Acta Botanica Hungarica 66(3–4), pp. 203–223, 2024
DOI: 10.1556/034.66.2024.3-4.5

NEW AND NOTEWORTHY LICHEN-FORMING AND LICHENICOLOUS FUNGI 14. *XANTHORIA PEDERSENII* AND *X. WENNERGRENII* – TWO NEW SPECIES FROM THE *XANTHORIA CALCICOLA* SUBCLADE (XANTHORIOIDEAE, TELOSCHISTACEAE) PROVED BY INTEGRATIVE APPROACH

S. Y. Kondratyuk[1, 2*], L. Lőkös[3], M. Hansson[2], U. Schiefelbein[4]
I. Kärnefelt[5] and A. Thell[5]

[1]*M. H. Kholodny Institute of Botany, Tereshchenkivska str. 2, 01004 Kyiv, Ukraine;*
*E-mail: ksya_net@ukr.net (*corresponding author)*
[2]*Molecular Cell Biology Division, Lund University, Sölvegatan 35B, SE-22362 Lund, Sweden*
[3]*Department of Botany, Hungarian Natural History Museum,*
H-1431 Budapest, Pf. 137, Hungary
[4]*University of Rostock, Botanical Garden, Schwaansche Strasse 2, 18055 Rostock, Germany;*
E-mail: ulf.schiefelbein@uni-rostock.de
[5]*Biological Museum, Lund University, Box 117, SE-22100 Lund, Sweden;*
E-mails: ingvar.karnefelt@biol.lu.se, arne.thell@biol.lu.se

(Received: 5 March 2024; Accepted: 10 March 2024)

Two species new to science, *Xanthoria pedersenii* and *X. wennergrenii* in the *Xanthoria calcicola* complex (*Xanthoria*, Xanthorioideae, Teloschistaceae), characterized by a complex of morphological, anatomical and molecular characters, are described, illustrated and compared with closely related taxa.

Key words: ascospore septum type, ascospore type, Denmark, Germany, integrative approach, lichen-forming fungi, new species, Sweden, *Xanthoria*

INTRODUCTION

Xanthoria has been considered a well-known genus although its taxonomy has been neglected for a long time. Seventeen lichen groups earlier included have been segregated as separate genera (Kondratyuk *et al.* 2022*b*). Prior to the molecular era, *Xanthoria* was composed of *ca* 50 species (Kärnefelt 1989). Today, 13 species belong to the genus (Kondratyuk *et al.* 2022*b*).

The name *Xanthoria calcicola* was proposed at species level by the Ukrainian lichenologist Alfred Oxner in 1937 for the infraspecific taxon *X. parietina* f. *congranulata* Cromb., described in the 19th century based on two diagnostic characters, i.e. a rugose centre of thallus and concave apothecia. Furthermore, Oxner emphasized the importance of isidia for this species. Since then, *Xanthoria calcicola* Oxner has been accepted as a rather common and widely

distributed species in the Mediterranean and Atlantic parts of Europe (Kondratyuk 2004, Nimis 1993, 2016, Nimis and Martellos 2023, Oxner 1937, Smith *et al.* 2009, Wirth *et al.* 2013). However, the aim of this paper is to study correlation between morphological and anatomical characters within the *X. calcicola* complex, collected in the southwestern Baltic Sea area.

Xanthoria ectaneoides (Nyl.) Zahlbr. was thought to be synonymous to *Xanthoria aureola* (Ach.) Erichsen, being positioned in the *Xanthoria calcicola* subclade. However, in a recent revision the *Xanthoria ectaneoides* complex was found to constitute a sister group to the *Xanthoria coomae* branch (Kondratyuk *et al.* 2023, 2024).

Two species new to science were found and described within this study. This integrative approach in taxonomy of the genus *Xanthoria* (Fr.) Th. Fr., particularly using details in ascospores and their septa, was elaborated by the Austrian lichenologist J. Poelt with colleagues in the 1990s (Giralt *et al.* 1993, Kondratyuk and Poelt 1997, Poelt and Petutschnig 1992*a*, *b*, etc.). A number of species described in those days were later confirmed by molecular data (Arup *et al.* 2013, Kondratyuk *et al.* 2013, 2017, 2020, 2022*a*).

MATERIAL AND METHODS

Material of the *X. calcicola* complex was collected at 25 localities in the southwestern Baltic Sea area during the past two years (Table 1). The specimens were sprayed with water ten minutes to half an hour before they were removed from the substrate using a plastic knife. Mature apothecia were cut by hand. Fifteen sections of each apothecium were mounted in a water droplet to contain enough ascospores for statistic measurements. The ascospores were exclusively measured outside the asci and in sections in a bright-field microscope. At least 50 ascospores were measured and included in the statistical analysis. The specimens were studied and determined at the Division of Molecular Cell Biology, Department of Biology, Lund University where also the DNA-vouchers were prepared. Sequences from the nuclear ITS-region were produced using standard methods and standard primers (see Kondratyuk et al. 2024).

Specimens studied in this study will be deposited in the herbaria C, GB, KW-L and LD. Sets of particular importance will be distributed in Plantae graecenses exsiccate.

Table 1
List of localities of investigated epilithic communities of *Xanthoria calcicola* s. l. (collectors: SK, *AT and NT, ** SK, AT and US)

Locality	Date/ Collector(s)	Position	Number of specimens		
			totally collected	with *X. pedersenii*	with *X. wernergrenii*
DENMARK					
1. Bornholm, Nexø, on rock wall	28.10.2022	55.0629° N, 15.1250° E	56	1	–
2. Østerlars par., the church, on rock wall	29.10.2022	55.1648° N, 14.9656° E	2	2	–
3. Hammershus castle ruins, on brick walls at the highest point of ruins	27.10.2023	55.2713° N, 14.7554° E	57	–	7
4. Nyker par., the church, on rock wall	29.10.2022	55.1396° N, 14.7595° E	11	2	2
5. Fyn, Svendborg Landevej, on concrete	28.05.2023	55.1860° N, 10.7330° E	44	–	1
6. Møn, Borre par., the church yard, on tiles on the cemetery wall	22.09.2022	54.9959° N, 12.4432° E	6	1	–
7. Zealand, Fanefjord par., the church, on tiles on the cemetery wall	11.10.2022	54.9013° N, 12.1511° E	23	5	–
8. Fjenneslev par., the church, on tiles on the cemetery wall	26.05.2023	55.4336° N, 11.6875° E	22	3	–
9. Gørløse par., the church, on tiles on the cemetery wall	3.12.2022	55.8853° N, 12.1991° E	22	10	–
10. Helsinge. the church yard, on tiles on the cemetery wall	26.03.2023	56.0208° N, 12.1969° E	170	2	–
11. Højby parish, the church, on tiles on the cemetery wall	25.06.2023*	55.9128° N, 11.5996° E	15	2	1
12. Søborg par., the church, on tile roof	16.04.2023	55.7352° N, 12.5120° E	70	6	–
13. Søborg par., the castle ruins, on modern brick inclusions	16.04.2023	55.0877° N, 12.3055° E	45	1	–
14. Ærø, Søby par., the church, on tiles on the cemetery wall	26.05.2023	54.9386° N, 10.2568° E	55	2	3
15. Marstal, the church, on tiles on the cemetery wall	26.05.2023	54.8550° N, 10.5170° E	59	4	6
16. Ærøskøbing, the church, on tiles on the cemetery wall	26.05.2023	54.8879° N, 10.4122° E	71	1	2
GERMANY					
17. Mecklenburg-Vorpommern, Rostock district, Cammin	2.10.2023**	53.967° N, 12.333° E	17	–	1
18. Rostock district, Alt Bukow, the church, on tiles on the cemetery wall	2.10.2023**	53.9963° N, 11.6077° E	47	3	2

Table 1 (continued)

Locality	Date/ Collector(s)	Position	Number of specimens		
			totally collected	with *X. pedersenii*	with *X. werner-grenii*
19. Nordwestmecklenburg district, Blowatz-Dreveskirchen	2.10.2023**	53.9939° N, 11.5385° E	37	–	1
SWEDEN					
20. Skåne, Bromma par., the church, on rocky wall	28.09.2022	55.4707° N, 13.8001° E	34	2	1
21. Dalby par., the church, on rocky wall	11.05.2023 7.01.2024	55.6646° N, 13.3461° E	79	–	1
22. Malmö, Västra Hamnen, on granitic rocks	16.08.2022	55.6133° N, 12.9813° E	14	2	–
23. Norra Vram par., the church, on tiles on the cemetery wall	12.11.2022	56.0870° N, 12.9734° E	15	1	–
24. Ramlösa (S of Helsinborg), on roadside rocks near parking area	12.08.2022	55.8056° N, 12.7333° E	5	1	–
25. Skanör par., the church, on vertical surfaces of thumbs at the cemetery	23.08.2022	55.4195° N, 12.8497° E	1	1	–
Total			977	53	28

RESULTS AND DISCUSSION

Molecular data on Xanthoria *species*

A wide species concept was earlier used for *Xanthoria parietina* and *X. aureola* (Lindblom and Ekman 2005, Tsurykau *et al.* 2020). However, using a larger set of morphological and anatomical characters, particularly spore measurements (Kondratyuk *et al.* 2023), led us to use a narrower concept, which also correlates better with molecular characters. Sequences of the new species were analyzed together with other *Xanthoria*-sequences from the GenBank to determine their phylogenetic positions. It turned out that they belong to the *Xanthoria calcicola* subclade (Fig. 1).

NEW TAXA

Xanthoria pedersenii S. Y. Kondr., Kärnefelt et A. Thell, *spec. nova* (Figs 2–4)

MycoBank No.: MB 853038

Similar to Xanthoria calcicola, *but differs in having thin, paper-like thalline lobes, in having smaller knob-like warts, which may resemble coarse isidia, which*

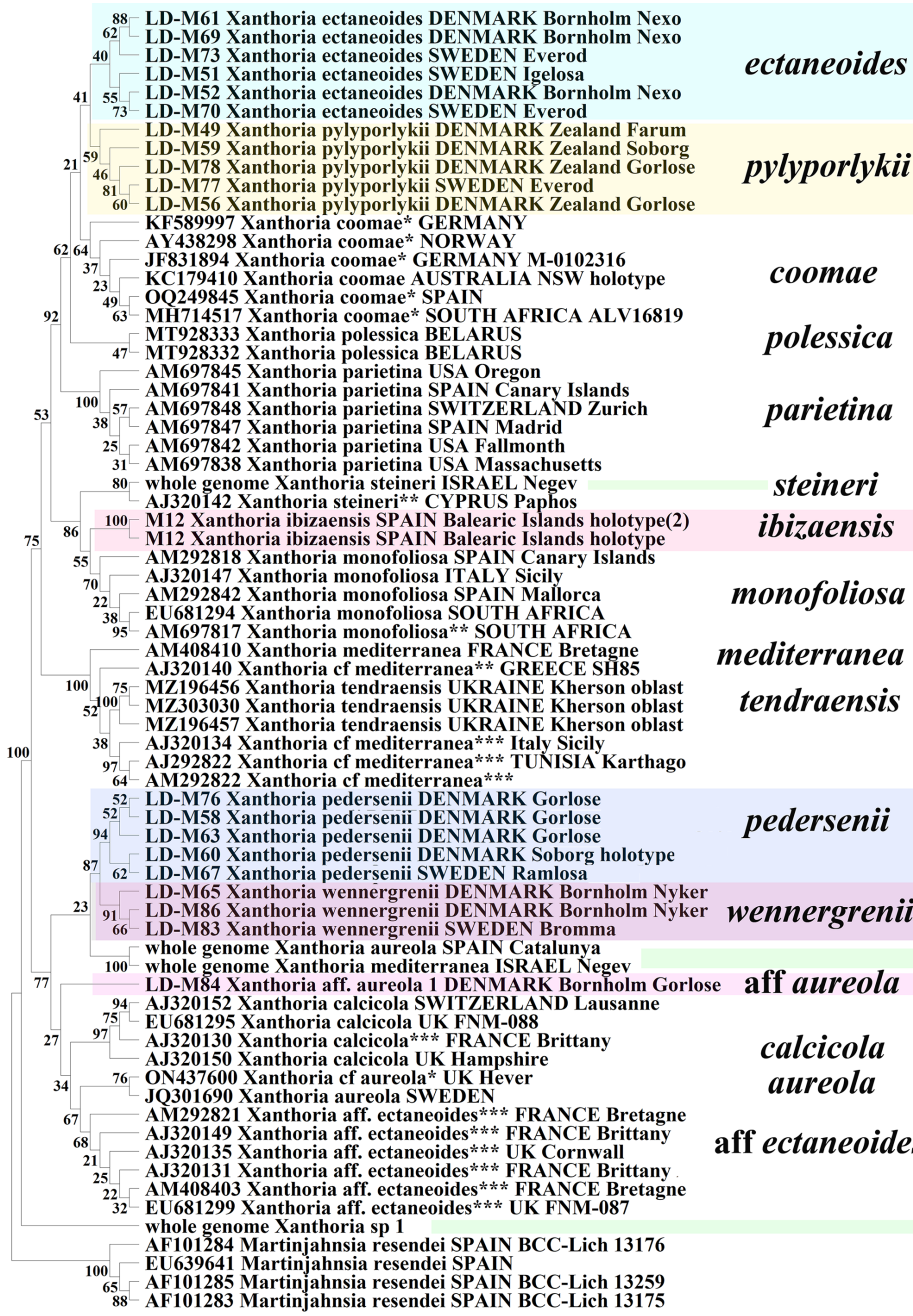

Fig. 1. Consensus MP tree after nrITS of the members of the genus *Xanthoria* for which hitherto molecular data available (* = data are submitted to GenBank under *Xanthoria parietina*, ** = data provided under *Xanthoria* sp., *** = data are provided under *Xanthoria ectaneoides*)

never fall off, in having much narrower ascospores and much wider range of variation of ascospore septa, as well as in having slightly shorter but wider conidia.

Type: Denmark. Zealand, Søborg, par., the church, 55.7352° N, 12.5120° E, on tile roof of rocky wall, coll.: S. Y. Kondratyuk SK23599 sub *Xanthoria pedersenii* (holotype) growing together with *X. ectaneoides*. Isotypes: SK23599A, SK23599B; SK23599C sub *Xanthoria pedersenii* with *Xanthoria* sp. 1; SK23599D sub *Xanthoria pedersenii* with *Xanthoria* sp. 1; SK23599E, etc. till SK23599G sub *Xanthoria pedersenii* with *Xanthoria* sp. 1; SK23599K sub *Xanthoria pedersenii* with *Xanthoria* sp. 1; SK23599L sub *Xanthoria pedersenii* with *Xanthoria* sp. 1; SK23599N sub *Xanthoria pedersenii* with *X. pylyporlykii*; SK23599O sub *Xanthoria pedersenii* with *Xanthoria* sp. 1; and SK23599P sub *Xanthoria pedersenii* with *Xanthoria* sp. 1, prepared for distribution in Plantae graecenses exsiccate.

Thallus from 15–20 mm across to 3–7(–11) cm in diam., often forming larger aggregations; film-like in the centre, while dissections and lobes are well developed in the peripheral zone, *ca* (3–)5–7(–10) mm wide, sometimes poorly presented, only occasionally well developed, but usually seen as incomplete circles, where only a half of thallus in semicircles (semi-acres), i.e. '*anularis*' morph (see Kondratyuk *et al.* 2024), to 1.5–2 cm wide observed; thalline lobes (4–)5–7(–10) mm long, only rarely to 10–15(–18) mm long (SK22016, SK23599)*, and from 1–1.5(–2) mm wide in the narrowest portions, widened towards the tips, to (2–)4–5(–8) mm, if dissected into smaller portions, the total width is 5–7(–12) mm, indistinct towards the centre, irregularly orientated; terminal portions of lobes to 2–3 mm wide, sometimes dissected into small, 0.5(–1) mm wide lobes, and *ca* 1 mm long, well seen from the underside, with more or less smooth surface (without or with rare wrinkles, i.e. thallus of *Xanthoria pylyporlykii* type, see Kondratyuk *et al.* 2024), light yellowish or whitish yellow, greenish yellow, or greyish yellow, centre wrinkled or uneven, dull orange or dirty greenish orange to dark brick or brownish orange or dark green-grey; secondary lobules to 0.3–1(–3) mm wide and to 1–3(–5) mm long to somewhat triangular, overgrowing terminal portions to 1–1.5(–3) mm diam., irregularly orientated with bright yellow tips well contrasting to the dull orange, yellow or dull brownish yellow centre of the thallus. Upper surface of lobes very wrinkled, crosswise, but usually irregular in the centre. Lower surface white, with scarce white hapters of *Xanthoria parietina* type (sensu Kondratyuk and Poelt 1997) to 175 μm wide and 50–60 μm long.

* Material from *Fraxinus* bark at Ramlösa (LD M67 SK22027) differs in having more developed and distinct thalline lobes towards the centre, and in having more distinct cross wrinkles. Thalline lobes to 10–15 mm long. These epiphytic specimens were from 3 mm wide in the narrow portions, to 4–10(–12) mm wide in the terminal portions.

Isidia present usually in places in the centre of thallus sometimes in several distant places of the same thallus, more often along thalline lobe edges, mainly on the most raised parts of the wrinkles; isidia initially very small, to 0.05–0.1 mm in diam., regularly rounded, more or less subconvex, usually furuncle-like (boil-bearing), i.e. dissolving in minute, gradually dissappearing sorediate particles, often aggregated in groups to 0.5(–1.5) mm across, seldom granular; rarely numerous and somewhat larger, to 0.1–0.15(–0.3)[–0.5] mm across, regularly rounded to almost spherical or pustulae-like, more or less convex, somewhat lighter than the thallus centre, conidiomata sparse, single or in groups; isidia lobulae-like, sparse, to 0.18–0.25 mm wide and 0.2–0.4 μm long. Thallus to (100–)125–200(–225) μm thick, upper cortex to 12–20(–25) μm thick, algal zone to (20–)30–50(–70) μm, algal cells 12.5–22 μm across; medulla to (50–)70–100(–125) μm thick, if cavities not developed, or with cavities and hollows to 40 μm thick or with groups of conglutinated hyphae, to 15–20 μm thick; lower cortex (12–)15–20 μm thick, cell lumina 5–6(–7) μm across in both cortical layers, paraplectenchymatous.

Apothecia rare and scattered in the centre, rarely numerous, often indistinct and easily overlooked, 0.5–1 mm in diam., or large, to 2–4(–5) mm in diam., to 0.25–0.45(–0.5) mm thick in section, raised, to 1–1.5 mm high, not attenuated at the basis, stipa to 0.7–0.8 mm in diam., slightly cup or 'wine glass' shaped, thalline margin pronounced, whitish yellow or greenish yellow, lighter and well contrasting the dull brownish orange thallus centre, sometimes with isidia-like granules; disc deeply concave, dull orange or brownish orange at first, soon becoming more or less plane, plate-like, to very undulating, with a more or less crenulate or cracked margin or emarginate when overmature; thalline margin to 100–150(–200) μm thick, sometimes with a hollow, cortical layer to 50 μm thick on the underside, cells rounded, thick walled, to 10–12.5 μm in diam.; true exciple to 70–80 μm thick in the uppermost lateral and to 25–35 μm wide/thick in lower lateral and basal portions; hymenium to 50–60 μm high; subhymenium very thin, to 15–20 μm thick; ascospores (7–)8–13(–15) × (4.5–)5.5–7.5(–8) μm, septa (3–)4–9(–11) μm wide. Conidiomata to 200–250 μm in diam., hyaline, spherical, immersed, often in groups up to 3 grape-like formations; conidia widely ellipsoid, somewhat attenuated at one or both ends, 2–3.5 × 1.5–2 μm.

Ecology: On siliceous and calcium-containing rocks in coastal areas. In Søby on the island Ærø, Denmark, *Xanthoria pedersenii* often overgrew thalli of *Xanthoria pylyporlykii* heavily damaged or killed by the lichenicolous fungus *Telogalla olivieri*. Only a single collection was made on bark (*Fraxinus excelsior*), in Ramlösa south of Helsingborg in Skåne, southernmost Sweden (voucher LD M67, SK22027).

Etymology: The new species is named after Christiern Pedersen (*ca* 1480–16 January 1554), a Danish canon, humanist, writer, printer and publisher,

Fig. 2. Xanthoria pedersenii – general view of the holotype (upper); general view of the isotype (599E) (lower)

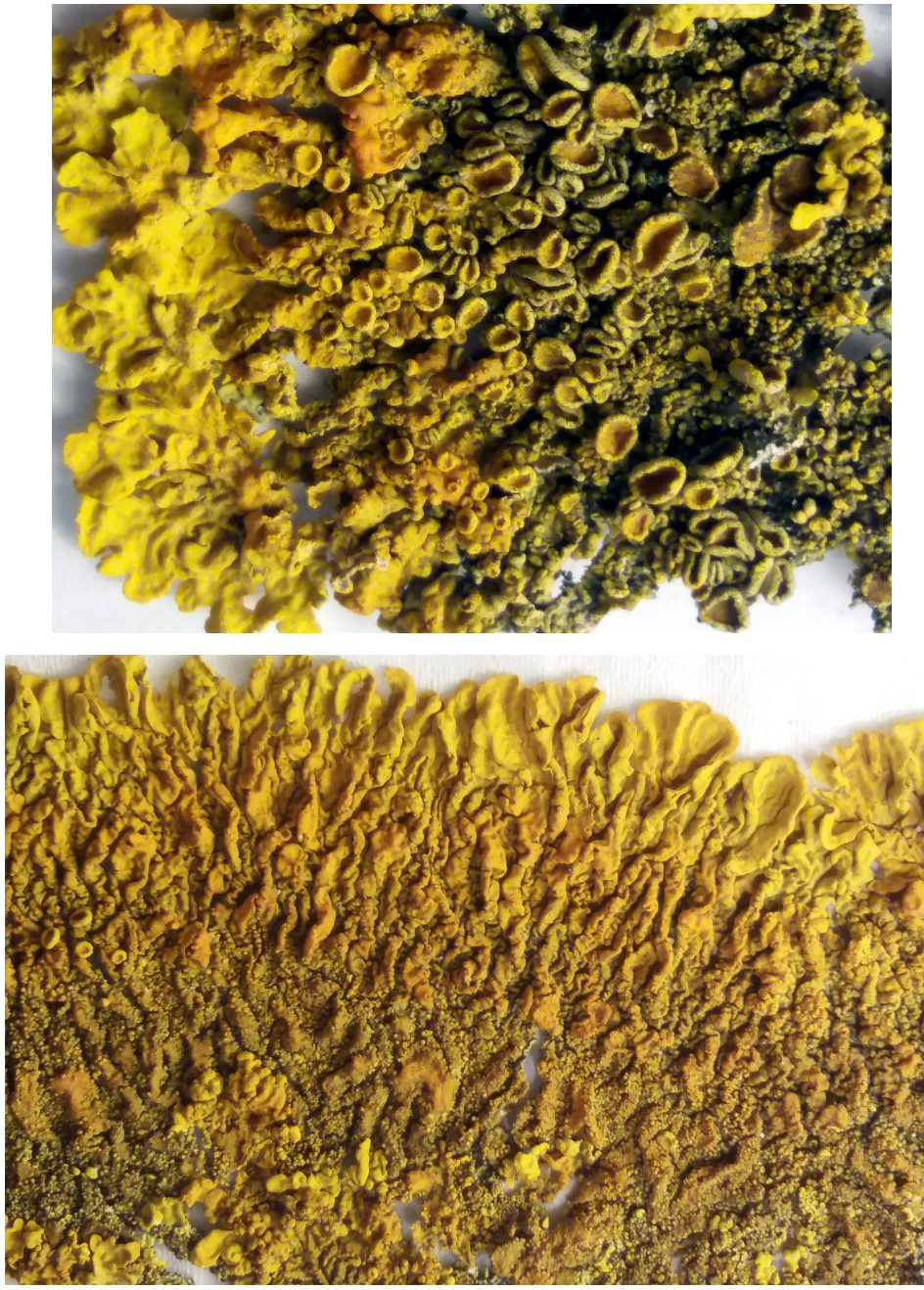

Fig. 3. Xanthoria pedersenii – enlarged peripheral zone with lobes of the isotypes, 599A (upper), 599F (lower)

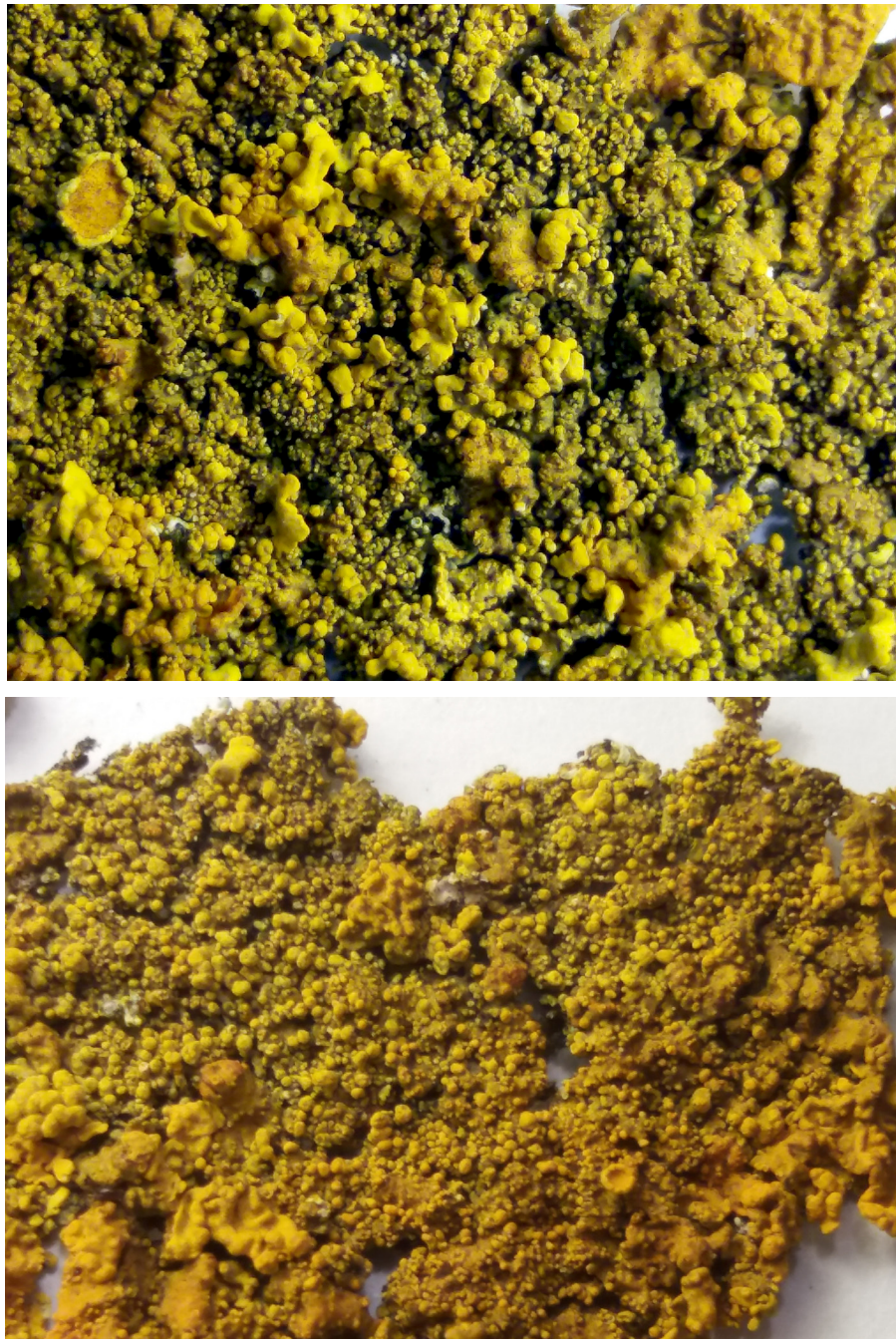

Fig. 4. Xanthoria pedersenii – enlarged portion of thallus with isidia (isotype, 599A)

who is best known for the new edition of Saxo's chronicle which thus saved the early Danish history for posterity and the translation of the Bible into Danish, known as 'Christian III's Bible'. His role in Denmark can be compared with the humanist and theologian Erasmus Rotterdam in the Netherlands.

Distribution: This species is found at 16 localities. The highest number of specimens was registered at the Danish localities Gørløse (10 specimens), Søborg (6 specimens), and Sandby (5 specimens). At the other 12 localities there were only one or two specimens (Table 1, Fig. 7).

Taxonomic notes: *Xanthoria pedersenii* is similar to *Xanthoria calcicola* in having a wrinkled central portion with scarce isidia or in having hemispherical isidia-like formations with conidiomata, but differs in having thin, paper-like thalline lobes, which are well-developed only in the narrow peripheral zone, in having smaller (shorter and narrower) lobes, sometimes long and irregularly orientated with a more or less reticulate surface at tips, wrinkled in the centre, in having smaller knob-like warts, which may resemble coarse isidia that do not fall off, to 0.2–0.3 mm in diam. *vs*. 0.3–0.6 mm wide warts, in having much narrower ascospores, (7–)8–13(–15) × (4.5–)5.5–7.5(–8) μm *vs*. 10–15 × 7–9 μm, and much wider range of variation of the septa, (3–)4–9(–11) μm *vs*. 5–6.5 μm wide, as in having slightly shorter but wider conidia, 2–3.5 × 1.5–2 μm *vs*. 2–4 × *ca* 1 μm.*

Xanthoria pedersenii is similar to *Xanthoria pylyporlykii* in having thin thalline lobes and often narrow overlapping and irregularly orientated lobes in the centre, but differs in having rather thick, downwards bent margins, in having a greenish and wrinkled surface especially in the centre, usually contrasting the more yellowish terminal portions, being raised and only slightly attenuated at the basis, scattered apothecia as well as in having minute, often degrading isidia of furuncle type, dissolving along ridges and in having shorter ascospores with narrower septa. *Xanthoria pedersenii* is similar to *Rusavskia* species in having separate/distinct long and narrow lobes and furuncle-like isidia dissolving in smaller portions, but differs in having plane thalline lobes, only slightly semi-convex due to downwards bent marginals, lack of true soredia, having much smaller isidia-like formations, minute and in small amount dissolving fragments (gradually forming a 'sorediate' thallus), and in having longer ascospores with wider septa.

The central portion of the thallus of *X. calcicola* becomes greenish or darker in moist field conditions, while it is reddish orange as dry. The bright yellow thalline margin of the apothecia is very distinct. Species of the *Xanthoria calcicola* group show similarities with species of the *Xanthoria ectane-*

* We were not able to identify 'yellowish crystals 2–5(–6) mm wide, 0.15–0.4 mm thick', in our collection from the southwestern part of the Baltic Sea basion region mentioned from Mediterranean collections of *Xanthoria calcicola* (Nimis and Martellos 2023), which considered sometimes as diagnostic character of *Xanthoria calcicola* (Lindblom and Ekman 2005).

Table 2
Distinguishing characters of *Xanthoria pedersenii*, *X. wennergrenii* and related species

Character / species	The *Xanthoria calcicola* complex		
	*X. calcicola****	*X. pedersenii*	*X. wennergrenii*
Thallus	rather large and thick	from 1.5 to 7 cm across	1–2.5 cm across
Thallus in section, μm	200–250	125–200	100–150
Thalline lobes	thick or distinctly thickened along the margins, well developed from centre to the tips	thin, paper-like, well developed in peripheral zone only	thin and small, well developed only in peripheral zone
Thalline lobe width, mm	to 10	to 5–7	to 3–5
Upper surface	smooth or wrinkled in the centre	±smooth or reticulate at tips, and wrinkled in the centre	smooth, rarely with wrinkles
Isidia-like formations, mm wide	wart-like, 0.3–0.6	regularly rounded, knob-like, 0.05–0.1	pustulae-like or isidia like, often eroded, 0.2–0.3
Ascospores, μm	10–15 × 7–9	8–13 × 5.5–7.5	13–17 × 5–7
Ascospore septa, μm wide	5–6.5	4–9	6–10
Conidia, μm	2–4 × *ca*. 1	2–3.5 × 1.5–2	unknown

*** According to molecular data *Xanthoria calcicola* is a complex taxon including at least two different taxa, which status is still waiting for clarifying

oides group. Both groups have a much darker greenish thallus in the centre while the peripheral zone usually is light yellowish especially in the field. Collections from Marstal, Ærø (locality 15 in Table 1; concrete wall along coast SK23845, SK23846), Søby (locality 14 in Table 1; SK23825, SK23826), and Højby, Zealand (locality 11 in Table 1; SK23872) differ by narrower ascospores. Additional taxa, not least among *Xanthoria*-material with a parasitic habit, may be discovered in extended phylogeny analyses.

Other specimens examined: – Denmark: Zealand, Gørløse, 3.12.2022, coll. S. Kondratyuk SK22011 (voucher LD-M63 of nrITS sequence) sub *Xanthoria pedersenii* growing side by side with *X. pylyporlykii*; SK22016 (voucher LD-M76 of nrITS sequence) sub *Xanthoria pylyporlykii* growing side by side with *X. pedersenii*; SK22017 (voucher LD-M58 of nrITS sequence) sub *Xanthoria pedersenii* with *Telogalla olivieri*; SK22018; SK22005-3; SK22007, SK22008, SK22009; Helsinge, 26.03.2023, coll. S. Kondratyuk sect 579 (voucher LD-M82) SK23578; Højby, the church, 25.06.2023, coll.: A. and N. Thell, SK23872 (differs in having very narrow ascospores); SK23873 ascospores to 8 μm wide; Bornholm, Nyker church, 29.10.2022, coll. S. Kondratyuk on bark of *Acer pseusoplatanoides* SK22273, SK22275; Østerlars, 29.10.2022, coll. S. Kondratyuk section 280 (specimen differs in having shorter ascospores and narrower septa); sections 281, 282. Møn, Fanefjord, 11.10.2022, coll. S. Kondratyuk section 167 (voucher LD-M85 for nrITS sequence) sub *Xanthoria pedersenii* with *Telogalla olivieri*; section 168 (differs in having wider ascospores); Borre church, 22.09.2022, coll. S. Kondratyuk section 159; Ærø, Marstal, 27.05.2023, coll. S. Kondratyuk roadside rock, section 833; Marstal, 27.05.2023, concrete wall along coast, section 844 sub *Xanthoria pedersenii* with *Telogalla olivieri,* section 845 (differs by very narrow ascospores), section 846 (differs by very narrow ascospores); Søby church, 26.05.2023, coll. S. Kondratyuk SK23825, SK23826 (differs by very narrow ascospores); Ærøskøbing, 28.05.2023, coll. S. Kondratyuk granite, coast, section 843 sub *Xanthoria pedersenii* with *Telogalla olivieri*. – Germany: Mecklenburg-Vorpommern, Alt Bukow, 2.10.2023, coll. S. Kondratyuk section 972; section 981 (long and narrow separate lobes well distinct with wrinkled surface in the centre); section 982 SK23981C sub *Xanthoria pedersenii* partly infected by *Xanthoria* sp. 1. – Sweden: Skåne, Ramlösa, 12.08.2022, coll. S. Kondratyuk (voucher LD-M67 for nrITS sequence) on bark of *Fraxinus*; Skanör church 23.08.2022, coll. S. Kondratyuk section 361; Malmö, Västra Hamnen, 16.08.2022, coll. S. Kondratyuk SK23442, SK23443.

Xanthoria wennergrenii S. Y. Kondr., Kärnefelt et A. Thell, *spec. nova* (Figs 5–6)

MycoBank No.: MB 853039

Similar to Xanthoria calcicola *and sister group according to nrITS sequences, but differs in having smaller thalline lobes, well developed in the peripheral zone only, pustule-like isidia and a more or less bulky centre of the thallus, longer ascospores and wider septa.*

Type: Denmark. Bornholm, Hammershus ruins, 55.2713° N, 14.7554° E, on brick walls at the highest part, 27.10.2023, coll.: S. Y. Kondratyuk SK23A55 – holotype – set with 6 isotypes will be distributed in the Plantae graecenses exsiccate.

Thallus foliose, from very small to 1–2.5 cm across, sometimes to very large, to 5(–8) cm in diam., initially irregular then more or less regularly rounded, with a rather well-developed peripheral zone in contrast to the thick or bulky 'isidiate' central portion with distinctly raised lobes, pustulae or isidia-like formations, very fragile, sometimes completely eroded to an isidiate-phyllidiate mass in the centre, dull greenish or dull greenish-greyish yellow, often damaged and eaten. Peripheral zone rather wide, to (5–)15 mm wide (if without apothecia), bright yellow, with long thalline lobes present; if thalli small (*ca* 1 cm across), both lobes and central portions can be very small but still very different with a bulky centre contrasting plane lobes in the peripheral portion; thalline lobes (4–)8–10(–15) mm long and 1(–2) mm wide at the narrowest portion, to (1–)3–5(–7) mm wide at the tips, somewhat widened towards the tips, if dissected to 5–7(–12) mm wide, rather thin, upper surface with a more or less smooth surface or with scarce irregular wrinkles, soon becoming irregularly wrinkled, very waved toward the centre, with more or less well-developed cross wrinkles, apparently rather thick due to downwards bent lobe margins or more or less raised marginal zones of lobes forming radiating ridges or wrinkles; centre upper surface at first warted, warts more or less hemispherical and rather low, to 0.2–0.3 mm in diam., mostly more or less regularly rounded, rather densely packed in the centre, soon becoming irregularly widened or raised and even more crowded, partly eaten pustules also observed, irregular pustules to 0.5(–1) mm across, hollow, very indistinct and isidiate or eroded, eaten by insects (seemingly sorediate), with very indistinct secondary lobules, erect or somewhat ascending, overlapping, forming an indistinctly ramified, coral-like or phyllidiate surface, tips of lobes, isidia or pustulae-like formations 0.05–0.15 mm in diam. with gradual transition to more or less hemispherical or cylindrical, finger-like formations to 0.1–0.2 mm in diam. to 0.5 mm long or thalline portions horizontally and irregularly orientated mixture of ascending secondary lobes, 0.2–0.3 mm wide to 0.5(–1) mm long, appearing as a crumble or fragile pustulae-like* isidiate mass, often heavily damaged or eaten by insects. Centre sometimes completely covered by flattened, rather wide warts, containing spherical formations, i.e. conidiomata or young apothecia, to 0.3–0.5(–0.7) mm in diam., rarely conidiomata reach 1(–1.2) mm in diam., spherical formations often produce regenerating secondary sublobules to (0.5–)1 mm across.

Apothecia from rather small, 0.2–0.4 mm in diam., hardly distinct among the bulky mass in the centre, to much larger, 1–3(–4.5) mm in diam. very often re-growing or eaten (see information on moss mites below), from rather rare to very numerous, occasionally raised, from urceolate or concave, plane to waved discs; discs brown to dull orange; ascospores (12–)13–17(–19) × 5–7(–8)

* Eaten or broken portions make impression that pustules are hollow inside.

μm (i.e. *Xanthoria ectaneoides* type), septa (5–)6–10(–12) μm wide (i.e. *Xanthoria coomae* type; see Kondratyuk *et al.* 2024).

Ecology: On tile roofs and vertical rocky walls, growing side by side with *X. ectaneoides*.

Distribution: This species is confirmed from Bornholm, Denmark, where it was collected in Nyker and Hammerhus. Additional specimens were collected at nine additional localities on the Danish islands Ærø, Fyn and Møn, but also in Skåne, Sweden, and in the Rostock area in Germany (Table 1, Fig. 7).

Etymology: The new species is named after Axel Wenner-Gren (originally Wennergren, 5 June 1881 – 24 November 1961), a Swedish industrialist and philanthropist, who established foundations to support research including a fellowship for the senior author supporting this taxonomic revision of the *Xanthoria calcicola* group.

Taxonomic notes: *Xanthoria wennergrenii* is similar to *Xanthoria calcicola* with a similar contrast between peripheral and central parts. The two species are sister groups according to nrITS phylogeny. *Xanthoria wennergrenii* differs in having thinner and smaller thalline lobes, well developed in the irregularly developed peripheral zone only, in having a thick and crumbled, bulky centre with pustulae-like isidia, longer ascospores with wider septa. *Xanthoria wennergrenii* forms a separate branch in the phylogenetic tree of the genus *Xanthoria* (Fig. 1).

Xanthoria wennergrenii is often growing together with *X. ectaneoides*. When the two species are represented only by very small thalli (usually to 1 cm across) with a few lobes and apothecia, their identification may be problematic. However, *X. wennergrenii* differs from *X. ectaneoides* in the lack of well-developed secondary sublobules, as well as in having shorter ascospores and septa (Kondratyuk *et al.* 2006, 2024).

Having *Xanthoria ectaneoides* type of ascospores and *Xanthoria coomae* type of septa, *Xanthoria wennergrenii* would be expected to be a member of the *Xanthoria coomae* complex together with *Xanthoria ectaneoides* and *X. pylyporlykii,* yet it is settled in the *Xanthoria calcicola* subbranch.

Thalli of *Xanthoria wennergrenii* are very sensitive to attacks of moss mites. If moss mites are frequent, they can completely destroy lichen thalli, preferably their central portions. Heavily damaged thalli of this species were observed at several localities on the island Bornholm in 2022. It is almost impossible to collect lichen specimens of this species without moss mites. Nonetheless, intact thalli were collected there, at Nyker church, which were used for morphological and anatomical investigation. The bulky central portion of thallus is probably very convenient for hosting moss mites and other insects. To preserve lichens of this species for the future, it is important to freeze the collected samples immediately when arriving from the field.

Fig. 5. Xanthoria wennergrenii – general view (holotype) (upper); enlarged portion of thallus with isidia (holotype) (lower)

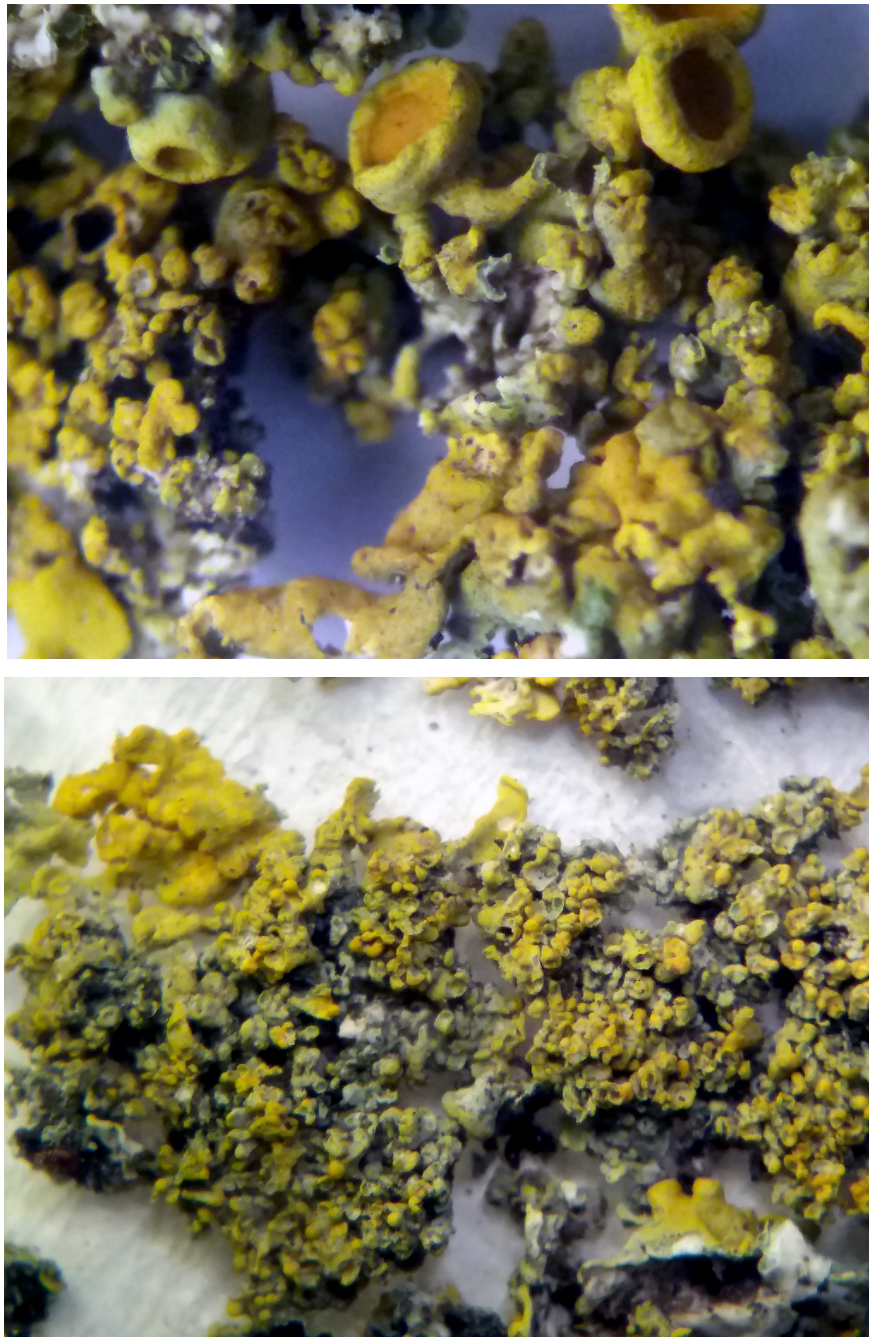

Fig. 6. *Xanthoria wennergrenii* – enlarged portion of thallus with isidia (holotype) (upper); enlarged portion of thallus with isidia damaged by moss mites (SK22278) (lower)

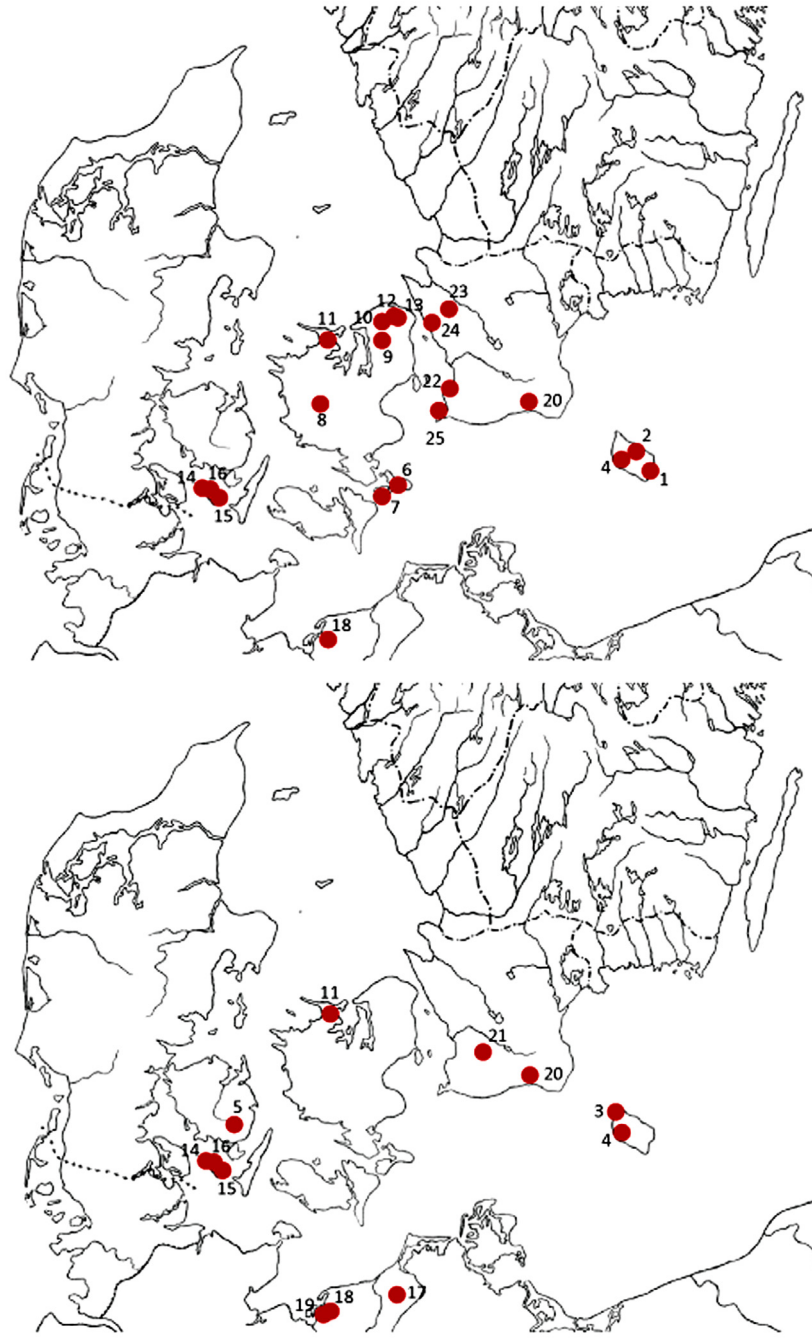

Fig. 7. Distribution of the *Xanthoria calcicola* complex in the western part of the Baltic Sea area: *X. pedersenii* (upper), *Xanthoria wennergrenii* (lower). Numbers of localities after Table 1

Other specimens examined: – Denmark: Zealand, Højby, 25.06.2023, coll.: N. and A. Thell SK23871*, SK23874; Ærø, Søby, 26.05.2023, coll. S. Kondratyuk SK23826**, *; SK23806, Ærøskøbing, 26.05.2023, coll. S. Kondratyuk SK23840, SK23841; Marstal, 26.05.2023, coll. S. Kondratyuk SK23835, SK23836, SK23847, SK23848, SK23849. SK23850. Bornholm, Nyker, 29.10.2022, coll. S. Kondratyuk SK22278 (voucher M65 for nrITS sequence), sub *Xanthoria wennergrenii* growing side by side with *X. ectaneoides* and *Physcia adscendens*; Nyker SK22278D (voucher M86 for nrITS sequence); SK22278C. SK23851; Fyn, Svendborg Landevej, 28.05.2023, coll. S. Kondratyuk SK23814. – Germany: Mecklenburg-Vorpommern, Cammin, 1.10.2023, coll.: S. Kondratyuk SK 23A28*; Alt Bukow, 26.05.2023, coll. S. Kondratyuk SK23979, SK23980; Blowatz 2.10.2023, coll. S. Kondratyuk SK24A19; – Sweden: Bromma, 28.09.2022, coll. S. Kondratyuk SK22149K (voucher M83 for nrITS sequence); SK22149G sub *Xanthoria wennergrenii* growing together with *X. pylyporlykii*; SK22149E sub *Xanthoria wennergrenii* growing together with *X. pylyporlykii*; SK22278 sub *Xanthoria wennergrenii* growing side by side with *X. pylyporlykii* and *Physcia adscendens*; Dalby, the church, 08.01.2023, coll. S. Kondratyuk SK24B21.

Key to species of *Xanthoria calcicola* complex and related taxa (i.e. with vegetative propagules)

1a Thallus thin, centre and peripheral zone are the same, true well developed isidia present especially in the centre *Xanthoria mediterranea****

1b Thallus usually thicker in section, rugose centre and peripheral zone are rather different 2

2a Thallus rather large, thalline lobes well developed and distinctly widened towards tips *Xanthoria calcicola*****

2b Thallus very varying from small to larger spots, but thalline lobes smaller and usually developed only in peripheral zone 3

3a Isidia regularly rounded, ± subconvex, 0.05–0.1 mm diam., ascospores small and narrow, 8–13 × 5.5–7.5 μm, ascospore septum 4–9 μm wide *Xanthoria pedersenii*

3b Isidia pustulae-like, (0.1–)0.2–0.3 mm diam., usually eroded to isidiate-phyllidiate mass, ascospores rather long, 13–17 × 5–7 μm, ascospore septum 6–10 μm wide *Xanthoria wennergrenii*

* Specimens differ in having somewhat shorter ascospores close to *Xanthoria parietina* type of ascospores (Kondratyuk *et al.* 2024) and their position will be repeatedly checked in the future investigations.

** Specimens from Søby (locality 14) differ in having much narrower ascospores with shorter ascospore septa.

*** *Xanthoria* aff. *aureola* (see Kondratyuk *et al.* 2024) has also true isidia, but its position will be settled later

**** see note to Table 2

*

Acknowledgements – SK is grateful to Dr J. K. Abbott, Head of the Department of Biology, Lund University, and to Prof. M. Hansson, Head of Molecular Cell Biology Division, Lund University for the benevolent support. SK is especially thankful to Dr Arne Thell and Dr Nataliya Thell (both from Lund University) for generous help and friendly support during evacuation of his family from home Institute in Ukraine. Thanks are due to Elisabeth Gauger Nilsson, Lars Fredriksson, David Stuart and Shakhira Zakhrabekova at the Molecular Cell Biology Division of Lund University for assistance, and to Christoffer Fägerström (Biological Museum of Lund University) for identifying moss mites living on/in lichens of the genus *Xanthoria*. This work was supported by a grant from the Wenner-Gren Stiftelserna (Wenner-Gren Foundations, Sweden) and ERASMUS+ for SK.

REFERENCES

Arup, U., Søchting, U. and Frödén, P. (2013): A new taxonomy of the family Teloschistaceae. – *Nordic J. Bot.* **31**(1): 16–83. https://doi.org/10.1111/j.1756-1051.2013.00062.x

Giralt, M., Nimis, P. L. and Poelt, J. (1993): Studien über einige Arten der Flechtengattung Xanthoria mit isidiiformen vegetativen Diasporen. – *J. Hattori Bot. Lab.* **74**: 271–285.

Kärnefelt, I. (1989): Morphology and phylogeny in the Teloschistales. – *Cryptog. Bot.* **1**: 147–203.

Kondratyuk, S. Ya. (2004): *Xanthoria*. – In: Khodosovtsev, A. Y., Kondratyuk, S. Y., Makarova, I. I. and Oxner, A. N. (eds): Handbook of the lichens of Russia. 9. Fuscideaceae, Teloschistaceae. Nauka, Sankt-Petersburg, pp. 270–286.

Kondratyuk, S. and Poelt, J. (1997): Two new Asian Xanthoria species (Teloschistaceae, lichenized Ascomycotina). – *Lichenologist* **29**: 173–190. https://doi.org/10.1017/S0024282997000200

Kondratyuk, S. Y., Kärnefelt, E. I. and Thell, A. (2006): New species of Xanthoria (Teloschistaceae) from Australia. – *Nuytsia* **16**(1): 63–76. https://doi.org/10.58828/nuy00458

Kondratyuk, S., Jeong, M.-H., Yu, N.-N., Kärnefelt, I., Thell, A., Elix, J. A., Kim, J., Kondratyuk, A. S. and Hur, J.-S. (2013): Four new genera of teloschistoid lichens (Teloschistaceae, Ascomycota) based on molecular phylogeny. – *Acta Bot. Hung.* **55**(3–4): 251–274. https://doi.org/10.1556/abot.55.2013.3-4.8

Kondratyuk, S. Y., Lőkös, L., Upreti, D. K., Nayaka, S., Mishra, G. K., Ravera, S., Jeong, M.-H., Jang, S.-H., Park, J. S. and Hur, J.-S. (2017): New monophyletic branches of the Teloschistaceae (lichen-forming Ascomycota) proved by three gene phylogeny. – *Acta Bot. Hung.* **59**(1–2): 71–136. https://doi.org/10.1556/034.59.2017.1-2.6

Kondratyuk, S. Y., Lőkös, L., Farkas, E., Kärnefelt, I., Thell, A., Yamamoto, Y. and Hur, J.-S. (2020): Three new genera of the Teloschistaceae proved by three gene phylogeny. – *Acta Bot. Hung.* **62**(1–2): 109–136. https://doi.org/10.1556/034.62.2020.1-2.7

Kondratyuk, S. Y., Persson, P.-E., Hansson, M., Lőkös, L., Kondratiuk, A. S., Fayyaz, I., Kouser, R., Afshan, N. S., Niazi, A. R., Zulfiqar, R., Khalid, A. N., Kärnefelt, I., Farkas, E., Hur, J.-S. and Thell, A. (2022*a*): Contributions to molecular phylogeny of lichens 4. New names in the Teloschistaceae. – *Acta Bot. Hung.* **64**(3–4): 313–336. https://doi.org/10.1556/034.64.2022.3-4.7

Kondratyuk, S. Y., Popova, L. P., Kondratiuk, A. S. and Lőkös, L. (2022*b*): The first enumeration of members of the Teloschistaceae (lichen-forming Ascomycetes) status

of which confirmed by three gene phylogeny. – *Studia bot. hung.* **53**(2): 137–234. https://doi.org/10.17110/StudBot.2022.53.2.137

Kondratyuk, S. Y., Suija, A., Kärnefelt, I. and Thell, A. (2023): Lichenicolous fungi of southern Scandinavia with particular reference to those associated with Xanthoria calcicola s. lat. – *Folia Crypt. Estonica* **60**: 129–136. https://doi.org/10.12697/fce.2023.60.12

Kondratyuk, S. Y., Lőkös, L., Persson, P. E., Hansson, M., Schiefelbein, U., Kärnefelt, I. and Thell, A. (2024): New and noteworthy lichen-forming and lichenicolous fungi 13. A revision of the Xanthoria ectaneoides complex (Xanthorioideae, Teloschistaceae) including the new species Xanthoria pylyporlykii. – *Acta Bot. Hung.* **66**(1–2): 47–77. https://doi.org/10.1556/034.66.2024.1-2.4

Lindblom, L. and Ekman, S. (2005): Molecular evidence supports the distinction between Xanthoria parietina and X. aureola (Teloschistaceae, lichenized Ascomycota). – *Mycol. Res.* **109**: 187–191. https://doi.org/10.1017/S0953756204001790

Nimis, P. L. (1993): *The lichens of Italy*. – Museo Regionale di Scienze Naturali, Torino, 897 pp.

Nimis, P. L. (2016): *The lichens of Italy – a second annotated catalogue*. – EUT Edizioni Università di Trieste, Trieste, 740 pp.

Nimis, P. L. and Martellos, S. (2023) *ITALIC – The information system on Italian lichens*. Version 7.0. – Dept. of Biology, University of Trieste, Trieste. Available at http://dryades.units.it/italic. Accessed 20 July 2023

Oxner, A. N. (1937): *Viznachnik lishainikiv URSR*. – Akademija Nauk Ukrainskoi RSR, Institut Botaniki, Kiev, 342 pp.

Poelt, J. and Petutschnig, W. (1992*a*): Beiträge zur Kenntnis der Flechtenflora des Himalaya IV. Die Gattungen Xanthoria und Teloschistes zugleich Versuch einer Revision der Xanthoria candelaria-Gruppe. – *Nova Hedwigia* **54**: 1–36.

Poelt, J. and Petutschnig, W. (1992*b*): Xanthoria candelaria und ähnliche Arten in Europa. – *Herzogia* **9**: 103–114.

Smith, C. W., Aptroot, A., Coppins, B. J., Fletcher, A., Gilbert, O. L., James, P. W. and Wolseley, P. A. (eds) (2009): The lichens of Great Britain and Ireland. – British Lichen Society, London, 1046 pp.

Tsurykau, A., Bely, P. and Arup, U. (2020): Xanthoria coomae and X. polessica, two additional synonyms for X. parietina. – *Plant Fungal Syst*. **65**(2): 620–623. https://doi.org/10.35535/pfsyst-2020-0033

Wirth, V., Hauck, M. and Schultz, M. (2013): *Die Flechten Deutschlands*. Band 1–2. – Ulmer, Stuttgart, 1244 pp.