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Additions to the biota of lichenicolous and lichenized fungi of Poland

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Abstract: Two lichenicolous fungi, *Ceratobasidium bulbillifaciens* and *Sclerococcum phaeophysciae*, and one lichen, *Xanthoria aureola*, are reported for the first time from Poland. For each species, the descriptions with notes on similar species, habitat preferences and general distribution are provided.

Keywords: lichens, lichenicolous fungi, distribution, Poland

INTRODUCTION

Lichen inventories bring new data on many species of lichens and lichenicolous fungi, among which are species new to science and new to countries. This is also the case of Poland. Despite lichenological surveys that began more than two centuries ago in the country, many novelties are still being recorded from less studied areas or groups of lichenized and lichenicolous fungi (e.g., Guzow-Krzemińska et al., 2017, 2018, 2019; Ertz et al., 2018; Malíček et al., 2018; Szczepańska et al., 2019; Szczepańska, 2020; Ossowska et al., 2021; Kossowska et al., 2022). In this paper two species of lichenicolous fungi and one lichen species are reported for the first time from Poland.

MATERIAL AND METHODS

Specimens studied were collected during various lichenological investigations in northern Poland and are deposited in herbarium UGDA. The taxa were identified by classical techniques, using dissecting and light microscopes. The descriptions of species are based on material from Poland. The DNA extraction and sequencing of nuITS marker of *Xanthoria aureola* follow the protocols presented in Ossowska et al. (2019). Localities of each species are placed in ATPOL grid square system (Zając, 1978) modified by Cieśliński & Fałtynowicz (1993).

RESULTS & DISCUSSIONS

THE SPECIES

Ceratobasidium bulbillifaciens Diederich & Lawrey (Fig. 1A)

Colonies of dispersed bulbils growing on corticolous sterile lichens. Mycelium not observed. Bulbils superficial, roundish to shortly ellipsoid, without hairs and crystals in polarized light, young greyish yellow, brown to dark brown when mature, up to 175 µm diam. Bulbils externally without specialized cells, internally composed of branched chains of subspherical to elongate, hyaline cells, 10–18 × 7–10(–12) µm. Septa without clamps (see also Diederich et al., 2022a).

Ceratobasidium bulbillifaciens is an inconspicuous species due to small bulbils and Polish specimens were incidentally collected with lichens and found only after the examination under stereomicroscope. The species can be confused with some lichenicolous species of the order Cantharellales Gäum., which are somehow similar in the morphology of bulbils. *Bulbilla applanata* Diederich, Flakus & Etayo has similar in colour, but larger bulbils (200–400 µm), and grows on members of genera of the order Peltigerales Walt. Watson in South America (Diederich et al., 2022a). Bulbils of *Burgoa angulosa* Diederich, Lawrey & Etayo are always whitish to slightly translucent with external cells roundish in surface view (6–9 µm diam.) and with internal hyphae, which are elongate, straight or curved and septate (individual cells 5–30 × 4.5–11 µm) (Diederich et al., 2022a). *Burgoa moriformis* Diederich, Ertz & Coppins has white and smaller bulbils (35–65 µm diam.) (Diederich et al., 2022a). Both *Burgoa* species grows on various lichens in Europe. *Parmeliicida pandemica* Diederich, F. Berger, Etayo & Lawrey is characterised by dark reddish brown bulbils and is known only from parmelioid lichens in Europe (Diederich et al., 2022a). *Burgellopsis nivea* Diederich & Lawrey has distinctly white and shiny bulbils and is known from saxicolous

sterile lichen in Scotland only (Diederich et al., 2022a).

Other species, *Burgella flavoparmeliae* Diederich & Lawrey, *B. lutea* Diederich, Capdet, A. I. Romero & Etayo and *Neoburgoa freyi* Diederich, E. Zimm. & Lawrey have yellow to orange (both *Burgella* species) or orange bulbils (*Neoburgoa freyi*) (Diederich et al., 2022a). *Bergerella atrofusca* Diederich & Lawrey develops dark reddish brown and shiny bulbils which are smaller in diameter [(20–)25–35(–45) µm] and *Minimedusa pubescens* Diederich, Lawrey & Heylen has smaller (60–80 µm diam.) bulbils with superficial radially oriented 'hairs' with more or less pointed apex (Diederich et al., 2022a).

Ceratobasidium bulbillifaciens may also be confused with *Athelia arachnoidea* (Berk.) Jülich, but this species has up to 0.5 mm diam. sclerotia, which develop on the mycelium (Diederich et al. 2022b). *Erythricium aurantiacum* (Lasch) D. Hawksw. & A. Henrici grows in similar lichen communities like *Ceratobasidium bulbillifaciens*, but its bulbils are orange (carrot red) and the fungus is a parasite of corticolous *Physcia* species (sometimes also growing on neighbouring other lichens) (Diederich et al., 2022c). In one of the specimens from Poland (UGDA L-59081) both species were found together, and the differences were very evident.

Ceratobasidium bulbillifaciens was found in Belgium, France, Germany, Great Britain, Luxembourg, the Netherlands, Slovakia, Sweden and Ukraine on thalli (or between thalli) of various lichens, mostly in *Xanthorion* communities (Diederich et al., 2022a). In Poland it was found on sterile lichens in two localities in northern Poland.

Specimens examined. Poland. Pobrzeże Kaszubskie, Nadmorski Landscape Park, Chłapowo, 54.808059°N, 18.374866°E, ATPOL grid square Ac–38, trees along street, on crustose sterile lichens growing on *Fraxinus excelsior*, 1 Oct. 2022, M. Kukwa 24048 (UGDA L-59081); Pobrzeże Kaszubskie, Mrzezino, by railway station, 54.652293°N, 18.412796°E, ATPOL grid square Ac–59, roadside trees, on sterile, crustose thalli growing on *Tilia cordata*, 29 Oct. 2022, M. Kukwa 24244 (UGDA L-59988).

Sclerococcum phaeophysciae Diederich & van den Boom (Fig. 1B)

Sporodochia superficial, flattened or rarely convex, dark brown to blackish, rounded to irregular, up to 600 µm diam. Conidiophores aggregated, hyaline or pale brown. Conidiogenous terminal, hyaline or pale brown, 5–10 µm diam. Conidia produced singly and easily separating, subspherical, ellipsoid to angular, smooth-walled, medium to dark brown, 1(–2)-septate (two conidia with 3 septa also found), 12–16 × 9–10 µm (see also Diederich & van den Boom, 2017).

Sclerococcum phaeophysciae is similar to *S. montagnei* Hafellner, which also has smooth-walled and mainly 1-septate conidia, however the latter species has smaller conidiomata (200–300 µm diam.), smaller conidia (1-septate conidia 10–13 × 6–9 µm) and is confined to *Lecanora rupicola* (L.) Zahlbr. (Hafellner, 1996; Diederich & van den Boom, 2017). *Cladophialophora parmeliae* (Etayo & Diederich) Diederich & Unter., which was originally placed in the genus *Sclerococcum* Fr., also has 1-septate conidia, but they are ornamented and smaller (7–9 × 3–3.5 µm), and the species grows on parmelioid lichens (Etayo & Diederich, 1996; Diederich et al., 2012).

Other lichenicolous species of *Sclerococcum* developing sporodochia and lichenicolous members of *Cladophialophora* Borelli, which were originally placed in the former genus, differ in conidia which are mostly aseptate or have more than two cells, and also inhabit other hosts (Etayo & Diederich, 1995; Diederich, 2010; Diederich et al., 2012; Diederich & van den Boom, 2017).

The species has been so far known from Belgium, Germany, Luxembourg and the Netherlands on mostly saxicolous, rarely corticolous thalli of *Phaeophyscia orbicularis* (Neck.) Moberg (Diederich & van den Boom, 2017). In Poland it was found in northern part of the country on thalli of the host growing on *Populus* cf. *nigra*.

Specimen examined. Poland. Mierzeja Helska, Nadmorski Landscape Park, SE of Władysławowo, 54.781767°N, 18.44376°E, ATPOL grid square Ac–39, solitary tree near buildings, on *Phaeophyscia orbicularis* growing on *Populus* cf. *nigra*, 3 Sept. 2022, M. Kukwa 23893 (UGDA L-57707).

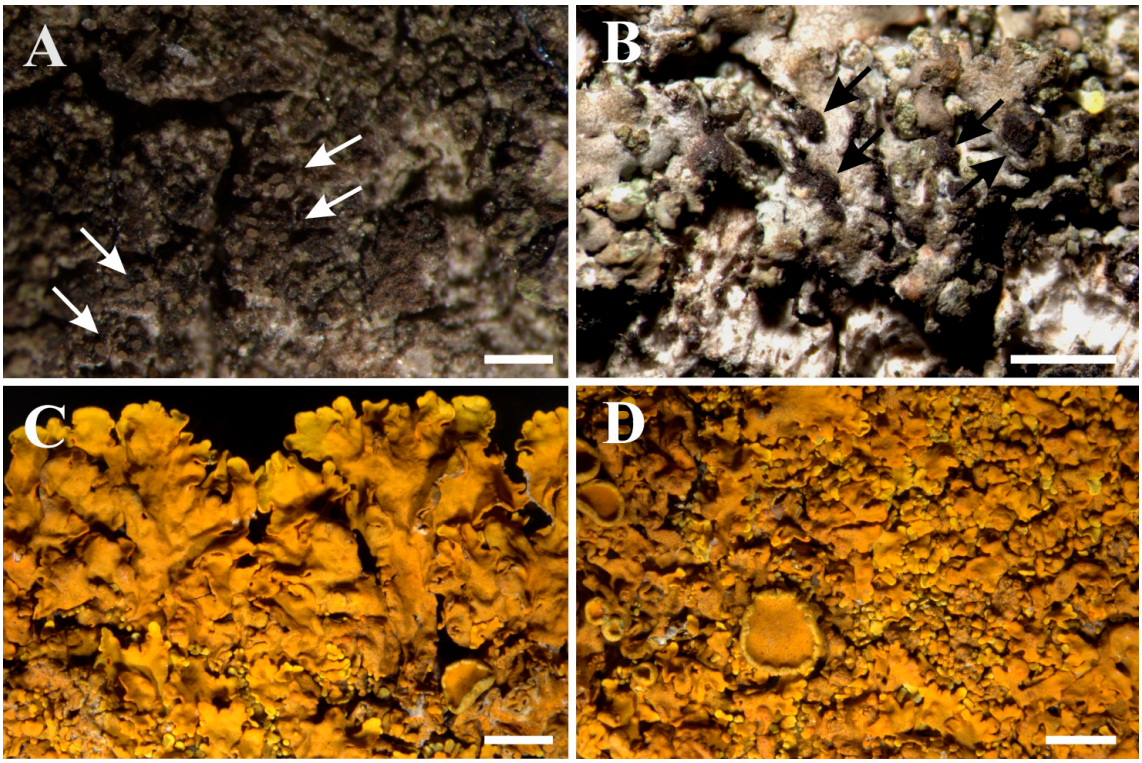

Fig. 1. A – *Ceratobasidium bulbillifaciens* (arrows indicate groups of bulbils). B – *Sclerococcum phaeophysciae* (arrows indicate sporodochia). C & D – *Xanthoria aureola*. Scales: A – 0.5 mm, B – 1 mm, C, D – 2 mm.

XANTHORIA AUREOLA (Ach.) Erichsen (Fig. 1C & D) Thallus foliose, rather loosely attached to substratum, yellow-orange. Lobes up to 1.1 mm wide at tips, truncated to rounded and not broadened at apex, flat to concave. Lobules in central part abundant, simple or more often branched, up to 0.5 mm wide. Upper surface of lobes and lobules rough. Lower surface yellowish near margins to white or violet-mottled in central part, attached by hapters. Apothecia present, lecanorine, up to 1.5 mm diam. (see also Lindblom & Ekman, 2005; Lindblom et al., 2005; Hitch et al., 2009; Nimis, 2022).

Xanthoria aureola is very similar to *X. calcicola* Oxner and *X. parietina* (L.) Th Fr., however it can be distinguished by scarcely overlapping, crenulate to strap-shaped lobes, which are up to 4 mm in width and not broadened at tips, laminal lobules, rough upper surface and the lack of isidia; apothecia are rarely present. *Xanthoria calcicola* also has rough upper surface of lobes, but it produces abundant, coarse, irregular, knob-like isidia in the central part of the thalli, whereas *X. parietina* has smooth upper surface, without lobules, more or less overlapping lobes, which are up to 6 mm wide and broadened at the tips, and apothecia are almost always present (Lindblom & Ekman, 2005, 2006, 2012; Lindblom et al., 2005; Hitch et al., 2009; Nimis, 2022).

Xanthoria aureola was often included in the concept of *X. parietina*, however both species are distinct phylogenetically (Lindblom & Ekman, 2005, 2006; Gaya et al., 2012). *Xanthoria aureola* is closely related to *X. calcicola* and sequences of *X. aureola* are nested within the clade of *X. calcicola* (e.g., Lindblom & Ekman, 2005), what may suggest that they should be treated as single taxon or alternatively as a species complex (Scherrer & Honegger, 2003,

under *X. ectaneoides* (Nyl.) Zahlbr.; Lindblom & Ekman, 2005). This can be supported by some morphological features shared by both species, i.e., the rough texture of the upper surface and larger thickness of the thallus (Lindblom & Ekman, 2005). However, haplotype networks, which according to Lindblom & Ekman (2005) is better tool to distinguish *X. aureola* from *X. calcicola*, indicate that there are no common IGS and nuITS haplotypes in these taxa. Therefore, Lindblom & Ekman (2005) concluded that *X. aureola* and *X. calcicola* are separate species, also due to morphological differences, e.g., the presence of lobules in *X. aureola* and isidia in *X. calcicola*. However, the relationship of both species needs to be further studied with more molecular markers and next generation sequence data, especially since Arup et al. (2013) suggested that *X. aureola* is probably not homogenous. The nuITS sequence of the specimen from Poland was checked using BLASTn search and it showed high similarity to the *X. aureola* sequences deposited in GenBank by Scherrer & Honegger (2003) (accession no. AJ320130, as *X. ectaneoides*) and Gaya et al. (2012) (accession no. JQ301690).

Xanthoria aureola grows mainly on exposed, nutrient-rich, siliceous or rarely basic rocks, usually in coastal or near the coast areas. The species is widely distributed in Europe (mostly coastal areas) and Macaronesia, and is also known from scattered localities in Africa and Asia (e.g., Literski & Mayhofer, 1998; Scherrer & Honegger, 2003 as *X. ectaneoides*; Lindblom & Ekman, 2005, 2012; Lindblom et al., 2005; Hitch et al., 2009; Arup et al., 2013; Hafellner & Türk, 2016 as *X. ectaneoides*; Amrani et al., 2018 as *X. ectaneoides*). In Poland it was found on concrete c. 150 m from the seashore.

Specimen examined. Poland. Mierzeja Helska, Nadmorski Landscape Park, Hel, 54.60165°N, 18.805078°E, ATPOL grid square Ad–51, horizontal surface of concrete fence, 11 Nov. 2022, M. Kukwa 24467 (UGDA L-60632, nuITS GenBank accession no.: OR136389).

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