Acta Botanica Hungarica 66(1–2), pp. 47–77, 2024
DOI: 10.1556/034.66.2024.1-2.3

NEW AND NOTEWORTHY LICHEN-FORMING AND LICHENICOLOUS FUNGI 13. A REVISION OF THE *XANTHORIA ECTANEOIDES* COMPLEX (XANTHORIOIDEAE, TELOSCHISTACEAE) INCLUDING THE NEW SPECIES *XANTHORIA PYLYPORLYKII*

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(Received: 12 January 2024; Accepted: 9 March 2024)

Xanthoria ectaneoides, usually recognised by its secondary sublobules, is circumscribed in a strict sense using spore size and a molecular phylogeny based on ITS-sequences. The species, earlier considered a synonym of *X. aureola,* forms a subclade with *X. coomae* and the new species *X. pylyporlykii*, described here, whereas *X. aureola* is positioned in the *Xanthoria calcicola* subclade. The new species *X. pylyporlykii* is characterised by a combination of characters typical either for *Xanthoria ectaneoides* or *X. coomae*.

Kew words: ascospore, ascospore septum, Denmark, Germany, lichen-forming fungi, Sweden, *Xanthoria aureola, X. ectaneoides, X. pylyporlykii*

INTRODUCTION

The genus *Xanthoria* has, in similarity with several other well-known lichen genera, been heavily re-evaluated in the molecular era. Morphological characters used for delimitations of species and genera showed good correlation with molecular data. Seventeen lichen groups, earlier included in *Xanthoria,* have been segregated as separate genera (Kondratyuk *et al.* 2022*b*). Of approximately 50 *Xanthoria* species in the pre-molecular era (Kärnefelt 1989), only 13 species remain in the genus in its strict sense (Kondratyuk *et al.* 2022*b*), although many new species have been described both in *Xanthoria* s. str. and its segregates.

The present work is limited to *Xanthoria* in its strict sense, where several subclades can be discerned, one of which is the *Xanthoria ectaneoides* subclade. The basionym for *Xanthoria ectaneoides* (Nyl.) Zahlbr. is *Physcia ectaneoides*

Nyl., described in the 19th century (Nylander 1883). The species is revised using a recent collection from areas around the southwestern part of the Baltic Sea. The phylogeny is based on ITS-sequences. Non-molecular characters were investigated for all specimens including the type specimen of *X. ectaneoides* from France. *Xanthoria ectaneoides* has been considered as a synonym of *X. aureola* (Ach.) Erichsen (Gaya *et al.* 2012, 2015, Lindblom and Ekman 2005). The wide species concept for *Xanthoria parietina* and *X. aureola* does not have support from molecular data.

Already in the 1990s, the senior author was aware of an undescribed taxon in Scandinavia with very long ascospores, to 20 μm long, and very wide ascospores septa, 11–12 μm wide. The undescribed taxon was recognised by its spore size since the ascospores of *Xanthoria parietina* are smaller, i.e. 10–15 × 6–8 μm with 6–8 μm wide septa. In 2022–2023 an extensive material of *Xanthoria* s. str. was collected in the southwestern Baltic Sea area, in connection with a project on lichenicolous fungi growing on *Xanthoria* (Kondratyuk *et al.* 2023). The undescribed taxon was found to be frequent in the investigated area.

Prior to describing a new species, a revision of all available types of old taxa of the genus *Xanthoria* was performed. Long ascospores (to 20 μm long) with wide septa (*ca* 11–12 μm) are revealed here as specific for *Xanthoria ectaneoides* (Nyl.) Zahlbr. (Nylander 1883), the second species to be described in *Xanthoria* after *X. parietina* (Linnaeus 1753).

The aim of this paper was to revise the *Xanthoria ectaneoides* complex, based on material from the area around the southwestern part of the Baltic Sea, using morphology, anatomy and molecular phylogeny. This integrative approach in taxonomy of the genus *Xanthoria*, i.e. correlation between morphology and anatomy, particularly details of ascospores and their septa, was elaborated by the Austrian lichenologist Josef Poelt and his colleagues in the premolecular era (Giralt *et al.* 1993, Kondratyuk and Poelt 1997, Poelt and Petutschnig 1992*a*, *b*, etc.). Several species described later were confirmed by molecular phylogeny (Arup *et al.* 2013, Kondratyuk *et al.* 2013, 2017, 2020).

MATERIAL AND METHODS

Lichen-forming fungi of the *Xanthoria calcicola* and the *X. parietina* complexes occurring on hard substrates, i.e., rocks, bricks, tiles and metal roofs were collected at 65 localities in southern Scandinavia, i.e. Skåne, the southernmost province of Sweden, southern Denmark and northern Mecklenburg-Vorpommern and Schleswig-Holstein in Germany (Table 1). The specimens will preferably be deposited at C, GB, KW-L, LD, some of them will be distributed in the exsiccate Plantae Graecenses. The revision was mainly based on our own collections and type specimens of *Xanthoria aureola*, *X. calcicola* and *X. ectaneoides*.

Table 1
List of localities for the *Xanthoria ectaneoides* complex (* = SK, ** = AT and NT, *** = US)

No	Locality	Date / collector(s)	Position	Number of specimens		
				Total	with *X. ectaneoides*	with *X. pylyporlykii*
1	Denmark, Amager, Tårnby par., the church, on tiles on the cemetery wall	13.08.2023*	55.6280° N, 12.6028° E	35	27	3
2	Bornholm, Nexø, on rock wall	28.10.2022*	55.0629° N, 15.1250° E	56	11	3
3	Nylars par., the church, on rock wall	28.10.2022*	55.0724° N, 14.8100° E	11	2	1
4	Nyker par., the church, on rock wall	29.10.2022*	55.1396° N, 14.7595° E	11	2	1
5	Østerlars par., the church, on rock wall	29.10.2022*	55.1648° N, 14.9656° E	2	–	2
6	Rønne par., the church, on tiles on the cemetery wall	29.10.2023*	55.0935° N, 14.7007° E	58	46	–
7	Svaneke par., on tiles on the church and cemetery wall	29.10.2023*	55.1343° N, 14.1412° E	72	44	7
8	Fyn, Svendborg Landevej, on concrete	28.05.2023*	55.1860° N, 10.7330° E	44	–	6
9	Jutland, Haderslev, the old church, on tiles on the cemetery wall	1.07.2023*	55.2501° N, 9.4891° E	33	5	
10	Skagen par., the church, on tiles on the northern wall at the church	16.07.2023**	57.7214° N, 10.5847°E	3	–	1
11	Møn, Borre par., the church, on tiles on the cemetery wall	22.09.2022*	54.9959° N, 12.4432° E	6	–	1
12	Fanefjord par., the church, on tiles on the cemetery wall	11.10.2022*	54.9013° N, 12.1511° E	23	2	2
13	Zealand, Lillerød par., the church, on tiles on the cemetery wall	11.06.2023*	55.8734° N, 12.3460° E	7		4
14	Bjernede par., the church, on tiles on the cemetery wall	26.05.2023*	55.462° N, 11.625° E	22	–	2
15	Farum par., the church, on tiles on the cemetery wall	4.02.2023*	55.8070° N, 12.3573° E	54	9	18
16	Fjenneslev par., the church, on tiles on the cemetery wall	26.05.2023*	55.4336° N, 11.6875° E	22		1
17	Gørløse par., the church, on tiles on the cemetery wall	3.12.2022*	55.8853° N, 12.1991° E	22	1	4
18	Helsinge, the church yard, on tiles on the cemetery wall	26.03.2023*	56.0208° N, 12.1969° E	170		14
19	Højby par., the church, on tiles on the cemetery wall	25.06.2023**	55.9128° N, 11.5996° E	15		3
20	Slangerup, SE edge of Lystrup forest, on tile roof	3.12.2022*	56.2316° N, 10.2303° E	4	–	3

Table 1 (continued)

No	Locality	Date / collector(s)	Position	Number of specimens		
				Total	with *X. ectaneoides*	with *X. pylyporlykii*
21	Søborg par., the castle ruins, on modern brick inclusions	16.04.2023*	55.0877° N, 12.3055° E	45		13
22	Søborg par., the church, on tile roof	16.04.2023*	55.7352° N, 12.5120° E	70		1
23	Ærø, Søby par., the church, on tiles on the cemetery wall	26.05.2023*	54.9386° N, 10.2568° E	55		2
24	Marstal, the church, on tiles on the cemetery wall	26.05.2023*	54.8550° N, 10.5170° E	59	1	9
25	Marstal, Ommel church, on tile roof	27.05.2023*	54.8646° N, 10.4891° E	17		3
26	Tranderup, the church	27.05.2023*	54.8941° N, 10.3101° E	9		2
27	Ærøskøbing, the church, on tiles on the cemetery wall	26.05.2023*	54.8879° N, 10.4122° E	71		2
28	Germany, Mecklenburg-Vorpommern, Rostock district, Cammin	1.10.2023*	53.967° N, 12.3333° E	17	1	3
29	Rostock district, Alt Bukow, the church, on tiles on the cemetery wall	2.10.2023*	53.9963° N, 11.6077° E	47	6	1
30	Rostock district, N of the nature reserve Heiligensee, branches on the beach	7036, 28.10.2023***	54.2297° N, 12.1769° E	7	5	
31	Rostock district, Rostock, opposite Kanonsberg	2.10.2023*	54.0914° N, 12.1300° E	23	5	1
32	Rostock district, Russow	2.10.2023*	54.0605° N, 11.6490° E	73	7	2
33	Nordwestmecklenburg district, Blowatz-Dreveskirchen	2.10.2023*	53.9939° N, 11.5385° E	37	29	1
34	Poel island, dirt road between Neuhof and Seedorf, transformer station, roof of the transformer station	7037, 4.11.2023***	53.9972° N, 11.4156° E	15	2	2
35	Poel island, Timmendorf, northern harbour pier, south exposed side of the pier, gneiss	7042, 4.11.2023***	53.9925° N, 11.3997° E	4		3
36	Poel island, Kirchdorf, church, southern side, brick	7051, 4.11.2023***	53.9944° N, 11.0381° E	3		3
37	Vorpommern-Rügen district, Darß peninsula, coast between light house and Ahrenshoop, branches from a tree fallen on the beach	6998, 3.10.2023***	54.4525° N, 12.4858° E	3		1

Table 1 (continued)

No	Locality	Date / collector(s)	Position	Number of specimens		
				Total	with *X. ectaneoides*	with *X. pylyporlykii*
38	Vorpommern-Rügen district, Darß peninsula, coast between light house and Ahrenshoop, branches from a tree fallen on the beach	7000, 3.10.2023***	54.4489° N, 12.4836° E	7	2	–
39	Schleswig-Holstein, Nordfriesland, Ockholm, churchyard, church, western side, brick	7005, 6.10.2023***	54.6652° N, 8.8275° E	4		1
40	Nordfriesland, Fahretoft, the church, western side, small annex, north exposed, brick	7009, 7.10.2023***	54.7055° N, 8.7908° E	3	2	
41	Nordfriesland, Nordmarsch-Langeneß, Kirchwarf, fence post, wood	7014, 7.10.2023***	54.6411° N, 8.6169° E	7	1	
42	Nordmarsch-Langeneß, harbour near Peterswarf, wooden bench, wood	7018, 7.10.2023***	54.6375° N, 8.6328° E	10	9	
43	Nordmarsch-Langeneß, harbour near Peterswarf, protection wall, xeric-supralittoral, sunny place, concrete, siliceous rock	7021, 7.10.2023***	54.6375° N, 8.6328° E	5	1	
44	Nordmarsch-Langeneß, Neuwarf, dyke, xeric supralittoral, sunny place, gneiss	7026, 7.10.2023***	54.6392° N, 8.645° E	5	5	1
45	Nordmarsch-Langeneß, harbour W of Mayenswarf, xeric supralittoral, sunny place, wood	7032, 7.10.2023***	54.6336° N, 8.5389° E	4		1
46	Sweden, Skåne, Bromma par., the church, on rocky wall	28.09.2022*	55.4707° N, 13.8001° E	34		2
47	Brönnestad par., Hovdala castle, on granitic rocks	26.08.2022*	56.1040° N, 13.7138° E	10		1
48	Bunkeflo par., Lernacken, on granitic rocks	12.07.2022*	55.5541° N, 12.9191° E	13	–	1
49	Everöd par., the church, on tile roof	4.03.2023*	55.9018° N, 14.0730° E	64	2	22
50	Gislöv par., Gislövsläge, on coastal granitic wall	6.09.2022*	55.3567° N, 13.2369° E	20	3	7
51	Hofterup par., Järavallen, on wooden substrate	9.06.2022*	55.6895° N, 12.9418° E	3		1
52	Husie par., the former LV4 military area, on cement columns	27.08.2022*	55.5773° N, 13.0840° E	6	1	2
53	Lund, Biologihuset	22.10.2022*	55.7118° N, 13.2066° E	17	3	

Table 1 (continued)

No	Locality	Date / collector(s)	Position	Number of specimens		
				Total	with *X. ectaneoides*	with *X. pylyporlykii*
54	Malmö, Västra Hamnen, on granitic rocks	16.08.2022*	55.6133° N, 12.9813° E	14	1	2
55	Stehag par., Stehag, Rapsvägen 3, on tile roof	30.06.2022–25.07.2023*, **	55.9009° N, 13.3948° E	45	23	19
56	Stehag par., NW Stehag, on rocks near roadside trees	5.02.2023*	55.9113° N, 13.3896° E	3		1
57	Norra Vram par., the church, on tiles on the cemetery wall	12.11.2022*, **	56.0870° N, 12.9734° E	15	3	18
58	Tofta par., the church, on tiles on the cemetery wall	2.04.2023*	56.8669° N, 12.9262° E	75	1	5
59	Igelösa par., the church, on tiles on the cemetery wall	11.05.2023*	55.7631° N, 13.2744° E	16	2	1
60	Mölleberga par., the church, on tiles on the cemetery wall	11.05.2023*	55.6085° N, 13.1770° E	14	1	
61	Ramlösa (S of Helsinborg), on roadside rocks near parking area	12.08.2022*	55.8056° N, 12.7333° E	5	2	1
62	Skanör par., the church, on vertical surfaces of thumbs at the cemetery	23.08.2022*	55.4195° N, 12.8497° E	1	1	
63	Svedala par., the church, on tiles on the cemetery wall	*	55.5122° N, 13.2256° E	7		1
	Total			1672	276	221

The specimens were sprayed with water preferably from ten minutes to half an hour before they were removed from the substrate. Mature apothecia were cut by hand. Fifteen sections of each apothecium were mounted in the same water droplet to contain a sufficient amount of ascospores, at least 50 in light field of the microscope, for statistic measurements. Ascospores were exclusively measured outside of asci and sections. At least 50 measurements of adult ascospores were performed and included in the further statistical analysis.

The specimens were studied and determined microscopically and vouchers for DNA-analyses prepared at the unit of Molecular Cell Biology, Department of Biology, Lund University.

DNA extraction, PCR amplification and sequencing

Genomic DNA was extracted directly from a portion of thallus with apothecia from each specimen using a modified 2% CTAB method

(Gardes and Bruns 1993). The ITS-nrDNA region was amplified using the primer pair ITS1F (Gardes and Bruns 1993) and ITS4 (White *et al.* 1990). PCR products were visualised on 1% agarose gel with ethidium bromide through Gel documentation system (Sambrook and Russel 2001). PCR products were sent for sequencing to Tartu, Estonia. However, molecular data for *Xanthoria ibizaensis* are obtained in the Molecular Cell Biology unit of Lund University (Sweden).

Phylogenetic analysis

The newly generated sequences were compared with GenBank database sequences using BLAST search (http://www.ncbi.nlm. nih.gov/BLAST/). All sequences were aligned with sequences of selected representatives of Teloschistaceae obtained from GenBank (see Table 2 for voucher details). Maximum likelihood (RAxML) analyses were performed for the representatives of the Teloschistoideae at first using RAxMLHPC v.8 on XSEDE (Stamatakis 2014) under the GTRGAMMA model on CIPRES Science Gateway (Miller *et al.* 2010). Rapid bootstrap analyses were performed with 1,000 bootstrap replicates. The matrix of the whole genus *Xanthoria* including 56 voucher specimens of the 13 species belonging to this genus and the outgroup *Martinjahnsia resendei* were analysed with Maximum Parsimony (MP), Minimum Evolution (ME) and Maximum Likelihood (ML) methods. The MP tree was obtained using the Tree-Bisection-Regrafting (TBR) algorithm, within the ME method the evolutionary distances were computed using the Maximum Composite Likelihood method (Tamura *et al.* 2004), and the ML analysis was conducted with the lowest BIC scores (Bayesian Information Criterion) model. The bootstrap consensus trees inferred from 1,000 replicates each. The analyses involved 59 nucleotide sequences, there were a total 580 positions in the final dataset. All three analyses were conducted in MEGA11 (Tamura *et al.* 2021).

RESULTS AND DISCUSSION

Results from statistical analysis of data on ascospores

The results from the statistical treatment of ascospore data are based on investigations of more than 900 specimens and data from about 45,000 ascospores. Results of measurements of minimum 50 ascospores from each specimen excluding the most extreme measurements were included in analysis.

Several types of ascospores were observed in *Xanthoria* species. However, in the present study we discuss spore-data exclusively from the *Xanthoria parietina, X. ectaneoides* and *X. coomae* types. Spore type and septum type may be different within a species (Table 3).

Table 2

Sequences used in the phylogenetic analyses (sequences generated for this study as well as new names are in bold). Abbreviations: Ref = references, * = sub *Xanthoria parietina*, ** = sub *Xanthoria* sp., *** = *Xanthoria ectaneoides*

Species, voucher number in the phylogenetic tree	Isolate	Country	nrITS	Ref
Martinjahnsia resendei	BCC-Lich 13176	Spain	AF101284	Martin and Winka 2000
Martinjahnsia resendei	Xres233b	Spain	EU639641	Gaya *et al.* 2008
Martinjahnsia resendei	BCC-Lich 13259	Spain	AF101285	Martin and Winka 2000
Martinjahnsia resendei	BCC-Lich 13175	Spain	AF101283	Martin and Winka 2000
Xanthoria aureola	LIQ109XAAU-2	Spain	whole genome	Llewellyn *et al.* 2023
Xanthoria aureola	Gaya 9	Sweden	JQ301690	Gaya *et al.* 2012
Xanthoria cf. *aureola*	SS0065	UK	ON437600	Brown unpubl.
Xanthoria calcicola	Voucher 105/1	Switzerland	AJ320152	Scherrer and Honegger 2003
Xanthoria calcicola	FNM-088	UK	EU681295	Fedorenko *et al.* 2009
Xanthoria calcicola	Voucher A6	France	AJ320130***	Scherrer and Honegger 2003
Xanthoria calcicola	Voucher 80	UK	AJ320150	Scherrer and Honegger 2003
Xanthoria coomae	2001 Lindblom BH19 (BG)	Norway	AY438298*	Lindblom and Ekman 2005
Xanthoria coomae	M-0102316	Germany	JF831894*	Beck and Mayr 2012
Xanthoria coomae	CANB Kondratyuk 20494, holotype	Australia	KC179410	Arup *et al.* 2013
Xanthoria coomae	Millanes 849(s) AM553	Spain	OQ249845*	Freire Rallo *et al.* 2023
Xanthoria coomae	ALV16819	South Africa	MH714517*	Wirth *et al.* 2018
Xanthoria ectaneoides	LD-M51	Sweden	LD-M51	this paper
Xanthoria ectaneoides	LD-M52	Denmark	LD-M52	this paper
Xanthoria ectaneoides	LD-M61	Denmark	LD-M61	this paper
Xanthoria ectaneoides	LD-M69	Denmark	LD-M69	this paper

Table 2 (continued)

Species, voucher number in the phylogenetic tree	Isolate	Country	nrITS	Ref
Xanthoria ectaneoides	LD-M70	Sweden	LD-M70	this paper
Xanthoria ectaneoides	LD-M73	Sweden	LD-M73	this paper
Xanthoria sp. 2	117(75.8) R. Honegger 379t1	France	AM408403***	Eichenberger 2007
Xanthoria sp. 2	FNM-087	UK	EU681299***	Fedorenko *et al.* 2009
Xanthoria sp. 2	Voucher B5	France	AJ320131***	Scherrer and Honegger 2003
Xanthoria sp. 2	Voucher 83, 84	UK	AJ320135***	Scherrer and Honegger 2003
Xanthoria sp. 2	Voucher 90/1, 90/2	France	AJ320149***	Scherrer and Honegger 2003
Xanthoria sp. 2	M158t5a1 929.12) R. Honegger 158t5	France	AM292821	Eichenberger 2007
Xanthoria ibizaensis	M12a, holotype	Spain	M12a	this paper
Xanthoria ibizaensis	M12b, holotype	Spain	M12b	this paper
Xanthoria mediterranea	705(117.15) R. Honegger 427t1	Italy	AM408410	Eichenberger 2007
Xanthoria mediterranea	LIQ75XAME-2	Israel	whole genome	Llewellyn *et al.* 2023
Xanthoria cf. *mediterranea*	SH85-2001	Greece	AJ320140**	Scherrer and Honegger 2003
Xanthoria cf. *mediterranea*	Voucher 43	Italy	AJ320134***	Scherrer and Honegger 2003
Xanthoria cf. *mediterranea*	L174t1 (100.3)	Tunisia	AM292822***	Scherrer and Honegger 2003
Xanthoria monofoliosa	Voucher 4	Italy	AJ320147****	Scherrer and Honegger 2003
Xanthoria monofoliosa	L104	Spain	AM292818****	Scherrer and Honegger 2003
Xanthoria monofoliosa	M282t1ad (97.19)	Italy	AM292842****	Scherrer and Honegger 2003
Xanthoria monofoliosa		Souch Africa	EU681817	Fedorenko *et al.* 2009
Xanthoria monofoliosa		South Africa	AM697817**	Eichenberger 2007
Xanthoria parietina	Honegger 56t8	USA	AM697845	Eichenberger 2007

Table 2 (continued)

Species, voucher number in the phylogenetic tree	Isolate	Country	nrITS	Ref
Xanthoria parietina	Honegger 271t1	Spain	AM697841	Eichenberger 2007
Xanthoria parietina	Honegger 320t2	Switzerland	AM697848	Eichenberger 2007
Xanthoria parietina	Honegger 265t1	Spain	AM697847	Eichenberger 2007
Xanthoria parietina	Honegger 347	USA	AM697842	Eichenberger 2007
Xanthoria parietina	Honegger 348t4	USA	AM697838	Eichenberger 2007
Xanthoria polessica	U3115	Belarus	MT928333	Tsurykau *et al.* 2020
Xanthoria polessica	U3114	Belarus	MT928332	Tsurykau *et al.* 2020
Xanthoria pylyporlykii	LD-M49	Denmark	LD-M49	this paper
Xanthoria pylyporlykii	LD-M56	Denmark	LD-M56	this paper
Xanthoria pylyporlykii	LD-M59	Denmark	LD-M59	this paper
Xanthoria pylyporlykii	LD-M77	Sweden	LD-M77	this paper
Xanthoria pylyporlykii	LD-M78	Denmark	LD-M78	this paper
Xanthoria sp. 1	TBL-2021 LIQ80XSP	Italy	whole genome	Llewellyn *et al.* 2023
Xanthoria steineri	LIQ73XASTE-2	Israel	whole genome	Llewellyn *et al.* 2023
Xanthoria steineri	SH5-2001	Cyprus	AJ320142**	Scherrer and Honegger 2003
Xanthoria tendraensis	KHER 12109a	Ukraine	MZ196456	Khodosovtsev *et al.* 2023
Xanthoria tendraensis	KHER 12109	Ukraine	MZ196457	Khodosovtsev *et al.* 2023
Xanthoria tendraensis	KHER 11232	Ukraine	MZ303030	Khodosovtsev *et al.* 2023

Table 3
Type of ascospores of some *Xanthoria* species

Species name	Spore type	Spore size (μm)	Septum type	Septum width (μm)	Approximate number of ascospores measured
X. parietina	'*parietina*'	10–15 × 6–8	'*parietina*'	6–8	500
X. ectaneoides	'*ectaneoides*'	15–18 × 5–7	'*ectaneoides*'	10–13	8,000
X. coomae	'*ectaneoides*'	15–17 × 6–8	'*coomae*'	7–10	1,000
X. pylyporlykii	'*parietina*'	12–15 × 6–8	'*coomae*'	7–10	10,000

Table 4
Molecular data on members of the genus *Xanthoria* (data on vouchers '*Xanthoria* sp.' available in GenBank are not included here)

	parietina	*aureola*	*steineri*	*mediterranea*	*ectaneoides*	*calcicola*	*coomae*	*polessica*	*monofoliosa*
nrITS	257	3		2	13	12	4	2	3
18S nrSSU	10	1			1	1			
28S nrLSU	22	1				2			
12S mtSSU	7	1		1	2	5	2		1
23S mtLSU	12				3	1			
hydrophobin	57				12	3			
beta-tubulin	30			1	5	1			
RPB2	1	1				1			
RPB1	1	1				1			
polyketide synthase gene	2								
28S-18S intergenic space	35	2				3			
putative non-ribosomal peptide synthase-like gene	1								
SLA2 gene, DNA lyase gene and MAT 1-2-1 gene	1								
whole genome	1	1	1						
Total	436	11	1	3	36	30	3	2	1

Xanthoria parietina is characterised by medium sized ascospores, 10–15 × 6–8 μm, – the *parietina* spore type – and a medium wide septum, 6–8 μm wide – the *parietina* septum type.

Xanthoria ectaneoides is the species with the longest ascospores (15–20 μm) – the *ectaneoides* type, and the widest (10–13 μm wide) septa – the *ectaneoides* type. These data come from measurements of the type specimen of *X. ectaneoides* and confirmed by measurements of more than 8,000 ascospores from collections in areas around the southwestern Baltic Sea. The spore types and septum types of *Xanthoria parietina* and *X. ectaneoides* are unique and not overlapping.

On the contrary, *X. coomae,* described in 2008 (Kondratyuk *et al.* 2008), is characterised by having the *Xanthoria ectaneoides* spore type and the *X. coomae* type of septum.

Xanthoria pylyporlykii, described here, is distinguished by the combination of *parietina* spore type and *coomae* septum type. These data are confirmed by measurements of more of 10,000 ascospores of specimens from southwestern Baltic region.

Molecular data on Xanthoria *species*

To check positions of the newly collected specimens, ITS-sequences from all *Xanthoria* species available in the GenBank were included in the analysis (Table 2). The number of *Xanthoria* sequences in the GenBank are submitted under the name *Xanthoria parietina*, in the pre-molecular era considered to be one of the most thoroughly studied of all lichen species (Honegger 1996), however, today it is clear that many of these sequences represent other species. Whole genomes of several *Xanthoria aureola*, *X. mediterranea*, *X. steineri* as well as *Xanthoria* sp. 1 and *Xanthoria* sp. 2 are now available (Tables 2 and 4) (Llewellyn *et al.* 2023). The nrITS sequences of these species mentioned, except for *Xanthoria* sp. 2 (data on nrITS of which are still not available via BLAST) were extracted from the whole genome and used in the present phylogeny analysis.

The phylogenetic tree based on ITS-sequences is divided in two main clades, the *X. calcicola* and *X. parietina* clades, and *Xanthoria monofoliosa* positioned on a separate branch (Arup *et al.* 2013, Fedorenko *et al.* 2009, 2012, Gaya *et al.* 2012, 2015, Kondratyuk *et al.* 2014, 2017, 2020).

The matrix of nrITS sequences contains more than 330 specimens of the genus *Xanthoria,* including also data on specimens named as *Xanthoria* sp. However, vouchers incorrectly named *Xanthoria parietina* are nested among other species, i.e. *Xanthoria coomae, X. monofoliosa, X. polessica*, and even true *Xanthoria ectaneoides* s. str. In the same way, sequences labelled *X. calcicola* and

X. ectaneoides in the GenBank are also spread on several branches. Some separate subclades probably represent undescribed species.

To illustrate the tree in the best way, only a selection of the sequences available in the GenBank were included. Thus, for *Xanthoria calcicola, X. coomae, X. monofoliosa* and *X. parietina*, the most frequently represented species in the GenBank, only 5–7 sequences were selected, whereas all sequences for *Xanthoria polessica, X. ibizaensis, X. mediterranea* where included. Species names are set according to positions in the tree, whereas their names in the GenBank submissions, if different, are indicated within brackets references / footnotes (Fig. 1 tree, and Table 4).

An ITS-sequence extracted from the whole genome of *Xanthoria steineri* (Llewyllen *et al.* 2023) helps to confirm additional specimens of this species from Cyprus.

NEW MOLECULAR DATA

Sequences for some *Xanthoria* species are produced within this study for the first time. These are *Xanthoria ibizaensis* S. Y. Kondr et A. S. Kondratiuk, the holotype, described from the Balearic Islands (Kondratyuk *et al.* 2020), position in the *Xanthoria monofoliosa* subclade (Fig. 1), *X. streineri* I. M. Lamb, described from Iran, is confirmed from Cyprus in this study using a voucher by Scherrer and Honegger (2003) mentioned as *Xanthoria* sp. SH5-2001, *X. ectaneoides*, six vouchers, the new species *X. pylyporlykii* (described below), five vouchers, and *Xanthoria* aff. *aureola*, one voucher.

Xanthoria ectaneoides (Nyl.) Zahlbr.
(= *Physcia ectaneoides* Nyl.)
(Figs 2–4)

France: 'Monspelii, Lavalette' [Herault, Montpellier], lectotype, H-NYL 32723.

Thallus from almost undeveloped or network-like with very narrow thalline main lobes where mostly apothecia make this lichen or '*anularis*' type i.e. similar to the Euroasian species *Kudratoviella anularis* (Clauzade et Poelt) S. Y. Kondr., L. Lőkös, Kärnefelt et A. Thell). The central portion of the thallus is degenerate, thus only peripheral parts are present (Kondratyuk *et al.* 2022*a*), to an almost single-level or more or less film-like, rosette-formed thallus, i.e. the *X. coomae* type of thallus, where separate lobes are not seen in the centre. Comparatively distinctly developed in the peripheral zone; small secondary sublobules present in the centre, often originating from remains of overmature apothecia as narrow overlapping parts.

Apothecia small, 1(–2) mm diam., numerous, usually widely dispersed, rarely crowded, in the centre of the thallus, lecanorine with more or less plane disc, usually with a smooth, rarely crenulate, thalline margin; ascospores narrow and rather long, 15–18(–20) × 5–7 μm with very wide ascospore septum 10–13 μm.

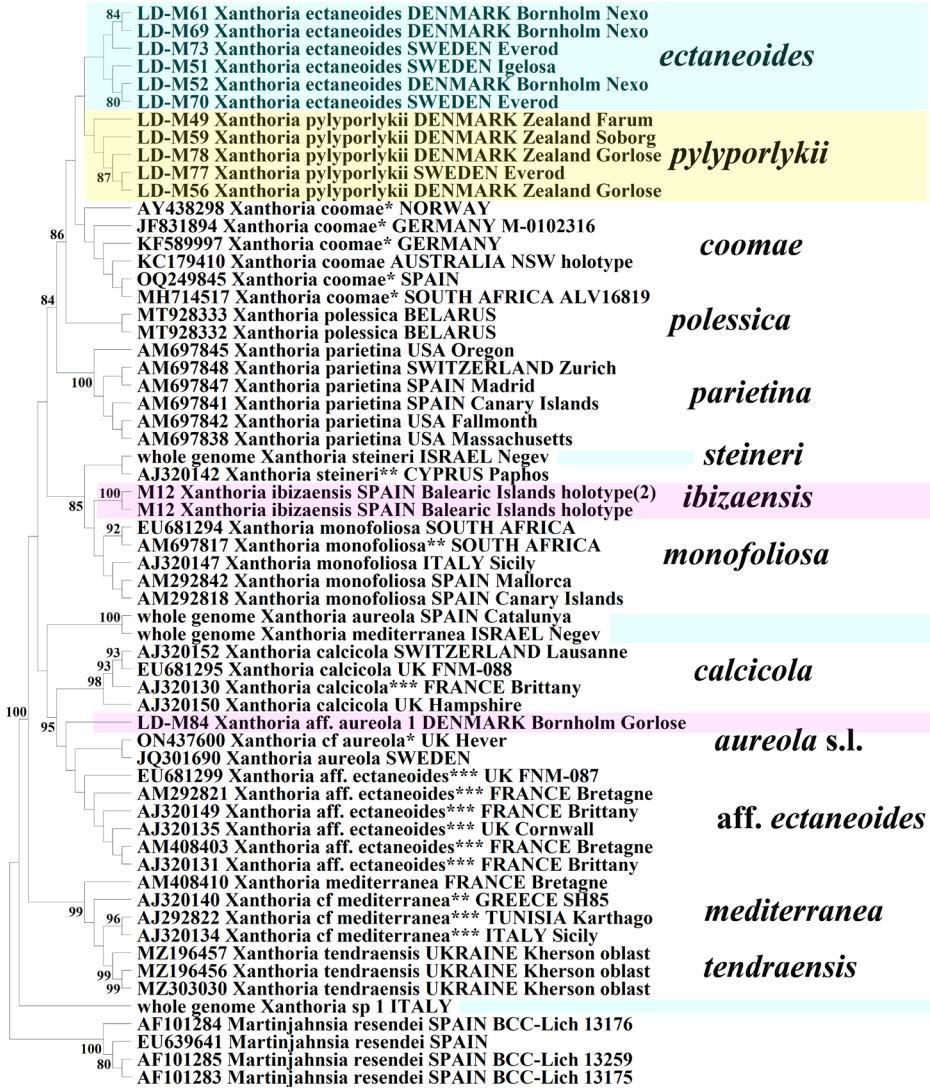

Fig. 1. Consensus MP tree after nrITS of the members of the genus *Xanthoria*. Abbreviations: * = data are submitted to GenBank under *Xanthoria parietina*, ** = data provided under *Xanthoria* sp., *** = data are provided under *Xanthoria ectaneoides*

Xanthoria ectaneoides and *X. pylyporlykii* form sister branches in the *Xanthoria ectaneoides* subclade (Fig. 1). *Xanthoria ectaneoides* used to be recognised exclusively by its secondary sublobules. In this study, species delimiting characters of the ascospores are added. Its closest relative, *Xanthoria pylyporlykii* is lacking secondary sublobules and differ by shorter ascospores and narrower ascospore septa, the *X. coomae* type.

Ecology: This species was described from limestone. From our study it is rather common in the southwestern Baltic area on hard substrates: tiles, concrete, metal and granite, as well as rarely collected on bark of trees.

Distribution: Since this species was considered a synonym of *X. aureola*, data on ecology and distribution are incomplete during the latest decades and therefore not considered. *Xanthoria ectaneoides* is found at more than 30 localities in Sweden, Denmark and Germany (Fig. 9, Table 1), however, is probably widely distributed in the European continent.

Taxonomic notes: *Xanthoria ectaneoides* has a characteristic thallus with a smooth central part, numerous secondary sublobules, lecanorine apothecia usually distantly spread, emarginate or with subconvex disc as overmature, the ascospores are the longest observed in the genus and the septum is the widest in the genus.

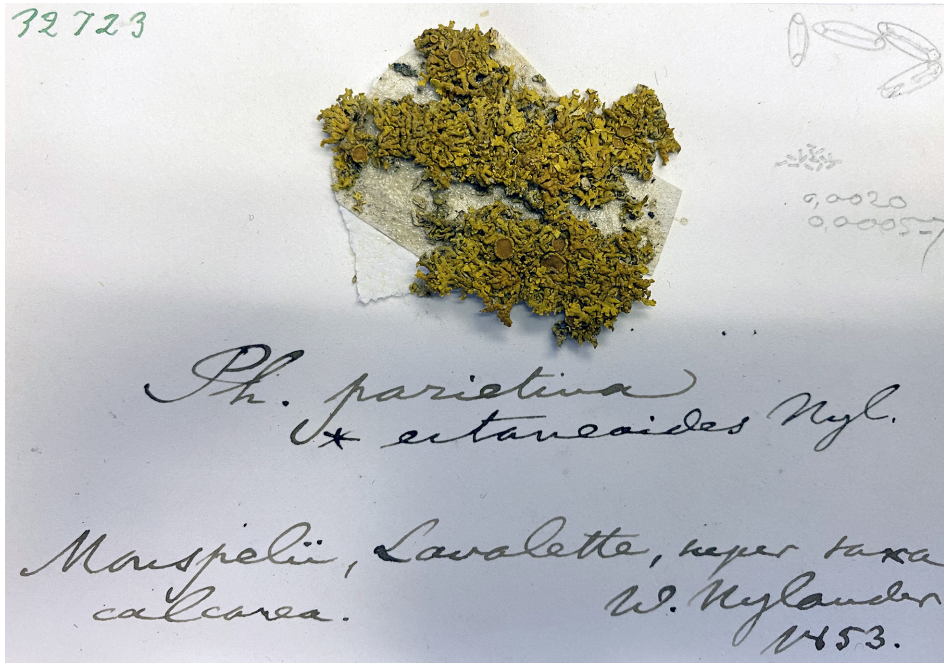

Fig. 2. The type specimen of *Xanthoria ectaneoides* (Nyl.) Zahlbr. (lectotype, H-NYL 32723), with Nylander's line drawings and handwritten measurements of 'conidia'. These, however, were in fact ascospores

Material referred to as '*Xanthoria ectaneoides* sensu German lichenologists' was typically used for sterile thalli densely covered by secondary lobules. Although we believe that most of these thalli really was true *X. ectaneoides*, this species appears as richly fertile in this study, with a variable development of the thallus.

Nylander's species *Physcia ectaneoides* (= *Xanthoria ectaneoides* (Nyl.) Zahlbr.) was accepted as a questionable taxon with numerous, very long and strap-shaped lobes, with a bulky appearance in the Mediterranean and Atlantic Europe, considered as a synonym of *X. aureola* (Gaya *et al.* 2012, 2015, Lindblom and Ekman 2005). This approach is not followed in this study since the two species are not the closest relatives but belong to different subclades.

The unfortunate confusion of measurements of conidia and apothecia in Nylander's original description have caused incorrect conclusions. At any case, *X. ectaneoides* wears the longest ascospores and widest septa of the genus. It is often supplied with sublobulae in the centre, which are lacking in closely related *X. coomae*. *Xanthoria ectaneoides* was earlier recognised by a bulky thallus due to numerous strap-like, overlapping lobes and by *X. parietina* type ascospores (see also *Xanthoria* sp. 2). However, true *X. ectaneoides* has no strap-like lobules forming a bulky thallus, but much shorter and narrower lobes, named '*secondary sublobules*', a term introduced here.

Fig. 3. *Xanthoria ectaneoides* (Nyl.) Zahlbr. (photo in field condition, Lund 25.04.2023)

Fig. 4. Xanthoria ectaneoides (Nyl.) Zahlbr. (SK23707, nrITS voucher LD-M52) host thallus heavily damaged by lichenicolous fungus *Telogalla olivieri* s. l.

The systematic position of *X. ectaneoides* and the new species *X. pylyporlykii* constitute a sister branch to *X. coomae* (see Fig. 1).

The position of *Xanthoria ectaneoides* is confirmed by five specimens, which are morphologically and anatomically identical with Nylander's type specimen of *Physcia ectaneoides*, however, the specimen is too old for a molecular study.

Most specimens determined as *Xanthoria ectaneoides* sensu German lichenologists based upon of numerous thalline sublobules on rocky surface, most likely belong to true *Xanthoria ectaneoides*. Richly fertile specimens of *Xanthoria ectaneoides* are common both in Scandinavia and Germany and can easily be confirmed by their nrITS-sequences (Table 1).

Specimens of *Xanthoria ectaneoides* examined: Nexø SK23703 (voucher LD-M61 for nrITS), SK23711 (voucher LD-M69 for nrITS), SK23707 (voucher LD-M52 for nrITS), SK23793, SK23795, SK23799, SK23800, SK23717, SK23719, SK23712, SK23793, SK23800. – Stehag SK23908, SK23890G, SK23890K, SK23905C, SK23901. SK23917B, SK23917, SK23971, SK23970, SK23968, SK23966, SK23964, SK23487, SK23488, SK23969, SK23963, SK23900. – Tårnby SK23932, SK23927D, SK23927C, SK23927B, SK23922E, SK23922C, SK23922B, SK23922, SK23917C, SK23917D, SK23917C, SK23939, SK23933F, SK23933E, SK23933D, SK23933C, SK23933B, SK23917, SK23930, SK23952. – Tårnby 918, 932, 931, 929, 928, 926, 924, 923, 922, 921, 920, 919, 933, 934, 945, 946, 947, 949, 950, 951, 954, 955, 956, 957, 958, 959, 962. – Marstal, concrete wall at sea coast, 27.05.2023 SK23847; Sandby / Fanefjord 524, 527; S Malmö 528; Norra Vrams 446, 447, 491; Nyker 450, 451; Everöd 555 (nrITS voucher LD-M70), 568; Igelösa 774; Skanör church 360. – Germany: Rostock SK23A12, SK23A11, SK23A09, SK23A01, SK23A04; Cammin, 1.10.2023 SK23A29; Russow SK23995, SK23994, SK23988, SK23987, SK23986, SK23985, SK23990; Alt Barlow SK23974, SK23975, SK23976, SK23978, SK23983, SK23977. – Farum SK23502 (nrITS voucher LD-M68), 506, 515, 572, 497, 535, 575, 571; Nyker 466, 467; S of Helsingborg 468, 469; SE Trelleborg 471, 484, 485; Igelösa 775; Tofta 779.

The *Xanthoria coomae* subclade is in need of an extended revision. *Xanthoria coomae* is commonly confused with the morphologically similar *Xanthoria parietina* (Fedorenko *et al.* 2009), whereas *X. ectaneoides* may include additional taxa.

Xanthoria sp. 2

The name *Xanthoria ectaneoides* was hitherto used along the coastal zone of Atlantic Europe for specimens with a narrow, strap-like, often semierect or semi-ascending lobes forming a rather bulky thallus, not considering the appearance of the ascospores. Such material is not conspecific with *Xanthoria ectaneoides* and therefore called '*Xanthoria* sp. 2' in the phylogenetic tree (Fig. 1). This material, positioned in the *Xanthoria calcicola* subclade, will be revised in a future study since it cannot belong in *Xanthoria ectaneoides* s. str. (Fig. 1).

Xanthoria aureola (Ach.) Erichsen

Basionym: *Parmelia aureola* Ach. – Lichenogr. Univ.: 437 (1810).

Type: Sweden, 'Suecia' [Bohuslän province (= 'Bahusia'), on seashore rocks] (H-ACH 1300 – lectotype, designated by Lindblom and Ekman 2005).

The description of *Xanthoria aureola* needs to be revised since it includes descriptions of both *Xanthoria aureola* s. str. (apothecia almost always absent, poorly developed ascospores, etc.) and *Xanthoria* sp. 2 (thalline lobes strap-shaped 0.3–1.3 mm wide, to slightly ascending, often irregularly overlapping in thallus centre, without vegetative diaspore, etc.).

The small, sterile and old type specimen of *Xanthoria aureola* is unusable for both spore- and DNA-studies (Fig. 5). It has rather wide and heavy thal-

Fig. 5. The type specimen of *Xanthoria aureola* (Ach.) Erichsen (lectotype, H-NYL 32723)

line, closely attached to substrate, sometimes with lobe margins bent downwards, supplied with minute isidia, i.e. the type of isidia unique for the *X. calcicola* group. Thus, *X. aureola,* having minute isidia, is also morphologically different from both the non-isidiate and richly sublobulate true *X. ectaneoides* and the non-isidiate, strap-like lobulate species with a bulky thallus, here called *Xanthoria* sp. 2.

Molecular data for *X. aureola* were published by Lindblom and Gaya with colleagues (Gaya *et al.* 2012, 2015, Lindblom and Ekman 2005, Llewyllen *et al.* 2023). They also revealed the position in the *Xanthoria calcicola* subclade for *X. aureola* (Gaya *et al.* 2012, 2015, Lindblom and Ekman 2005). Lindblom and Ekman (2005) proposed to synonymise *X. ectaneoides* (*Xanthoria* sp. 2) with the Acharian species *Xanthoria aureola.* However, *X. aureola* is neither conspecific with *Xanthoria* sp. 2 nor, and even less, with *X. ectaneoides* s. str. (Fig. 1).

Furthermore, *Xanthoria ectaneoides* sequences in the GenBank from Sicily, Italy and Tunisia probably belong to *Xanthoria mediterranea* (but not to *X. tendraensis*) or close, maybe undescribed relatives to these two taxa (see Khodosovtsev *et al.* 2023).

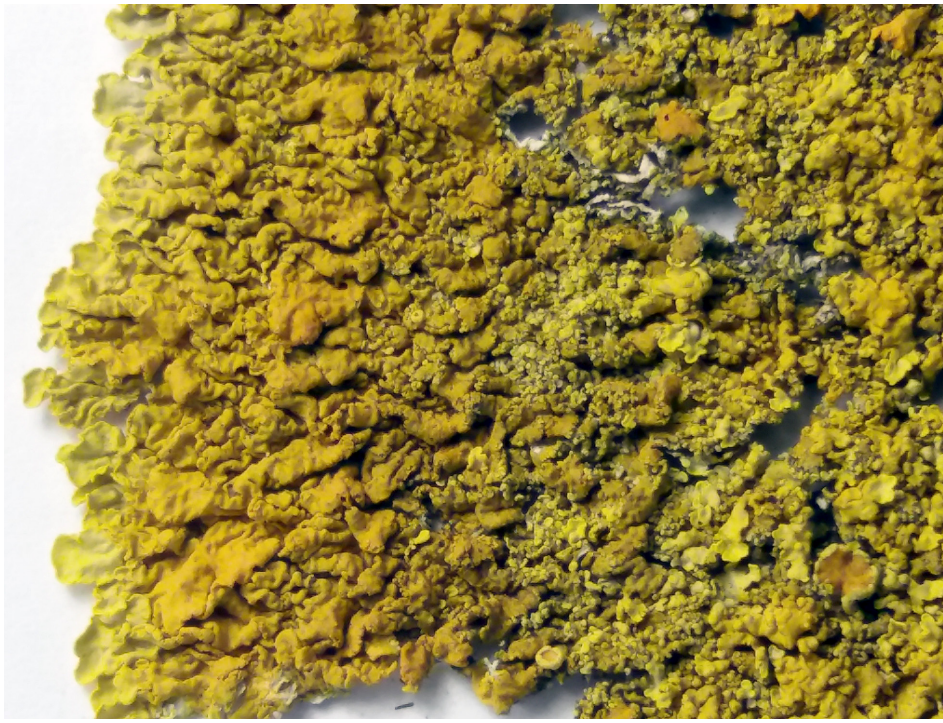

Fig. 6. *Xanthoria* aff. *aureola* 1 (voucher LD-M84) from Gørløse locality, Bornholm, Denmark

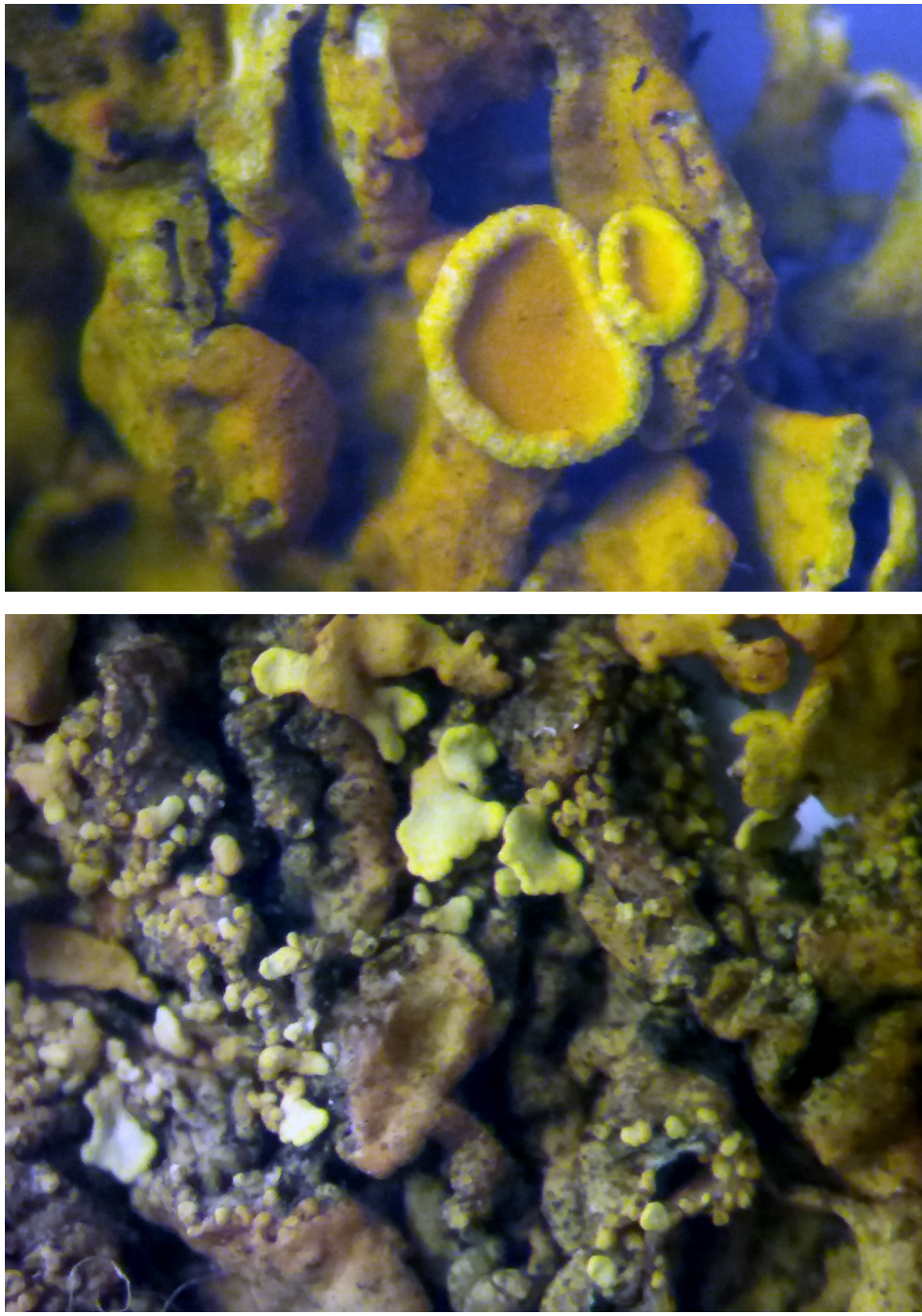

Fig. 7. *Xanthoria* aff. *aureola* 1 (voucher LD-M84) from Gørløse locality, Bornholm, Denmark. Enlarged portion with apothecium (upper), and enlarged portion with isidia (lower)

Xanthoria aff. *aureola* 1

A first attempt to select fertile collections for DNA-vouchers of *Xanthoria aureola* was made in this study. The richly fertile specimen with minute isidia from Gørløse in Zealand, Denmark (voucher LD-M84) was included in our phylogenetic analysis as *X. aff. aureola* 1 (Fig. 1).

Xanthoria pylyporlykii S. Y. Kondr., Kärnefelt et A. Thell, *spec. nova*
(Fig. 8)

MycoBank No.: 853037

Similar to Xanthoria ectaneoides*, according to nrITS-sequences in sister position to* X. ectaneoides*, but differs in having wider thalline lobes, usually well-developed overlapping and irregularly orientated in the centre of the thallus, shorter ascospores and narrower ascospore septum.*

Type: Denmark, Søborg par., the castle ruins 55.0877°N, 12.3055°E, on modern brick inclusions, 16.04.2023 Coll.: S.Y. Kondratyuk SK23721 – holotype (C, voucher LD-M59 for nrITS); isotypes as set for the Plantae Graecenses exsiccate are prepared; SK23721B – isotype; SK23723, SK23723C, SK23722B sub *Xanthoria pylyporlykii* with *Telogalla olivieri*, SK23723D sub *Xanthoria pylyporlykii* with *Athelia* killing the centre and infected by *Xanthoria* sp. 1 (particularly on killed portions) (KW-L); SK23723E sub *Xanthoria pylyporlykii* infected by *Xanthoria* sp. 1, SK23723F sub *Xanthoria pylyporlykii* infected by *Xanthoria* sp. 1, SK23723G sub *Xanthoria pylyporlykii* infected by *Xanthoria* sp. 1, SK23723H sub *Xanthoria pylyporlykii* infected by *Xanthoria* sp. 1 (KW-L) – isotypes).

Thallus foliose, usually well developed and regularly rounded, of rather wide range from small to 3–5(–9) cm across, more or less rounded to widely oval / ellipsoid or forming much larger irregular aggregations; often with damaged, blackening or completely killed and collapsed central portions, forming film-like centre sometimes with distinct wrinkles or indistinct or covered with numerous apothecia, while lobes with reticulate upper surface are more or less developed only in the peripheral zone (without apothecia) to 5–7(–10) mm wide; sometimes brighter, yellow in the peripheral zone with the thicker and darker, greenish centre (distinctly greenish especially in wet conditions and very similar to *Xanthoria calcicola*) are rather different and contrasting, especially when the secondary, flat and horizontally orientated lobes are present in the centre; sometimes forming incomplete circles ('arcs') 1.5–2 cm wide and to 10 cm long, or wide circles (to 10–20 cm diam., where the central portion is completely collapsed) where narrow peripheral zone and numerous apothecia from the inner side of such circles are developed, similar to *Kudratoviella anularis* (Kondratyuk *et al.* 2023).

Thalline lobes thin, paper-like, 5–7(–10) long and 1–1.5(–2) mm wide in the narrowest portions while to 3–5(–7) mm wide in the widened terminal portions; sometimes secondary lobules are overlapping and irregularly orientated in the centre and well developed, somewhat 'triangle' to 1–1.5(–3) mm across forming variegated colouration owing bright yellow tips and well contrasting to darker greyish- or greenish-whitish towards the centre, somewhat raised above the thalline centre, horizontally orientated.

Thallus in section to (75–)100–140(–180) μm thick, upper cortical layer 5–7(–12) μm thick, sometimes irregularly developed, paraplectenchymatous, lumina to 5–7(–12) μm diam./across; algal zone to (25–)30–50(–70) μm thick, medullar layer to 50–70 μm thick, the lower cortical layer to 10–15(–20) μm thick, paraplectenchymatous with vertically slightly elongated cells.

Apothecia 1–3(–5) mm diam., in section to 0.2–0.3 mm thick from not very numerous, more or less distant, to rather numerous and crowded, usually distinct due to dark orange discs, contrasting the yellow thallus, more or less raised, lecanorine, initially with a permanent thalline margin, developing to zeorine or biatorine, discs more or less plane to slightly concave (reminding of *Xanthoria calcicola*), undulating at overmature, thalline margin distinctly raised above the disc giving the apothecia a concave impression, often becoming crenulate, or only in form of portions to distinctly zeorine, crowded at overmature; in zeorine or biatorine apothecia: true exciple rather thin, permanent, concolorous with the disc or slightly lighter, rather distinct; in section, thalline

Fig. 8. *Xanthoria pylyporlykii* S. Y. Kondr., Kärnefelt et A. Thell (holotype)

exciple to 125 μm thick with cortical layer to 25–30 μm thick on underside; true exciple to 120–150 μm thick in the uppermost lateral portion and to 20–25 μm thick in the lower basal and basal portions; hymenium to 55–60 μm thick; ascospores sometimes with somewhat attenuated ends, more or less widened at the septa, (10–)11–15(–15.5) × 6–7.5(–8) μm, septa (5–)7–10 μm wide.

Conidiomata to 250–270 μm diam., hyaline, situated between the upper and the lower cortex of thallus; conidia very small ellipsoid, (1–)1.5–2.5(–3) μm.

Ecology: on rocky walls, tile roof of rock walls, on brick fragments of old ruins (Søborg, Hammershus castle ruins, etc.), often growing side by side with *Xanthoria ectaneoides* and growing together or overgrowing *Physcia adscendens*, *Phaeophyscia orbicularis*, etc. *Xanthoria pylyporlykii* is also confirmed from bark of *Acer platanoides* in coastal zone, so far only from a few localities in Æroskobing (SK23814, SK23815), Marstal (SK 23816, SK 23817) and Tranderup (SK23818), all within Ærø Island.

Xanthoria pylyporlykii is host for several lichenicolous fungi, e.g. *Telogalla olivieri*, *Bryostigma parietinaria*, *Pyrenochaeta xanthoriae*, *Athelia arachnoidea*, *Xanthoriicola epiphysciae* of which the first three are very common. The entire collection of *Xanthoria pylyporlykii*, 27 specimens at the locality Svendborg Landevej, southern Funen, and 23 specimens in Søby on Ærø were damaged by *Telogalla olivieri*, compared with only 30% in Fjenneslev, western Zealand. The number of infected specimens was much lower at other localities.

A rather high number of specimens of *Xanthoria ectaneoides* and *X. pylyporlykii* damaged by *Telogalla olivieri* was recently collected in Svaneke and Rønne on Bornholm.

Distribution: *Xanthoria pylyporlykii* is represented by more than 215 specimens from 44 localities around the western part of the Baltic Sea, i.e. in Skåne, southernmost Sweden, southern Denmark and northern Germany (Table 1, Fig. 9), however, it is probably distributed also in other Atlantic parts of Europe.

Etymology: It is named after Pylyp Stepanovych Orlyk (11[21] October 1672–26 May 1742), author of the famous 'Constitution of Pylyp Orlyk', Hetman of Ukraine in-exile, secretary and close associate of Hetman Ivan Mazepa as well as his successor. Pylyp Orlyk lived in Kristianstad with his family after an official invitation from the Swedish king Karl XII. Latin version of 'Constitution of Pylyp Orlyk' with his signature is still kept in Sweden.

Taxonomic notes: After morphological characters *Xanthoria pylyporlykii* combines characters of *Xanthoria ectaneoides* in having *Xanthoria coomae* type of thallus and secondary lobules in the centre and *Xanthoria calcicola* in having greenish (especially in wet condition) centre, which is different from the peripheral zone.

Xanthoria pylyporlykii is similar to *Xanthoria ectaneoides*, its closest relative according to the phylogeny based on nrITS-sequences, however the new species usually differs in having a well-developed and regularly rounded thallus with a wider peripheral zone, (5–7(–10) mm wide vs. 1–3 mm wide in

X. ectaneoides), in the lack of secondary sublobules (*vs*. especially numerous in the centre of *X. ectaneoides*); in having wider thalline lobes, usually well-developed, overlapping and irregularly orientated in the centre of the thallus, as well as and in having shorter ascospores with shorter septa.

Xanthoria pylyporlykii usually reminds of *Xanthoria calcicola* in having a dark greenish thallus centre wearing secondary lobes, but differs by much larger, flat and horizontally orientated secondary lobes with a smooth surface, as well as in having much wider ascospore septum.

Xanthoria pylyporlykii and *Xanthoria coomae* both have horizontally orientated, overlapping secondary lobes in the centre (Everöd, SK23498, SK23544, SK23545, SK23546), lobes developed only in the peripheral zone, however, *X. pylyporlykii* has a thinner thallus centre with a smooth surface (not wrinkled as in *Xanthoria coomae*). Furthermore, *X. pylyporlykii* differs by smaller, both narrower and shorter, and horizontally orientated thalline lobes in the narrower peripheral zone and in having shorter ascospores.

Two sequences in the GenBank, MT644879 and KJ027710, submitted as *Xanthoria parietina* probably represent *Xanthoria pylyporlykii*.

Selected specimens of *Xanthoria pylyporlykii*: Denmark, Søborg roof SK23723J, SK23723I sub *Xanthoria pylyporlykii* growing together with *Xanthoria ectaneoides,* SK23723K, SK23723L sub *Xanthoria pylyporlykii*, SK23723M, SK23723N, SK23723O, SK23723P, SK23723R. Paratype specimens of *Xanthoria pylyporlykii* from Søborg will be distributed as set of the Plantae Graecenses exsiccate. – Sweden, Skåne, Kristianstad municipality, Everöd, tile roof of rocky wall around church and cemetery, 4 March 2023 Coll.: S. Kondratyuk SK 23498 (KW-L) sub *Telogalla olivieri* s.l. on rather damaged thalli of *Xanthoria pylyporlykii* with *Xanthoriicola epiphysciae*; SK 23499 (LD) (nrITS voucher LD-M77) sub *Xanthoria pylyporlykii* partly infected by *Xanthoria* sp. 1***; SK 23498; SK23540 (voucher LD-M73 for nrITS), Everöd SK23569 (voucher LD-M75 for nrITS); Everöd SK23546 sub *Xanthoria pylyporlykii* with *Athelia arachnoidea*, SK23548 sub *Xanthoria pylyporlykii* with *Telogalla olivieri*, SK23554 sub *Xanthoria pylyporlykii*, growing side by side with *Xanthoria ectaneoides*, SK23555 sub *Xanthoria ectaneoides,* growing side by side with *Xanthoria pylyporlykii*, SK23556 sub *Xanthoria pylyporlykii*, growing side by side with *Xanthoria ectaneoides.* – Helsinge, roof, 26.03.2023 SK23751 (nrITS voucher LD-M79); SK23741B LD-M79 voucher 742 sub *Xanthoria pylyporlykii* growing together with *X. ectaneoides*; SK23741 [7 of 8] sub 742] section 741 sub *Xanthoria pylyporlykii* and *Xanthoria* sp. 1***, SK23741H [3 of 8], SK23741C [6 of 8], SK23741D [5 of 8] sub *Xanthoria pylyporlykii* with *Athelia* in places of the centre,

*** Initial thalli of *Xanthoria* sp. 1 are especially numerous on damaged and decaying portions of thalli of *Xanthoria pylyporlykii*. Status of *Xanthoria* sp. 1 is under revision including molecular phylogenetic study and will be discussed elsewhere. Within the first observations of the lichenicolous fungi associated with saxicolous specimens of *Xanthoria calcicola* s. lat. in southernmost Scandinavia (see Kondratyuk *et al.* 2023), it was found as lichenicolous lichen species with the field name '*Xanthoria* aff. *calcicola*'. It was recorded from a number of localities and originally was considered among lichenicolous fungi. However, after finding richly fertile specimens growing on rock surface as well as on bark of trees it was excluded from list of true lichenicolous fungi.

SK23741E [4 of 8], SK23741G [1 of 8] sub *Pyrenochaeta xanthoriae* on *Xanthoria pylyporlykii*. SK23741 'B' [8 of 8] section 742 = M79 sub *Xanthoria pylyporlykii* growing together with *X. ectaneoides*; Helsinge SK23747 (voucher for nrITS sequence LD-M55) sub *Xanthoria pylyporlykii* with *Pyrenochaeta xanthoriae*, and with small addition of *Xanthoria ectaneoides*. – Denmark, Søborg ruins SK23720; SK23720B; SK23720C sub *Xanthoria pylyporlykii* growing together with *Xanthoria* cf. *ectaneoides*; roof, SK23722 sub *Xanthoria pylyporlykii* partly infected by *Xanthoria* sp. 1. – Nexo, 28.10.2022 on separate rocks near rocky wall SK23716 (voucher LD-M53 for nrITS), SK23716B. – Helsinge 26.03.2023, tile roof of rocky wall Coll.: S. Kondratyuk SK23748 (voucher LD-M72 for nrITS) sub *Pyrenochaeta xanthoriae* on *Xanthoria pylyporlykii* [centre killed by lichenicolous fungus]; SK23749 (voucher LD-M54 for nrITS), SK23747 (voucher LD-M55 for nrITS) sub *Xanthoria pylyporlykii* with *Pyrenochaeta xanthoriae*, and with small addition of *Xanthoria ectaneoides*; 26iii2023 roof of eastern wall SK23751 (voucher LD-M71 for nrITS) sub *Xanthoria pylyporlykii* growing together with *Xanthoria ectaneoides* and partly infected by *Xanthoria* sp. 1. – ***; SK23584 sub *Xanthoria pylyporlykii* partly infected by *Xanthoria* sp. 1. – ***, SK23585 sub *Xanthoria pylyporlykii* partly infected by *Xanthoria* sp. 1. – *** and *Telogalla olivieri*, growing side by side with *Physcia adscendens* and *Phaeophyscia orbicularis*; SK23741G sub *Xanthoria pylyporlykii* with *Pyrenochaeta xanthoriae*. – Denmark, Søborg ruins SK23763 sub *Xanthoria pylyporlykii* with *Telogalla olivieri*, SK23764 sub *Telogalla olivieri* on *Xanthoria pylyporlykii*, SK23766B sub *Xanthoria pylyporlykii* with *Telogalla olivieri,* growing together with *Xanthoria calcicola*; SK23768C sub *Xanthoria pylyporlykii* with *Telogalla olivieri* and *Xanthoria* sp. 1. – ***, SK23768E sub *Xanthoria pylyporlykii* with *Telogalla olivieri*; SK23595 sub *Xanthoria pylyporlykii* with *Telogalla olivieri*, two sets for the Plantae Gracenses exsiccate (one as *Telogalla olivieri* on *Xanthoria pylyporlykii*) with specimens of this collections (as SK23595B, SK23595C, SK23595D, etc) are prepared; SK23701 (voucher LD-M81 for nrITS) sub *Xanthoria pylyporlykii* partly infected by *Xanthoria* sp. 1***; SK23701B [2 of 5] sub *Xanthoria pylyporlykii* partly infected by *Xanthoria* sp. 1***; SK23701C [4 of 5] sub *Xanthoria pylyporlykii* partly infected by *Xanthoria* sp. 1***, SK23701D [3 of 5] sub *Xanthoria pylyporlykii* partly infected by *Xanthoria* sp. 1***, SK23701E [5 of 5] sub *Xanthoria pylyporlykii* partly infected by *Xanthoria* sp. 1***. – Stehag SK23878 sub *Xanthoria pylyporlykii* with *Telogalla olivieri*, SK23885B sub *Xanthoria pylyporlykii* killed by *Bryostigma parietinaria,* SK23885E sub *Xanthoria pylyporlykii* damaged by *Bryostigma parietinaria*, and by *Phoma* sp., SK23893C sub *Xanthoria pylyporlykii* with *Telogalla olivieri*, SK23893D sub *Xanthoria pylyporlykii* with *Bryostigma parietinaria*, SK23890L sub *Xanthoria pylyporlykii* with *Telogalla olivieri*, *Bryostigma parietinaria*, [and other lichens], SK23890H sub *Xanthoria pylyporlykii* with *Bryostigma parietinaria*, [and other lichens], SK23897C sub *Xanthoria pylyporlykii* with *Telogalla olivieri,* SK23897D sub *Xanthoria pylyporlykii* with *Telogalla olivieri*. – Farum SK23495 sub *Xanthoria pylyporlykii* killed by *Telogalla olivieri*, SK23498 sub *Xanthoria pylyporlykii* with *Telogalla olivieri*, SK23509 sub *Xanthoria pylyporlykii* with *Telogalla olivieri*, SK23511 sub *Xanthoria pylyporlykii* with *Telogalla olivieri*, SK23512 sub *Xanthoria pylyporlykii* with *Telogalla olivieri*, growing side by side with *Xanthoria ectaneoides*; SK23534 sub *Xanthoria pylyporlykii*, growing side by side with *Xanthoria ectaneoides*; SK23535 sub *Xanthoria ectaneoides*, growing side by side with *Xanthoria pylyporlykii*; SK23536 sub *Xanthoria pylyporlykii*, growing side by side with *Xanthoria ectaneoides*; Farum 576 (nrITS voucher LD-M49). – Norra Vrams SK23492 sub *Xanthoria pylyporlykii* with *Telogalla olivieri*, SK23493 sub *Xanthoria pylyporlykii* with *Telogalla olivieri*. – Tofta SK23788D sub *Xanthoria pylyporlykii* with *Athelia archnoidea*. – Gørløse SK 23329 (voucher LD-M56 for nrITS). – Malmö 12.07.2022 SK22049 (section 49, and section 587) (voucher LD-M78 for nrITS), SK22049B, SK22049C. – Järavallen 9.06.2022, wood SK22046 (voucher LD-M66 for nrITS).

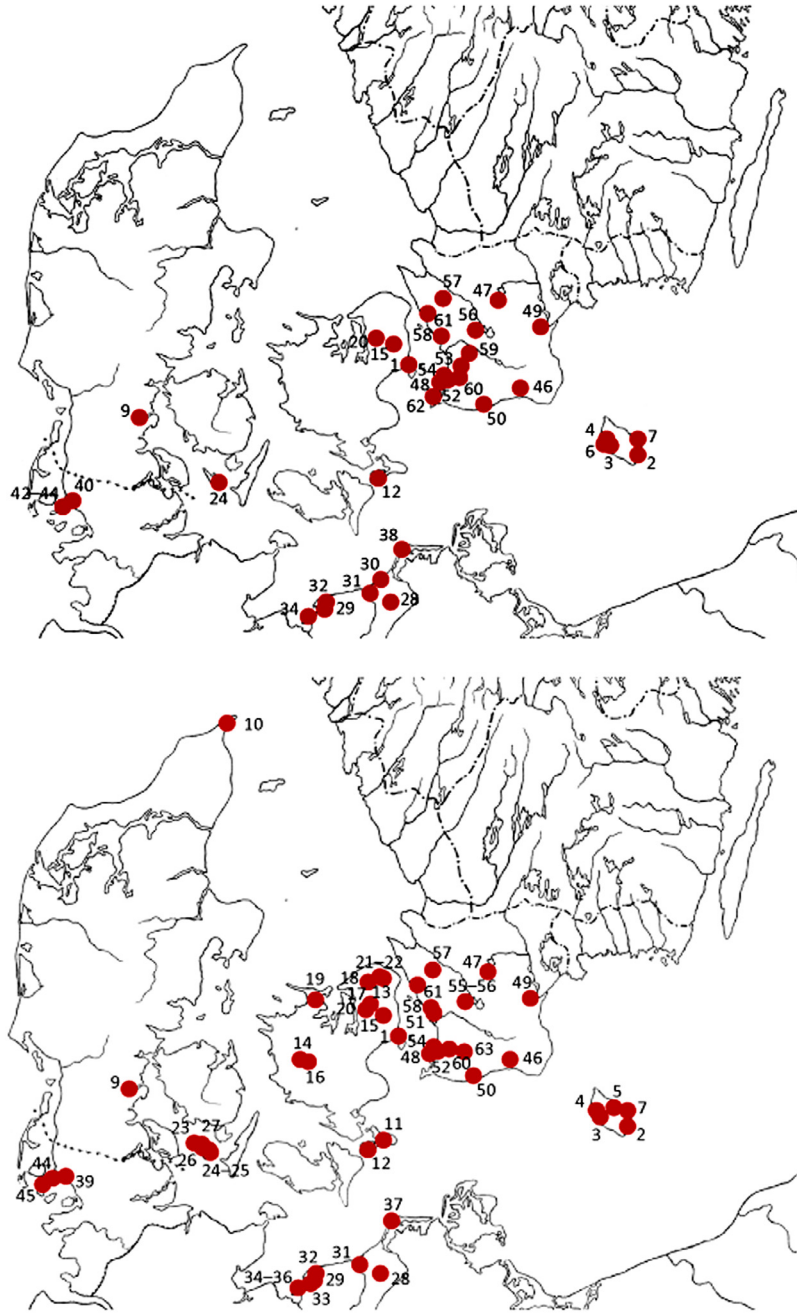

Fig. 9. Distribution of *Xanthoria ectaneoides* complex in the southwestern part of the Baltic Sea area: *Xanthoria ectaneoides* (upper), *X. pylyporlykii* (lower). Numbers of localities after Table 1

Xanthoria pylyporlykii in the *Xanthoria coomae* subclade known so far from Sweden, Denmark and Germany, is similar to *X. ectaneoides* but differs in having a more developed thallus with richly dissected thalline lobes and ascospores with narrower septa, is a rather common epilithic species in the investigated region growing side by side with *Xanthoria calcicola.* It is characterised by rather variegated to very large size thallus similar to the *Xanthoria coomae* type of thallus, with a more or less film like centre, and thalline lobes, developed only in the peripheral zone, with narrower and shorter thalline lobes than those characteristic for *Xanthoria parietina*, usually with numerous to very crowded apothecia as well as minute secondary thalline lobules in the centre of the thallus.

Molecular data from *Xanthoria ectaneoides*, *X. ibizaensis* and *X. steineri* are for the first time included in a phylogeny of the genus. *Xanthoria ectaneoides* and *X. pylyporlykii* were both revealed to belong to the *Xanthoria coomae* subclade of the genus.

Furthermore, representatives of ***Xanthoria steineri*** are included in the phylogenetic tree. The position of this species is based on nrITS sequences retrieved from whole genome data.

*

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 Unit, Lund University for the benevolent support. SK is especially thankful to Drs Arne and Nataliya Thell, Lund University, for generous help and support during evacuation of the Kondratyuk family from Ukraine. Thanks are due to Elisabeth Gauger Nilsson, Lars Fredriksson, David Stuart and Shakhira Zakhrabekova at the Molecular Cell Biology Unit of Lund University for assistance, and 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.

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