CZECH MYCOL. 61(2): 175–185, 2010

Crepidotus ehrendorferi in Slovakia and taxonomic notes on related species

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Ripková S. and Glejdura S. (2010): *Crepidotus ehrendorferi* in Slovakia and taxonomic notes on related species. Czech Mycol. 61(2): 175–185.

Described in 1988 from Austria, *Crepidotus ehrendorferi* Hauskn. et Krisai was recorded in Slovakia in 2009 for the first time. It was found on *Tilia cordata*, a hitherto unknown host. Macro– and micromorphological characters of the Slovak collections are described and illustrated. The identification and confusion of *C. ehrendorferi* with other *Crepidotus* species is discussed; the knowledge of its occurrence, ecology and threat is summarised.

Key words: Basidiomycota, *Inocybaceae*, *Crepidotus applanatus*, *C. crocophyllus*, *C. stenocystis*, *C. malachioides*, ecology, occurrence.

Ripková S. a Glejdura S. (2010): *Crepidotus ehrendorferi* na Slovensku a taxonomické poznámky k príbuzným druhom. – Czech Mycol. 61(2): 175–185.

Crepidotus ehrendorferi Hauskn. et Krisai, opísaný z Rakúska v roku 1988, sme na Slovensku zaznamenali prvýkrát až v roku 2009. Našli sme ho na dosiaľ neznámom hostiteľovi – *Tilia cordata*. V práci uvádzame opis a vyobrazenie makro– a mikromorfologických znakov našich slovenských zberov. Vyjadrujeme sa k určovaniu a možnej zámene *C. ehrendorferi* s inými druhmi rodu *Crepidotus*; sumarizujeme poznatky o jeho výskyte, ekológii a ohrozenosti.

INTRODUCTION

It has been years since the new species *Crepidotus ehrendorferi* Hauskn. et Krisai was described from neighbouring Austria (Hausknecht and Krisai 1988) and we had hoped to find it also in Slovakia. In 2009, it was the latter author of the paper who succeeded. While foraying in the Borová hora Arboretum near the city of Zvolen, he collected a strikingly orange tinged crepidotoid fungus whose identity as *C. ehrendorferi* was proved microscopically. The combination of macro- and micromorphological characters makes the species easily identifiable. On the contrary, it seems to be difficult to find it. The knowledge of its occurrence and ecology

is poor not only in Slovakia, but in the whole of Europe (Consiglio and Setti 2008). The aim of our paper is therefore to present the Slovak collections of *C. ehrendorferi*, extending its distribution area. We have also included descriptions of macro– and micromorphological characters and ecological characteristics.

MATERIAL AND METHODS

The study is based on the examination of eight collections of *Crepidotus ehrendorferi* (c. 20 fruitbodies in all development stages) found at one site with an area of about 20 × 40 m, on five branches and trunks lying at 3–20 m from each other. The specimens are kept in S. Glejdura's private herbarium and in SLO. The abbreviation of S. Glejdura's herbarium is PSG, the abbreviation of the SLO herbarium is cited in accordance with the Index Herbariorum (Holmgren et al. 1990). Data on voucher specimens are presented in their original form.

The macromorphological characters were observed on fresh material, the micromorphological characters in dried material under an Olympus BX41 light microscope with an oil immersion lens. The microscopical mounts were prepared with a 5% aqueous solution of KOH and a solution of Congo Red in ammonia (1 ml of 25% ammonia added in a filtrated solution of 1.5 g of Congo Red in 50 ml of distilled water). The colours of microstructures were examined in KOH; the measurements were made in Congo Red. For the measurements (30 per specimen; three specimens were measured: SLO 707, PSG 8/78, PSG 8/81) of microcharacters (spores, cheilocystidia, basidia and terminal cells of pileipellis) minimum, maximum (in parentheses) and average ± standard deviation values are presented. Abbreviations: L = number of lamellae reaching the stipe, l = number of lamellulae between each pair of lamellae, Q = ratio of length and width of spores. References to colours of macromorphological characters follow Kornerup and Wanscher (1974). Descriptive terminology follows Vellinga (1988). The nomenclature of vascular plants is based on the work by Marhold (1998). The name of the vegetation type follows Hančinský (1972). The taxonomical concept of the genus *Crepidotus* is based on works by Senn-Irlet (1995), Pouzar (2005b) and Consiglio and Setti (2008).

RESULTS AND DISCUSSION

Crepidotus ehrendorferi Hauskn. et Krisai, Pl. Syst. Evol. 161: 183, 1988

H o l o t y p e. Austria: Vindobona (Vienna), in silva "Lainzer Tiergarten" nominata: in monte Bärenberg dicto, 1. 9. 1986, leg. E. Mrazek, WU 6554.

Fig. 1. *Crepidotus ehrendorferi*: juvenile basidiocarp (PSG 8/77). Photo by S. Glejdura.

Fig. 2. *Crepidotus ehrendorferi*: adult basidiocarps (PSG 8/78). Photo by S. Glejdura.

Fig. 3. *Crepidotus ehrendorferi*: old basidiocarp (PSG 8/77). Photo by S. Glejdura.

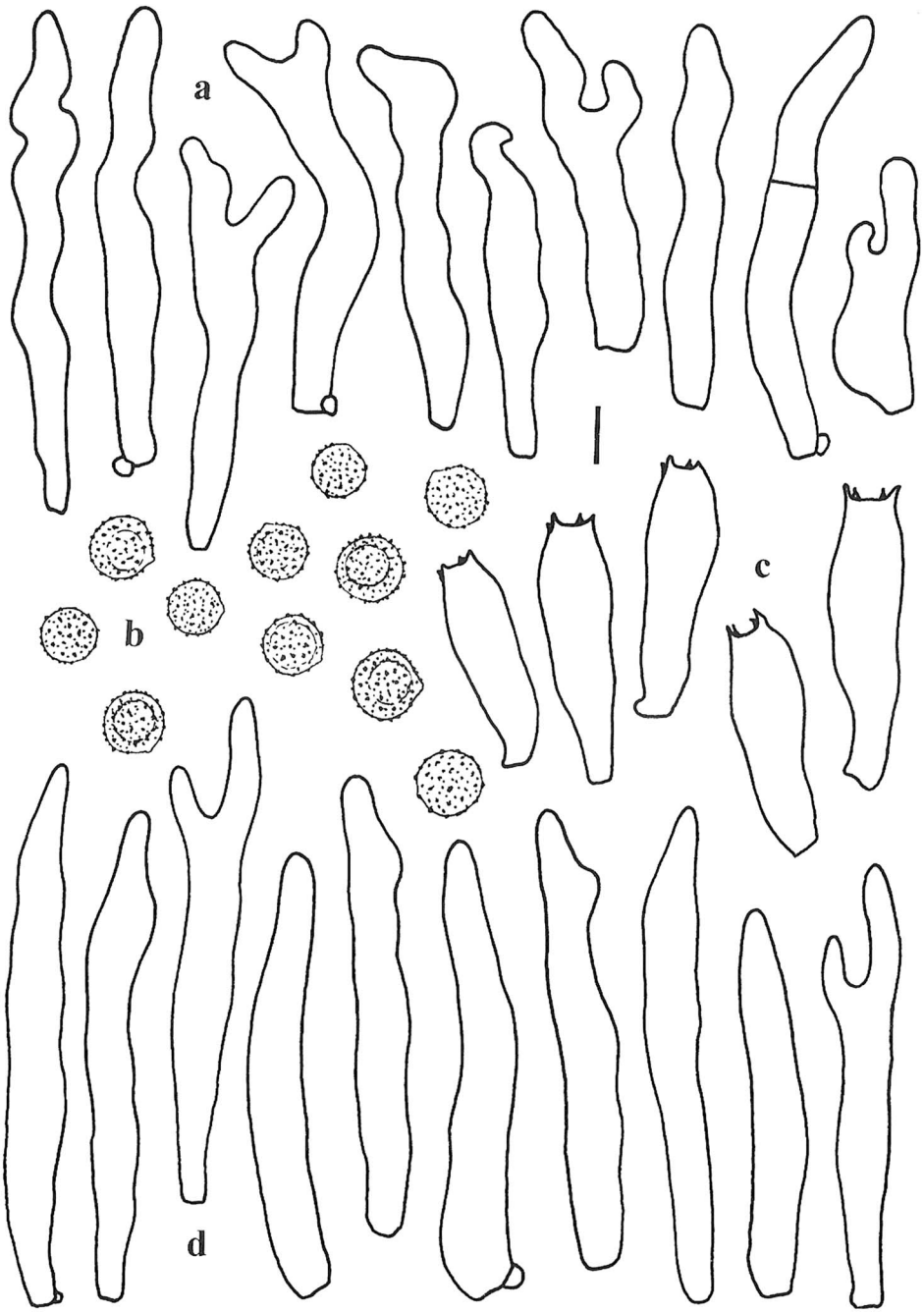

Fig. 4. *Crepidotus ehrendorferi*: a – cheilocystidia, b – spores, c – basidia, d – terminal cells of pileipellis (SLO 707). Scale bar = 10 µm.

Description. Basidiocarps (Figs. 1–3) growing solitary or in small groups. Pileus 15–50 × 10–35 mm, irregularly circular, flabelliform, rounded flabelliform or reniform, plano-convex; margin inflexed, straight, becoming slightly undate when old; juvenile light orange (5A4-5) to salmon (6A4), turning pale orange (5A3) to orange white (5A2) with age; similar in colour, surface at first velutinous, later glabrous, somewhat translucently striate at margin when old and wet, with whitish tomentum at point of attachment; slightly hygrophanous. Stipe only visible when young, later vanishing and basidiocarps attached to the substratum laterally or dorsally, 1.5–3 mm long, 1–1.5 mm wide, excentric to lateral, cylindrical, slightly curved, light orange (5A4-5) to brownish orange (6C8), the orange tint distinct also in old and dry basidiocarps, velutinous. Context 2–3 mm, thickest below the point of attachment, when young salmon (6A4), later light orange (5A4), but only under pileus surface, otherwise fading to orange white (5A2) or cream (4A3), or cream all over; taste mild to somewhat bitter after a while; smell indistinct. Lamellae L = 14–39, l = 3, up to 6 mm wide, adnexed, pale orange (5A3), orange white (5A2) to cream (4A3) when young, at maturity light brown (5D4) to clay (5D5), edge fimbriate, whitish. Spore print greyish brown (5D5).

Spores (5–)5.8–7.7(–9.7) × (5.2–)5.9–7.8(–9.7) µm, Q = (0.92–)0.97–1.02(–1.05), globose, punctate under light microscope, yellowish to brown-yellowish in KOH. Basidia 4-spored, (22–)25.7–31.9(–35) × (6–)7.2–8.6(–9) µm, clavate, hyaline, thin-walled. Cheilocystidia (24–)33.6–59.2(–78) × (4.5–)5.1–7.5(–10.5) µm, mostly cylindrical and flexuous, less often utriform or clavate, rarely septate; at the tips mostly tapered, less frequently obtuse, often branched, i.e. forked or antler-like, hyaline, thin-walled. Pileipellis a trichoderm of 4–10 µm wide hyphae; terminal cells (39–)43.2–63.1(–82) × (4–)5.5–7.1(–9) µm, narrowly conical, cylindrical or flexuous; in the upper part mostly tapered, some forked, unseptate, hyaline, thin-walled. Clamp connections present in all tissues (Fig. 4).

Published figures and/or descriptions. Hausknecht and Krisai (1988), Cetto (1993), Senn-Irlet (1995), Consiglio and Setti (2008).

Material studied

Slovakia, Zvolenská kotlina Basin, Borová hora Arboretum, c. 3 km N of the city centre of Zvolen, alt. 298 m, NNW-facing slope, coord. 48° 35' 56.03" N, 19° 8' 0.85" E, *Tilieto-Aceretum* inferiora, on bark and wood of fallen decaying branch of *Tilia cordata*, 11 Sep 2009, leg. S. Glejdura (PSG 8/76). Ibid., on wood of decaying fallen branch of *Tilia cordata*, 13 Sep 2009 (PSG 8/77). Ibid., on wood of decaying fallen branch of *Tilia cordata*, 18 Sep 2009 (PSG 8/78). Ibid., on wood of decaying fallen branch of *Tilia cordata*, 28 Sep 2009, leg. S. Ripková (SLO 707). Ibid., on wood of decaying fallen branch of *Tilia cordata*, 26 Oct 2009 (PSG 8/79). Ibid., on wood of decaying fallen trunk of *Tilia cordata*, 3 Nov 2009 (PSG 8/80). Ibid., on wood of decaying standing branch (branch growing from fallen trunk) of *Tilia cordata*, 5 Nov 2009 (PSG 8/81). Ibid., on wood of decaying fallen trunk of *Tilia cordata*, 19 Nov 2009 (PSG 8/82).

Ecology

Borová hora Arboretum – the locality of *Crepidotus ehrendorferi* in Slovakia – is a research and development site of the Technical University in Zvolen. It represents an important collection of trees which originally grew in natural forests of Slovakia (approx. 1500 taxa – species and infraspecific taxa), as well as a collection of roses (approx. 600 taxa) and cacti (approx. 600 taxa). The Arboretum was founded in 1965, designated a Protected Site in 1981 and has currently an area of 47.84 ha (Lukáčik et al. 2005).

Besides mostly planted and non-native trees, there are also some remnants of natural vegetation in the Arboretum. An example of such vegetation type is *Tilieto-Aceretum* inferiora covering an estimated area of 2 ha – the collecting site of *C. ehrendorferi* (Greštiak 1975, Križová 1985). The tree layer is mainly formed by *Tilia cordata*, *Quercus robur* and *Acer campestre*. These are up to 100-year-old trees. In the vicinity of the collecting site of *C. ehrendorferi*, the *Tilia* and *Quercus* trees were mostly 60 years old and *Acer* trees 20 years old. The shrub layer is species rich, mainly represented by *Corylus avellana*, *Ribes* sp., *Rubus* sp., *Sambucus nigra*, and *Swida sanguinea*. The herb layer is composed of *Aegopodium podagraria*, *Asarum europaeum*, *Galeobdolon luteum*, *Geranium* sp., *Mercurialis perennis*, *Lonicera xylosteum*, *Stellaria holostea*, *Pulmonaria obscura*, and some other species (the checklist of taxa is based on an autumn relevé). The bedrock is formed by travertines or travertine slopes with an admixture of loess or quartzose gravels; the soil is represented by typical pararendzina with travertine. The mean annual precipitation is 640 mm, the mean annual temperature 8.8 °C. The altitude is 298 m, and the slope orientation north-northwestern (Obr 1975, Lukáčik et al. 2005).

C. ehrendorferi produced basidiocarps on wood and bark of dead decaying branches (diam. 2.5–4 cm) and trunks (diam. up to 11 cm) of *Tilia cordata* which were a part of heaps after cutting; three trees were cut and the site became more lighted. Most basidiocarps were recorded on woody substrates lying directly on the soil or lying in the heap approx. 60 cm above the ground; in one case the basidiocarps grew freely above the ground at a height of approx. 170 cm (on a branch protruding from a fallen trunk). No other fungi shared the same substrates with *C. ehrendorferi*. Although fructifying in the same period and in the vicinity of *C. ehrendorferi*, the species *Ascocoryne cylichnium* (Tul.) Korf, *Holwaya mucida* (Schulzer) Korf et Abawi and *Peziza* cf. *granularis* Donadini grew on other parts of *Tilia cordata* wood. We observed the production of basidiocarps from September to November. It is interesting to add that it was the only site with such a concentration of lying wood. Although there were some other fallen trees (not cut) within the vegetation type, none of them was colonised by *C. ehrendorferi* basidiocarps.

Summing up the ecological data from the literature, *C. ehrendorferi* is a saprotroph, producing basidiocarps on decaying trunks of *Fagus sylvatica* (Hausknecht and Krisai 1988, Horak 2005, Cetto 1993, Consiglio and Setti 2008) and probably of *Populus* sp. (Consiglio and Setti 2008) from June to October (Hausknecht and Krisai 1988). More detailed characteristics of the habitat of *C. ehrendorferi* is included only by Hausknecht and Krisai (1988), i.e. deciduous (*Fagus*, *Quercus*) primeval-like forest with many old trees (the forest is a part of the Viennese Lainzer Tiergarten Nature Reserve).

Threat. *Crepidotus ehrendorferi* is classified as endangered in Austria (Krisai-Greilhuber 1999), Switzerland (Senn-Irlet et al. 2007) and France (Moreau pers. comm.).

Identity of *Crepidotus ehrendorferi*

Comparing our observations of *C. ehrendorferi* with the published ones (Hausknecht and Krisai 1988, Consiglio and Setti 2008), we did not find distinct differences in cheilocystidia. On the other hand, the spores measured in our material are larger. Even the average and standard deviation values exceed 7 µm. The ratio of length and width of spores (Q) does not exceed the value of 1.05. This is why we have described the shape of spores as globose, contrary to Consiglio and Setti (2008), who described the spores as globose to subglobose with Q up to 1.12. The pileipellis, although described by Consiglio and Setti (2008) as a cutis transitional to a trichoderm, is a distinct trichoderm in our material. The shape of the terminal cells that we have observed fit well to what is illustrated by Hausknecht and Krisai (1988) as well as Consiglio and Setti (2008). However, we have not observed any pigmentation of the terminal cells of pileipellis, as presented by Consiglio and Setti (2008) (Tab. 1). In spite of the above mentioned differences in micromorphology of *C. ehrendorferi*, we do not consider them to support a new taxon, but only to demonstrate the species' variability.

Comparison of *Crepidotus ehrendorferi* with species of similar spore morphology

It is the striking orange tinge on the basidiomata of *Crepidotus ehrendorferi* which led some authors, e.g. Hausknecht and Krisai (1988), Ripková (2002), Horak (2005), and Consiglio and Setti (2008), to compare the species with other similarly coloured European *Crepidotus* species, such as *C. crocophyllus* (Berk.) Sacc. and *C. macedonicus* Pilát. However, the taxonomy of *Crepidotus* is also based on microscopical characters, namely spore shape and ornamentation (Bandala and Montoya 2004, Senn-Irlet 1995). We therefore compared *C. ehrendorferi* also with species of similar spore morphology.

Tab. 1. Comparison of spores, cheilocystidia and pileipellis of *Crepidotus ehrendorferi*. Data are shortened.

data source spore size	cheilocystidia size and shape	pileipellis characteristics
Hausknecht and Krisai (1988) (4.7–)6–6.5(–7) µm	28–63 × 4–9 µm; flexuous-contorted, sometimes forked, knobbed	a trichoderm made of thin-walled, unseptate, erect, sub-regularly arranged, 6–9 µm thick hyphae
Consiglio and Setti (2008) 5.8–6.9 × 5.5–6.6 µm Q = 0.98–1.12	34–55 × 5.0–7.6 µm; cylindrical, lageniform, subfusoid, often apically tapered, flexuous, strangulated	a cutis of smooth, cylindrical, interwoven, 3–12 µm wide hyphae, with variably erect terminal cells, up to 12 µm wide, transitional to a trichoderm, with ± deep brown intracellular pigment, some hyphae with fine pigment encrusting the outer wall
Our observations (5–)5.8–7.7(–9.7) × (5.2–)5.9–7.8(–9.7) µm Q = (0.92–)0.97–1.02(–1.05)	(24–)33.6–59.2(–78) × (4.5–)5.1–7.5(–10.5) µm; cylindrical, flexuous, less utriform, clavate, rarely septate; at the tips tapered, less obtuse, often forked or antler-like	a trichoderm of 4–10 µm wide hyphae, terminal cells (39–)43.2–63.1(–82) × (4–)5.5–7.1(–9) µm, narrowly conical, cylindrical or flexuous; in the upper part mostly tapered, some forked, unseptate, hyaline, thin-walled

C. ehrendorferi belongs to the group of four other hitherto known *Crepidotus* species in Europe having globose or subglobose spores: *C. applanatus* (Pers.) P. Kumm., *C. crocophyllus*, *C. stenocystis* Pouzar, and *C. malachioides* Consiglio, Prydiuk et Setti. Following the terminology by Vellinga (1988), globose spores have Q = 0.95–1.05, subglobose ones Q = 1.05–1.15 (Tab. 2). There are also other European species producing globose to subglobose spores, such as *C. carpaticus* Pilát, *C. cristatus* Senn-Irlet et Immerzeel, *C. cinnabarinus* Peck and *C. cesatii* (Rabenh.) Sacc. However, these species produce also broadly ellipsoid spores with Q 1.15–1.3 (cf. Senn-Irlet 1995, Senn-Irlet and Immerzeel 2003), which easily distinguishes them from the five above-mentioned species.

Having a similar globose to subglobose spore shape as well as baculate spore ornamentation observed under a scanning electron microscope (SEM) (Senn-Irlet 1995, Consiglio and Setti 2008), the delimitation of *C. ehrendorferi*, *C. applanatus*, *C. crocophyllus*, *C. stenocystis*, and *C. malachioides* is further based on characters of pileipellis and cheilocystidia. As shown in Tab. 2, *C. ehrendorferi* is easily distinguishable from the other species by a characteristic type of pileipellis, i.e. a trichoderm. *C. malachioides* also has a unique pileipellis, i.e. composed of capitate pileocystidia forming a hymeniderm. Within the species with a cutis, *C. applanatus*, *C. crocophyllus* and *C. stenocystis*, only *C. crocophyllus* has incrusted and coloured hyphae and thick-walled terminal cells. The last two species have different cheilocystidia: *C. applanatus* has mostly capitate cheilocystidia, whereas *C. stenocystis* has lageniform ones (Pouzar 2005a).

Besides including *C. carpaticus*, *C. applanatus*, *C. crocophyllus* and *C. ehrendorferi* into the section *Sphaerula* sensu Hesler and Smith (1965), i.e. among the *Crepidotus* taxa with globose to subglobose and verrucose spores, Consiglio and Setti (2008) included also the newly described *C. malachioides* and the North American taxa *C. malachius* (Berk. et M. A. Curtis) Sacc. var. *malachius* and *C. malachius* var. *trichifer* Hesler et A. H. Sm. Consiglio and Setti (2008), who studied the neotype of *C. applanatus* (L 986.062-019) and the isotope of *C. malachius* (FH-258654), stated that it is practically impossible to distinguish these two taxa macroscopically; microscopically, however, there are significant differences in spore size. They presented spore size for *C. applanatus* 4.9–5.8 × 4.7–5.4 µm, for *C. malachius* var. *malachius* 6.2–7.3 × 5.9–6.9 µm (the range of standard deviation of length and width). Although a separation of these two taxa thus seems to be justified, Bandala et al. (2008) placed the name *C. malachius* into synonymy of *C. applanatus*. They studied the holotype of *C. malachius* (K 5730) and considered it conspecific with *C. applanatus*, presenting a spore size of 5.5–6.5 × 5.5–6.3 µm (the range of mean values of length and width) (Bandala et al. 2008). Taking into account that Bandala et al. (2008) did not find any distinct differences between the two taxa, we agree to interpret *C. malachius* as a synonym of *C. applanatus*.

C. malachius var. *trichifer* was distinguished from the nominate variety by presence of pileocystidia (Hesler and Smith 1965). The authors noted that cheilocystidia are also characteristic of this variety and described them as cylindrical, some subcapitate, usually more or less constricted and flexuous. It is interesting that Hesler and Smith (1965) included also the figure of a lageniform one. Consiglio and Setti (2008) studied the holotype of *C. malachius* var. *trichifer* and considered it identical with *C. stenocystis*. Consequently, they placed the name *C. stenocystis* into the synonymy of *C. malachius* var. *trichifer*. However, we agree with Pouzar (2005a) and accept the species rank of *C. stenocystis* because of the distinct and unique characters of its cheilocystidia within the genus (lageniform, cylindrical, hardly clavate). Moreover, the published drawings of micromorphological characters by Consiglio and Setti (2008) show some other significant differences: cheilocystidia of the holotype of *C. stenocystis* are mostly attenuated in their upper part (which is typical of this species), but cheilocystidia of the holotype of *C. malachius* var. *trichifer* are mostly capitate (which is characteristic of e.g. *C. applanatus*). On the other hand, cheilocystidia of *C. malachius* var. *trichifer* depicted in the photographs by these authors (Consiglio and Setti 2008) seem to be characteristically attenuated at apex. It is a pity that the bases of the cheilocystidia (an important character) are not distinctly visible in these photographs. It is not clear from which specimens the photographs were taken, too. As we are not able to identify the shape of the cheilocystidia neither based on the work by Hesler and Smith (1965) nor Consiglio and Setti (2008), and we have not studied any relevant herbarium material, we keep the status of *C. malachius* var. *trichifer* open for the time being.

Of the other North American *Crepidotus* taxa, *C. sinuosus* Hesler et A.H. Sm. is different in pileipellis characters, whereas *C. applanatus* var. *globiger* (Berk.) Pilát and *C. applanatus* var. *diversus* Hesler et A.H. Sm. differ in spore and cheilocystidium characters (Hausknecht and Krisai 1988).

Tab. 2. Comparison of some micromorphological characters of European *Crepidotus* species with globose to subglobose spores. Characters which we consider to be supporting are in boldface.

species*	**spore size (µm)**	**cheilocystidia size (µm); cheilocystidia shape**	**pileipellis type; terminal cells/pileocystidia shape**
C. ehrendorferi	5.5–7.0 × 5.5–7.0	28–50 × 5–11; cylindrical, narrowly utriform, flexuous, many with branched uppermost part	**a trichoderm**; terminal cells narrowly conical or cylindrical, occasionally branched or somewhat mucronate
C. applanatus	4.5–7.0 × 4.5–6.5	23–68 × 3–10 × 11–16; clavate, **capitate**, rarely flexuous, angled or slightly branched	a cutis of repent, hyaline, cylindrical hyphae; pileocystidia narrowly utriform, subcapitate
C. crocophyllus	5.5–7 × 5.5–7	26–60 × 5–12(–15); clavate, narrowly lageniform, sometimes almost cylindrical, subcapitate, flexuous, rarely branched	a cutis of repent, hyaline hyphae mixed with bundles of ascending, finely **incrusted coloured hyphae**; **terminal cells** conical or cylindrical, sometimes flexuous, often **thick-walled**
*C. stenocystis***	5.0–7.5 × 5.0–7.0	(20–)30–75(–90) × 5–10; cylindrical, narrowly **lageniform**, narrowly utriform, mixed with some flexuous, angled or forked ones, rarely subcapitate	a cutis of repent, hyaline, cylindrical, sometimes minutely incrusted hyphae; pileocystidia narrowly lageniform
C. malachioides	5.4–6.3 × 5.2–6.4	35–46 × 3.8–5.4; pyriform, capitate, rarely clavate	a cutis; pileocystidia capitate, forming **a hymeniderm**

* For better comparison of all included species, we used the work of one author, i.e. Senn-Irlet (1995) as a data source; an exception is *C. malachioides*, which was described later and for which we used the original work by Consiglio and Setti (2008). Data are shortened.

** *C. stenocystis* Pouzar (2005a) = *C. applanatus* var. *subglobiger* Singer sensu Senn-Irlet (1995).

ACKNOWLEDGEMENTS

Botanists Eva Križová and Karol Ujházy (Technical University Zvolen, Faculty of Forestry, Zvolen), are acknowledged for their advisory note on the habitat of the *Crepidotus ehrendorferi* collections. Thanks also go out to Zdeněk Pouzar (Nad Královskou oborou 23, Praha) for reading and commenting on the manuscript. The Slovak Grant Agency VEGA (grants no. 2/5087/25, 2/0062/10 and 1/0557/10) supported this study.

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