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BIODIVERSITY AND DISTRIBUTION OF CYANOBACTERIA AT DRONNING MAUD LAND, EAST ANTARCTICA

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ABSTRACT. *Biodiversity and distribution of cyanobacteria at Dronning Maud Land, East Antarctica*.The current study describes the biodiversity and distribution of cyanobacteria from the natural habitats of Schirmacher land, East Antarctica surveyed during 23rd Indian Antarctic Expedition (2003–2004). Cyanobacteria were mapped using the Global Positioning System (GPS). A total of 109 species (91 species were non-heterocystous and 18 species were heterocystous) from 30 genera and 9 families were recorded; 67, 86 and 14 species of cyanobacteria were identified at altitudes of sea level >100 m, 101–150 m and 398–461 m, respectively. The relative frequency and relative density of cyanobacterial populations in the microbial mats showed that 11 species from 8 genera were abundant and 6 species (*Phormidium angustissimum, P. tenue, P. uncinatum Schizothrix vaginata, Nostoc kihlmanii* and *Plectonema terebrans*) could be considered as dominant species in the study area.

Key words. Antarctic, cyanobacteria, biodiversity, blue-green algae, Schirmacher oasis, Species distribution.

RESUMEN. *Biodiversidad y distribución de las cianobacterias de Dronning Maud Land, Antártida Oriental*. En este estudio se describe la biodiversidad y distribución de las cianobacterias presentes en los hábitats naturales de Schirmacher, Antártida Oriental, muestreados durante la 23ª Expedición India a la Antártida (2003-2004). Las muestras de cianobacterias fueron georreferenciadas mediante un GPS. Se identificaron 109 especies (91 no heterocistadas y 18 provistas de heterocistes) de 30 géneros y 9 familias; en los tramos de altitud sobre el nivel del mar >100 m, 101-150 m y 398-461 m se detectaron 67, 86 y 14 especies, respectivamente. La frecuencia y densidad relativas de las poblaciones de cianobacterias en los tapices microbianos mostraron que 11 especies de 8 géneros eran abundantes y que 6 especies (*Phormidium angustissimum, P. tenue, P. uncinatum, Schizothrix vaginata, Nostoc kihlmanii* y *Plectonema terebrans*) se pueden considerar como dominantes en el área de estudio.

Palabras clave. Algas verde-azuladas, Antártida, cianobacterias, distribución de especies, oasis de Schirmacher.

INTRODUCTION

Cyanobacteria have often been recorded as the dominant photoautotrophs in terrestrial habitats of the Antarctic ecosystem. Except for recent studies which have utilized molecular genetic approaches (e.g. Taton *et al.*, 2003), Antarctic cyanobacteria have been identified using morphological features (Vincent, 2000a). According to Komárek (1999), many Antarctic taxa have been erroneously assigned to cosmopolitan species due to the use of taxonomic keys developed for temperate and tropical microflora. The hypothesis that there are endemic cyanobacteria in polar environments (Vincent, 2000b) is supported by Antarctica having been geographically isolated for several million years, by the difficulty of long-range dispersal and by observation that there has probably been environmental selection for adaptive survival strategies.

Early taxonomic studies on the distribution of cyanobacteria have been reviewed by Hirano (1965) and Koob (1967). The taxonomy of Antarctic algae and cyanobacteria was extensively reviewed by Broady (1979, 1996). In general studies have been superficial due to inadequacies in scope of collections, treatment of samples and reliability of identifications. These problems are also found in more recent studies such as those describing diversity and distribution of micro-algae from South Orkney Islands (Broady, 1979), ice free areas of Lützow-Holm Bay (Akiyama, 1967; Ohtani, 1987), southern Victoria Land (Seaburg *et al.*, 1979), inland mountains of western Dronning Maud Land (Ryan et al., 1989), Edward VII Peninsula (Broady, 1989), Pensacola Mountains (Parker *et al.*, 1982), Framnes Mountains (Broady, 1981) and Queen Maud Range (Claridge *et al.*, 1971; Cameron 1972a, 1972b). Pankow *et al.* (1990, 1991) reported 220 species of algae including 100 cyanobacterial taxa from 600 samples during 1988 and 1989 and 98 species of cyanobacteria from 251 samples respectively collected from Schirmacher oasis.

A review of the geographical, ecological and physiological properties of the polar algae (Elster & Benson 2004) discusses the possibilities of future application of Arctic and Antarctic environmental research in the context of applied cryobiology. For instance, cyanobacteria that survive under extreme environmental conditions could produce novel bioactive compounds with useful properties (Gustafson *et al.*, 1989; Patterson *et al.*, 1991, Thajuddin and Subramanian, 2005). This survey of biodiversity and distribution of cyanobacteria at Schirmacher Oasis in Dronning Maud Land, East Antarctica, during 23rd Indian Antarctic Expedition (2003 – 2004), is a first step towards recognition of species of potential applied importance.

MATERIALS AND METHODS

The Schirmacher Oasis, Dronning Maud land (70^{o}46’04”-70^{o}44’21”S; 11^{o}49’54”-11^{o}26’ 03”E) is approximately 70 km south of Prinsesse Astrid Kyst. It consists of number of rocky hills and valleys varying in altitude from 0 to 461 m above the sea level. It has a maximum width of 3km and a length of 20km and is oriented in an east-west direction. The northeastern and north western corners border ice-shelf while the southwestern extremity borders the polar ice-sheet. The southeastern end lies on a rocky portion. The region can be divided into four distinct topographic units – the southern continental ice sheet, rocky hill slopes, lakes and northern undulatory shelf ice.

The area has three types of lakes *viz*.

pro-glacial, land locked and epi-shelf lakes, all of which are in closed basins. The average annual temperature is -10^{o}C and mean wind velocity is about 10ms^{-1}. The average precipitation (snow) ranges between 250-300mm and relative air humidity is 15-20%. During the short summer, melt-streams from which flow into the lakes. The valleys are ice-free because the mountains block ice flow from the polar plateau and low precipitation and strong katabatic winds lead to little snow accumulation.

Samples were collected by the first author on 1st January to 25th February 2004. Sixty five samples of visible algal mats and colonies were collected from different streams, ponds, lakes and areas of moss carpets. Samples were scraped into sterile plastic bottles using sterile blades and forceps and were transported frozen using dry ice to the National Centre for Antarctic and Ocean Research, Headland Sada, Vasco-Da-Gama, Goa 403804, India and Department of Microbiology, Bharathidasan University, India for taxonomic and cultural studies.

At each site, water temperature, pH and conductivity were recorded (tab. 1) using Orion 4 Star meter (Thermo Electron Corporation, USA). A portion of each sample was preserved in 4% formalin, stained with iodine and methylene blue for subsequent light microscopic examination of cyanobacteria. Slides were mounted in glycerin and sealed with wax and were stored at the Polar Herbarium of the National Centre for Antarctic and Ocean Research (NCAOR), Goa, India. An additional portion of each sample was used for isolation of cyanobacteria for future studies.

Specimens were observed with an Olympus BX51 microscope equipped with DP-70 camera and image analysis software and a Leitz Diaplon (Germany) photomicrographic unit. The morphological parameters such as cell shape, width and length of intercalary cells; presence or absence of constriction at the cross wall, and of a sheath; color of the sheath; nature of trichomes and filaments; presence or absence of heterocyst; width and length of heterocyst were taken into consideration during the identification of taxa. For each biometrical character, 30 measurements were obtained from cells, heterocyst, and filaments sampled at random. Identifications of morphospecies were made using the major floras to cyanobacteria of Geitler (1932), Desikachary (1959), Anagnostidis & Komárek (1988) and Komárek & Anagnostidis (1989) as well as descriptions in the Antarctic literature (Broady, 1982; Broady & Kibblewhite, 1991; McKnight *et al.*, 1998) were used for identification of cyanobacterial morphotypes. Relative frequency (RF) and relative density (RD) of each species (Table 2) were calculated using a method similar to that of Priddle & Belcher (1982):

RF = (Number of samples in which species is present × 100) /Total number of species

RD = (Total number of species in

Altitudes (m)	**Water temperature (ºC)**	**pH**	**Conductivity (mV)**
Sea level to 100	0.8 - 10.2	4.8 - 8.3	95 - 272
101 - 150	0.6 - 12.1	4.8 - 12.1	11 - 208
398 - 461	4.8 - 7.8	5.5 - 5.9	120 - 180

Table 1. Physical parameters of different altitudes of Schirmacher Oasis, East Antarctica. *Parámetros físicos, a diferentes altitudes, del oasis de Schirmacher, Antártida Oriental.*

S.No	Organisms	Altitude[1] I	II	III	Relative Frequency	Relative Density	Contribution[2]
	Family : Chroococcaceae						
1.	*Chroococcus limneticus* var. *elegans* (Lem.) Hollerbach		+		3.1	10.3	R
2.	*Chroococcus minimus* (Keissler) Lemm.	+	+		9.2	11.59	R
3.	*Chroococcus minutus* (Kütz.) Näg.	+	+		10.8	13.1	F
4.	*Chroococcus pallidus* Näg.	+	+		4.6	11.54	R
5.	*Chroococcus varius* Braun (Fig. 2c)	+			1.5	12.33	R
6.	*Gloeocapsa atrata* (Turt.) Kütz.		+		1.5	7.5	R
7.	*Gloeocapsa fusco-lutea* (Näg.) Kütz.	+	+		3.1	8.6	R
8.	*Gloeocapsa granosa* (Berk.) Kütz. (Fig. 2g)	+	+		24.6	29.8	R
9.	*Gloeocapsa luteo-fusca* Martens.		+		1.5	8.5	R
10.	*Gloeocapsa magma* (Bréb.) Kütz.		+	+	7.7	13.9	R
11.	*Gloeocapsa montana* Kütz.		+		7.7	12.8	R
12.	*Gloeocapsa polydermatica* Kütz.		+		1.5	8.6	R
13.	*Gloeocapsa rupestris* Kütz.		+		3.1	7.9	R
1 4.	*Gloeocapsa sanguinea* (Ag.) Kütz.	+	+	+	33.8	26.9	A
15.	*Gloeocapsa ralfsiana* (Harv.) Kütz.	+			1.5	8.8	R
16.	*Gloeocapsa alpina* (Näg.) Brand.		+		1.5	4.2	R
17.	*Gloeocapsa kuetzingiana* Näg.	+	+		3.1	7.1	R
18.	*Gloeothece samoensis* Wille. (Fig. 2f)		+		6.2	20.7	F
19.	*Gloeothece rupestris* Kütz.		+	+	3.1	10.3	R
20.	*Aphanocapsa delicatissima* W. et. G. S. West. (Fig. 2b)	+	+		7.7	11.8	R
21.	*Aphanocapsa montana* Cramer		+		4.6	9.6	R
22.	*Aphanocapsa muscicola* (Menegh.) Wille	+	+		6.2	15.3	R
23.	*Aphanothece caldariorum* Richter, P.	+	+		4.6	12.0	R
24.	*Aphanothece clathrata* W. et. G. S. West (Fig. 2a)	+	+		3.1	12.2	R
25.	*Aphanothece heterospora* Rabenh.	+	+		3.1	12.5	R
26.	*Aphanothece pallida* (Kütz.) Rabenhorst	+	+		3.1	10.7	R
27.	*Aphanothece saxicola* Näg.	+			1.5	8.9	R
28.	*Synechococcus aeruginosus* Näg.	+	+		4.6	6.5	R
29.	*Synechococcus cedrorum* Sauv.		+		1.5	7.1	R
30.	*Synechococcus major* Schröter. (Fig. 2d)	+			1.5	8.3	R
31.	*Synechocystis aquatilis* Sauv.	+	+		10.8	11.1	R
32.	*Synechocystis pevalekii* Erceg.	+	+		13.8	18.6	F
33.	*Synechocystis sallensis* Skuja (Fig. 2e)		+		1.5	8.0	R
	Family : Entophysolidaceae						
34.	*Chlorogloea microcystoides* Geitler.	+			1.5	5.7	R
35.	*Chamaesiphon subglobosus* (Rostaf.) Lemm.		+		1.5	5.2	R
	Family : Pleurocapsaceae						
36.	*Myxosarcina chroococcoides* Geitler		+		1.5	4.3	R
37.	*Pleurocapsa minor* Hansg.	+			1.5	11.4	R
	Family : Hyallaceae						
38.	*Xenococcus* sp. UN1		+		1.5	16.1	R
	Family : Oscillatoriaceae						
39.	*Spirulina jenneri* (Stiz.) Geitler		+		1.5	19.4	R
40.	*Oscillatoria anguina* (Bory) Gom. (Fig. 2h)	+			1.5	14.3	R
41.	*Oscillatoria animalis* Agardh.		+		1.5	9.1	R
42.	*Oscillatoria borneti* var. *tenuis* Zukal	+	+		9.2	27.7	F
43.	*Oscillatoria brevis* (Kütz.) Gomont.		+		3.1	11.1	R
44.	*Oscillatoria granulata* Gardner		+		6.2	11.5	R
45.	*Oscillatoria irrigua* Kütz.	+			1.5	5.9	R
46.	*Oscillatoria ornata* Kütz.	+			1.5	7.9	R
47.	*Oscillatoria pseudogemminata* Schmid.		+		1.5	3.6	R
48.	*Oscillatoria sancta* (Kütz.) Gom.	+			1.5	11.1	R
49.	*Oscillatoria subbrevis* Schmidle	+	+		27.7	31.8	A
50.	*Oscillatoria subproboscidea* West, W. and G. S.	+	+		6.2	17.2	F
51.	*Oscillatoria tenuis* Agardh.	+	+		4.6	26.7	F
52.	*Oscillatoria terebreformis* Ag. ex Gomont	+	+	+	16.9	27.3	A
53.	*Oscillatoria chlorina* Kütz. ex Gomont		+		1.5	8.3	R
54.	*Oscillatoria willei* Gardner em. Drouet	+			1.5	7.3	R
55.	*Phormidium ambiguum* Gomont	+	+		10.8	33.3	A
56.	*Phormidium angustissimum* W. et. G. S. West	+	+	+	46.2	38.5	D

57. *Phormidium anomala* Rao C. B.	+	+		4.6	7.1	R
58. *Phormidium antarcticum* W. et. G. S. West	+	+		13.8	21.7	F
59. *Phormidium autumnale* (Ag.) Gom	+	+	+	13.8	5.1	R
60. *Phormidium corium* (Ag.) Gom.	+	+		35.4	25.0	A
61. *Phormidium crouanii* Gom.		+		1.5	8.3	R
62. *Phormidium foveolarum* (Montagne.) Gom.		+		9.2	10.4	R
63. *Phormidium fragile* (Menegh.) Gom.	+	+		9.2	11.6	R
64. *Phormidium laminosum* Gom.	+	+		12.3	10.7	F
65. *Phormidium pristleyi* F. E. Fritsch. (Fig. 2i)		+		1.5	6.7	R
66. *Phormidium mucosum* Gardner.	+			4.6	9.7	R
67. *Phormidium subincrustatum* Fritsch and Rich.		+		1.5	10.3	R
68. *Phormidium subfuscum* Kütz. ex. Gom.	+			1.5	9.7	R
69. *Phormidium tenue* (Menegh.) Gom.	+	+		40.0	44.0	D
70. *Phormidium uncinatum* (Ag.) Gom	+	+	+	52.3	46.4	D
71. *Phormidium viride* (Vaucher) Lemm.		+		3.1	7.3	R
72. *Lyngbya aerugineo-coerulea* (Kütz.) Gom.	+	+	+	10.8	17.6	F
73. *Lyngbya aestuarii* Liebm.		+		1.5	10.3	R
74. *Lyngbya attenuata* F. E. Fritsch		+		4.6	12.5	R
75. *Lyngbya confervoides* Ag. ex. Gom.	+			1.5	16.2	R
76. *Lyngbya infixa* Fremy.		+		6.6	19.2	F
77. *Lyngbya sp.* UN2	+		+	3.1	12.1	R
78. *Phormidium molle* Gom.	+	+		4.6	5.8	R
79. *Lyngbya lutea (*Ag.) Gom	+	+		16.9	31.0	A
80. *Lyngbya martensiana* Menegh. (Fig. 2j)	+	+		20.0	30.4	A
81. *Lyngbya nigra* C. Ag. ex. Gom. (Fig. 2 k)	+	+		18.5	22.5	F
82. *Lyngbya semiplena* (C. Ag.) J. Ag.		+		1.5	6.3	R
83. *Microcoleus sociatus* West et. West (Fig. 2 l)	+	+	+	6.6	7.9	R
84. *Microcoleus vaginatus* (Vauch.) Gom. (Fig. 2m)		+		1.5	5.1	R
85. *Schizothrix antarctica* F. E. Fritsch.		+		3.1	5.1	R
86. *Schizothrix vaginata* (Näg.) Gom.	+	+	+	41.2	42.8	D
87. *Porphyrosiphon notarisii* (Menegh.) Kütz.	+			1.5	7.9	R
Family : Nostocaceae						
88. *Nostoc commune* Vaucher (Fig. 2p)	+	+		23.1	33.3	A
89. *Nostoc kihlmanii* Lemm. (Fig. 2o)	+	+	+	29.2	42.8	D
90. *Nostoc pruniforme* (Kütz.) Hariot.				1.5	7.1	R
91. *Nostoc verrucosum* Vaucher (Fig. 2n)		+		3.1	16.2	R
92. *Nostoc antarcticum* W. et G.S.West	+			1.5	6.8	R
93. *Anabaena cylindrica* Lemm.	+			1.5	11.5	R
94. *Anabaena* sp. UN3		+		1.5	12.1	R
95. *Nodularia harveyana* (Twaites) Thuret.		+		1.5	8.3	R
96. *Psudanabaena constricta* (Szafer) Lauterb.	+	+		4.6	10.8	R
Family : Scytonemataceae						
97. *Plectonema gracillimum* (Zopf) Hansgirg	+	+	+	46.2	22.2	D
98. *Plectonema terebrans* Born. et Flah.	+	+	+	15.4	22.2	F
99. *Plectonema* sp. UN4		+		3.1	10.7	R
100. *Scytonema myochrous* (Dillw.) Ag. ex. Born. et. Flah. (Fig. 2s)	+	+		16.9	33.3	A
101. *Tolypothrix distorta* (Kütz.) Born et Flah. (Fig. 2t)		+		1.5	6.3	R
102. *Tolypothrix byssoidea* (Hass.) Kirchner ex Bornet et Flah.		+		1.5	17.6	R
Family : Rivulariaceae						
103. *Calothrix crustacea* Thuret. (Fig. 2q)	+	+		7.8	27.3	F
104. *Calothrix cylindrica* Fremy (Fig. 2r)	+	+		16.9	25.0	F
105. *Calothrix gelatinosa* (Böcher) V. Poljanskij		+		1.5	10.3	R
106. *Calothrix parietina* Thuret ex. Born et. Flah.		+		1.5	5.4	R
107. *Calothrix braunii* Born et. Flah.	+			1.5	5.1	R
108. *Rivularia minutula* (Kütz.) Born et. Flah	+	+		26.2	38.4	A
Family : Stigonemataceae						
109. *Stigonema minutum* (Ag.) Hass. Ex Bornet et Flah.	+	+		7.8	37.5	A
Total number of species	67	89	14			

[1]Altitudes : I – Sea level to 100 meter; II – 1001 to 150 meters; III – 398 to 461 meters; [2]Based on relative frequency and density data (see Materials and methods).R – Rare or Occasional; F – Frequent; A – Abundant; D - Dominant

Table 2. Biodiversity, distribution, relative frequency and density of cyanobacteria from different altitudes of Dronning Moud, East Antarctica. *Biodiversidad, distribución, frecuencia relativa y densidad relativa de cianobacterias, a diferentes altitudes en Dronning Moud, Antártida Oriental.*

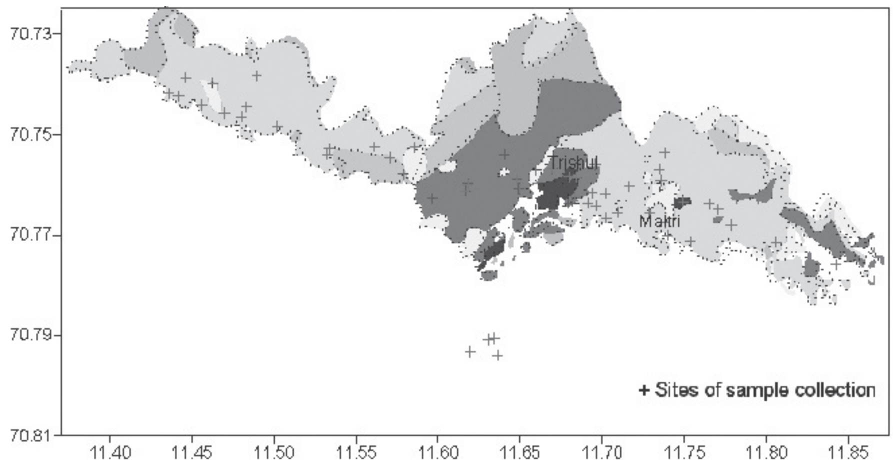


Figure 1. Distribution of microbial mats near lakes and streams of Schimacher Oasis, East Antarctica.
Distribución de tapices microbianos en lagos y arroyos del oasis de Schimacher, Antártida Oriental.

microscope field × 100)/ Total number of individuals in microscope field,

where microscope field represent in an area of 1.31 mm^2. The average between relative frequency and density (RFD) was calculated for each species; RFD represent an index for its relative dominance:

RFD = (RF + RD)/2

The maximum value was considered as 100% and on this basis species of a site were divided in to four classes, ie., 1 – 25 (rare or occasional), 26 – 50 (frequent), 51 – 75 (abundant), and 76 – 100 (dominant).

RESULTS AND DISCUSSION

Variations in temperature, pH and conductivity were observed at different altitudes during the sampling periods (tab. 1). Acidic pH was recorded in the soils of high altitudes (398 to 461 m) where only 14 morphotypes were identified. The maximum cyanobacterial diversity was recorded in soils of slightly acidic to alkaline pH (6.0 to 8.3). Air temperature and soil conductivity does not show any strict correlation with the diversity and distribution of cyanobacteria.

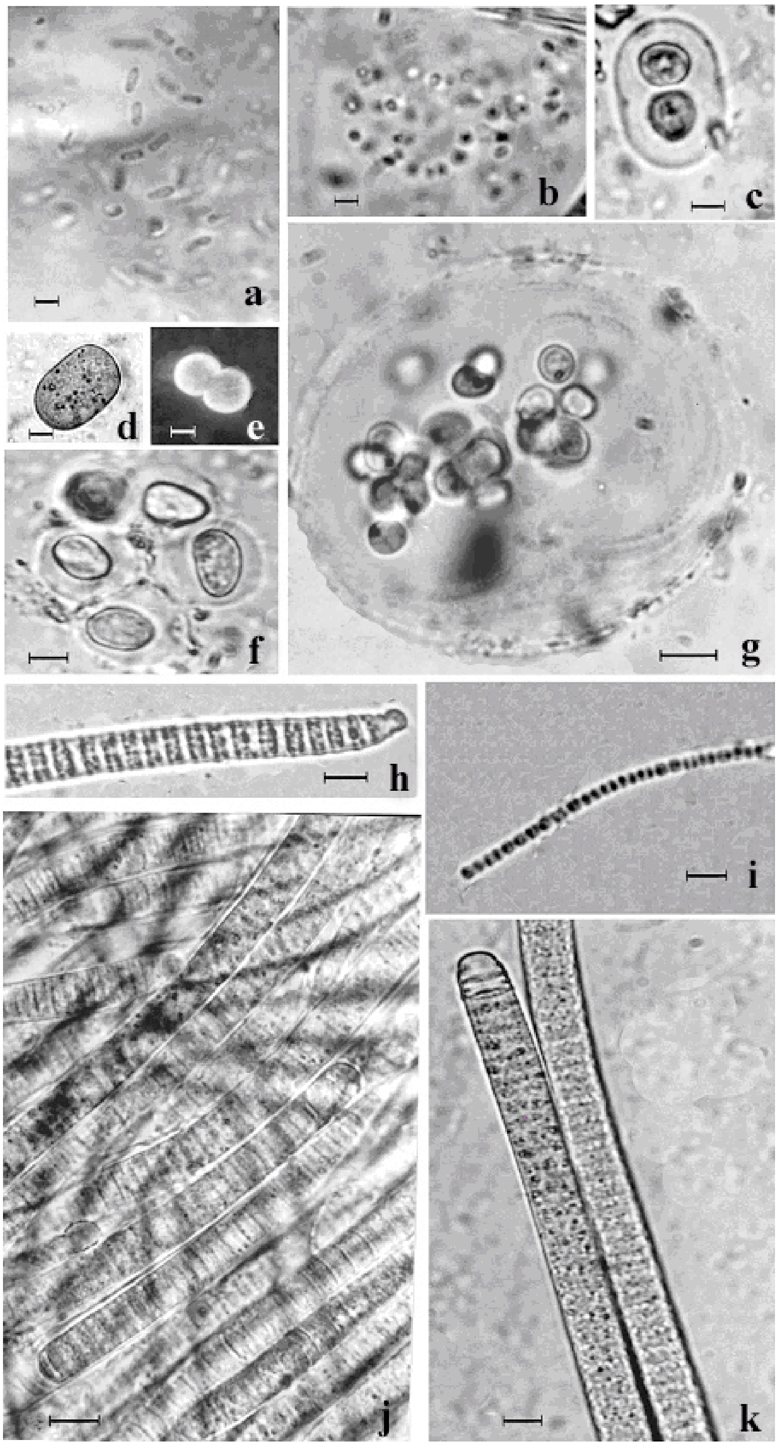
Biodiversity, distribution, relative frequency and density of cyanobacteria from different altitudes are presented in table 2. A total of 109 morphospecies from 30 genera and 9 families were recorded from 60 sixty sites (fig. 1). Photomicrographs of most common morphotypes are shown in fig 2 (a-t).

Microbial mats collected from pebbles and stones lying in streams and lakes contained 91 non-heterocystous and 18 heterocystous morphospecies . The maximal diversity of cyanobacteria associated with stream habitats may be because of cumulative factors, such as: continuous flow of fresh nutrients; oxygenic condition, availability of light and quick rise of temperature because of less quantity of water. As regards its quality of diversity and endemism in Antarctica is concern, it is very poor because of its climatic and geographical location on earth. When geographical distribution was considered, with the exception of *Oscillatoria subproboscidea*, a species apparently endemic to Antarctica (Komárek, 1999), the species found in this study have been found in various biotopes outside Antarctica and appear to have cosmopolitan distributions. Our results support the suggestion that endemism may be rare among Antarctic cyanobacteria.

The heterocystous forms fix atmospheric nitrogen and enrich the habitat for settling of other organisms such algae, mosses and lichens. Of the 109 species recorded only 16.5% (18 species) were heterocystous, but, of these *Nostoc commune, Nostoc kihlmanii, Scytonema myochrous, Rivularia minutula* and *Stigonema minutum* were often abundant (tab.2). Jones (1977) has demonstrated that N_2-fixation is sensitive to water stress. *Nostoc commune* is the most frequently noted macroscopic morphospecies at the Oasis. The heterocystous forms supply nitrogen to mosses and in turn mosses offer the wet substratum which is very much needed by cyanophytes. The moss cushions, growing on wet places, especially below the temporary melting borders of snow drifts showed rich diversity and abundance of cyanobacteria. 67, 86 and 14 morphospecies were found at altitudes of sea level to 100 m, 101–150 m and 398–461 m respectively (tab. 2). Relative abundance and diversity seems to decrease with increasing altitude and latitude, from the coast to the ice slope regions due to severe climatic conditions (Pickard & Seppelt, 1984; Broady, 1996; Broady & Weinstein, 1998). As many as 11 species *viz. Gloeocapsa sanguinea, Oscillatoria terebreformis*, *Phormidium angustissimum, P. autumnale, P. uncinatum, Lyngbya aerugino-coerulea, Microcoleus sociatus, Schizothrix vaginata, Nostoc kihlmanii Plectonema gracillimum* and *Pl. terebrans* were considered as versatile species since they grew in all surveyed areas and altitudes (tab. 2) .

Thirty-eight unicellular/colonial morphospecies were identified at varying abundance (tab. 2). Most unicellular and filamentous forms are surrounded by varied thickness of mucilaginous sheath which protects against rapid desiccation and enables quick absorption of water. Therefore most species reported were of rare occurrence in samples and often there were only a few cells or filaments. In microbial mats 11 morphospecies from 8 genera were abundant or dominant (tab. 2). Kashyap *et al.* (1988) recorded 34 morphospecies including unicellular, filamentous non-heterocystous and heterocystous forms in streams, lakes, associated with mosses and on soils of Schirmacher Oasis and reported that *Stigonema minutum*, *Nostoc commune* and *Gloeocapsa* sp. were associated with all moss samples. Pandey *et al.* (1995) studied the algal and cyanobacterial flora of six freshwater streams of Schirmacher Oasis and reported 30 species of algae predominantly belonging to cyanobacteria. Algal flora from soil, water, moss and lichen samples collected from thirty lakes of Schirmacher Oasis was analysed by Shukla *et al.* (1999). They revealed the presence of a total of 16 taxa of Cyanobacteria 4 Chlorophyceae and 3 Bacillariophyceae. Occurrence and distribution of the algal flora of Schirmacher Oasis was recorded by Singh (2000) and reported 33 taxa grouped under cyanophytes, green algae and diatoms.

In the Schirmacher Oasis 220 taxa have been evident since 1965 (Alesinskaja & Bardin, 1965; Komárek & Ruzicka, 1966; Lavrenko, 1966; Simonov, 1971; Saag, 1979). This is approximately one third of all the check-list of algae listed from Antarctic continent. Primary production in the lakes of Schirmacher Oasis was observed by Kaup (1986). Pankow *et al.* (1987) reported 72 taxa from Schirmacher Oasis of which 25 were new to Antarctica and later reported 133 taxa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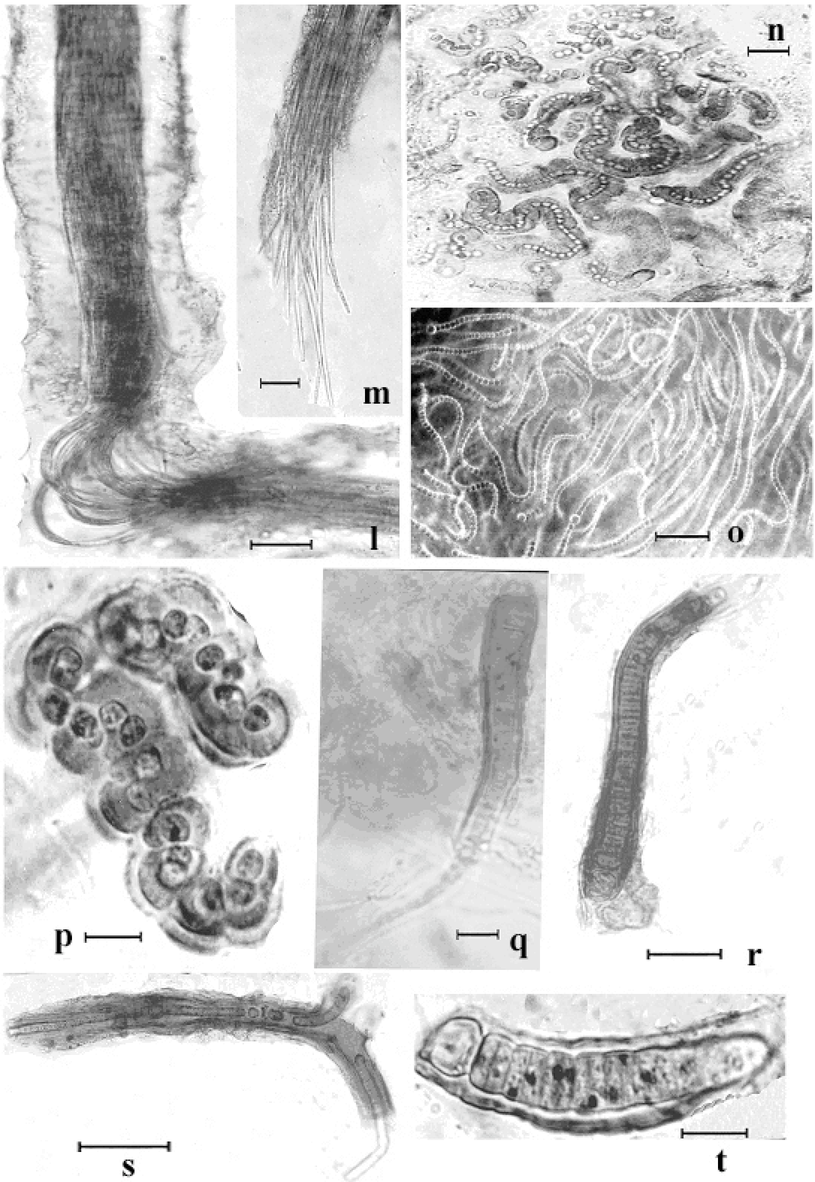

Fig. 2 (a–t). Photomicrographs illustrating the morphological appearance of cyanobacteria of Schimacher Oasis, East Antartica. a: *Aphanothece clathrata*; b: *Aphanocapsa delicatissima*; c: *Chroococcus varius*; d: *Synechococcus major*; e: *Synechocystis sallensis*; f: *Gloeothece samoensis*; g: *Gloeocapsa granosa*; h: *Oscillatoria anguina*; i: *Phormidium pristleyi*; j: *Lyngbya martensiana*; k: *Lyngbya nigra*; l: *Microcoleus sociatus*; m: *Microcoleus vaginatus*; n: *Nostoc verrucosum*; o: *Nostoc kihlmanii*; p: *Nostoc commune*; q: *Calothrix crustaceae*; r: *Calothrix cylindrica*; s: *Scytonema mychrous* and t: *Tolypothrix distorta*. All bright field microphotographs. Bars, 10 µm. *(a-t). Fotomicrografías ilustrando la apariencia morfológica de las cianobactarias del oasis de Schimacher, Antártida Oriental.*

and out of these 38 were new to continental Antarctica (Pankow *et al.*, 1990). The data on relative frequency and density revealed that six species such as *Phormidium angustissimum, P. tenue, P. uncinatum, Schizothrix vaginata, Nostoc kihlmanii* and *Plectonema terebrans* could be considered abundant in the study area, since they grow luxuriantly in most of the areas surveyed. As many as 48 species belonging to the family Oscillatoriaceae could be considered as dominant species in their biodiversity and several species belonging to *Lyngbya, Oscillatoria* and *Phormidium* are the most frequently reported taxa observed in the Antarctic terrestrial ecosystem, including streams, ponds, lakes, moist soils of different altitudes, which showed their morphological plasticity in adapting to harsh climatic conditions.

Schirmacher Oasis represents a very important area in east Antarctica, because its cyanobacterial diversity and distribution, which are more or less common with those in many other areas. This area could be more suitable for monitoring the effects of environmental changes with the succession of cyanobacteria and other algal forms, and to use this area for long term ecological research.

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