

The *Cladonia cariosa* group in Greenland

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Abstract. Five of the known strains of *Cladonia cariosa* are found in Greenland. Common is *C. cariosa* with atranorin and with atranorin and norstictic acid. Rarer are types with homosekikaic acid, fumarprotocetraric acid or rangiformic acid instead of norstictic acid. In all, the chemical diversity of the *C. cariosa* group is high in the Arctic with the joint occurrence of Eurasian and N-American strains. The psoromic acid strain of *C. symphyrcarpia* is widely distributed in Greenland. A species with porphyritic acid chemically conforms with *C. galindezii*. *C. krogiana* is reported new to Greenland. The strains and species occur together quite often and only few geographical and ecological differences were found. None of the strains or species is exclusively Arctic.

1 Introduction

The *Cladonia cariosa* group is a “problem group” (CULBERSON 1969, CULBERSON et al. 1993, PIERCEY-NORMORE 2003). Its members resemble each other morphologically and often bear no podetia.

The group is chemically diverse. Several species have been described based on chemistry (see in CULBERSON 1969). Those species, which lack morphological/anatomical or ecological distinction, are nowadays considered as chemical strains (e. g. HUOVINEN et al. 1989, AHTI 2000).

Here the holarctic species of the *C. cariosa* group are shortly discussed. *C. apodocarpa* Robb. (fumarprotocetraric acid (fum.) & atranorin (atr.)) and the similar *C. petrophila* R. C. Harris (fum. & perlatolic acid) are described from America (CULBERSON 1969, HARRIS 1992, AHTI 2000). *C. peziziformis* (With.) Laundon (fum.) is widely distributed in both hemispheres (AHTI 2000).

AHTI (2000) combines six chemotypes in *C. subcariosa* Nyl., which have been described as separate species: *C. subcariosa* s. str. (as chemotype I: atr. & norstictic acid (nor.), homohevedride (hhe.)), *C. polycarpia* Merr. (chemotype II: like chemotype I with additional stictic acid and other substances of the chemosyndrom), *C. polycarpoides* Nyl. (chemotype III: nor. & hhe., rarely traces of other substances), *C. sobolescens* Nyl. ex Vainio (chemotype IV: fum., rarely with hhe.), *C. subclavulifera* Asah. (chemotype V: fum. & nor.) and finally *C. brevis* Sandst. (chemotype VI: psoromic acid (pso.), sometimes rangiformic acid (ran.) in podetia).

Of all species mentioned before, only *C. polycarpoides* (chemotype III of *C. subcariosa*) is reported from the Arctic (KRISTINSSON et al. 2006: Russia).

C. cariosa (Ach.) Spreng. is common in N-America and Eurasia, also in the Arctic. The chemical variation within the species is considerable. Common are strains with atr. and with nor. & atr., rarer are reports for fum. & atr. and homosekikaic acid (hom.) & atr. (HUOVINEN et al. 1989: both in N-America) or ran. & atr., sometimes with additional

fum. (CULBERSON et al. 1993). *C. cariosa* s. str. is widespread in Greenland (KRISTINSSON et al. 2006), but little is known about the ecological preferences of chemical strains.

C. symphy carpia (Flörke) Fr. is known from both hemispheres. A common strain has nor. & atr. (e. g. BRODO & AHTI 1996), sometimes with additional ran. (CULBERSON et al. 1993). A strain with pso. & atr. has been described as *C. dahliana* Kristinsson from Iceland (KRISTINSSON 1974). Both strains are reported from the Arctic (e. g. ELVEBAKK & HERTEL 1996, *dahliana*: ZHURBENKO & AHTI 2005). *C. symphy carpia* can also be found with only atr. (e. g. BRODO & AHTI 1996, ZHURBENKO & AHTI 2005 for the Russian Arctic) or with fum. & atr., and in the southern hemisphere with nor., stictic acid & atr. (STENROOS & AHTI 1990). A strain with atr. & nor. & bourgeanic acid probably belongs to this group (AZUAGA et al. 2001). *C. symphy carpia* (HANSEN 1983) and *C. dahliana* (HANSEN 1999, LÜNTERBUSCH & DANIÉLS 2004) are reported for Greenland. HANSEN (1983) mentions atranorin for his sample. But because of the P reaction, which he describes as golden yellow, it is possible, that this sample also belongs to the pso. strain.

C. galindezii Øvstedal is another species of the section *Helopodium* (STENROOS 1993) with inconspicuous podetia. It contains porphyritic acid (por.) & atr. and has been described from the Antarctic (ØVSTEDAL 1988). It has also been found in the northern hemisphere (Andorra: AZUAGA et al. 2001; cf. West and East Greenland: LÜNTERBUSCH et al. 1995, LÜNTERBUSCH & DANIÉLS 2004, BÜLTMANN 2005).

C. krogiana Løfall & Timdal possibly also belongs to this section (LØFALL & TIMDAL 2002). The species has been described from Norway. With barbatic acid (bar.) & chlorovinotorin (5,7-dichloro-3-O-methylnorlichexanthone) the chemistry is unusual (LØFALL & TIMDAL 2002).

During vegetation studies in Greenland we sampled all lichens, which we could not identify in the field. The *Cladonia* samples were routinely checked by TLC. This included many thalli of the *C. cariosa* group. We identified the plant community and measured habitat factors for our relevés, which we could relate to the distribution of chemical strains and species of the *C. cariosa* group.

To add information about the chemical strains from other regions of Greenland, we included TLC analyses of herbarium samples. The information from plots and herbarium samples together, give a first picture of the distribution and ecology of *C. cariosa* and related species in Greenland.

2 Methods

Relevés were made in the Ammassalik District (SE Greenland), the Umanak District (NW Greenland) and the Kangerlussuaq area (W Greenland). Relevés are sized from 0.16 m² to 4 m². Cryptogams were collected for analyses if necessary. Specimens of the *C. cariosa* group were analysed by TLC (standard method according to CULBERSON 1972; solvent system A). After careful spraying with 10 % sulphuric acid, the plates

were slowly air dried and checked for fatty acids. Fatty acids in low amounts can not be recognized this way.

We added 69 samples from the herbarium Copenhagen C (10 collections made by Dahl, 7 by E. S. Hansen, 4 by K. Hansen, 3 by Hartz, 32 by Gelting, 1 by Topham, 1 by Sørensen, 3 by Alstrup & Daniëls and 8 by Alstrup), 17 from herbarium MSUN and 12 relevés of the AZV project (SIEG & DANIËLS 2005, SIEG et al. 2006).

In all, results from 187 relevés, 86 herbarium specimens and 508 TLC analyses are evaluated here.

The distribution of chemical strains and species is shown for phytogeographical districts (BÖCHER et al. 1978). Plant communities are pooled to classes (names according to DANIËLS & WILHELM 2002). The occurrence of strains/species is also related to aspect, soil pH, Ca^{2+} content (methods of soil analysis see LÜNTERBUSCH & DANIËLS 2004) and altitude. The median values of the strains/species for pH, Ca^{2+} content and altitude are checked for significant differences by Mann-Whitney U test (SPSS version 12).

A pdf-file with a complete list of samples, localities and habitat factors can be obtained from the first author on request.

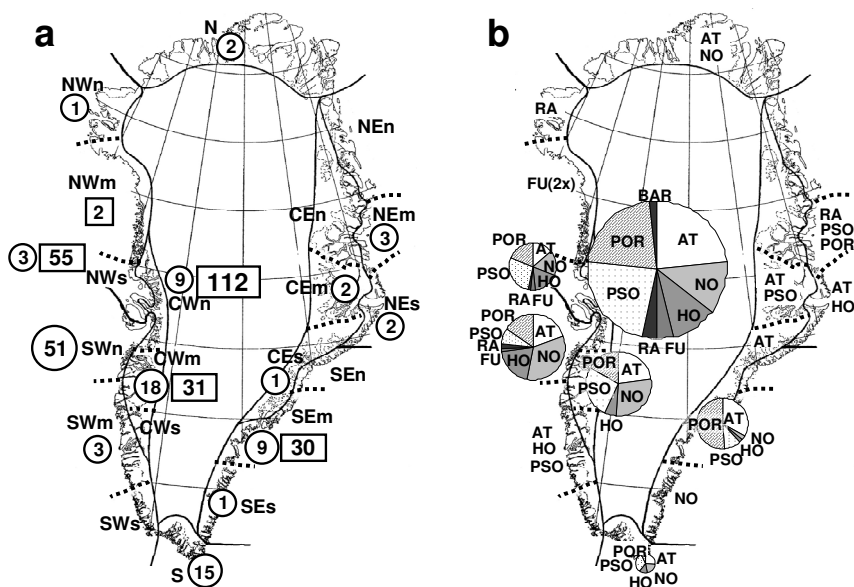


Fig. 1. Numbers of samples (a) and abundance of chemical strains/species (b) in the phytogeographical districts of Greenland.

a: in circles: numbers of herbarium samples, in rectangles: numbers of plots;

b: size of circles proportional to number of samples; no circles: only one sample of strain/species, (2x): two samples

Abbrev.: AT: *C. cariosa* strain with only atranorin (atr.), NO with atr. & norstictic acid, HO with atr. & homosekikaic acid, FU with atr. & fumarprotocetraric acid, RA with atr. & rangiformic acid, PSO: *C. dahliana*, POR: *C. cf. galindezii*, BAR: *C. krogiana*

3 Results

Eight strains or species of the *C. cariosa* group were found in Greenland. Both common strains of *C. cariosa* s. str. (atr., atr. & nor.) are also common (Tab. 1) and widespread in Greenland (Fig. 1b). Of the rarer chemotypes we found strains with hom. & atr., fum. & atr. and ran. & atr.

Quite common and widespread in Greenland are also *C. dahliana* and *C. cf. galindezii*. In two samples we were surprised to find bar. and an additional major substance. We do not have the reference substances for confirmation, but the RF value is in accordance with that given for chlorovinetorin by ELIX & CROOK (1992). So with the description in LØFALL & TİMDAL (2002) and the TLC, we are sure enough to report here *C. krogiana* new to Greenland (Nuugaatsiaq Island, abt. 71°30' N53°W, CWn, altitude 10 and 50 m asl., SW aspect, pH 5-6, plant community snow bed community: *Polygono-Salicetum herbaceae*).

Tab. 1. Number of specimens of strains and species from plots and herbarium samples (a) and strains/species found together in either relevés or distinct herbarium samples (b) abbrev. as in Fig. 1.

	AT	NO	HO	FU	RA	PSO	POR	BAR
a								
relevés	50	31	24	9	5	52	57	2
herbarium samples	29	32	16	1	3	21	18	0
sum	79	63	40	10	8	73	75	2
b								
AT		13	8	1	1	14	12	1
NO			6	2	2	13	6	
HO				1		3	5	
FU					1			
RA							1	
PSO							9	

The “diversity of strains” in the phytogeographical district seems related to the number of samples (Fig. 1a & 1b). Western Greenland is diverse. In CWn even all eight strains/species were found. The small number of strains in North Greenland might also be due to the small number of samples.

In W and S Greenland the two common *C. cariosa* strains (AT, NO), the strain with hom. (HO), *C. dahliana* (PSO) and *C. cf. galindezii* (POR) are the most abundant types (Fig. 1b). A rather high proportion of *C. cf. galindezii* was found in SE Greenland (Fig. 1b). The strain with fum. & atr. (FU) was only found in West Greenland, the strain with ran. & atr. (RA) seems widespread. Both are too rarely collected for conclusions. *C. krogiana* was found only in two samples in CWn.

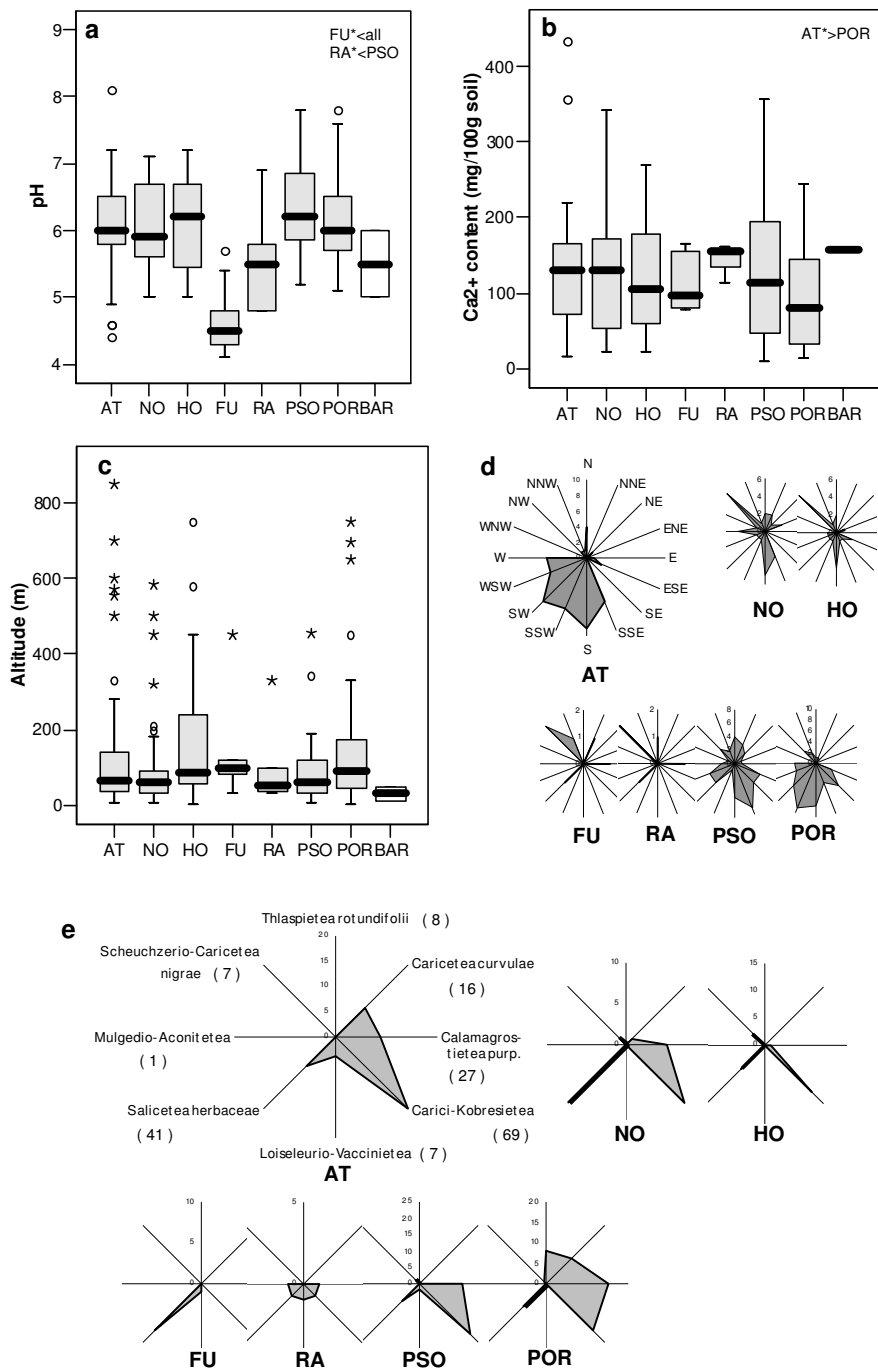


Fig. 2. Strains and species of the *C. cariosa* group with habitat factors and phytosociological classes abbrev. as in Fig. 1. Fig. 2e: Numbers in brackets: number of relevés of the phytosociological classes. (Fig. 2 d-e: scale = numbers of samples)

In 20 % of the relevés (35 out of 174) and 32 % of herbarium collections (22 out of 69) two or more of the eight strains/species were found in one relevé or in one herbarium envelope. In 10 relevés and nine herbarium envelopes three strains/species, in one envelope even four occurred together (*C. cariosa* with atr, with nor. & atr., with hom. & atr. and *C. dahliana*). Which strains co-occur seems to depend on the abundance of strains (Tab. 1). The quite common co-occurrence of different strains or species of the *C. cariosa* group lets assume, that the strains are ecologically similar.

Indeed the strains show little significant differences according to habitat factors. The strain with fum. & atr. (FU) was found at significantly lower pH values than all other types and the strain with ran. & atr. (RA) at lower values than *C. dahliana* (Fig. 2a). The soil of plots with *C. cf. galindezii* were significantly poorer in Ca^{2+} than of the *C. cariosa* strain AT (Fig. 2b). No significant differences were found for altitude (Fig. 2c).

C. cariosa with atr. (AT) and *C. cf. galindezii* (POR) prefer southerly aspects (Fig. 2d).

As most plots stem from *Carici-Kobresietea* vegetation, it is not surprising, that most strains show their centre in this class (Fig. 2e). *Carici-Kobresietea* is followed by steppe vegetation (*Calamagrostietea purpurascens*). The *C. cariosa* strains NO and FU also quite commonly occur in snow bed vegetation (*Salicetea herbaceae*), *C. cf. galindezii* (POR) also in *Thlaspietea* and *Caricetea curvulae* vegetation. *C. dahliana* appears to have the strongest preference for *Carici-Kobresietea* and *Calamagrostietea* vegetation.

4 Discussion

C. cariosa in Greenland shows a remarkable chemical diversity with typically Eurasian and North American strains (HUOVINEN et al. 1989). One of the American strains (FU) was up to now only recorded in West Greenland. None of the strains is exclusive for the Arctic.

At least in the *C. cariosa* group diversity does not decline from southern areas to the Arctic as was observed for a number of other lichen species by LEUCKERT & POELT (1978).

The strains/species of the *C. cariosa* group are ecologically quite similar. PARK (1985) found distinct differences of soil type and soil chemistry for two strains of *C. subcariosa* (*C. polycarpia*, *C. polycarpoides*). In this study only minor differences were found for soil parameters. *C. dahliana* is a strain of *C. symphyarpa*, which is calciphilous (e. g. WIRTH 2001, BÜLTMANN 2006). But neither pH value nor Ca^{2+} content show this trend for *C. dahliana* in Greenland. However *C. dahliana* has a stronger preference for the non-acidic dwarf shrub or grass vegetation *Carici-Kobresietea* and *Calamagrostietea* than the other strains.

Acknowledgements. We want to thank Vagn Alstrup and Eric Steen Hansen for the possibility to study material from the herbarium in Copenhagen, Vagn Alstrup and Teuer Ahti, Helsinki Teuvo also for their help with identifying Greenland lichens.

We dedicate this paper to Fred Daniëls, who introduced us to the Arctic. We will not forget the joint expeditions with Fred Daniëls to Greenland, which gave the impulse to this study.

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Jahr/Year: 2008

Band/Volume: [70_3-4_2008](#)

Autor(en)/Author(s): Bültmann Helga, Lünterbusch Christoph

Artikel/Article: [The Cladonia cariosa group in Greenland 305-312](#)