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DYNAMICS OF CYCLOPOID POPULATION IN A TROPICAL ESTUARY

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The abundance of nauplii, copepodites and adults of oithonids in the Cochin Backwater was estimated for an year from periodical samples. From the laboratory cultured animals, the duration of development in each stage was calculated and using Edmonson's method, the parameters of population dynamics were calculated and found that the instantaneous population growth varied from -1.064 to 0.395 and the instantaneous mortality rate from -6.513 to 4.637 within the year of study. The production of oithonids had two peaks, one in May-June and the other in November-December. The mean production for the year 1971 works out to 0.24 mg/m^3/ day (53.33 copepods).

INTRODUCTION

Cochin Backwater is a typical bar built estuary (Wellershaus, 1972) situated in the southwest coast of India whose hydrology (Shynamma and Balakrishnan, 1973), phytoplankton and primary production (Qasim *et al.*, 1974) and zooplankton biomass (Madhupratap and Haridas, 1975) have been studied extensively in recent years. In the estuarine ecosystem, copepods as a group form a major component of zooplankton biomass. The taxonomy of the copepod component attracted much attention of the biologists (Pillai, 1971), while nothing is known about the population dynamics and production rate. The present attempt is made in this direction.

MATERIAL AND METHODS

Fortnightly collections except in July and December during the year 1971 were analysed based on samples collected from a fixed station from Cochin Backwater (Fig. 1). The collections were made between 0700 to 0800 hr using a net made of No. 2 bolting nylon of 0.069 mm mesh and having a mouth opening of 35 cm diameter. The volume of water filtered through the net was determined by a T. S. K. no. 487 flow meter attached at the mouth of the net. In the surface hauls made, it was estimated that on an average 10.5 m^3 /10 min was filtered. The collections were preserved in 5% neutral formalin and the total volume of plankton was estimated by displacement. Each sample was made up to 250 ml with 5% formaldehyde. After throughly shaking the sample, an aliquot of 10 ml was taken in a counting chamber and all the adult *Oithona* upto species and oithonid nauplii and copepodites were counted. The counts were later calculated for 1 m^3 of water filtered. Along with each plankton collection, measurement of salinity and temperature were also made. The mean values for each month are presented in Table 1.

The duration of development was determined by maintaining a culture of gravid females of mixed *Oithona* sp. During the time, they were fed with a mixed culture of *Chlorella* sp. and *Synechocystis* sp. The temperature varies in the backwater by a few degrees and so its influence on the duration of develop-

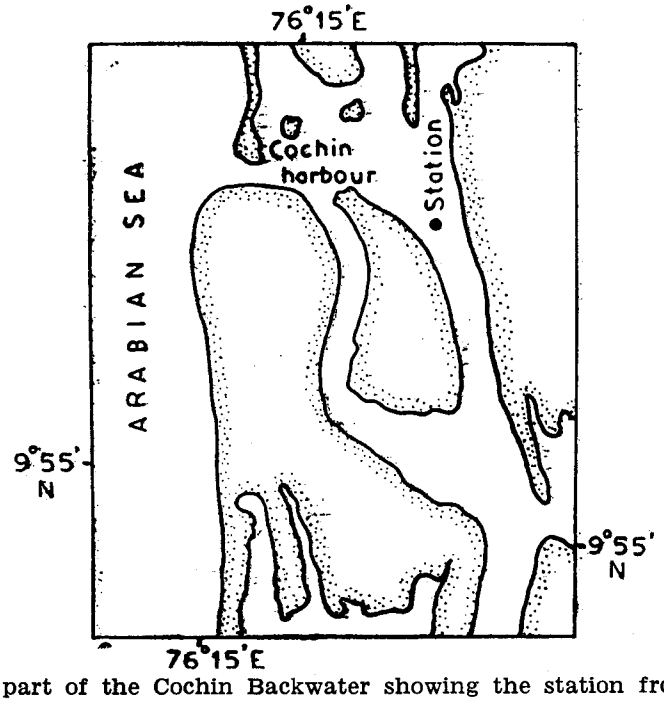

Fig. 1. A part of the Cochin Backwater showing the station from which collections were made.

TABLE 1. AVERAGE MONTHLY VALUES OF PLANKTON BIOMASS, SALINITY AND TEMPERATURE IN THE COCHIN BACKWATER

Month	Volume of Plankton (ml)	Salinity (‰)	Temperature (°C)
January	3.7	31.37	28.4
February	3.7	31.57	28.4
March	3.7	34.32	27.5
April	10.0	30.96	30.7
May	43.7	16.36	29.8
June	33.7	1.85	28.1
July	10.0	3.67	27.1
August	7.5	5.25	28.2
September	8.7	7.20	27.9
October	7.5	5.66	27.9
November	27.5	19.44	28.6
December	77.5	26.35	27.8

ment is very marginal. In the present study the temperature was maintained at 28°C (±1). To avoid bacteria and ciliates, Tetracycline hydrochloride at a concentration of 4.5 mg/l was used. The time observed from the hatching of egg to the development of Copepodite I was taken as the duration for naupliar development, and the duration from copepodite I to the development of Copepodite VI (*i.e.*, adult) was taken as the life span of copepodite stage.

In the determination of mean individual wet weight for copepods, animals freshly preserved in 5% neutral formalin were pooled, weighed and the mean weight was 0.0045 mg/copepod. Considering the preservation, smallness and the sensitivity of the balance (Keroy monopan balance), the mean wet weight need to be taken as provisional. Therefore, in calculations, number of copepods produced has also been given.

Environmental features

The hydrology of the Cochin Backwater is highly dynamic and present a cyclic pattern. Taking into consideration of salinity and dilution, three periods can be made out (Table 1). January to April corresponds to premonsoon season in which salinity is in conformity with that of the inshore waters. During the months of May to September with the prevalence of SW monsoonal conditions, the salinity drastically changes from marine to brackish water state. With change in monsoonal conditions, a period of recovery to marine condition sets in October and continues till December.

RESULTS AND DISCUSSION

Standing stock

Monthly mean values of total biomass show that there are two peaks, one coinciding with the onset of dilution in May-June and another in November-December, corresponding to the period of recovery of salinity to marine conditions. It is well evident from the occurrence of nauplii and copepodites throughout the year that *Oithona* breeds continuously. The breeding of *Oithona* too has two peaks as illustrated (Fig. 2) which corresponds to the general zooplankton peaks mentioned above. There are ten species of *Oithona* and their species-wise composition of adult *Oithona* for the period is given in Table 2.

Population dynamics

The method as outlined by Edmondson (1960, 1971) for the calculation of the reproductive rate was used in principle. Accordingly once the duration of development of a particular stage, say copepodite is known from the quantity of copepodites and adults per m^3, obtained by analysing the preserved sample, the production of copepod can be computed.

The quantity of copepodites present in an ecosystem represent the increment they would make after a span of short period (D in days) taken for development. Thus, the increment per day is equal to 1/D. Based on this logic, the birth rate per day per m^3 of water can be calculated from

$$B = \frac{E}{D} \qquad (1)$$

where B=number moulted per day, E=number of developing individuals of a particular stage (copepodite) per m^3, and D=mean duration of development.

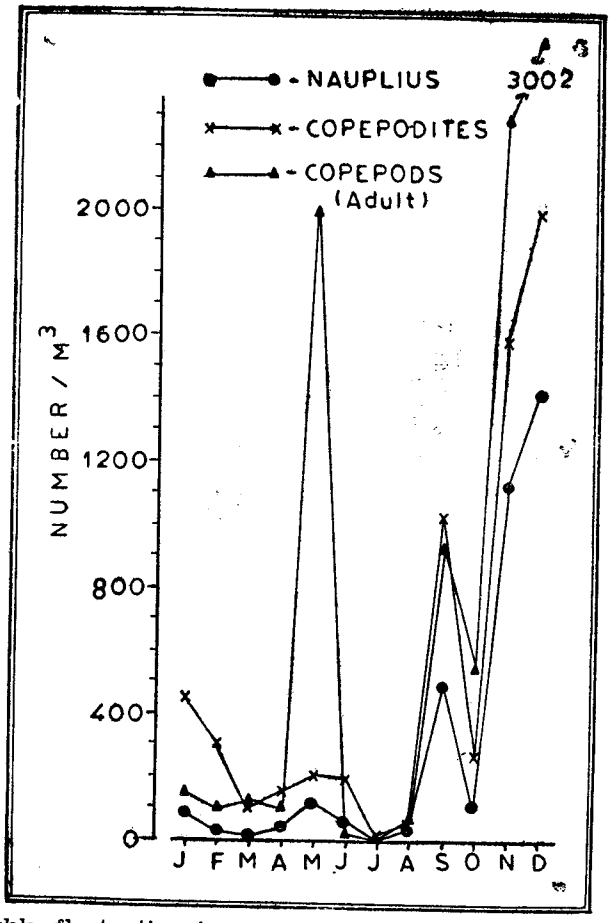

Fig. 2. Monthly fluctuation in composition of nauplius, copepodites, and adults of Oithonids

This is on the assumption that the duration of development being short, the mortality is small, and the bias introduced is negligible. The instantaneous natality rate (b) can be calculated as follows:

$$e^{b} = 1 + B \qquad (2)$$

From the exponential equation for population growth;

$$N_t = N_o\, e^{rt} \quad \text{where} \quad t > O \qquad (3)$$

the instantaneous population growth rate (r) is calculated from the quantity of copepods in the successive collections following the expression

$$r = \frac{\ln N_t - \ln N_o}{T} \qquad (4)$$

TABLE 2. AVERAGE MONTHLY OCCURRENCE (No./m³) OF NAUPLII AND COPEPODITES OF OITHONIDS AND *Oithona* SPP.

Species	January	February	March	April	May	June	July	August	September	October	November	December
Oithona brevicornis	85.05	82.16	93.80	60.18	870.02	2.97	—	15.39	40.37	513.87	2139.24	890.00
O. plumifera	3.80	—	—	—	—	—	—	—	—	—	—	—
O. hebes	16.15	14.04	30.86	4.75	368.66	11.00	—	7.81	123.50	15.75	95.63	79.00
O. oculata	9.50	—	—	—	—	—	—	—	—	—	—	76.00
O. simplex	17.78	7.10	—	—	—	—	—	—	4.75	—	21.37	1881.00
O. similis	10.95	—	—	—	—	—	—	—	—	—	—	—
O. attenuata	2.85	—	—	—	—	—	—	—	—	—	—	57.00
O. nana	7.12	—	—	—	76.00	4.72	—	7.87	4.51	—	4.76	—
O. rigida	2.85	—	—	22.75	650.62	6.24	2.37	25.91	753.12	—	19.00	—
O. linearis	—	—	—	—	—	—	2.37	—	—	—	—	19.00
Stages												
Nauplii	87.63	32.06	16.62	45.12	118.75	57.00	4.75	35.62	491.62	111.62	112.75	2546.00
Copepodites	448.87	311.12	111.62	159.12	211.61	94.99	16.62	66.49	1021.12	258.87	1567.50	3743.00

where N_0 =number of copepods per m^3 in one collection; N_t =number of copepods per m^3 in the following collection; and T=the time interval in between the samplings.

Once 'b' and 'r' are known, instantaneous mortality rate (d) can be found out by difference.

$$d = b - r \tag{5}$$

The production of copepods (P) for a period is calculated from the natality rate for the said period (B_t) following the equation proposed by Galkovskaya (1971).

$$P = B_t \tfrac{1}{2} (N_o + N_t) \tag{6}$$

In Table 3, production of copepods in number is designated as Pno, in terms of wet weight in milligrams as Pmg, and mean daily production in wet weight as $\bar{P}$mg.

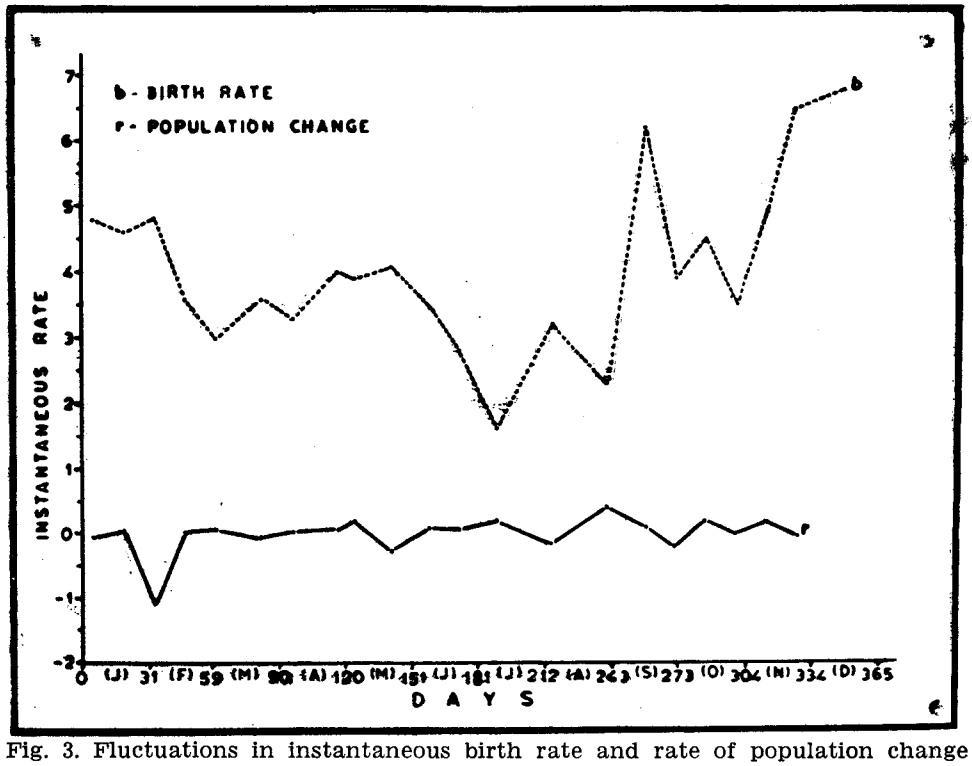

Fig. 3. Fluctuations in instantaneous birth rate and rate of population change during 1971.

It is likely that eggs and nauplii of *Oithona* are not retained efficiently by the net because of the large mesh size. Therefore, production of copepodite is not calculated; however, as a means of giving a general picture, natality of copepodite have been worked out. The results and calculations of parameters of population dynamics are as given in Table 3.

TABLE 3. CALCULATED PRODUCTION OF *Oithona* SPP. IN

Date	Nauplii	Days★	Natality of Copepodites	Copepodites	Days★	Copepods
	No./m³		No./day/m³	No./m³		No./m
				E	D	N
Jan. 5	130.15	3	43.38	484.50	4	152.00
19	45.12	3	15.14	413.25	4	140.11
Feb. 2	59.37	3	11.79	482.12	4	168.61
16	4.75	3	1.58	140.12	4	37.99
Mar. 2	2.37	3	0.79	78.37	4	47.48
23	30.87	3	10.29	144.87	4	201.86
Apr. 6	59.37	3	19.79	104.50	4	54.62
27	30.87	3	10.29	213.75	4	156.74
May 4	76.00	3	25.33	192.37	4	282.61
21	161.50	3	53.83	230.85	4	3648.00
Jun. 8	76.00	3	25.33	125.87	4	37.99
22	38.00	3	12.67	64.12	4	11.87
Jul. 13	4.75	3	1.25	16.62	4	4.74
Aug. 3	26.12	3	8.71	97.37	4	111.60
30	45.12	3	15.04	35.62	4	2.37
Sep. 14	584.25	3	194.75	1938.00	4	883.50
28	399.00	3	133.00	204.25	4	969.00
Oct. 12	185.25	3	61.75	384.75	4	52.25
26	38.00	3	12.67	133.00	4	1007.00
Nov. 9	161.50	3	53.83	494.00	4	646.00
23	2090.00	3	696.67	2641.00	4	3914.00
Dec. 14	2546.00	3	848.67	3743.00	4	3002.00

★ Duration of development in days

COCHIN BACKWATER FOR THE YEAR 1971

Natality of Copepods No./day/m³	Instantaneous birth rate of Copepods	Rate of copepod population growth	Mortality of copepod population	Production of copepods		
				No./m³	Wet weight mg/m³	Monthwise mean production mg/m³/day
B	b	r	d	Pno	Pgm	$\overline{P}$mg
121.12	4.81	—0.01	—4.82	—	—	
103.31	4.65	+0.01	+4.64	267.17	1.20	0.050
120.53	4.80	—1.06	—5.86	257.67	1.16	
35.03	3.58	+0.01	+3.57	223.83	1.01	0.082
19.59	3.03	+0.07	+2.96	77.76	0.35	
36.22	3.62	—0.09	—3.71	144.26	0.65	0.036
26.12	3.30	+0.05	+3.25	164.46	0.74	
53.44	4.00	+0.08	+3.92	131.80	0.59	0.042
48.09	3.91	+0.15	+3.76	273.11	1.23	
57.71	4.07	—0.25	—4.32	2013.39	9.06	0.468
31.47	3.48	—0.08	—3.56	1900.70	8.55	
16.03	2.83	—0.05	—2.88	56.40	0.25	0.136
4.15	1.64	+0.15	+1.49	24.33	0.11	0.010
24.34	3.23	—0.14	—3.37	62.32	0.28	
8.90	2.29	+0.39	+1.89	81.32	0.37	0.175
484.50	6.18	+0.07	+6.11	451.83	2.03	
51.06	3.97	—0.21	—4.17	1410.75	6.35	0.287
96.19	4.58	+0.21	+4.37	561.68	2.53	
33.25	3.53	—0.03	—3.56	625.81	2.82	0.205
123.50	4.82	+0.13	+4.69	859.75	3.87	
660.25	6.50	—0.01	—6.51	2403.50	10.82	0.624
935.75	6.81	—	—	4118.25	18.53	0.882

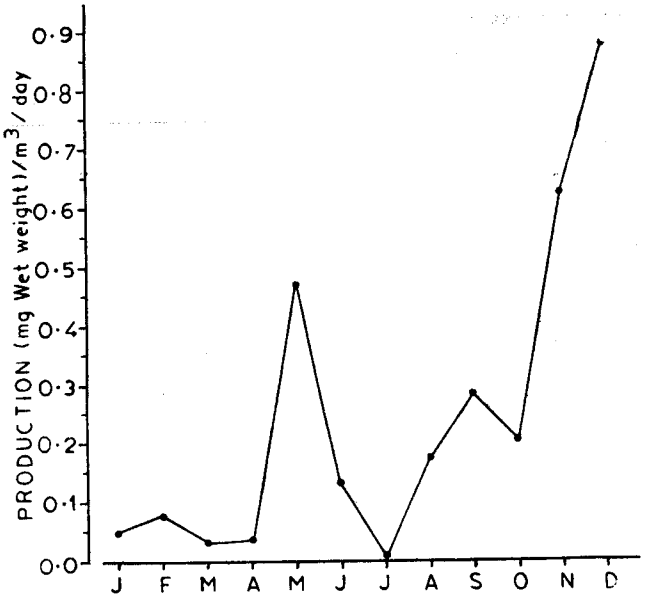

Fig. 4. Monthwise mean daily production of adult Oithonids in wet weight

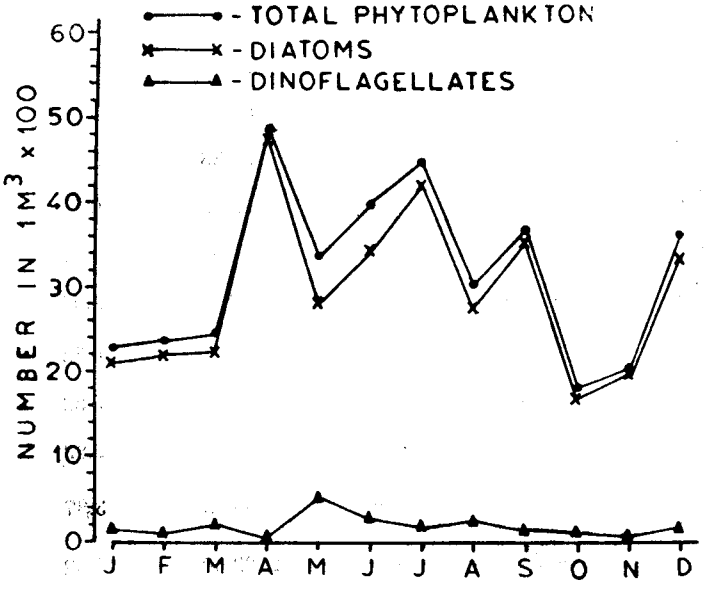

Fig. 5. Monthly fluctuations in phytoplankton components for the year 1971 (Drawn after Gopinathan, 1972)

The population growth curve and birth rate curve will be parallel if constant mortality is operating in the ecosystem. Conversely when the population growth curve is constant, birth rate and mortality rate will be parallel. In *Oithona*, the population growth rate curve (Fig. 3) shows mild oscillations and tends to be steady, while the instantaneous birth rate shows wide fluctuations and is always positive evincing high predatory rate on these copepods and the amount of energy passed on to the higher trophic levels. The negative growth changes are soon made up. The prey and predator relationship as given by Margalef (1968), and Parsons and Takahashi (1973) show that the growth of prey and predator are complementary; with the fall in density of the prey; the predator too succumb to the fall. But the vital factor is a stable ecosystem is stability. The stability of the population growth curve without violent fluctuations show the high order of stability present in the Cochin Backwater ecosystem.

The mean production (Fig. 4) for *Oithona* for the year works out to 0.24 mg/m^3/day (53.33 copepods). The mean daily production is lower than the yearly daily mean during January through March and again in June through August. The highest production rate is met with in the month of December and the lowest in July. The *Oithona* are herbivores, and their count as compared with that of phytoplankton as observed by Gopinathan (1972) from the same locality for the same period shows (Fig. 5) that no mutual relationship exists between them. The fluctuations in *Oithona* population is not because of lack of food (Qasim *et. al.*, 1969; Qasim, 1970). Temperature is more or less stable, and the *Oithona* peak coincides with the period of dilution and recovery, and as such salinity acts as controlling factor.

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DISCUSSION

JILLETT : Absence of a direct relationship between the production of *Oithona* and the standing crop of phytoplankton does not necessarily mean that these two parameters are not connected. The standing crop of phytoplankton really represents the difference between reproduction and mortality, including grazing mortality.

MARTIN THOMPSON : Based on the previous studies on the production of phytoplankton in the Cochin Backwater (Qasim *et al.*, 1969; Qasim, 1970), there is no paucity of food (phytoplankton) for the herbivores (secondary producers) since the production of phytoplankton is very high and as such there is no depletion in the standing crop of phytoplankton as a result of grazing and as such there is no direct relationship between the production of *Oithona* and the standing crop phytoplankton.