POLISH POLAR RESEARCH
vol. 27, no. 3, pp. 207–242, 2006

The lichen genus *Cladonia* (Cladoniaceae, lichenized Ascomycota) from Spitsbergen

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Abstract: The paper presents the results of taxonomical work concerning the lichen genus *Cladonia* Hill ex P. Browne from the Arctic island Spitsbergen (Svalbard). The work is based on studies of herbarium material collected during several Polish expeditions (deposited in Polish herbaria) and on the field work carried out by the author in 2002. The materials originate from the west coast of the island. Specimens were studied using methods of classical taxonomy supported by chemical analysis of the lichen substances. Twenty-seven taxa have been recognized in the materials examined. The description (morphological characters and chemistry), ecology and distribution of particular taxa are presented. An updated key for identification of taxa is included. Habitus photos of the species are submitted.

Key words: Arctic, Svalbard, Spitsbergen, lichens, *Cladonia*, taxonomy, distribution, ecology.

Introduction

Svalbard is a group of Arctic islands situated between 74°–81° N and 10°–35° E. The archipelago consists of five main islands (Spitsbergen, Nordaustlandet, Edgeøya, Prins Karls Forland, Barentsøya) and about 150 lesser ones. The largest island is Spitsbergen. Approximately 60% of the land area of Svalbard is covered by glaciers with many outlet glaciers terminating in the sea (Hisdal 1985, 1998). However, from the beginning of the XX century permanent deglaciation process has been observed (Jania 1988; Ziaja 1999). The climate of this region can be defined as Arctic and oceanic. It is conditioned by latitude and circumfluence of water. Svalbard is classified as an Arctic Desert area. But due to warm North Atlantic currents, Svalbard's climate is not as severe as it would be expected at such latitudes (Brázdil 1988; Hisdal 1998). Geological records can be subdivided into three main units: the metamorphic basement complex, the unaltered sedimentary cover

rocks and the unconsolidated deposits. The soils are a component of the environment which occurs on the least area (Ziaja 1999). Many regions are covered by cryogenic initial soil and poorly developed Arctic brown soil (Skiba and Kuczek 1993). In many cases, within the regions covered by glaciers, water bodies and rocky formations, evolution of soils is not possible. However, the global warming-up of the climate, deglaciation and succession of vegetation accelerate formation of soils (Ziaja 1999). Above mentioned abiotic and biotic factors are important for biodiversity, frequency and distribution of lichens, including the representatives of the genus *Cladonia* Hill ex P. Browne. It should be pointed out that in the Svalbard region lichens and bryophytes often constitute a major component of the biomass in areas free from ice.

Representatives of the genus *Cladonia* are fruticose lichens, which as a rule consist of two kinds of thallus: horizontal primary thallus (squamulose or seldom crustose, sometimes disappearing) and vertical secondary thallus (podetia). Almost 40 species of *Cladonia* have been recorded in the region of Svalbard so far. The genus in this part of the Arctic, besides the lichen genera *Caloplaca* Th. Fr. and *Rhizocarpon* Ramond ex DC., is one of the richest in species (Elvebakk and Hertel 1996). Some of the species are widespread and abundant, being significant components of the tundra, some other taxa have been reported only from single or few localities. This could either be explained by the lack of sufficient data on their occurrence or real rarity in the region (Osyczka 2005). Similarity of many taxa and morphological deformations of thallus due to severe climate factors frequently causes difficulties in species determination.

The history of lichenological researches, juxtaposition of important works with records of lichen species and list of all recorded lichens (with commentary) in Svalbard region can be found in the paper by Elvebakk and Hertel (1996).

The main goal of this study is the critical review of the total material belonging to the genus *Cladonia* from the largest island of Svalbard, which was gathered during Polish expeditions.

Material and methods

The results presented here are based on studies of herbarium materials and on the field work carried out by the author during the summer season in 2002. This lichenological research comprised several areas of the west coast of Spitsbergen: Hornsund, Sørkapp Land, Bellsund, Adventfjorden and Grønfjorden (Isfjorden), Petuniabukta (Billefjorden) and Kaffiøyra (Oscar II Land). Field research encompassed various habitats located on plains of raised marine terraces, on nival moraine ridges, in valley of pronival and proglacial streams, on storm ridges, at bottoms and on slopes of mountain massifs.

Taxa were identified using methods of classical taxonomy supported by chemical analyses. Lichen substances were determined by thin-layer chromatography (TLC) in solvent system A and C according to White and James (1985) and Orange *et al.* (2001).

The key, besides taxa ascertained in this work, includes also all species reported from Svalbard, excepting doubtful records (after Elvebakk and Hertel 1996). The distributions of species given here are based on the results of own research and on literature data. The representative specimens of particular taxa are presented in Figs 1 to 6.

Nomenclature of lichens adopted here is that of Santesson *et al*. (2004). Majority of examined specimens are currently deposited in the lichenological herbarium of the Institute of Botany of the Jagiellonian University (KRA). Small collections are present also in herbaria: KRAM-L (W. Szafer Institute of Botany of the Polish Academy of Sciences in Cracov), TRN (Nicolaus Copernicus University in Toruń), H (Botanical Museum of the University of Helsinki) and BG (University of Bergen).

Results

Key to the taxa of the genus *Cladonia*:

1. Primary thallus very rarely present, areolate granular, quickly disappearing. Podetia tall, richly branched, bushy, forming tufts, without cortex, soredia and scyphi 2
1. Primary thallus generally present, squamulose. Podetia variously shaped, corticate or/and sorediate, sometimes with scyphi 5
   2. Podetia yellowish-green, greenish-grey, usnic acid 3
   2. Podetia ashen-grey, without usnic acid, fumarprotocetraric acid present 4
3. Thallus forming tight, rounded tufs, podetia without obvious main stems, perlatolic acid . . . . . *C. stellaris*
3. Thallus forming loose cushions, podetia with obvious main stems, usnic acid . . . . . *C. arbuscula* ssp. *mitis*
3. Thallus forming loose cushions, podetia with obvious main stems, usnic acid and fumarprotocetraric acid . . . . . *C. arbuscula* ssp. *arbuscula*
   4. Surface and stereome at base of thallus ash-grey, pycnidia without pinkish-red jelly . . . . . *C. rangiferina*
   4. Surface and stereome at base of thallus dark brown to black, pycnidia with pinkish-red jelly . . . . . *C. stygia*
5. Primary squamules always conspicuous and rather big-sized, often forming dense mats, podetia frequently absent 6
5. Primary squamules conspicuous or disappearing, podetia well developed 7
   6. Lower surface of primary squamules yellow, upper surface yellowish-green or olive, usnic acid . . . . . *C. luteoalba*
   6. Lower surface of primary squamules white or brownish-white, upper surface grayish or grayish-brown, norstictic acid . . . . . *C. symphycarpia*

6. Lower surface of primary squamules usually pure white, upper surface grayish-green, squamules rather thin, podetia often present, scyphose, atranorin and fumarprotocetraric acid · *C. macrophyllodes*
6. Lower surface of primary squamules white, upper surface usually dark green, squamules rather thick, podetia sometimes present, scyphi absent, atranorin, ± fumarprotocetraric acid · *C. turgida*
7. Primary squamules not seen, podetia usually tall and well developed · · · · · · · · · 8
7. Primary squamules conspicuous, sometimes disappearing in older specimens · · · · · 9
8. Podetia slender, richly branched, sometimes with narrow scyphi, grayish-green or yellowish-green, usnic acid and barbatic acid · · · · · · · · · · · · *C. amaurocraea*
8. Podetia sparsely branched, without scyphi, with open axils, pale yellow or greenish-yellow, usnic acid, ± squamatic acid, never barbatic acid · · · · · · · *C. uncialis*
9. Hymenial discs red or pale brown, podetia at base sometimes yellowish · · · · · · · 10
9. Hymenial discs brown or dark brown, podetia at base not yellowish · · · · · · · · · 16
10. Podetia grayish-green, blunt, without usnic acid, barbatic acid present · *C. macilenta* ssp. *floerkeana*
10. Podetia green-yellowish, with well developed or narrow and deformed scyphi, usnic acid generally present · 11
11. Podetia sorediate · 12
11. Podetia without soredia · 14
12. Hymenial discs pale brown · *C. carneola*
12. Hymenial discs red · 13
13. Podetia with narrow or deformed scyphi, soredia farinose · · · · · · · · · C. deformis
13. Podetia with wide scyphi, soredia granular · · · · · · · · · · · · · · · · · *C. pleurota*
14. Podetia tall, blunt or with narrow scyphi, covered by numerous squamules · *C. bellidiflora*
14. Podetia short, with wide scyphi · 15
15. Podetia without squamules, barbatic acid · · · · · · · · · · · · · · · · · · *C. borealis*
15. Podetia sometimes decorated by squamules, zeorin · · · · · · · · · · · · *C. coccifera*
16. Podetia usually with well developed and wide scyphi · · · · · · · · · · · · · · 17
16. Podetia with narrow, sometimes deformed scyphi or without scyphi · · · · · · 22
17. Podetia with farinose or granulose soredia · 18
17. Podetia without soredia · 19
18. Podetia farinose or rarely granulose, sorediate down to base · · · · · · *C. fimbriata*
18. Podetia granulose sorediate, corticate at base · · · · · · · · · · · · *C. chlorophaea*
19. Podetia irregular, variable in form, robust, usually with irregular scyphi, frequently decorated by squamules · *C. phyllophora*
19. Podetia regular, with well developed scyphi, sometimes sparsely decorated by squamules or microsquamules · 20
20. Podetia smooth with rather continuous cortex, generally with central proliferations · *C. verticillata*
20. Podetia covered by granules or cortical plates, generally with marginal proliferations · 21
21. Podetia usually with cortical plates, grayish-green or olive-brown, primary squamules thin and not forming dense mat, fumarprotocetraric acid only · · · · · · · *C. pyxidata*

21. Podetia usually granulose, brownish, primary squamules thick and forming dense mat, fumarprotocetraric acid and sometimes atranorin . . . . . *C. pocillum*
21. Podetia with verruculous cortex, partly granulose, grayish-green to brownish-green, merochlorophaeic acid . . . . . *C. merochlorophaea*
22. Podetial surface farinose to granulose sorediate 23
22. Podetial surface granulose, verruculose, areolate or smoothly corticate, sometimes squmulose or microsquamulose 27
23. Podetia blunt at the tips, without scyphi 24
23. Podetia often with narrow scyphi and marginal proliferations 26
24. Primary squamules rather large and abundant, surface of podetia irregular, often decorated by small squamules and branched at the tips, norstictic acid and atranorin . . . . . *C. acuminata*
24. Primary squamules small and frequently disappearing, surface of podetia regular, usually without squamules, subulate at the tips 25
25. Usnic acid and barbatic acid . . . . . *C. cyanipes*
25. Fumarprotocetraric acid . . . . . *C. cornuta*
26. Podetia slender and rather tall, narrow scyphi close, fumarprotocetraric acid . . . . . *C. subulata*
26. Podetia often swollen, with gaping scyphi, squamatic acid . . . . . *C. cenotea*
27. Podetia visibly elongated, simple or branched, smooth or with squamules, with scyphi or without scyphi 28
27. Podetia usually blunt or with very narrow scyphi, usually squat, simple or branched at the tips 35
28. Surface of podetia verruculose, areolate, frequently with strongly divided cortex, in some places without cortex, often with numerous squamules 29
28. Podetia continuously corticate or areolate, squamules or microsquamules rather sparse 30
29. Primary squamules small and evanescent, podetia brownish-gray or greenish-gray, melanotic at base, with narrow scyphi or without scyphi, generally with marginal proliferations, podetial squamules sparse . . . . . *C. stricta*
29. Primary squamules fairly large and usually persistent, podetia greenish-brown or olive-brown, melanotic at base, sometimes with irregular scyphi, generally with central proliferations, podetial squamules numerous . . . . . *C. trassii*
29. Primary squamules fairly large and usually persistent, podetia greenish-brown or olive-brown, always with distinct and centrally proliferating scyphi, podetial squamules always numerous . . . . . *C. uliginosa*
30. Squamatic acid 31
30. Fumarprotocetraric acid, ± atranorin 32
31. Podetia slender, usually erect, matt, often with microsquamules, not becoming black at base, without dark brown corticate patches . . . . . *C. crispata* var. *cetrariiformis*
31. Podetia stout, often procumbent, frequently rough, glossy, without squamules or microsquamules, inside dark or black, becoming black at base, dark brown or black corticate patches rather conspicuous . . . . . *C. subfurcata*
32. Basal dead part of podetia pale yellow or yellow 33
32. Basal dead part of podetia not yellow, podetia brownish or blackish at base . . . 34

33. Podetia slender and tall, smooth, grayish-green to brownish, atranorin usually absent, only sometimes small amounts of atranorin present · · · · · · · · · · · · · *C. maxima*
33. Podetia not very tall, somewhat pruinose, with distinct grayish tint, atranorin always abundant · *C. ecmocyna*
    34. Podetia regular, usually erect, smooth, with narrow or without scyphi, infrequently branched, squamules sometimes present only at the basal part · · · · · · *C. gracilis*
    34. Podetia frequently irregular and procumbent, often rough and with protuberances, without or with quite wide scyphi, squamules often present up to the tips · *C. macroceras*
35. Podetia small and rather thick, typically club-shaped, crowned with brown aphotecia, without squamules, atranorin · *C. cariosa*
35. Podetia rather subulate, blunt or with very narrow scyphi, covered by squamules, without atranorin · 36
    36. Podetia covered by peltate and protruding areoles or squamules, without scyphi, psoromic acid · *C. macrophylla*
    36. Podetia abundantly scaly, often covered by extremely small squamules, sometimes with very narrow and open scyphi, squamatic acid · · · · · · · · · · *C. squamosa*

Descriptions of taxa

Cladonia amaurocraea (Flörke) Schaer.
(Fig. 1A)

Lich. Helv. Spic. 1(1): 34 (1823).

Description. — Primary squamules not seen. Podetia slender, 10–100 mm tall, grayish-green to yellowish-green, irregularly or dichotomously branched, sometimes with scyphi. Scyphi narrow, rapidly flaring, often with short marginal proliferations. Surface of podetia smooth, matt, areolate-corticate, rarely continuously corticate. Hymenial discs brown.

Chemistry. — PD-, K-, C-, KC+ yellow; contains usnic and barbatic acids. Usnic acid presents in a cortex, barbatic acid in medulla (Brodo *et al.* 2001). Barbatic acid might be absent in rare cases (Krog *et al.* 1980).

Remarks. — Juvenile specimens and those modified by climate factors can be confused with *Cladonia uncialis*. However, *C. amaurocraea* in comparison with *C. uncialis*, has usually longer and slender podetia, it is less regularly branched and sometimes is scyphose (*C. uncialis* never forms scyphi). *C. uncialis* contains usnic and squamatic acids or usnic acid alone. It never produces barbatic acid which typically appears in *C. amaurocraea*. On the other site, squamatic acid is never present in *C. amaurocraea*. Both species often occur together in the same localities and then can be mixed. Some forms of *C. gracilis* or *C. macroceras*, which often grow in the same habitats as *C. amaurocraea*, could apparently be similar. However, these species have brownish-green, never yellowish colour of podetia. Moreover, they always contain fumarprotocetraric acid, which never appears in *C. amaurocraea*.

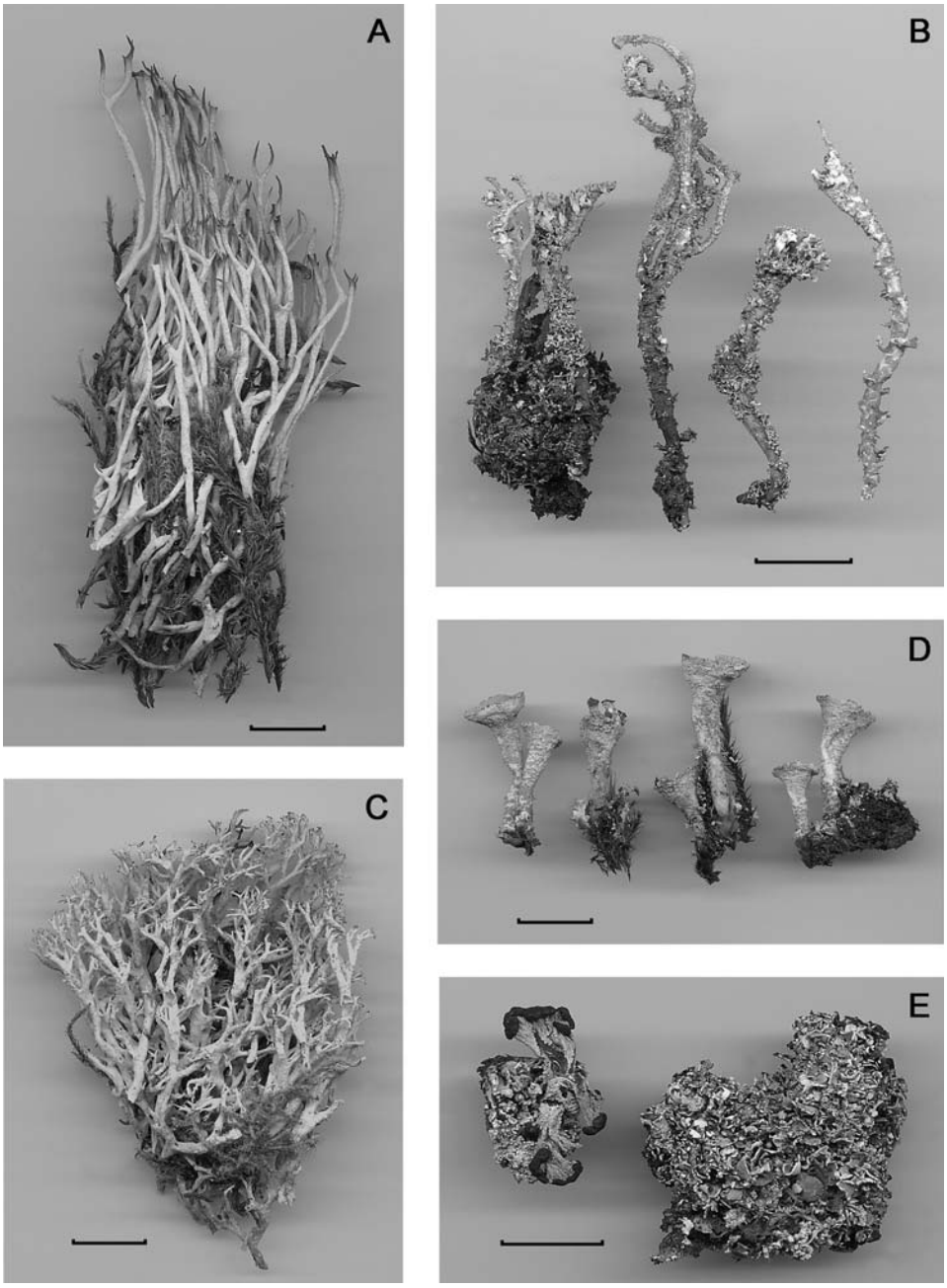

Fig. 1. Representatives of the genus *Cladonia* from Spitsbergen. **A**. *Cladonia amaurocraea* [*P. Osyczka 304 (KRA)*]. **B**. *Cladonia bellidiflora* [*P. Osyczka 402 (KRA)*]. **C**. *Cladonia arbuscula* ssp. *mitis* [*P. Osyczka 258 (KRA)*]. **D**. *Cladonia borealis* [*P. Osyczka 403 (KRA)*]. **E**. *Cladonia cariosa* [*F. Święs 2520 (KRA)*]. Scale bars 1 cm.

Ecology. — This species grows on soil, in light and usually dry places. It prefers decaying type of substratum, frequently grows among mosses. The species occurs in communities: *Flavocetraria nivalis–Cladonia rangiferina, Cetrariella delisei, Racomitrium lanuginosum*, *Saxifraga nivalis, Solorina crocea, Umbilicaria alpina* (Dubiel and Olech 1990) and also in communities dominated by *Deschampsia alpina* and *Dryas octopetala* (Osyczka 2003).

Distribution. — Sørkapp Land (Hofmann 1968; Dubiel and Olech 1990; Olech 1990; Gumińska *et al.* 1991; Osyczka 2003), Hornsund (Elenkin 1907; Nowak 1965; Eurola 1968; Osyczka 2003), Bellsund (Lynge 1938; Osyczka 2003), Isfjorden (Eurola 1968; Osyczka 2003), Kaffiøyra (Osyczka 2003), Amsterdamøya (Hertel and Ullrich 1976). The species is widespread and occurs in areas from see level to mountain tops (Osyczka 2004a).

Cladonia arbuscula ssp. *mitis* (Sandst.) Ruoss
(Fig. 1C)

Bot. Helv. 97: 260 (1987).

Cladonia mitis Sandst., *Cladina mitis* (Sandst.) Mong., *Cladina arbuscula* ssp. *mitis* (Sandst.) Burgaz.

Description. — Primary thallus granular crustose, evanescent. Podetia erect and typically fruticose, up to 5(8) cm tall, 0.5–2 mm thick, yellowish-white to yellowish-green, richly branched generally by dichotomy, trichotomy or tetrachotomy, never scyphose, apices subulate and divergent, axils sometimes open. Surface of podetia ecorticate, smooth, matt, frequently cottony. Hymenial discs brown.

Chemistry. — PD-, K-, C-, KC+ yellow, UV-; contains usnic acid, isousnic acid inconstant. Rangiformic and norrangiformic acids were not detected, but these components might occur in the species (Ruoss 1987; Ruoss and Ahti 1989; Ahti and Kashiwadani 1984; Stenroos 1993, 1995; Brodo *et al.* 2001).

Remarks. — *Cladonia arbuscula* ssp. *mitis* is frequently deformed and stunted by climate factors and then morphologically resembles *C. arbuscula* ssp. *arbuscula* and *C. portentosa*. However, chemically *C. arbuscula* ssp. *arbuscula*, beside usnic acid, contains fumarprotocetraric acid and *C. portentosa* contains perlatolic acid with or without usnic acid. Probably *C. portentosa* does not occur in the region of Spitsbergen and data on its occurrence (Hadač 1989) are highly doubtful. *Cladonia arbuscula* ssp. *arbuscula* was reported only by Ahti (1961) from southern part of Edgeøya.

Ecology. — It grows on soil, frequently among mosses, in light and usually dry places. It is very often distinctive lichen for plains of raised marine terraces. The species occurs in communities: *Flavocetraria nivalis–Cladonia rangiferina*, *Cetrariella delisei*, *Racomitrium lanuginosum*, *Gymnomitrion coralloides*, *Saxifraga nivalis*, *Solorina crocea*, *Sphaerophorus globosus*, *Umbilicaria arctica* (Dubiel and Olech 1990), *Chrysosplenium tetrandrum–Cochlearia groenlandica* (Dubiel and Olech 1992). The species appears also in communities dominated by *Deschampsia alpina* and *Dryas octopetala* (Osyczka 2003).

Distribution. — It is one of the most widespread lichens along the whole coast of Spitsbergen (*e.g.* Eurola 1968; Osyczka 2003) being apparent and main component of the tundra.

Cladonia bellidiflora (Ach.) Schaer.
(Fig. 1B)

Lich. Helv. Spic. 1(1): 21 (1823).

Description. — Primary squamules inconspicuous, evanescent, rarely permanent. Podetia rather tall, up to 5(9) cm, yellowish-green to grayish-green, at base frequently straw, simple or slightly branched, blunt or sometimes with narrow scyphi. Surface of podetia discontinuously corticated, densely covered by squamules. Hymenial discs red.

Chemistry. — PD-, K-, KC+ yellow or KC-, UV+; contains (1) squamatic and usnic acids or (2) squamatic acid. Second chemotype is rarer. Several chemotypes of the species is actually known in the world (*e.g.* Galloway 1985; Huovinen *et al.* 1989a; Lindsay 1975; Ahti and Kashiwadani 1984; Stenroos and Ahti 1990; Stenroos *et al.* 1992; Stenroos 1993). Squamatic acid is characteristic of the Northern Hemisphere (Stenroos 1993).

Remarks. — Variability of the species is quite large but if red apothecia are present its determination is not difficult, even in the field. The different chemistries of *C. bellidiflora* do not correlate with morphological characters (Stenroos and Ahti 1990; Stenroos 1993).

Ecology. — The species grows on soil, mosses and humus, in light and rather dry places. Frequently occurs among mosses. It occurs in communities: *Flavocetraria nivalis–Cladonia rangiferina*, *Tetraplodon mnioides* (Dubiel and Olech 1990) and also in communities dominated by *Racomitrium lanuginosum* (Osyczka 2003).

Distribution. — Danskøyane (Fries 1867), Amsterdamøya (Fries 1867; Lynge 1938), Norskøyane, Lomfjorden, Magdalenefjorden, Kobbefjorden, Virgohamna, Smeerenburgfjorden, Klovningen, Holmiabukta, Raudfjorden, Isfjorden, Kongsfjorden (Lynge 1938), Bellsund (Lynge 1938; Osyczka 2003), Hornsund (Osyczka 2003), Sørkapp Land (Dubiel and Olech 1990; Olech 1990; Osyczka 2003). Besides Spitsbergen the species was also recorded in: Nordaustlandet (Fries 1867; Lynge 1938), Edgeøya (Aptroot and Alstrup 1991) and Prins Karls Forland (Lynge 1938). *Cladonia bellidiflora* is a rather common species, mostly in the sea-coast regions and in lower parts of mountain massifs.

Cladonia borealis S. Stenroos
(Fig. 1D)

Ann. Bot. Fenn. 26: 160 (1989).

Description. — Primary squamules persistent, up to 5 mm, lobed, usually with dark yellow or orange tint at base. Podetia up to 2.5 cm tall, simple, yellow-

ish-green, always with scyphi. Scyphi 12 mm wide, gradually flaring. Surface of podetia covered by rounded cortical plates, areolate to continuously corticate at base. Hymenial discs red.

Chemistry. — PD-, K-, C-, KC+ yellow; contains usnic acid, barbatic acid and 4-O-demethylbarbatic acid (accessory). According to Stenroos (1993), in Antarctic and peri-Antarctic populations usnic acid might be occasionally absent.

Remarks. — *C. coccifera* is almost identical with *C. borealis* in appearance and habitat, but contains zeorin rather than barbatic acid (Stenroos 1989).

Ecology. — It grows on soil and humus, sometimes among mosses, in light and dry places. The species occurs in communities: *Flavocetraria nivalis–Cladonia rangiferina*, *Cetrariella delisei*, *Racomitrium lanuginosum*, *Gymnomitrion corralloides*, *Orphniospora moriopsis*, *Tetraplodon mnioides*, *Solorina crocea*, *Ranunculus glacialis* (Dubiel and Olech 1990 – based on materials published as *C. coccifera* but belonging to *C. borealis*) and also in communities dominated by *Dryas octopetala* and *Festuca vivipara* (Osyczka 2003).

Distribution. — After taxonomical revision of the *C. coccifera* group by Stenroos (1989), only one locality of *C. borealis* was marked on the map of Svalbard. However, it is sure, that the species is pioneer and widespread. Numerous localities of *C. borealis* was ascertained in the region of Sørkapp Land, Hornsund, Bellsund, Isfjorden and Kaffiøyra (Osyczka 2003). It occurs in the areas elevated from sea level to mountain tops.

Cladonia cariosa (Ach.) Spreng.
(Fig. 1E)

Syst. Veg. 4(1): 272 (1827).

Description. — Primary squamules persistent, rather thick, up to 2 mm long. Podetia sometimes unformed. If present, up to 1.5 cm tall, grayish-brown to grayish-green, usually simple, somewhat torn, fissured in upper parts, without scyphi. Surface of podetia areolate-corticate. Apothecia always present. Hymenial discs brown.

Chemistry. — PD-, K+ yellow; contains atranorin. The second chemical race with fumarprotocetraric acid (besides atranorin) is known in other regions of the world (Stenroos 1995; Brodo *et al.* 2001).

Remarks. — In the case of the lack of podetia the species might be confused especially with *C. symphycarpia*, which has usually broader primary squamules and besides atranorin often produces norstictic acid (present in all investigated specimens from Spitsbergen).

Ecology. — Grows on soil in dry places. The species occurs in *Racomitrium lanuginosum* community (Dubiel and Olech 1990) and in community dominated by *Flavocetraria nivalis* (Osyczka 2003).

Distribution. — Lomfjorden, Magdalenefjorden, Treurenbergfjorden, Isfjorden, Van Keulenfjorden, Sørkappøya (Lynge 1938), Bellsund (Osyczka

2003), Hornsund (Nowak 1965), Sørkapp Land (Dubiel and Olech 1990; Olech 1990; Osyczka 2003). Localities of the species in the region of Spitsbergen are scattered.

Cladonia carneola (Fr.) Fr.
(Fig. 2B)

Lichenogr. Eur. Reform. 233 (1831).

Description. — Primary squamules persistent, up to 5 mm long. Podetia up to 2 cm tall, greenish-yellow, simple, always with scyphi. Scyphi up to 5(7) mm wide, gradually or suddenly flaring, with typical dentate margins. Surface of podetia farinose sorediate, sometimes partly with scattered granules or cortical plates (especially in basal part). Hymenial discs waxy or pale brown.

Chemistry. — PD-, K-, C-, KC+ yellow, UV-; contains usnic acid, zeorin and irregularly barbatic acid. Constant presence of barbatic acid is rather characteristic of the populations in the Southern Hemisphere (Stenroos 1993), however, this component has been also found in specimens from the Northern Hemisphere (*e.g.* Wetmore 1967; Nourish 1977; Brodo *et al.* 2001). 4-O-demethylbarbatic, isousnic acids and some unknown fatty acids may be also present (Stenroos 1993). Occasionally zeorin might be absent (Stenroos 1995).

Remarks. — In the case of the lack of apothecia *C. carneola* might be confused with *C. pleurota*, which has red fructifications, less dentate cup margins, thicker soredia and never contains barbatic acid.

Ecology. — Grows on soil and humus, sometimes among mosses, in light or shade and in rather dry places. It may grow together with other *Cladonia* representatives (such as *C. macroceras*, *C. pocillum*, *C. pyxidata*) and *Tetraplodon mnioides* and *Racomitrium lanuginosum* (Osyczka 2003).

Distribution. — Amsterdamøya (Lynge 1938; Hertel and Ullrich 1976), Sørkapp Land (Olech 1990; Osyczka 2003), Hornsund (Osyczka 2003). Besides Spitsbergen recorded on Nordaustlandet (Lynge 1938). The species is rare.

Cladonia chlorophaea (Flörke ex Sommerf.) Spreng.
(Fig. 2A)

Syst. Veget. 4(1): 273 (1827).

Description. — Primary squamules persistent, abundant, up to 3(5) mm long. Podetia up to 3.5 cm tall, grayish-green, simple or sometimes branched by marginally proliferating scyphi, always with scyphi,. Scyphi up to 8 mm wide, gradually flaring. Surface of podetia granulose sorediate, with scattered squamules at base. Hymenial discs brown.

Chemistry. — PD+ red, K-, C-, KC-; contains fumarprotocetraric acid complex. This is a typical chemotype for the Northern Hemisphere. Atranorin constitutes common component in the specimens from the Southern Hemisphere (Ahti

and Kashiwadani 1984; Galloway 1985; Stenroos *et al.* 1992; Stenroos 1993; Osyczka and Olech 2005).

Remarks. — The species is morphologically similar to *C. merochlorophaea*, which contains merochlorophaeic and 4-O-demethylcryptochlorophaeic acids and demonstrates a tendency to brownish tint.

Ecology. — It grows on soil, sometimes on mosses and humus, in light and rather dry places. The species occurs in *Polygonum viviparum* community (Dubiel and Olech 1990) and also in communities dominated by *Dryas octopetala* (Osyczka 2003).

Distribution. — It is a rather frequent species, recorded by several authors along the west coast of Spitsbergen (*e.g.* Lynge 1938; Eurola 1968; Hertel and Ullrich 1976; Eurola and Hakala 1977; Elvebakk 1984; Hartmann 1980; Hadač 1989; Dubiel and Olech 1990, 1992; Osyczka 2003). Relatively many localities were found in south-west part of Bellsund (Osyczka 2003).

Cladonia coccifera (L.) Willd.
(Fig. 2C)

Fl. Berol. Prodr. 361 (1787).

Description. — Primary squamules persistent, up to 7 mm long. Podetia up to 2 cm tall, simple, yellowish-green, sometimes yellow at base, always with scyphi. Scyphi up to 10 mm wide, gradually flaring. Surface of podetia granulose to areolate or continuously corticate at base, often decorated by characteristic scaly plates. Hymenial discs red.

Chemistry. — PD-, K-, C-, KC+ yellow; contains usnic acid and zeorin. Isousnic acid, porphyrilic acid and some fatty acids may be present as accessory substances (Stenroos 1989).

Remarks. — The species might be confused especially with morphologically similar *C. borealis*. The most important morphological characteristics of *C. coccifera* comprise relatively large size of primary squamules and scaly plates, which appear on the upper surface of the podetia and the interior part of the scyphi (Stenroos 1989). The presence of zeorin is very helpful for distinction *C. coccifera* from *C. borealis*, especially in the case of specimens originating from the Arctic. As a consequence of severe climate factors scaly plates typical of *C. coccifera* may be feebly developed or mechanically plucked. In the field the species might be easily overlooked (Osyczka 2005).

Ecology. — The species grows on soil, in light and dry places. Specimens of *C. coccifera* were found in the valley of pronival stream within solifluction tongue zone and at the bottom of mountain massif.

Distribution. — Hornsund (Osyczka 2003, 2005). The species was reported by several authors but these reports should to be treated as *C. coccifera* s.l. Certainly, large part of collections belong to *C. borealis*. It seems, that *C. coccifera* s.str. is very rare in this part of the Arctic.

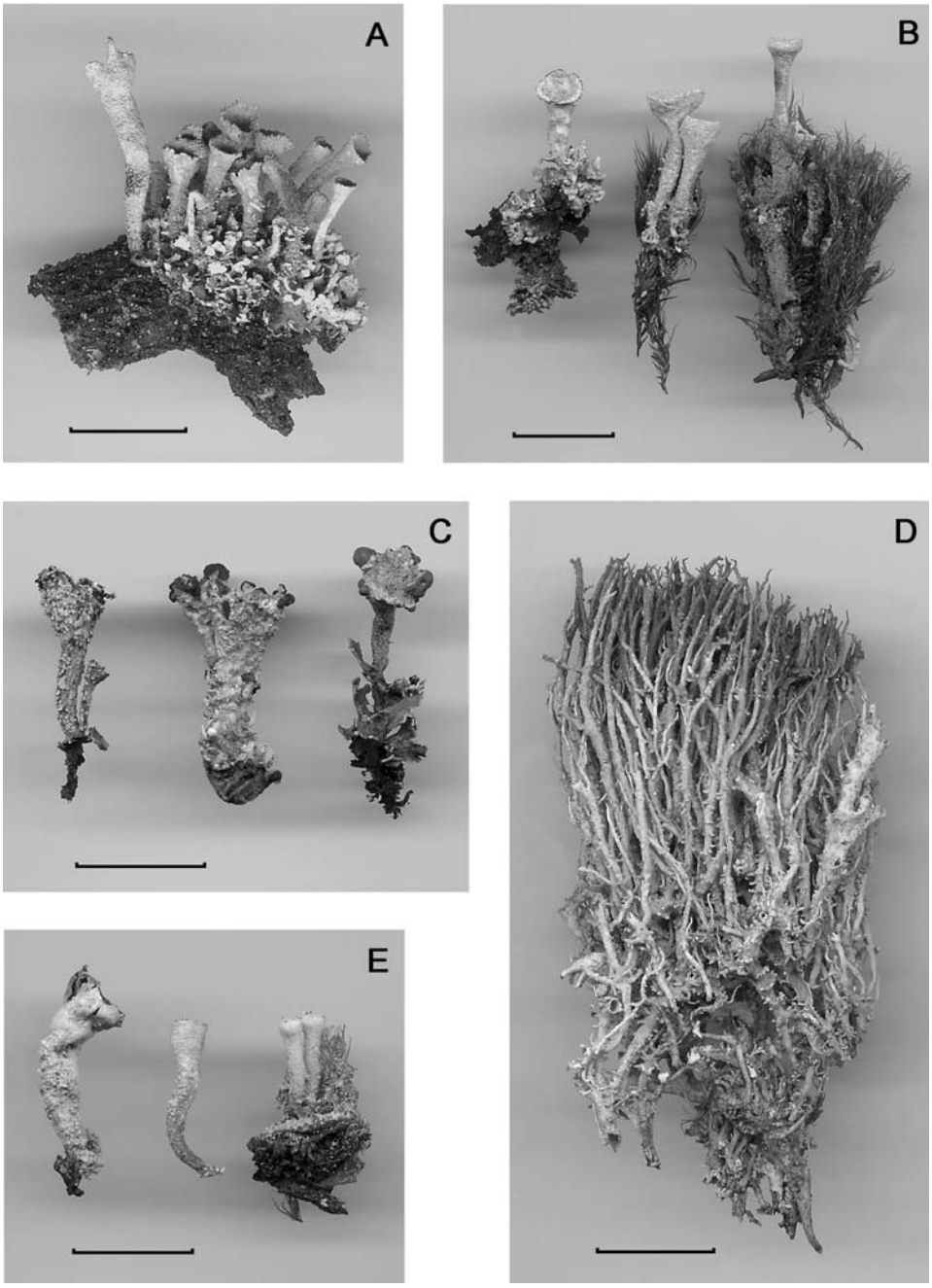

Fig. 2. Representatives of the genus *Cladonia* from Spitsbergen. **A**. *Cladonia chlorophaea* [*P. Osyczka 407 (KRA)*]. **B**. *Cladonia carneola* [*P. Osyczka 310 (KRA)*]. **C**. *Cladonia coccifera* [*P. Osyczka 336 (KRA)*]. **D**. *Cladonia crispata* var. *cetrariiformis* [*P. Osyczka 313 (KRA)*]. **E**. *Cladonia deformis* [*F. Święs 2531 (KRA)*]. Scale bars 1 cm.

Cladonia crispata var. *cetrariiformis* (Delise) Vain. in Olivier
(Fig. 2D)

Rev. Bot. Bull. Mens. 4: 238 (1886).

Description. — Primary squamules early evanescent, rather small, up to 3 mm long. Podetia slender, usually tall (10–100 mm high) and thin (1–2 mm thick), yellowish-brown to brownish-olive, often decaying and pale at base, sparse irregularly or dichotomously branched, pointed or with very narrow scyphi. Surface of podetia areolate to continuously corticate, often covered by microsquamules. Hymenial discs brown.

Chemistry. — PD-, K-, C-, KC-, UV+; contains squamatic acid. For *C. crispata* there were reported other chemotypes with barbatic acid, thamnolic acid and squamatic acid with addition of baeomycesic acid (Tønsberg 1980; Huovinen and Ahti 1988; Walker and Lintott 1997; Brodo *et al.* 2001).

Remarks. — Poorly developed specimens of the taxon might be confused with several species, *e.g. C. amaurocraea*, *C. gracilis*, *C. macroceras*, *C. stricta*. In distinction to these species *C. crispata* var. *cetrariiformis* contains squamatic acid. *C. subfurcata*, which also contains squamatic acid, frequently has procumbent, rough podetia, with dark brown or black corticate patches and becoming black at base. Moreover, it has glossy surface of podetia.

Ecology. — It grows on soil, in dry or slightly humid places, frequently appears among mosses. The species occurs in communities: *Flavocetraria nivalis–Cladonia rangiferina*, *Racomitrium lanuginosum*, *Saxifraga nivalis* (Dubiel and Olech 1990).

Distribution. — Sørkapp Land (Dubiel and Olech 1990; Olech 1990; Osyczka 2003, 2005), Hornsund (Osyczka 2003, 2005), Bellsund (Osyczka 2003, 2005). Probably the taxon is more common than was formerly considered.

Cladonia deformis (L.) Hoffm.
(Fig. 2E)

Deutschl. Fl. 2: 120 (1796).

Description. — Primary squamules small and usually disappearing. Podetia up to 2.5 cm tall, yellowish-green, simple, elongated, always with scyphi. Scyphi rather narrow, irregular and deformed, up to 5(7) mm wide, sometimes only a little more wide than podetial stalk, gradually flaring. Surface of podetia farinose sorediate, sometimes corticate at base. Hymenial discs brown.

Chemistry. — PD-, K-, C-, KC+ yellow, UV-; contains usnic acid and zeorin. Isousnic acid accompanies usnic acid (Stenroos 1993). This is a typical composition of the species. (Stenroos 1993; Stenroos and Ahti 1992).

Remarks. — *Cladonia deformis* sometimes closely resembles *C. pleurota*, which has similar chemical composition, but is usually shorter and has granular soredia. *Cladonia carneola* has pale brown apothecia and beside usnic acid and zeorin usually contains barbatic acid. *Cladonia sulphurina* (also with red apothecia and farinose soredia) does not contain zeorin and produces squamatic acid.

Ecology. — Grows on soil, sometimes on mosses and humus, in light and usually dry places. The species occurs in *Flavocetraria nivalis–Cladonia rangiferina* community and in communities strongly connected with bird colonies: *Tetraplodon mnioides* (Dubiel and Olech 1990) and *Luzula confusa–Salix polaris* (Dubiel and Olech 1992).

Distribution. — Magdalenefjorden, Kobbefjorden, Treurenbergfjorden, Danskøya (Fries 1867), Sorgfjorden, Kobbefjorden, Danskøya, Amsterdamøya, Isfjorden (Lynge 1924, 1938), Hornsund (Østhagen 1971; Dubiel and Olech 1992), Amsterdamøya (Hertel and Ullrich 1976), Isfjorden-Adventfjorden (Eurola and Hakala 1977), Sørkapp Land (Dubiel and Olech 1990; Olech 1990), Bellsund (Osyczka 2003), north-west part of Nordaustlandet (Lynge 1938; Østhagen 1971). It is quite common but dispersed species.

Cladonia fimbriata (L.) Fr.
(Fig. 3A)

Lichenogr. Eur. Reform. 222 (1831).

Description. — Primary squamules persistent, up to 5 mm long. Podetia up to 2 cm tall, gray-green to green, simple, sometimes elongated, always with scyphi. Scyphi up to 5 mm wide, rapidly flaring, rather regular, with entire or slightly dentate margins. Surface of podetia farinose sorediate, sometimes corticate at base. Hymenial discs brown.

Chemistry. — PD+ red, K-, C-, KC-; contains fumarprotocetraric acid complex. Atranorin may be exceptionally present in this species (Walker and Lintott 1997, Stenroos 1995).

Remarks. — The species might be similar to *C. chlorophaea*, which has granular soredia, usually gradually flaring scyphi and sometimes marginal proliferations.

Ecology. — It grows on soil in light and dry places. Single locality of the species was found on the slope of mountain massif. In this place *C. fimbriata* was associated with *C. macroceras* and *C. arbuscula* ssp. *mitis* and *Saxifraga hyperborea*.

Distribution. — Rarely reported species. Placed on floristic lists from Hornsund and Isfjorden (Eurola 1968; Hartmann 1980) and reported from Indre Norskøya (Lynge 1938). Also recorded in few localities on Nordaustlandet (Paulson 1928; Lynge 1938). Presently *C. fimbriata* was found on the slope of Angelfjellet in Hornsund region (Osyczka 2003).

Cladonia gracilis ssp. *elongata* (Wulfen) Vain.
(Fig. 3B)

Acta Soc. Fauna Fl. Fenn. 53(1): 92 (1922).

Cladonia elongata (Wulfen) Hoffm.

Description. — Primary squamules inconspicuous, persistent or evanescent, up to 3 mm long. Podetia up to 5(7) cm tall, 0.5–2 mm thick, brownish-olive to

brown, simple or a little branched, sometimes dwarfed and twisted, blunt or with narrow scyphi. Scyphi, if present, up to 3 mm wide, closed, with dentate margins or with marginal proliferations. Surface of podetia almost continuously corticate to shallowly areolate, smooth, sometimes with scattered squamules (especially at base). Hymenial discs brown.

Chemistry. — PD+ red, K- or K+ yellow, C-, KC-; contains fumarprotocetraric acid complex, rarely atranorin. Small amount of atranorin was detected only in several studied specimens. However, atranorin in small quantity might be regularly present in the taxon (Ahti 1980; Stenroos 1995; Brodo *et al.* 2001).

Remarks. — The taxon often resembles *C. macroceras* but has usually shorter, slender and smoother podetia.

Ecology. — Grows on soil, mosses and humus, in light and rather dry places. Frequently appears among mosses. The taxon occurs in communities: *Saxifraga hyperborea–Ranunculus spitsbergensis* (Dubiel and Olech 1990), *Chrysoplenium tetrandrum–Cochlearia groenlandica*, *Luzula confusa–Salix polaris* and *Tetraplodon mnioides–Aplodon wormskjoldii* (Dubiel and Olech 1992).

Distribution. — Only small part of herbal material belonging to the *C. gracilis* group from Spitsbergen was subjected to revision (Ahti 1980). *C. gracilis* was reported under various names by several authors from numerous localities of the west coast of Spitsbergen (*e.g.* Lynge 1924, 1938; Hadač 1946; Nowak 1965; Eurola 1968; Hartmann 1980; Gugnacka-Fiedor and Noryśkiewicz 1982). Supposedly some part of the material might belongs to *C. gracilis* ssp. *elongata*, however, probably large part refer to *C. macroceras* which is very common in the region of Spitsbergen (Ahti 1980; Osyczka 2003, 2004b). *Cladonia gracilis* ssp. *elonga*ta was recorded in the areas of: Raudfjorden (Ahti 1980), Sørkapp Land (Dubiel and Olech 1990; Olech 1990; Osyczka 2003), Hornsund (Dubiel and Olech 1992; Osyczka 2003), Bellsund (Osyczka 2003), Isfjorden-Adventfjorden (Osyczka 2003).

Cladonia macroceras (Delise) Hav.
(Fig. 3C, D)

Bergens Mus. Crbok, Naturvidensk. Rekke 1927(3): 12 (1928 [1927]).

Description. — Primary squamules often well developed, persistent or sometimes evanescent, up to 3 mm long. Podetia up to 5(8) cm tall, 2–4 mm thick, brown to brownish-olive, simple or frequently somewhat branched, well-formed or often dwarfed, twisted and deformed, blunt or with scyphi. Scyphi, if present, up to 7 mm wide, with dentate margins or with marginal proliferations. Surface of podetia almost continuously corticate to shallowly areolate, often with squamules and protuberances. Hymenial discs brown.

Chemistry. — PD+ red, K+ yellow or K-, C-, KC-; contains fumarprotocetraric acid complex, atranorin very common but not constant. Especially in the Arctic and sub-Arctic regions atranorin is frequently present in the species.

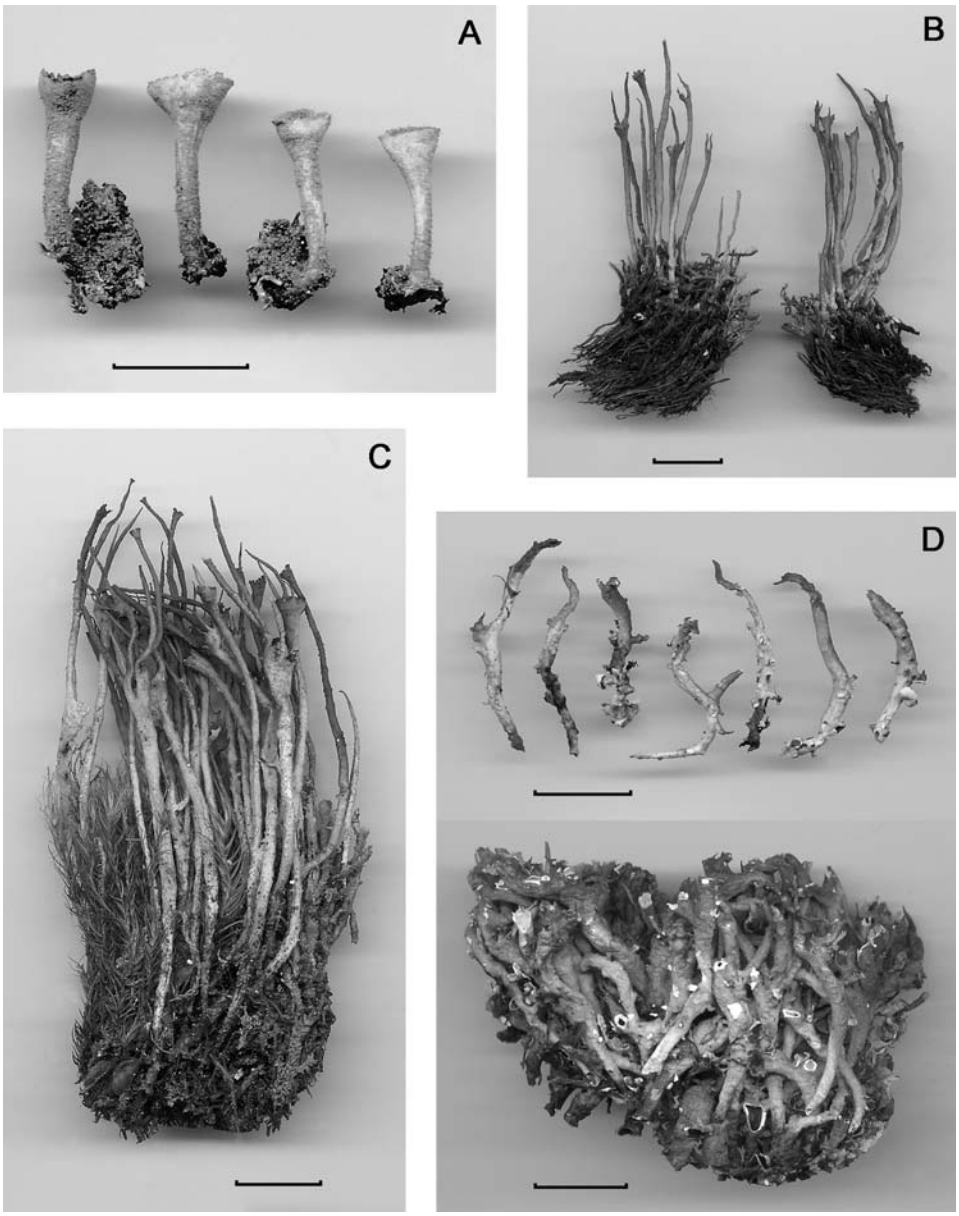

Fig. 3. Representatives of the genus *Cladonia* from Spitsbergen. **A**. *Cladonia fimbriata* [*P. Osyczka 318 (KRA)*]. **B**. *Cladonia gracilis* ssp. *elongata* [*P. Osyczka 412 (KRA)*]. **C**. *Cladonia macroceras* [*P. Osyczka 419 (KRA)*]. **D**. *Cladonia macroceras* [*P. Osyczka 432 (KRA)*]. Scale bars 1 cm.

Remarks. — The species might be very easly mistaken with *C. gracilis*, especially with ssp. *elongata*. *Cladonia macroceras* shapes usually longer, thicker and more irregular podetia. Podetial surface is generally horny and often decorated by

abundant squamules (Ahti 1980; Osyczka 2004b). Specimens of *C. macroceras* characteristically deformed by severe climate factors are relatively easily recognizable. *C. ecmocyna* Leight. and *C. maxima* (Asahina) Ahti are other species, which might be similar to *C. macroceras*. However, *C. ecmocyna* is grayer (at least at base) and always contains large amount of atranorin. *C. maxima* forms very tall and slender podetia, without squamules (only sometimes sparse squamules are present).

Ecology. — The species grows on soil, mosses and humus, in light and rather dry places. Frequently appears among mosses. It occurs in communities: *Flavocetraria nivalis–Cladonia rangiferina*, *Cetrariella delisei*, *Racomitrium lanuginosum*, *Saxifraga nivalis*, *Juncus biglumis*, *Dupontia peligera*, *Solorina crocea*, *Phippisia algida*, *Tetraplodon mnioides* (Dubiel and Olech 1990). The species appears also in communities dominated by *Deschampsia alpina*, *Dryas octopetala*, *Carex stans* and *C. subspathacea* (Osyczka 2003).

Distribution. — *Cladonia macroceras* is very widespread in the region of Spitsbergen (Osyczka 2003, 2004b). It was recorded in several localities at Sørkapp Land (Dubiel and Olech 1990; Olech 1990; Osyczka 2003) and found in many places in the regions of Hornsund, Bellsund, Isfjorden, Billefjorden and Kaffiøyra (Osyczka 2003). It was also found in the region of Kongsfjorden and reported by Schade (1966) as *Cladonia uncialis* f. *rubescens* Büttner and Schade (Ahti 1980). According to Ahti (1980), *C. macroceras* is the most common species of the *C. gracilis* group in the Arctic (including Spitsbergen, Jan Mayen, Bjørnøya).

Cladonia macrophyllodes Nyl.
(Fig. 4A)

Flora 58: 447 (1875).

Description. — Primary squamules generally very well developed, reaching large size, up to 14 mm long, usually erect, upper surface grayish-green, lower surface white. Podetia frequently absent. If present, up to 1.5 cm, grayish-green, simple, always with scyphi. Scyphi up to 5 mm wide, usually rapidly flaring, shallow. Surface of podetia areolate to continuously corticate. Hymenial discs brown.

Chemistry. — PD+ red, K+ yellow, C-, KC-; contains fumarprotocetraric acid complex and atranorin.

Remarks. — The species sometimes creates central proliferations and then might be confused with *C. verticillata*, which is generally browner, does not contain atranorin and has small primary squamules. Primary squamules of *C. macrophyllodes* devoid of podetia sometimes might resemble primary squamules of *C. symphycarpia*. However, in the region of Spitsbergen the latter species, beside atranorin contains norstictic acid or sometimes psoromic acid.

Ecology. — *C. macrophyllodes* grows on soil, sometimes on mosses and humus, in light and dry places. The species occurs in communities: *Flavocetraria nivalis–Cladonia rangiferina*, *Umbilicaria cylindrica* (Dubiel and Olech 1990) and also in communities dominated by *Deschampsia alpina* (Osyczka 2003).

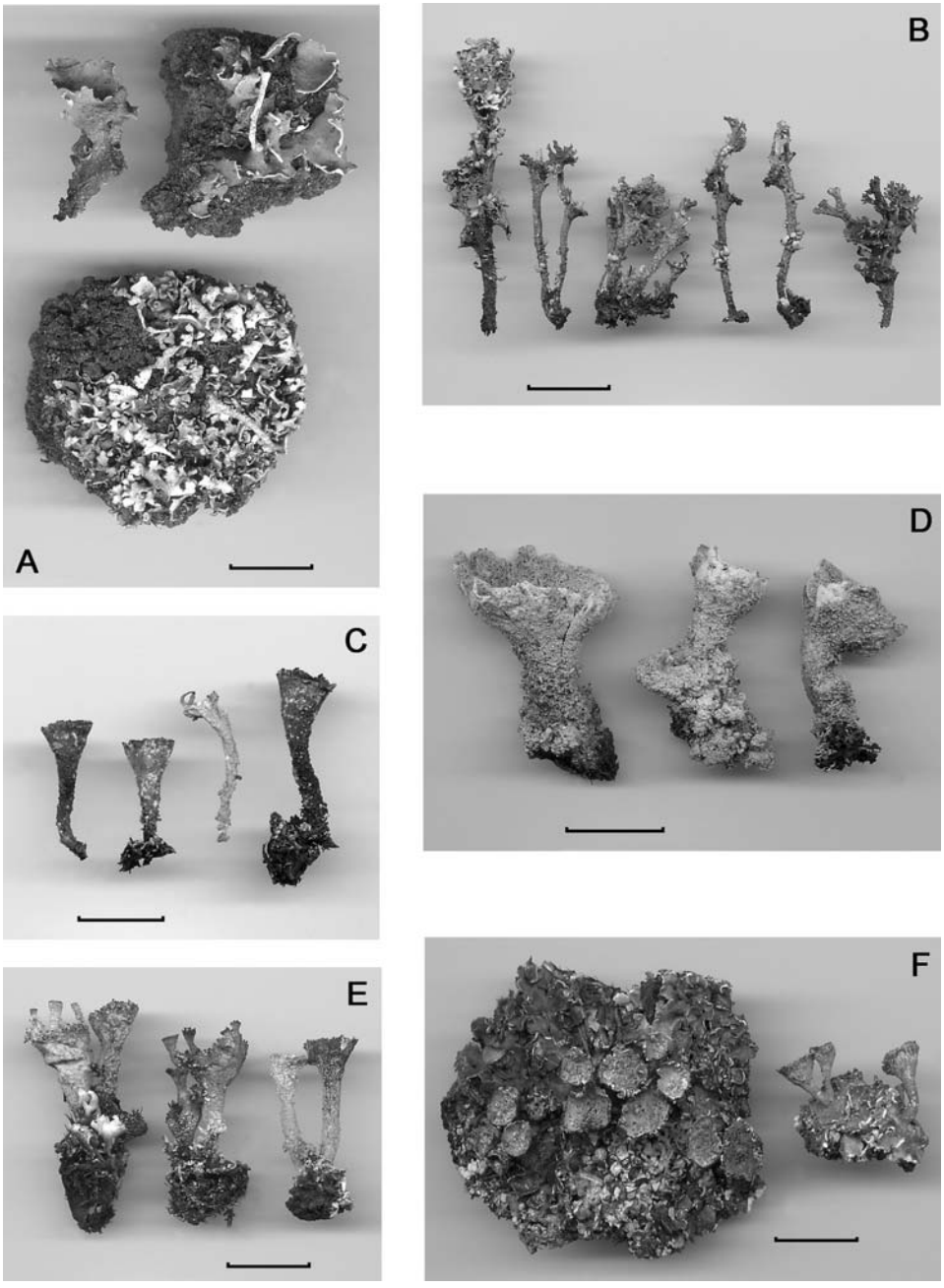

Fig. 4. Representatives of the genus *Cladonia* from Spitsbergen. **A**. *Cladonia macrophyllodes* [*P. Osyczka 320 (KRA)*]. **B**. *Cladonia phyllophora* [*P. Osyczka 328 (KRA)*]. **C**. *Cladonia merochlorophaea* [*P. Osyczka 322 (KRA)*]. **D**. *Cladonia pleurota* [*P. Osyczka 436 (KRA)*]. **E**. *Cladonia pyxidata* [*P. Osyczka 442 (KRA)*]. **F**. *Cladonia pocillum* [*P. Osyczka 331 (KRA)*]. Scale bars 1 cm.

Distribution. — Sørkapp Land (Dubiel and Olech 1990; Olech 1990; Alstrup and Olech 1993; Osyczka 2003), Hornsund (Osyczka 2003), Bellsund (Elvebakk and Hertel 1996; Osyczka 2003). Also occurs on Nordaustlandet (Elvebakk and Hertel 1996). Scattered localities of this species are known from south and south-central part of the west coast of Spitsbergen.

Cladonia merochlorophaea Asahina
(Fig. 4C)

J. Jap. Bot. 16: 713 (1940).

Description. — Primary squamules persistent or evanescent, up to 2(3) mm long. Podetia up to 2.5 cm tall, brownish-green to brownish-gray, simple or sometimes branched by marginally proliferating scyphi, always with scyphi. Scyphi up to 7 mm wide, usually gradually flaring, margins often dentate and ragged. Surface of podetia verruculose-corticate, sometimes partly granulose. Hymenial discs brown.

Chemistry. — PD+ red or PD-, K-, KC+ pinkish; contains merochlorophaeic acid and 4-O-demethylcryptochlorophaeic acid, fumarprotocetraric acid complex inconstant. Presence of merochlorophaeic acid, which is essential feature distinguishing the species, not always implicate the presence of fumarprotocetraric acid (Ferry and Pickering 1989).

Remarks. — Chemical analysis allows to avoid confusion the species with *C. chlorophaea* and *C. pyxidata*.

Ecology. — It grows on soil, mosses and humus, in rather light and dry places. The species occurs in *Tetraplodon mnioides* community (based on material previously published as *C. pyxidata* – Dubiel and Olech 1990). Frequently it is associated with *C. chlorophaea* or *C. pyxidata* (Osyczka 2003, 2005).

Distribution. — Rarely reported taxon but it might appear more frequently. The species is known from Isfjorden-Colesbukta (Elvebakk and Tønsberg 1992), Hornsund (Elvebakk and Tønsberg 1992; Osyczka 2003, 2005), Sørkapp Land (Osyczka 2003, 2005) and Bellsund (Osyczka 2003, 2005).

Cladonia phyllophora Hoffm.
(Fig. 4B)

Deutschl. Fl. 2: 126 (1796).

Cladonia degenerans (Flörke) Spreng.

Description. — Primary squamules persistent or freqently evanescent, up to 4 mm long. Podetia often very variable in form and deformed, mostly up to 3 cm tall, gray-green to olive-brown, blackened at base, simple or sparsely branched, usually with irregular scyphi. Scyphi rather narrow, freqently indistinct, sometimes decorated by small and thick squamules. Surface of podetia continuously corticate or partly areolate. Hymenial discs brown.

Chemistry. — PD+ red, K-, C-, KC-; contains fumarprotocetraric acid complex. In Chilean populations there is known a rare strain also with atranorin (Ahti and Kashiwadani 1984; Stenroos 1995).

Remarks. — The species has podetia extremely variable in form. In the region of Spitsbergen it could resemble *C. gracilis* ssp. *elongata* or *C. verticillata*. However, *C. phyllophora* forms more irregular and deformed podetia and is distinctly blackened at base.

Ecology. — The species grows on soil, rarely on mosses and humus, in light or shadow and rather dry places. Frequently it is associated with *Cladonia pyxidata*, *C. arbuscula* ssp. *mitis*, *Cetrariella delisei* and *Racomitrium lanuginosum* (Osyczka 2003).

Distribution. — At first it was recorded from Magdalenefjorden and Kongsfjorden (Fries 1867; Lynge 1938). Later reported from Isfjorden and Hornsund (Eurola 1968; Kobayashi *et al.* 1990; Osyczka 2003), Bellsund (Elvebakk and Hertel 1996; Osyczka 2003) and Sørkapp Land (Olech 1990).

Cladonia pleurota (Flörke) Schaer.
(Fig. 4D)

Enum. Crit. Lich. Eur. 186 (1850).

Description. — Primary squamules persistent, up to 5 mm long. Podetia usually short, up to 2 cm tall, grayish-green to yellowish-green, generally simple, always with scyphi. Scyphi often broad, up to 1.5 cm wide, rapidly or gradually flaring, with regular or somewhat ragged margins. Surface of podetia granulose sorediate or sometimes farinose sorediate, corticate at base. Hymenial discs red.

Chemistry. — PD-, K-, C-, KC+ yellow, UV-; contains usnic acid and zeorin. Porphyrilic acid may be occasionally present (Stenroos 1993) but was not detected in examined specimens.

Remarks. — The species might be confused especially with *C. deformis*, which also contains usnic acid and zeorin but has powdery soredia, more irregular and narrow scyphi. *C. borealis* has no soredia and contains rather barbatic acid than zeorin. *C. carneola* has waxy or pale brown apothecia and besides zeorin contains usually barbatic acid.

Ecology. — It grows on soil, often on mosses and humus, in light and dry places. The species occurs in *Flavocetraria nivalis–Cladonia rangiferina* community and in *Tetraplodon mnioides* community, which is strongly connected with bird colonies (Dubiel and Olech 1990).

Distribution. — It is quite common but rather dispersed species. Reported from: Sørkapp Land (Dubiel and Olech 1990; Olech 1990; Osyczka 2003), Hornsund (Eurola 1968; Hadač 1989; Osyczka 2003), Bellsund (Lynge 1938; Osyczka 2003), Isfjorden (Lynge 1924; Eurola 1968), Amsterdamøya (Hertel and Ullrich 1976), Magdalenefjorden (Lynge 1938). Also reported form Prins Karls Forland (Summerhayes and Elton 1923).

Cladonia pocillum (Ach.) Grognot
(Fig. 4F)

Pl. Crypt. Saône-et-Loire 82 (1863).

Cladonia pyxidata var. *pocillum* (Ach.) Schaer., *Cladonia pyxidata* ssp. *pocillum* (Ach.) Fink

Description. — Primary squamules persistent, abundant, up to 4(5) mm long, brown to brownish-green, densely packed, often forming quite regular rosettes, usually chalk-white inside rosettes. Podetia usually short, frequently aggregated inside rosettes, up to 2 cm tall, brownish-green to brown, simple, always with scyphi. Scyphi up to 7 mm wide, usually gradually flaring. Surface of podetia granulose to verruculose corticate, sometimes continuously corticate at base, in the upper parts frequently with microsquamules. Hymenial discs brown.

Chemistry. — PD+ red, K- or rarely K+ yellow, C-, KC-; contains fumarprotocetraric acid complex and rarely atranorin. Only in the Northern Hemisphere populations atranorin is occasionally present.

Remarks. — The species is close to *C. pyxidata*. *C. pocillum* can be distinguished by thick, densely packed and characteristically formed primary squamules.

Ecology. — *C. pocillum* grows on soil, frequently on mosses and humus, in exposed and rather dry sites. It is one of the first species from the genus *Cladonia*, which colonizes marine terraces without or with poorly developed vegetation and recent glacier moraines. The species occurs *inter alia* in communities: *Gymnomitrion coralloides*, *Polygonum viviparum* (Dubiel and Olech 1990) and in *Luzula confusa–Salix polaris* community, which is connected with bird colonies (Dubiel and Olech 1992). It can also be found in communities dominated by *Flavocetraria nivalis*, *Deschampsia alpina*, *Dryas octopetala*, *Carex stans* and *C. subspathacea* (Osyczka 2003).

Distribution. — It is one of the most frequent species of *Cladonia*, known from many areas of Svalbard (*e.g.* Lynge 1938; Summerhayes and Elton 1923; Nowak 1965; Eurola 1968; Hertel and Ullrich 1976; Hadač 1989; Elvebakk and Hertel 1996; Osyczka 2003). The species appears in areas elevated from see level to mountain tops.

Cladonia pyxidata (L.) Hoffm.
(Fig. 4E)

Deutschl. Fl. 2: 121 (1796).

Description. — Primary squamules persistent, usually scattered, up to 3(5) mm long. Podetia up to 2 cm tall, brownish-green to brownish-olive, simple or rarely branched by marginal proliferating scyphi, always with scyphi. Scyphi up to 10 mm wide, usually gradually flaring. Surface of podetia granulose to areolate-corticate or with cortical plates, more corticate at base. Hymenial discs brown.

Chemistry. — PD+ red, K-, C-, KC-; contains fumarprotocetraric acid complex.

Remarks. — *C. pyxidata* might be confused with *C. chlorophaea* or *C. merochlorophaea*, especially in the case of old and deformed specimens. In the Northern Hemisphere *C. chlorophaea* contains also only fumarprotocetraric acid complex but is at least partly covered by soredia. *C. merochlorophaea* produces merochlorophaeic and 4-O-methylcryptochlorophaeic acids.

Ecology. — *C. pyxidata* grows on soil, sometimes on mosses and humus, usually in exposed and rather dry sites. The species occurs *inter alia* in communities: *Polygonum viviparum*, *Saxifraga nivalis*, *Saxifraga aizoides*, *Papaver dahlianum* and in *Tetraplodon mnioides* community, which is connected with bird colonies (Dubiel and Olech 1990). It can also be found in communities dominated by *Deschampsia alpina*, *Dryas octopetala* and *Racomitrium lanuginosum* (Osyczka 2003).

Distribution. — It is a common species, reported from Spitsbergen by several authors (*e.g.* Summerhayes and Elton 1923; Lynge 1924, 1938; Paulson 1928; Hadač 1946, 1989; Nowak 1965; Eurola 1968; Hertel and Ullrich 1976; Hartmann 1980; Gugnacka-Fiedor and Noryśkiewicz 1982; Brossard *et al.* 1984; Nimis 1985; Dubiel and Olech 1990; Olech 1990; Elvebakk and Hertel 1996; Osyczka 2003). The species appears in areas elevated from see level to mountain tops.

Cladonia rangiferina (L.) F.H. Wigg.
(Fig. 5A)

Prim. Fl. Holsat. 90 (1780).

Cladina rangiferina (L.) Nyl.

Description. — Primary thallus granular crustose, evanescent. Podetia erect and typically fruticose, up to 6(8) cm tall, 0.5–2 mm thick, ashen-grey, grayish-white to silver-gray, richly branched generally by dichotomy, trichotomy or tetrachotomy, never scyphose, apices divergent or bent toward the same side, axils sometimes open. Surface of podetia ecorticate, smooth, matt, frequently cottony or fibrous. Hymenial discs brown.

Chemistry. — PD+ red, K+ yellow, C-, KC-, UV-; contains fumarprotocetraric acid complex and atranorin. Some small amounts of other unidentified substances might be present in the species (Ruoss and Ahti 1989).

Remarks. — The species is very similar to *C. stygia* in chemical, morphological, ecological and genetic aspects (Ruoss and Ahti 1989; Brodo *et al.* 2001, Stenroos *et al.* 2002).

Ecology. — It grows on soil, frequently on a peaty substratum and among mosses, in light and usually dry places. The species occurs *inter alia* in communities: *Flavocetraria nivalis–Cladonia rangiferina*, *Racomitrium lanuginosum* and *Saxifraga nivalis* (Dubiel and Olech 1990, 1993).

Distribution. — It is frequent but locally dispersed. Reported from: Sørkapp Land (Dubiel and Olech 1990, 1993; Olech 1990; Osyczka 2003), Hornsund (Eurola 1968; Nowak 1965; Osyczka 2003), Bellsund (Elvebakk 1984; Osyczka 2003),

Isfjorden (Eurola 1968; Elvebakk 1982), Kaffiøyra (Osyczka 2003), Kongsfjorden (Lynge 1938; Brossard *et al.* 1984; Nimis 1985), Krossfjorden (Elvebakk 1982), Amsterdamøya (Hertel and Ullrich 1976), Kobbefjorden (Lynge 1938). Also recorded in Prins Karls Forland, Nordaustlandet (Lynge 1938) and Bjørnøya (Summerhayes and Elton 1923). It seems that the species occurs more frequently in southern part of Spitsbergen than in central and northern parts.

Cladonia stricta (Nyl.) Nyl.
(Fig. 5B)

Flora 52: 294 (1869).

Description. — Primary squamules usually evanescent, up to 1.5 mm long. Podetia up to 5(7) cm tall, 1.5–2 mm thick, gray to brownish-gray, blackened at base, simple or somewhat branched, blunt or with narrow scyphi. Scyphi, if present, up to 3 mm wide, often with small teeth or quite large marginal proliferations. If scyphi are well-developed then with perforation at the bottom. Surface of podetia verruculose-corticate or somewhat areolate-corticate, sometimes decorated by sparsely distributed small squamules. Hymenial discs brown.

Chemistry. — PD+ red, K- or K+ yellow, C-, KC-; contains fumarprotocetraric acid complex, atranorin inconstant (but frequent). Majority of the examined specimens contained atranorin. This substance often is present in the species (Ahti 1998).

Remarks. — The species might be confused with a similar Arctic-alpine *C. trassii*, which has a long-living primary thallus and rather shorter podetia with numerous squamules and always contains atranorin. *Cladonia phyllophora* has thicker, stuggy and more corticated podetia and does not contain atranorin.

Ecology. — *C. stricta* grows on soil, frequently among mosses, sometimes on mosses and humus, usually in light and rather dry places. The species often occurs in communities dominated by *Racomitrium lanuginosum* and *Deschampsia alpina*. It is frequently associated with *Cladonia arbuscula* ssp. *mitis*, *Cetrariella delisei*, *Flavocetraria nivalis*, *Sanionia uncinata* (Osyczka 2003).

Distribution. — It has been considered as a common species in the region of Spitsbergen (Elvebakk and Hertel 1996). However, due to the last taxonomic revision of *Cladonia stricta* (Nyl.) Nyl. (Ahti 1998) and its division into three species (*C. stricta* s.str., *C. trassii* Ahti and *C. uliginosa* (Ahti) Ahti), all earlier reports should be treated as *C. stricta* s.lat. Probably large materials from Spitsbergen belong to *C. trassii*. In this part of the Arctic *C. stricta* is considerably rarer than *C. trassii*. Scattered localities of *C. stricta* s.str. were found at Sørkapp Land, Hornsund, Bellsund, Isfjorden (Osyczka 2003).

Cladonia stygia (Fr.) Ruoss
(Fig. 5D)

Bot. Helv. 95: 241 (1985).

Cladina stygia (Fr.) Ahti.

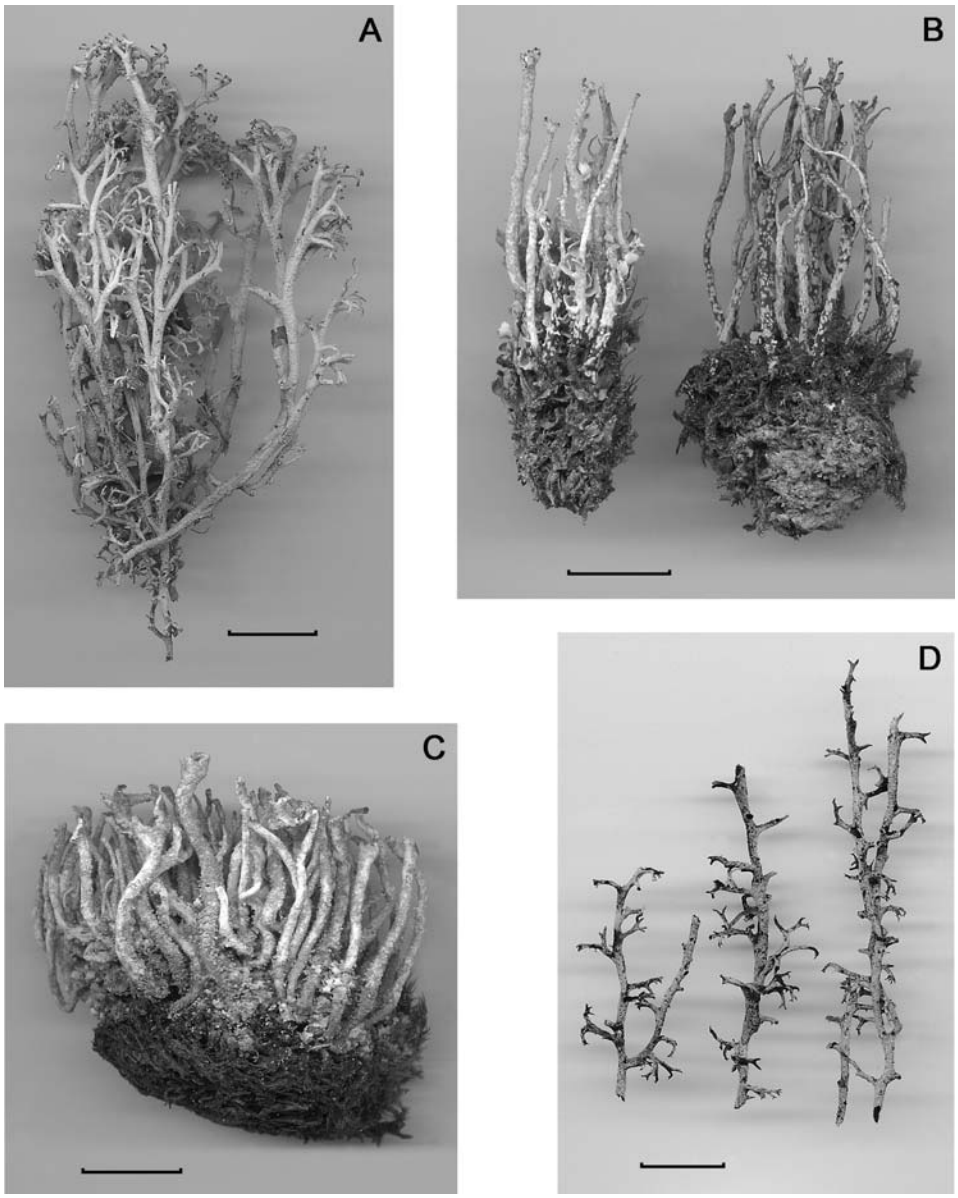

Fig. 5. Representatives of the genus *Cladonia* from Spitsbergen. **A**. *Cladonia rangiferina* [*P. Osyczka 456 (KRA)*]. **B**. *Cladonia stricta* [*P. Osyczka 460 (KRA)*]. **C**. *Cladonia subulata* [*M. Olech (KRA)*]. **D**. *Cladonia stygia* [*P. Osyczka 334 (H; KRA)*]. Scale bars 1 cm.

Description. — Primary thallus granular crustose, evanescent. Podetia erect and typically fruticose, up to 5(8) cm tall, 0.5–2 mm thick, ashen-gray to dark silver-gray, surface and stereome at base dark brown to black. Podetia richly branched generally by dichotomy, trichotomy or tetrachotomy, never scyphose,

apices divergent or bent toward the same side, axils frequently open. Surface of podetia ecorticate, rather smooth, matt, sometimes cottony or fibrous. Pycnidia with pinkish-red jelly. Hymenial discs brown.

Chemistry. — PD+ red, K+ yellow, C-, KC-, UV-; contains fumarprotocetraric acid complex and atranorin. Atranorin might be rarely absent (Ahti and Hyvönen 1985). Some small amounts of other unidentified substances might be present in the species (Ruoss and Ahti 1989).

Remarks. — Dark brown or black colour of stereome and surface of basal part and pinkish-red jelly in the conidiomata separate this species from similar *C. rangiferina*.

Ecology. — Two specimens of *C. stygia* were found on plains of raised marine terraces, in light sites, on a peaty substratum and accompanied by *C. rangiferina* and moss *Racomitrium lanuginosum*. Peatlands and bogs are typical habitats for *C. stygia*.

Distribution. — The species was reported as new to Spitsbergen from Hornsund area (Osyczka 2005). Earlier *C. stygia* was recorded on Bjørnøya (Ahti and Hyvönen 1985).

Cladonia subulata (L.) Weber ex F.H. Wigg.
(Fig. 5C)

Prim. Fl. Holsat. 90 (1780).

Description. — Primary squamules persistent or sometimes evanescent, up to 3(4) mm long. Podetia up to 4(5) cm tall, usually elongated, greenish-gray to brownish-gray, subulate at tips or with scyphi, simple or sometimes branched by marginal proliferating scyphi. Scyphi, if present, narrow, gradually flaring. Surface of podetia farinose to granulose sorediate. Hymenial discs brown.

Chemistry. — PD+ red, K-, C-, KC-; contains fumarprotocetraric acid complex.

Remarks. — Occasionally podetia of *C. subulata* are not elongated and have relatively wide scyphi and then might be somewhat similar to *C. fimbriata*. However, *C. fimbriata* has a dainty shape, more farinose soredia, green tint, and rapidly flaring, regular scyphi. *Cladonia cornuta* could be similar to *C. subulata*, but always is covered by cortex at base. *Cladonia cornuta* was reported from the region of Spitsbergen (Lynge 1938; Eurola 1968), but these reports need confirmation.

Ecology. — *C. subulata* grows on soil or humus, in light and rather dry places. The species was associated with *C. macroceras*, *C. chlorophaea* and *Sanionia uncinata*.

Distribution. — It was reported from northern part of Spitsbergen region by Lynge (1938) as a rather common lichen – Magdalenefjorden, Raudfjorden, Holmiabukta, Danskøya, Kongsfjorden. Later recorded in the areas of Liefdefjorden (Elvebakk and Hertel 1996), Bellsund-Reindalen (Elvebakk and Hertel 1996) and Reindalspasset (Elvebakk and Hertel 1996), Hornsund (Nowak 1965;

Osyczka 2003) and Sørkapp Land (Olech 1990; Osyczka 2003). Also found on Edgeøya (Aptroot and Alstrup 1991). It is probably rather common species.

Cladonia symphycarpia (Flörke) Fr.
(Fig. 6A)

Sched. Crit. Lich. Suec. 8–9: 20 (1826).

Cladonia symphycarpa (Ach.) Fr.

Description. — Primary squamules always persistent, generally well developed and large, 3–10 × 2–6 mm, lower surface white or brownish-white, upper surface grayish or grayish-brown. Podetia not seen here. Generally rarely produced, short in proportion to primary squamules, stocky, without scyphi, unbranched or somewhat club-shaped at the upper part, usually grooved and with crevices. Surface of podetia areolate-corticate. Hymenial discs brown.

Chemistry. — PD+ yellow, K+ orange, C-, KC-; all examined specimens belong to the most common chemotype with norstictic acid and atranorin. However, there are known another chemotypes of the species (*e.g.* Huovinen *et al*. 1989b; Stenroos and Ahti 1990; Stenroos and Ahti 1992; Brodo *et al.* 2001). The psoromic strain was sometimes called *C. dahliana* Kristinsson (but currently treated as chemotype of *C. symphycarpia*) and was recognized in the region of Van Keulenfjorden (Elvebakk and Hertel 1996).

Remarks. — Climate factors of Spitsbergen region (*e.g.* snow cover) often cause that primary squamules are poorly developed or pressed into the soil. Then *C. symphycarpia* could be overlooked or mistakenly determined. *C. cariosa* has much smaller primary squamules and contains only atranorin. An Arctic-alpine species *C. subcervicornis* (Vainio) Kernst. has a dull greyish-brown lower surface of primary squamules. Upper surface of primary squamules of *C. macrophyllodes* is greener and the species contains fumarprotocetraric acid and atranorin.

Ecology. — It grows on soil, in open, light and dry areas. The species often grows in the mesophile type of tundra.

Distribution. — Up to now the species was reported from Sørkapp Land (Olech 1990; Osyczka 2003, 2005) and mistakenly determined as *C. subcervicornis*, it was found by Lynge (1938) in the regions of Van Keulenfjorden, Amsterdamøya and Nordaustlandet (Elvebakk and Hertel 1996). Additional several localities of *C. symphycarpia* were found in the region of Bellsund (Osyczka 2003, 2005).

Cladonia trassii Ahti
(Fig. 6B)

Folia Cryptog. Estonica, Fasc. 32: 7 (1998).

Description. — Primary squamules usually persistent, often fairly large and well-developed, up to 5 mm long. Podetia up to 5(6) cm tall, 1–3 mm thick, greenish-gray to brownish-olive, often strongly browned in part, frequently melanotic at

base, unbranched or somewhat branched usually by dichotomy, pointed or with irregular scyphi. Scyphi up to 3 mm wide, if well-developed, when centrally proliferating. Surface of podetia areolate-corticate, often largely decorticate, usually with numerous squamules. Hymenial discs brown.

Chemistry. — PD+ red, K+ yellow, C-, KC-; contains fumarprotocetraric acid complex and atranorin.

Remarks. — In contrary to *C. trassii*, similar *C. stricta* has usually evanescent and smaller primary squamules, sparse podetial squamules and does not obligatorily contain atranorin. *C. uliginosa* (earlier treated as a variety of *C. stricta*) is very close to *C. trassii*, but forms common and well-developed scyphi. *C. uliginosa* was found in the region of Svalbard (Øvstedal pers. comm.).

Ecology. — *C. trassi* grows on soil, frequently among mosses, often on humus and mosses, usually in light, dry or moist places. The species often occurs in communities dominated by *Deschampsia alpina*, *Racomitrium lanuginosum* and *Festuca vivipara* (Osyczka 2005). Similarly like *C. stricta* it is often associated with *C. arbuscula* ssp. *mitis*, *Cetrariella delisei*, *Flavocetraria nivalis*, *Sanionia uncinata* (Osyczka 2003).

Distribution. — *Cladonia trassii* was relatively recently described at the species level (Ahti 1998). From Spitsbergen it was reported from Sørkapp Land, Hornsund, Bellsund, Isfjorden (Grønfjorden), Kaffiøyra (Osyczka 2003, 2005). Surely, it is quite widespread species in the whole region of Svalbard. *C. trassii* in this part of the Arctic appears more frequently than *C. stricta* (Osyczka 2005).

Cladonia uncialis (L.) Weber ex F.H. Wigg.
(Fig. 6C)

Prim. Fl. Holsat. 90 (1780).

Description. — Primary squamules not seen. Secondary thallus consists of branched, thin-walled podetia, which form characteristic distinct camps, tufts or dense bushes. Podetia up to 5 cm tall, 1–4 mm thick, pale yellow to greenish-yellow, with open axils, pointed and thorn-like, never scyphose, tips of brunches divergent. Surface of podetia smooth, matt, areolate-corticate. Hymenial discs brown.

Chemistry. — PD-, K-, C-, KC-, UV+ or UV-; contains usnic acid and squamatic acid (inconstant). Majority of examined specimens contain squamatic acid.

Remarks. — *Cladonia uncialis* together with *C. amaurocraea* belongs to the section *Unciales*. These species might resemble each other, often settle the same habitats and frequently grow jointly.

Ecology. — It grows on soil, frequently among mosses, in light and usually dry places. The species often occurs in communities dominated by *Cetrariella delisei* and *Racomitrium lanuginosum*. It is often associated with *C. amaurocraea*, *C. arbuscula* ssp. *mitis*, *Flavocetraria nivalis* (Osyczka 2003).

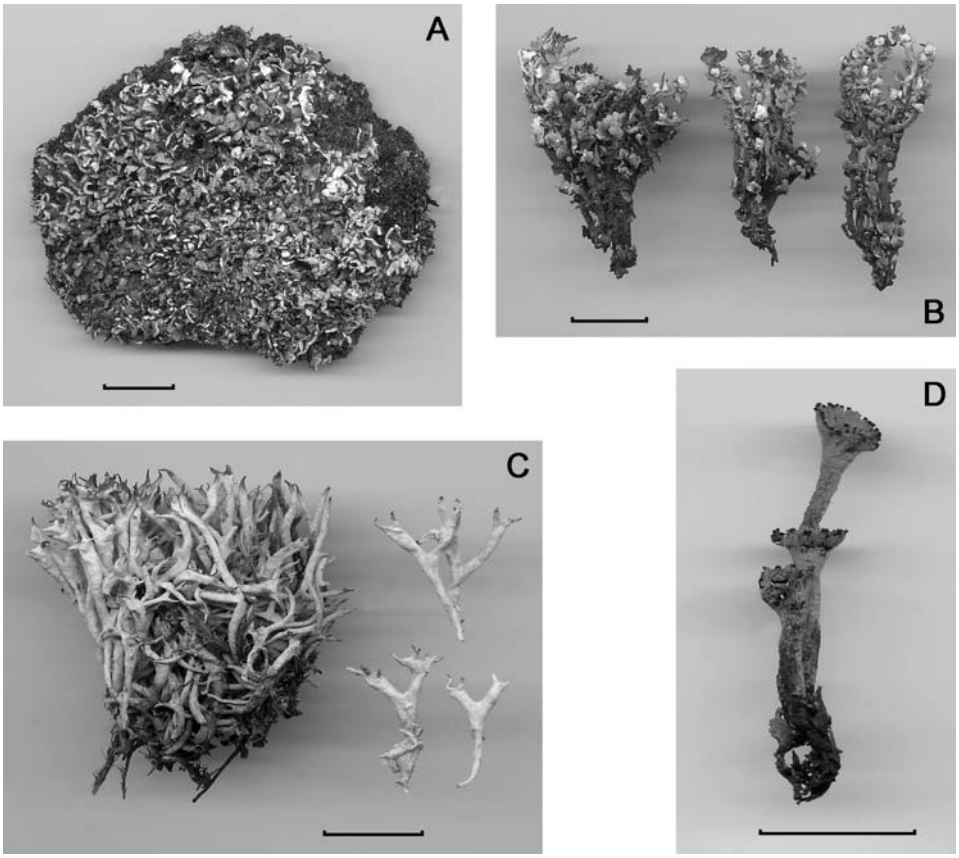

Fig. 6. Representatives of the genus *Cladonia* from Spitsbergen. **A**. *Cladonia symphycarpia* [*F. Święs 2548 (KRA)*]. **B**. *Cladonia trassii* [*P. Osyczka 282 (BG; H; KRA)*]. **C**. *Cladonia uncialis* [*P. Osyczka 464 (KRA)*]. **D**. *Cladonia verticillata* [*P. Osyczka 311 (KRA)*]. Scale bars 1 cm.

Distribution. — *Cladonia uncialis* is a widespread species and was reported by several authors (*e.g.* Lynge 1924, 1938; Paulson 1928; Hadač 1946; Hertel and Ullrich 1976; Hartmann 1980; Elvebakk 1985; Brossard *et al.* 1984; Kobayashi *et al.* 1990, Osyczka 2003). However it occurs more rarely than *C. amaurocraea*.

Cladonia verticillata (Hoffm.) Schaer.
(Fig. 6D)

Lich. Helv. Spic. 1(1): 31 (1823).

Cladonia cervicornis ssp. *verticillata* (Hoffm.) Ahti.

Description. — Primary squamules persistent, up to 4 mm long. Podetia up to 2 cm tall, greenish-brown to olive-brown, simple or often branched by racily centrally proliferating scyphi, always with scyphi. Scyphi up to 7 mm wide, regular, rapidly flaring, shallow, with dentate margins, usually with slightly convex bot-

tom. Surface of podetia continuously corticate, somewhat areolate, sometimes decorated by microsquamules. Hymenial discs brown.

Chemistry. — PD+ red, K-, C-, KC-; contains fumarprotocetraric acid complex.

Remarks. — Van Herk and Aptroot (2003) proposed to treat the three taxa of the *C. cervicornis* group at the species level: *C. cervicornis* s.str., *C. verticillata* and *C. pulvinata*. The last species can be easily determined thanks to the presence of psoromic acid instead of fumarprotocetraric acid. Both *C. cervicornis* and *C. verticillata* contain fumarprotocetraric acid, but these taxa can be distinguished mainly due to different characters of the basal squamules: their colour, shape, size and orientation (van Herk and Aptroot 2003). Primary squamules of *C. verticillata* are smaller, more sparse, less persistent and not curled in comparison to primary squamules of *C. cervicornis*. In the past *C. cervicornis* from Svalbard was reported from Nordaustlandet-Brennevinsfjorden (Lynge 1938) and Prins Karls Forland Island (Paulson 1923; Summerhayes and Elton 1923). However, it has rather Mediterranean and sub-Atlantic type of distribution (Nimis 1993; van Herk and Aptroot 2003).

Ecology. — The species was found on the slightly acid soil in dry place at the bottom of mountain massif. It was associated with other *Cladonia* representatives (such as: *C. macroceras*, *C. pocillum*, *C. pyxidata*) and bryophyte *Gymnomitrion corallioides*.

Distribution. — It seems to be very rare. Only one locality of the species was reported from Hornsund (Osyczka 2005).

Conclusions

Altogether 27 species of *Cladonia* were recognized in the examined materials from Spitsbergen. In Cladoniaceae, only representatives of the genus *Cladonia* were found in the explored region, of which three belong to the subgenus *Cladina*. Majority of recorded species are bipolar or have cosmopolitan distribution in the world. In the Northern Hemisphere they are known especially from the Arctic and boreal zone. Some of the taxa are common in the Antarctic and sub-Antarctic region (compare: Stenroos 1993, Osyczka and Olech 2005). Any endemic species in the Spitsbergen region has been found. Only four taxa (*C. amaurocraea, C. macroceras, C. stricta, C. uncialis*) are restricted to the Northern Hemisphere.

Basing on the results of this study species may be classified into three simple categories of frequency: very rare on Spitsbergen (one or two localities), rare (3–15 localities) and common or locally scattered (more than 15 localities). These categories follow those proposed by Elvebakk and Hertel (1996). Several of the investigated taxa were found in numerous localities and certainly are common and widespread. These are: *C. amaurocraea*, *C. bellidiflora*, *C. borealis*, *C. chlorophaea*, *C. gracilis*

Fig. 7. The raised marine terrace near Kvartsittodden (Hornsund) covered by the tundra dominated by *Racomitrium lanuginosum* and *Flavocetraria nivalis*. Following most common species of *Cladonia* may be found on such locality: *C. amaurocraea*, *C. arbuscula* ssp. *mitis*, *C. borealis*, *C. macroceras*, *C. pocillum*, *C. pyxidata*, *C. rangiferina*, *C. trassii, C. uncialis*.

ssp. *elongata*, *C. macroceras*, *C. arbuscula* ssp. *mitis*, *C. pocillum*, *C. pyxidata*, *C. rangiferina*, *C. trassii* and *C. uncialis*. However, localities of these lichens may be locally scattered. Rare species are: *C. cariosa*, *C. carneola*, *C. crispata* var. *cetrariiformis*, *C. deformis*, *C. macrophyllodes*, *C. merochlorophaea*, *C. phyllophora*, *C. pleurota*, *C. stricta*, *C. subulata* and *C. symphycarpia*. It is interesting that localities of rarer species are often grouped in relatively small area. Four following taxa: *C. coccifera*, *C. fimbriata*, *C. stygia* and *C. verticillata* were found only in one or two localities and it is possible that they are very rare on Spitsberegen.

Most localities of *Cladonia* are situated on plains of raised marine terraces (Fig. 7), in valleys of pronival and proglacial streams, and at the bottoms of mountain massifs (Fig. 8). Nearly 75% of recorded localities are elevated below 150 m a.s.l. In many places of such regions development of Arctic tundra is conspicuous and in the effect Arctic soil development is possible. It is a very important factor because the genus *Cladonia* in the region of Spitsbergen is typically terricolous or occurs on mosses or humus. It is worth of notice that the majority of ice-free surface of Spitsbergen is covered by rocky formations (Hisdal 1998), which are occupied as a rule by epilitic lichen communities (Dubiel and Olech 1991).

Representatives of *Cladonia* are connected with acid or slightly acid substratum. They prefer rather light places which are sheltered from wind. Frequently they occur

Fig. 8. Tufts of *Cladonia amaurocraea* (right bottom) and *Cladonia arbuscula* ssp. *mitis* (left top) between mosses at the bottom of Gulliksenfjellet massif (Hornsund).

between rocks, boulders, in local depressions, on rocky ledges or in rock crevices. They inhabit mostly places with south-west, west or north-west expositions, where during summer season the sunlight accelerates snow thawing. Some species can be found on strongly peaty substratum (for example: *C. rangiferina*, *C. stygia*). Specimens of the genus *Cladonia* can be met mostly within communities dominated by *Flavocetraria nivalis*, *Cetrariella delisei*, *Racomitrium lanuginosum*, *Saxifraga nivalis* and *Cladonia arbuscula* ssp. *mitis* or *Cladonia rangiferina*. Some of taxa, for example: *C. pocillum*, *C. pyxidata*, representatives of the *C. coccifera* group, frequently occur in nitrophilous communities connected with bird nests.

Only some specimens of *Cladonia* from Spitsbergen were observed with apothecia. The majority of the genus representatives appear in sterile form. Intensely sorediate forms (refer to species with soredia) also are not frequent. In this region *Cladonia* often spread by producing small propagules, such as squamules, microsquamules or granules which are easily detached and carried by wind. Even in the case when specimens are almost totally corticate, they are cracked and fragile.

It is still difficult to determine the complete number of *Cladonia* species and their precise distribution and frequency in the region of Spitsbergen and whole Svalbard archipelago. Many local factors (like: lack of suitable substrate, snow cover, strong wind, heavy grazing, competition, etc.) may affect the presence or absence of many *Cladonia* species. Furthermore, our knowledge is reduced by the lack of sufficient lichen material from many less accessible Arctic regions.

Acknowledgments. — I would like to express my gratitude to all persons from the Institute of Geophysics of Polish Academy of Sciences, Institute of Oceanology of Polish Academy of Science and Institute of Geology and Mineral Deposits of University of Mining and Metallurgy who have helped me in organization of my Spitsbergen expediton. Thanks are due to Prof. Florian Święs for delivery of his reach lichen collection from Bellsund area to our herbarium. I thank also Prof. Maria Olech and Prof. Wanda Gugnacka-Fiedor for access to their lichen collection. I wish to thank Prof. Teuvo Ahti for checking my determinations of some *Cladonia* specimens. I appreciate the Governor of Svalbard for permission for my field research in the region of Spitsbergen. Part of this research was supported by the State Committee for Scientific Research (KBN), grant No 3 P04F 059 22.

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Received 2 January 2006
Accepted 28 June 2006