

Biochemical composition of Antarctic zooplankton from the Indian Ocean sector

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Zooplankton samples were analysed for faunal composition, organic carbon, protein, carbohydrate and lipid content. Total zooplankton biomass (as displacement volume) varied from 0.032 to 0.500 ml.m⁻³ ($\bar{x}=0.23\pm0.14$) in upper 200 m with significant differences between the Antarctic and the sub-Antarctic waters. Calanoid copepods were numerically the predominant group comprising $\geq 80\%$ of total counts, whereas, euphausiid *Euphausia superba* was abundant in samples collected south of lat. 55°S. Organic carbon concentrations ranged from 0.83 to 13.04 mgC.m⁻³ ($\bar{x}=5.91\pm3.59$). Lipid was the principal biochemical component, varying between 11.08 to 27.65% ($\bar{x}=21.04\pm4.39$). Protein content showed large variations and ranged between 8.02 and 29.9% ($\bar{x}=19.57\pm6.25$). Values for carbohydrate content varied from 11.01 to 27.65% ($\bar{x}=19.62\pm4.80$). Higher accumulation of lipids in Antarctic zooplankton during phytoplankton blooms (austral summer) could be an adaptative phenomenon, and may function as metabolic reserve and insulation layer.

Most of the information on distribution and abundance of Antarctic zooplankton comes from the Atlantic sector of the Southern Ocean, especially from the peninsula region and the Antarctic Circumpolar Current-Weddell Sea region¹⁻³. In comparison, the information is scanty on zooplankton from the Indian Ocean sector⁴⁻⁸.

The present paper reports results from studies on major biochemical composition, abundance and species contribution of assorted zooplankton, including Antarctic krill collected during the austral summer of 1986-87.

Materials and Methods

Oceanographic observations during the VI-Indian scientific expedition to Antarctica (VI-ISEXA) were made during 27 December 1986 to 6 March 1987, on board *M.V. Thuleland*, from the stations along a predetermined cruise track (Fig. 1). Water samples were collected from standard hydrographic depths using metallic Nansen samplers fitted with reversing thermometers. For phytoplankton biomass seawater samples were collected with PVC Niskin samplers. Water samples were filtered (Whatman GF/F filters) and chlorophyll-*a* (chl-*a*) was determined fluorometrically⁹ (Turner Designs Fluorometer).

Zooplankton samples were collected throughout the austral summer (22 February to 6 March 1987) from 21 stations using a Bongo net (60 cm mouth diam, mesh size of 400 μ m). Samples were

collected with vertical hauls from 200 m to the surface at a speed of about 1 m.s⁻¹ at each station. After recording the biomass (displacement volume), a sub sample was preserved for taxo-

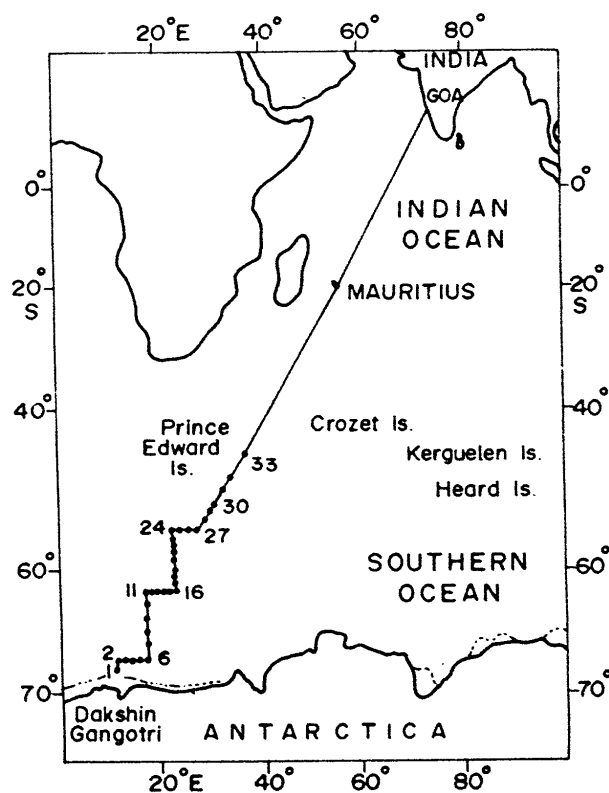


Fig. 1—Sampling locations in the Southern Ocean

onomic studies. Remaining zooplankton samples were washed with distilled water and kept frozen until analysis. Samples were dried at 70°C until a constant weight was obtained [a factor (78.8) for dry weight equivalent was calculated]. Dried samples were powdered and were analysed for organic carbon¹⁰, carbohydrate¹¹, protein¹², and lipid¹³.

Results and Discussion

Physico-chemical characteristics of the study area are presented in Table 1. Wide fluctuations were observed in surface water temperature and salinity. Sea surface temperature ranged from -1.8°C to 1.98°C ($\bar{x}=1.7\pm 0.4$) with increase towards the north. Salinity of the surface water ranged between 33.94 to 37.37×10^{-3} ($\bar{x}=35.70\pm 1.12$). The dissolved oxygen content of surface water varied from 8 to 10 ml.l⁻¹ ($\bar{x}=7.97\pm 0.44$). Surface water pH also showed small variations (8.04 to 8.25; $\bar{x}=8.12\pm 0.04$). Chlorophyll-*a* values for 0 to 75 m varied from 16 to 99 mg.m⁻³ ($\bar{x}=38.18\pm 28.10$) with a highest values being at lat. 63°S.

Zooplankton biomass increased gradually from Antarctic convergence zone (lat. 46°S) to the south (Table 2). Biomass values were generally higher in the Antarctic divergence region (between lat. 60° to 65°S). Mean biomass values differ significantly between Antarctic convergence and divergence zone (Man-Whitney U test, $P<0.05$, $n_1=11$, $n_2=10$). The biomass values varied between 0.032-0.445 ml. m⁻³ ($\bar{x}=0.212\pm 0.114$, $n=11$) and 0.037-0.500 ml. m⁻³, ($\bar{x}=0.212\pm 0.114$, $n=11$) and 0.037-0.500 ml. m⁻³, ($\bar{x}=0.245\pm 0.166$, $n=10$), with a overall mean biomass of 0.230 ± 0.140 , $n=21$ for the entire study area. Highest biomass of 0.5 ml.m⁻³ recorded at lat. 62°S (st. 17) was mainly due to swarming of antarctic krill and the lowest values was at lat. 57° (st. 2).

The standing stock of zooplankton biomass in terms of dry weight equivalent varied from 2.52 to 39.40 mg.m⁻³ ($\bar{x}=17.86\pm 10.85$) in the study area and is comparable with the mean values of 50 mg.m⁻³ reported for the Southern Ocean¹⁴. However, the sample to sample variations were very high with coefficients of variation >1 (Fig. 2). Pant¹⁵ and Mathew⁷ suggested that variation in zooplankton biomass may be due to the day to day fluctuations in the chlorophyll concentrations. In terms of organic carbon the values ranged between 0.83 to 13.04 mg.m⁻³ ($\bar{x}=5.91\pm 3.59$).

All the samples were combined and a mean total abundance (%) of zooplankton in the upper

200 m depth are shown in Fig. 3. Zooplankton samples consisted of copepods, cheatognaths, ostracods, polychaets and amphipods. The abundance of euphausiids (adult and juvenile stages) were observed in waters south of lat. 55°S. Generally, copepods (mainly calanoids) were the most abundant constituents (89.4%) of zooplankton communities. Cheatognaths (2.8%), Foraminifera (2.5%), Appendicularia (1.5%) and euphausiids (1.2%) were other groups occurred throughout the sampling location. Hopkins¹⁶ reported that copepods, cheatognaths and euphausiids were the main constituents of a zooplankton community in the open Southern Ocean. It is true for the present study also where the three groups (Copepoda, Cheatognatha and Foraminifera) constituted

Table 1—Physico-chemical characteristics of the surface water

St. no.	Temp. (°C)	pH	D.O. (ml l ⁻¹)	Salinity ($\times 10^{-3}$)
2	0.58	8.12	7.84	34.73
6	1.09	8.04	—	34.31
7	1.62	8.12	—	34.08
9	1.80	8.10	—	34.67
10	1.80	8.25	8.40	35.30
11	1.90	8.12	—	—
14	1.80	8.10	7.50	36.00
15	1.89	8.12	7.61	36.00
17	1.92	8.13	7.72	—
18	1.83	8.13	7.95	35.73
19	1.80	8.11	7.72	36.00
20	—	8.11	8.90	37.30
21	1.98	8.11	8.06	36.00
23	—	—	—	37.00
24	1.98	8.12	—	37.30
26	1.98	8.13	—	—

— data not available

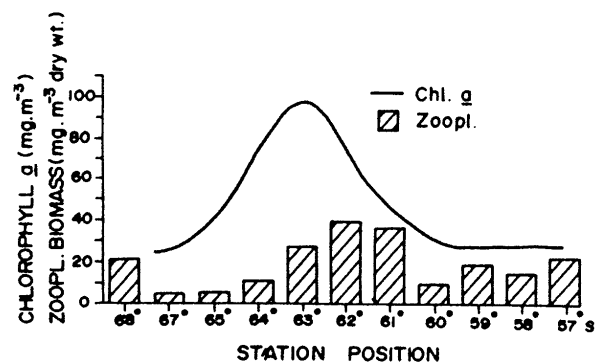


Fig. 2—Latitudinal variation in zooplankton biomass (dry wt.) and column chlorophyll-*a*

Table 2—Details of zooplankton sampling in Antarctic waters

St. no.	Lat. (°S)	Long. (°E)	Zooplankton biomass				Major groups*
			A	B	C	D	
2	68.00	13.00	0.037	2.62	0.90	—	1-3
6	68.00	16.59	0.265	21.65	7.39	16	1, 2, 4
7	67.00	17.01	0.059	4.83	1.65	17	1, 2, 5
9	64.59	16.59	0.074	6.06	2.07	39	1, 2, 4
10	64.00	16.59	0.139	11.36	3.89	82	1, 2, 6
11	63.00	17.00	0.347	28.35	9.70	99	1, 2, 6
14	63.00	20.00	0.284	23.20	7.93	—	1, 2, 6
15	63.00	21.00	0.258	21.08	7.21	—	1, 2, 6
17	62.00	22.00	0.500	40.85	13.96	50	1, 2, 4
18	61.00	21.59	0.468	38.24	13.06	32	1, 2, 6
19	60.00	21.59	0.136	11.11	3.80	21	1, 2, 6
20	59.00	22.00	0.242	19.77	6.76	21	1, 2, 7
21	58.00	21.59	0.189	15.44	5.28	24	1, 2
23	57.00	23.00	0.445	36.36	12.44	—	1, 2, 4
24	57.00	24.00	0.032	3.02	1.03	—	1, 2, 4
26	56.59	25.59	0.287	22.45	8.02	19	1, 2
29	55.00	29.22	0.120	9.80	3.35	—	1, 2
30	54.00	30.32	0.160	13.07	4.47	—	1, 2, 4
31	50.00	34.52	0.340	27.78	9.50	—	1, 2, 4
32	49.00	35.58	0.210	17.16	5.87	—	1, 4, 6
33	48.00	36.59	0.170	13.89	4.75	—	1, 2, 4

A = Displacement volume ml. m⁻³; B = dry wt. (mg. m⁻³); C = organic carbon (mg. m⁻³); and D = chlorophyll-*a* (mg. m⁻³)

*1 = Copepods; 2 = Euphausiid; 3 = Appendicularia; 4 = Cheatognaths; 5 = Polychaetes; 6 = Amphipods; 7 = Foraminifera

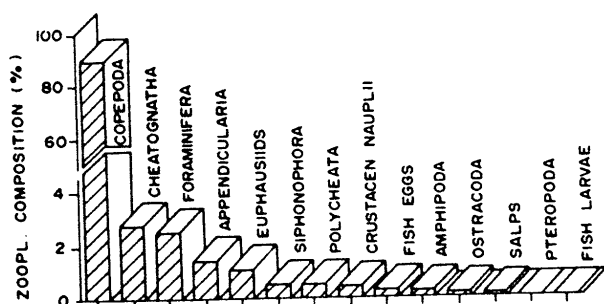


Fig. 3—Composition (%) of major zooplankton taxa

> 94% of total zooplankton in terms of numbers. Siphonophora, polychaete larvae and amphipods were the other major components of the zooplankton.

The protein content of zooplankton showed large variations (Fig. 4) and varied between 8.02 and 29.9% ($\bar{x}=19.57 \pm 6.25$). These values are comparable with those reported for mixed zoo-

plankton from higher latitudes^{17,18}. Carbohydrate content varied from 11.01 to 27.65% ($\bar{x}=19.62 \pm 4.80$). Lipid contributed 11.08 to 24.32% ($\bar{x}=21.04 \pm 4.39$) of dry weight of zooplankton. Relatively higher lipid values are generally observed for temperate zooplankton^{14,19-21}, where accumulation of lipids during summer months has been demonstrated in calanoid copepods, amphipods, cheatognaths, polychaetes and in euphausiids. Relatively higher accumulation of lipid suggest that it serves as an effective energy reserve to tide over formidable winter. Therefore, lipids play a major, and often crucial role in the survival strategies of organisms in polar regions²².

In general, the biochemical composition of zooplankton exhibited spatial variation. This was perhaps due to differences in compositions at these stations. The population of dominating species, the antarctic krill *Euphausia superba*, which contain high amount of proteins and lipids^{21,22}, was most fluctuating in the study area²³. Hence the composition of biochemical compounds in mixed zooplankton will be influenced by the presence or absence of *E. superba* in the sample.

It is well known that zooplankton from higher

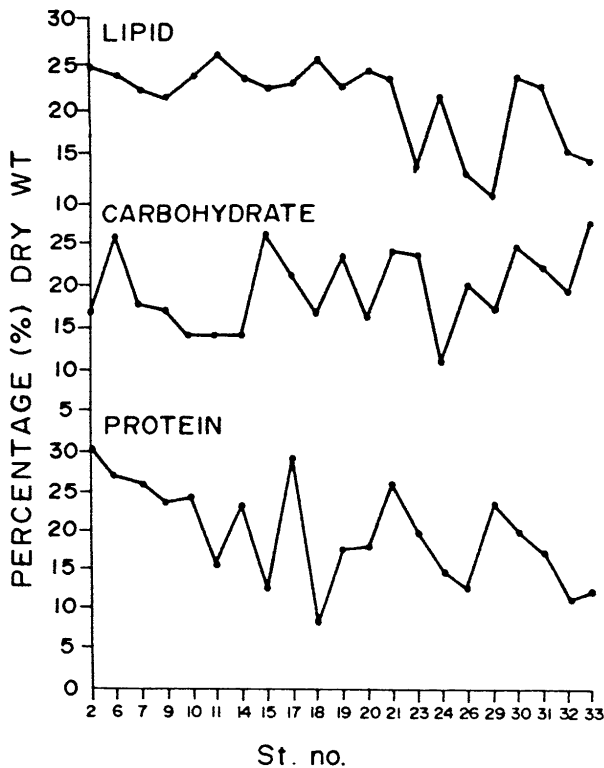


Fig. 4—Variation in biochemical composition of assorted zooplankton in the Antarctic waters

latitudes normally derive energy from the oxidation of carbohydrates and lipids and proteins are utilized during starvation^{17,18}. The reduced protein values in the present study also support the earlier findings that protein accumulations in antarctic zooplankton are generally lower than lipids and carbohydrates. In terms of the organic carbon lipid contributed maximum with very high percentage (47.55%) as compared to protein and carbohydrate which contributed about 29.10 and 23.3%, respectively which could be attributed to the presence of non protein nitrogenous (NPN) compounds^{17,24}. Lipid protein ratio has been considered as an indicator of calories²⁵. Thus the high lipid:protein ratio >0.9 indicate a higher caloric content in the Antarctic zooplankton.

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References

- 1 Marin V, *Deep-Sea Res.* 34 (1987) 105.
- 2 Hopkins T L & Torres J J, *Polar Biol.* 9 (1988) 79.
- 3 Hubold G, Hempel I & Meyer M, *Polar Biol.* 8 (1988) 225.
- 4 Goswami S C, in *Scientific Report—First Indian Expedition to Antarctica*, Tech Pub No. 1, (Dept. of Ocean Development, New Delhi) 1983, 202.
- 5 El-Sayed S Z, in *Antarctic nutrient cycles and food webs*, edited by W R Siegfried, P C Condy and R M Laws (Springer-Verlag, Berlin) 1985, 284.
- 6 Hampton I, in *Antarctic nutrient cycles and food webs*, edited by W R Siegfried, P C Condy and R M Laws (Springer-Verlag, Berlin) 1985, 249.
- 7 Mathew K J, in *Scientific Report—Third Indian Expedition to Antarctica*, Tech Pub No 3, (Dept of Ocean Development, New Delhi) 1986, 149.
- 8 Endo Y, Imaseki T & Komaki Y, *Mem Natl Inst Polar Res.* (special issue) 44 (1986) 107.
- 9 Strickland J D H & Parsons T R, *A practical handbook of seawater analysis*, Bull. No. 167, (Fish Res Bd Canada, Ottawa) 1972, pp. 310.
- 10 El-Wakeel S K & Riley J P, *J Cons Perm Int Explor Mer.* 22 (1957) 180.
- 11 Parsons T R, Maita Y & Lalli C W, *A manual of chemical and biological methods for seawater analysis* (Pergamon Press, New York) 1984, 101.
- 12 Herbert D, Phipps P J & Strange R C, in *Methods in microbiology*, Vol. 5B, edited by J R Nortis and D W Ribbons (Academic Press, London) 1971, 244.
- 13 Dubois M, Gillas K A, Hamilton J K, Rebur R A & Smith F, *Anal Chem.* 28 (1956) 350.
- 14 Everson I, in *Marine ecology*, edited by R M Laws (Academic Press, London) 1984, 463.
- 15 Pant A, in *Scientific Report—Third Indian Expedition to Antarctica*, Tech Pub No 3, (Dept of Ocean Development, New Delhi) 1986, 87.
- 16 Hopkins T L, *Ant Res Ser.* 17 (1977) 347.
- 17 Reeve M R, Raymont J E G & Raymont J K B, *Mar Biol.* 6 (1970) 357.
- 18 Raymont J E G, in *Essay in hydrobiology*, (Univ of Exeter, Southampton) 1972, 83.
- 19 Lee R F & Hirota J, *Limnol Oceanogr.* 18 (1973) 227.
- 20 Ferguson C F & Raymont J K B, *J Mar Biol Assoc UK.* 54 (1974) 719.
- 21 Reinhardt S B & Van Vleet F S, *Antarctic J U S.* 19 (1984) 139.
- 22 Fahl K & Kattner G, *Polar Biol.* 13 (1993) 405.
- 23 Ingole B S & Parulekar A H, *J Biosci.* 18 (1993) 141.
- 24 Madhuratap M, Venugopal P & Haridas P, *Indian J Mar Sci.* 8 (1979) 155.
- 25 Sertorio T Z, Cassiani I. & Palmero S, *Mem di Biologia Marina ed Oceanografia.* 15 (1985) 91.