5.1

	Lam.	Spore Codes			Cheilocystidium Ratios		
	L	O	P	D	A/M	A/B	B/M
H. naviculosporum	60-88	O2 O3	P1 P2	(D2) D3	1.07-1.41	0.98-1.38	0.85-1.17
H. catalaunicum	70-120	O2	P0 P1	(D2) D3	1.15-1.69	0.82-1.13	1.25-1.78
H. nanum	48-108	O1 O2	P0P1(P2)	(D1)D2D3	1.01-1.47	0.95-1.54	0.83-1.18
EG980924.01	64	O1 O2	P0 P1	D2 D3	1.27	**1.58**	0.94
EG151229.01	50-60	O1 O2	P0 P1	D3	1.36	1.17	**1.29**

Number of collections in the Database: *H. naviculosporum* 13, *H. nanum* 44, *H. catalaunicum* 9.

Hebeloma* section *Scabrispora (Romagn.) Beker & U. Eberh., *Hebeloma* (Fr.) P. Kumm.: 425 (2016)

Hebeloma lindae Beker & U. Eberh., *Hebeloma* (Fr.) P. Kumm.: 457 (2016)

Types: SPAIN: Balearic Islands, Es Trenc ses covetes, Mallorca (N39.3534, E2.9771, alt. approx. 5 m a.s.l.) on calcareous, sandy soil in coniferous dune woodland under *Pinus halepensis* Mill., Dec. 9 2009, H.J. Beker, L. Davies (Holotype. *herbarium* acc. no. BR 5020184115555).

Original diagnosis

Hebeloma lindae with its large stature, its rooting and very floccose stipe without annulus, is macroscopically distinctive within the southern European conifer forests where it occurs. The stipe tendency to root indicates H. sect. Scabrispora. It is reminiscent of H. laterinum except that the stipe hardly discolours. Microscopically, the spores weakly ornamented and the perispore only weakly

loosening in a few spores (O2; P0,P1), with average length less than 11 µm and average width greater than 5.7 µm and with Q value less than 1.8, together with the cheilocystidia with an average apical width of at most 5.2 µm and average basal width of at most 6 µm, are sufficient characters to separate H. lindae from other species within H. sect. Scabrispora.

Macroscopic description (EG181124.01; HJB20683) (Figure 5.0)

Pileus 30-62 mm in diameter, subglobular to convex, orbicular to slightly lobate, margin subinvolute to inflexed, smooth, showing no universal veil remnants. Surface smooth or cracked, tacky when moist, almost unicoloured, shades of brown (7.5YR5/4; 5/6) to reddish-brown (5YR6/3.5), tending to fade slightly towards the margin, but colours hardly homogeneous, rather marbled, also because of the frosted covering, which is especially thick on the margin of young specimens.

Lamellae emarginate, segmentiform to subventricose, 4-6 mm broad, density in the subcrowded range (L *ca.* 72-76); edge slightly paler, finely fimbriate, dry.

Stipe 40-55 × 15-22 mm, clavate (28 mm), tapered or shortly rooting, white tending to discolour brown, but not markedly, pruinose-flocculose; stuffed to fistulose. No cortinate velar remnants.

Context firm, fleshy, whitish, pale brownish in stipe cortical layers; smell very faint, almost absent, taste not recorded.

Microscopic description (Figures 5.1, 5.2, 5.3, 5.4. 5.5 and 5.6)

Spores 9.0 10.1 10.6 (11.8) × 5.5 6.0 6.4 µm, Q = (1.51) 1.58 1.70 1.84 (1.86), shape amygdaloid. Ornamentation mostly subdistinct. Myxosporium undilating to rugulose, rarely scantily vesiculate. Dextrinoidity soon strong (7C8; 7C/D8), soon after very strong (9C8; 9C/D8). Apical modification of the spore walls: an apical thinning of the coriotunica and a concomitant thinning of the epitunica due to an apical protrusion of the corium (reduced pore). Spore Code: **O2; P0 P1; D3 D4**.

Basidia 22-36 × 6.4-9.0 µm, avg. Q = 3.8, generally clavate, four-spored.

Cheilocystidia (12) 15 29 50 (54) × (3.0) 3.8 4.6 5.6 (7.0) × 2.8 3.6 5.0 (5.4) × (2.4) 2.8 3.8 5.0 (5.6) µm, lamellar edge substerile. Generally short, main shape cylindrical, sometimes lageniform, rarely clavate-lageniform. Occurrence of special features: often irregular, sinuous; occasionally branched. Cheilocystidium Ratios: **A/M = 1.28; A/B = 1.26; B/M = 1.07**.

Pleurocystidia none noted.

Habit and habitat gregarious on calcareous, grassy soil under *Cistus albidus* in mixed woodland with *Quercus ilex*, *Pinus halepensis* Mill. and other Mediterranean plants. **IUCN Habitat:** 1. Forest & Woodland; 1.4 Temperate forest (includes Mediterranean forests). **Italian Ecoregion:** 2 Mediterranean Division; 2A1a Italian Part of Ligurian-Provencal Province.

ITALY: Liguria, Le Manie plateau, Finale Ligure (SV), (N44.184361, E8.3745, alt. 280 m a.s.l.), *Cistus albidus*, *Quercus ilex* and *Pinus halepensis*, Nov. 24 2018, F. Boccardo (GDOR FB4559; EG181124.01; HJB20683).

Notes and comments

The rooting stipe base and the mostly cylindroid cystidial shape provide conclusive evidence pointing to *Hebeloma* sect. *Scabrispora.* Within the section, the stout stature, somewhat limited brown discolouring of stipe and stipe base context, and hypodistinct spore ornamentation clearly suggest *Hebeloma lindae.* The growth in Mediterranean environment with *Cistus albidus*, *Quercus ilex* and *Pinus halepensis* is an additional corroborative element. Moreover, the identification received full support by the phylogenetic analysis.

Fig. 5.0. *Hebeloma lindae* (EG181124.01). Photo credit: Fabrizio Boccardo

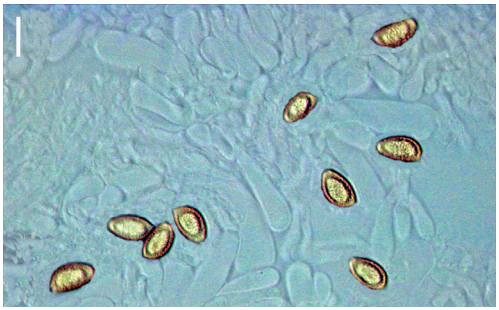

Fig. 5.1. *H. lindae* (EG181124.01). Spore ornamentation. Scale bar 10 μm. Photo credit: Alessandro Fellin

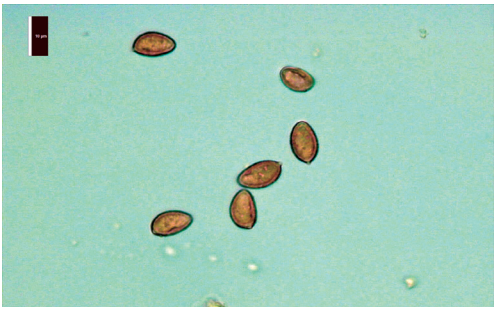

Fig. 5.2. *H. lindae* (EG181224.01). Spores in Melzer's. Scale bar 10 μm. Photo credit: Alessandro Fellin

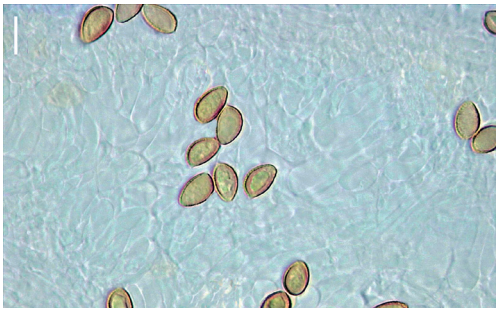

Fig. 5.3. *H. lindae* (EG181124.01). Spores in KOH. Scale bar 10 μm. Photo credit: Alessandro Fellin

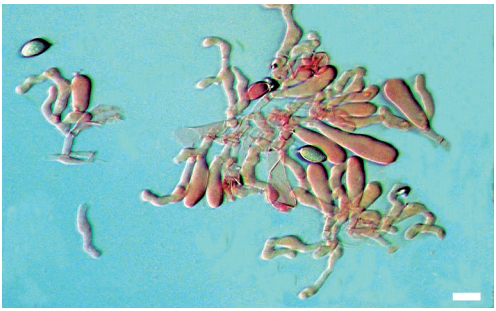

Fig. 5.4. *H. lindae* (EG181124.01). Cheilocystidia. Scale bar 10 μm. Photo credit: Alessandro Fellin

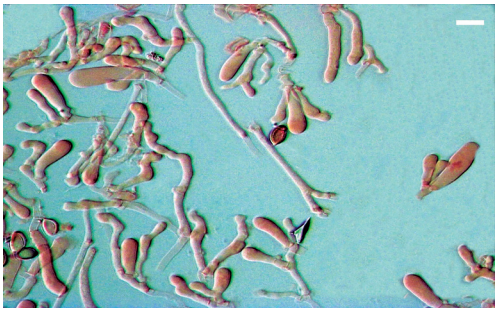

Fig. 5.5. *H. lindae* (EG181124.01). Cheilocystidia. Scale bar 10 µm. Photo credit: Alessandro Fellin

Nonetheless, in comparison with the data on this species on the Database, apart from slight quantitative differences in M and A/B ratio avg. values, a significant discrepancy is in the degree of spore dextrinoidity, which in the material analysed is D3 D4. This discordance advised re-testing dextrinoidity, but since the results were identical, D4 is to be considered part, if rare, of the variability in spore reaction to Melzer's of this species. This is supported by a recent additional collection from Calabria, which is ecologically, macro- and micro-morphologically perfectly congruent with *H. lindae* but for the D4 spore reaction in Melzer's. The collection, not yet analysed phylogenetically, will be documented in a future paper.

Hebeloma lindae was established only few years ago based on material from the Balearic Islands (Beker *et al.* 2016). *H. laterinum*, its sister species from a phylogenetic viewpoint, is also morphologically close. It differs especially in the strong and extensive discolouring of stipe base and the generally paler pileus colours. *H. laterinum* can also grow with a much wider spectrum of hosts, in both temperate and Mediterranean environments. They include *Pinus* sp. (its favoured associate), *Abies* sp., *Cedrus* sp., *Dryas* sp., *Fagus* sp., *Helianthemum* sp., *Picea* sp., *Populus* sp., *Quercus* sp., *Salix* sp. and *Tilia* sp. When growing in mixed broadleaf woodland, additional but putative hosts are *Betula* sp., *Carpinus* sp., *Cistus* sp. and *Corylus* sp.

Hebeloma lindae is phylogenetically distinct in all single locus results (Monograph: 460).

Thus far, the species has been found only in Europe. The relatively few collections known to date have been reported from Greece, Italy and Spain, growing only in Mediterranean forests, woodland and scrub. In Italy, to date, the species has been reported only from Sicily (Grilli & Brugaletta, 2017 and the Supplement) and Liguria, but as hinted at above it is probably present also in the Mediterranean areas of other regions.

Tables 4. Comparison of *Hebeloma lindae*

	Sp. length	**Sp. width**	**Sp. Q**	**Ch. L**	**Ch. A**	**Ch. M**	**Ch. B**
H. laterinum	8.5-11.2	4.9-6.5	1.58-1.87	22-39	3.9-8.9	3.4-9.1	3.7-7.8
H. lindae	9.7-10.9	5.9-6.5	1.61-1.77	21-43	4.4-5.6	3.8-4.8	3.7-5.4
EG181124.01	10.1	6.0	1.70	29	4.6	3.6	3.8

	Lam.	**Spore Codes**			**Cheilocystidium Ratios**		
	L	**O**	**P**	**D**	**A/M**	**A/B**	**B/M**
H. laterinum	40-130	(O2) O3	P1 P2	D3 (D4)	0.92-1.23	0.69-1.40	0.83-1.51
H. lindae	66-110	O2	P0 P1	D3	0.94-1.29	0.92-1.22	0.97-1.16
EG181124.01	72-76	O2	P0 P1	D3 **D4**	1.28	**1.26**	1.07

Number of collections in the Database: *H. lindae* 20, *H. laterinum* 139.

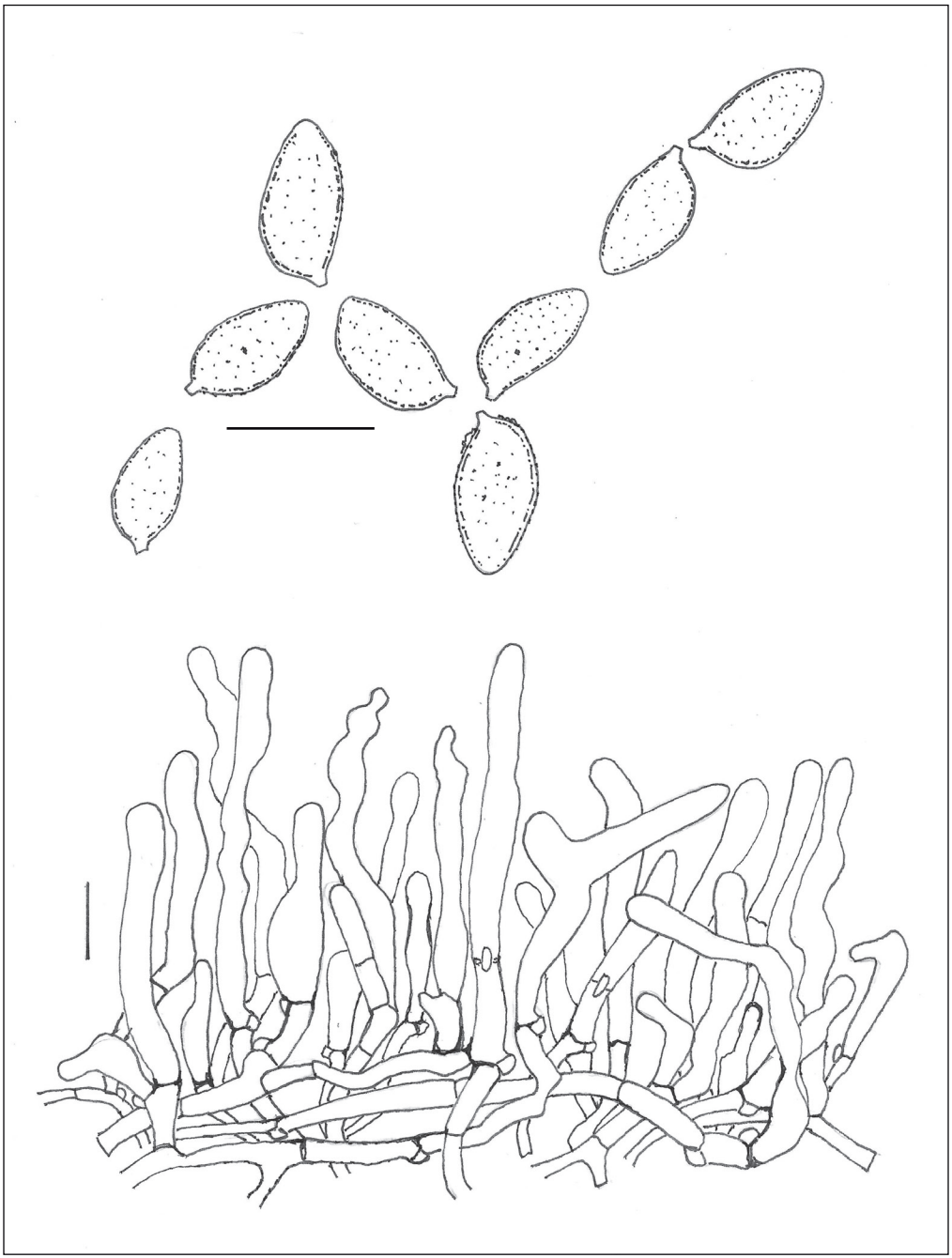

Fig. 5.6. *H.ebeloma lindae* (EG181124.01). Spores and cheilocystidia. Scale bars 10 μm. Plate credit: Edmondo Grilli

Acknowledgements

A particular debt of gratitude is owed to H.J. Beker and U. Eberhardt for sequencing the Italian collections and providing the molecular corroboration to the morphological identification of the species. We also thank I. Bonini, Director of the Botanical Museum (Botanical Garden, Herbarium) SIMUS, Department of Life Sciences, University of Siena, for the loan of exsiccata and L. La Chiusa and M. Contu for making available exsiccata and photographs of the collection of *Hebeloma nanum* from Lombardy and the collection of *H. catalaunicum* from Sardinia respectively.

Authors' addresses

Edmondo Grilli
C.so V. Emanuele II, 346, I-65122 Pescara (PE-Italy).
Corresponding author: grillie42@gmail.com

Fabrizio Boccardo
Via Filippo Bettini 14/11, 16162 Genova (GE-Italy).
E-mail: micete@libero.it

Alessandro Fellin
Via G. Canestrini 10/B, I-38028, Novella (TN-Italy).
E-mail: fellin6384@yahoo.it

Bibliography

Bartlett P., Eberhardt U., Schutz N. & Beker H.J. – 2021: Machine learning for species identification: the *Hebeloma* project from database to website. *Biodivers Inf. Sci.* Stand 5: e73972. (doi. org/ 10. 3897/ biss.5. 73972)

Bartlett P., Eberhardt U., Schutz N. & Beker H.J. – 2022a: Species determination using AI machine-learning algorithms: *Hebeloma* as a case study. *IMA Fungus* 13: 13. (doi. org/10. 1186/ s43008- 022- 00099-x)

Bartlett P., Eberhardt U. & Beker H.J. – 2022b: Demystifying *Hebeloma*: introducing hebeloma.org and its database. *IMA Fungus* 13: 18. (doi:10.1186/s43008-022-00105-2)

Batsch A. – 1789: *Elenchi fungorum, Continuatio secunda*. Halae Magdeburgicae.

Beker H.J., Eberhardt U. & Vesterholt J. – 2016: *Hebeloma (Fr.) P. Kummer*. Fungi Europaei 14. Edizioni Tecnografica, Lomazzo, Italia.

Clericuzio M., Cantini D., Vizzini A. & Dovana F. – 2022: Investigating the basidiomycete diversity of Grosseto province (Italy, Tuscany): an annotated check-list. *Mycot.* 137 (2): 1- 138.

Eberhardt U., Beker H.J., Vila J., Vesterholt J., Llimona X. & Gadjieva R. – 2009: *Hebeloma* species associated with *Cistus*. *Mycol. Res.* **113**: 153-162.

Eberhardt U., Schütz N., Bartlett P. & Beker J.H. – 2022: 96 North American taxa sorted–Peck's *Hebeloma* revisited. *Mycologia* **114**: 337-387. (doi: 10.1080/00275514.2021.2012063)

Eberhardt U., Grilli E., Schütz N., Bartlett P. & Beker J.H. – 2023a: Old but not obsolete: A new life for some of Murrill's (*Hebeloma*) names. *Mycologia* **115**: 375-426. (doi: 10.1080/00275514.2023.2188387)

Eberhardt U., Schütz N., Bartlett P. & Beker J.H. – 2023b: Many were named, but few are current: The *Hebeloma* of Hesler, Smith, and co-authors. *Mycologia*, vol. **115** (6): 813-870. (doi: 10.1080/00275514.2023.2230538)

Fries E.M. – 1836-1838 (1838): *Epicrisis Systematis Mycologici*. Upsaliae.

Grilli E. & Brugaletta E. – 2017: *Hebeloma lindae* in Sicily. First report for the Italian territory. *Micol. Veg. Medit.* **31** (2): 111-122.

Grilli E., Beker H.J., Eberhardt U., Schütz N., Leonardi M. & Vizzini A. – 2016: Unexpected species diversity and contrasting evolutionary hypotheses in *Hebeloma* (*Agaricales*) sections *Sinapizantia* and *Velutipes* in Europe. *Mycol. Prog*. **15** (5): 1-46.

Grilli E., Beker H.J., Eberhardt U. & Schütz N. – 2020: *Hebeloma (Fr.) P. Kummer*. Supplement based on collections from Italy. Fungi Europaei 14A. Candusso Editrice. Origgio, Italia.

Grilli E. & Fellin A. – 2023: Addenda to the *Hebeloma* funga of Italy. *Hebeloma pusillum* and *H. subconcolor*. *RMR, Boll. AMER* **120**: 36-55.

Grilli E., Parra L.A., Beker H.J. & Eberhardt U. – 2015: Some nomenclatural and taxonomic considerations on *Agaricus subtestaceus* Batsch 1789 and *A. testaceus* Fr. 1838. *RMR, Boll. AMER* **94**: 3-11.

Kornerup A. & Wanscher J.H. – 1978: *Methuen Handbook of Colour*. Eyre Methuen, London.

Lange J.E. – 1938: *Flora agaricina danica.* Vol. 3. Recato A/S.Copenhagen.

Munsell – 1975: *Soil Color Charts*. Munsell Color. Baltimore.

Pecoraro L., Caruso T., Gupta V.K., Borris P., Zhang Y.Ch. & Lei C. – 2021: Analysis of macrofungal communities reveals a complex reciprocal influence between Mediterranean montane calcareous grassland and surrounding forest habitats. *J. of System. and Evol*. **58** (2): 278-288.

Quadraccia L. – 1984: Combinaisons et taxons nouveaux. *Doc. Mycol*. **14** (56): 27-32.

Salerni E., Laganà A., Barluzzi C., De Dominicis V. & Perini C. – 1998: Mycofloristic studies in deciduous oak-woods in the province of Siena (Tuscany, Italy). *Flora Medit.* **8**: 93-133.

Smith A.H., Evenson V.S. & Mitchell D.H. – 1983: *The veiled species of Hebeloma in the Western United States*. The Univ. of Michigan Press. Ann Arbor.

Vesterholt J. – 1989: A revision of *Hebeloma* sect. *Indusiata* in the Nordic countries. *Nord. J. Bot*. **9**: 289-319.

Vesterholt J. – 2005: *The genus Hebeloma*. Fungi of Northern Europe. Vol. 3. Svampetryk: 146 p.

Zotti M. & Orsino F. – 2001: The Checklist of Ligurian macrofungi. *Flora Medit*. **11**: 115-294.