

BIOLOGICAL STUDIES IN THE ANTARTIC WATERS : A REVIEW

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INTRODUCTION

Antarctic ocean is the most productive ocean in the world (Nienhuis, 1981) having few species with large population. Although the reasons for this unusual productivity are not yet fully understood, the study of the marine ecosystems are the priorities of the Antarctic biological programme.

In the Southern Ocean important organism regulating simple food chain is a crustacean, *Euphausia superba*, Dana, popularly known as krill. This protein rich species has been a target in recent years and investigations are underway to harvest these krills on sustainable yield basis for human consumption.

The biota of lakes and ice free areas on Antarctic continent is of special interest owing to adaptations to the extreme environments. The simplicity of this terrestrial ecosystem provides opportunities to study the physiological processes that are responsible to survive extreme climatic conditions.

Since the launching of the first Indian Antarctic Expedition in 1981 biological work has been taken up on a large scale to understand the various ecosystems. In the present paper biological work carried out so far from 1st to the 6th Indian Scientific Expedition to Antarctica has been reviewed.

SUMMER BIOLOGICAL PROGRAMME

Summer biological programme lasts for 2 to 3 months from December to March subjected to weather conditions. During summer diverse ecosystems such as icy shelf, polynya, fast ice, pack ice, sub-Antarctic islands, oceanic waters and terrestrial biology are being studied to estimate phytoplankton productivity, standing stock of krill, other zooplanktons, seabirds and mammals.

First two expeditions were of short duration, in which attempts were made to survey and understand the area for implementing exhaustive long term biological programme. The number of biologists participated and work carried out during these expeditions is given in Table 1.

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Studies on primary productivity revealed that pack ice zone showed relatively high carbon assimilation rate with the average primary production of $2.11 \text{ mg Cm}^{-3} \text{ day}^{-1}$ (Table 2) (Matondkar and Qasim, 1983). The qualitative studies on the macro and meiobenthos showed existence of rich benthic fauna and high standing crop as a result of high biological productivity (Parulekar *et al.*, 1983). The maximum concentration of sea birds and mammals in the vicinity of pack ice also confirms the area of high productivity.

The third and fourth expeditions laid more emphasis on marine biological work. The ice edge area and polynya were studied to assess and confirm the previous studies. The phytoplankton communities were found to comprise of two quite different elements, first from the ice algae released by melting and second consists of phytoplanktonic algae (Pant, 1986). Three distinct pattern in zooplankton data indicated period of grazing, multiplication and growth (Mathew and Vincent, 1986). The zooplankton biomass and phytoplankton cell counts relationship showed that the growth of krill along the ice edge is influenced by release of ice algae into the marine systems. (Fig. 1).

Detailed investigation of Priyadarshani lake in Schirmacher oasis indicated the dominance of microinvertebrates in the lake bottom and in the supra littoral sediments covered with moss beds, (Table 3) (Ingole *et al.*, 1987).

The interdisciplinary system-oriented oceanographic work was given more priority during fifth and sixth expeditions. Ice edge zone, fast ice, pack ice, polynya and open waters were studied for estimating primary production zooplankton biomass and particulate organic matter (POM) in relation to food chain dynamics. Large scale day to day variation in POM suggests patchy distribution (Dhargalkar and Bhosle, in Press).

The distribution of phytoplankton biomass in the euphotic zone was fairly uniform and ranged from 0.09 to 2.62 mg m^{-3} . The integrated values of zooplankton biomass and chlorophyll *a* showed inverse relationship indicating grazing (Fig. 2). The distribution and abundance of consumer species displayed direct relationship with biomass and population density. Highest population density $1665/100 \text{ km}^3$ of krill was recorded in between latitude $60^\circ \sim 70^\circ$ s similar to that of sea birds.

The data collected so far during summer do not show continuity and lacunae that exists are required to be filled in by taking up most systematic and time bound biological programme.

WINTER BIOLOGICAL STUDIES

After commissioning first permanent Indian Antarctic Station, Dakshin Gangotri in 1984, it was possible to pursue year round biological programme. Since then number of biologists continued to work during Antarctic winter undertaking various investigations (Table 4).

When plans were on to set up permanent station, one of the biologist was sent to winter at Davis, Australian Antarctic Research Station in the Vestfold Hills during 1983 winter. Offshore waters of the Vestfold Hills was studied for sea-weed distribution, abundance, animal association and biochemical estimation. The macrophytes growing in

the inshore waters of the Vestfold Hills support large number of invertebrate species (Fig. 3). Macrophyte species *Palmaria decipiens* support significantly ($P < 0.001$) greater animal biomass which could be attributed to the available food resource (Dhargalkar *et.al.*, in press).

These macrophytes when subjected to different light intensities found to regulate their photochemical mechanism of the cell component. Similarly, exposure to different temperature exhibited eurythermal nature. This type of adaptation explains survival strategy, species diversity and endemism to the region.

During the first winter at Dakshin Gangotri, micro-biological work of Schirmacher oasis was undertaken. Data revealed that prevailing soil temperature was found to limit the distribution and abundance of group of bacteria (Fig. 4). The seasonal variation in temperature indicated that even though winter population belong to the same taxonomic group as that of summer and spring it exhibited altogether different adaptation strategy (Matondkar, 1986).

Primary production and chl *a* content of water in polynya and under pack ice were studied during second wintering. Cultures of *Chaetoceros* sp, *Fragilaria circumlaris*, *Navicula distans* and mixed cultures when exposed to different light intensities and temperatures showed that high temperatures and low light intensity decrease the photosynthetic efficiency, Fig. 5a,b (Verlenkar, 1985).

During the third wintering detailed investigations on phytoplankton production in water column and in the sea-ice, zooplankton biomass and particulate organic matter were carried out. Studies revealed that when sea is covered with 2 m thick sea ice, phytoplankton and sea ice algae contribute substantially to particulate organic matter (Dhargalkar, in press). The seasonal variation in planktonic organisms showed significant effect on POM concentration at different depths. Gradual increase in zooplankton biomass was noticed from winter to spring to summer in accordance with the phytoplankton population (Fig. 6).

Under biomass programme population dynamics and breeding cycles of the Adelie penguins were studied. The annual cycle of the birds in the vicinity of the Dakshin Gangotri is given in Table 5. However, the arrival and departure of the bird species depends on the climatic conditions and available food resources in the surrounding water.

Overall, the work carried out so far under marine biology is restricted to a small area enroute Goa to Antarctica with minimum time of the supply ship. On the basis of data collected so far, it is difficult to come to the reliable interpretation to assess the living resources. Hence, it is envisaged that the activities are required to be intensified with well defined programme for the realistic assessment of the living resources, particularly krill. Limitations for marine biological work on supply ship can be overcome by a separate and small ship exclusively for marine science work.

Not much scientific information in this part of Antarctica is available as a whole and in particular during winter. Keeping in view this gap it is suggested that cruises may be undertaken during early September upto the pack ice to collect scientific information on

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the water quality, krill biology, birds and mammals, their behaviour and population dynamics which will help to estimate potential of krill resources. Along with this a team of biologists may also be sent to work during winter to collect detailed information and to conduct experiments to know the status of krill during winter. It has been noticed that winter strategies of krill and allied species in the Southern Ocean are not taken into account while krill estimates are made based on summer data.

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Table 1. Institute of oceanography and other organizations – summer programme Antarctica

YEARS INVESTIGATION	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87
BIOLOGICAL OCEANOGRAPHY						
NO. OF PARTICIPANTS	3	1	3	3	2	4
PHYTOPLANKTON PRODUCTION	√	√	√	√	√	√
ZOOPLANKTON AND KRILL STUDY	√	√	√	√	√	√
BENTHIC PRODUCTION	√			√	√	√
BIOCHEMICAL STUDIES OF POM					√	
BACTERIAL STUDY	√	√	√	√		√
MAMMAL STUDY	√					√
BIRD STUDY	√					√
UNDERWATER DIVING						√
OASIS & LAKE STUDY	√	√	√	√	√	√
REPORTS	√	√	√	√	√	√

Table 2. Minimum, maximum and mean values of primary production, chlorophyll *a*, phaeopigments, particulate organic carbon ATP, and nutrients at the surface of Antarctic waters

	Min.	Max.	Mean	No. of obs.
Primary production (mgCm ⁻³ day ¹)	0.021	9.95	2.11	13
Chlorophyll <i>a</i> (mg m ⁻³)	0.05	1.5	0.28	16
Phaeopigments (mg m ⁻³)	0.0	0.66	0.10	16
Particulate organic carbon (mgCm ⁻³)	126	811	328.12	16
Adenosine tri phosphate (live carbon) mg m ⁻³)	0.02	1.40	0.31	16
PO ₄ ³⁻ -P (μg-atl ⁻¹)	0.23	1.71	1.24	14
SiO ₄ -Si (μg-atl ⁻¹)	1.1	106.8	35.21	14
NO ₃ ⁻ -N (μg-at l ⁻¹)	0.1	23.9	7.9	14
NO ₂ ⁻ -N (μg-atl ⁻¹)	0.08	0.68	0.27	14

Table 3. Micro-faunal density (number/m²) and biomass (µg/m²) recorded at Priyadarshini lake, Schirmacher Oasis, Antarctica, (Values in parentheses are biomass µg/m²)

Taxon	Jan	Feb	Jan	Feb
Nematoda	272.5 (122.6)	182.5(82.10)	12(05.60)	02.5(01.10)
Turbellaria	125.5(68.6)	97.5(43.80)	75.0(33.80)	30.0(13.50)
Ciliata	135.0(0.68)	107.5(54)	52.5(0.26)	22.5(0.11)
Tardigrada	140.0(63.30)	52.5(3.60)	80.0(36.00)	12.5(5.60)
Resting egg	140.0(0.70)	230.0(1.15)	367.5(1.84)	507.5(2.54)
Rotifera	10.0(0.05)	07.5(0.03)	05.0(0.02)	—
Protozoa	20.0(0.10)	115.0(0.55)	167.5(0.84)	100.0(0.50)
Acarida	12.0(05.00)	—	05.0(02.30)	—
Oligochaeta	12.0(05.00)	07.5(03.40)	—	—
Unidentified	42.0(18.50)	22.5(10.10)	15.0(06.80)	12.5(05.60)
Total	935.0(284.33)	822.5(165.27)	780.0(87.46)	687.5(28.95)

Table 4. National Institute of Oceanography/C.S.I.R. winterization : Davis (Australia), Dakshin Gangotri (India) Biology

Year	Davis	Dakshin Gangotri		
	1983—84	1984—85	1985—86	1986—87
Investigations				
No. of participants	1	1	1	1
Microbiological study of the shirmacher oasis		√		
Effect of temperature on the bacterial culture		√		
Phytoplankton production in the fast ice zone			√	√
Effect of light and temperature on phytoplankton culture and macrophytes (Seaweeds)	√		√	
Zooplankton production in the fast ice zone				√
Biochemical study of the particulate matter				√
Marine biomass production—sea birds, marine mammals and krill	√			√
Ecological studies on marine macrophytes	√			
Biochemical studies and pollution	√			
Epiphytic fauna associated with macrophytes	√			
Terrestrial flora	√			√
Reports	√	√	√	√

Table 5. Annual cycle of Antarctic birds at Dakshin Gangotri, Indian Antarctic Station (1986-87)

Bird species	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May
1. <i>Catharta maccormicki</i> (South Polar Skua)					Near Station Garbage Dump							Departure
2. <i>Pagodroma nivea</i> (Snow Petrel)					Seen in the vicinity of D.G.							Departure
3. <i>Oceanites oceanicus</i> (Wilson's Storm Petrel)					Recorded at ice shelf (Lazarev station)							Departure
4. <i>Daption capense</i> (Cape petrel)					Seen in the vicinity of D.G.							Departure
5. <i>Pygoscelis adeliae</i> (Adelie penguin)					About 500 Birds were nesting at old lazarev station							Departure
6. <i>Aptenodytes forsteri</i> (Emperor penguin)					Colony was disturbed by Russian operation							Departure
					Gather at the fast ice for moulting during December-March							Departure
					Arrival							

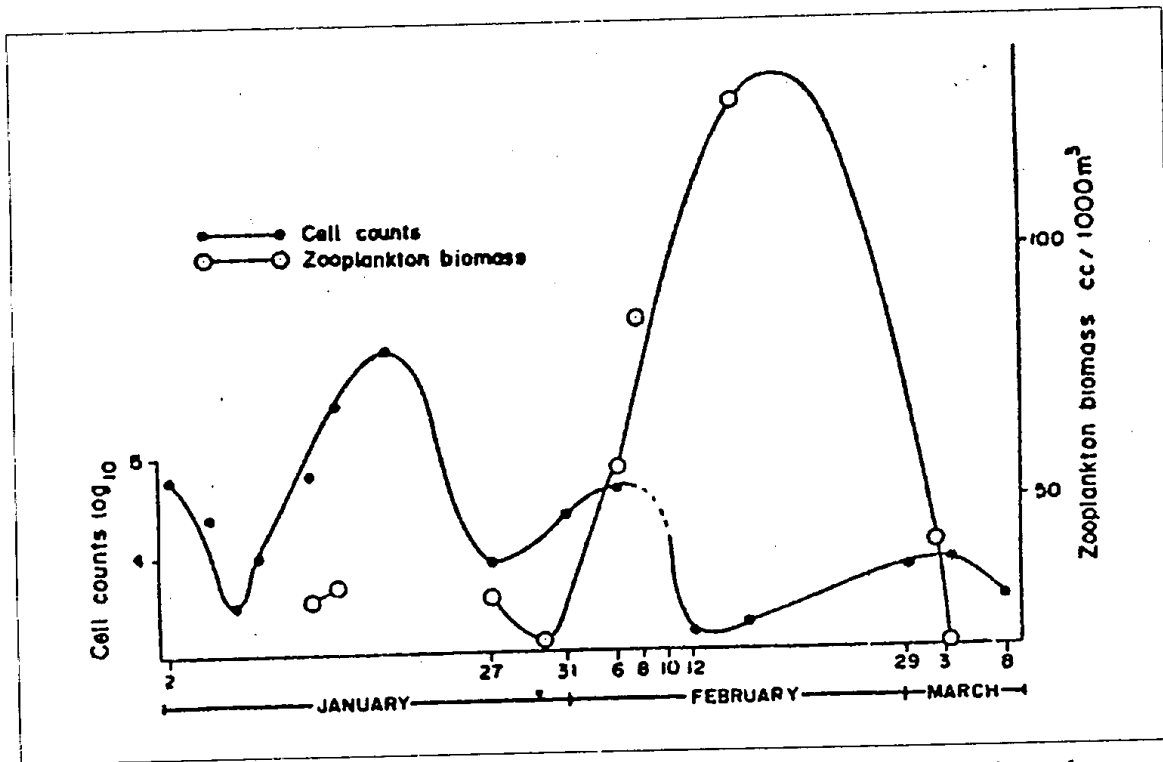


Fig. 1. Relationship between Phytoplankton and Zooplankton—Zooplankton data

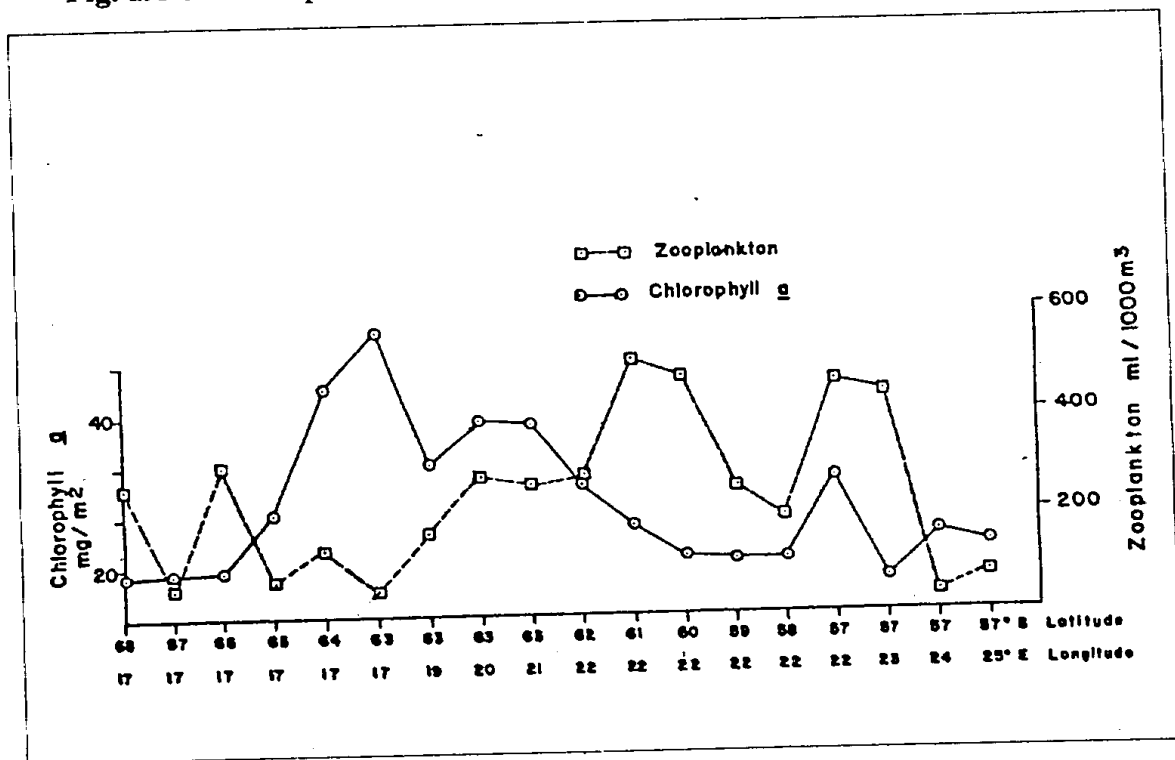


Fig. 2. Antarctic Vth Indian Expedition.

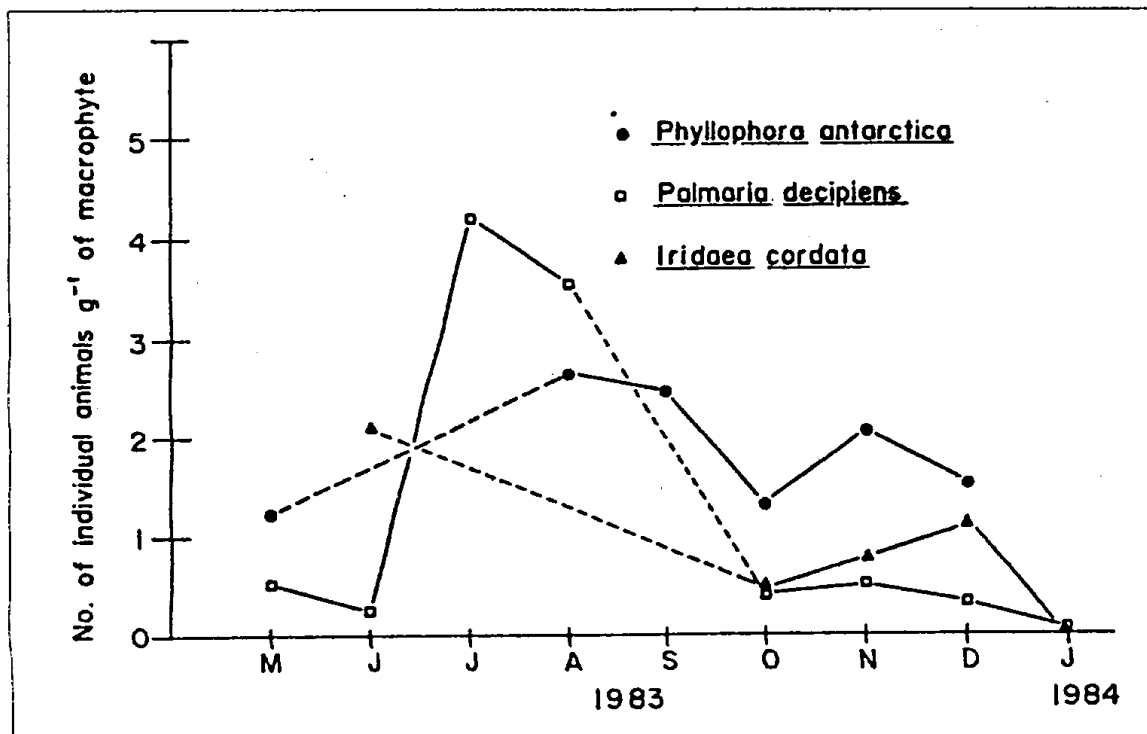


Fig. 3. Seasonal variations in the total number of epiphytic animals g⁻¹ of macrophyte for the three macrophyte species supporting the greatest epiphytic animal populations.

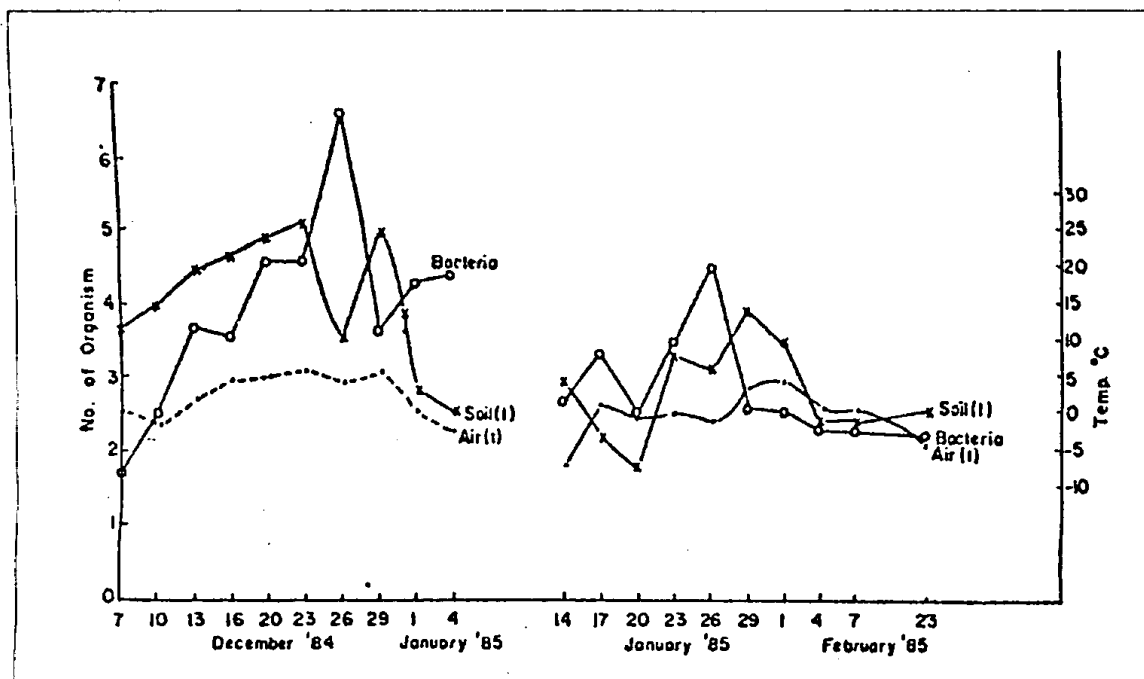


Fig. 4. Effect of daily temperature variations on bacterial population.

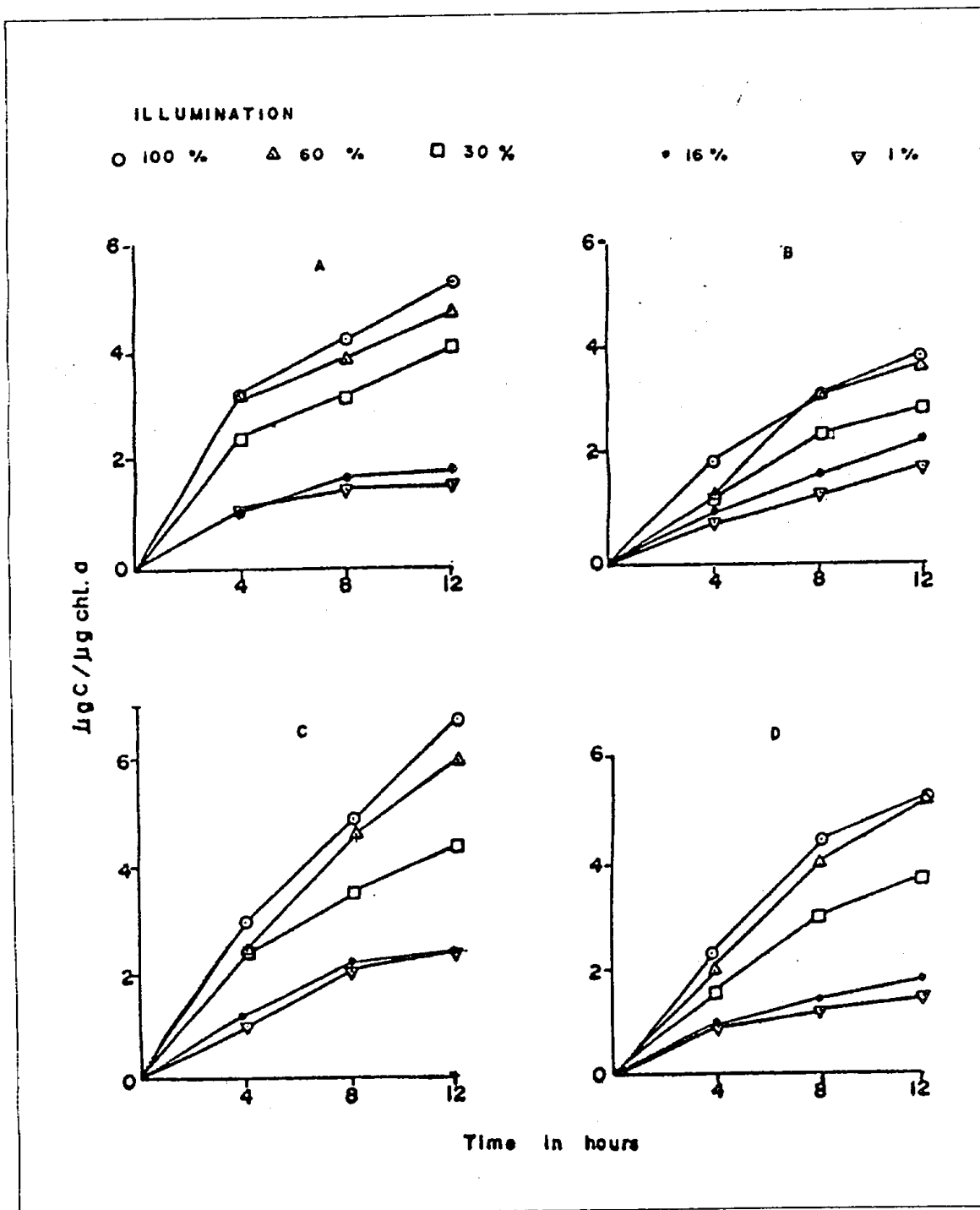


Fig. 5a. Effect of varying light intensity on the rate of photosynthesis of the phytoplankton cultures, at a constant temperature of 10°C.
 A—*Chaetoceros* sp., B—*Fragilaria circumlaris*
 C—*Navicula distans* and D—mixed diatom culture.
 100% illumination corresponds to the light intensity of 7000 lux.

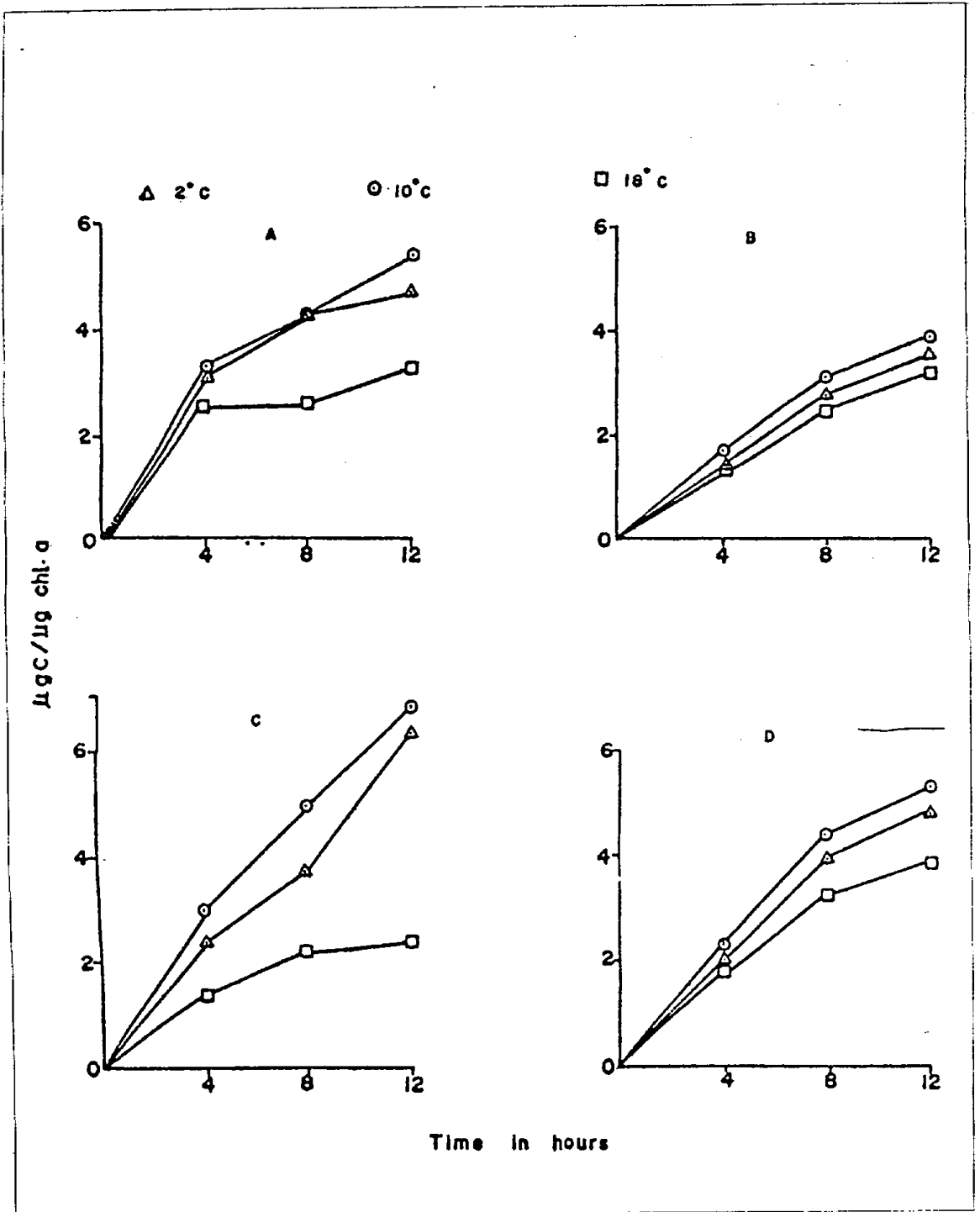


Fig. 5b. Effect of changes in temperature on the rate of photosynthesis of phytoplankton cultures at a constant light intensity of 7000 lux.
 A—*Chaetoceros* sp., B—*Fragilaria circumlaris*
 C—*Navicula distans* and D—mixed diatom culture

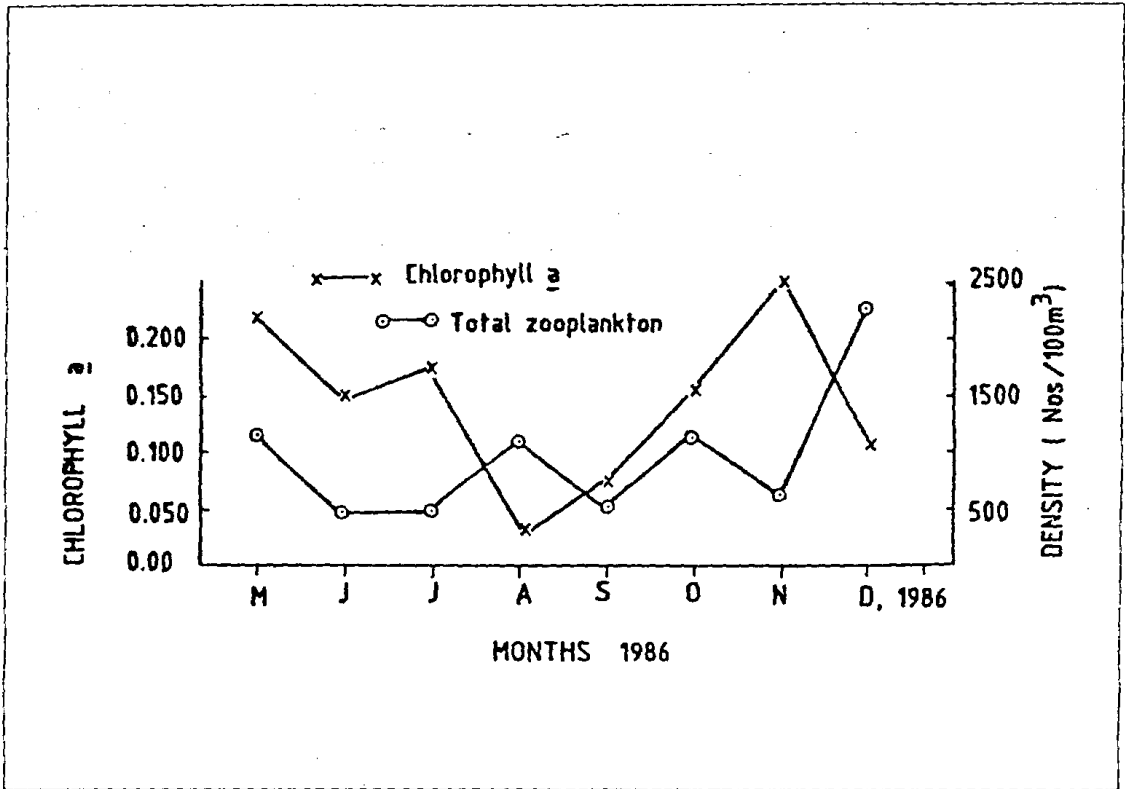


Fig. 6. Seasonal change in chlorophyll *a* and total number of zooplankton.

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