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Some Aspects of the Limnology of Bolgoda Lake II, Sri Lanka.
1. Composition and Seasonal Fluctuation of Zooplankton

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Abstract: The abundance, distribution and composition of various groups of zooplankton; Nauplii, Copepoda, Rotifera, Cladocera and Ostracoda inhabiting Bolgoda Lake II, Sri Lanka were studied. Some physical factors influencing the seasonal abundance and pattern of fluctuation were described. This investigation revealed that wind and rainfall were the major factors that contributed to the abundance of the zooplankton population during the monsoonal periods. The nauplii and the copepoda contributed about 70% of the zooplankton in the lake and their densities varied with depth.

1. Introduction

In Sri Lanka, a great deal of scientific research is now focussed on limnological studies of inland lakes and reservoirs[4,10,11,17] especially with the development of inland fisheries. Studies on the hydrobiology of Colombo lake[5] referred to monthly production of the total zooplankton while the density of zooplankton[7] for periods August-September 1979 and March-April 1980 have been determined for Parakrama Samudra, Sri Lanka. The importance of the abundance of zooplankton has been stressed in understanding the limnology for tropical countries Africa[13] India[14] and South East Asia[10] Larval fishes depend on zooplankton as the main food source[2] and some adult fishes feed on plankton exclusively or at certain size ranges. Zooplankton constituted the major food item for *Oreochromis mossambica (Tilapia mossambica)* of 25 mm[6] Since Sri Lanka reservoirs are stocked with *Tilapia* as a protein source for human consumption, studies on zooplankton abundance and composition are essential in assessing success of *Tilapia* production in various water bodies of Sri Lanka. Hence this study deals with the composition, distribution and population pattern of zooplankton taxa at Bolgoda Lake II.

2. Study Area

Bolgoda Lake 11 (Figure 1) is a man-made lake situated 22 miles to the south of Colombo at 79°55'E, 6°41'N at an elevation of 7.5 meters above sea level in the wet zone of Sri Lanka. The lake is shallow with an average depth of 1.93 meters and an area of 298 hectares. The inflow of water is from the Bolgoda Ganga (river) and the monsoonal rains, while the outflow is via the Talpitiya canal into the sea. The outlet into the sea is kept closed by a sand bar which is opened

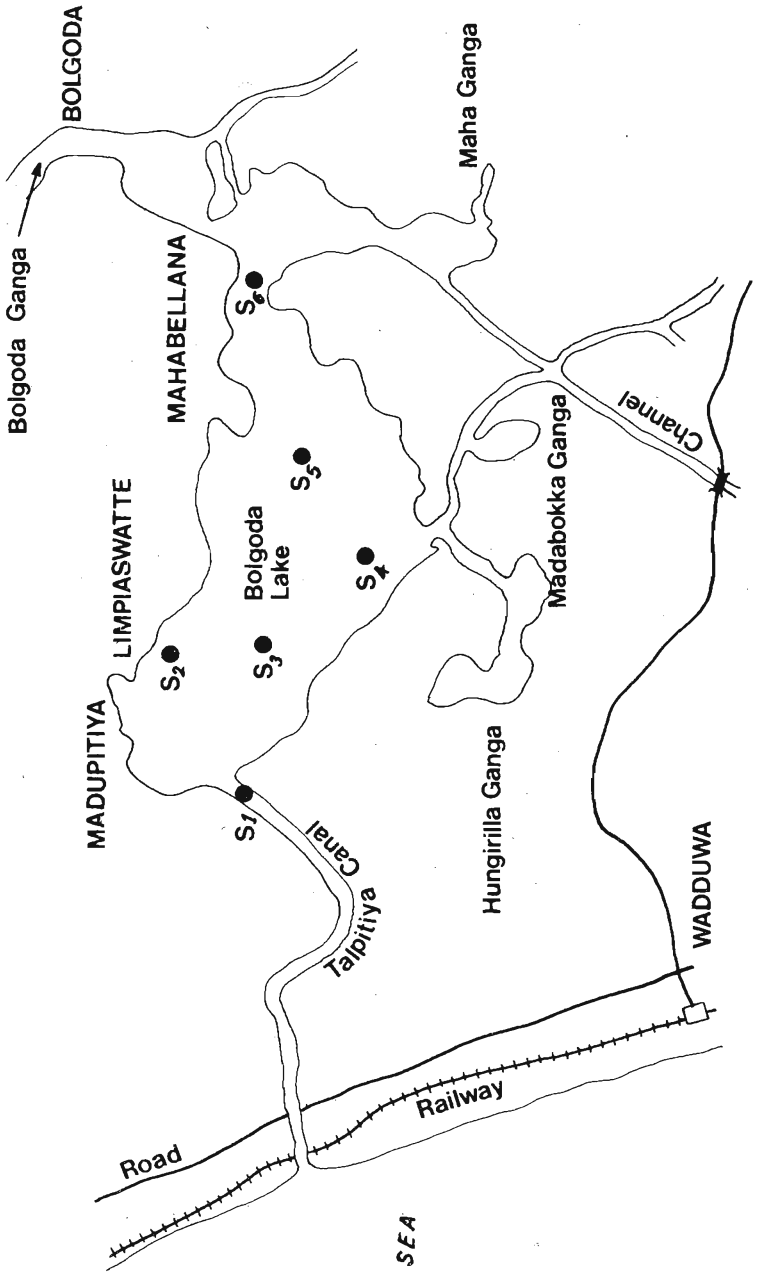

Figure 1. Map of Bolgoda Lake II showing sampling stations (S1 - S6).

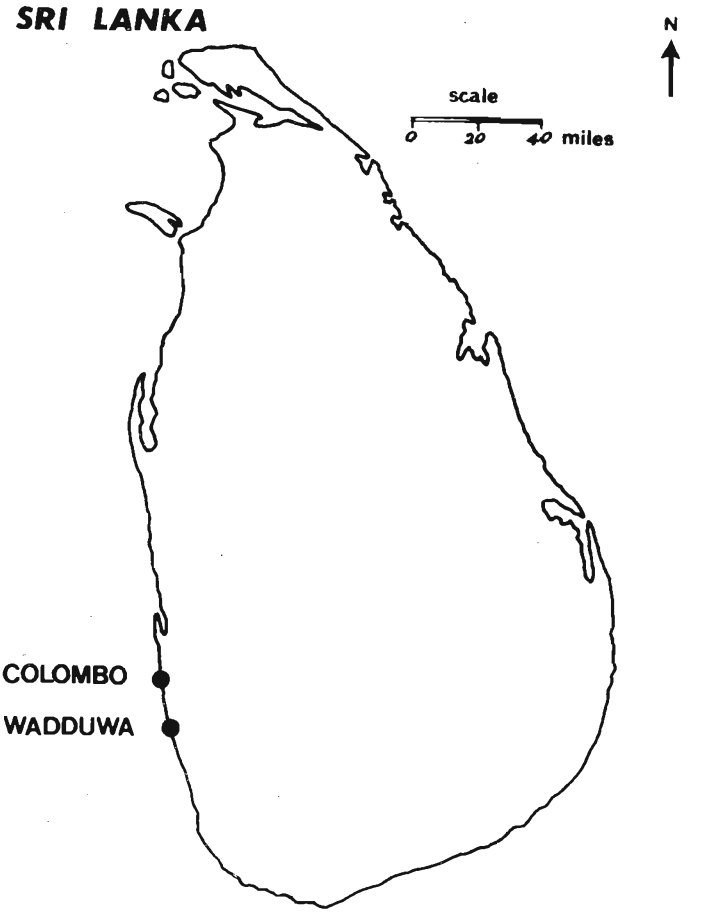

Figure 1. Geological Map of Sri Lanka.

periodically when the waters of Bolgoda Lake II begin to flood. During the period of study (October 1980 - September 1981) the sand bar remained closed. The sea water could enter the canal only through seepage.

The lake is used as a water source for irrigation of neighbouring paddy fields and fishing by inhabitants living in the vicinity of the lake.

Table 1. Composition of Zooplankton at Bolgoda Lake II during the Year 1980 – 1981.

Category I — Nauplii
- (1) Copepod nauplii
- (2) Prawn nauplii (Palaemonidae)

Category II — Copepoda
- (1) Mesocyclops leukartii
- (2) Microcyclops sp.
- (3) Diaptomus sp.
- (4) Eudiaptonus sp.
- (5) Atteyella sp.

Category III — Rotifera
- (1) Asplanchna sp.
- (2) Brachionus caudatus
- (3) Brachionus falcatus
- (4) Brachionus nilsoni
- (5) Keratella earlinae
- (6) Keratella cochlearis
- (7) Keratella sp.
- (8) Euchlanis sp.
- (9) Trichocerca sp.
- (10) Polyarthra vulgaris
- (11) Polyarthra sp.
- (12) Synantherina semibullata
- (13) Testudinella patina
- (14) Lecane lunaris

Category IV — Cladocera
- (1) Allona sp.
- (2) Bosmina sp.
- (3) Chydorus sp.

Category V — Ostracoda
- (1) Cypricercus sp.
- (2) Cypridiopsis sp.
- (3) Cypris sp.

3. Materials & Methods

Six stations (Figure 1 - Stations 1 to 6) were chosen (inlet, outlet, edge and centre) for this study. Preliminary sampling was done in order to determine a suitable sample size. Ten litre sample size was chosen as a satisfactory measure of the zooplankton in the lake. A Ruttner sampler was used to collect the zooplankton from the surface, middle (at half the depth) and bottom (slightly above muddy layer) at each station. Sampling was done in the mornings till afternoon (9.00 am to 2.30 pm) at all stations, monthly. Each 10 litre sample was sieved through a 60 μ mesh and the zooplankton collected in 150 ml bottles in 4% formalin for storage. The samples were analysed in the laboratory using a Zeiss inverted microscope and numbers per litre determined.

The monthly rainfall and windspeed values (Table 2) were obtained from the Department of Meteorology from their recording station at Ratmalana (S.W. of Colombo) which is about 4 km from the study area. Other physical factors (Table 2) such as depth, temperature, transparency and turbidity were measured at each station. The mean values of these physical factors for the lake were calculated from these measurements obtained at each station. The monthly depth was measured by sinking a weighted tape, the air temperatures by a standard thermometer and the water temperature at the surface, middle and bottom at each station by using a temperature probe (Dectan Model ECT-S). The transparency of the water was measured by a Secchi disc and the turbidity of the lake determined by using the method outlined by the American Public Health Association[1].

4. RESULTS

4.1 Composition of fauna

Zooplankton fauna collected were identified [3,8,9,15], and grouped under the categories Nauplii, Copepoda, Rotifera, Cladocera and Ostracoda. In the samples the protozoans being extremely low were omitted from population studies of the plankton. Species present in zooplankton during the period October 1980 - September 1981 are listed (Table I). The copepods were represented by the cyclopoids *(Mesocyclops* and *Microcyclops),* the calanoids *(Diaptomus* and *Endiaptomus)* and the harpacticords by a single genus *Atteyella,* Ceylopoids being abundant in this category. In the rotifers the species richness was exhibited with nine genera and fourteen species. The *Keratella* and *Brachionus* were the most abundant. The cladocerans and ostracods were not common together contributing less than 7% of total zooplankton collected (Table 4) and represented each by three genera.

Table 2. Monthly variation of Turbidity, Depth, Transparency, Air and Water Temperatures, total monthly rainfall and mean windspeed at Bolgoda Lake II for the year 1980 – 1981 (±2 SE).

Month	*Mean Turbidity (NTU)*	*Mean Depth (Meters)*	*Mean Trans-parency (Meters)*	*Mean Air Temperature (°C)*	*Mean Water Temperature (°C)*	*Total Rain-fall (m.m.)*	*Mean Wind Speed M=Morning A=Afternoon (k.m/hr)*
October	9.60 ± 2.73	2.24 ± 0.13	1.39 ± 0.13	29.78 ± 0.63	29.90 ± 0.27	370.3	M - 4.3 A - 6.3
November	5.41 ± 3.36	1.83 ± 0.13	1.44 ± 0.03	30.75 ± 0.49	29.70 ± 0.27	333.5	M - 3.6 A - 5.3
December	8.51 ± 3.46	1.94 ± 0.18	1.54 ± 0.37	30.83 ± 0.47	28.51 ± 0.13	211.1	M - 5.0 A - 9.0
January	2.42 ± 0.72	1.91 ± 0.09	1.66 ± 0.11	31.33 ± 1.08	29.26 ± 0.49	155.2	M - 4.1 A - 8.7
February	0.97 ± 1.03	1.98 ± 0.057	1.67 ± 0.20	31.20 ± 0.88	29.86 ± 0.42	83.3	M - 3.8 A - 9.3
March	2.47 ± 1.14	1.86 ± 0.14	1.35 ± 0.24	33.71 ± 0.68	32.08 ± 0.27	69.4	M - 4.1 A - 8.9
April	2.66 ± 0.62	2.06 ± 0.06	1.38 ± 0.19	32.55 ± 0.52	31.93 ± 0.34	268.6	M - 4.0 A - 6.1
May	2.17 ± 0.33	1.93 ± 0.10	1.54 ± 0.11	32.78 ± 0.51	31.25 ± 0.37	528.9	M - 4.6 A - 6.5
June	3.00 ± 0.36	2.11 ± 0.07	1.61 ± 0.09	30.05 ± 0.61	28.59 ± 0.48	187.6	M - 8.1 A - 8.5
July	2.63 ± 1.53	1.76 ± 0.09	1.49 ± 0.09	30.0 ± 0.85	28.67 ± 0.37	19.6	M - 11.4 A - 10.5
August	2.06 ± 0.26	1.77 ± 0.15	1.59 ± 0.15	31.58 ± 0.70	29.46 ± 0.26	97.7	M - 7 .4 A - 7.3
September	2.34 ± 0.48	1.73 ± 0.04	1.50 ± 0.08	31.25 ± 0.61	29.98 ± 0.40	144.5	M - 8.5 A - 8.1

Table 3. Rations and Degrees of Freedom for Zooplankton Density Distribution at Bolgoda Lake II.

Taxa	F-values (* ≤ 0.01 and ** ≤ 0.001)		
	Station (5,187)	Depth (2,187)	Month (11,187)
Nauplii	21.14**	9.47**	17.99**
Copepoda	15.61**	5.03*	25.35**
Rotifera	9.42**	2.06	40.05**
Cladocera	3.18*	2.74	7.17**
Ostracoda	3.35*	2.90	21.42**

Table 4. Relative Abundance of Zooplankton at different stations at Bolgoda Lake II for the year 1980 – 1981.

Taxa	*Sampling Stations*					
	1	*2*	*3*	*4*	*5*	*6*
Total Zooplankton	3914.8	2021.4	2640.9	2906.7	3494.1	3440.4
Nauplii %	48.2	38.9	35.1	38.7	42.0	40.7
Copepoda %	31.2	33.6	35.7	35.4	32.8	33.2
Rotifera %	14.2	18.4	19.4	17.7	18.2	17.4
Cladocera %	3.8	6.4	6.1	4.4	4.1	5.0
Ostracoda %	2.6	2.7	3.7	3.8	2.9	3.7

4.2 Population Structure

Highest zooplankton recorded were at stations 1,5 and 6 (Table 4). Stations 5 and 6 are near the point of discharge of waters and debris from the Bolgoda Ganga. Station I was at the outlet of the lake; the entrance to the Talpitiya canal where large amount of debris was collected from the submerged and surrounding vegetation. A noteworthy feature was that the fish traps were placed by the fishermen close to stations 1,5 and 6.

The nauplii and copepods contributed to more than 70% of the total zooplankton in all the six stations (Table 4) while the rotifers, cladocerans and

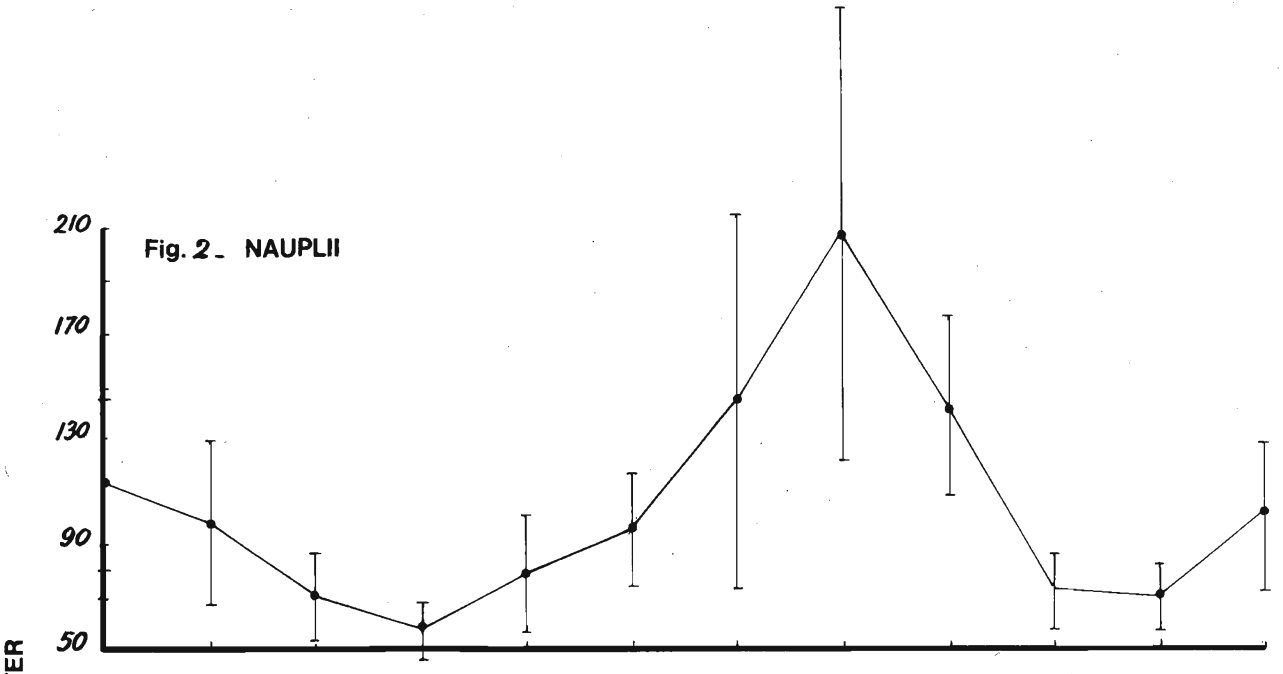

Figure 2. Monthly population of Nauplii (Nos./1. ± 2 S. E.).

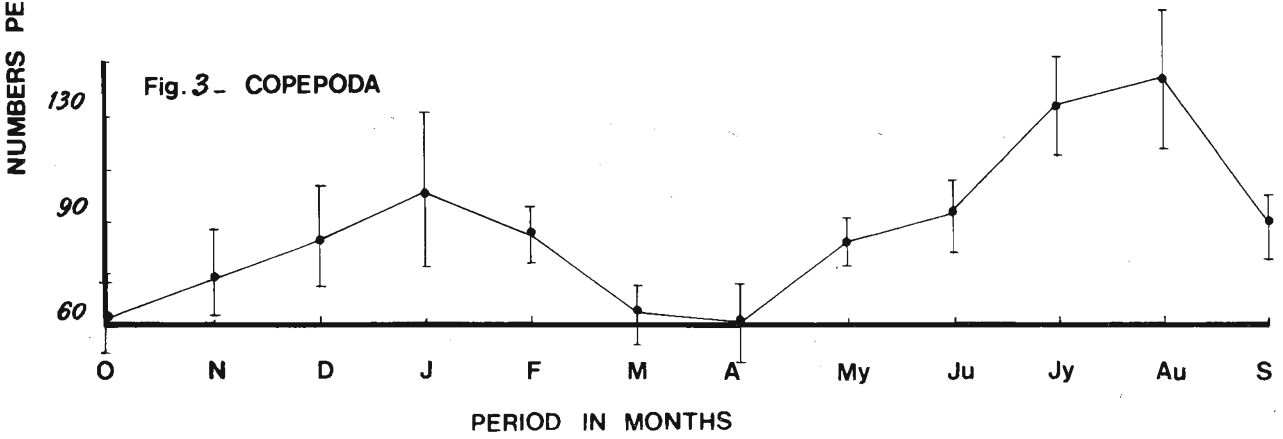

Figure 3. Monthly population of Copepoda (Nos./1. ± 2 S. E.).

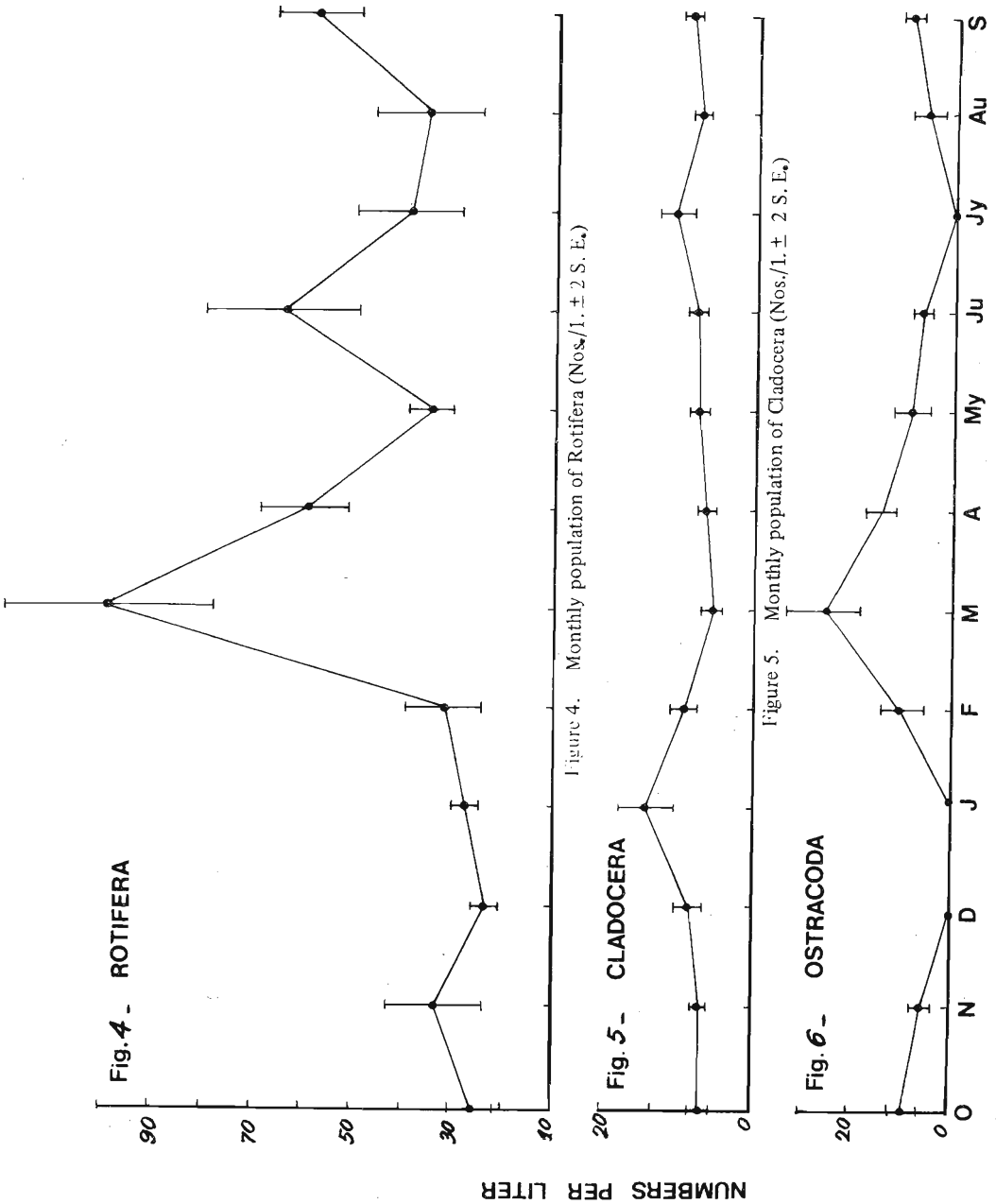

Figure 4. Monthly population of Rotifera (Nos./l. ± 2 S. E.)

Figure 5. Monthly population of Cladocera (Nos./l. ± 2 S. E.)

Figure 6. Monthly population of Ostracoda (Nos./l. ± 2 S. E.)

ostracods formed less than 30% of the total zooplankton (Table 4). The nauplii which formed the major zooplankton were copepod and prawn nauplii. The standing crop of nauplii increased during the monsoonal months of October and May, the lowest recorded in the intermonsoonal months of January and August (Figure 2). The copepods (Figure 3) reached a maximum in January and August, the lowest numbers recorded were in October and April. The rotifers (Figure 4) showed pulses in March, June and September with lowest recorded in December and May. The cladocerans (Figure 5) showed a maximum in January and July while the population remained low for most months of the year. The ostracod (Figure 6) population disappeared in the months of December, January and July while a significant peak occurred in March.

The copepod and rotifer females with eggs occurred throughout the year but in most cases the eggs were detached. In the cladocera, the eggs were outside the brood chamber. This may be due to agitation while sampling and transport. However an estimate of females with eggs could not be made.

The zooplankton categories Nauplii, Copepoda, Rotifera, Cladocera and Ostracoda were statistically analysed in relation to stations, depths and months as indicated in Table 3. The nauplii abundance varied significantly at the 0.001 level for stations, depths and months. The copepoda also varied significantly at the 0.001 level for stations and months and at the 0.01 level for depths. The densities of rotifers, cladocerans and ostracods differed significantly with stations and months as shown in Table 3.

The relative abundance (Table 4) of nauplii was observed in stations 1, 5 and 6, with densities ranging from 35 - 49%. The copepodids were abundant at stations 3 and 4, and their percentage composition ranged from 31 - 36%. Similarly the densities of rotifers ranged from 14 - 20% with the largest density at station 3; the cladocera from 3 - 7% with abundance at stations 2 & 3; the ostracoda from 2 - 4% with highest densities at stations 3, 4 & 6.

4.3 Physical Factors

The highest rainfall (Table 2) was recorded during the monsoonal periods of the S.W. Monsoon in April, May and June and the N.E. Monsoon in the months of October, November and December. Comparatively less rain fell in the intermonsoonal periods January to March and July to September. In addition to the total rainfall the lake received water from the Bolgoda Ganga which in turn connects with Bolgoda Lake I and the Panadura Estuary (S.W. Colombo). The lake was calm in the mornings with windspeed (Table 2) increasing in the afternoons causing the water to be turbulent. This phenomenon existed from October to May. From June to September, the windspeed was approximately the same both in the mornings and in the afternoons.

The mean air temperatures ranged from 29 - 34°C while the mean water temperature varied from 28°to 32°C. The hottest periods were the intermonsoonal months. The depth varied from 1.7 m to 2.2 m. Various factors such as rainfall, windspeed, decomposition of debris, accumulation and movement of allocthonous material and seepage may be responsible for the change in depth of the lake. The transparency varied from 1.3 to 1.6 meters while the turbidity ranged from 0.9 to 9.6 NTU during the period of study. The turbidity was high during the monsoonal period, October to December.

5. Discussion

According to the trophic classification of lakes[16] the Bolgoda Lake II could be characterised as eutrophic. Unlike Parakrama Samudra[17] in the dry zone, the Bolgoda Lake lies in the wet zone and the water level varies only slightly per month even though the mean annual depth fluctuates during the year between 1.7 and 2.2 meters. The water level rises during the monsoonal periods to compensate for the loss during the prevailing dry season. Similarly there is not much disparity in the monthly water temperatures. It is difficult to draw any suitable conclusion regarding the relationship between water temperature and the zooplankton population[5] However it could be said that it is a combination of several external factors that govern the plankton fluctuations. The main external factors, wind effects, monsoonal rains, input from the Bolgoda Ganga, the movement of allocthonus material and bottom deposits probably play a role in the process of zooplankton production as evidenced by the largest concentration (Table 4) of zooplankton at the inlet (stations 5 & 6) and the outlet (station 1). These concentrations in population could be attributed directly or indirectly to the major external factors mentioned above. These factors in turn determine underwater light conditions and the nutrient necessary for phytoplankton production[12] on which the zooplankton feed. The interrelationship of the zooplankton and the phytoplankton at Bolgoda Lake will be discussed in a subsequent paper.

It was evident that in the zooplankton populations only the nauplii peaks coincided with the monsoonal periods. The nauplii population in the lake could only result from two sources (a) the population in the lake and (b) the contribution from the Bolgoda Ganga. These zooplankton included the larval stages of the copepodid and palaemonid prawn nauplii. Sampling was done at Bolgoda Lake in the mornings and in the afternoons at different depths and the analysis of densities (Table 4) of nauplii at different stations indicated a variation with depth, showing the possibility of migration or diurnal variation. Costa & De Silva[4] reported that the nauplii showed a tendency for migration to the surface only in the evening for Colombo Lake.

The noteworthy feature was that the rest of the zooplankton populations (Copepoda, Rotifera, Cladocera, Ostracoda) showed seasonal fluctuations with peaks during the intermonsoonal period. The copepodids showed peaks in January and August, rotifers with a major peak in March and minor peaks in June and September, the cladocera with peaks in the intermonsoonal months of January and July with the ostracoda in March. However the accumulation of zooplankton at the inlet and outlet of the lake were much greater and hence the fishermen had located their traps at these points for a better catch of fish.

The variation of nauplii densities with months confirmed the peaks obtained in October and May (Figure 2). The change in nauplii densities with depth may be connected with feeding or linked with other prevailing environmental factors. The copepodids being plankton feeders follow the movement pattern of the phytoplankton and zooplankton. The nauplii were the most abundant and hence the copepodids may have fed more on the nauplii rather than the rest of the zooplankton. Support for this phenomenon is seen in the alternation of the copepodid peaks with those of the nauplii. Furthermore a significant change in the copepodid densities with depth (Table 3) was observed which indicates the possibility of diurnal variation. The change in copepodid densities with months confirmed the peaks obtained in July and August. The variation of rotifer, cladoceran and ostracod densities with period confirmed the occurrence of peaks as observed in Figures 4,5 and 6, respectively. However as no variation occurred with depth it could be assumed that the rotifers, cladocerans and ostracods were uniformly distributed.

The zooplankton form the food of different species of fish and it is evident that a knowledge of their species composition and seasonal fluctuation patterns are of great value in the culturing of fish. Thus the data on zooplankton presented could be the basis for further research as it could be utilised in the development of inland fisheries.

6. Summary

(1) Population of zooplankton groups Nauplii, Copepoda, Rotifera, Cladocera and Ostracoda for Bolgoda Lake II was estimated during the period October 1980 to September 1981.

(2) Environmental factors such as rainfall, windspeed, air and water temperature, turbidity, transparency and depth were studied.

(3) Composition of species inhabiting the lake was determined according to the categories of zooplankton. The category rotifera was found to be rich in species even though less in abundance when compared with the copepoda.

(4) The nauplii and copepoda contributed about 70% of the zooplankton in the lake.

(5) The major factors effecting population abundance were wind and rainfall during monsoonal periods while other environmental factors mentioned were of minor importance.

(6) The nauplii and copepodid densities varied with depths while the other categories such as the rotifera, cladocera and ostracoda were uniformly distributed with depth.

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