

## **Phenotypic and ecological diversity of freshwater coccoid cyanobacteria from maritime Antarctica and islands of NW Weddell Sea. I. Synechococcales.**

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### **Abstract**

The review of freshwater natural populations of coccoid cyanobacteria from the ecosystems of the coastal Antarctica in the vicinity of Antarctic Peninsula is presented in two consequent articles. The natural cyanobacterial populations were studied from deglaciaded regions with aquatic and terrestrial habitats, mainly from the islands Nelson and King George (South Shetland Islands) and from the northern deglaciaded part of the James Ross Island (NW part of the Weddell Sea). Majority of identified morphospecies was distinctly ecologically restricted and their cultivation was not successful; the molecular evaluation was therefore not possible. All morphotypes appeared also in small quantities, and only few morphospecies created locally more intense populations. However, the knowledge of phenotype variation is important for the classification of Antarctic cyanobacterial diversity. This first article contains 11 taxa (morphospecies) from 9 genera from the simple phylogenetic clade, classified recently in the order Synechococcales (the second part will contain species from more complicated unicellular cyanobacterial orders). Our results were compared with literary data, but several populations occurred only rarely in atypical stages and their taxonomic classification was difficult. The modern cyanobacterial system (Hoffmann et al. 2005, Komárek et al. 2013) is used for the classification.

**Key words:** maritime Antarctica, coccoid cyanobacteria - Synechococcales, James Ross Island, King George Island, Nelson Island, taxonomy, ecology

**Abbreviations:** D - description of morphology, E - ecology, L - locality, N - notes, JRI - James Ross Island, KGI - King George Island

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## Introduction

The present paper contains the first part (Synechococcales) of the review of the natural populations of coccoid cyanobacteria from the South Shetland Islands (maritime Antarctica), particularly from the deglaciated areas of the northern part of the Nelson Island, from few deglaciated areas of the island King George and from the deglaciated northern part of the James Ross Island (near the NE coast of Antarctic peninsula). The microflora of these coastal Antarctic areas is similar and only small differences appear between different islands. Our review contains the list of registered unicellular and colonial cyanobacterial taxa, evaluation of morphology of various populations, and detailed descriptions of morphological variation, particularly of dominant and characteristic morphotypes. It is interesting that coccoid cyanobacteria occur in Antarctica in relatively rich diversity, but they develop characteristic or mass populations very rarely. They are spread in specialized microphyte communities usually and their

cultivation under standardized conditions is complicated.

Unicellular cyanobacteria were recognized as a polyphyletic group, which must be classified in the modern system in different phylogenetic clades (Castenholz 2001, Hoffmann et al. 2005, Komárek et al. 2013), at least into six taxonomic orders, separated by the distant position in the phylogenetic trees and by cytomorphological markers. Only the types from the order Synechococcales are included in the first part of our review. The members of the more complicated colonial orders Chroococcales, Pleurocapsales and Chroococciopsidales are summarized in the next part. However, many problems still occur also in this simple order and classification and the taxonomic position of many types is unclear. We included into our review all the definable morphotypes from the mentioned taxonomic group, found in habitats of studied areas, as a basis for further research.

## Material and Methods

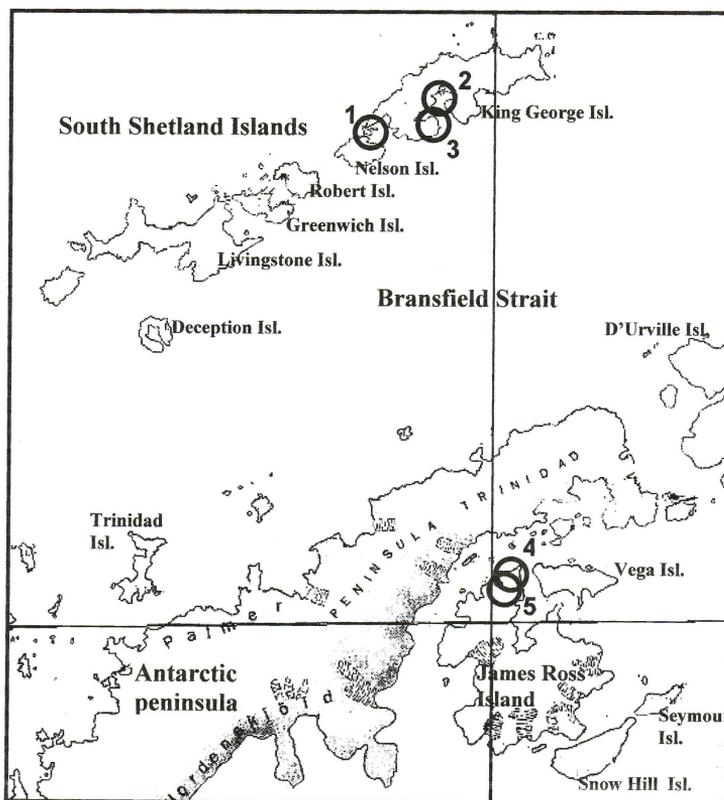
### *Sampling periods*

Natural cyanobacterial populations in several localities of maritime Antarctica (South Shetland Islands) and from the Island James Ross (*see* Fig. 1) were studied. The material was collected in five Antarctic summer seasons:

1. During the period February 10<sup>th</sup> to March 2<sup>nd</sup> 1989; from the Fildes Peninsula (South Shetland Islands, SW part of King George Island - KGI) and north coast of Nelson Island; both neighboring areas are free of ice.
2. In the period of December 12<sup>th</sup> 1995 to February 28<sup>th</sup> 1996; from the vicinity of Polish Antarctic Station "Henryk Arctowski" (South Shetland Islands, S coast of King George Island, Admiralty Bay).
3. In the period of January 19<sup>th</sup> to February 24<sup>th</sup> 2002; from the Fildes Peninsula, particularly in its northern part, in the vicinity of the Uruguayan Antarctic Station "Artigas".
4. - 5. During the Antarctic summer seasons in 2006 (January 24<sup>th</sup> – February 26<sup>th</sup>) and 2009 (January 1<sup>st</sup> – February 16<sup>th</sup>), from the northern part of James Ross Island (JRI).

The field studies were realized particularly in a vicinity of the Russian Station „Bellingshausen“, Uruguayan Station „Artigas“, Polish Station „Henryk Arctowski“ (all

in King George Island), and the Czech field Antarctic Station „J. G. Mendel“ on the northern coast of James Ross Island, and finished at the Institute of Botany of the Czech Academy of Sciences, under the support of the Grant Agency of the Czech Republic (grant No. 206/05/0253). The material was studied in living state by microscopic techniques, a part was used for culturing and part was preserved by formol (*i.e.* solutions of formaldehyde in water,  $\pm 2\%$  of final concentration).



**Fig. 1.** Locality with collection of our material: 1 = north, deglaciated part of Nelson Island, Ardley Island and Fildes peninsula; 2-3 = deglaciated parts of the central King George Island (vicinity of Admiralty Bay, particularly of Henryk Arctowski Station and Damay peninsula; 4-5 = northern deglaciated parts of James Ross Island (Ulu peninsula).

### *Sampling sites*

Material of cyanobacterial populations was collected from following areas:

- 1) Central part of South Shetland Islands, King George Island, particularly the vicinity of Admiralty Bay, Fildes peninsula, Ardley Island and from the northern deglaciated part of Nelson Island ( $\pm 62^\circ$  S,  $58-59^\circ$  W).
- 2) James Ross Island in NW part of Weddell Sea, especially deglaciated Ulu peninsula ( $63^\circ 58' - 63^\circ 46' S$ ,  $57^\circ 46' - 58^\circ 07' W$ ).

The samples were collected from soil habitats, streams, seepages and from littoral and benthos of lakes in the whole area (*cf.* Komárek et Elster 2008). The main localities are particularly mentioned in descriptions of different species.

#### *Local microclimate*

The vegetation season starts in the whole area (both regions in the vicinity of Antarctic peninsula) in November and the communities of microflora develop in the time when the average temperature is higher than 0°C and when in the area dominate days with flowing water. The vegetation season in the area ends at the end of February and in March. To the main ecological factors influencing the development of cyanoprokaryotic communities belong the water in liquid phase, prevailing temperature over 0°C and almost continual radiation. The substrate of the whole area is mostly slightly alkaline with corresponding amount of nutrients. The ecological parameters of the studied area, especially the basic temperature and the main characteristics of various habitats with cyanobacterial communities in deglaciated areas (creeks, seepages, wet rocks, littoral and benthos of lakes and wetted soils) are described in Komárek et Elster (2008).

#### *Methods*

Altogether, 62 samples were collected in Nelson Island and King George Island in February – March 1989, 135 samples in the season 1995-1996 and 58 samples in 2002. In James Ross Island were collected 137 samples in 2006, 297 samples in 2009. In laboratories of the Polish Antarctic station "Henryk Arctowski" and the Czech Antarctic station "J. G. Mendel" was studied the fresh material by optical microscope, documented and measured. Later was used a part of material for cultivation or preserved by formol. All found taxa were registered and documented. In the following review, descriptions of morphology (D), sometimes with diagnoses of new described species), ecology (E), localities (L) and with taxonomic remarks to individual taxa (N) are given. The results from cultivation, which was successful only in few cases are not included into this paper. Therefore, only description of natural populations is given here.

## **Results**

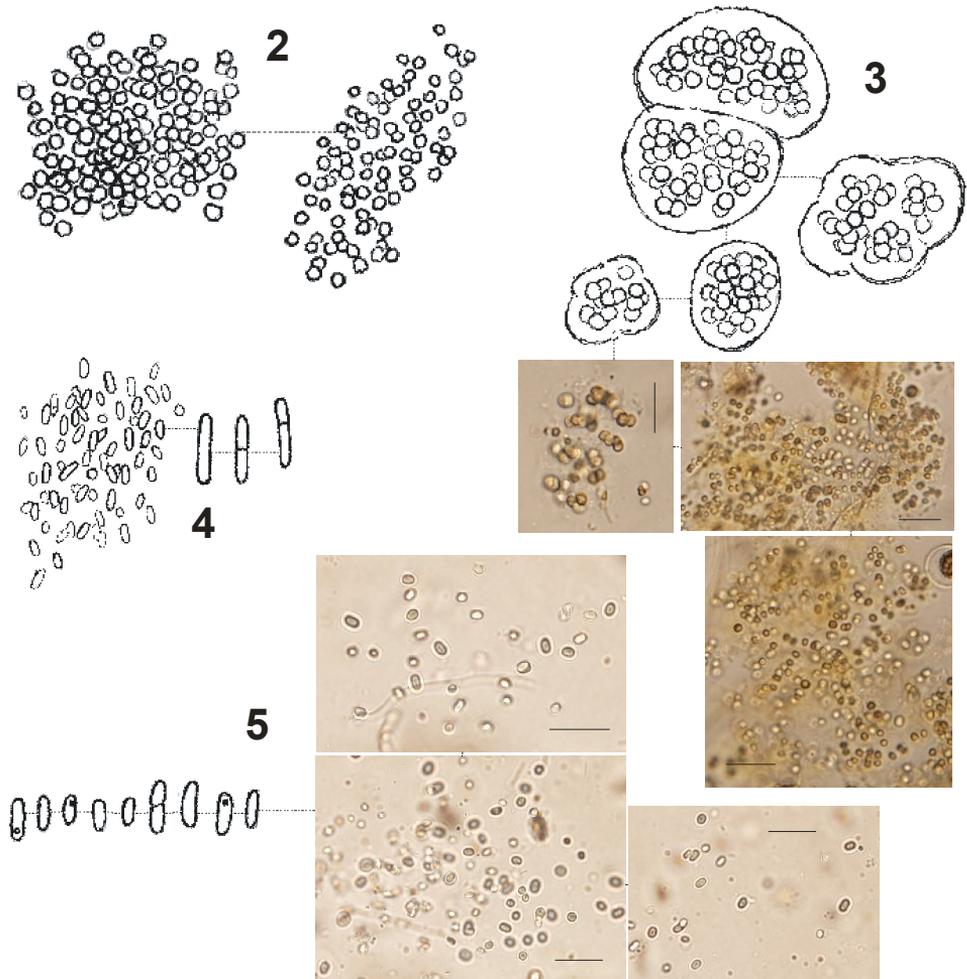
### ***Aphanocapsa nivalis* Lagerheim 1894 (Fig. 2)**

**D:** Small, pale green or greyish, microscopic, irregular colonies, with ± densely, irregularly arranged, green to dark green, spherical cells. Colonies are only rarely with more free situated cells. Cells with ± homogeneous content, 2-3 µm in diameter.

**E.:** Occurs sporadically, only rarely in cryosestic communities and in the near vicinity to snow fields. More common only locally.

**L:** It was found rarely only in maritime Antarctica, particularly in South Shetlands (KGI). It is almost lacking in JRI, where cryosestic algae are missing. (The absence of cryoseston in JRI is caused by climatic factors: the evaporation and sublimation of snow from surface of snow fields and glaciers surpass the melting; the presence of liquid water is therefore in these habitats limited and the conditions for development of snow algae restricted.). Similar types occur near snow fields very rarely.

**N:** Not quite clear taxon, relations to other morphologically similar *Aphanocapsa* species are possible. – The genus *Aphanocapsa* occurs in Antarctic cyanobacterial communities in several morpho- and ecotypes, the taxonomy of which is unclear.



**Fig. 2.** *Aphanocapsa nivalis*, two colonies.

**Fig. 3.** *Aphanocapsa* aff. *hyalina*, various colonies.

**Fig. 4.** *Anathece* sp., colony and details of cells.

**Fig. 5.** *Anathece* sp., small colonies, details of cells. Bars = 20 $\mu$ m.

***Aphanocapsa* aff. *parasitica* (Kützing) Komárek et Anagnostidis 1995**

**D:** Microscopic colonies with  $\pm$  densely, irregularly arranged cells in amorphous, indistinct, colorless mucilaginous envelope. Cells spherical, with grey content, about 1-2  $\mu$ m in diameter.

**E:** Among clusters of other algae and cyanobacteria, on the bottom of pools and mostly in well developed and stabilized seepages. Very rarely occurs as a main component of these benthic communities. Rarely grows in the middle grey, "foliose" layer in seepages, in central and western deglaciated parts of KGI (Nelson Isl., Fildes peninsula).

**L:** Found in maritime Antarctica and in stabilized seepages in JRI (Monolith Lake, Ginger Lake), very rarely. A little different morphotype of *Aphanocapsa* occurs in KGI, mostly in shallow moss pools.

**N:** Resembles morphologically *A. parasitica* or planktic *A. holsatica*, but sometimes forms a dense mass of very fine cells in slime („flattened colonies?“). Identity of all these populations and taxonomic identification is questionable. The identification as planktic *Aphanocapsa elachista* is improbable (Broady 1984).

***Aphanocapsa* aff. *hyalina* (Lyngbye) Hansgirg 1892 (Fig. 3)**

**D:** Free, microscopic, irregular, small mucilaginous, colorless, indistinct colonies, with slightly packet-like arranged cells, with colorless, homogeneous, diffluent mucilage. Gelatinous envelopes irregular, not delimited, but usually with visible margin, structureless, sometimes with characteristic morphology of slimy envelopes. Cells spherical, greyish-blue to bright blue-green, without individual envelopes, about 2-4.5 µm in diameter, arranged irregularly, sometimes in small, packet-like, individual clusters with several cells.

**E:** In mats of other cyanobacterial assemblages, in stabilized seepages, perhaps also in littoral of stabilized lakes, very rarely subaerophytic on wet rocks, also in community of various *Gloeocapsa* species. From seepages never rich and probably heterogeneous, rarely epiphytic on “*Tolypothrix*”. Perhaps also subaerophytically (littoral of the lake).

**L:** Rarely in seepages of JRI (Monolith Lake). More common in KGI (about 9 localities in the whole visited deglaciated areas).

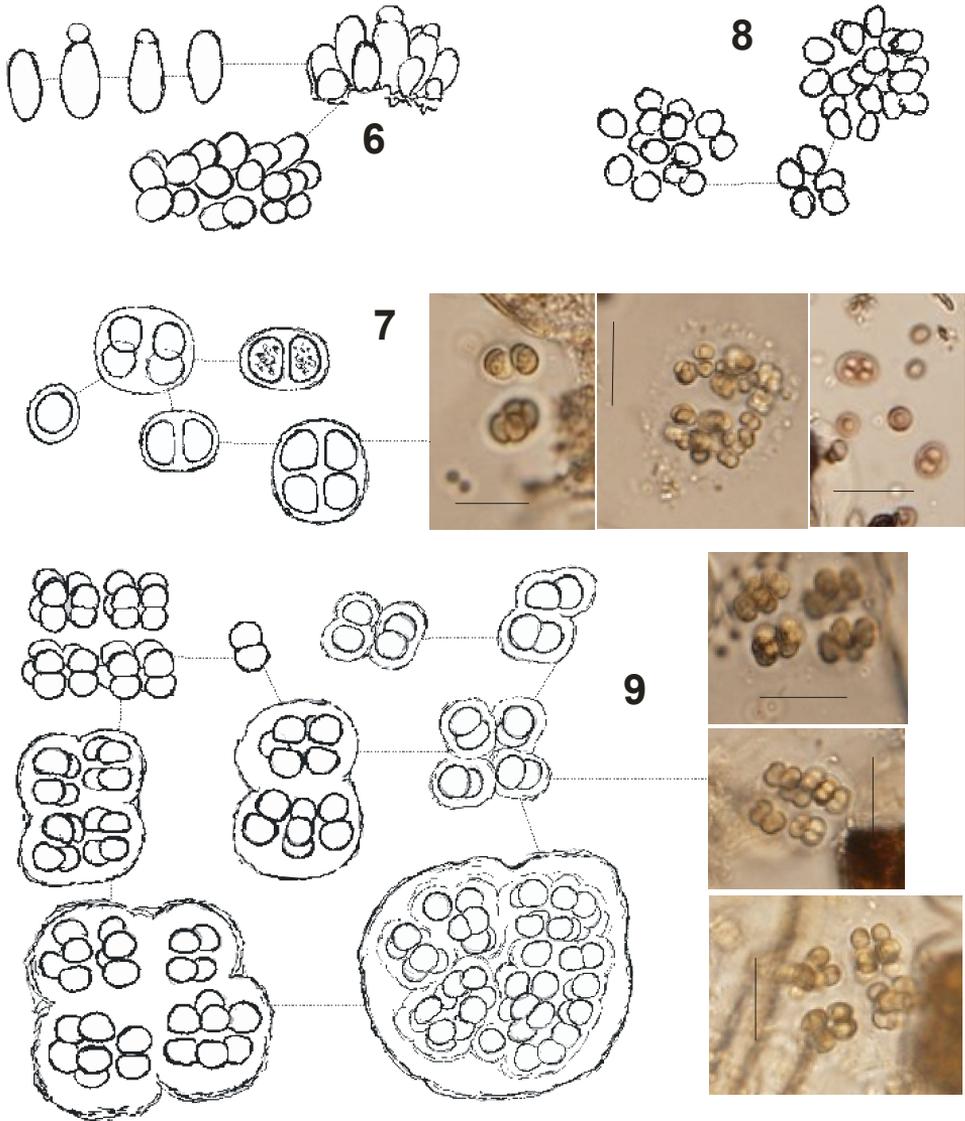
**N:** Specimens, morphologically similar to *Aphanocapsa hyalina* were sporadically found on the same localities as *Chlorogloea antarctica*. Transient types between both these coccoid types were not recognized, but several characters resembling relationships between both morphotypes exist (size and form of cells in the same habitat); the ecological relations between both types should be explained in future. Possibly exist similar stages of *Chlorogloea antarctica* in populations with the same ecology. Morphologically (result of division process?) a little similar to the genus *Eucapsis* (?).

***Anathece* sp. (Fig. 4)**

**D:** Colonies microscopic, with colorless mucilage without distinct margin, with irregularly situated cells. Cells are cylindrical (up to slightly biscuit-like or rounded) with variable length, pale greyish blue-green, with homogeneous content, rarely with one polar granulum, 3-7.5(19) x 2.2-2.6 µm; they can reach up to 19 µm of length, aggregated irregularly in mucilaginous colonies. The long cells divide sometimes asymmetrically. The mucilage is very fine, diffluent, structureless, special gelatinous envelopes are not around the cells, in slime are the cells irregularly and scarcely distributed. The slightly visible chromatoplasma resembles the parietal location of thylakoids.

**E:** Mostly occurs together with *Leptolyngbya borchgrevinkii*. It grows on the edge of streams with rich developed cyanobacterial mats (but always only as an additional species) and among other cyanoprokaryotes; especially in stabilized seepages and on the edge of larger creeks. The larger type was found sporadically in heavily eutrophised coastal pools (by sea lions; *Synechococcus/Spirillum* type?)

**L:** It was found mainly in seepages in the vicinity of Monolith Lake (JRI in 2009), among other cyanobacteria and in several localities with corresponding ecology. Maybe forms special morpho- and ecotypes in various localities. Often also in colonies of *Aphanothece* in streams. Found repeatedly in JRI (in KGI occurs sporadically the special modification, which concerns possibly eubacteria).



**Fig. 6.** *Chamaesiphon* aff. *minutus*, solitary cells and groups of cells.

**Fig. 7.** *Chroococcus* aff. *minutus*, colonies.

**Fig. 8.** *Coelomorion chroococcoideum*, colonies.

**Fig. 9.** *Eucapsis austro-alpina*, solitary cells and colonies. Bars = 20µm.

**N:** Probably member of *Anathece*, which was recently separated from the traditional genus *Aphanothece*. The microscopic mucilaginous colonies with diffluent, fine, colorless slime and with irregularly disposed cylindrical cells resemble species of this genus. However, the cells are sometimes larger and have characters rather of the genus *Synechococcus*. Moreover, it is known, that *Synechococcus*-like cyanobacteria are genetically very diverse, and our material from JRI can be one from many clusters of

*Synechococcus*-like types. It occurs in two main morphological modifications, sometimes without transitions, the close relation of which is, however, possible. A smaller type of the same morphotype was found less frequently in the same habitats and on the same localities, with the following differences (Fig. 5): Small groups of cells in colorless, fine, not structured and diffluent slime, larger colonies (but always microscopic) are very rare. Cells oval up to cylindrical, greyish blue-green, usually with 1-2 distinct granules,  $2.4-4.2 \times \pm 2.6 \mu\text{m}$ . One strain of this type was transferred in culture, where the variability of the length of cells is clearly visible. The solitary cells of this morphotype sometimes occur in seepage communities, resembling the *Synechococcus*-stage.

***Chamaesiphon* aff. *minutus* (Rostafinski) Lemmermann 1910** (Fig. 6)

**D:** One small *Chamaesiphon* species from the typical subgenus *Chamaesiphon* was found in JRI, commonly epiphytic on *Hassallia* sp. div. in the small littoral stagnat water at the Green Lake near the Santa Martha Cove, on the east shore of the Ulu peninsula. The cells are attached vertically and  $\pm$  densely and parallel to the substrate, obovoid,  $(2.2)3-10.6 \times 2.4-5 \mu\text{m}$ , with greyish blue-green,  $\pm$  homogeneous content. Exospores liberate solitary, spherical,  $2-2.6 \mu\text{m}$  in diameter.

**E:** Epiphytic on filamentous cyanobacteria in littoral of lakes, rarely in stones.

**L:** Only one locality (JRI, Green Lake).

**N:** This species corresponds morphologically to the European species *Ch. minutus* and therefore is recorded under this name. It belongs probably to the special clade of simple *Chamaesiphon* with heteropolar cells and parietal thylakoids.

***Chroococcus* aff. *minutus* (Kützing) Nägeli 1849** (Fig. 7)

**D:** It forms small groups of cells in microscopic, solitary, usually 4-8-celled colonies, where the cells are situated irregularly in amorphous, colorless, indistinct and diffluent mucilage, sometimes with individual indistinct envelopes around solitary cells or around small groups of cells after division. Cells are  $\pm$  spherical or hemispherical with pale or greyish blue-green, olive-green or slightly violet, non-granulated protoplast,  $2.5-5 \mu\text{m}$  in diameter.

**E:** It occurs in cyanophycean assemblages in seepages.

**L:** Five localities from the vicinity of Monolith Lake and from the slopes around Abernathy Flats were registered in JRI. A little larger populations occur in other localities of JRI (2006). Similar types, evidently also identical with „*Chroococcus* aff. *minutus*“ occur in seepages in several localities of KGI.

**N:** It corresponds morphologically to *Ch. minutus*, but the phylogenetic confirmation is necessary. The smallest type is probably taxonomically more different from this *Chroococcus* morphotype, but it was found always only in small quantities, and its variation is not clear. - Several populations from JRI, which belong probably to the typical genus *Chroococcus* (cf. Komárková et al. 2009), have rusty brown cells and occur in morain pools near Lachman Lakes; the cells are  $10-17 \mu\text{m}$  in diameter, with diffluent, not lamellated envelopes and occur in seepages and littoral of the Green Lake, near the Andreassen Point. Locally is quite common also in morain pool near the Lake Lachman II, morain pool „Dulanek“ and in littoral of Lake Lachman II. In some populations occur rusty envelopes and also brownish cells (in seepages near Monolith Lake).

***Coelomoron chroococcoideum* (W. et G.S.West) comb. nova** (Fig. 8)

Syn. and basionym: *Microcystis chroococcoidea* W. et G.S.West 1911

**D:** Small, few-celled,  $\pm$  spherical colonies with apparently radially and densely arranged, spherical to very slightly elongated cells, with homogeneous content, usually with distinct chromatoplasma, 3.2-5.8  $\mu\text{m}$  in diameter.

**E:** Described originally from a salty lake in Antarctica, but found from us mostly sporadically in old seepages with mosses in coastal areas of KGI, less in JRI.

**L:** Described already by West's from Antarctica (!), studied more intensely from seepages in KGI. Few specimens occurred in seepages near Monolith Lake (JRI) with more free arranged cells and similar rather to the species of *Aphanocapsa*.

**N:** Surely not *Microcystis*. Not studied by molecular methods, but morphologically corresponds well to the genus *Coelomoron*. From the planktic genus *Microcystis*, which represent a very unique phylogenetic cluster, differs clearly by absence of gas vesicles and by ecology, which belong to diacritical characters of this genus. *C. chroococcoideum* is also variable and other populations belong possibly to this genotype. Cells with intensely blue-green color, which are densely packed in small colonies were found particularly at the KGI. Such colonies occur rarely among other cyanoprokaryotes in seepages. Specimens, comparable with *Coelomoron microcystoides* were found in JRI (2009) in samples from the mats in one lake among hills near the eastern coast of Ulu peninsula ( $\pm 63^\circ 58' \text{S}$ ,  $57^\circ 30' \text{W}$ ).

***Cyanodictyon* ? sp.**

**D:** Very fine, agglomerated cells in rows, pale grey-bluish. Small colonies with only short (few-celled) rows of elongated cells, with delimited mucilage, spherical or variously elongated. Cells very small, often liberated and occurring like „pico-cells“ in the sample.

**E:** Commonly in one morain tarn (occurs in littoral with detritus and mosses) and in one seepage sample. Another or possibly identical type was found on wet rocks.

**L:** Known only from KGI, from wet localities on rocky substrate in Jardine Peak.

**N:** Identified only according to morphological organization of colonies.

***Eucapsis austro-alpina* spec. nova** (Fig. 9)

**D:** Small solitary colonies with cells arranged into flat plates or  $\pm$  cubic, irregular formations, forming mostly 16-celled, rather cubic colonies with cells in  $\pm$  perpendicular position, maximally 32-celled, very rarely more-celled. Cells  $\pm$  spherical,  $\pm$  agglomerated, with pale or bright blue-green cell content and slightly visible chromatoplasma, 2.5-6.2(7)  $\mu\text{m}$  in diameter. Enveloping mucilage colorless, homogeneous,  $\pm$  rounded, delimited but diffluent at the margin, not very wide, sometimes almost invisible in LM. – Type (iconotype) see Fig. 9.

**E:** It occurs among cyanobacteria in well developed mats in seepages, in littoral of stabilized, old lakes and less in morain pools.

**L:** Interestingly, only rarely recorded from maritime Antarctica, but commonly occurs in Ulu peninsula, JRI. The typical populations were collected particularly in the inflow and in littoral of Green Lake (stabilized lake) and in the vicinity of Monolith Lake. Other populations were found in seepages and morain pools near Lake Lachman II and in pools near Green Lake.

**N:** Specimens from KGI were originally designated like „*Eucapsis alpina*“ and in our populations occur also together with flat, *Merismopedia*-like specimens. The wide

variation in cell size is characteristic for the species, similarly like in other *Merismopedia* and *Eucapsis*-taxa. In JRI (2006) was studied the material of *Eucapsis/Merismopedia* population from one sample. The final taxonomic position must be solved by help of molecular analyses. It differs from other *Eucapsis*-species by morphology of colonies, character of mucilage (which is mostly similar to the tropical *E. densa*), size of cells and ecology. – The genus *Eucapsis* contains more than 10 morphospecies, from which few are known only from tropical habitats. The morpho-species, occurring in oligotrophic, clear, cold and usually slightly acidic mountain and nordic wetlands, mainly from *E. alpina*-complex are ecologically mostly similar to our populations. This species (*sensu lato*) is mostly distributed in northern temperate zone, where forms several morphotypes (Komárek et Anagnostidis 1998), the taxonomic value of which is not clear. The genus was confirmed genetically, and from recent studies (Komárková et al. 2009) follows that in *Eucapsis* belong also other morphologically similar types with not very regularly organized cells, classified sooner in the genus *Chroococcus* (resp. subg. *Limnococcus*, now the genus *Limnococcus*). The Antarctic populations belong in a vicinity of this widely variable complex of morphotypes, but the differences are stable and distinct in such a degree, that the separation into special morphospecies is justifiable for the future taxonomic evaluation by molecular methods.

***Merismopedia* sp.** (Fig. 10)

**D:** Small, restricted flat colonies with spherical or hemispherical cells, arranged ± regularly in one plate. Mucilage indistinct, colorless. Cells ± spherical, pale blue-green, 3.2-6.2 µm in diameter.

**E:** Occurs sporadically in stabilized seepages and small lakes, less frequently in morain pools, always in small quantities; commonly grows together with *Eucapsis austro-alpina*, but the shape of colonies and cells is distinctly different.

**L:** Occurs commonly in JRI, in morain pools near the Lake Lachman II and in seepages near Monolith Lake.

**N:** A type with small, only few-celled colonies occurs usually together with *Eucapsis*, which is, however, more common (they exist *Eucapsis*-populations without *Merismopedia*). Probably a special species of *Merismopedia*, the taxonomic evaluation needs more material. – In KGI was found one small population similar to *Merismopedia* aff. *warmingiana* in one heavily eutrophized coastal pool (by sea lions, Fildes peninsula), but the material was insufficient for detailed study. It was the only material of this genus from KGI.

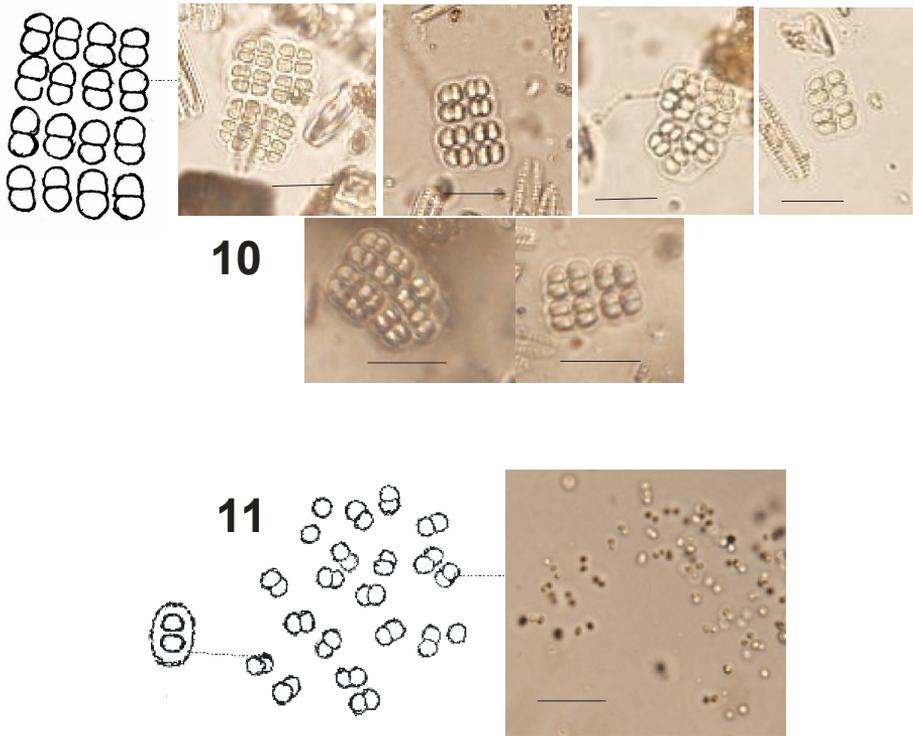
***Synechocystis* sp.** (Fig. 11)

**D:** Solitary, spherical cells, with pale blue-green, homogeneous content, 2.6-5 µm in diameter.

**E:** Usually subaerophytic on wet rocky walls. Often together with subaerophytic *Gloeocapsa*-type (possibly stage of member of this genus), but not occurring always on other localities with *Gloeocapsa*.

**L:** Found sporadically on JRI on wet rocks of the Ulu peninsula. Similar morphotypes were collected from seepages in KGI (e.g. near Ferraz Station), with bluish or free-floating („planktic“) cells. A similar type with intensely reddish color occurred commonly in one small lake near the Damay Point and in the stream flowing from this lake. Problematic taxon without cultivation and molecular studies.

**N:** Similar types from various localities have small cytomorphological deviations and differ also ecologically.



**Fig. 10.** *Merismopedia* sp., various colonies.

**Fig. 11.** *Synechocystis* sp., solitary and dividing cells. Bars = 20µm.

## Discussion

The modern classification of cyanobacteria is based on combined polyphasic evaluation of genetic and phenotypic diversity of populations and strains from various ecologically delimited habitats and from different geographic areas. Because different populations and taxa are restricted to various habitats and geographic areas, the phenotypic analysis of cyanobacterial microflora from distant regions and habitats must be an integral part of modern taxonomic classification. However, the morphological characters must be continually revised and corrected in agreement with genetic investigations. The exact phenotypic evaluation of cyanobacterial microflora is important of any region or biotope, especially from extreme habi-

tats. Modern "floristic" papers are therefore still necessary for the present taxonomic classification. However, they must fulfill several demands:

(1) They must be in agreement with recent taxonomic revisions based on and coinciding with the most modern molecular data. The completed evaluation of microflora of any region must be based on morphological evaluation in the first step, comprising all the morpho- and ecotypes of the studied region, but it must be also in agreement with the genetic knowledge of cyanobacterial diversity of the studied taxonomic group.

(2) It must be comparable with principles of traditional taxonomy, because the binomial nomenclatoric designations of

taxonomic units are still the only used in traditional as well as in most modern studies based on molecular procedures, but the arbitrary use of scientific names is a source of confusions. The name is the symbol of distinct and clearly defined taxonomic unit (genotype + ecotype + morphotype), and should be applied in this, and only this sense.

The coccoid cyanobacteria have usually a simple morphology and they were often identified also from specialized Antarctic ecosystems as the commonly distributed morphospecies from temperate or tropical zones, according to common identification books (Pankow et al. 1987, Vinocur et Pizarro 1995, and others). This is in contrast with our results, supported by previous molecular analyses. From our analyses follows that the number of OTUs or species of coccoid cyanobacteria is higher than is registered in this and other reviews. Just from the difficult cultivation and from small deviations in the morphology follows, that the Antarctic populations represent rich set of specialized and adapted forms. This problem is necessary to solve by special molecular studies, with comparison of morphologically similar populations from Antarctica and other regions.

The most serious problem in our work was that the majority of populations of unicellular and colonial cyanobacteria from the studied area were not yet studied by molecular sequencing. The main reason is the methodology. Cyanobacteria, particularly from various extreme, polar and tropical habitats are ecologically specialized and their transfer into cultures is not easy. Moreover, the cultured populations change often their character under standardized laboratory conditions (form of cells, disappearing of characteristic mucilaginous envelopes, etc.). The cultivation is more or less successful in filamentous, aheterocytous morpho- and ecotypes, but numerous coccoid ecotypes were not yet transferred in monospecific cultures and their phylogenetic position is

not exactly known. We tried to isolate all the studied populations from James Ross Island (JRI) in cultures, but we were successful only in very few cases. The cultured strains of coccoid cyanobacterial types occur sporadically and without any specific identification also in all previous molecular studies from Antarctic environments (Holm-Hansen 1964, Howard-Williams et al. 1986, Fritsen et Priscu 1998, Gordon et al. 2000, Taton et al. 2003, 2006, Sabbe et al. 2004, Jungblut et al. 2005, and others). However, the diversity of this type of cyanobacteria is more wider, as follows from our observations (Komárek 1999, Komárek et al. 2008) and also from the previous floristic and taxonomic studies from Antarctica (Broady 1986, 1989, 1996, 2005, Broady et Ohtani 1990, Ohtani et al. 1991, Luścińska et Kyč 1993, Vinocur et Pizarro 1995, Pizarro et al. 1996, Komárek 1999, Mataloni et al. 2000, Cavacini 2001, Mataloni et Pose 2001, and others).

The freshwater algal vegetation of the region of maritime Antarctica is still little known, particularly in the light of modern taxonomic concepts. E.g., the freshwater algal vegetation on JRI was mentioned only once up to now. In the paper of Hawes et Brazier (1991) are described only the main ecological parameters in creeks and seepages of this area and the characterization of different morphotypes is presented very shortly and needs other studies in detail. The common ecological situation (in respect to the microvegetation) of the whole area is presented in our recent studies (Komárek et Elster 2008, Komárek et al. 2008). The cyanobacterial flora is similar to the microvegetation of other polar regions, especially of maritime Antarctica, but several differences also appeared. Of course, it is different from other known habitats over the world. The morphological characteristics of populations of coccoid types from the order Synechococcales are described in this article, as a background of consequent

ecological and molecular studies. From the comparison with other cyanobacterial group follows that also in unicellular mor-

photypes of cyanobacteria from Antarctica will be detected numerous endemic types.

### Concluding remarks

Our paper represents the first review of simplest coccoid cyanobacteria from the large deglaciated area in the vicinity of the Czech Antarctic Station „J. G. Mendel“ at the James Ross Island in coastal Antarctica. The elaboration is based on living material, which was documented and measured. In our samples, several cyanobacterial coccoid morphotypes were recognized from freshwater phycocoenoses of the

studied area, which can not be identified on the specific level. They did not occur in clear developed populations and we had no possibility to recognize better their variability during the vegetation season. We demonstrate therefore only their morphological review with descriptions and taxonomic remarks, without taxonomic evaluation, as a material for future research.

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