Seventeenth Indian Expedition to Antarctica, Scientific Report 2000
Department of Ocean Development, Technical Publication No. 15, PP 221-231

ECOLOGICAL STUDY OF ALGAL FLORA OF SCHIRMACHER OASIS OF ANTARCTICA

S.C. Singh
Banaras Hindu University, Varanasi

Abstract

Investigations were conducted in the Schirmacher oasis of Antarctica on the algal and cyanobacterial flora. However their diversity is not fully known as often collections have not been made from all habitats on a techniques have been inadequate for recognition of the total flora. Identification can be unreliable and are often left at generic level. Despite this it seems that they largely comprise cosmopolitan species but at a reduced diversity relative to other regions. Among the different species of algae, the cyanobacterial dominance was recorded. Phormidium and Nostoc species were much more dominant.

Introduction

Antarctica covers an area of about 14,000,000 sq. km. (5,400,000 sq. miles). The Antarctic circle (66°33's) defines the area where there is continuous sunlight in summer and continuous darkness in winter. Antarctica provides a harsh environment for growth and survival of organisms. Nevertheless, terrestrial and aquatic organisms are encountered in restricted areas and therefore presumably have special physiological features enabling them to survive at low temperatures and prolonged period of darkness (Fogg & Home 1970). There are numerous organisms, which survive the removal of all or almost all their cellular water without irreversible damage mainly by suspending their metabolism in dry state. Such organisms are referred as desiccation tolerant (Bewely 1979). Many cyanobacteria expresses marked tolerance to desiccation (Potts & Friedmann 1981, Brock 1975, Whitton et al. 1979; Whitton &

Potts 1982). Following pioneering investigations of the algal flora of the Victoria Land by West & West (1911) and Fritsch (1912, 1917) several investigations have been conducted to study the patterns of distribution and taxonomy of algae in continental Antarctica (Hirano, 1965, 1979; Parker et al., 1972; Karasawa & Fukushima, 1977; Priddle & Belcher, 1981, 1982; Broady 1982, 1989; Hawes, 1989; Howard Williams et al 1986).

In this report, we present results on distribution of algae mainly cyanbacteria from Schirmacher oasis.

Study Site

The Schirmacher oasis (70° 46' 04" - 70° 44' 21"S; 11° 49' 54" - 11° 26' 03"E), Dronning -Moud land, is approximately 70 km south of princes Astrid coast. It has a maximum width of 3km and a length of 20 km and is oriented in east-west direction. Average annual temperature is -10°C and mean wind velocity of about 10 ms-1. Average precipitation (snow) ranges between 250-300 mm and relative air humidity is 50 percent. During polar summer ice melts and water flows often into lakes. Two types of streams were observed, derived from glaciers, or from snow. Some terrestrial type of habitat of algae is summarized in Table 1.

Table I : Summary of habitats of terrestrial algae in Antarctica.

Algal community	Habitat
Lithophytic	On or within rock substrata
Epilithic	On external, exposed surfaces
Enolithic	Within diaphanous rocks, up to a few mm. below the surface
Chesmoendolithic	Within fissures and cracks open to the rock surface.
Cryptoendolithic	Within minute cavities inside the rock matrix.
Hypolithic	On the water surfaces of diaphanous stones lying on soils.

Edaphic	On the surface of and within soils classified broadly as: (i) alumic mineral soils, (ii) biogenic soils enriched in nutrients by bird and seal activity, (iii) brown earth soils which are restricted to Maritime Antarctica where they are found only below the two Antarctic vascular plants (Walton, 1984).
Epiphytic	On the living surfaces of mosses and liverworts.
Cryophilic	Between ice crystals in surface layers of melting snow.

Materials and Methods

Algal growths were usually visible to the naked eye as vivid green or blue green growths and occasionally less than 10x hand held lens. The presence of chasmolithic algae was ascertained by splitting rocks with a geological hammer. Algal samplers were removed into sterile polythene bags using clean forceps. All samples collected were brought to the field station and examined using bright field microscopy with magnifications up to 1000x.

Few terrestrial algae from macroscopic growths which can be identified by their visual appearance Prasiola crispa and Nostoc commune are the most frequently noted species and are often recorded in general botanical surveys. (e.g. Smith, 1972; Longton 1973). Enrichment of cultures, e.g. soil moist plate enrichment cultures (Lund, 1945) to stimulate the growth of a range of taxa present in low numbers.

Many terrestrial microalgae was identified with confidence only following their isolation and study of unialgal culture. Alsi the medium and growth conditions are selective for particular taxa. Additionally it can't always be assumed that the culture algae are active in the habitat. They may be present only in low numbers as resulting stages.

[a] Analysis of occurrence and distribution of algae

To understand the algal occurrence and distribution on the Antarctic soils, analysis of propegule banks of soils, snow, ice and following method did epiphytic surfaces (mainly with mosses and Lichens). Ice and snow were collected using aseptic precautions. Samples were melted and filtered through membrane filters (micropore filters) and was examined microscopically for the presence of recognizable algae.

[b] Analysis of the propagule bank of soils & rocks

The algal flora in the vicinity of Maitri station and at other site of Schirmacher oasis was analysed floristically using direct microscopic examination of the samples.

Identification of algae & cyanobacteria

Algal samples were scrapped from rocks and sediments into sterile plastic bags and specimen tubes using a variety of clean implements. Algal and cyanobacterial samples collected during the expeditions were brought to field station and examined microscopically within 24h. of collection.

Identification was made using Bourelly, 1966, 1968, 1970, Geitler 1932; Desikachary, 1959; Rippka et al., 1979.

Algal and cyanobacteral abundance relationship

Relative frequency and density of a species was determined as follows :-

$$\text{Relative frequency (RF)} = \frac{\text{No. of samples in which sps is present}}{\text{Total No. of samples}} \times 100$$

$$\text{Relative density (R.D.)} = \frac{\text{No. of individual of a sps. in microscopic field}}{\text{Total number of individuals in microscopic field}} \times 100$$

The average relative frequency and density (RFD) for a species was calculated as (RF + RD)/2.

The maximum 'value at site was considered as 100 present and all species at that site were divided into 4 classes, i.e. 0-25 (taxon present); 26-50 (common constituent); 51-75 (important) and 76-100 (dominant).

Results

The cyanobacteria Nostoc and Phormidium constitutes the dominant flora in Antarctic ecosystem showing in Table-2. During the course of the present investigation new algal species were encountered, although with some new variation. Some filamentous species (Oscillatoriaceae and filamentous green algae) remained attached to the rocks. The black epilithic crusts were abundant on rock surface occasionally covered by water during the period of heavy snow melts, for instance at the edge of the stream. Among different taxa recorded, Phormidium sp was dominant.

Cyanobacterial patches with copious mucilage were abundant on soil surface near the edge of the lakes and in the depression created by the turning of small rocks and stones in slow running streams. At some places they were in semiaquatic condition. Nostoc commune grew luxurantily at this habitat.

The streams due to the glacier melts near the Maitri lake exhibited the maximum number of cyanobacteria in contrast to the minimum on hill-tops and snow drift stream. More than half of the cyanobacterial species were N2-fixing, and Oscillatoria sp. Phormidium sps and Nostoc sps were present in the most of the lakes.

It is not only the low temperature that regulates the terrestrial microbial survival and growth but also the restricted availability of water associated osmotic-stress and substratum instability. It has also been demonstrated that N2-fixation is more sensitive to water stress. (Jones- 1977).

Discussion

Our observations that algal flora of Schirmacher oasis were dominated by cyanobacteria (80 percent of the total species recorded) is in conformity to the observations of Broady (1982). Among the cyanobacteria, the Oscillatorian forms were abundant and the contribution of N2-fixing species (including non-heterocystous forms like gloeocapsa) was more than 50% suggesting that they might play a significant role in Nitrogen-fixation.

The cyanobacterial population inhabiting the Antarctic-region must content with wide adaptability to extreme enviromental factors like low temperature, intermittent freezing and desiccation and above optimal and solar radiation. Very few organisms were able to withstand these factors but cyanobacteria, especially members of Oscillatoriales and Nostocales have been reported to grow luxuriantly under these conditions of low temperature. The survival mechanism of the algal population in this harsh environment still needs somee more investigation.

Acknowledgement

The author wish to thank the Department of Ocean Development, Govt, of India for supporting the work at Antarctica. Author is grateful to Mr. K.R. Sivan, team leader for the XVII Antarctica Expedition for full support and kind cooperation during the expedition. Author thanks the Head, Department of Botany, B.H.U. and is grateful to University Grant Commission for financial help.

REFERENCES

Fogg, G.E. & A.J. Home 1970. The physiology of Antarctic freshwater algae. In : R.w. Holdgate (ed), Antarctic ecology, New York, Academic press : 638-732.

Bewley, J. D. (1979). Physiological aspects of desiccation tolerance. Ann. Rev. Plant Physiol, 30 : 195-238.

Potts, M. and Friedman, E.J. (1981). Effects of water stress on cryptoendolithic cyanobateria from hot desert rocks. Arch. Microbiol. 130 : 267-271.

Brock, T.D. (1975). Effect of water potential on Microcoleus (cyanophyceae) from a desert crust. J. Phycol. 11 : 316-320.

Whitton, B.A., Donaldson, A. and Potts, M. (1979). Nitrogen fixation by Nostoc collonies in terrestrial environments of Aldabra Atoll, Indian Ocean. Phycologia. 18 : 278-287.

Whitton, B.A. and Potts (982). Marine Littoral. In : The biology of cyanobacteria, (eds N.G. Carr and B.A. whitton). Blackwell Scientific Publications., Oxf. Lond., Edinburgh, Boston, Melbourne pp. 515-542.

West, W. & G.S. West (1911). Freshwater algae-British Antarctic Expedition. 1907-1909; Reports on scientific investigations I. Part 7 : 263-298.

Fritch, F. E. 1912. Fresh water algae of National Antarctic Expedition (under captain Scott) 1902-1904. National Antarctic Exped. Nat. History 6 : 1-61.

Fritch, F.E., 1917. Fresh water algae. British Antarctic (Terra Nova). Expedition 1910-1913. Nat. Hist. Rep. Bot. 1:1-16.

Hirano, M. 1965. Freshwater algae in the Antarctic regions. In : F. van Meighem. P. van Dye & J. Schell. Biogeography and Ecology in Antarctica. The Hague : 127-193.

Hirano, M. 1979. Freshwater algae from yukidorizava, near Syova station, Antarctica. Mem. Natl. Inst. Polar Res. Special Issue. 11 : 1-26.

Parker, B.C., G.L. Samsell & G. W. Prescott, 1972. Freshwater algae of the Antarctic Peninsula 1. Systematics and Ecology in the U.S. Palmer station area. In. Antarctic Terrestrial Biology, ed. G. Llano, Antarctic Research Series, American Geophysical Union, Washington D.C. : vol 20 : 69-81.

Karasawa, S. & H. Fukushima 1977, Diatom flora and environmental factors in some fresh water pond of east ongul island. Arctact. Res. 59 : 46-53.

Priddle, J & J. M. Belcher, 1981. Freshwater biolgoy at Rothera Point, Adelaide island: 11 Algae. Brit. Ant. sur. Bull. 55 : 1-9.

Priddle. J & J. H. Belcher, 1982. An annotated list of benthic algae (excluding diatoms) from freshwater lakes on singly island Brit. Ant. Sur. Bull. 57 : 41-53.

Broady, P. A., 1982. Taxonomy and ecology of algae in a freshwater stream in Taylor valley, victoria land, Antarctica Arch Hydrobiol. Suppl. 63 : 331-349.

Broady, P. A. 1989. Broad scale patterns in the distribution of aquatic and terrestrial vegetation at three ice free regions on Ross island. Antarctica. Hydrobiologia 172 : 77-95.

Hawes, I., 1989. Filamentous green algae in freshwater streams on signy island, Antarctica, Hydrobiologia. 172 : 1-18.

Howard-Williams, C.C.L., Vincent, P.A. Broady & W. F. Vincent 1986. Antarctic stream ecosystems : Varaibility in enviromental properties and algal community structure. Review ges Hydrobiol 71 : 511-544.

Smith, R. I. L. (1972) Vegtation of the South orkney Islands with particular refrence to signy Island. Br. Antarct. Surv. Sci. Rep. 68,124.

Longton, R. E. (1973). Observation of soil algae I. The ecology, size and taxonmy of British Soil diatoms. Part I. New Phytol 44, 196-219.

Bourrelly, P. 1966. les Algues d'eau douce. Initiation a la system atique 1 Les Algues at vertes, Paris, Boubee & Cie 512 pp.

Bourrelly, P. 1968. Les Algues D'eau douce. Initiation a la systematique 2. Les Algues Jaunes et. brunes. Paris. Boubee & cie 438 pp.

Geilter W. 1932. Cyanophyceae. Akademischa verlagsgese Uschaft m.b.H. Leipzig, 1196pp.

Desikachary T.V. 1959. Cyanophyta. Indian council of Agril. Research, New Delhi, India, 686 pp.

Rippka, R. J. Deurelles, J. b. Waterburry, M. Herdman & R. y. Stanier 1979. Genetic assignments, strain histories and properties of pure culture of cyanobacteria, J. gen. microbiol 111 : 1-61.

Jones, K (1977) : The effects of moisture on acetylene reduction by mats *of* blue-green algae in sub-tropical grassland. Ann. Bot., 44 : pp 801-806.

Table-II : Lakes of *Schirmacher oasis* of Antarctica

Name of Algae	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1. Nostoc commune	P	P	P	P	P	P	P	-	P	-	-	P	P	P	-	-	-	P	P	-	-	P	-	-	-	-	P	P	P	-
*2. Nostoc disciforme**	-	-	P	P	P	-	P	-	P	-	-	P	P	-	-	-	-	-	-	-	-	P	-	-	-	-	-	P	P	-
*3. Nostoc minutum**	-	-	P	-	P	-	P	-	P	-	-	-	-	-	-	-	-	P	P	-	-	-	-	-	-	-	-	P	-	-
4. Anabaena sp.	-	-	P	-	-	-	-	-	P	-	-	-	-	-	-	-	-	-	-	P	-	P	-	-	-	P	-	P	P	-
5. Aphanothece sp.	-	-	P	P	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	P	-	P	-	-	-	P	P	-
6. Calothrix brevissima	-	-	P	P	-	-	P	-	-	-	P	-	-	-	-	-	-	-	-	-	-	-	-	-	P	-	-	-	-	-
7. Chorococcus giganticus	-	P	-	-	P	-	-	-	-	-	P	-	P	-	-	P	-	-	-	-	-	-	-	P	-	-	-	-	-	-
8. Chrococcus limnticus	-	-	P	-	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	P	-	-	-	-	-
9. Chrococcus macrococcus	-	P	P	P	P	-	-	-	-	-	P	P	P	-	-	-	-	-	-	-	-	P	P	P	P	-	-	-	-	-
10. Gloeocapsa sp.	P	P	-	P	P	P	-	-	P	-	-	P	P	P	-	-	-	-	-	-	-	P	P	-	-	-	P	P	-	P
*11. Gloeocapsa alpina**	-	-	-	-	-	-	P	P	-	-	-	P	-	-	-	-	-	-	-	-	-	P	-	-	-	-	-	P	-	P
12. Gloeocapsa kuetzingiana	P	P	P	-	-	P	P	P	-	-	-	-	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	P	P
13. Oscillatoria sp.	P	P	P	P	P	P	P	P	-	-	P	P	-	-	-	-	P	P	-	-	-	P	P	-	-	-	P	P	-	P
*14. Oscillatoria fracta**	-	-	P	P	P	-	-	-	-	-	P	P	-	-	-	-	-	P	-	-	-	-	P	P	-	-	-	P	-	-
15. Lyngbya martebsiena	P	P	P	-	-	P	P	-	-	-	P	P	-	-	-	-	P	P	-	-	-	-	P	P	-	-	-	P	-	-
*16. Lyngbya lutea**	-	-	-	-	-	P	P	-	-	P	-	P	-	-	-	-	-	P	-	-	-	-	P	-	-	-	-	P	-	-
17. Phormidium sp.	P	P	P	P	P	P	P	-	-	P	P	P	-	-	P	P	P	P	P	-	P	P	P	-	-	P	P	P	P	-
18. Stigonema sansabarius	-	-	-	P	P	-	-	-	-	P	-	-	-	-	P	-	-	P	-	-	-	-	-	-	-	-	-	-	P	-

Name of Algae	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
19. Stigonema lavaralei	-	-	-	P	-	-					-		-	-	-	-	-	P	-	-	-	-	-	-	-	-	-	-	-	-
20. Stigonema harmoides	-	-	-	-	P	-	-	P	P	-	-	-	-	-	-	-	-	-	-	P	-	-	-	-	-	-	-	P	-	-
21. Synechococcus sp.	-	P	P	P	-	-	P	P	P	-	-	P	-	-	-	-	-	-	-	-	-	P	P	-	-	-	-	P	P	-
22. Hantzschia sp.	-	P	P	P	P	P	-	-	P	P	-	P	P	-	-	-	-	-	-	-	-	P	-	-	-	-	P	-	P	-
*23. Hantzschia sp.**	-	P	P	-	-	P	-	-	P	-	-	-	P	-	-	-	P	-	-	-	-	-	-	P	-	-	P	P	P	-
24. Navicula sp.	-	-	P	P	P	-	-	-	P	-	-	-	P	P	-	-	P	P	-	-	-	-	-	P	P	-	-	P	-	-
25. Pinnularia sp.	P	P	P	-	-	P	P	P	P	-	-	-	P	-	-	-	P	P	-	-	-	-	-	P	P	-	-	P	-	-
*26. Bicosoeca sp.**	-	-	-	P	P	-	-	-	P	-	-	-	P	P	-	-	-	-	-	-	-	-	-	-	P	P	-	-	P	-
27. Chloreococcum sp	-	-	P	P	P	P	P	-		P	-	-	P	P	-	-	P	P	-	-	-	-	-	-	P	-	-	-	-	-
28. Urospora sp.	-	-	-	P	P	-	-	-	-	-		-	-	-	-	-	P	-	-	-	-	-	-	-	P	-	P	-	P	-
29. Cylindrocapsa geminella	-	-	-	P	P	-	-	-	-	-	-	-	-	-	-	-	-	P	-	-	-	-	-	-	P	P	-	-	P	-
*30. Chlamydomonas subcaudata**	-	-	-	P	P	-	-	-	-	-	-	-	-	P	P	-	-	-	-	-	P	-	-	-	P	-	-	-	-	-
*31. Trochiscia rubra**	-	-	-	-	P	-	-	-	-	-	-	-	-	P	-	-	-	-	-	-	-	-	P	-	-	-	-	-	-	P
*32. Palmodictyon viride**	-	-	-	-	P	-	-	-	-	-	-	-	P	P	-	-	-	-	-	-	-	-	P	-	-	-	-	-	-	-
33. Chlorella sp.	-	-	P	P	P	P	-	-	P	-	-	P	P	-	-	P	P	-	-	-	-	-	-	P	-	P	-	P	-	-

/» = Present

- absent

** = species which ore found with some neu variations.*