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#### SHORT COMMUNICATION

## Notes on *Candelariella reflexa* s. str. (Ascomycota, Candelariaceae) in Poland

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#### Abstract

This paper presents new localities of the epiphytic lichen *Candelariella reflexa* (Nyl.) Lettau found in NE Poland. The species has been reported in Poland for over two decades, but the progress of research on the taxonomy of this genus requires confirmation of the data by the currently accepted taxonomic approach. The paper also discusses the diagnostic features of the species that help distinguish it from other similar taxa.

#### Keywords

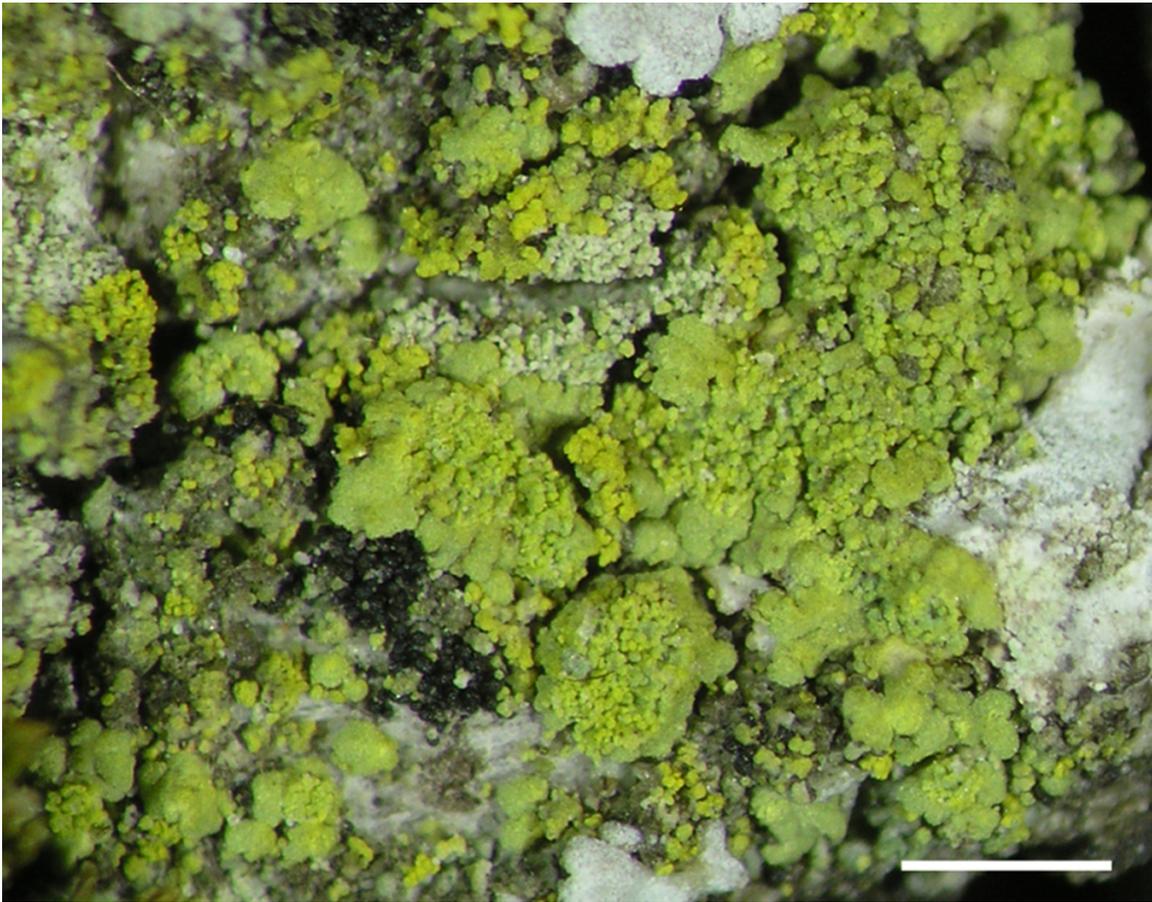
lichens; *Candelinella*; *Opeltiella*; new localities; NE Poland

The genus *Candelariella* Mull. Arg. includes mostly lichen-forming fungi (a few species are lichenicolous) with crustose thalli, ranging from warted-areolate, subsquamulose to vaguely or sometimes distinctly placodioid (lobed at the edges). It includes species forming biatorine or lecanorine apothecia, with 8- or multi-spored asci, containing colorless, ellipsoidal or rarely spherical, aseptate (or rarely 1-septate), often biguttulate ascospores (Cannon et al., 2021; Etayo et al., 2021; Westberg, 2005). All lichenized species contain pulvinic acid and its derivatives, due to which they show a distinctive yellow color, except for a few species with gray thalli (Yakovchenko et al., 2017).

The genus currently includes about 50 species, of which eight species occur in Poland (Fałtynowicz & Kossowska, 2016). However, the taxon is polyphyletic, so the number may change with some species segregated into other genera (Kondratyuk et al., 2020). Since many species of the genus are widely distributed around the world (Liu et al., 2019; Westberg, 2004) and are usually associated with anthropogenic habitats (especially enriched with nitrogen compounds), they are included in most local lists of species. Despite their small size, species of *Candelariella* are relatively easy to distinguish in the field due to the characteristic light-yellow color of the thallus (in some species, the thallus is gray) and apothecia (Lendemer & Westberg, 2010). However, slight phenotypic differences make identification of the individual species difficult when using only standard taxonomic methods without molecular analyses. In the case of some morphologically similar species, the key diagnostic feature

may be the number of spores in the asci, which can be 8- or multi-spored (up to 32 spores). However, the identification of individual species using standard taxonomic methods (without molecular analyses) is not easy or even impossible in the case of sterile specimens. This problem is particularly pronounced in the case of sorediate species, which rarely form apothecia (Lücking et al., 2021; Tehler, 1982). As a result, the general occurrence of some species and their status require verification.

Three species of the genus *Candelariella* producing soredia have been recorded from Poland so far: *Candelariella efflorescens* R.C. Harris & W.R. Buck., *C. reflexa* (Nyl.) Lettau (Figure 1) and *C. medians* (Nyl.) A.L. Sm. The first two are epiphytes, while the last is a saxicolous species that grows mainly on calcareous substrate (Fałtynowicz, 2003). These different ecological preferences allow a preliminary distinction of *C. medians* from the two other species in the field. However, the current status of the two epiphytic sorediate members of the genus *Candelariella* in Poland is not clear, as they have been shown in the past based on different taxonomic approaches. The situation is also complicated by the fact that these species occur mainly in sterile form, without apothecia. Research by Kubiak and Westberg (2011) showed that at least part of the specimens reported in the past as *C. reflexa* may belong to *C. efflorescens*. The need to verify the presence of *C. reflexa* in Poland through the verification of herbarium specimens or further field research has become obvious (Fałtynowicz & Kossowska, 2016). As a result of numerous inventories of the epiphytic lichen biota of north-eastern Poland, carried



**Figure 1** *Candelariella reflexa* s. str. – placodioid thallus with crateriform soralia. Scale bar = 0.5 mm.

out during the last years, fertile specimens of sorediate *Candelariella* consistent with the currently accepted diagnosis of *C. reflexa* (Figure 1) were found (Kubiak & Westberg, 2011; Lendemer & Westberg, 2010; Westberg, 2007), and are presented in this paper.

All specimens presented in this work were found on the bark of trees growing along local roads (tree alleys) in open areas, near rivers, lakes, and small water reservoirs. In each case, it was a mature European ash, *Fraxinus excelsior*. This may indicate the preference of this lichen for rather sunny but, at the same time, quite humid conditions. As with other *Candelariella* species, it is also likely to be favored by eutrophication (Nimis, 2023). However, any general assessment of the ecology of *C. reflexa* in Poland or Central Europe requires much broader research (cf. Bomble, 2016).

*Candelariella reflexa* is quite a characteristic species and if the thallus is typically developed then correct identification is also possible in the case of sterile specimens (Figure 1, Table 1; see Bomble, 2016 and Lendemer & Westberg, 2010).

However, specimens with poorly developed thalli can be problematic to determine (Hauck et al., 2013), especially in an area where the ranges of different species overlap. The differences between *C. reflexa* and *C. efflorescens* are described in detail by Kubiak and Westberg (2011), and the most important ones are also shown in Table 1. *C. reflexa* may be confused with *C. xanthostigmoides* (Müll. Arg.) R.W. Rogers, which differs in its smaller areoles and in soralia development, which are

initially formed at the edges of the areoles and then enlarge towards their center. Eventually, they merge and cover the thallus with a layer of farinose soredia. The occurrence of *C. xanthostigmoides* in Poland has not been confirmed so far, but the species is known from several neighboring countries: the Czech Republic (Malíček & Palice, 2013), Germany (Schiefelbein et al., 2020), and Ukraine (Khodosovtsev & Dar-mostuk, 2020).

In the past few years, several new sorediate species of the genus *Candelariella* have been described from outside Europe (Table 1). Among them, the most similar to *C. reflexa* are *C. makarevichiae* S. Y. Kondr., L. Lökös et J.-S. Hur. and *C. subsquamulosa* D. Liu et Hur – described from South Korea (Kondratyuk et al., 2018; Liu et al., 2019), *C. rubrisoli* D. Liu & J.-S. Hur – described from China (Liu et al., 2019), *C. flavosorediata* Kalb & Aptroot – described recently from Réunion Island (Kalb & Aptroot, 2021), and *C. magellanica* Etayo – known only from Navarino Island, belonging to the Cape Horn Biosphere Reserve, Chile (Etayo et al., 2021). A summary of the most important characteristics that differentiate the above-mentioned species from *C. reflexa* is given in Table 1.

It should be clarified that according to the new species combination proposed by Kondratyuk et al. (2020), *C. makarevichiae* was transferred to the newly created genus *Candelinella* S. Y. Kondr. – as *Candelinella makarevichiae* (S. Y. Kondr., L. Lökös et J.-S. Hur) S. Y. Kondr., and *C. rubrisoli* to the genus *Opeltiella* S. Y. Kondr., as *Opeltiella rubrisoli*

**Table 1** Comparison of morphological characters of selected sorediate species of *Candelariella* s.lat.

| Species   | Thallus  | Soralia and soredia   | No of ascospores in ascus | Illustrations in scientific publications   |
|---|--|---|---------------------------|--|
| <i>Candelariella reflexa</i> (Nyl.)<br>Lettau   | Squamules or areoles (up to 1(-2) mm in diam.), the outer part of which consists of distinct, more or less regularly arranged segments (lobes), rather wide (up to 0.6 mm long) and loosely attached to the substrate (almost rosette-shaped); usually greenish-yellow, with pulverulent surface | Soralia formed in the center of areoles (crater-shaped), soredia coarse-grained 30–80 µm in diam.   | 8                         | Bomble (2013, 2016), Lendemer and Westberg (2010)  |
| <i>Candelariella efflorescens</i><br>R.C.Harris & W.R.Buck.   | Dispersed or ± contiguous granules or minute squamules (to ca. 0.2(-0.3) mm in diam.), soon dissolved into entire sorediate crust; yellow, matt surface  | Soralia discrete, formed on the margin of the squamules and then spread over their upper surface; soredia 15–40(-50) µm diam.   | >8 (24–30)                | Bomble (2016), Kubiak and Westberg (2011), Westberg (2007), Westberg and Clerc (2012)                                  |
| <i>Candelariella xanthostigmoides</i> (Müll. Arg.)<br>R. W. Rogers  |  |   | 8                         | Bomble (2016), John (2015), Khodosovtsev and Darmostuk (2020), Lendemer and Westberg (2010), Yakovchenko et al. (2017) |
| <i>Candelariella flavosorediata</i><br>Kalb & Aptroot   | Isolated granules or areoles (c. 0.1–0.3 mm diam.), irregular in outline and surface; bright yellow, when mature mostly obscured by soredia  | Soralia indistinct, soredia powdery, c. 25 µm diam.   | 8                         | Kalb and Aptroot (2021)  |
| <i>Opeltiella rubrisoli</i> (D. Liu & Hur) S. Y. Kondr.<br>[= <i>Candelariella rubrisoli</i> D. Liu & J.-S Hur]   | Areolate to subsquamulose (0.06–0.22 mm diam.), areoles irregular, scattered or composed of several aggregation to imbricate sometimes, slightly ascending from one side, usually breaks and ultimately dissolves into the soredia, forming a ± continuous leprose crust                         | Soralia appear on the edge of thallus and dispersed inward or to the lower side of squamules, covering the entire upper surface, soredia granular, (30-)40–54–70(-80) µm                    | Not known                 | Liu et al. (2019)  |
| <i>Candelinella makarevichiae</i><br>(S. Y. Kondr., L. Lőkös et J.-S. Hur) S. Y. Kondr [ <i>Candelariella makarevichiae</i> S. Y. Kondr., L. Lőkös et J.-S. Hur.] | Areolate, areoles more or less rounded to irregular (0.15–0.3(-0.5) mm diam.), slightly semi-convex, very distant from each other (rarely clustered in groups), closely adhering to the substrate, even in peripheral parts; over time completely covered with a mass of soredia; dull citrine   | Soralia formed on the upper surface of the areoles (usually in their center), initially distinct, rounded and slightly convex, then aggregate and merging; soredia small, c. 20–30 µm diam. | Not known (8?)            | Kondratyuk et al. (2018)   |

(D. Liu et J.-S. Hur) S. Y. Kondr. In the same study, *Candelariella subsquamulosa* was included as a synonym of the species *Opeltiella rubrisoli*.

Based on the new data presented in the article, as well as other published data consistent with the taxonomic approach used here, it can be concluded that *C. reflexa* is not a common species, both in Poland and throughout Central Europe (cf. Bomble, 2016). It is certainly much rarer than *C. efflorescens* (Bielczyk et al., 2020; Vondrák et al., 2018), which has a much broader ecological scale, both in terms of habitat type and local microclimatic conditions (Kubiak & Westberg, 2011), and in conditions of increased eutrophication it grows intensively, becoming an expansive species.

#### Specimens examined:

1. Poland, Olsztyn Lakeland, Bartązek, old roadside trees, 53°42'40.37" N, 20°29'52.68" E, ATPOL Be52, on *Fraxinus excelsior*; 11 Jul. 2015.
2. Poland, Olsztyn Lakeland, Tuławki, old roadside trees, 53°45'35.78" N, 20°34'30.26" E, ATPOL Be33, on *Fraxinus excelsior*; 12 May 2017.
3. Poland, Biebrza Basin, Biebrza National Park, Dębowo, near the water sluice, old trees by the river, 53°30'60.4" N, 22°55'88.4" E, ATPOL Bf69; on *Fraxinus excelsior*; 21 Jul. 2021.

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