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Diversity and Abundance of Microzooplankton of Coastal Waters of South Goa

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Abstract: The diversity and abundance of the microzooplankton community of two coastal waters of Colva and Arossim, South Goa was assessed during the period of July2013 to December 2013. Higher range of population density was recorded at the site of Colva. Tintinnids were the major contributors of the microzooplankton population apart from the dinoflagellates, immatured copepods, nauplii and some other larval forms. Tintinnids were about 89.59%, followed by 5.08% of Nauplii, 2.87% Dinoflagellates, 1.77% of *Oikopleura dioica*, 0.49% of Immatured Copepods and 0.20% of Megalopa found at Arosim. A total of 57 and 45 species of microzooplanktons were observed at the sites of Colva and Arossim respectively. In the present study most of the tintinnids and dinoflagellates were assessed up to species level.

Key words: Tintinnids・Megalopa・Simpson Index・Nutrients Inflow

INTRODUCTION

Zooplankton plays a key role in the transfer of energy from the primary producers to the higher trophic levels. Zooplankton has a wider range in vertical distribution than phytoplankton, being found even in deep waters. In species composition, zooplankton includes Protozoa, Coelenterata, Ctenophora, Crustacea, Gastropoda, Chaetognatha, Tunicata and Planktonic larvae. The distribution of some species is closely related to water movement and may serve as indicator of warm and cold currents. Zooplankton is divided into holoplankton and meroplankton. The former includes animals which are planktonic throughout their life, like the copepodes, siphonophores, ctenophores and chaetognaths. Meroplankton includes planktonic larval stages of various benthic forms. Among holoplankton, copepoda is the most important, with numerous species, larger quantity and wider distribution. Those found in oceanic waters are referred to as off-shore planktons. Holoplankton is a rather monotonous in composition, while meroplankton shows great variety. There are thus clear-cut differences between the two. But holoplanktonic organisms may be brought into the neretic waters by sudden changes in ocean currents. Based on size zooplanktons are classified into micro (20 – 200 μm), meso (200 – 500 μm) and macro (>500 μm) zooplankton.

Microzooplankton plays a significant role in pelagic ecosystems, as they transfer autotrophic carbon to higher tropic levels [1, 2]. Measurements on grazing activity in the marine environment show that Microzooplankton (MZP) is an important consumer of phytoplankton [3-5]. MZP plays an important role in controlling the phytoplankton production in nutrient enriched environments, such as the Southern Ocean and estuaries [6-8]. Microzooplankton is a group of taxonomically diverse, tiny phagotrophic organisms, which are often abundant in marine waters. They compromise a significant part in numbers of the marine zoo-plankton community, even though their biomass is usually less than the biomass of meso and macro-zooplankton. Available information [7, 8] reveals that microzooplankton graze on most of the primary production in coastal and oceanic environments and hence they are important in the trophodynamics of pelagic food webs. The following are the important microzooplankton communities: Dinoflagellates, Tintinnids, Crustaceans and Larval Stages of various marine organisms and Appendicularians.

Zooplankton distribution and abundance of water column at four transects between Goa to Gujarat during January to February was studied by Padmavati and Goswami [9]. They observed the dominance of copepods among the different groups of zooplanktons studied.

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The response of microzooplankton to coastal upwelling and summer stratification in the Southern Arabian Sea was studied by Jyothibabu *et al.* [10]. The study revealed during the late summer monsoon period river runoff and upwelling has caused high nutrient concentration in the surface of water of the southwest coast of India supporting high phytoplankton abundance. The high abundance of phytoplankton supported the exceptionally high abundance of tintinnid ciliates. Even though the species composition and distribution of zooplankton in general is well known, the diversity and distribution of microzooplankton of coastal waters of Arabian Sea in specific to Goa coast are poorly known. Hence the present study has revealed Species diversity and abundance of microzooplankton of coastal waters of Colva and Arossim of South Goa.

MATERIALS AND METHODS

Study Area: Goa lies on the west coast of India between latitudes 14° 54' to 15° 48' N and longitude 73° 40' to 74° 20' E. Being tropical, Goa has equable climate characterized by heavy rainfall during south-west monsoon. It has a coastline of 105 kms with creeks and estuaries. Colva (Site I) is located at 15° 28'N latitude and 73° 91'E longitude and Arossim (Site II) is located at 15°33'N latitude and 73°89'E longitude. Both the selected sites for the present study are coastal marine areas. But there is influx of fresh water at Arossim through a rivulet. Both the sites receive different environmental stresses.

The surface water samples at both sites were collected by filtering the water samples initially through 200µm bolting net, from July 2013 to December 2013 at fortnight intervals. The water samples were then brought to the laboratory and were subjected for microzooplankton investigation. To 500 ml of filtered water samples, 3 ml of 1% Rose Bengal prepared in formaldehyde (1 gm of Rose Bengal + 1000ml of 4 % formaldehyde) was added. Then the samples were left for 48 hours for microzooplankton to settle. Then the samples were concentrated to 10 ml by filtering through a 20 µm bolting net by gravity settling and siphoning procedure. From this 1 ml of sample was mounted on a Sedgewick Rafter and microzooplanktons were enumerated and identified with a Lynx Binocular Microscope. The abundance is reported as number per liter (No/L). Random microphotographs were taken (Pixellink camera). Most of the Dinoflagellates, Tintinids and Appendicularians were identified to the species level with available literature [11-13]. Micrometazoans were identified upto group level (Larval stages of metazoans i.e. nauplii, cypris, megalopa and immatured copepods).

Statistical Analysis: In the present study the following Alfa indices of diversity were computed following Magurran [14] to investigate the various aspects of microzooplankton assemblages.

Species Richness (R): It is a quantitative measure which refers only to the number of species recorded in each equal volume of water (Unit volume). This is the easiest measured index of diversity. Since all the samples of same volume, species richness is calculated as the total number of species present per 1000 ml of water [15].

The Shannon – Wiener Information Function (H^{+}): It is the most commonly used index in ecological studies. It is a quantitative method that measures the average diversity of a sample. It takes into consideration of both the total number of species in a population and the relative frequency of occurrence of the species.

Simpson's Index (D): It is heavily weighted towards the most abundance species and less sensitive to species richness.

Evenness (E): The E value gives a better view of relationship of dominant and rare species to total population to assess whether all the species found in the samples are evenly distributed.

RESULTS

The present study on Microzooplankton was carried out for a period of six months. The data obtained is presented in Table 1. The relative abundance of Microzooplankton was estimated in terms of percentage (Table 2). Tintinnids were the Major contributors to the microzooplankton population at both the sites. At Colva Tintinnids formed the dominant group contributing to 63.71% followed by 29.21% of Dinoflagellates, 4.51% of Nauplii, 1.40% of *Oikopleura dioica,* 1.02% of Immatured Copepods and 0.15% of Cypris. At Arossim also Tintinnids were dominant contributing to 89.59%, followed by 5.08% of Nauplii, 2.87% Dinoflagellates, 1.77% of *Oikopleura dioica*, 0.49% of Immatured Copepods and 0.20% of Megalopa. The percentage occurrence of all the microzooplanktons has been clearly depicted in a graphical form (Fig. 1).

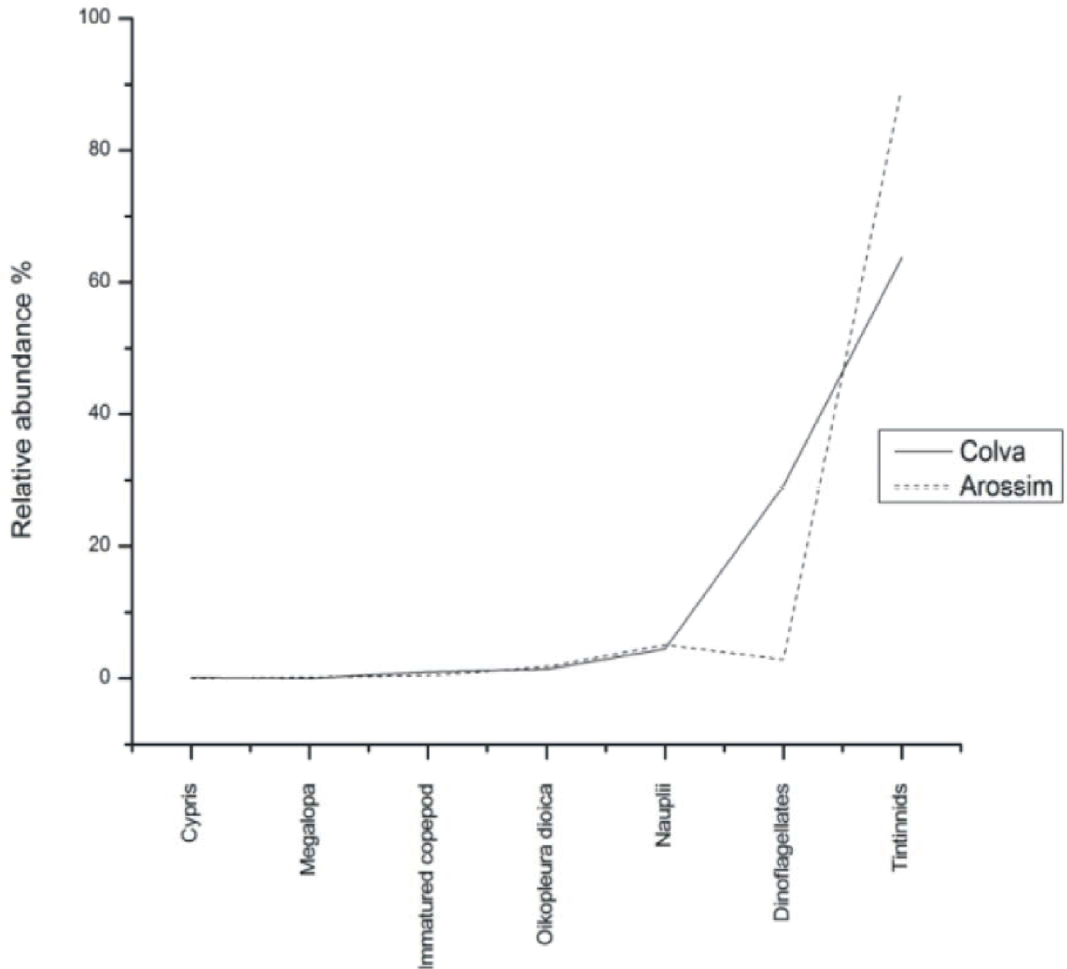

Fig. 1: Percentage of various microzooplankton groups recorded during the study period

In the present study most of the Dinoflagellates and Tintinnids were identified up to species level. Only one species of Appendicularian i.e. *Oikopleura dioica* was recorded. Micrometazoans were identified up to group level (Larval stages of Metazoans i.e. Nauplii, Cypris, Megalopa and Immatured Copepod). The number of constituent species of Microzooplankton in each group was Dinoflagellates – 7, Tintinnids – 49, Metazoan Larvae – 3 (Nauplii, Cypris and Megalopa), Immatured Copepods – 1 and Appendicularian – 1 (*Oikopleura dioica*). About 7 species of dinoflagellates belonging to 4 genera were identified. It includes: *Ceratium biceps, Ceratium hirundinella, Ceratium longipes, Ceratium tripos, Noctiluca* sp*.*, *Protoperidinium* sp. *and Pyrocystis fusiformis.* Tintinnids were found to be the first dominant group in the present study. The examination of the collected planktonic samples revealed the presence of 49 species of tintinnids belonging to 18 genera. *Dictyocysta elegans*, *Dictyocysta* sp.1 and *Tintinnopsis lobiancoi* were found to be dominant at the site of Colva. *Eutintinnus* sp.1, *Dictyocysta* sp.1 and *Tintinnopsis compressa* were the dominant species of tintinnids at the site of Arossim. The species of tintinnids observed in the present study includes: *Acanthostomella* sp., *Amphorella brandti*, *Amplectella tricholaria*, *Codonellopsis orthoceras*, *Codonellopsis pusilla*, *Coxliella fasciata*, *Cyttarocylis brandti*, *Cyttarocylis magna,* etc.

The Shannon's Diversity (H^+) Index of microzooplankton varied from 1.802 to 3.237 and 2.104 to 3.051 at the sites of Colva and Arossim, respectively. Simpson's Dominant Index (D) of microzooplankton at the site of Colva ranged from 0.043 to 0.286 and that of Arossim ranged from 0.055 to 0.132. The Evenness Index (E) of microzooplankton of the sites Colva and Arossim was estimated to be from 0.575 to 0.971 and 0.855 to 0.984 respectively.

Table 1: Diversity and Abundance of Microzooplankton (No./1000 ml) at Colva & Arossim, South Goa

		COLVA					AROSSIM				
Sl. No.	Name of Species	Aug.2013	Sept.2013	Oct.2013	Nov.2013	Dec.2013	Aug.2013	Sept.2013	Oct.2013	Nov.2013	Dec.2013
	Dinoflagellates										
1.	*Ceratium biceps*	-	40	40	-	-	-	-	-	-	-
2.	*Ceratium hirundinella*	2690	147	60	40	40	-	-	20	47	-
3.	*Ceratium longipes*	1715	20	-	20	-	-	-	-	-	-
4.	*Ceratium tripos*	-	240	-	70	-	-	-	-	-	-
5.	*Noctiluca* sp.	270	60	-	-	-	-	60	-	-	-
6.	*Protoperidinium* sp.	130	30	20	-	20	-	-	-	-	-
7.	*Pyrocystis fusiformis*	-	230	20	90	40	65	40	-	30	30
	Tintinnids										
8.	*Acanthostomella* sp.	-	300	40	70	-	-	80	-	-	53
9.	*Amphorella brandti*	-	190	20	236	100	40	60	106	73	70
10.	*Amplectella tricollaria*	-	-	-	40	-	-	-	-	-	-
11.	*Codonellopsis orthoceras*	110	-	-	-	-	-	-	-	-	-
12.	*Codonellopsis pusilla*	-	-	-	20	-	-	-	-	-	-
13.	*Coxliella fasciata*	20	320	50	43	20	-	40	-	20	-
14.	*Cyttarocylis brandti*	-	-	-	-	-	-	-	-	40	40
15.	*Cyttarocylis magna*	-	20	-	-	-	-	-	20	-	-
16.	*Dictyocysta elegans*	-	230	1610	90	40	-	80	120	20	-
17.	*Dictyocysta* sp.1	-	1030	-	20	-	40	410	-	-	-
18.	*Dictyocysta* sp.2	-	368	50	40	-	-	150	97	-	-
19.	*Dictyocysta* sp.3	-	-	30	-	-	-	110	150	-	-
20.	*Dictyocysta* sp.4	-	-	90	-	50	-	-	170	35	30
21.	*Dictyocysta* sp.5	-	-	-	-	85	-	-	-	-	-
22.	*Epiplocylis blanda*	-	-	-	-	40	-	20	-	-	-
23.	*Epiplocylis undella*	-	-	-	-	20	-	-	-	-	-
24.	*Epiplocyloides ralumensis*	-	-	20	-	-	-	-	-	-	-
25.	*Epiplocyloides reticulate*	-	50	40	-	-	-	-	-	-	-
26.	*Eutintinnus lususundae*	20	160	150	130	-	40	115	70	-	20
27.	*Eutitinnus fraknoii*	60	-	-	-	-	-	-	-	-	-
28.	*Eutintinnus* sp. 1	133	277	50	57	100	20	335	127	75	170
29.	*Eutintinnus* sp. 2	30	300	-	40	40	-	165	20	40	25
30.	*Favella ehrenbergii*	-	90	-	-	-	-	20	20	-	-
31.	*Favella panamensis*	-	-	155	-	140	-	-	93	27	60
32.	*Favella* sp.	-	87	-	-	-	-	60	130	-	-
33.	*Helicostomella subulata*	-	-	-	65	20	-	-	-	-	-
34.	*Leprotintinnus nordqvisti*	-	60	40	73	40	-	115	80	-	-
35.	*Leprotintinnus pellucidum*	-	20	-	20	40	-	100	80	-	40
36.	*Leprotintinnus simplex*	100	300	70	90	86	-	157	140	20	40
37.	*Petalotricha ampulla*	-	65	-	-	-	-	-	-	-	-
38.	*Proplectella fastigata*	-	-	-	-	-	-	-	-	-	40
39.	*Proplectella perpusilla*	220	20	-	-	20	-	-	-	-	-
40.	*Tintinnopsis campanula*	-	240	-	-	20	-	-	120	-	-
41.	*Tintinnopsis compressa*	-	-	-	60	80	-	-	320	-	107
42.	*Tintinnopsis corniger*	40	-	60	20	20	20	55	90	-	35
43.	*Tintinnopsis cylindrical*	20	20	53	30	40	-	140	160	-	90
44.	*Tintinnopsis davidoffi*	40	-	-	20	-	-	20	40	-	-
45.	*Tintinnopsis gracilis*	-	205	110	60	90	-	60	200	30	133
46.	*Tintinnopsis lobiancoi*	30	488	128	65	94	-	260	185	57	130
47.	*Tintinnopsis nana*	-	-	145	80	20	-	20	-	-	30
48.	*Tintinnopsis orientalis*	-	-	120	20	193	-	-	100	40	73
49.	*Tintinnopsis radix*	40	60	30	25	67	-	60	255	-	40
50.	*Tintinnopsis rotundata*	-	20	-	-	20	-	20	-	-	250
51.	*Tintinnopsis tocantinensis*	110	120	77	30	75	-	40	230	60	70
52.	*Undella claparedei*	-	-	-	-	-	-	-	-	-	200
53.	*Undella globosa*	-	100	80	50	20	-	-	-	20	20
54.	*Undella hyaline*	20	20	20	90	60	-	84	90	30	202
55.	*Undella pentagona*	-	40	-	-	-	-	20	-	-	-
56.	*Undella turgid*	20	-	380	20	20	-	-	-	-	390
57.	Nauplii	120	220	307	234	50	50	120	160	167	20
58.	Cypris	30	-	-	-	-	-	-	-	-	-
59.	Immatured copepods	-	140	-	70	-	-	20	-	30	-
60.	*Oikopleura dioica*	60	70	110	20	30	20	40	80	20	20
61.	Megalopa	-	-	-	-	-	20	-	-	-	-

Table 2: Relative Abundance of Microzooplankton at Colva and Arossim, South Goa

Sl No.	Name of the group	Colva	Arossim
1.	Dinoflagellates	29.21%	2.87%
2.	Tintinnids	63.71%	89.59%
3.	Nauplii	4.51%	5.08%
4.	Cypris	0.15%	-
5.	Megalopa	-	0.20%
6.	Immatured copepod	1.02%	0.49%
7.	*Oikopleura dioica*	1.40%	1.77%

DISCUSSION

The density and diversity of microzooplankton was observed to be the highest at the site of Colva as compared to the site of Arossim. The Abundance, Species Richness and Simpson's Dominance were found to be greater at the site of Colva. Colva beach is a tourist spot. Anthropogenic activity is higher at this site in comparison to that of Arossim. Relatively higher loads of nutrients at this site due to anthropogenic inputs might have favoured the growth of microzooplankton resulting into enhancement of population density of microzooplankton. The present results are in par with the findings of Prabhu *et al.* [16] and Araujo *et al*. [17]. The observed low diversity of microzooplankton population at the site of Arossim might be due to the flow of fresh water and less anthropogenic stress.

Tintinnids were the dominant group at both the sites. They were the major contributors to the microzooplankton. In general tintinnids feed on the nano and pico plankton of smaller size [10] and being the protozoans they divide to increase the number upon the availability of the food. Enhancement in smaller diatoms like *Thassiosira* or *Nitzschia* might have worked as available food for them which could have enhanced the faster division of tintinnids resulting into higher abundance. Copepods are typically identified as the dominant predators of tintinnids. Absence of copepods enhanced the population density of tintinnids at both the sites. Tintinnids are important diet of many zooplanktons including fish larvae. Dinoflagellates were the 2nd and 3rd dominant group in the present study. The spatial and temporal distribution of dinoflagellates in the Arabian Sea off Mangalore was dominated by ceratium [18]. Similarly in the present study the dominance of ceratium was observed among the dinoflagellates at both the sites.

Higher range of Shannon diversity value observed at Colva indicated increase in species diversity. Simpson's index value was found to be higher at Arossim, which indicated an increase in the number of dominant species. When Shannon diversity was high, low Simpson's Dominance was observed. It shows clearly that the number of dominant species was reduced with an increase in diversity of species. Higher Eveness Index value was observed at Arossim, which indicated that the species distribution was more even at this site. The anthropogenic activities like Idol immersion during certain festival occasions are insisting significant stress on the water bodies across India. Commercialization of holy festivals has led to replacement of traditional clay models with non- biodegradable materials like Plaster of Paris that contain heavy metals which are potentially hazardous as they bio- accumulate and bio-magnify along the food chain. Studies have been conducted on the pollution caused by Idol immersion activities [19, 20]. Similarly, Durga Idol immersion was witnessed on 13th October 2013 at Colva. Along with the Idols, flowers, fruits, wood ashes, etc. were also introduced into the water body. Turbidity plays an important role in the abundance of any planktonic community in an aquatic ecosystem [21].

The Idol immersion changed the quality of water and rendered the environment unfavourable for the growth and multiplication of microzooplankton. Lower densities and less number of species of microzooplankton observed at Colva during post Idol immersion period could be attributed to the deterioration of water quality. The present findings are in par with the reports of Yeolekar and Bandekar [19] and Vyas *et al*. [20]. A greater fluctuation in Abundance and Species Richness was observed at Arossim. This could be attributed to influx of fresh water and land runoff.

CONCLUSION

Microzooplanktons are very sensitive to their immediate environment. Any alteration in the environment leads to change in the microzooplankton communities in terms of tolerance, abundance, diversity and dominance in the habitat. Therefore observation of microzooplankton population may be used as a reliable tool for biomonitoring studies to assess the pollution status of the environment. Hence the studies on microzooplankton have been well recognized and included as an important component in the Global Ocean Ecosystem Dynamics (GLOBEC) and Joint Global Ocean Flux Study (JGOFS) Programmes where they have been shown to be the major movers of energy, carbon cycling and remineralization of nutrients in the oceans.

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