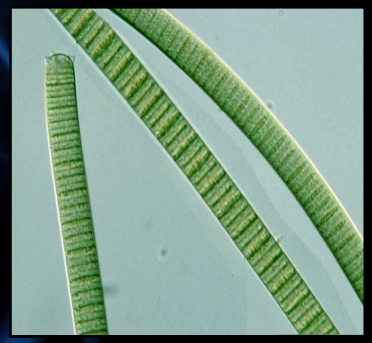
ALGAL DIVERSITY OF FRESHWATER STREAMS OF SCHIRMACHER OASIS, ANTARCTICA



By

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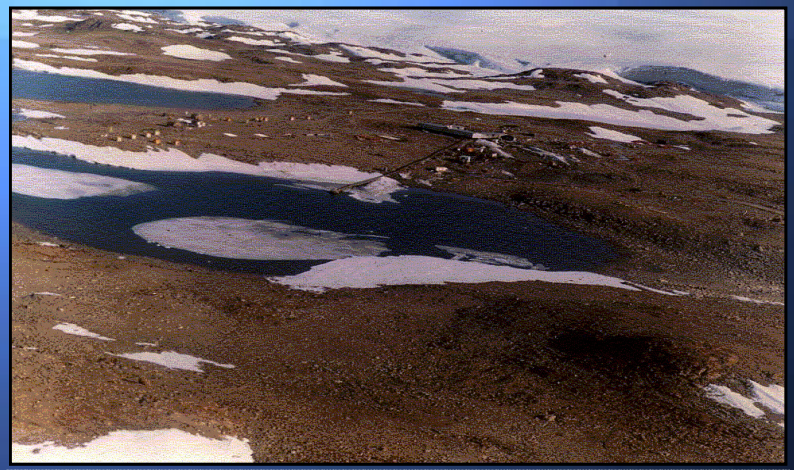
INTRODUCTION

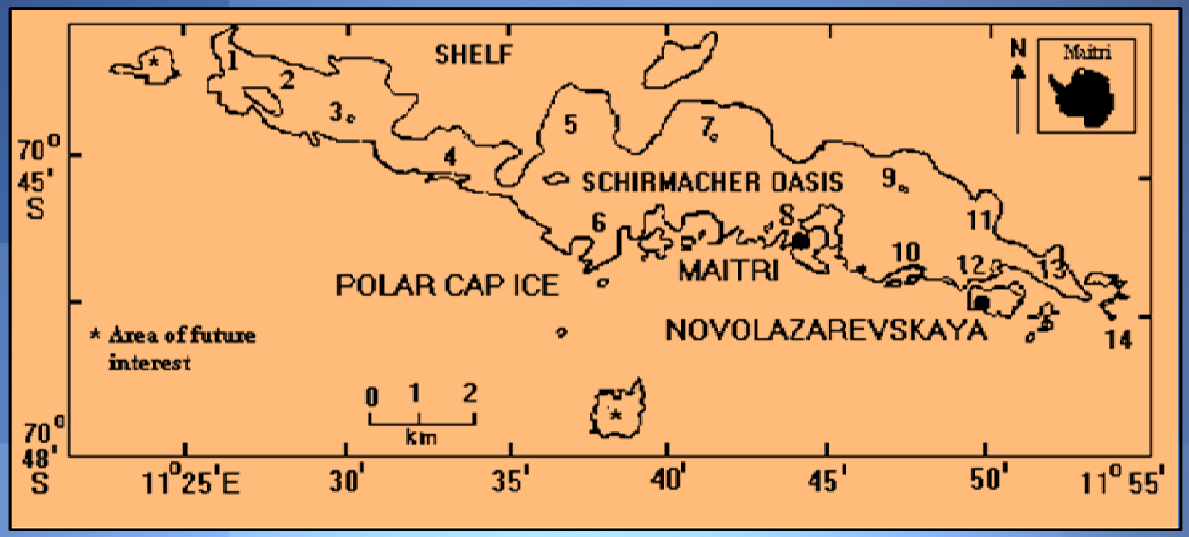
- The Antarctic flora has evolved millions of years ago on the supercontinent of Gondwana and originally consisted of warmer and wetter, forests of podocarps and southern beech.
- The separation of South America from Antarctica 30-35 million years ago allowed the Antarctic Circumpolar Current to form, which isolated Antarctica climatically and caused it to become much colder. The Antarctic flora subsequently died out in Antarctica, but is still an important component of the flora of southern Neotropic (South America) and Australasia, which were also former parts of Gondwana.
- Antarctica provides most harsh environment for growth and survival of organisms. The terrestrial and aquatic organisms are encountered in restricted areas and it has been presumed that they have special physiological features enabling them to survive at low temperatures and prolonged period of darkness.
- Several investigations have been conducted to study the patterns of distribution and taxonomy of aquatic algae in continental Antarctica
- A great variety of fresh-water planktonic and Aufwuchs algae from small melt pools and year-round ponds at various places in Antarctica are described.
- In Schirmacher Oasis area, fresh-water habitats exhibit the complete range of trophic levels from extreme oligotrophy with a paucity of species and low organic production to hypereutrophy with blooms of a single or a few species.



Maitri along with fresh water lakes in Schirmacher Oasis

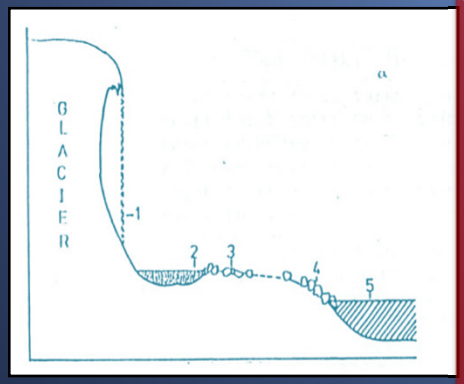
Materials and Methods: Study area

Location map of Indian permanent Stations in Antarctica

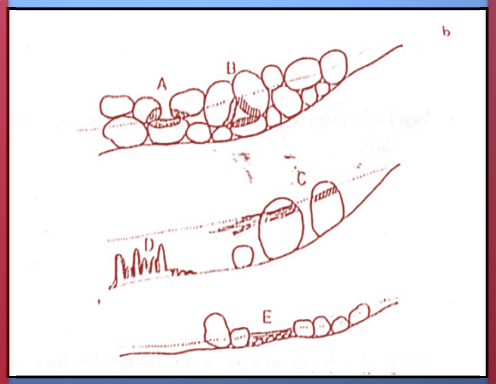


Map of Schirmacher Oasis (SO) showing the location of 14 different sampling sites. The location of the Indian Antarctic Station, Maitri and the Russian Antarctic Station, Novolazarevskaya are also seen.

- The Schimacher Oasis has a width of 3 km and a length of about 20 km and is oriented in east west direction (70⁰46'04"-70⁰44'21"S; 11⁰ 49'54"-11⁰26'03" E).



- During the polar summer, ice melts and water flows in the stream forming lakes
- A Scematic representation of vertical profile of a stream originating from a glacier and enterning a lake. The numbers represent place of water sampling from glacier (1), Pond, (2) proper stream, (3) Lower stream (4) and lake (5)



Two types of streams were observed: one derived from glaciers and second from snow . Diagrammatic representation of different habitats of algae and cyanobacteria

Materials and Methods: Algal study

- We examined the algae and cyanobacteria from three streams of glacier origin (WN, SEM, ST) which were about 500-1000 m in length and the three short (ca 200-400 m) snow drift melt water streams (EGF, EM, NS) were also examined.
- Algal samples were scraped form rocks and sediments into sterile plastic bags and specimen tubes using clean implements. Algal and cyanobacterial samples collected during the expeditions were brought to the field station and examined microscopically within 24h of collection. Identification was made using Bourelly, Geitler, and Desikachary.

Alpha diversity

$$\lambda = \sum_{i=1}^{R} p_i^2$$

Simpson index

$$H' = -\sum_{i=1}^{s} pi \log_2 pi$$

Shannon Wiener index

Species Richness

$$SR = S - 1 / \ln(n)$$

$$SR = S/\sqrt{n}$$

$$SR = S(n)^{1/2}$$

Evenness or Equitability

$$E = S/\log N_i - \log Ns$$

$$E_1 = D - D_{min}/D_{max} - D_{min}$$

$$E_2 = D/D_{max}$$

$$E_3 = H'/H'_{max} = H'/l_n(S) = l_n(N_i)/l_n(N_0)$$

$$E_4 = e^{H'}/S = N1/N0$$

$$E_5 = (1/\lambda) / e^{H'}$$

Beta diversity

$$\beta w = S/\sqrt{\alpha} - 1$$

Gamma diversity

$$\gamma = \alpha \times \beta \times Q$$

Cluster analysis

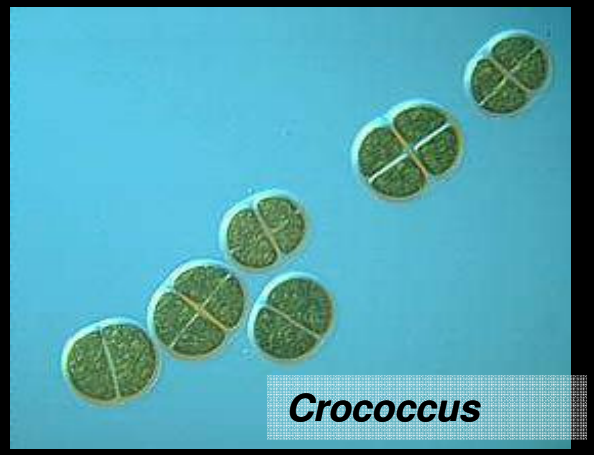
- It was done on the basis of species [+nce/ -nce] composition using Euclidean distance measure

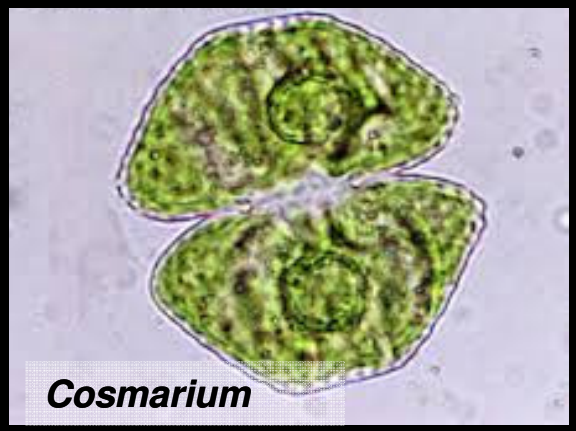
Results and discussion: Algal Species diversity

- The algal and cyanobacterial species which have been encountered in different streams of Oasis have been presented in (Table).
- It is evident that various streams situated at different locations varied in flora composition.
- The glacier bound stream SEM near Maitri Lake shows maximum abundance of cyanobacteria whereas the number of species encountered was minimum in Hill top snow drift bound stream EGF near German Station (extreme west of Oasis).
- Among the Cyanobacteria more than half of species were nitrogen fixers and *Oscillatoria limosa*, *Phormidium frigidum* and *Nostoc commune* were present in all the six streams studied.

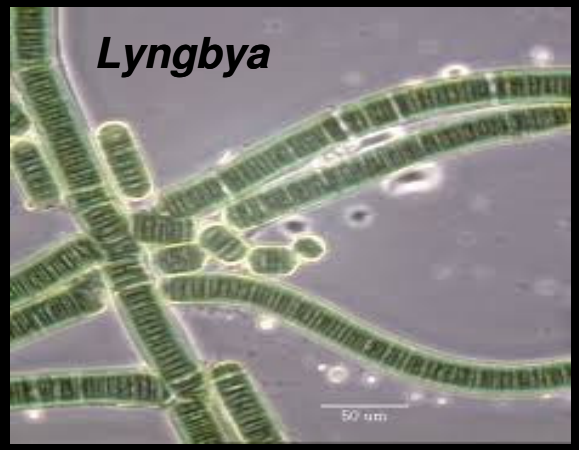
Algae and Cyanobacteria	Different fresh water streams					
	WM[1]	SEM[2]	ST[3]	EGF[4]	EM[5]	NS[6]
Chroococcus minutus	-	+	+	-	-	-
Gloeocapsa kuetzingiana	+	+	+	-	+	-
G. ralfsiana	+	+	+	-	+	+
G.magma	+	+	-	+	-	+
Aphanothece nidulans	-	-	+	-	-	+
Chaemasiphon subglobous	-	+	-	+	+	-
Lyngbya aeusturaii	-	+	-	-	+	+
L. attenuate	+	-	+	-	-	+
Oscillatoria limosa	+	+	+	+	+	+
O. kuetlitzii	+	+	+	-	+	-
O. limnetica	+	+	-	+	-	-
O. agardhii	-	-	+	-	+	+
Phormidium fragile	-	+	+	-	+	+
P.frigidum	+	+	+	+	+	+
P. autumnale	+	-	-	+	-	+
Plectonema sp	-	+	+	-	-	-
Nostoc commune	+	+	+	+	+	+
N.sphaericum	-	+	-	-	+	+
N. punctiforme	+	-	+	+	-	-
Nostoc sp	+	+	+	-	-	+
Anabaena sp.	-	+	+	-	+	-
Calothrix gracilis	-	+	+	+	-	+
C. parietina	+	+	-	+	+	+
C. brevissima	-	+	+	-	-	-
Tolypothrix conglutinata	-	-	+	-	+	+
Uronema sp	+	+	+	+	-	+
Cosmareum leave	-	+	+	+	+	+
Pinnularia borealis	+	+	+	-	-	-
Navicula multicopis	-	+	+	-	+	-
Nitzschia obtuse	-	+	+	-	-	+

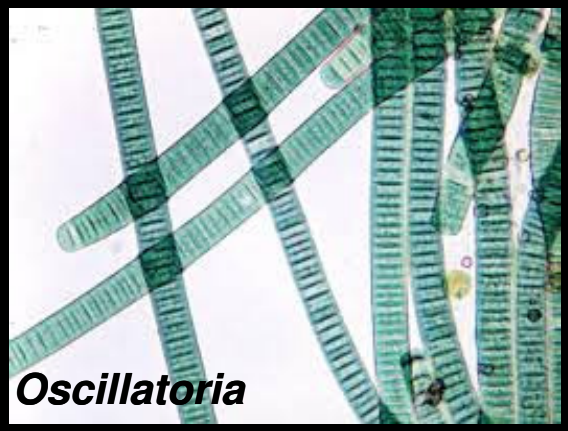
+ Present – Absent SO- Schirmacher oasis WM - West of Novolazaraveskaya (Russian Station in SO, SEM – South East of Maitri (Indian Station in Antarctica), ST- South of Trishul (a Nunateck in SO, EGF – East of George Foster (German Station in Antarctica), EM – East of Maitri, NS – North of Shivling


Crococcus


Cosmarium

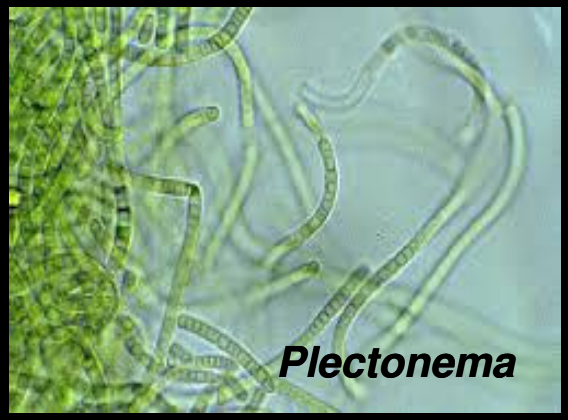

Gloeocapsa

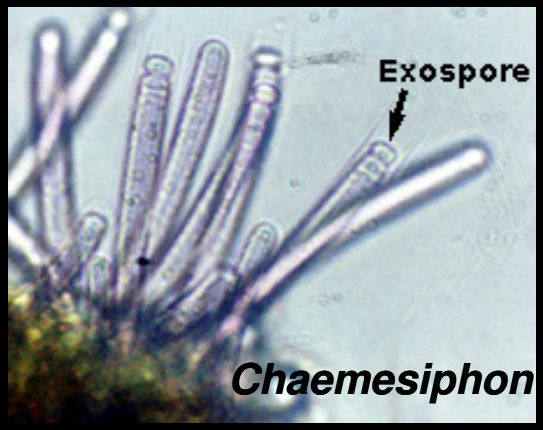

Lyngbya


Oscillatoria


Phormidium


Nostoc


Plectonema

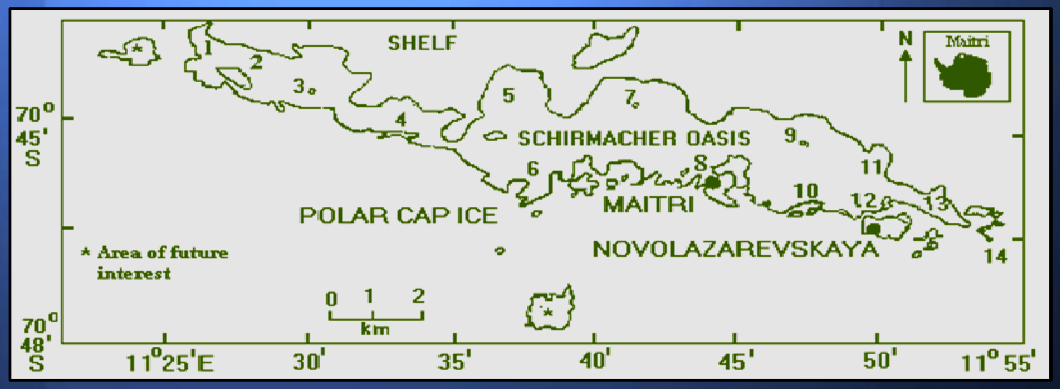

Exospore
Chaemesiphon

Results and discussion: Diversity Indices

- On the basis of relative frequency and density of species in six freshwater streams, the diversity indices was calculated to determine the richness, diversity and evenness.
- The value of Menhinck index (R2) of richness indicated that species richness of algae and Cyanobacteria was highest in stream SEM followed by stream NS. The lowest species richness was recorded in stream EGF. Although the values of Margalef's index of richness (R1) are higher than R2, it also followed the same trend.
- The species richness in different streams was in the order of SEM>NS>ST>EM>WN>EGF> The diversity indices revealed that maximum diversity exists in stream SEM and minimum in EGF.
- The species diversity (NI) decreases in order of SEM>NS>ST>EM>WN>EGF whereas value of λ increases with increase in diversity index (N1). The other diversity indices (H' & N1) also followed the same trend and not much difference was recorded in the indices of ST & NS, EM & WN stream. The evenness indices E4 (Hill ratio) and E5 (Modified Hill ratio) varies between 0.9 to 0.98 the higher value seems to be related to the dominance of several species.
- There is not much difference in the values of β diversity of the streams studied and these ranged from 29 to 29.188 whereas the γ – diversity is highest in stream SEM and lowest in WN. Evidently, it allows the comparison of stream diversity and gives an idea about how and which stream is different with the other stream as in the present study we have recorded that minimum γ diversity is found in stream EGF and maximum in SEM thus we can say that both are much different in comparison to other streams.

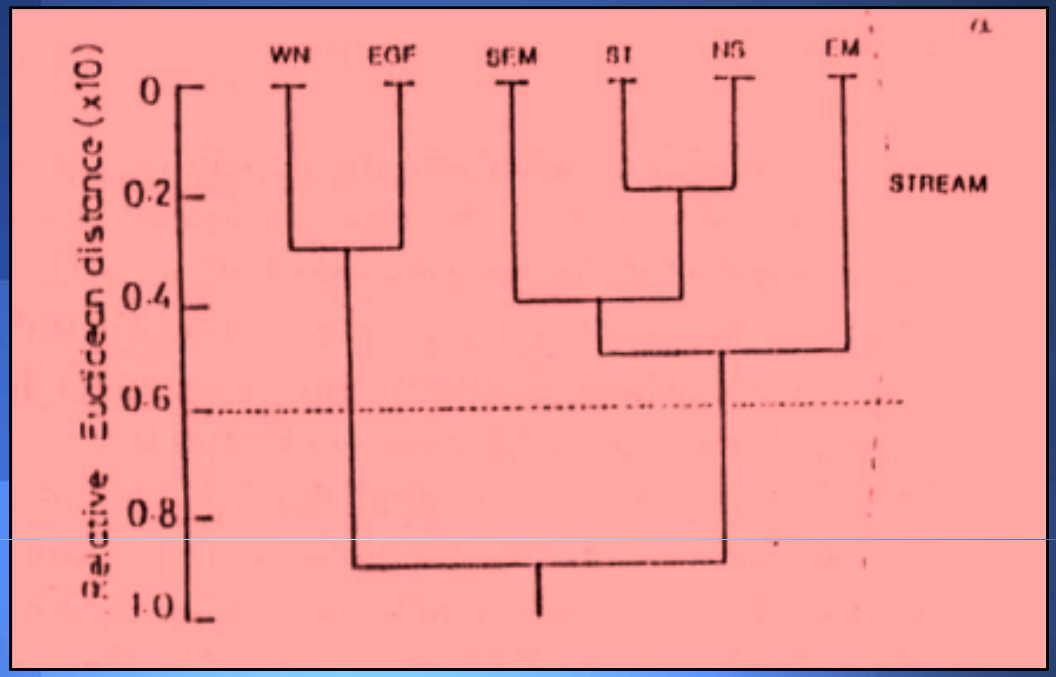
Diversity Indices		Freshwater Streams					
		WN	SEM	ST	EGF	EM	NS
Unified indices	Simpson's index (λ)	0.09	0.5	0.07	0.11	0.09	0.06
	Shannon Wiener index (H')	2.50	-2.98	-2.83	2.30	-2.50	-2.78
Species Richness	Menhinck index (R_1)	3.05	5.00	4.42	2.39	3.13	3.91
	Marglef index (R_2)	1.51	2.41	2.02	1.20	1.60	1.90
Evenness indices	Species Evenness (E_1)	0.92	0.94	0.92	0.93	0.92	0.95
	Species Evenness (E_2)	0.81	0.82	0.77	0.83	0.81	0.85
	Species Evenness (E_3)	0.80	0.81	0.76	0.82	0.80	0.84
	Hill Ratio (E_4)	0.93	0.97	0.90	0.93	0.94	0.98
	Modified Hill Ratio(E_5)	0.93	0.97	0.90	0.92	0.93	0.98
Beta Diversity	β-diversity (βw)	29.0	29.188	29.158	29.0	29.188	29.158
Gamma Diversity	γ-diversity	435	518.5	496.88	400.2	437.82	486.355

Various Diversity indices of Algae and Cyanobacteria



Results and discussion: Cluster analysis

- To illustrate the results we have used a cut off distance of 0.06 (shown as horizontal dash line in)
- At this level of resemblance there are two distinct clusters.
- in one cluster stream WN and EGF. and in second cluster stream SEM, ST, NS & EM. has been categorized.
- This shows the similarities between the streams of the clusters in terms of the algal composition.



Dendogram of clustering of Six freshwater streams using Euclidean distance

Some field photographs

Cyanobacteria growing on exposed part

Expedition vessel

Rocky area of the Schirmacher Oasis (inset a helicopter flying over the Maitri station and the continental ice is also seen).

Penguine Rookery

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