

Diel Variations of Zooplankton at Kavaratti Atoll (Lakshadweep)

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Occurrence, abundance and diel variations of major groups and species of zooplankton at 2 stations at Kavaratti Atoll (Lakshadweep) during October 1971 were studied. Zooplankton and water samples, for the environmental parameters, were collected at every 2 hr interval covering the entire tidal cycle. Diel variations in the environmental parameters were not significant except for dissolved oxygen content in the lagoon. Average zooplankton biomass values were higher (140.8 g/1000m³) for the station outside the coral reef than for the lagoon station (104.7 g/1000m³). Nocturnal abundance of zooplankton was observed at both stations. Swarms (31496.0/10m³) of the luminescent ostracod, *Cypridina* sp. resulted in high zooplankton abundance particularly in the night samples. Faunistic composition was more diverse at sea than in the lagoon.

Earlier work carried out in the coral reef areas, including the Laccadive archipelago atolls, indicate that zooplankton is an important source of food for coral and coral reef community¹⁻⁵. Production of organic matter from Kavaratti Atoll has been studied^{6,7} and the chemical characteristics of the waters around Kavaratti have been described by Sankaranarayanan⁸. The occurrence of a bloom of the blue green alga *Trichodesmium* sp. from the Laccadive region is described by Qasim⁹. The present paper deals with diel variations in the zooplankton community with special reference to copepods at Kavaratti Atoll.

Materials and Methods

Kavaratti (10°33.5'N, 72°38'E) is one of the atolls of Laccadive Archipelago. It is oriented along a north-south axis with the coral reef and lagoon on the west and the island to the east. The average depth of the lagoon is about 2 m.

Zooplankton samples for diurnal studies were taken at every 2 hr interval covering the entire tidal cycle (16-17 October 1971). Horizontal samples were collected from 2 fixed stations (Fig. 1), one situated in the sea and outside the coral reef (st 1) and the other in the lagoon (st 2). Collections from both the stations were made with a square zooplankton net (mouth area 0.25 m² and mesh width 0.3 mm). The net was towed for about 5 min and the amount of water filtered was determined by a calibrated flowmeter. Zooplankton samples were fixed in 4% formaldehyde buffered with 1% hexamine. Twenty-six plankton samples were analysed for determination of biomass by wet weight method and for numerical abundance of dominant groups and species. The copepod species diversity values were calculated from the formula given by Fisher *et al.*¹⁰.

Water samples were taken simultaneously with zooplankton collections for the determination¹¹ of various environmental parameters (pH, temperature, salinity, dissolved oxygen content, PO₄-P, NO₃-N and SiO₃-Si).

Results

Diel changes in different environmental parameters are shown in Fig. 2. Changes in pH, PO₄-P, NO₃-N values were almost similar at both the stations.

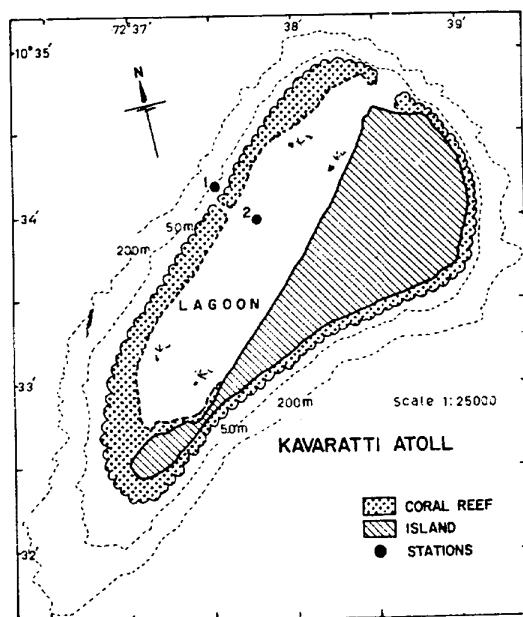


Fig. 1—Location of stations

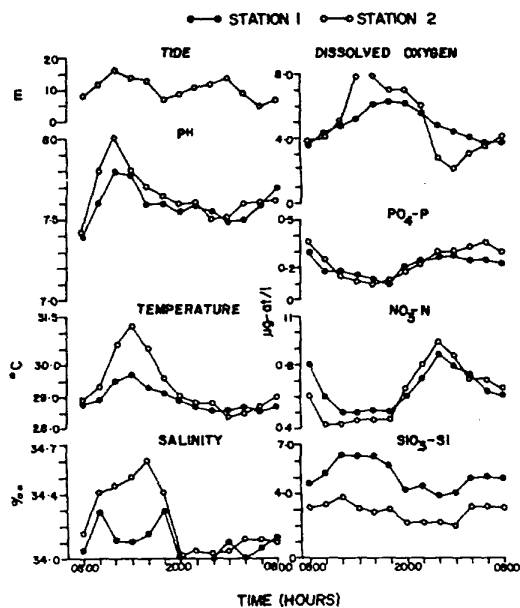


Fig. 2—Diurnal variations in environmental parameters at 2 stations at Kavaratti atoll

Fluctuations in SiO_3-Si values were more at sea. The range in pH was from 7.4 to 8 with higher and lower values in the day and night samples respectively. Variations in dissolved oxygen content were particularly significant in the lagoon. Temperature of the water in the lagoon was higher than the surrounding sea and varied from 28.8 to 29.7°C at st 1 and from 28.4 to 31.2°C at st 2.

Zooplankton biomass—Higher values were obtained at st 1 (av. 140.8 g/1000 m³) than at st 2 (av. 104.7 g/1000 m³). There was greater nocturnal abundance of zooplankton at both the stations. The biomass values for the night and day samples at sts 1 and 2 were 159.9 and 121.8 g/1000 m³ and 127.3 and 82.1 g/1000 m³ respectively. Values were higher for the samples collected during the morning and decreased gradually with the lowest values recorded at 1400 hrs. The values increased again at dusk with peak at 0200 hrs at both the stations (Fig. 3). The tides also influenced the zooplankton abundance and biomass values were higher during the flood tide at st 2 when the oceanic plankton were swept into the lagoon from the surrounding sea. The correlation coefficient (*r*) values obtained between the zooplankton biomass and the various environmental parameters gave negative significant value ($r=0.711, P<0.01$) with temperature at st 2 indicating a greater zooplankton abundance when the temperature was low.

Species composition and diurnal variation—Ostracods dominated the zooplankton community at

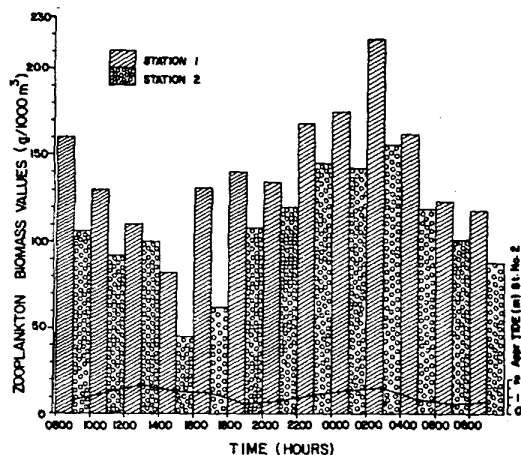


Fig. 3—Zooplankton biomass values at 2 stations at Kavaratti Atoll over entire tidal cycle

Table 1—Percentage Occurrence of Major Planktonic Groups at 2 Stations in Day and Night Collections

Groups	St 1		St 2	
	Day	Night	Day	Night
Hydromedusae	0.8	—	—	—
Siphonophora	0.1	—	—	—
Polychaeta larvae	0.31	1.16	1.43	3.27
Cirriped larvae	0.12	—	2.52	0.61
Decapod larvae	3.14	5.09	4.39	3.81
Copepoda	33.74	22.42	5.86	7.36
Amphipoda	—	0.81	3.16	5.83
Ostracoda	55.59	61.39	66.5	70.23
Mysidacea	0.01	2.55	2.99	3.75
Euphausiacea	0.05	0.75	—	—
Chaetognatha	1.14	0.8	0.26	—
Gastropod larvae	1.93	2.03	9.2	3.54
Pteropoda	0.07	—	—	—
Appendicularia	0.15	—	—	—
Invertebrate eggs	2.	1.31	2.05	0.61
Fish eggs	0.44	1.46	0.13	0.92
Fish larvae	0.35	0.19	1.49	0.04

— = Not observed

both the stations. The faunistic composition showed more diversity at st 1. Hydromedusae, siphonophores, euphausiids, pteropods and appendicularians were recorded only in the samples collected from this station. Diel variations in the occurrence and abundance of major groups were also observed at both the stations. Based on the total counts of zooplankton, the percentage occurrence of different groups in the day and night samples are given in Table 1. Besides these taxa, few specimens of cyphonautes larvae, isopods, cladocerans, stomatopod larvae were also encountered in the samples and all

these constituted minor fraction of plankton population at both the stations. The distribution and abundance of the dominant groups and their species over the tidal cycle at both the stations are as follows:

Copepoda: This group was poorly represented in the plankton samples collected from st 2. However, at st 1, they were recorded in large numbers and comprised mostly of calanoid copepods. The percentage occurrence of calanoid, harpacticoid and cyclopoid copepods at st 1 were 86.73, 2.28 and 10.99% respectively whereas at st 2, their percentages were 27.85, 42.45 and 29.70% respectively.

Qualitative and quantitative variations in the occurrence of copepod species were observed at these 2 stations. Many of the copepod species were observed in plankton samples from st 1 (Table 2). Similarly,

harpacticoid forms such as *Clytemnestra scutellata* and *Miracia efferata* were recorded from st 2 (Table 2). Calanoid copepod population was quite poor in the lagoon. *Canthocalanus pauper*, *Paracalanus aculeatus*, *Centropages orsinii* and *Acartia danae* were recorded in greater numbers in the samples collected from the lagoon station during flood tide and were probably brought from the surrounding sea.

Species of the genus *Paracalanus* were recorded in large numbers at both the stations. Members of the families Paracalanidae and Centropagidae showed positive correlation indicating that these species can coexist (Tables 3 and 4). The families Macrosetellidae and Sapphirinidae gave negative correlation with most of the other families at st 1 while Macrosetellidae and Clytemnestridae were negatively correlated with other families at st 2 implying that they form a group by themselves and occurred abundantly when the members of the other families were either absent or were poorly represented.

The copepod species diversity (D) values varied from 0.82 to 2.61 at st 1 and from 0.58 to 1.79 at st 2. Higher value at the former station was obtained for the day samples while at the latter station, it was for the night samples. The percentage occurrence of some of the common species over the entire tidal cycle is shown in Fig. 4. These species occurred invariably in all the samples at st 1 but were more abundant in the day collections. However, at st 2, *Clytemnestra scutellata* and *Macrosetella gracilis* were recorded only in the night samples.

Hydromedusae and the siphonophores were observed in small numbers in the day samples. *Eirene ceylonensis*, *Eirene* spp and *Obelia* spp were the common hydromedusae in the samples and the siphonophores were represented by *Diphyes chamissonis*, *Diphyes* spp and *Lensia* spp. The mysids, viz. *Animysis hanseni* and *Gastrosaccus* sp., were abundant in the samples from both the stations, occurring more in the night samples. *Stylocheiron suhmii* was the only euphausiid species recorded and occurred in greater numbers (112/m³) at 0200 hrs at st 1. Chaetognath population was quite poor in the lagoon and was not observed there in the night collections. Species of the genus *Sagitta* such as *S. bedoti*, *S. enflata*, *S. neglecta*, *S. pacifica* and *Sagitta* spp were recorded. *S. neglecta* was obtained in greater numbers in the night samples from st 1. *Cypridina* sp. accounted for the ostracod swarms at both the stations. The number as high as 31496/10 m³ was obtained in the night samples from the lagoon. The decapod population comprised mostly of crab zoea, pagurid larvae, caridean larvae and adults and developmental stages of lucifers. *Lucifer hanseni* was the common species, few specimens of *L. typus* were obtained in the day samples at st 1. The hyperiid

Table 2—Population Density (No./m³) of Common Copepod Species at 2 Stations

Species	St 1		St 2	
	Max.	Min.	Max.	Min.
Suborder : Calanoida				
<i>Canthocalanus pauper</i> (Giesbrecht)	8.1	0.4	2.3	0.04
<i>Undinula vulgaris</i> (Dana)	36.9	0.5	—	—
<i>Eucalanus crassus</i> (Giesbrecht)	57.2	6.5	3.9	0.3
<i>E. monachus</i> Giesbrecht	2.4	0.02	—	—
<i>E. attenuatus</i> (Dana)	0.8	0.03	—	—
<i>Paracalanus aculeatus</i> Giesbrecht	10.2	0.9	3.4	0.2
<i>Paracalanus</i> spp	113.9	3.2	26.9	0.3
<i>Acrocalanus gracilis</i> Giesbrecht	8.6	0.4	—	—
<i>A. longicornis</i> Giesbrecht	1.3	0.02	—	—
<i>Euchaeta marina</i> (Prestandrea)	0.5	0.01	—	—
<i>Scolecithrix danae</i> (Lubbock)	0.4	0.02	—	—
<i>Centropages orsinii</i> Giesbrecht	14.2	1.3	1.6	0.05
<i>Labidocera pavo</i> Giesbrecht	4.1	0.06	—	—
<i>L. detrunata</i> (Dana)	1.3	0.01	—	—
<i>Pontellina plumata</i> (Dana)	8.6	0.1	—	—
<i>Pontella spinipes</i> Giesbrecht	1.2	0.4	—	—
<i>Acartia danae</i> Giesbrecht	10.2	0.8	8.9	0.01
<i>A. negligens</i> Dana	0.6	0.02	—	—
<i>Acartia</i> sp.	18.7	1.4	3.2	0.5
Suborder : Harpacticoida				
<i>Clytemnestra scutellata</i> Dana	—	—	6.4	0.02
<i>Macrosetella gracilis</i> (Dana)	2.9	0.4	51.5	0.9
<i>Miracia efferata</i> Dana	—	—	18.6	0.3
Suborder : Cyclopoida				
<i>Oithona plumifera</i> Baird	1.9	0.2	—	—
<i>O. similis</i> Claus	1.1	0.2	—	—
<i>Oithona</i> spp	18.2	2.1	13.2	0.3
<i>Oncaea venusta</i> Philippi	1.6	0.1	—	—
<i>Corycaeus speciosus</i> Dana	4.5	0.6	—	—
<i>Corycaeus</i> spp	12.3	1.1	2.4	0.7
<i>Sapphirina ovatolanceolata</i> Dana	0.3	0.01	—	—
= Not observed				

Table 3—Correlation Matrix for 9 Major Copepod Families at St 1 over Entire Tidal Cycle

	Eucalanidae	Paracalanidae	Centropagidae	Pontellidae	Acartiidae	Macrosetellidae	Oithonidae	Corycaidae	Sapphirinidae
Eucalanidae	—								
Paracalanidae	0.264	—							
Centropagidae	0.318	0.566*	—						
Pontellidae	0.151	0.539	0.698†	—					
Acartiidae	0.373	0.732†	0.589*	0.284	—				
Macrosetellidae	-0.377	-0.529	-0.291	-0.237	0.286	—			
Oithonidae	0.417	0.427	0.411	0.061	0.121	0.325	—		
Corycaidae	0.354	0.237	0.732†	0.868†	0.326	0.208	0.340	—	
Sapphirinidae	-0.216	-0.279	-0.436	-0.104	-0.174	-0.577*	-0.264	-0.176	—

Significant at *5% and †1% level

Table 4—Correlation Matrix for 9 Copepod families at St 2 over Entire Tidal Cycle

	Calanidae	Eucalanidae	Paracalanidae	Centropagidae	Acartiidae	Macrosetellidae	Clytemnestridae	Oithonidae	Corycaidae
Calanidae	—								
Eucalanidae	0.162	—							
Paracalanidae	0.774†	0.565*	—						
Centropagidae	0.855‡	0.742†	0.544	—					
Acartiidae	0.929‡	0.262	0.751†	0.836‡	—				
Macrosetellidae	-0.322	-0.422	-0.353	-0.041	-0.262	—			
Clytemnestridae	-0.107	-0.262	-0.217	0.252	-0.110	0.842‡	—		
Oithonidae	0.371	0.514	0.409	0.024	0.416	0.777†	0.724†	—	
Corycaidae	0.612*	0.609*	0.855‡	0.635*	0.838‡	-0.499	-0.242	0.589*	—

Significant at *5%, †1% and ‡0.1% level

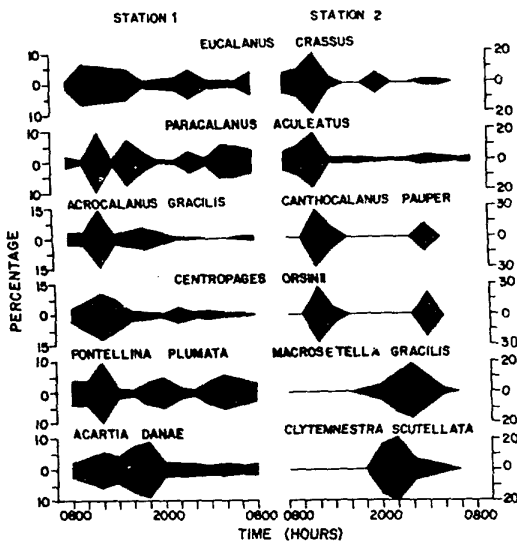


Fig. 4—Percentage distribution of common copepod species at 2 stations at Kavaratti Atoll over the tidal cycle

amphipods occurred in greater numbers at station outside the reef while the gammarid amphipods were abundant in the lagoon. The appendicularians (*Oikopleura* sp.) and pteropods (*Creseis* sp.) were recorded in the day samples. Fish eggs and fish larvae

were quite common in all the plankton samples. The fish larvae belonging to the families Gobiidae, Myctophidae and Holocentridae were present in the plankton collections from both the stations.

Discussion

Kavaratti is a perfect atoll¹². It differs from the atolls in the Pacific by the shallowness of its lagoon. The fluctuations in the oxygen levels of the lagoon water may be due to the thick growth of macrophytes and shallow depth. Oxygen values varied from 2.01 to 7.91 ml/litre at the lagoon station. Qasim *et al.*⁷ and Sankaranarayanan⁸ recorded diurnal variations in the dissolved oxygen content from 3.05 to 7.86 and 1.74 to 8.83 ml/litre respectively from Kavaratti lagoon. The values of nutrient salts were quite low during day but increased slightly in the night samples (Fig. 2). Qasim *et al.*⁷ also reported low and high concentration of PO₄-P in the day and night samples respectively. However, for NO₃-N, they observed the reverse trend.

Spectacular ostracod swarms of *Cypridina* sp. contributed to very high zooplankton biomass values at both the stations. Tranter and George⁴ also obtained unusually high biomass values from the lagoon (835 mg/m³) and from the surrounding sea (588 mg/m³) at Kavaratti Atoll during 20-22 October 1968

and attributed these very high values to ostracod swarms. During the present study, zooplankton biomass values were higher at sea. The mean numerical abundance of zooplankton in the lagoon was about 26% less compared to sea. As the sea water enters the lagoon only on the western side (Fig. 1), it is possible that oceanic plankton are being consumed by the coral reef community from the water flowing across the reef. Tranter and George⁴ in their studies of zooplankton at 2 Laccadive atolls reported depletion of zooplankton in transit from ocean to lagoon to be 61 and 23% at Kavaratti and Kalpeni reefs respectively. Glynn¹³ gave the rate of consumption of haloplankters at Laurel reef to be 83% at night and 35% during the day.

Diel variations in the occurrence and abundance of zooplankton groups and species were observed at both the stations. Copepod species distribution in particular was quite different in the day and night samples collected from the Kavaratti lagoon. It may not be associated with the phenomenon of vertical migration as the average depth there is about 2m. The transparency of the water coupled with high incident radiation may be forcing the lagoon plankton to take refuge in the grass bed *Thalassia hemprichii* and *Cymodocea isoetifolia* and come up during the night. Three copepod species, viz. *Clytemnestra scutellata*, *Macrosetella gracilis* and *Acartia* sp., were in association with the grass bed and their gut contents consisted mostly of organic detritus. Fenchel¹⁴ showed that organic detritus derived from the turtle grass serves as food to animal communities. Gerber and Marshall¹⁵ reported that detritus constituted 95% of the gut contents of copepod *Undinula vulgaris* from lagoon of Eniwetik atoll.

Qasim *et al.*⁷ obtained high organic production values (4.9 gmC/m²/day) from the Kavaratti reef which is equivalent to 14.7 mgC/cm²/strip/day. This is in order of magnitude greater than the energy available to the reef in the form of zooplankton carbon⁴. From the biomass values recorded from the station outside the

coral reef over the tidal cycle, the energy available to the reef in the form of zooplankton carbon works out to be only 0.27 gmC/m²/day. It means that the energy available to the reef in the form of zooplankton is not sufficient and the coral reef must supplement the food from some other source. Gerber and Marshall¹⁵ stated that mucous and organic particles represent significant source of energy in the coral reef food chain. Existence of demersal plankton in the vicinity of coral reefs was reported^{1,3,16} which is supposed to be an important source of energy to the coral reef community.

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References

- 1 Emery A R, *Limnol Oceanogr*, **13** (1968) 293.
- 2 Johannes R E, Coles S L & Kuenzel N T, *Limnol Oceanogr*, **15** (1970) 579.
- 3 Porter J W, in *Proceedings 2nd international symposium on coral reefs*, Vol. 1, edited by C.M. Cameron (Great Barrier Reef Committee, Brisbane) 1974, 111.
- 4 Tranter D J & George G, in *Proceedings symposium on corals and coral reefs*, edited by C. Mukundan and C.S. Gopinadha Pillai (Marine Biological Association of India) 1972, 239.
- 5 Goswami S C, *Proc Indian natn Sci Acad*, **39B**, 1973, 676.
- 6 Qasim S Z & Sankaranarayanan V N, *Mar Biol*, **15** (1972) 193.
- 7 Qasim S Z, Bhattathiri P M A & Reddy C V G, *Int Rev ges Hydrobiol*, **57** (1972) 207.
- 8 Sankaranarayanan V N, *Indian J mar Sci*, **2** (1973) 23.
- 9 Qasim S Z, *Deep Sea Res*, **17** (1970) 655.
- 10 Fisher R A, Corbet A S & William C B, *J Animal Ecol*, **12** (1943) 42.
- 11 Strickland J D H & Parsons T R, *Bull Fish Res Bd Can*, **167** (1968) 311.
- 12 Gardiner J S (editor), *The fauna and geography of the Maldiva and Laccadive Archipelago*, 2 Vols (Cambridge University Press) 1906, 1097pp.
- 13 Glynn P W, *J mar Res*, **35** (1977) 567.
- 14 Fenchel T, *Limnol Oceanogr*, **15** (1970) 14.
- 15 Gerber R P & Marshall N, *Limnol Oceanogr*, **19** (1974) 815.
- 16 Johannes R E & Tepley L, in *Proceedings 2nd international symposium on coral reefs*, Vol. 1, edited by C.M. Cameron (Great Barrier Reef Committee, Brisbane) 1974, 127.