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Zooplankton ecology in Kavaratti atoll, Lakshadweep, India

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ABSTRACT

Variations in physico-chemical parameters, zooplankton abundance, their distribution, seasonal and diurnal variations in Kavaratti atoll, Lakshadweep were studied for two years. The range of variation in water temperature was 27. 0-31.8°C, pH 7.1-8.4, diss. 0_2 2.2-7.5 ml/1 and salinity 33.0-35.3 ppt. with the lowest values during monsoon. Day time zooplankton density was low (63-1,987 no./m^3) while it was high at night (1,404-5,762 no./m^3). Density varied betwen stations and over seasons. Substratum appeared to control the day time density of drifting zooplankton. Density was the lowest during monsoon in day time samples (202-359 no./m^3) while it was the highest in night samples (4,275 no./m^3) especially during the monsoon. Fish eggs and larvae (16-32.1 %) and copepods (16.8-26.7 %) dominated in the day time samples, while decapod larvae (26.8 %) and ostracods (20.6 %) dominated in the night samples, zooplankton density was the maximum between 2100 and 0300 hrs and density showed no definite relation with tide. The lagoon appeared to hold its own zooplankton, which is distinct in character and response to physico-chemical parameters.

Introduction

Zooplankton represent a major source of food for the coral reef community (Emery, 1968; Goreau *et al,* 1971; Tranter and George, 1972; Glynn, 1973). However, evidences as to their source, abundance and dynamics in the reef area have been conflicting. Thus it is important to know their ecology, specifically the abundance, distribution, seasonal variations and the influence of physico-chemical parameters on them. It is equally important to know whether they are entirely or partly derived from oceanic source or a component of the reef community itself and this knowledge is a pre-requisite for resource management and development of reef based fishery.

Studies on zooplankton of Lakshadweep atolls are few and far between. Qasim *et al.* (1972) reported extremely low zooplankton abundance in Kavaratti atoll. Tranter and George (1972) observed high abundance at night in the atoll. Madhupratap *et al.* (1977) suggested that the reef community is nourished by oceanic zooplankton washed into the lagoon from the sea. Goswami (1973, 1979) made observa-

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tions on zooplankton groups, environmental parameters and their diel variations in the atoll and reported higher abundance in the lagoon during flood tide. Goswami (1983) found some copepods endemic in Kavaratii atoll. Since all these, were short term studies, Nair *et al.* (1986) invited attention to the need of detailed and continuous studies on zooplankton in the lagoons of the Lakshadweep atolls. The present work is the result of a two year study (January, 1988 to December, 1989) on the abundance, distribution and seasonal and diurnal variations of zooplankton in Kavaratti atoll, Lakshadweep in relation to hydrological parameters.

Material and methods

Kavaratti atoll (10°33'N and 72° 28'E) has on the western side of the island a lagoon of 4,500 m long and 1,200 m wide. Maximum depth at high water in the lagoon is 3.5 m. Zooplankton samples were collected fortnightly from stations 1 to 5 (Fig. 1) between 0900 and 1100 hrs and also at night (2100 hrs) from station 5. Depth at the stations varied between 1 to 2.5 m. Station 1 was characterised by sandy bottom, 2 and 5 were on thick seagrass beds, station 3 was on the reef, with coral boulders and station 4 was characterised by thickets of life corals. Since towing of zooplankton net was difficult in the shallow stations, 1000 litres (1 cubic metre) of water was filtered through a conical hand net made of nylon bolting silk. The collection was done by pouring 1000 liters of quickly drawn water from the surface, with a plastic bucket of 10 1 capacity ensuring least escape of zooplankton. Samples were preserved in 5 % formaldehyde. Surface water samples were also taken from the stations of study and analysed for temperature, pH, diss. 0_2 and salinity by following standard methods (FAO, 1975). All the operations were made from a small fibre glass boat. Diurnal study was conducted every month at station 5, from March to November, 1989 following the methods indicated earlier at an interval of 3

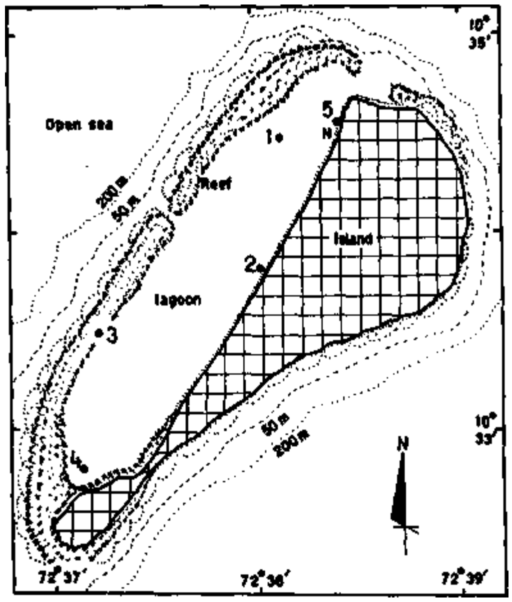

Fig. 1. Kavaratti atoll showing location of stations.

TABLE 1. *Range of physico-chemical parameters in stations. 1 to 5 (day time) and 5N (night time in station - 5) during Jan., 1988 to Dec, 1989.*

Stns	Temp. (°C)	pH	Diss.0_2 (ml/1)^2	Sail, (ppt.)
1	27.0-30.9	7.7-8.3	3.5-7.5	33.6-35.3
2	27.3-31.2	7.2-8.3	3.4-7.4	33.0-35.3
3	27.0-31.8	7.7-8.3	2.9-6.5	33.0-35.2
4	27.4-31.7	7.7-8.4	3.5-7.0	33.6-35.3
5	27.0-31.0	7.6-8.3	3.2-6.8	33.4-35.0
5N	27.5-31.5	7.1-8.0	2.2-5.7	33.1-35.0

hours, continuously for 24 hours. Height of water column was measured using a long, graduated scale.

Results and discussion

The ranges in physico-chemical parameters are shown in Table 1, which depicts no significant variation between stations. At night the average range of pH and dissolved 0_2 was lower than the day time values, due to the release of $C0_2$ and consumption of dissolved 0_2 due to intense respiration by the reef community. Though the range of variations was low, all the parameters exhibited significant seasonality ($P<0.01$) with the lowest values during monsoon (Table 2).

Average zooplankton density in all the stations was comparatively lower during day (63-1,987 no./m^3) while night samples showed high numerical density (1,404-5,762 no./m^3) as depicted in Fig. 2. Similar results were reported from Kavaratti by Qasim *et al.* (1972), Tranter and George (1972) and Goswami (1979). Reefs harbour demersal zooplankton, which hide in the substratum during day and emerge to swim freely at night (Aldredge and King, 1977) and are maintained themselves within the reef habitat (Emery, 1968). Goswami (1979) suggested that zooplankton washing into the lagoon from the sea may be taking refuge in the reef substratum during day and emerge out at night.

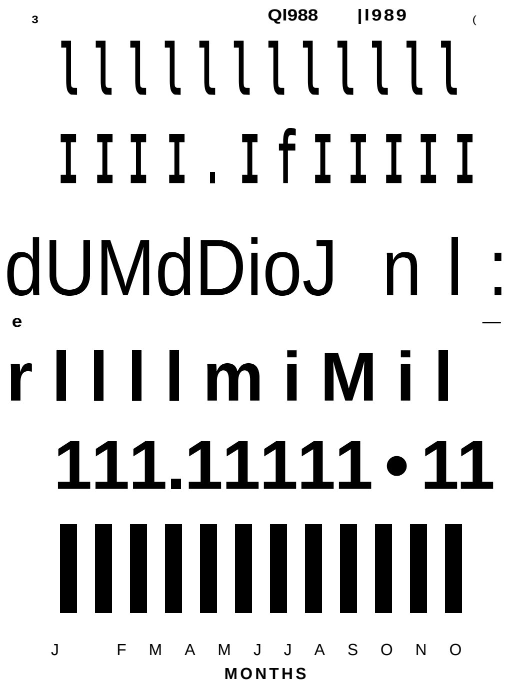

Fig. 2. Monthly average day time zooplankton density (log 10 no/m^3) in stations 1 to 5 and density at night in station 5 (5N), during January, 1988 to December, 1989.

Two way ANOVA test showed significant ($P<0.01$) variation in zooplankton density between stations and over seasons (Table 3). Maximum average density was observed in statin 1 (587.9 no./m^3) and the lowest in station 2 (222.8 no./m^3) followed by station 5 (233.8 no./m^3). Since, there was no significant variation in physico-chemical parameters between these stations, the type of substratum seemed to play a major role in the density variations between stations as found by Emery (1968) and Sale *et al.* (1976) who observed difference in zooplankton in sheltered areas from that of the non-sheltered areas in reefs. Seagrasses provided shelter for zooplankton (Goswami, 1973). The interstices of seagrass foliage in station 2 and 5 may be providing more area of shelter than the rocky station 3 and the coral dominated station 4, keeping the density of drifting plankton lower in station 2 and 5. The highest density in station 1 may be due to the lack of suitable shelter, as it was located over sandy area resulting in the plankton being

TABLE 2. *Pre-monsoon, monsoon and post-monsson seasonal averages of hydrographical parameters for stations 1 to 6*

PR-Mon. = Pre-monsoon, Mon. = Monsoon, PO-Mon. = Post-monsoon

	stations					
Temp.						
PR.Mon.	29.98+0.80	29.94+0.83	29.9610.85	30.1310.93	30.25+0.92	30.50+0.94
Mon.	28.60±0.92	28.80±0.83	28.7810.84	28.7510.79	28.7710.79	28.77+0.82
PO-Mon.	29.45±0.78	29.26±0.80	29.2810.76	29.3110.73	29.3810.69	29.50+0.71
pH						
PR-Mon.	8.25+0.1	8.26±0.05	8.2510.03	8.2810.03	8.2610.10	8.2710.10
Mon.	7.94±0.31	8.05±0.22	8.0610.23	8.0510.23	8.0510.23	8.07+0.22
PO-Mon.	8.16±0.17	8.19±0.16	8.1810.15	8.1810.16	8.1810.17	8.1910.16
Diss. 0_2						
PR-Mon	4.69±0.68	4.96±1.23	4.5611.37	4.8510.78	4.6410.98	5.2311.24
Mon.	4.48+0.68	5.06±0.81	5.1910.74	5.1010.76	5.08+0.82	5.1410.70
PO-Mon.	4.7310.99	4.93±0.96	5.0111.01	4.8110.82	5.1211.06	5.6911.22
Salinity						
PR-Mon.	34.58±0.45	34.61±0.42	34.6810.42	34.6310.44	34.59+0.42	34.5210.48
Mon.	33.8110.65	34.1910.46	34.1810.44	34.2710.42	34.25+0.42	34.2210.42
PO-Mon	34.79±0.37	34.7410.37	34.8110.29	34.7610.37	34.7310.45	34.6910.48
Silicty						
PR.Mon.	5.4110.56	4.3510.88	4.1311.19	4.4311.07	4.7110.79	4.1510.91
Mon.	3.48+0.47	2.7810.76	2.76+0.86	2.6010.62	2.7610.68	2.45+0.61
PO-Mon.	4.61±0.82	3.3410.63	4.1710.81	3.9610.62	4.1310.53	3.88+0.51
Phosphate						
PR-Mon.	0.37+0.12	0.3210.10	0.4910.68	0.26+0.12	0.3310.10	0.31+0.11
Mon.	0.37+0.10	0.2210.10	0.2410.10	0.24+0.10	0.2610.10	0.25+0.01
PO-Mon	0.29+0.10	0.2910.10	0.2610.10	0.2610.11	0.27+0.11	0.2210.11
Nitrite						
PR-Mon.	0.95+0.58	0.7910.56	0.7910.60	0.7110.56	0.81+0.56	0.9510.57
Mon.	0.33±0.26	0.2310.17	0.16+0.17	0.2910.22	0.1910.10	0.1810.11
PO-Mon.	0.79±0.54	0.65+0.44	0.6710.47	0.6410.49	0.6410.47	0.6710.52
Nitrate						
PR-Mon.	0.14±0.10	0.1710.11	0.1310.10	0.1310.10	0.14+0.10	0.1510.10
Mon.	0.08±0.03	0.0810.04	0.09+0.05	0.0910.06	0.1410.21	0.14+0.22
PO-Mon.	0.13±0.10	0.1010.06	0.0910.06	0.1110.07	0.1210.66	0.09+0.06
Calcium						
PR-Mon.	434.40+5.02	427.0615.10	424.5615.73	424.3815.44	428.7514.67	420.63+5.54
Mon.	435.00±4.90	431.0616.60	429.5016.16	429.1315.89	429.13+6.65	426.9016.36
PO-Mon.	433.4415.46	426.5316.14	422.8815.26	422.7515.46	427.9415.14	421.5015.49

drifted in water.

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Day time zooplankton in all the **stations showed low average values during monsoon (122.4-359 no./m^3) while** in this season the night time abundance was high (4,275.1 no./m^3) (Table 3), indicating a distinct nature of night plankton. Reefs harbour resident zooplankton with entirely distinct composition and behaviour from that of oceanic plankton (Emery, 1968; Tranter and George, 1972; Aldredge and King, 1977). The seasonality may be associated with variations in physico-chemical parameters. In a steady environment, even slight changes may trigger a biological response. In the present study, zoea, megalopa, decapod larvae and ostracods were the major groups which showed difference in seasonal variation between day and night samples,

TABLE 3. *Average zooplankton abundance (no. Im^3) during pre-monsoon (PR-Mon), monsoon (Mon) and post-monsoon (PO-Mon) seasons and average of their total occurrence in stations 1 to 5 and at night in station -5.*

Seasons	Stations					
	1	2	3	4	5	5N (night)
PR-Mon	682.8	270.1	501.8	346.4	264.5	1,571.9
Mon	359.0	137.1	202.0	122.4	202.3	4,275.1
PO-Mon	722.8	261.1	457.5	482.8	234.5	2,020.0
Average	587.9	222.8	387.1	317.2	253.8	2,622.3

The average numerical counts and percentage composition of major zooplankton groups are shown in Table 4. All the rare groups are put together in the table as "other groups". Twenty one taxa were found to be common in day and night samples. In addition to these doliolum, salps, euphausiids,

TABLE 4. *Average of numerical counts (no. Im^3) and percentage composition (in parenthesis) of major groups of zooplankton in stations 1 to 5 (day time samples) and 5N (night samples from station 5)*

Zooplankton	Stations					
groups	1	2	3	4	5	5N (night)
Copepods	56.7(19.1)	53.9(22.5)	112.7(25.9)	76.4(26.7)	37.1(16.8)	366.0(13.6)
Siphonophores	6.4(2.1)	5.7(2.4)	7.4(1.7)	6.1(2.1)	6.2(0.1)	0.2(0.2)
Fish eggs & larvae	82.7(27.8)	56.8(23.7)	69.1(16)	48.0(16.8)	70.9(32.1)	302.0(11.2)
Megalopa	1.5(0.5)	0.9(0.4)	0.5(0.12)	0.8(0.3)	0.0(0.0)	212.7(7.9)
Zoea	19.3(6.5)	16.6(6.9)	89.7(20.6)	25.8(9.1)	37.2(17.9)	309.2(11.5)
Decapod larvae	32.8(11.0)	28.8(12.0)	59.9(13.8)	36.6(12.8)	12.7(5.7)	723.0(26.8)
Chaetognaths	7.4(2.5)	4.7(1.9)	15.3(3.5)	6.9(2.4)	4.4(0.3)	0.55(0.2)
Madusae	6.9(2.3)	4.5(2.0)	6.2(1.4)	2.0(0.7)	0.88(0.4)	18.0(0.7)
Polychaetes	6.6(2.2)	5.2(2.3)	6.3(1.5)	8.4(2.9)	2.6(1.2)	10.9(0.4)
Amphipods	12.3(4.1)	7.3(3.0)	8.4(1.9)	6.8(2.4)	0.6(0.3)	34.5(1.3)
Ostracods	4.4(1.4)	4.1(1.7)	3.3(0.8)	4.3(1.5)	11.7(6.3)	555.0(20.6)
Bivalve larvae	14.4(4.9)	8.9(3.7)	9.6(2.2)	12.6(4.4)	1.1(0.5)	7.9(0.3)
Gastropod larvae	25.7(8.6)	18.8(6.8)	21.2(4.9)	21.3(7.4)	16.0(7.2)	22.3(0.8)
Isopods	1.5(0.5)	2.5(1.2)	1.6(0.4)	3.3(1.1)	0.6(0.3)	6.6(0.2)
Invertebrate eggs	4.6(1.6)	4.8(2.0)	4.0(0.9)	6.1(2.1)	3.9(1.8)	22.9(0.8)
Forminiferans	7.9(2.0)	9.5(3.9)	12.8(2.9)	9.8(3.4)	15.0(7.8)	47.0(1.7)
Other groups	6.9(2.7)	6.6(4.0)	6.7(1.6)	8.7(3.0)	1.3(0.9)	43.4(1.7)

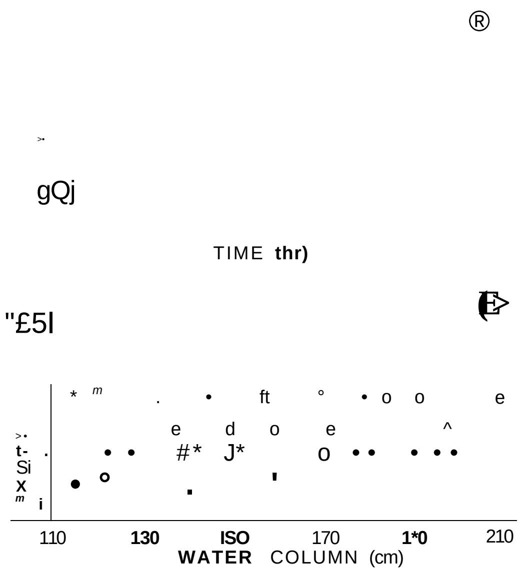

Fig. 3. a. Diurnal variation in zooplankton abundance and b. zooplankton abundance over the 24 hour tidal cycle expressed as height of water column.

tunicates and tanaidaceans were also present in the night samples. Madhupratap *et al.* (1977) observed domination of molluscan larvae in the zooplankton at Kavaratti and poor representation of copepods. In the present study, the daytime samples were dominated by fish eggs and larvae (16 - 32.1 %) followed by copepods (16.8 - 26.7 %) and decapod larvae (5.7-13.8 %) while the night samples were dominated by decapod larvae (26.8 %) followed by ostracods (20.6 %) and copepods (13.6 %). Swarms of ostracods in the order of 1,000 no./m^3 at night was reported by Tranter and George (1972) at Kavaratii. Still higher concentration of ostracods at the rate of 1,986 no. /m^3 was observed during late monsoon period in the present investigation. The high density of decapods and ostracods in night samples kept the percentage of all other groups low despite their higher density.

The diurnal study in the lagoon showed low zooplankton density upto 1800 hrs, but it increased sharply from 2100 hrs and maintained a high level upto 0300 hrs. Density decreased sharply by 0900 hrs (Fig. 3 a). A similar pattern was observed by Goswami (1979) at Kavaratti and reported that the higher abundance was when the oceanic plankton swept into the lagoon during high tide. But a series of diurnal observations during the present study over a 24 hr tidal cycle showed no definite relation between tide and total zooplankton (Fig. 3 b) and major groups, indicating that the contribution of oceanic plankton to the lagoon through tide was nqt significant. Hence, it may be concluded that the source of the increased quantity of the night plankton may be endemic to the lagoon where the plankters hide among sea grasses and other suitable shelters during the day. They may be distinct from that of the oceanic plankton. If these are true, in the Kavaratti atoll, there may not be any significant supply of plankton into the lagoon from the sea and the lagoon harbours its own zooplankton which is distinct in composition, character and also in response to physico-chemical variations.

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