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Characteristics of Macrobenthic Assemblage from sub-littoral sediment off the Lazarev Sea, East Antarctica

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Comparative account of the occurrence and abundance of benthic macro-organisms collected from the Lazarev Sea in Queen Maud Land, (east Antarctica), during austral summer of 1984-85 and 1992-93 (fourth and twelfth Indian Antarctic expeditions) is presented and discussed. Total 42 seabed samples were taken from 15 locations in the depth ranged of 150 to 700 m. Sediment of the Lazarev Sea ranged from silty clay to sandy clay. The fraction of silt-clay and sand varied between 60.5 to 75.5 and 24.3 to 39.5 %, respectively. Organic carbon content of shelf sediment ranged from 1.29 to 6.95mg. g^{-1} (mean=4.16±1.97 sd;n=42). Faunal density ranged from 1882 to 9643 ind.m^{-2} (mean=4895.2±2852.5 sd; n=15). The total macrobenthic standing crop varied from 2.928 to 20.833 g.m^{-2} (mean=8.91±5.69 sd, n=15) on dry weight basis. A total of 69 macroinvertebrate species inhabiting the benthic environment of Polynia region is presented with ecological information about collection site. Most of the benthic species appear to have circumpolar distribution. The significant positive correlation of surface chlorophyll-*a* with sediment organic content and benthic biomass propose a strong bentho-pelagic coupling in a seasonally locked environment.

[**Key words:** Macrobenthos; species diversity; standing stock; Ice shelf; Polynia; Lazarev Sea; East Antarctica]

Introduction

Antarctic benthic fauna contain endemic species surviving in a harsh environment characterized by extremely low but stable temperature regime having large but short-lived input of organic matter[1]. The diverse and abundant benthic fauna of Antarctic waters exhibit a number of particular features such as slow and seasonal growth, longevity and seasonal reproduction in a highly seasonal environment. As reviewed by Arnaud and Hain[2] the distribution of Antarctic shelf and slope macrobenthos is poorly studied and very little is known about its relationship with the environmental conditions. There are few reports on the feeding biology of bryozoans under laboratory[3] and *in situ* conditions[4]. The winter period has been considered as starvation[5] as low levels of water column chlorophyll-*a* in winter impose a seasonal resource limitation[5]. The aim of the present study is to contribute to a better understanding of the Antarctic shelf benthos. An attempt had been made to quantify the abundance and biomass of littoral macrobenthic communities from the Lazarev Sea and to probe trophic structure in greater detail. The sediment samples collected during two subsequent Indian Antarctic expeditions (fourth and twelfth) were pooled to describe a more appropriate conclusion, generally accepted by scientific communities.

Materials and Methods

Study area

The area under investigation lies in the Polynia region of the Lazarev Sea in Queen Maud Land, east Antarctica (lat. 69°45′ to 70°00′S; long. 11°30′ to 13°30′E, (Table 1, Fig. 1), close to the first Indian Antarctic research station *Dakshin Gangothri*. The area gets covered with fast ice from ~ April to November, every year. The ice usually thaws, and is cleared from the area in ~ January each year to provide a free water mass that extends for several kilometers. The new sea-ice generally reforms in March/April, however, the time of setting in of fast ice differ from year to year. Variations in meteorological parameters (monthly mean) recorded during 1984-85 at *Dakshin Gangothri* (The Indian permanent research station in east Antarctica) are presented in Table 2. The average annual air temperature was -17.7°C (minimum: -31.4°C, maximum: -3.2°C). However, the extreme minimum and maximum, temperature recorded were -52°C (16 Aug. 1985) and +6°C (21 Dec 1985)[6], respectively.

Filed Sampling

A total of 42 sediment samples were collected in shelf region of Lazarev Sea during two Indian expeditions. Water depth at sampling stations varied from 120-700 m. Surface as well as bottom water was

Table 1—Geographical position of sampling stations along with sediment composition and faunal standing stock

Stn.No.	Geographic position		Depth (m)	Faunal standing stock		Sediment Composition		
	Lat.(°S)	Long.(°E)		Density ind. m^{-2}	Biomass g .m^{-2}	Silt/ clay (%)	Sand (%)	O.C. mg/g
P-I	69,46'95	12,42'44	600	1882	3.97	66.5	33.5	1. 39
P-III	69,59'50	12,48'14	700	7232	12.71	70	29.5	1.19
P-VI	69,54'10	12,49'63	150	3705	6.85	62.2	34. 8	5.16
P - VII	69,53'36	12,36'42	120	1941	2.96	71.4	28.6	3.97
P-VIII	69,57'74	12,47'36	200	9173	20.3	68.2	31. 6	2.07
P-X	69,53' 90	12,44'32	155	9643	11.01	69.7	30.2	5.95
P-XI	69,53'83	12,05'42	180	4116	5.37	66.5	32.2	6.95
P-XIII	69,54'00	11,46'00	200	2940	4. 86	75.7	24.3	1.29
P-2	69,51'37	12,57'76	191	9643	18.9	69.3	30.7	6.23
P-3	69,54'25	12,53'17	270	4116	9.39	60.5	39.5	6.84
P-4	69,54'35	12,53'19	282	2528	3.37	66.8	33.2	5.55
P-5	69,53'39	12,47'47	157	4881	12.61	70.3	29.7	3.87
P-6	69,57'25	12,04'38	195	6703	13.24	62.2	37.8	4.56
P-7	69,58'85	11,42'57	194	2176	3.36	65.1	34. 9	3.57
P-9	70,01'50	11,47'74	245	2764	4.71	68.6	31.4	2.78
Mean				4895.2	8.91	67.5	32.2	4. 09
± SD				±2852.5	±5.69	± 04.0	±03.8	±2.0

*O.C. Organic carbon

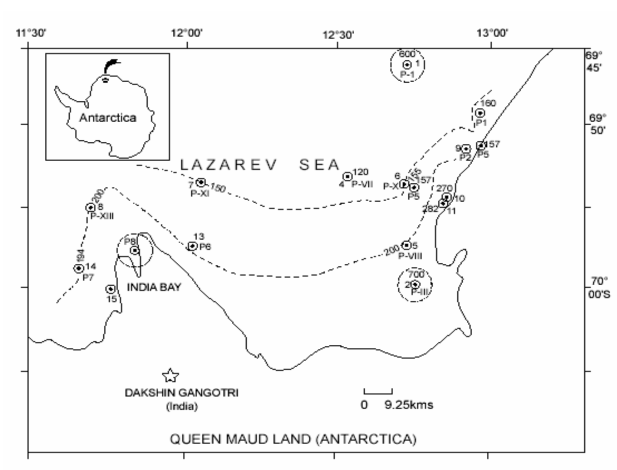

Fig. 1—Locations of the sampling stations Lazarev Sea, east Antarctica

collected using Niskin samplers to analyzing the temperature, salinity, *p*H and chlorophyll-a (Chl-*a*), dissolved oxygen and dissolved nutrients. Seabed sampling was conducted during the austral summer of 1984-85 (22 samples) 1992-93 (20 samples) using a La Fond Snapper that sampled an area of 0.017m^2. Two-three snappers were taken at each location. Separate samples were obtained for texture analysis and faunal composition. Faunal samples were sieved through a 0.5 mm mesh screen in filtered seawater and residual was fixed in 5% formalin-rose Bengal (1 g.l^{-1}) solution neutralized with borax (15 g.l^{-1}).

Sediment texture

For sediment analysis, about 15-20 g (depending upon the fine material present) sediment was removed from each grab sample. The sediment was repeatedly washed in distilled water until all the chloride ions detectable with 4% silver nitrate were removed. These samples were treated with 10% sodium hexametaphosphate and kept overnight for dispersion before being subjected to grain size analysis[7]. Sediment organic carbon was estimated by following the method of El Wakeel and Riley[8].

Extraction of macrofauna

In the laboratory, faunal samples were again washed through 0.5 mm mesh sieve in filtered running water, to clear the adhering sediment. All the animals were sorted according to different taxa and were preserved in 70% ethyl alcohol plus 5% glycerin. The taxonomic identification of fauna was based primarily on the keys of Fauvel[9], Gosner[10] and Day[11]. Considering the taxonomic importance of the material, only the wet weight of fauna was taken and converted into dry weight following conversion factors described by Crips[12].

Data processing

All the raw data was treated with Excel statistical package and further analyzed following the standard method described by Clarke and Warwick[13] using the PRIMER (Plymouth Routine in Multivariate

Table 2—Some of the meteorological parameters observed at Dakshin Gangothri during1985-86 (based on 3 hourly observations)*

Months	Temperature (°C)			Wind speed	Pressure	Sunshine
	Min.	Max.	Mean	(Knots)	(mb)	(hr.$^{-dy}$)
February, 85	-23	0	1-13.0	18	980.5	9
March	-26	-4	-16	17.2	985.8	12
April	-32	-4	-18.7	21.4	983.2	8
May	-36	-13	-28.8	21.2	988.5	4
June	-34	-10	-26	25	987.1	0
July	-46	-10	-32	20.8	970.6	2
August	-52	-14	-34.6	12.1	984.3	6
September	-43	-14	-30.2	21.5	973	12
October	-33	-10	-22.7	22	977.9	16
November	-27	-3	-16.5	15.3	976	20
December	-16	6	-8.6	15.9	981. 5	24
January, 86	-14	4	-6.4	14.2	986.9	23

(*Source: Lal, 1987)[6]

Ecological Research) software package and after square root transformation. The biomass data was subjected to multidimensional scaling (MDS) ordination and cluster analysis. Ordination of all environmental data and those variables, which gave the best correlation with faunal data, were carried out with correlation matrix analysis.

Results

Environmental characteristics

Details of the meteorological and oceanographic conditions prevailed during the austral summer of 1984-85 and 1992- 93 are presented in Table 2. Surface water temperature remained low with values varying from - 0.2 to - 2.0°C (mean = -1.27±0.6; n=12). Salinity of the surface water varied from 33.2 to 34.2 PSU (mean =33.8±0.2 sd:n=12). A sharp decrease in salinity generally occurred from December to February, which attributed to the summer melting of shelf ice. Dissolved oxygen (D.O.) showed high fluctuation between 1984-85 and 1992-93 seasons. The mean D. O. value of 5.9 ml l^{-1} was recorded in 1984-85 and 7.4 ml l^{-1} in 1992-93, with an overall mean value of 6.6±0.93 ml l^{-1}. Hydrogen ion concentration (*p*H) ranged from 7.40 to 8.12 (mean=7.94 ±0.19 sd;n=15; Fig. 2).

Bathymetry

Since the data on bathymetry of the near shelf area of the Lazarev Sea was not available, a spot sounding was conducted during the present investigation at 165 locations with the help of shallow water echosounder. Based on the sounding data, depth contours were prepared and presented in Fig. 1. The minimum and maximum depth of 70 and 700 m, respectively was recorded during the January-February, 1993. The water depth varied greatly within the distance of 200-300 meters, near the shelf, perhaps could be due to the grounding of icebergs. Generally, the depth was higher close to the ice shelf.

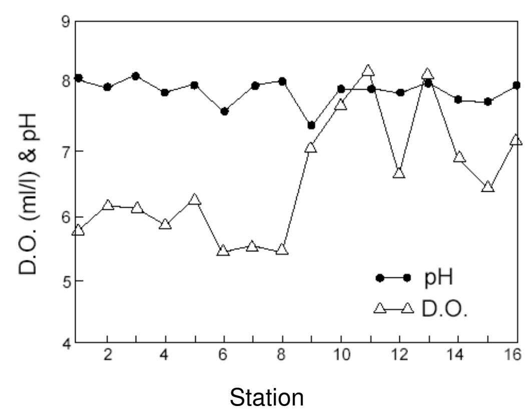

Fig. 2—Dissolved Oxygen and pH in surface water

Sediment characteristics

Sediment of the Lazarev Sea is terrigenous calcareous in nature and range from silty clay to sandy silt. The fraction of sand varied between 24.3 and 39.5% (mean =32.2±3.8; sd;N=15). Percentage of silt-clay fraction varied between 60.5 and 75.7% (mean =67.5±4.0 sd;N=15; Table 1). Sediment from the shallower depths (<500 m) had sandy silt with pebbles. Top layer of sediment had thick layer of sponge spicule mats, skeletal material of bryozoan, coral fragments and mollusks shells. Organic carbon contents of Antarctic shelf sediments ranged from 1.29 to 6.95 mg.g^{-1} (mean =4.16±1.97 sd;n=15). In general, the siliceous sediments are rich in organic carbon content.

Faunal abundance and biomass

Macrofauna of the littoral zone of the Lazarev Sea comprised 69 species belonging to 9 phyla (Table 3). Major components of the community were polychaetes, mollusks, crustaceans, and echinoderms. In terms of the faunal density, Crustacea were numerically dominant (24.0%) followed closely by Annelida (23.2%). Mollusca contributed 21%, whereas Echinodermata, Porifera and Coelenterata accounted for 12.2%, 8.7% and 6.4%, respectively to the macrofaunal density (Table 3). All the other taxa contributed 4.2% to the macrofauna. In terms of the biomass (dry weight), Annelida dominated with 41.1% followed by Crustacea (32.2%), Echinodermata (8.3%), Porifera (7.3%) and Mollusca (5.0%). Other groups, such as Nemertina, Nematoda and Ostracoda Coelenterata together, contributed 6.1% to the total dry weight. Bryozoans and hydrozoans, although contributed substantially, were not considered for biomass estimates due to their fragmentary occurrence. The density of macrofauna varied between 1882 to 9643 ind.m^{-2} (mean =4895.2±2852.5 sd; n=15; Table 1). One-way ANOVA indicated high variations (P< 0.001) in faunal abundance between the sampling stations.

Table 3—Macrofaunal communities (mean of three replicates) from the littoral zone of the Lazarev Sea, east Antarctica.

Community/dominant groups	No. of species	Percent contribution to	
		Density	Biomass
PORIFERA	6	8.7	7.3
COLENTERATA	7	6.4	4.0
ANNELIDA (Polychaeta,Oligochaeta)	3	23.2	41.1
CRUSTACEA (Amphipoda, Isopoda, Tanaidacea, Cumacea, Nebalialea	14	24	32.2
MOLLUSCA (Bivalvia, Gastropoda, Scapopoda, Brachiopoda)	19	21.3	5.0
ECHINODERMATA (Holothuroidea, Ophiuroidea, Asteroidea)	10	12.2	8.3
Other miscellaneous groups	10	4.2	2.6
Total	69	100	100

Table 4—Occurrence (%) and frequency distribution (%) of macrobenthic species

No. of species	Frequency (%)	Prevalence (%)
1	1.70	13
1	3.40	27
3	4.50	40
3	5.90	47
3	11.80	93
4	2.50	20
4	2.70	33
4	9.50	73
5	7.60	60
7	10.50	80
8	11.90	87
8	12.70	100
9	6.70	53
9	8.40	67
Total=69	100	

Benthic biomass

In general, the biomass of sponges, holothurians, bryozoans, crinoids and ophiuroids was more. A metabolic conversion factor for macrofauna consumption was used according to Gerlach[14], which applies to both respiration and production, per unit biomass and probably also to food ingested (macrofauna:x1). The total energy used by benthic macrofauna (∑) showed a positive relationship with epibenthic faunal density. Standing stock of benthic biomass (dry wt.) varied between 2.96 to 20.30 g.m^{-2} with a mean of 8.9 ±5.7 sd; n=15 (Table 1).

Species composition and distribution

Among the 69 macroinvertebrates identified from the 15 station, the most diverse phyla were Mollusca with 19 species followed by Arthropoda with 17 identified species. Ten species were belonging to Ehinodermata, 07 to Coelenterata and 06 to Porifera. Othere 13 species represented the minor and rare phyla. Out of the 69 identified species, only 08 were collected from all the 15 locations with 100% prevalence (Table 4). *Rosella antarctica; Hippadenella* sp*., Lanae* sp*., Epimeria robusta., Gnathiphimedia mendibularis., O. rossi., Shackletonia* sp., were the most widely distributed with 100% occurrence (Table 4). On an average 35-56 species were recorded in each grab sample (Fig. 3). However, the most dominant species in term of number of organisms were the suspension-feeding bivalves *Limopsis marionensis and Parmaphorella mawsoni* and polychaete *Lepidonotinae* sp., *Terebellidae* sp. and *Lineus* sp. and they were observed in all the samples. Compared to the shallower depths, species diversity, abundance and biomass were less variable at deeper depths (200-700m).

The epifauna was made up of sponges, holothurians, bryozoans, hydroid, and ophiuroids. The

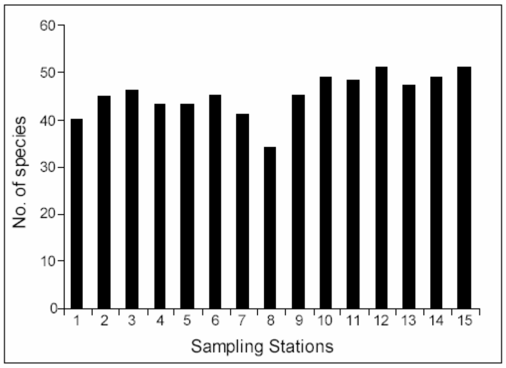

Fig. 3—Variation in the number of macrobenthic species in the study area

sponge fauna was dominated by glass sponges (*Rosella* spp.), which were presented in large number and variety, especially hexactinellids with their large siliceous spicules. Molluscan fauna was dominated by bivalves *Limopsis marionensis, Limatula hodgsoni* and *Philobrya* sp., with relatively stable population and *Trophon longstaffi* and *Chlanidota* sp. of the gastropods. Brachiopods were very common at all stations, most of them attach to other organisms. The attachment was to sedimentary plants and animals such as, algae, hydroids, bryozoans, and spines of echinoids and large spicules of sponges.

Crustaceans, especially amphipods, isopods and tanaids occurred prominently in all the samples. Among the amphipods, *Orchomenella franklini, Shackletonia* sp., and among the isopods, *Serolis polita* and *S. cornuta* were common. Ophiuroids are one of the commonest groups recorded in Antarctic benthic fauna. *Ophiurolepsis gelida* and *Ophisparte gigas* were found almost at all the sampling stations. The asteroid, *Labidiaster annulatus*, was found at greater depth, whereas *Odontaster validus,* a common starfish having circumpolar distribution, was collected from shallower depths.

Discussion

The data for macrofauna abundance showed significant variation between the sampling stations (P>0.05). Faunal abundance was low at deeper station close to the ice-shelf as compared to the stations away from the ice-shelf. The principal reason for this may be the sediment texture, variation in the sampling depths and availability of food[15]. Samples from near shelf area had more sand content compared to those away from shelf area, possibly due to the deposition of material locked in ice sheets or icebergs. Detritus and bacteria forms the major food for deep-sea benthos[16]. Detritus is produced mainly in the euphotic zone and reaches benthos after passing through the benthopelagic zone. The absolute amount of organic matter reaching seafloor therefore depends on the level of primary production in the surface water and depth of the water column[17&18]. A clear indication of this effect was evident from significant positive correlation between sediment organic carbon and surface water chlorophyll- a (Fig. 4) and Chl-*a* production with macrobenthic biomass (Fig. 5).

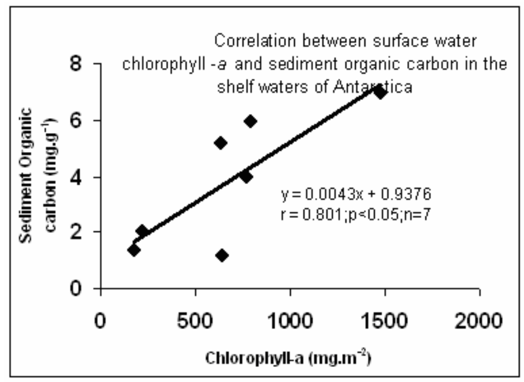

Fig. 4—Correlation between sediment organic carbon and surface water chlorophyll-*a*

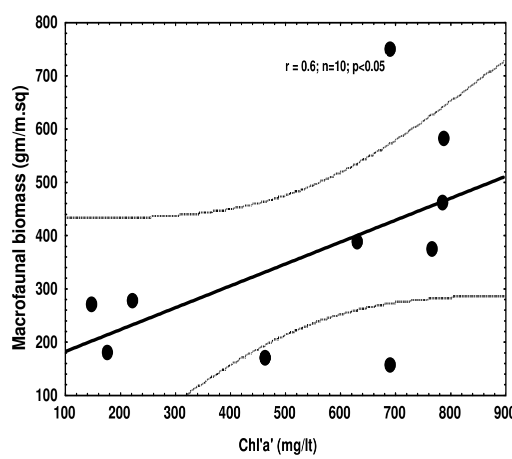

Fig. 5—Correlation between surface water chlorophyll-a and macrobenthic biomass

A significant inverse relationship between the water depth and sediment organic carbon (Table 5) indicate that water depth and distance from the ice shelf could be vital in making food available to benthos. The hard substrates on the seafloor at deeper regions could significantly increase the area suitable for faunal attachment and the availability of sufficient

Table 5—Correlation matrix analysis of physico-chemical parameters and macrofaunal standing stock

	Depth	Density	Biomass	Temp.	Salinity	pH	DO	OC
Depth	—							
Density	-0.048	—						
Biomass	-0.0275	**0.903***	—					
Temp.	-0.001	0.33	0.304	—				
Salinity	**0.655***	-0.286	0.262	0.345	—			
pH	0.258	**-0.606****	-0.072	**-0.501***	0.238	—		
DO	-0.077	-0.048	0.01g.	-0.328	-0.364	0.079	—	—
OC	**-0.524***	**0.589***	-0.046	0.36	-0.483	**-0.532***	0.344	—

*P < 0.05

food, especially for suspension feeders[19]. Sponges are the most conspicuous sessile organisms among Antarctic macrobenthos that provide refuges for motile species and attachment sites for a range of sessile as well as motile fauna. Prominent species collected during the present investigations were *Rosella antarctica* and *Isodictya echinata* observed at the majority of sampling locations. Even though the present study covers a portion of the Queen Maud Land area, it is interesting to note that many "typical Antarctic species" are included in the collection.

Significant proportion of the Antarctic benthic biomass, perhaps as much as 60%, is in the form of sessile organisms, which are largely unavailable to the benthic consumer or not readily utilized by it. The main reason for higher benthic biomass in Antarctic shelf area is postulated to the absence of crabs, sharks, the limited diversity of teleosts and skates[20]. The supremacy of slow-moving invertebrate megafauna, and occurrence of dense ophiuroid and crinoid population, essentially points towards the absence of skeleton-breaking predators in Antarctica. The food requirement of the benthic fauna showed a positive relationship with epifaunal density. The plankton shower in Antarctica forms the major source of food for bottom animals[5&21]. Hence, the abundance of such epifauna must be responsible for the low biomass of infaunal animals by preventing food reaching the sediments.

The values of organic carbon in the sediment support the assumptions that, it can support higher productivity. However, in spite of having high biomass the population of Antarctic benthos shows a low productivity since the organic matter is sometimes resuspended due to breaking of shelf ice and then again available to suspension feeders.

Quantitative data on macrobenthos collected in two occasions (1984-85 and 1992-93) in the Lazarev Sea showed similar changes for major population variables. Biomass showed a general increase in 8 years and a major part of the increase proportion was due to molluscan species. The increased benthic biomass attributed to the availability of sedimentary organic matter to the bottom.

Pelagic-benthic coupling

The Chl-*a* production in surface water showed significant positive correlation with sediment organic carbon ($r=0.801$; $n=7$; $p<0.05$ Fig. 4) and macrobenthic biomass ($r=0.6$; $n=10$; $p<0.05$; Fig. 5). Although the production of Chl-a was significantly higher in austral summer than winter, the production of smallest category picoplankton takes place almost all year around in shelf water and insures the continuous supply of particulate matters to the bottom fauna. This will certainly reflect on the overall energy flux in the water column and its availability to the bottom fauna. Benthic communities of continental Antarctica are supposed to depend on the water column productivity and the consumption of carbon was considerably greater by the Antarctic benthos than the zooplankton. This is probably due to the large benthic biomass[1]. Round the year study conducted in the pack ice zone of the Queen Maud Land, indicated Chl-*a* maxima during December (3.68 mg m^{-3}), with a abrupt production of Chl-*a* throughout the year[22]. Round the year, study of benthic production may give the true picture of water column and benthic productivity in the Antarctic Ocean, which help in assessing the carbon budget and potential living resources of the area.

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