

36. Zooplankton characteristics of the coastal ecosystem off Bombay, India.

Vijayalakshmi R. Nair & Neelam Ramaiah

National Institute of Oceanography Regional Centre,
Versova, Bombay 400 061, India.

KEY WORDS: Zooplankton production, community structure, coastal ecosystem off Bombay.

ABSTRACT

The nearshore waters of Bombay sustain a rich and diverse zooplankton fauna. Continuous observations for a period of 15 months indicated a variation from 0.4 to 19.9 mg C.m⁻³ (av. 4.3 mg C.m⁻³) in zooplankton biomass. The zooplankton production peak was found during the postmonsoon period of October to January following the unusually high phytoplankton production of the monsoon period (June to September, av. cell count 729 x 10³.l⁻¹). Of the forty two species, *Acartia spinicauda* dominated the copepod community. Four species of chaetognaths were found in the area with predominance of *Sagitta bedoti*. Among the penaeid larvae *Metapenaeus affinis* was the most common species. Population of omnivores dominated the zooplankton community. On an average the percentage contributions of omnivores, herbivores and carnivores were respectively 69, 20 and 11. The zooplankton community appears to be partially influenced by the high fluxes of anthropogenic pollutants reaching the coastal waters from the interior creek system.

INTRODUCTION

Production potential and community structure of zooplankton off Bombay coast are of importance due to its vital location along the central west coast of India. Though a few reports on zooplankton are available for the area (Gajbhiye & Desai, 1981; Nair et al., 1983; Gajbhiye et al., 1991) a comprehensive account on zooplankton has yet to be established and the present study contemplates this aspect. Rapid industrialisation of this metropolis has caused environmental stress in some of the creek environments (Zingde et al., 1979; Lodh, 1990; Nair et al., 1991) which may have subtle impact on the

coastal marine ecosystem off Bombay. Hence the baseline evolved is useful for future assessment of the zooplankton community primarily to understand the change, if any, over a period of time.

MATERIAL AND METHODS

Zooplankton samples were collected every month from October 1985 to September 1986 from selected locations off Bombay (Fig. 1), from depths of 15 to 20 m. A Heron Tranter net (mesh size 0.3 mm; mouth area 0.25 m²) fitted with a TSK flow meter was used for oblique collections. Analysis of zooplankton was done as per standard procedure (IOBC, 1969), in which displacement volume is considered as biomass. Zooplankton were identified and enumerated from whole samples or aliquots depending on sample size. Trophic grouping of total zooplankton and copepods were based on food and feeding habits (Raymont, 1983; Timonin, 1971). A duplicate sample was collected for estimation of organic carbon content following the method of E1 Wakeel & Riley (1957) in which biomass values are converted into carbon equivalents. Water samples were collected for relevant environmental parameters to monitor the water quality. The Shannon-Wiener diversity index H', evenness E and the Margalef D value were estimated (Margalef, 1968).

RESULTS AND DISCUSSION

The fluctuations in various physico-chemical parameters (Table 1) are

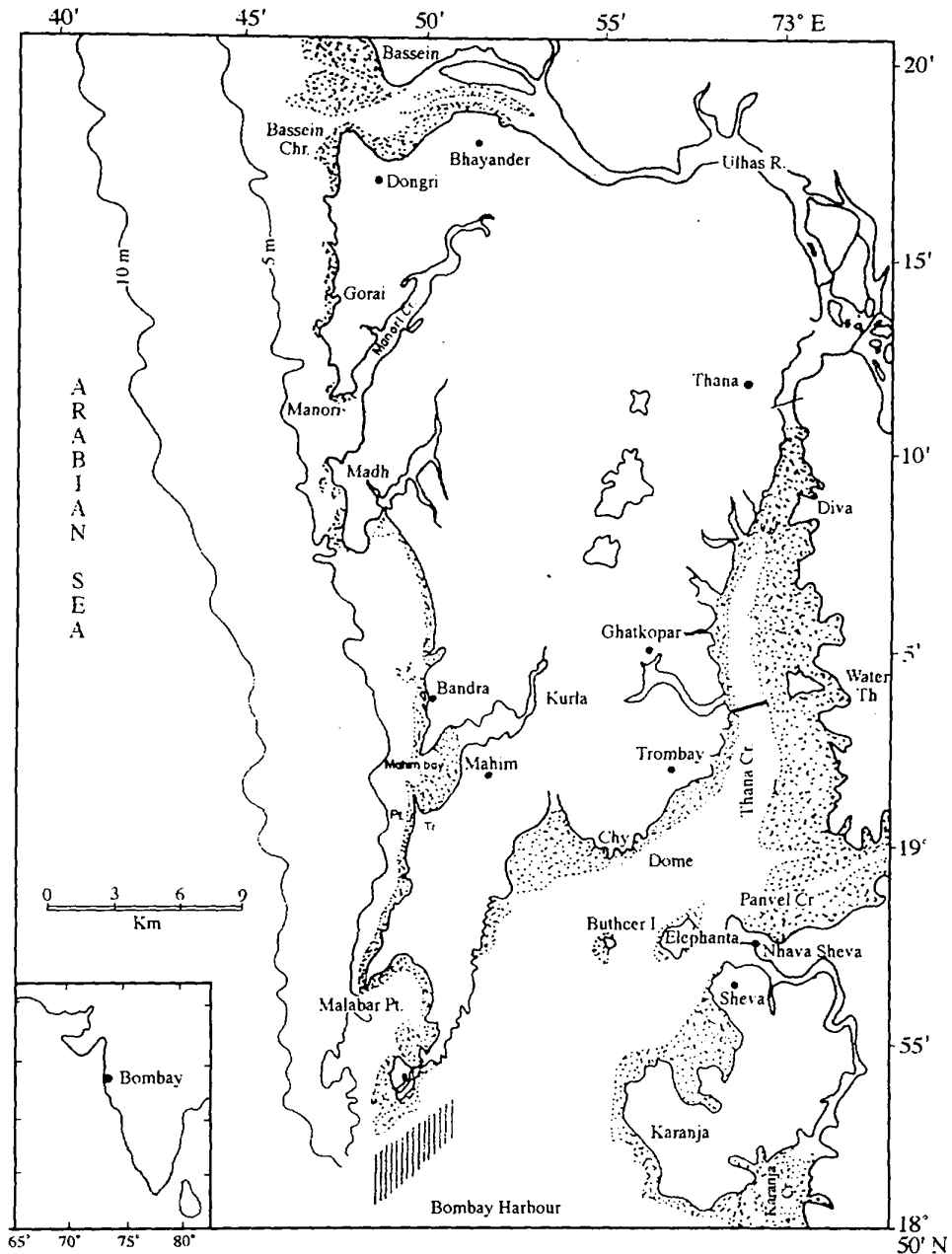


Fig. 1. Bombay coast showing location of observation (hatched area).

linked with the monsoon. During the monsoon period salinity values are relatively low due to freshwater input through the adjacent creeks. Oxygen level is comparable to a healthy coastal marine environment. However, concentration of nutrients particularly nitrate is always high. Most of the creeks around Bombay receives sewage and industrial effluent. The present area of

investigation is most influenced by the Thana creek which receives $>180.10^6$ m^3/day of industrial effluent and 350.10^6 m^3/day of domestic sewage (Lodh, 1990). This enhanced the levels of nitrate in the nearshore environment and supported a rich phytoplankton population. Chlorophyll a has a maximum during the monsoon (av. 2.4 $mg.m^{-3}$) with comparable values for the

premonsoon (av. 1.3 mg.m⁻³) and postmonsoon (1.1 mg.m⁻³) periods. Phytoplankton cell counts also show a similar trend with a peak coinciding with the monsoon (Table 1).

Zooplankton potential

Maximum standing stock was observed during the postmonsoon period with a peak in October (2.9 ml.m⁻³). In terms of carbon equivalent the production varied from 0.4 to 19.9 (av. 4.3) mg C.m⁻³ (Fig. 2). The ratios for monsoon, premonsoon, postmonsoon was 1 : 1.4 : 2.9. Population density of zooplankton was maximum for the premonsoon period (Table 1). The relatively low population density during the postmonsoon period was due to the aggregations of medusae and ctenophores in the area (Fig. 3). It appears that these gelatinous organisms are transported to the area from the interior creek environment of Thana where proliferation of medusae (*Blackfordia virginica*, *Eivene ceylonensis* and *Eutima commensalis*) and ctenophores (*Pleurobrachia globosa*) is a recurrent phenomenon associated with industrial waste input (Lodh, 1990).

Copepods

The contribution of copepods varied from 44 - 97% of the total population

of zooplankton. They dominated the zooplankton community except in April and June. Forty-two species of copepods belonging to 19 genera were identified. On average the number of species recorded for monsoon, premonsoon and postmonsoon were in the order of 19, 18 and 14 respectively. *Acartia* was the dominant genus. The common species observed were *A. spinicauda*, *A. centrura*, *Centropages dorsispinatus*, *Paracalanus aculeatus*, *A. pacifica*, *Eucalanus subcrassus* and *Canthocalanus pauper* (Fig. 4). *A. spinicauda* dominated the copepod population in October 1985 (61%) while *A. centrura* contributed 52 and 74% of the total number of copepods

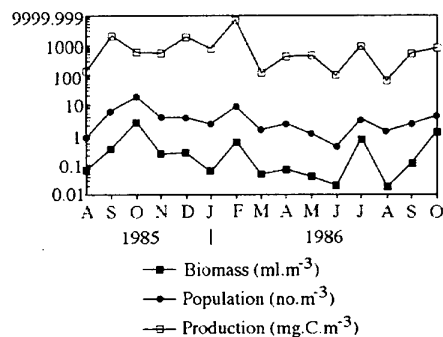


Fig. 2. Variation in zooplankton biomass and population off Bombay.

Table 1. Water quality and selected plankton characteristics off Bombay. Values are given as range and average in parenthesis.

Parameter	Premonsoon (February-May)	Monsoon (June-September)	Postmonsoon (October-January)
Temperature (°C)	27.0-30.0(28.1)	27.0-29.2(27.7)	25.0-28.0(25.7)
Salinity ‰	35.6-37.0(36.4)	26.9-35.8(33.2)	34.8-36.6(35.7)
pH	7.9-8.2(8.1)	7.7-8.1(7.9)	7.7-8.2(7.9)
DO (mg/l)	6.1-8.1(6.8)	6.2-8.7(7.5)	4.1-7.6(6.1)
BOD (mg/l)	1.7-2.6(2.1)	0.3-2.2(1.6)	1.0-2.5(1.5)
Phosphate (µgat/l)	0.3-2.6(1.7)	0.7-4.4(1.9)	1.4-4.9(3.0)
Nitrite (µgat/l)	0.1-2.8(0.8)	0.1-1.8(0.8)	0.7-4.7(2.3)
Nitrate (µgat/l)	1.4-17.3(8.8)	0.2-23.9(10.3)	1.1-29.2(13.7)
Chlorophyll a (mg/m ³)	0.5-2.6(1.3)	0.5-4.8(2.4)	0.5-2.1(1.1)
Phytoplankton cell count (n x 10 ³ /l)	61-114(88.2)	83-2735(729.3)	26-528(107.4)
Zooplankton biomass (ml/m ³)	0.04-0.64(0.20)	0.02-0.78(0.23)	0.6-2.9(0.87)
Zooplankton production (mg C/m ³)	1.1-9.1(3.5)	0.4-6.5(2.4)	2.5-19.9(6.9)
Zooplankton population (n/m ³)	122-6971(2005)	67-2235(414)	586-1938(994)
Taxonomic groups (n)	7-15(11)	10-14(12)	13-16(14)

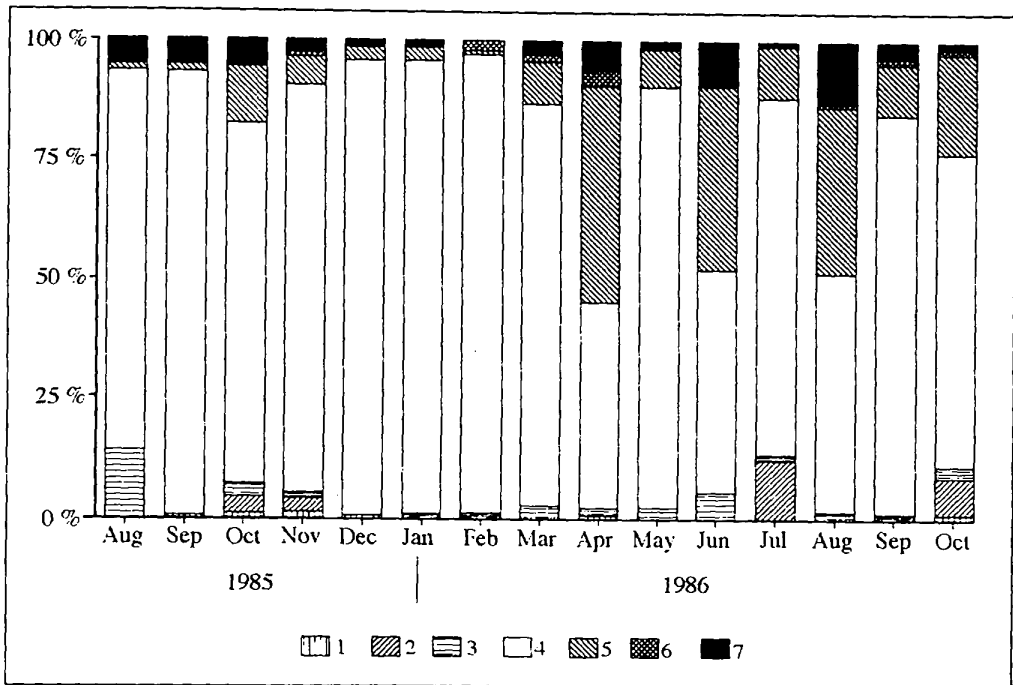


Fig. 3. Relative percentages of major groups of zooplankton off Bombay. 1) medusae, 2) ctenophores, 3) actinoptera, 4) copepods, 5) decapods, 6) gastropods, 7) other groups.

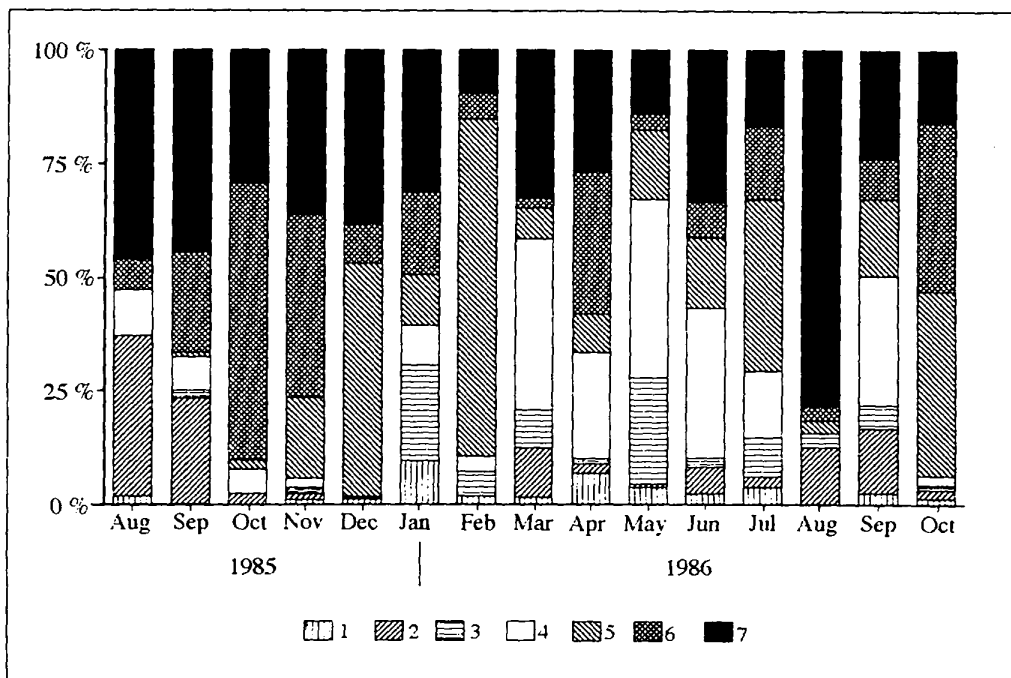


Fig. 4. Relative percentages of common species of copepods off Bombay. 1) *Canthocalanus pauper*, 2) *Eucalanus subcrassus*, 3) *Paracalanus aculeatus*, 4) *Acrocalanus* sp., 5) *Acartia centrura*, 6) *A. spinicauda*, 7) other species.

during December and February respectively. *Temora turbinata*, *Euterpina* sp., *Microsetella* sp., *Oncaea* sp. and *Pseudodiaptomus annandalei* were restricted to the monsoon period while *Euchaeta indica* and *Centropages orsinii* were encountered only during the premonsoon period. *Allodiaptomus* sp was found only in the postmonsoon season. The Shannon-Wiener diversity index (H') fluctuated between 1.65 and 3.46 with a maximum value in January when 17 species were recorded. An evenness (E) of 0.85 was recorded at that time. The minimum value of H' coincided with the E value of 0.45 when the total number of species dropped to 13. The Margalef D value showed a variation of 0.82 (June) to 2.23 (December) when the respective numbers of species found were 20 and 11. The species composition indicated dominance of omnivores (70%) over herbivores (23%) and carnivores (7%). Though a peak in phytoplankton density was found during the monsoon period, the population maximum of phytophagous copepod in the community did not synchronise with it (Table 2).

Decapods

Decapods were present throughout the period of investigation contributing 0.6 (February) to 45.2% (April) of the total population of zooplankton population. Seasonal maximum density (no. ind. m^{-3}) was during the premonsoon (73), rather than the monsoon (55), and postmonsoon (41) periods. Among the decapods, Sergestidae, Penaeidae, Caridea, Scyllaridae, Thalassinidae, Paguridae, Porcellanidae and Brachy-

ura were present. The major part of the population were larval stages, the only exception being Sergestidae represented by adults of *Acetes* and *Lucifer*. Brachyura formed the largest group among the decapod larvae (0.1 to 99.9%; av. 49%) represented by the zoea and megalopa larvae. A relatively stable population was found during the postmonsoon period. Penaeid larvae were dominated by *Metapenaeus*. The species present were *M. affinis*, *M. dobsoni*, *M. monoceros*, *Penaeus indicus* and *Parapenaeopsis* sp. The breeding period of penaeids appears to be the monsoon and premonsoon periods. The distribution pattern of *Acetes* indicated maximum abundance during April to July coinciding with the lean fishing season off the Bombay coast.

Chaetognaths

Chaetognaths contributed 0.2% (December) to 13% (August) of the total zooplankton numbers. m^{-3} . Maximum average population density was observed during the premonsoon period ($19.m^{-3}$) than it drops in the postmonsoon ($8.m^{-3}$) and the monsoon ($6.m^{-3}$) period. *Sagitta bedoti* was the dominant species. Other common species observed in the area were *S. enflata*, *S. oceania* and *S. robusta* (Ramaiah & Nair, 1993). *S. robusta* showed a very low frequency of occurrence, and *S. bedoti* exhibited continuous breeding with intense spawning during December, February to June, and August.

Community structure

The different groups represented (Fig. 3; Table 1) in the collections varied

Table 2. Percentage contribution of herbivores, omnivores and carnivores to the zooplankton community.

Group	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Total zooplankton															
Herbivores	9.1	12.5	9.3	4.9	2.5	31.5	11.0	44.0	23.4	61.0	24.9	19.5	15.6	35.9	2.9
Omnivores	59.6	84.9	80.7	87.7	97.0	48.2	85.7	41.2	70.2	31.5	64.4	61.8	76.8	58.2	82.2
Carnivores	30.9	1.6	10.0	7.4	0.5	20.3	3.3	14.9	6.4	7.5	10.7	18.7	7.6	5.9	14.9
Copepods															
Herbivores	11	11	5.3	3.5	1.3	32.6	9.3	48.9	33.7	67.7	41.2	25.3	11.0	39.5	2.8
Omnivores	73.5	88.4	91.2	95.2	98.6	47.0	88.3	38.1	56.7	26.4	49.4	68.1	79.0	55.8	92.6
Carnivores	15.4	0.6	3.5	1.4	0.1	20.2	2.3	13.0	9.6	6.0	9.4	6.7	10.0	4.7	4.6

from 7 to 16 (av. 12). Higher densities in medusae and ctenophores were observed during the postmonsoon (av. 25 ind.m⁻³) than during the other two seasons (av. 11 ind.m⁻³). Larval stages of gastropods and bivalves were fairly abundant with maximum abundance respectively for the premonsoon and postmonsoon periods. Polychaetes, ostracods, mysids, isopods, amphipods, cirripede larvae, stomatopod larvae, copelates, fish eggs and fish larvae were common in the collection. Larvae of anthozoans and echinoderms, pteropods, cladocerans and cumaceans were rarely recorded from the area. *Salpa maxima* and *Ritteriella ambonensis* appeared in low numbers in September (4 ind.m⁻³), leading at intervals to congregations in October (30 ind.m⁻³), disappearing again in November. This appears to be a recurring phenomenon coinciding with the peak fishing season, particularly that of pomfret fishery (Lodh et al., 1989). Salps contributed 43% of the gut content of pomfret caught in this area. Invariably omnivores predominated the area except during March and May (Table 2). On average the relative percentages of omnivores, herbivores and carnivores were 69, 20, and 11. Dominance of omnivores in the polluted creek environments of Bombay has already been reported (Gajbhiye, et al., 1991).

In order to study the coexistence of the different groups of zooplankton, a matrix of correlation over time was worked out. A significant positive correlation implies coexistence between the groups. R values at $p < 0.001$ were considered to be the best correlation. Chaetognaths and siphonophores indicated a significant positive correlation, suggesting an association of gelatinous carnivores. Cumaceans and copelates coexisted, whereas thaliaceans occurred along with isopods and amphipods. Gastropods showed a significant correlation with echinoderm larvae while cirripede larvae and fish larvae occurred together. A negative correlation was observed between copepods and decapods.

Characteristic features

The area supports a fairly rich and diverse zooplankton community, and is

twice as productive compared with the coastal waters north and south of the survey zone (Lodh, 1990). The production peak in zooplankton was succeeding the phytoplankton bloom. However, the zooplankton community was not dominated by herbivores even during the phytoplankton bloom period, indicating deviation from the normal pattern. Considerable increase in zooplankton standing stock was reported from the interior polluted locations of Thana creek because of high populations of carnivores compared to herbivores. Such an unbalanced state of the zooplankton community is a characteristic feature of areas receiving substantial industrial waste inputs (Lodh, 1990). Enhancement in nutrient level, dominance of omnivores and proliferation of gelatinous carnivores in the area are indicative of the influx of polluted water masses from the Thana creek. Such fluxes of anthropogenic pollutants lead to subtle modifications in the coastal marine ecosystem off Bombay.

REFERENCES

- EL WAKEEL, S.K. & J.P. RILEY, 1957. Determination of organic carbon in marine muds. *J. Cons. Perm. Int. Explor. Mer.*, 22: 188-183.
- GAJBHIYE, S.N. & B.N. DESAI, 1981. Zooplankton variability in polluted and unpolluted waters around Bombay. *Mahasagar. Bull. Natn. Inst. Oceanogr.*, 14: 173-182.
- GAJBHIYE, S.N., R. STEPHEN, V.R. NAIR & B.N. DESAI, 1991. Copepods of the nearshore waters of Bombay. *Indian J. Mar. Sci.*, 20: 187-194.
- IOBC (Indian Ocean Biological Centre). 1969. Handbook to the International Zooplankton collections. 1. Station list. IOBC Natn. Inst. Oceanogr. CSIR, Cochin, India: 129 pp.
- LODH, N.M., 1990. Ecological studies on plankton from nearshore waters of Bombay. Ph. D. Thesis. University of Bombay: 203 pp.
- LODH, N.M., S.N. GAJBHIYE & V.R. NAIR, 1988. Unusual congregation of salps off Veraval & Bombay, West Coast of India. *Indian J. Mar. Sci.*, 17: 128-130.
- MARGALEF, R., 1968. Perspectives in ecological theory. Univ. of Chicago Press. Chicago: 111 pp.
- NAIR, V.R., S.N. GAJBHIYE & B.N. DESAI, 1991. Effect of pollution on the distribution of chaetognaths in the nearshore waters of Bombay. *Indian J. Mar. Sci.*, 20: 43-48.

NAIR, V.R., S.N. GAJBHIYE & F.H. SAYED, 1983. Variations in the organic carbon content of zooplankton in the nearshore waters of Bombay, Maharashtra. *Indian J. Mar. Sci.*, 12: 160-165.

RAMAIAH, N. & V.R. NAIR, 1993. Population abundance and species composition of chaetognaths in the Bombay harbour - Thana and Bassein creek estuarine complex. *Indian J. Mar. Sci.*, 22: 89-93.

RAYMONT, J.E.G., 1983. Plankton and productivity in the oceans. 2. Zooplankton. Pergamon Press (2nd ed.): 824 pp.

TIMONIN, A.G., 1971. The structure of plankton communities in the Indian Ocean. *Mar. Biol.*, 9: 281-289.

ZINGDE, M.D., S.K. TRIVEDI & B.N. DESAI, 1979. Physico-chemical studies on coastal pollution off Bombay. *Indian J. Mar. Sci.*, 8: 271-277.