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Secondary production and zooplankton biomass in a tropical coastal lagoon near Mangalore, southwest coast of India

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ABSTRACT

A study on occurrence and distribution of zooplankton, secondary production and selected hydrographical characteristics was carried out for one year (April 1996 to May 1997) in Talapady lagoon near Mangalore Q2°47' N, 74-51' E). The variations in secondary production and zooplankton biomass followed a bimodal distribution with peaks during premonsoon and postmonsoon. Secondary production varied between traces and 0.85 gC.nr^3 and biomass between negligible and 14,45,000 no.nr^3 during the period of study. Diel studies showed variations, with higher production and biomass early in the day (0600 and 0900 h). Copepods (39%) and nauplius (29%) dominated the zooplankton assemblage of the lagoon.

Introduction

Though studies on the zooplankton biomass in the estuaries of India are many, those pertaining to coastal lagoons are few (Devasundaram and Roy, 1954; Thampi, 1959; Banerjee and Roychoundhury, 1966; Patnaik, 1973; Raman *et al,* 1975).

The present study was carried out for a period of 12 months (April, 1996 to March, 1997). The study covered secondary production, zooplankton biomass, composition and their variations on a seasonal and diel basis. An attempt has been made to correlate secondary production and biomass with selected hydrobiological parameters which include water temperature, pH, primary productivity, phytoplankton pigments, suspended particulate matter, dissolved organic matter and particulate organic carbon.

Material and methods

Talapady lagoon (12°47'N, 74°51'E) is located 10km south of old Mangalore port on the southwest coast of India. This is a blind lagoon, lying parallel to the Arabian Sea, situated at the confluence of the Talapady river with the sea (Fig. 1). It is fringed by mangrove vegetation, predominantly of the genera *Avicennia* and *Rhizophora.* It has a water spread area of 20ha, and a mean depth of lm. The lagoon opens into the Arabian Sea during the southwest monsoon through an opening in the sandbar. During the rest of the year the high water flows over the sand bar into the lagoon. There is influx from the river during the southwest monsoon

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transporting silt laden fresh water into the lagoon. The river dries up and becomes an extension of the lagoon during summer.

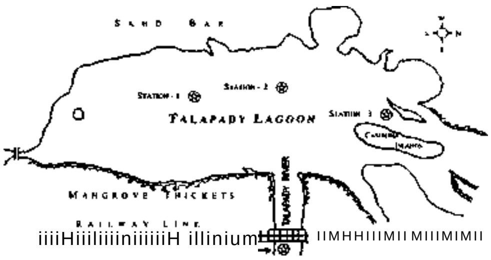


Fig. 1. Layout of Talapady lagoon showing sampling stations.

Plankton was collected by filtering about 1001 of surface water, using a plastic bucket through a continuous zooplankton and phytoplankton separator made out of nylon bolting silk. Samples were preserved in 5% buffered formalin and later analysed in the laboratory using an Olympus CX-40 trinnocular microscope. Secondary production was estimated following the method suggested by Dalai and Parulekar (1986) based on displacement volume. Collections were made on a monthly basis at midday from 4 stations in the lagoon (Fig. 1) employing a dug - out canoe. Diel variation studies were

TABLE 1. *Seasonal averages of hydrobiological parameters in Talapady lagoon*

Parameters	Monsoon (June-Sep.)	Postmonsoon (Oct.-Jan.)	Premonsoon (Feb.-May)
Water temperature (^{G}C)	28.5 ±2.8	29.0 ±1.7	32.8 ±1.4
Suspended particulate matter (mg.l^{1})	199.4 ±363.4	14.1 ±3.1	38.5 ±40.1
pH	7.6 ±0.7	7.4±0.1	8.0 ±0.6
DO (ml.l^{1})	5.32 ±0.40	5.68 ±0.38	4.67 ± 0.69
Salinity (x 10^{3})	1.3 ±1.8	8.5 ±5.7	15.1 ±3.9
Dissolved organic matter (mg C^.r^{1})	2.92 ±2.25	3.97 ±3.32	5.85 ± 1.39
Particulate organic carbon (mg.l^{1})	1.45 ± 0.66	2.05 ±1.68	1.08 ±0.70
NH3-N (ug.at.1^{1})	16.01 ±8.22	15.52 ±6.65	18.30 ±5.65
$N0_2$-N (ug.at.$l^{''1}$)	1.39 ± 0.20	3.08 ±4.50	1.80 ±0.28
$N0_3$-N (ug.at.l^{1})	9.14 ±5.29	5.35 ±5.13	4.15 ±1.28
Total dissolved introgen (ug.at.l^{1})	34.24 ±5.67	81.70 ±51.18	55.31 ±10.78
$P0_4$-P (ug.at.l^{1})	4.95 ±1.05	4.36 ±0.62	4.63 ± 0.98
Sio_3-Si (ug.atl^{1})	9.05 ± 1.65	10.84 ±7.16	7.47 ± 2.73
Sio_3-Si (ug.at.l^{1})	104.25 ±32.01	90.88 ±21.15	33.15 ± 18.05
Primary productivity (mg.C.mMr^{1})	0.20 ±0.21	3.65 ± 4.45	2.52 ±2.04
Bacillariophyceae counts (no.m^{3})	9,437	11,388	4,50,083
Cyanophyceae counts (no.m^{3})	48,097	1,11,842	1,90,172
Chlorophyceae counts (no.m^{3})	15,528	8,380	62,726
Dinophyceae counts (no.m^{3})	2,066	95	2,188
Chlorophyll *a* (mg.nv^{3})	3.18 ±2.68	2.82 ±1.94	5.85 ±6.99
Chlorophyll *b* (mg.nr^{3})	9.00 ±13.77	0.91 ±0.24	2.57 ±4.21
Chlorophyll c (mg.nr^{3})	15.76 ±25.64	1.74 ±0.74	2.29 ±2.93
Total carotenoids (mg.nr^{3})	2.05 ±1.73	0.21 ±0.16	1.82 ±1.81
Phaeopigments (mg.nr^{3})	16.38 ±11.5	6.93 ±3.54	12.94 ±11.12

undertaken on a day each during monsoon (26 July, 1996), postmonsoon (7 December, 1996) and premonsoon (27 March, 1997) in the lighted part of the day at three hourly intervals at station 2. Measurements for water temperature were made at the site using a mercury thermometer. About 51 of surface water samples were collected and transported to the laboratory for hydrobiological parameters. Primary productivity was assessed by the 14C technique. Nutrients and phytoplankton pigments were estimated by the spectrophotometric technique of Parsons *et al.* (1989). The pH was assessed using a Systronics 323 pH meter. Suspended particulate matter (SPM) and particulate organic carbon (POC) as per Parsons *et al.* (1989). Salinity was analysed after Strickland and Parsons (1972) while total dissolved nitrogen and total disolved phosphorus by Koroleff (1968). Dissolved organic matter was estimated by the Potassium Permanganate method of Jhingran *et al.* (1969).

Two way Analysis of variance (ANOVA) was attemped on seasonal and diel variation data of secondary production and total zooplankton biomas, using the statistical software MINITAB (Ver. 8.3). Correlation matrices were also worked out.

Results and discussion

Hydrobiology

The seasonal averages of various hydrobiological parameters in Talapady lagoon are presented in Table 1. Distinct seasonal variations were observed, with least production during the monsoon. This can be attributed to higher freshwater influx of silt laden flood waters during monsoon resulting in reduced salinity and lower light penetration. Phytoplankton pigments such as chlorophyll b, chlorophyll c and carotenoids are accessory light harvesting pigments, showing higher levels during monsoon when light intensity is generally reduced. Phaeopigments the degradation products of chlorophyll, too registered a peak in monsoon. These inactive or degraded pigment products are drained into the lagoon by increased drainage from the catchment areas of the river.

Secondary production

Secondary production in the lagoon ranged from traces to 0.85 gC.m"^{3}. Monthly and spatial variation in production is depicted in Fig. 2. Premonsoon months were observed to record the highest production (Average : 0.65gC. m^{3}). The period during monsoon recorded least production. Two way ANOVA of the data on monthly and

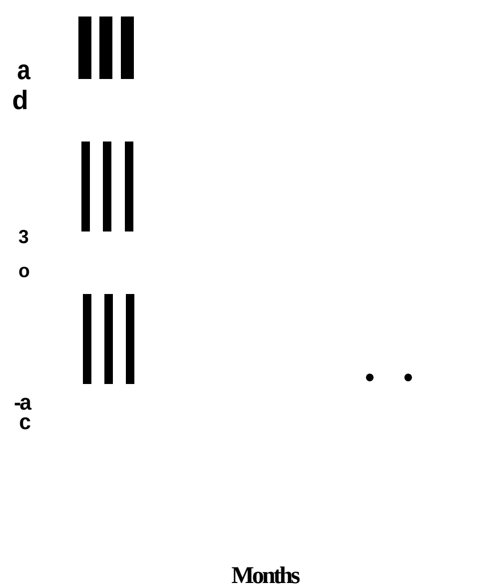


Fig. 2. Monthly and Spatial variations in secondary production.

TABLE 2. *Analysis of variance : Monthly variation of secondary production by stations*

Source of variation	Sum of squares	DF	Mean squares	F
Between months	1.4250	11	0.1296	14.24*
Between stations	0.0522	3	0.0174	1.91
Residual	0.2992	33	0.0091	
Total	1.7764	47		

*p<0.05.

spatial variation of secondary production reveals significant variation between the months with no significant spatial variation (Table 2). The month of April, with a mean secondary production of 0.52gC.m"[3], was observed to have the highest production. Spatially, station 2 & 3, located in the mangroves were observed to have the highest secondary production (Average: 0.13 gC.m"[3] and 0.14 gC.m"[3] respectively). The mangrove swamps are characterised by higher rates of primary production which in turn support a host of detritus feeding zooplankters.

Factors such as swarming of zooplankton supported by higher rates of phytoplankton production, increased salinity and light availability besides lower trubidity can be attributed to the higher values of secondary production recorded during the premonsoon months. Table 3 gives the significant correlation matrices of various hydrobiological parameters against secondary production. Salinity was observed to be significantly correlated with the standing crop. Pillai *et al.* (1975) reported high correlation between salinity and zooplankton standing crop (r = 0.655) in Cochin backwaters. In the present study, secondary production was also observed to be significantly correlated with phytoplankton groups viz., Bacillariophyceae, Cyanophyceae and Chlorophyceae, besides pigments such as chlorophyll *a* and carotenoids. This clearly indicates that the production of zooplankton is largely controlled by the availability of algae as food for zooplankton. Zooplankton production

TABLE 3. *Correlation between secondary production and total zooplankton biomass with statistically significant hydrobiological parameters*

	Total zooplankton counts	Secondary production
Zooplankton biomass	0.989*	-
Total phytoplankton counts	0.788*	0.698*
Bacillariophyceae counts	0.634*	0.530®
Cyanophyceae counts	0.762*	0.732*
Chlorophyceae count	0.786*	0.865*
Chlorophyll *a*	0.627*	0.536®
Carotenoid pigments	0.546®	0.569®
Salinity	0.529®	0.507®-

+p<0.05, @p<0.010.

TABLE 4. *Analysis of variance : Diel variation of secondary production by days*

Source of variation	Sum of squares	DF	Mean squares	F
Between days	0.0128	2	0.0064	16.0*
Between time of the day	0.0046	4	0.0011	2.75
Residual	0.0031	8	0.0004	
Total	0.0204	14		

*p<0.05.

exhibited a negative correlation with primary productivity (r = -0.056). Zooplankton production was also observed to be negatively correlated with the suspended particulate load in the waters (R =-0.101), which influences through phytoplankton distribution and abundance.

Diel variation of production recorded higher values early in the day (Average : 0600 h-0.08gC.nr^3 and 0900h-0.07gC.nr^3). Light intensity and surface water temperatures can be attributed to the higher zooplankton production, early in the day. Statistically

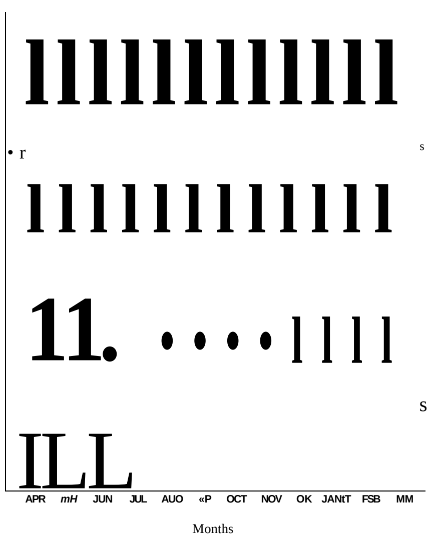


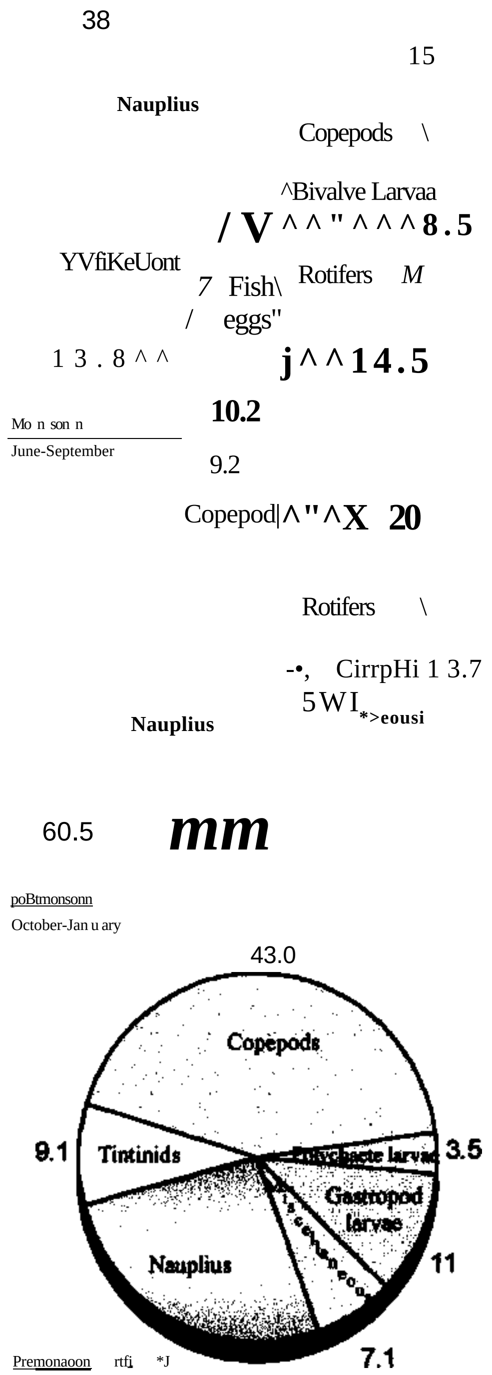
Fig. 3. Monthly and spatial variations in total zooplankton biomass.

significant differences were observed between the days of study (Table 4) in diel experiments. Highest production was recorded during the premonsoon day (Average : 0.08gC.nr^3).

Zooplankton biomass

The average monthly zooplankton counts and percentage composition of major groups for different seasons are shown in Figs. 3 and 4 respectively. Premonsoon period was observed to be the most productive (Average : 2,55,765 no.m"^{3}) as in the case of secondary production. The data exhibited a bimodal distribution with peaks in premonsoon and postmonsoon. Similar peaks have been reported by workers elsewhere (Haridas *et al.,* 1973; Pillai *et at.,* 1975). Two way ANOVA showed significant variation in zooplankton biomass between months (Table 5). The month of April followed by May recorded the highest biomass (Averages : 5,73,050 no.m"^{3}) and 3,98,160 no.m"^{3}) respectively). As in production, the zooplankton biomass at stations 2 and 3, in the viscinity of mangroves were higher (averages : 54,290 no.m^{-3} and 56,170 no.m"^{3} respectively).

Qualitatively, copepods accounted for the bulk of zooplankton (43%) followed by nauplius (26.3%) and gastropod larvae (11%) during the premonsoon months. The postmonsoon



*all values are in percentages

Fig. 4. Seasonal averages of major groups of zooplankton based on pooled averages.

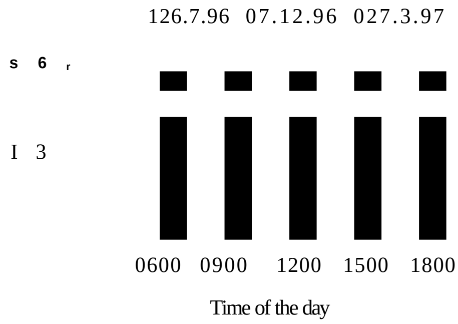


Fig. 5. Dial variation of total zooplankton biomass on three days of monsoon, postmonsoon and premonsoon.

period was characterised by the presence of nauplius (60.5%) and rotifers (20%); while monsoon months saw the dominance of nauplius (38%), copepods (15%) and rotifers (14.5%). Copepods (39%) dominated the zooplankton assemblage of the lagoon in general. Salinity was observed to be an important parameter regulating the spatial and temporal variation in zooplankton biomass.

Total zooplankton biomass, was observed to be significantly correlated (Table 3) with salinity, chlorophyll *a*, carotenoid pigments, total phytoplankton counts, Bacillariophyceae counts, Cyanophyceae counts and Chlorophyceae counts. A similar relationship between salinity and zooplankton biomass in Chilka lake has been reported by Banerjee and Roychoudhury (1966). A negative correlation was seen with primary productivity (r = -0.118) and suspended particulate matter (r =-0.067).

Diel variation of total zooplankton biomass is presented in Fig. 5. Mean values point out a peak at 0900 h (Average : 47,090 no.m^{-3}). Higher numbers were observed early in the day. Statistically, significant variation was observed

TABLE 5. *Analysis of variance : Monthly variation of total zooplankton counts by stations*

Source of variation	Sum of squares	DF	Mean squares	F
Between months	2534795	11	230436	17.7*
Between stations	77827	3	25942	1.99
Residual	428545	33	12986	
Total	3041167	47		

*p<0.05.

TABLE 6. *Analysis of variance: Diel variation of zooplankton biomass by days*

Source of variation	Sum of squares	DF	Mean squares	F
Between days	80110	2	40055	13.5*
Between time of the day	33497	4	8374	2.8
Residual	23685	8	2961	
Total	137292	14		

*p<0.05.

between days (Table 6), with higher numbers recorded during the premonsoon day (average : 52,440 no.nr^3).

Hence it can be concluded that this mangrove fringed coastal lagoon is productive at the primary as well as seondary level, particularly during the premonsoon and postmonsoon months.

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