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IMPACT OF CLIMATE CHANGE ON THE DIVERSITY AND DISTRIBUTION OF MOSS-INHABITING INVERTEBRATE FAUNA IN SCHIRMACHER OASIS, EAST ANTARCTICA

A. K. SANYAL[1], K. VENKATARAMAN, J.K. DE AND BULGANIN MITRA
Zoological Survey of India, M-Block, New Alipur, Kolkata
[1]E-mail: asokzsi@yahoo.co.in

INTRODUCTION

Climate change have impacts on marine, terrestrial and limnetic systems, and hence will influence future biological diversity of the globe. Present day Polar Regions experience greater rates of climatic change than elsewhere on the earth. The smallest shift of climate may threat to these uniquely adapted fauna of this extreme environment. However, some small areas of terrestrial habitat still supporting terrestrial and limnetic biotas have been continuously available for periods of time ranging from the several million to only a few thousand years. Among them Schirmacher oasis (17 km long in East-West trend in between 11° 22′ 40″ and 11° 54′ 20″ longitude and about 0.7 km to 3.3 km wide in between 70° 43′ 50″ and 70° 46′ 40″ latitude) of East Antarctica is one of the largest ice-free terrestrial and limnetic habitat which support an unique ecosystem of Antarctica. Habitats of the Schirmacher oasis can be defined as.

Cryptoendothilic and fauna therein are associated with mosses. The moss-inhabiting fauna of Schirmacher oasis, being exposed to highly unstable and often extreme environmental condition are commonly regarded as more sensitive to the changes in climate than those inhabiting biomass having less severe environment. But nothing was reported on the effect of the gradual increasing of temperature to the terrestrial and limnetic invertebrate fauna in the Oasis.

The present article reviews the study of different scientists, including present authors on the moss-inhabiting invertebrate fauna of Schirmacher oasis of last fifteen years (1985-2000). The analysis of data so far recorded shows that the faunal density was much higher in the year 1987 than in 1985 (Ingole & Parulekar, 1993). The findings made by the scientists of Zoological survey of India (1990-2000) also support the previous results. It has also been observed that the microscopic Protozoa and Nematoda population were much more in the year 1996 than in 1990. The faunal records made in the year 2000 reveal that mite population was quantitatively and qualitatively more than earlier records from the oasis. Considering one physical parameter i.e., surface water temperature of the lakes it has been observed that the temperature ranged between 1.0° C to 3.0° C, 1.0° C to 7.9° C, 1.0° C to 7.8° C, 1.9° C to 4.0° C, 1.0° C to 4.2° C, 1.9° C to 8.4° C, 1.2 C to 7.9° C and 1.8° C to 8.9° C in 1985, 1987, 1990, 1992, 1994, 1996,1999 and 2000 austral summer respectively.

The present paper reports invertebrate species so far recorded from Schirmacher oasis and their correlation with temperature in aquatic and terrestrial ecosystems with the comments on impact of climatic changes on moss-inhabiting fauna at Schirmacher oasis.

Keywords: Antarctica, Schirmacher Oasis, Invertebrate fauna.

Table 1 : List of moss-inhabiting invertebrate genus/species reported from Schirmacher oasis

Sl.No.	Group	Sl. No.	Species
1.	PROTOZOA	1.	*Arcella arenaria* Greef
		2.	*Diplochlamys* sp.
		3.	*Parmulina* sp.
		4.	*Centropyxix aerophila* (Diflandre)
		5.	*Difflugia* sp.
		6.	*Nebella* sp.
		7.	*Corythion dubium* Taranck
		8.	*Assulina muscorum* Greef
		9.	*Euglypha* sp.
		10.	*Trinema* sp.
		11.	*Colpoda* sp.
		12.	*Oxytricha fallax* Stein
		13.	*Stylonchia* sp.
2.	ROTIFERA	14.	*Philodina gregarina*
3.	TARDIGRADA	15.	*Hypsibius chinensis* (Plate)
		16.	*Macrobiotus polaris* (Murray)
		17.	*Echinoiscoides* sp.
4.	NEMATODA	18.	*Helicotylenchus* sp.
		19.	*Rotylenchus* sp.
		20.	*Dorylaimus* sp.
		21.	*Rhabditis* sp.
		22.	*Mononchus* sp.
		23.	*Teratocephalus tilbrooki*
		24.	*Plectus* sp.
5.	COLLEMBOLA	25.	*Xenella* sp.
		26.	*Isotoma* sp.
		27.	*Cryptopygus antarcticus*
		28.	*Calx* sp.
		29.	*Sphaeridia* sp.
6.	ACARINA	30.	*Chelacaropsis moorei* Baker
		31.	*Nanorchestes* sp. nr. *antarcticus* Strandtmann
		32.	*Pronematus* sp.
		33.	*Paratydeus* sp.
		34.	*Raphignathus* sp.
		35.	*Pediculaster* sp. nr. *mongolichus* Mahunka
		36.	*Acarus siro* Linnaeus
		37.	*Tyrophagus longior* (Gervais)
		38.	*Suidasia nesbitti* Hughes
		39.	*Proctolaelaps antarcticus* Sanyal & Gupta
		40.	*Hypoaspis* sp. nr. *oblonga* (halberd)
		41.	*Hypoaspis* sp.
		42.	*Haplochthonius antarcticus* Sanyal, Basak & Barman
		43.	*Haplochthonius maitri* Sanyal, Basak & Barman
		44.	*Haplochthonius longisetosus* Sanyal, Basak & Barman
		45.	*Maudheimia petronia* Wallwork
7.	TURBELLARIA	46.	*Neorhabdocoel* sp.
		47.	*Kalyptorhynchia* sp.
8.	OLIGOCHAETA		NOT IDENTIFIED

Table 2 : Physico-chemical parameter of the lakes of Schirmacher Oasis in austral summer (Year-wise)

	1985	1987	1990	1992	1994	1996	1999	2000
Surface water Temperature (°C)	3.0	7.9	7.8	4.0	4.2	8.1	7.9	8.2
D.O. mgl^{-1}	10.5	12.02	9.9	8.5	8.4	11.2	11.0	10.2
pH	8.1	8.77	8.25	8.25	5.6	8.4	7.9	8.0

Brief description of the Lake watersystems at Schirmacher Oasis

The lakes in Antarctica vary from brackish to freshwater in nature, depending upon their distance from the coast. In Schirmacher oasis the hill slopes remain covered with ice in winter, but in summer melting water gets accumulated in the depression areas between the hills and forming the large and small fresh water lakes. The shape, size and the formation of the lakes depend very much upon the quantity of melting water. The catchment consists of barren moraine material, and patches of macrophytes in wet area. The majority of these lakes are archaic, possessing no outflow, and the annual ablation rate is generally balanced by the summer ephemeral inflow of glacial melt streams.

Moss-inhabiting invertebrate Faunal Composition at Schirmacher Oasis

Altogether 47 species of 8 micro faunal groups were identified from this Oasis of which Acarina (16 species) shares the maximum number of species followed by Protozoa (13 species), Nematoda (7 species), Collembola (5 species), Tardigarda (3 species), Turbellaria (2 species) Rotifera (1 species) and Oligochaeta (species not known) (Table.2).

The scientific exploration in Schirmacher Oasis was started in 1965 with the publication of Bardin & Leflat on the chemical characteristics of the lake water system. This was followed by investigation on the nutrient concentrations and primary productivity in some freshwater lakes of Schirmacher Oasis (Kaup, 1988a, b).

Ingole & Parulekar (1987) were the first to report Protozoa from this region and recorded only one species of ciliate. They have stated that Protozoa are the most dominant group and comprising of 22.31% of the total lacustrine fauna of this area.

Ingole & Parulekar (1988, 1990 and 1993), Fondekar & Goes (1988) and Hussain *et al.* (1990) studied the limnology, chemistry and benthic fauna of the lake water system of the oasis. The study revealed 7 microfaunal groups, dominated by Protozoa, Rotifera, Nematoda, Turbellaria, Tardigrada, Oligochaeta and Acarina. Faunal density was found to be high in moss-associated sediments.

Hazra (1994) was the first to record 5 genera/species of nematode from the Schirmacher oasis. Further addition of other 5 genera/species of nematode from this oasis was made by Mitra (1999).

Afterwards Mitra *et al.* (1997) and Mitra (1999) reported 17 species of Protozoa from this area of which 16 were new to the Oasis. Chaterjee *et al.* (2000) first time made the community analysis of testacean species from this oasis.

Hazra & Mitra (2002) studied 36 sites (33 lakes and 3 swampy areas) and reported 6 micro faunal groups from this oasis. They also reported that the faunal density is much more in the lakes, situated in between shelf and Polar ice caps. Among the protozoans, *Assulina muscurum* Greef is the most widely distributed species and among the nematodes, the *Tylenchorhyncus* sp. is the most dominant genus and represented by 41% of the total nematode fauna of this oasis. Ghosh *et al.* (2000) studied the nematode fauna of this area and described the first new species *Antarctenchus motililus* Gosh, Chaterjee, Mitra & De (2005) from the Scirmacher Oasis.

Venkataraman (1995) reported a lone species of Rotifera *Philodina gregarina* and Mitra (1999) recorded 2 species of Tardigrada from this oasis.

Mitra (1999) was the first man who reported two species of Collembola and two unidentified mite species from this Oasis. Afterwards Sanyal (2004, 2005), Sanyal *et al.* (2002) and Sanyal & Gupta (2005) reported 17 species of mites including five new species which was the pioneering work on mites from Schirmacher Oasis.

DISCUSSION

Over 150 years of Antarctic biological research has produced more than 2000 publications in the field of taxonomy, biology, physiology and ecology of different groups of invertebrate fauna of marine, terrestrial and lacustrine fauna. But very few works have so far been documented on the threats of the invertebrate fauna due to recent climatic change over the Antarctica and Schirmacher Oasis in particular.

Maritime Antarctic freshwater habitats are amongst the fastest changing environments on earth. Temperature has raised around 1° C and ice cover has dramatically decreased in 15 years (Peak, 2005). Environment changes pose a range of problems for species that vary between site and species. Abilities to cope with change differ from individual to species levels. Researches on abilities to withstand have focused primarily on temperature changes, but other environmental factors are also likely to be affected. It is still unknown to us how biota in Schirmacher Oasis will respond to climatic change.

The present paper has summarized the changing pattern of faunal composition and density due to various factors which are directly related with risen of temperatures from 1985 to 2000. Summer cooling is particularly important to Antarctic terrestrial ecosystem that is poised at the interface of ice and water. All the invertebrate species of this area are going to reproduce or multiply their numbers in the short span of austral summer.

In the austral summer of the year 1985, Ingole & Parulekar (1987) observed that among the seven microfaunal groups found in the Oasis, the nematodes were the dominant group (22.13%). In other comparative studies in austral summer between 1985 and 1987, it was found that faunal density had a strong correlation with organic carbon content and the sediment texture and therefore the faunal density was much higher in 1987 than in 1985 (Ingole & Parulekar,1993).

According to Ando (1979) increase of air temperature in 1987, must be a factor responsible for the differentiation of faunal standing crop between 1985 and 1987 and may affect the microfauna with other factors. While studying the ecobiology of a freshwater lake at Schirmacher Oasis, Ingole and Dhargalkar (1998) showed that faunal density was increasing year-wise i.e. 1639 (1985), 2930 (1987), 3569 (1992) and 3489 (1994) respectively. According to them the increase in population of microorganisms was due to increased sedimentation, organic enrichment and silt deposition from an inflow of streams.

Afterwards several workers (Mitra, 1999; Ghosh *et al*., 2002 & 2005; Hazra & Mitra, 2008; Sanyal *et al.* 2002; Sanyal, 2004 & 2005; Sanyal & Hazra, 2008) have worked on the invertebrate faunal composition and contributed 47 species under 8 microfaunal groups (Table 2). From their findings it has been found that addition of species has been made in every austral summer but the numbers of micro faunal groups were not changed.

Mitra (1999) reported that dominancy of the immature forms in the population particularly in the groups like, Protozoa, Nematoda and Acarina indicated the over lapping of generation. This was the clear indication that the environment was suitable for their reproduction or multiplication. Sanyal (2004) reported that mite population was quantitatively and qualitatively more than earlier records from the Oasis.

Chatterjee *et al.* (2000) stated that the assemblages of Testaceans were dependant upon more than one abiotic parameter. They also opined that pH of water might be the most important factor influencing the community structure of the Testaceans.

The reason for maximum aggregation of population in the upper layer during summer in Antarctic region might be related to the density of texture of moss which acted as a source of food for nematodes and other invertebrate fauna (Maslen, 1981).

From the above analysis it is clear that the gradual increase of temperature accelerates the melting of ice, which increases the sedimentation of the lakes, phytoplankton productivity and ultimately increases the population density of the invertebrate fauna.

As a whole, 47 species under 8 micro faunal groups are so far reported from this area. It is interesting to note that the finding on Oligochaeta by Ingole & Parulekar (1987) in Scirmacher Oasis was not reported by the recent workers. This may be the indication of loss of biodiversity due to increase of population density of other groups dominated over this area.

From the above analysis it can be concluded that Schirmacher Oasis is also under threat of recent climatic change. These changes are not only in temperature but also precipitation, increased sedimentation, organic enrichment, silt deposition, pH concentration, etc. Current models predict that subantarctic and Maritime Antarctic terrestrial sites are likely to warm significantly over the next 100 years, by possibly as much as 5° C. According to Peck (2005), that species diversity, community biomass and complexity will increase in coming years. So there is every possibility that new species will eventually appear on the Schirmacher Oasis as warming continues, and these new species could displace the current endemic groups. Therefore, a long term monitoring work on the climate change in the area is highly needed to understand the impact on the global warming on the moss-inhabiting faunal composition of this extreme and unique ecosystem of the earth.

SUMMARY

Since the beginning of the Indian scientific expedition to Antarctica many scientists were engaged to study the moss-inhabiting invertebrate faunal composition of terrestrial and limnetic ecosystem of Schirmacher Oasis. Fifteen years (1985-2000) of meteorological data indicate that there is a trend of warming the lake water system of the Schirmacher Oasis which has an impact on the faunal composition of this ice-free area of East Antarctica. The record shows gradual increase of temperature directly correlates with the increase of faunal population density and low species richness.

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