



The lichen genus *Cladonia* of King George Island, South Shetland Islands, Antarctica

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Abstract: The paper presents the results of taxonomical investigation of the genus *Cladonia* Hill ex P. Browne from King George Island. Individuals belonging to this lichen genus were studied using methods of classical herbarium taxonomy supported by chemical analysis. Fourteen species have been recognized in the study area, with *C. asahinae* J.W. Thomson being reported from King George Island for the first time, and *C. cervicornis* subsp. *mawsonii* reported as new for the South Shetland Islands. The occurrence of *C. cariosa* is confirmed for the Antarctic region. The diagnostic characters, ecology and important remarks referring to particular species are briefly presented. An updated key for identification of the species from King George Island and neighbouring islands of South Shetlands is included.

Key words: Antarctica, King George Island, lichens, *Cladonia*, taxonomy, distribution.

Introduction

Lichens (lichenized fungi) constitute a dominant form of life on ice free areas of Antarctica. For their pioneer nature lichens play a fundamental role in terrestrial ecosystems of this part of the world. Representatives of the genus *Cladonia* Hill ex P. Browne are fruticose lichens, which as a rule consist of two kinds of thallus: horizontal primary thallus (squamulose or crustose, sometimes disappearing) and vertical secondary thallus (podetia). Strong morphological modifications caused by severe climatic conditions of polar regions as well as morphological similarity of many taxa causes difficulties in their identification and taxonomy.

The number of *Cladonia* species occurring in Antarctica remains unclear. The most significant step towards better understanding of the Antarctic *Cladonia* was carried out by Stenroos (1993). The author published an important taxonomic study and revision of the lichen family Cladoniaceae in the whole Antarctic and peri-Ant-

arctic regions. She recognized 38 species of *Cladonia* (including *Cladina* – treated in the study as a separate genus). Øvstedal and Smith (2001) recognized 27 taxa representing the genus *Cladonia* in the whole Antarctic region. Olech (2001) considered also 27 species as possibly occurring in this part of Southern Hemisphere.

King George Island (62° 23' S and 58° 67' W) is the largest of the South Shetland Islands. It is situated some 120 kilometers from the Antarctic Continent and belongs to the, so-called, maritime Antarctic. Information on *Cladonia* species from this island is very limited, although several species constitute important components of the Antarctic tundra. Redón (1985) recorded six species of *Cladonia* from the South Shetland Islands but did not indicate the localities. Andreev (1988) reported five species of *Cladonia* from Fildes Peninsula, Olech (1989a, 1994) found four species in the Admiralty Bay region and five species in King George Bay region. However, many species required a revision from the viewpoint of modern lichenology. Stenroos (1993) reported eleven species of *Cladonia* from King George Island. Chen and Ahti (1999) recognized eight taxa from Fildes Peninsula (south western part of the island).

The main purpose of this study is to review critically and revise herbarium material belonging to the genus *Cladonia* from King George Island, gathered during Polish Antarctic expeditions.

Material and methods

The results presented here are based both on studies of herbarium material and experience from field work carried out during the XI (1987/88), XIII (1989/90), XVI (1991–93), XX (1995/96) and XXVI (2001/02) Polish Antarctic Expeditions to the *Arctowski* Station. Material was collected on King George Island mainly in the regions of Admiralty Bay and King George Bay. The taxa were identified using methods of classical herbarium taxonomy, supported by chemical analyses. Identification of lichen substances was performed using thin-layer chromatography (TLC) according to standardized methods (Culberson 1972; White and James 1985). The key to the taxa was prepared basing on the original material and literature data (Stenroos 1993). All species hitherto reported and confirmed from the South Shetlands are included. Species descriptions are based on the specimens we examined. The material has been deposited in the lichen herbarium of the Institute of Botany of the Jagiellonian University (KRA).

Results

Key to the taxa of the genus *Cladonia* (subgenus *Cladonia*)

1. Primary squamules conspicuous and permanent, wide and elongate, often forming dense mats. Podetia frequently absent. If present, simple, some-

- times frayed at the apical parts, ending in brown, clavate apothecia. Atranorin only or with porphyrilic acid 2
- Primary squamules rather small, sometimes evanescent, usually not forming mats. Podetia variable, often branched, subulate or with scyphi, frequently without apothecia. Generally usnic acid or fumarprotocetraric acid 3
- 2(1).** Atranorin only *C. cariosa*
- Atranorin and porphyrilic acid *C. galindezii*
- 3(1).** Apothecia red, rarely pale brown. Podetia yellowish-green or whitish-green, at the base often becoming yellow, usually with scyphi. Usnic acid generally present 4
- Apothecia brown. Podetia greyish-green, brownish-green or brown, not yellow at the base, subulate or with scyphi, sometimes richly branched. Usnic acid absent, fumarprotocetraric acid generally present 9
- 4(3).** Podetia without soredia, covered by cortical, often rounded plates, always with well-developed scyphi *C. borealis*
- Podetia covered by farinose or granulose soredia, subulate or with scyphi 5
- 5(4).** Podetia without scyphi or with poorly developed scyphi. Barbatic acid or squamatic acid 6
- Podetia with well-developed scyphi. Usnic acid and zeorin 7
- 6(5).** Podetia clavate or subulate, with greyish tint. Barbatic acid *C. weymouthii*
- Podetia blunt or with deformed scyphi, with yellowish-green tint, sometimes cracked. Squamatic acid *C. sulphurina*
- 7(5).** Podetia sorediate down to the base, scyphal margins dentate, hymenia pale brown. Zeorin and usually barbatic acid *C. carneola*
- Podetia farinose to granulose sorediate, sometimes corticate at the base, scyphal margins regular or irregular, hymenia red. Zeorin without barbatic acid 8
- 8(7).** Primary squamules small, often disappearing. Podetia farinose sorediate, stalks elongated, scyphi rather narrow *C. deformis*
- Primary squamules small or rather large. Podetia farinose to granulose sorediate, stalks not elongated, scyphi often wide *C. pleurota*
- 9(3).** Podetia with well-developed and usually wide scyphi, characteristically goblet-shaped 10
- Podetia blunt, subulate or with usually narrow (or deformed) scyphi 16
- 10(9).** Podetial surface farinose to granulose sorediate 11

- Podetial surface verruculose, granulose, areolate or corticate 13
- 11(10).** Podetia farinose sorediate down to the base, single, with regular and usually rapidly expanded scyphi. Fumaroprotocetraic acid only
 *C. fimbriata*
- Podetia granulose sorediate, sometimes branched from scyphal margins, with regular or irregular and usually gradually expanded scyphi 12
- 12(11).** Fatty acids present and fumarprotocetraric acid *C. asahinae*
- Fatty acid absent, fumarprotocetraric acid often with atranorin
 *C. chlorophaea*
- 13(10).** Podetial surface throughout corticate or roughly areolate, scyphal margins dentate, generally proliferating from central part of scyphi
 *C. cervicornis ssp. mawsonii*
- Podetial surface verruculose, granulose or with corticate plates, scyphi regular or irregular, generally proliferating from marginal part of scyphi
 14
- 14 (13).** Podetial surface verruculose, partly granulose. Fumarprotocetraric acid (rarely absent), homosekikaic and sekikaic acid . . . *C. novochlorophaea*
- Podetial surface with corticate plates or granulose. Fumarprotocetraric acid only 15
- 15 (14).** Primary squamules rather sparse, thin, not creating dense crusts. Podetia generally with corticate plates *C. pyxidata*
- Primary squamules numerous, thick, often creating dense crusts and rosettes. Podetial surface generally granulose *C. pocillum*
- 16 (9).** Podetial surface farinose to granulose sorediate 17
- Podetial surface granulose, areolate or corticate, often with numerous squamules up to the tips 18
- 17 (16).** Podetia generally subulate, rarely with narrow scyphi, apical parts sorediate, corticate at the base *C. cornuta*
- Podetia subulate or with scyphi, sorediate down to the base . . . *C. subulata*
- 18 (16).** Podetia without or with a few squamules, corticate throughout, sometimes areolate, generally brown-green *C. gracilis*
- Podetia with numerous and distinct squamules, corticate only at the base, generally grey-green 19
- 19 (18).** Podetia with rather densely arranged microsquamules, squamules and lobules, usually not turning black at the base. Thamnic or squamatic acid *C. squamosa*
- Podetia with not densely arranged squamules, often turning black at the base. Fumarprotocetraric acid *C. sarmentosa*

Descriptions of the taxa

Cladonia asahinae J.W. Thomson
(Fig. 1A)

J. Jap. Bot. 51: 361 (1977).

Description. — Primary squamules persistent, up to 3 mm long, brownish-green. Podetia up to 20–25 mm tall, greyish-green to yellowish-green, simple, always with scyphi (up to 5 mm wide). Surface of podetia covered in the upper part by granular soredia or corticate granules, in the lower part usually with microsquamules. Apothecia brown (not seen here), produced on the margins of podetial scyphi.

Chemistry. — PD+ red, K–, KC–, C–; contains fumarprotocetraric acid and fatty acids.

Remarks. — The species may be confused with *C. fimbriata*, which is covered throughout by powdery soredia and never contains fatty acids. *Cladonia chlorophaea* (Flörke ex Sommerf.) Spreng. also does not contain fatty acids.

Ecology. — The species grows on soil, gravelly ground and mosses, often near bird nests, usually in open habitats. It is associated with *Cladonia chlorophaea*, *Physconia muscigena* (Ach.) Poelt, *Xanthoria candelaria* (L.) Th. Fr., *Rinodina olivaceobrunnea* C.W. Dodge et G.E. Baker, *Sanionia uncinata* (Hedw.) Loeske.

Specimens examined. — Admiralty Bay region: Demay, SE, alt. 50 m, 12 December 1987, AO1521 (KRA); Rescuers Hills, NE, alt. 100 m, 8 December 1987, AO1522 (KRA); Stenhouse Bluff, S, alt. 50 m, 22 November 1987, AO1523 (KRA); Point Hennequin, SW, alt. 30 m, 21 January 1990, AO1524 (KRA); Mount Wawel, SW, alt. 80 m, 31 January 2002, AO1942 (KRA).

Cladonia borealis S. Stenroos
(Fig. 1B)

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

Description. — Primary squamules persistent, up to 10 mm long, yellowish-green, usually with dark yellow or orange tint at the base. Podetia up to 2.5 cm tall, yellowish-green, simple, always with scyphi. Scyphi up to 15 mm wide, usually gradually expanded. Podetial surface devoid of soredia, in the upper parts covered by rounded cortical plates (also inside cups), areolate to continuously corticate at the base. Basal part of podetia frequently becoming plainly yellow or orange. Apothecia red, rare, sedentary on the margins of podetial scyphi.

Chemistry. — PD–, K–, KC+ yellow, C–; contains usnic acid, barbatic acid and 4-O-demethylbarbatic acid (accessory).

Remarks. — Morphologically, *C. borealis* closely resembles *C. coccifera* (L.) Willd but differs in the chemical aspect (Stenroos 1989). According to Stenroos (1993) *C. coccifera* does not occur in the Antarctic and peri-Antarctic regions.

Ecology. — *Cladonia borealis* grows on soil, mosses or humus, gravelly and stony ground, frequently found on rock ledges, distributed in open or sheltered habitats. It is usually accompanied by *Polytrichastrum alpinum* (Hedw.) G.L. Sm., *Barbilophozia hatcheri* (A. Evans) Loeske, *Sphaerophorus globosus* (Huds.) Vain., *Cetraria aculeata* (Schreb.) Fr., *Ochrolechia frigida* (Sw.) Lynge, *Andreaea* spp., *Deschampsia antarctica* Desv., *Psoroma hypnorum* (Vahl) Gray.

Selected specimens examined. — Admiralty Bay region: Demay Point, alt. 30 m, 18 January 1987, AO 1525 (KRA); moraines at the northern edge of Ecology Glacier, alt. 50 m, 7 January 2002, AO1940 (KRA); Ubocz, S, alt. 180 m, 15 January 1990, AO1537 (KRA); Jersak Hills, alt. 185 m, 27 November 1987, AO1541 (KRA); Crepin Point, alt. 10 m, 25 January 1988, AO1549 (KRA); Yellow Point, W, alt. 30 m, 19 December 1987, AO1552 (KRA); Ullman Spur, NW, alt. 50 m, 19 December 1987, AO1559 (KRA); Mount Wawel, NE, alt. 100 m, 6 February 1987, AO1565 (KRA). King George Bay region: Eagle Bluff, alt. 100 m, 1 January 1990, AO1943 (KRA).

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

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

Description. — Primary squamules persistent and permanent (1–5 × 1–3 mm), greyish-brown, protruding from the ground, tongue-shaped, sometimes lobed. Podetia sometimes absent. If present, up to 1.5 cm tall, greyish-brown or grey-green, usually simple but fissured especially in their upper parts, sometimes branched once or twice, never producing scyphi. Surface of podetia not sorediate, covered by cortex divided into areoles or, less often, continuous cortex. Prominent, brown apothecia always present, situated on the tips of podetia and giving them club-shaped appearance.

Chemistry. — PD–, K+ yellow; contains atranorin.

Remarks. — The species is very similar to the Antarctic endemic taxon *C. galindezii*, which has larger primary squamules forming more dense and hard mats. Moreover, *C. galindezii* contains porphyritic acid, which is not present in *C. cariosa*.

Ecology. — *Cladonia cariosa* grows on soil, gravelly ground and humus, rather in open and sun exposed habitats, frequently appears on glacier moraines. It is usually associated with *Massalongia intricata* Øvstedal.

Selected specimens examined. — Admiralty Bay region: Sphinx Hill, N, alt. 140 m, 8 December 1987, AO1581 (KRA); moraines at the northern edge of Ecology Glacier, alt. 20 m, 8 February 2002, AO1582 (KRA); moraines at the northern edge of Ecology Glacier, alt. 30 m, 25 January 1996, AO1583; Cytadela, N, alt. 50 m, 13 March 1987, AO1590 (KRA); Mount Wawel, NW, alt. 100 m, 6 February 1987, AO1597 (KRA).

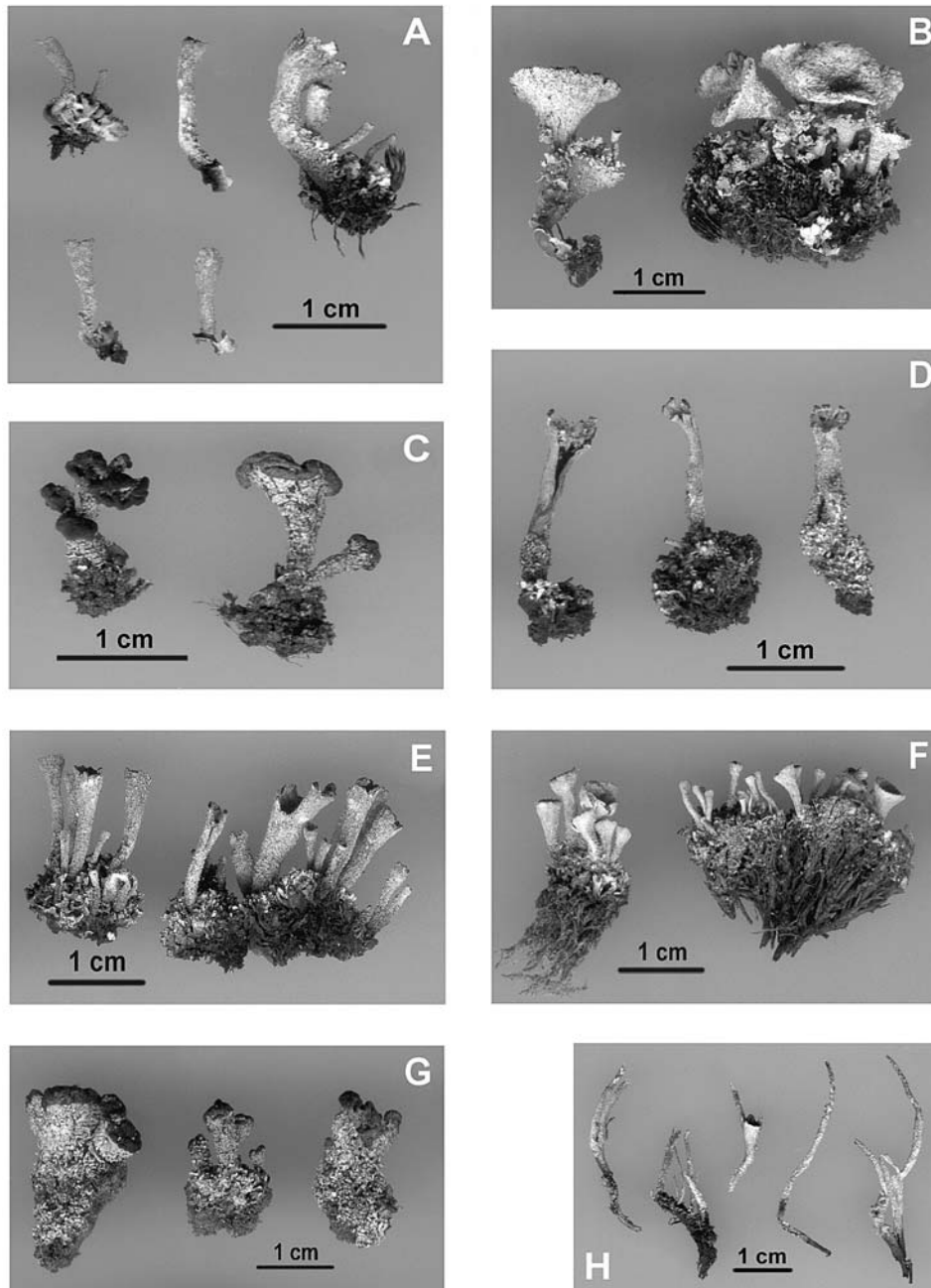


Fig. 1. Specimens of the genus *Cladonia* from King George Island. **A.** *C. asahinae* (AO 1942). **B.** *C. borealis* (AO1940). **C.** *C. cariosa* (AO1583). **D.** *C. cervicornis* subsp. *mawsonii* (AO1603). **E.** *C. chlorophaea* (AO1606). **F.** *C. fimbriata* (AO1630). **G.** *C. galindezii* (AO1637). **H.** *C. gracilis* (AO1856).

Cladonia cervicornis (Ach.) Flot.
subsp. *mawsonii* (C.W. Dodge) S. Stenroos *et* Ahti
(Fig. 1D)

Ann. Bot. Fenn. 27: 320 (1991).

Cladonia mawsonii C.W. Dodge, Brit. Austral. New Zealand Antarct. Res. Exped. 1929–1931 Rep., Ser. B, 7: 128 (1948).

Description. — Primary squamules persistent, up to 3 mm long, brownish-green. Podetia up to 2–3 cm tall, brown or greyish-brown, sometimes melanotic at the base, simple or branched by centrally proliferating scyphi. Scyphi up to 5 mm wide, scyphal margins dentate or with small, digitate proliferations. Surface of podetia without soredia, nearly throughout corticate or with cortex divided into areoles, sometimes decorated by microsquamules and squamules. Apothecia brown, produced on the margins of scyphi or on proliferations.

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

Remarks. — This taxon strongly resembles the northern *C. verticillata* (Hoffm.) Schaer. (*C. cervicornis* subsp. *verticillata* (Hoffm.) Ahti). *C. cervicornis* subsp. *mawsonii* has elongated and slender podetia, insignificant and irregular scyphi and infrequent proliferations.

Ecology. — It was found on soil in an inland locality.

Specimen examined. — Admiralty Bay region: Creeping Slopes, alt. 140 m, 2 February 1987, AO1603 (KRA).

Cladonia chlorophaea (Flörke *ex* Sommerf.) Spreng.
(Fig. 1E)

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

Description. — Primary squamules persistent, up to 3 mm long, greyish-green to brownish-olive. Podetia up to 3.5 cm tall, brownish-green or olive-brown, simple or sometimes branched by marginal proliferating scyphi. Scyphi up to 10 mm wide, with irregular or dentate margins, usually gradually expanded, turning brown in the case of older podetia. Surface of podetia covered by granular soredia and corticate granules, sometimes decorated with small squamules, especially at the base. Apothecia brown, very rarely produced on marginal proliferations of scyphi.

Chemistry. — PD–, K+ or K–, KC–, C–; contains fumarprotocetraric acid complex, atranorin (inconstant but frequent). The majority of the studied specimens of the species from King George Island contain atranorin.

Remarks. — The species might be confused with *C. novochlorophaea* and *C. pyxidata*, especially in the cases of old and deformed specimens. However, these two species are devoid of soredia and never contain atranorin. *C. novochlorophaea* produces homosekikaic and sekikaic acids.

Ecology. — *Cladonia chlorophaea* grows on soil, mosses or humus, and on gravelly or stony ground, in open or partially sheltered habitats, frequently appears

on glacier moraines. The species is usually associated with *Usnea antarctica* Du Rietz, *Ochrolechia frigida*, *Polytrichum piliferum* Hedw., *Megaspora verrucosa* (Ach.) Hafellner et V. Wirth, *Massalongia carnosus* (Dicks.) Körb., *Syntrichia* spp., *Sanionia uncinata*.

Selected specimens examined. — Admiralty Bay region: Uchatka Point, NW, alt. 30 m, 4 February 1987, AO1604 (KRA); Demay, S, alt. 160 m, 2 February 1987, AO1606 (KRA); Rescuers Hills, N, alt. 70 m, 2 December 1987, AO1722 (KRA); Penguin Ridge, NE, alt. 50 m, 23 January 1987, AO1613 (KRA), Jasnorzewski Gardens, alt. 10 m, 28 January 1987, AO1727 (KRA); Ullman Spur, NW, alt. 25 m, alt. 19 December 1987, AO1622 (KRA); Cape Vaureal, SW, alt. 35 m, 10 January 1988, AO1623 (KRA).

Cladonia fimbriata (L.) Fr.

(Fig. 1F)

Lichenogr. Eur. Reform. 222 (1831).

Description. — Primary squamules persistent, up to 3 mm long, greyish-green. Podetia up to 2 cm tall, simple, greyish-green to green, always with scyphi. Scyphi up to 5 mm wide, rapidly expanded, regular, occasionally with small-finger proliferations. Surface of podetia covered throughout by farinose soredia, sometimes corticated at the base. Apothecia brown (not seen here), produced on the margins of scyphi.

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

Remarks. — The species might be confused with *C. asahinae*, which has granular soredia and contains fatty acids. *C. fimbriata* may resemble *C. chlorophaea* but has more powdery soredia, more regular and rapidly extended scyphi and never contains antranorin.

Ecology. — The species grows on soil, mosses or humus, in open or partially sheltered habitats, frequently appears on recent glacier moraines. It is associated with *Sanionia uncinata*, *Polytrichastrum alpinum*, *Cephaloziella varians* (Gottsche) Steph.

Selected specimens examined. — Admiralty Bay region: moraines by the northern edge of Ecology Glacier NE, alt. 20 m, 17 January 1987, AO1630 (KRA); Ornithologists Creek, alt. 45 m, 25 January 2002, AO1631 (KRA).

Cladonia galindezii Øvstedal

(Fig. 1G)

Cryptog. Bryol. Lichénol. 9: 137 (1988).

Description. — Primary squamules persistent and permanent (1–5 × 1–5 mm), greyish-brown to brownish-green, rather large and thick, protruding from the ground, tongue-shaped, densely gathered and forming mats. Podetia sometimes absent. If present, up to 2 cm tall, greyish-brown to brownish-green, usually

simple but fissured especially in their upper parts, sometimes sparsely branched. Surface of podetia not sorediate, covered by cortex divided into plates or less often continuous cortex. Apothecia brown and prominent, situated on the tips of podetia and giving its club-shaped appearance.

Chemistry. — PD–, K+ yellow; contains atranorin and porphyritic acid.

Remarks. — The similar species *C. cariosa* does not contain porphyritic acid. Furthermore, *C. galindezii* has more densely packed primary squamules and more stout podetia.

Ecology. — The species occurs on soil, mosses or humus and stony ground, in open or sheltered situations, frequently appears on recent glacier moraines and rock crevices. It is accompanied by *Psoroma hypnorum*, *Massalongia carnosa*, *M. intricata*, *Megaspora verrucosa*, *Candelariella flava* (C.W. Dodge et Baker) Castello et Nimis, *Syntrichia princeps* (De Not.) Mitt., *Ceratodon purpureus* (Hedw.) Brid., *Bryum pseudotriquetum* (Hedw.) C.F. Gaertn., B. Mey. et Scherb.

Selected specimens examined. — Admiralty Bay region: Blue Dyke, E, alt. 20 m, 25 January 1987, AO1633 (KRA); moraines by the northern edge of Ecology Glacier, alt. 60 m, 6 January 1990, AO1637 (KRA); Ubocz, NE, alt. 80 m, 15 December 1987, AO1638 (KRA); Krzysiński Point, N, alt. 50 m, 13 March 1987, AO1640 (KRA); Ullman Spur, NE, alt. 10 m, 19 December 1987, AO1644 (KRA); Vaureal Peak, alt. 60 m, 19 January 1989, AO1647 (KRA).

Cladonia gracilis (L.) Willd.

(Fig. 1H)

Fl. Berol. Prodr. 363. 1787

Description. — Primary squamules persistent or sometimes evanescent, rather small and inconspicuous, greyish-green to brownish-green. Podetia up to 8 cm tall, brownish-green to brown, simple or sparsely branched, often twisted and stunted, subulate at the tips or with scyphi. Scyphi up to 5 mm wide, with dentate margins or with proliferations. Surface of podetia corticate, often with cracked or areolate cortex, sometimes decorated by sparsely distributed squamules. Apothecia brown (not seen here), produced on the margins of scyphi.

Chemistry. — PD+ red, K– or K+ brownish, KC–, C–. Contains fumarprotocetraric acid complex, atranorin inconstant.

Remarks. — The taxon is characterised by a large variability. Severe climate factors contribute to strong morphological modifications. Thus, determination at the subspecies level is often very difficult. However, the investigated specimens belong apparently to subsp. *elongata* (Wulfen) Vain. Three subspecies of *C. gracilis* (subsp. *gracilis*, subsp. *elongata*, subsp. *tenerrima*) were recognized in the remote south areas (Ahti 1980).

Ecology. — *Cladonia gracilis* occurs on stony ground and mosses, in open or in sheltered habitats, often appears on inland rocks. It is usually associated with

Andreaea spp., *Sanionia uncinata*, *Polytrichastrum alpinum*, *Usnea antarctica*, *Stereocaulon alpinum* Laurer, *Psoroma hypnorum*.

Selected specimens examined. — Admiralty Bay region: Demay SE, alt. 100 m, 2 December 1987, AO1851 (KRA); Mount Flagstaff, alt. 60 m, 4 March 1987, AO1852 (KRA); Point Hennequin, alt. 30 m, 31 January 2002, AO1856 (KRA).

Cladonia pleurota (Flörke) Schaer.

(Fig. 2A)

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

Description. — Primary squamules persistent, up to 5 mm long, yellowish-green. Podetia up to 2 cm tall, simple, yellowish-green, always with scyphi. Scyphi often wide, up to 1.5 cm wide, usually gradually expanded, sometimes with short proliferations on the margins. Surface of podetia granular soresiate, corticate at the basal part. Apothecia red (not seen here), produced on the margins of scyphi or on short proliferations.

Chemistry. — PD–, K–, KC+ yellow, C–; contains usnic acid and zeorin.

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

Ecology. — It was found on mosses in a rock crevice.

Specimen examined. — Admiralty Bay region: Penguin Ridge, alt. 35 m, 20 January 1987, AO1667 (KRA).

Cladonia pocillum (Ach.) Grognot

(Fig. 2B)

Pl. Crypt. Saône-et-Loire 82 (1863).

Description. — Primary squamules persistent, up to 3 mm long, thick, brown to brownish-green, frequently forming crusts and regular rosettes, often chalk-white inside rosettes. Podetia up to 2 cm tall, simple, brownish-green to brown, always with scyphi. Scyphi up to 8 mm wide, gradually expanded. Podetial surface devoid of soresia, in the upper parts covered by cortical granules (also inside cups), areolate to continuously corticate at the base. Apothecia brown (not seen here), formed on the margins of scyphi.

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

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

Ecology. — The species is common on mosses or humus, soil and stony ground, in open or partially sheltered sites, frequently in fellfield and rock crevices. It very often occurs in nitrophilous communities, usually close to bird nests.

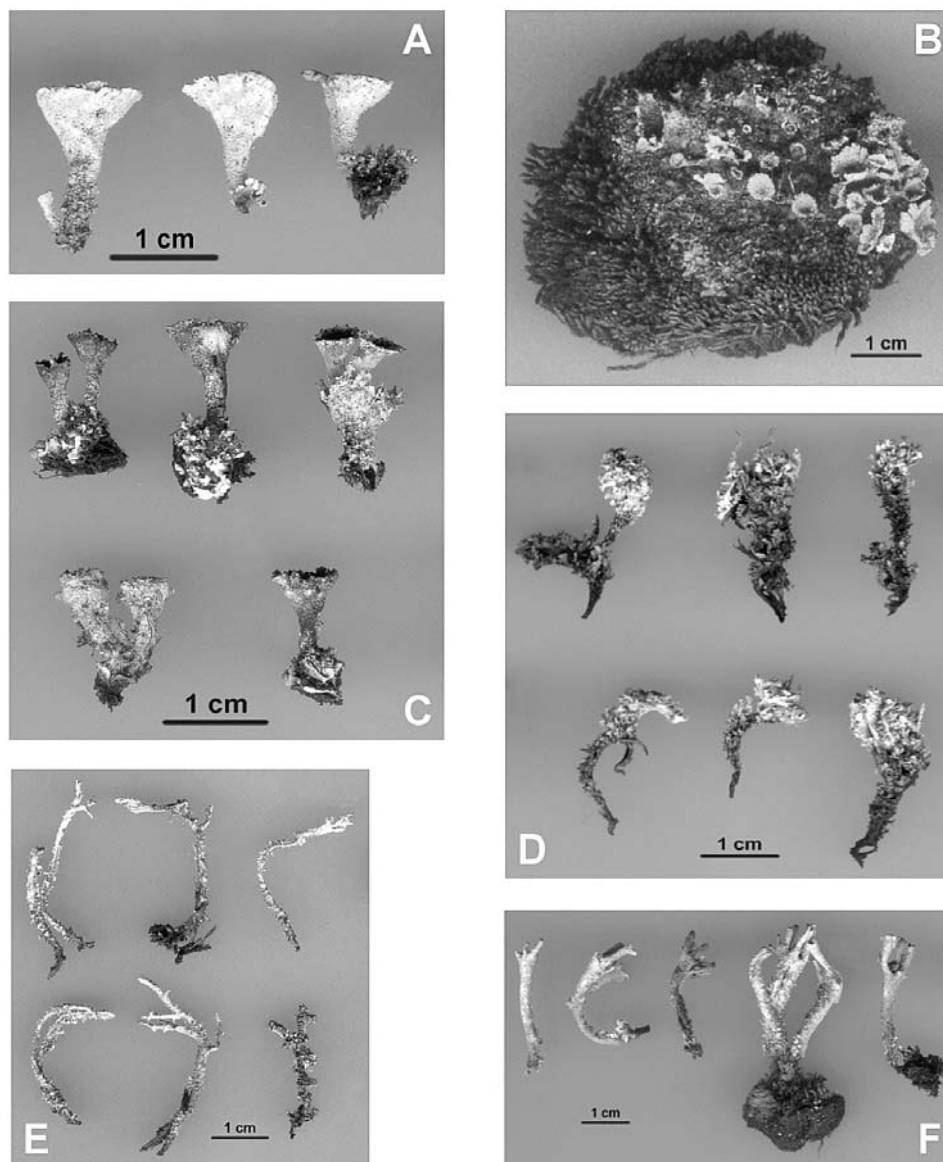


Fig. 2. Specimens of the genus *Cladonia* from King George Island. **A.** *C. pleurota* (AO1667). **B.** *C. pocillum* (AO1825). **C.** *C. pyxidata* (AO1701). **D.** *C. sarmentosa* (AO1681); **E.** *C. squamosa* (AO1652). **F.** *C. subulata* (AO1659).

The most common accompanying species are *Rinodina olivaceobrunnea*, *Physconia muscigena*, *Psoroma cinnamomea* Malme, *Candelariella flava*, *Ochrolechia frigida*, *Syntrichia princeps*, *S. filaris* (Müll. Hal.) Zand.

Selected specimens examined. — Admiralty Bay region: Red Hill, alt. 100 m, 4 March 1987, AO1812 (KRA); Baszta, alt. 150 m, 5 January 1990, AO1820

(KRA); Demay Point, alt. 10 m, 2 February 1987, AO1825 (KRA); Sphinx Hill, alt. 110 m, 5 February 1980, AO1821 (KRA); Penguin Ridge, alt. 55 m, 23 January 1987, AO1827 (KRA); Jardine Peak, N, alt. 160m, 2 February 1980, AO1839 (KRA); Tyrrell Ridge, alt 100 m, 5 March 1987, AO1843 (KRA); Ullman Spur, N, alt. 30 m, 19 December 1987, AO1846 (KRA). King George Bay region: Lions Rump, alt. 10 m, 1 January 1990, AO 1944 (KRA).

Cladonia pyxidata (L.) Hoffm.

(Fig. 2C)

Deutschl. Fl. 2: 121 (1796).

Description. — Primary squamules persistent, up to 4 mm long, greyish-green to brownish-olive. Podetia up to 2 cm tall, greyish-green to brownish-olive, simple or rarely branched by proliferating scyphi (up to 1.5 cm wide). Surface of podetia without soredia, covered by granular or areolate cortex (distracted granules inside the scyphi), more corticated at the basal part, sometimes sparsely decorated by squamules. Apothecia brown, very rare, produced on the margins of scyphi.

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

Remarks. — In the case of old and deformed specimens, *C. pyxidata* might be confused with *C. chlorophaea* or *C. novochlorophaea*. Podetia of *C. chlorophaea* are at least partly covered by soredia and often contain atranorin. *C. novochlorophaea* contains homosekikaic and sekikaic acids.

Ecology. — *Cladonia pyxidata* grows on soil, mosses or humus and gravelly or stony ground, in open or partially sheltered sites. It is associated with *Rinodina olivaceobrunnea*, *Ochrolechia frigida*, *Bartramia patens* Brid., *Barbilophozia hatcheri*.

Selected specimens examined. — Admiralty Bay region: Uchatka Point, NW, alt. 30 m, 4 February 1987, AO1701 (KRA); Demay, N, alt. 100 m, 10 December 1987, AO1706 (KRA); Petrels Creek, E, alt. 40 m, 5 January 1990, AO1705 (KRA); Hala, alt. 40 m, 1 May 1987, AO1708 (KRA); Jersak Hills, alt. 150 m, 21 November 1987, AO1710 (KRA); Round Hill, alt. 20 m, 4 March 1987, AO1712 (KRA); Mount Birkenmajer, alt. 220 m, 4 March 1987, AO1713 (KRA).

Cladonia sarmentosa (Hook. f. et Taylor) C.W. Dodge

(Fig. 2D)

Brit. Austral. New Zealand Antarct. Res. Exped. 1929–1931 Rep., Ser. B, 7: 129 (1948).

Description. — Primary squamules persistent, up to 3 mm long, greyish-green. Podetia up to 4 (5) cm tall, greyish-green to brownish-green, usually simple, subulate at the tips or rarely with narrow scyphi (up to 2 mm wide). Surface of podetia without soredia, covered by strongly divided, granular or areolate cortex, more corticated at the base, decorated by numerous squamules towards the tips or

scyphi, sometimes blackish at basal part. Apothecia brown (not seen here), produced on the subulate tips or on the margins of scyphi.

Chemistry. — Pd+ red, K– or K+ brownish, KC–, C–; contains fumarprotocetraric acid complex, atranorin occasionally present.

Remarks. — The species might sometimes be confused with *C. squamosa*, which is richly decorated by microsquamules or squamules and usually contains thamnolic acid or, more rarely, squamatic acid.

Ecology. — The species grows on soil, gravelly ground and mosses, in sheltered or rarely, in open localities. The most frequently associated taxa are: *Polytrichastrum alpinum*, *Usnea antarctica*, *Stereocaulon alpinum*, *Cetraria aculeata*, *Sphaerophorus globosus*, *Bryoria forsteri* Olech et Bystr., *Psoroma hypnorum* and *Deschampsia antarctica*.

Selected specimens examined. — Admiralty Bay region: Creeping Slopes, alt. 140 m, 2 February 1987, AO1696 (KRA); Rescuers Hills, N, alt. 60 m, 22 January 1988, AO1670 (KRA); Jasnorzewski Gardens, S, alt. 10 m, 28 January 1987, AO1681 (KRA); Uplaz, alt. 30 m, 23 January 1987, AO1685 (KRA); Jersak Hills, N, alt. 150 m, 9 February 1990, AO1692 (KRA); Mount Wawel, NW, alt. 100 m, 6 February 1987, AO1697 (KRA).

Cladonia squamosa Hoffm.

(Fig. 2E)

Deutschl. Fl. 2: 125 (1796).

Cladonia squamosa var. *subsquamosa* (Nyl. ex Leight.) Vain., Meddeland. Soc. Fauna Fl. Fenn. 6: 113 (1881).

Description. — Primary squamules persistent, up to 3 mm long, greyish-green. Podetia up to 5 cm tall, greyish-green to brownish-green, simple or sparsely branched, blunt at the tips or with very narrow scyphi, axils and apical part open (only sometimes subulate at the tips). Surface of podetia devoid of soredia, richly squamulose, largely without cortex between the squamules, with cortical plates at the basal parts. Apothecia brown (not seen here), produced on the apices of podetia.

Chemistry. — PD+ yellow or PD–, K+ yellow or K–, KC–, C–; contains (1) thamnolic acid or (2) squamatic acid. Two chemotypes were ascertained in the investigated region but only one specimen contains squamatic acid.

Remarks. — The thamnolic acid chemotype has been often considered as the separate species – *C. subsquamosa* (Nyl. ex Leight.) Cromb.

Ecology. — It grows on soil, gravelly ground and mosses, in sheltered or open habitats and is usually associated with *Andreaea gainii* Card., *Sanionia uncinata*, *Barbilophozia hatcheri*, *Usnea antarctica*, *Cetraria aculeata*.

Selected specimens examined. — Admiralty Bay region: moraines by the northern edge of Ecology Glacier, alt. 40 m, 21 January 1996, AO1651 (KRA); Point Hennequin, alt. 30 m, 31 January 2002, AO1652 (KRA); Mount Wawel, NW, alt. 50 m, 12 February 1987, AO1653 (KRA).

Cladonia subulata (L.) Weber ex F.H. Wigg.
(Fig. 2F)

Prim. Fl. Holsat. 90 (1780).

Description. — Primary squamules persistent or sometimes evanescent, up to 3 mm long, grey to greenish-grey. Podetia up to 4 cm tall, greenish-grey or brownish-grey, subulate at the tips or with scyphi, simple or sometimes branched by marginal proliferating scyphi. Scyphi, if present, rather narrow, gradually expanding, irregular, sometimes with digitate proliferations. Surface of podetia covered by powdery soredia, becoming granulose towards the base. Apothecia brown (not seen here), formed on the apices of podetia.

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

Remarks. — Sometimes *C. subulata* has rather wide scyphi and may be seemingly similar to *C. fimbriata*. However, *C. fimbriata* has a dainty form, green tint, and rapidly extended and regular scyphi.

Ecology. — *Cladonia subulata* occurs on soil and mosses, in sheltered or rarely open places, frequently found on inland rocks at rather higher altitudes. It is usually accompanied by *Cetraria aculeata*, *Sphaerophorus globosus*, *Ochrolechia frigida*, *Lecidella wulfenii* (Hepp) Körb., *Rinodina olivaceobrunnea*, *Polytrichastrum alpinum*, *Andreaea* spp., *Sanionia uncinata*.

Selected specimens examined. — Admiralty Bay region: Demay Point, alt. 30 m, 16 January 1992, AO1654 (KRA); Ubocz, alt. 180 m, 15 January 1990, AO1657 (KRA); Kapitan Peak N, alt. 60 m, 9 January 2002, AO1659 (KRA); British Point, alt. 25 m, 4 March 1987, AO1662 (KRA); Basalt Point, alt. 10 m, 18 January 1988, AO1661 (KRA).

Conclusions

Altogether 14 species belonging to the genus *Cladonia* (Cladoniaceae) are reported from the study area. In Cladoniaceae, only representatives of *Cladonia* were found in the explored region. Most species are bipolar or have cosmopolitan distribution. *C. cervicornis* subsp. *mawsonii*, *C. galindezii*, *C. sarmentosa* are known only from the Southern Hemisphere. Among these three taxa, *C. galindezii* is endemic to the Antarctic region. Hitherto known distribution of *Cladonia* species in the Antarctic and sub-Antarctic regions is presented in several papers (e.g. Stenroos 1993; Olech 2001; Øvstedal *et al.* 2001; Sjøchting *et al.* 2004). Some of the investigated taxa were found in numerous localities and it is possible to consider them as widespread ones in the region of King George Island. They are: *C. borealis*, *C. chlorophaea*, *C. galindezii*, *C. pocillum*, *C. pyxidata*, and *C. sarmentosa*. Other species, such as: *C. asahinae*, *C. cariosa*, *C. fimbriata*, *C. gracilis*, *C.*

squamosa, *C. subulata*, were recorded in few localities. Two taxa: *C. cervicornis* subsp. *mawsonii* and *C. pleurota* were found only in single locality.

Cladonia cervicornis subsp. *mawsonii* is a new lichen for King George Island and for the whole South Shetland Islands archipelago. In the Antarctic and sub-Antarctic regions this taxon has hitherto been known from South Orkney Islands (Signy I.), Prince Edward Is (Prince Edward I.), Macquarie Island (Stenroos 1993) and South Georgia (Øvstedal and Smith 2001). *C. asahinae* is recorded for the first time from King George Island. Until now the species was reported only from Livingston Island (Stenroos 1993). Besides the South Shetlands, *C. asahinae* was recorded in the region of Antarctic Peninsula, South Orkney Is and also South Georgia (Stenroos 1993).

The most interesting result of this study is the confirmation of the occurrence of *C. cariosa* in the Antarctic region. Because Øvstedal (1988) described the new lichen species *C. galindezii*, the occurrence of the *C. cariosa* was uncertain. Both species belong to the same section of *Helopodium* and are morphologically very similar. However, they differ in the chemical aspect. *C. cariosa* was reported earlier from the South Shetland Is (King George I., Livingston I.) by Olech (1989a, b). However, at that time this report was not conclusive because materials were not identified using chemical analysis. It is worth noting that *C. galindezii* is more widespread on King George Island than *C. cariosa*. Squamules of primary thallus of *Cladonia*, published as *Cladonia cf. cariosa*, were also reported from Macquarie Island by Stenroos (1993).

Three subspecies of *C. gracilis*: subsp. *gracilis*, subsp. *elongata*, subsp. *tenerima* were recognized in the remote southern areas (Ahti 1980). Strong morphological modifications of the species due to severe climate factors often make the identification of *C. gracilis* at the subspecies level very difficult. However, the examined individuals of this species originating from King George Island could be placed in subsp. *elongata* (Wulfen) Vain.

Despite the rich herbarium material gathered during several expeditions, five species: *C. deformis* (L.) Hoffm., *C. carneola* (Fr.) Fr., *C. weymouthii* Wilson ex Archer, *C. cornuta* (L.) Hoffm. and *C. novochlorophaea* (Sipman) Brodo et Ahti were not found in the investigated region. However, these taxa were reported earlier by other authors from King George Island and adjoining small Ardley Island: *Cladonia deformis* – on King George I. and Ardley I. (Chen and Ahti 1999), *C. cornuta* – on King George I. (Stenroos 1993; Chen and Ahti 1999) and Ardley I. (Chen and Ahti 1999), *C. novochlorophaea* – on King George I. and Ardley I. (Stenroos 1993; Chen and Ahti 1999). *C. carneola* and *C. weymouthii* – known only from Ardley I. (Chen and Ahti 1999).

The analysis of *Cladonia* specimens from King George Island (KRA) did not confirmed the presence of *C. furcata* (Huds.) Schrad., *C. phyllophora* Hoffm. and *C. lepidophora* Ahti et Kashiw., reported erroneously from this region by Olech (1989a, 1994) and Myrcha et al. (1991). So far the occurrence of these species has been confirmed only in the sub-Antarctic region (Stenroos 1993).

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