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Zooplankton Diversity and Seasonal Variation in Population Density of Harsool Dam in India

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Abstract: Zooplankton occupies a central place between autotrophic and heterotrophic and constitutes an important link in the food chain of a freshwater ecosystem. The presence and frequency of zooplankton are always influenced by physical-chemical factors and nutrient content in the water. In the present study, diversity, seasonal fluctuations and correlation coefficients of zooplankton were determined from July 2008 to June 2009 at Harsool Dam in Aurangabad (M.S.), India. A total of 25 species of zooplankton were recorded belonging to order Cladoceran (8 species), Copepoda (5 species), Rotifera (10 species), and Ostracoda (2 species). In this study 10,860 zooplankton (organisms/liter) with a maximum percentage of 31.67% Cladocera, 33.88% Copepoda, 29.65% Rotifera and 4.78% Ostracoda were observed in the Harsool Dam during the study period. Summer showed a longer food chain than other seasons. According to the Shannon Index, the values showed that the waters of the Harsool Dam were contaminated. Homogeneity indices indicated that all species are equally common in a sample.

Keywords: Zooplankton, Biodiversity indices, Seasonal variation, Significance, Harsool dam

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Introduction

Zooplankton is a small animal found in all aquatic ecosystems, especially in the nautical and coastal areas of the ocean, ponds, lakes, and rivers. They are classified by size and stage of development. Size categories include picoplankton with dimensions less than 2 microns, nanoplankton with dimensions between 2 and 20 microns, microplankton with dimensions between 20 and 200 microns, macroplankton with dimensions between 20 and 200 mm and mega-plankton with a size of more than 200 mm (Lynn, 2007). The zooplankton community comprises primary consumers (who eat phytoplankton) and secondary consumers (who feed on another zooplankton). They create a direct link between primary producers and higher trophic concentrations, such as fish. Almost all fish depend on zooplankton during the larval stage, and some fish continue to eat zooplankton throughout their lives (Madin *et al*., 2001).

The concept of biodiversity seems to provide a scientific basis for the widespread wishes to conserve natural ecosystems in aquatic regimes. While adequate protection of biodiversity often requires a vast network of aquatic rules that exclude human intervention, preserving it elsewhere does not necessarily prohibit the use of resources. Limnologists and planners need to understand the basics of plankton diversity. The "zooplankton diversity" in the aquatic ecosystem refers to a variety of species. Zooplankton diversity can refer to alleles or genotypes within a population, species, or life forms within a community of zooplankton and species or life forms throughout water depending on context and scope. Furthermore, biodiversity (whether for agriculture, fishing, forestry, or evolutionary processes) is essential to stabilize ecosystems, protect overall environmental quality, and understand the intrinsic value of all species on earth (Honest and Wilson, 1991).

Earlier studies have found positive correlations between biomass production and biodiversity (Elton, 1927). The diversity of species and ecosystems is often related to the amount of living and non-living organic matter they contain. However, it appears that biodiversity depends less on the characteristics of a single ecosystem than on the interactions between ecosystems.

Biodiversity is a property at the population level. At the same time, the concept of functional diversity is more related to the stability and stress of the ecosystem and physical and chemical factors to determine the dynamics of the population in the lenticular ecosystem. Despite its enormous importance for determining productivity and calculating biodiversity, only a few studies on population dynamics, diversity, and conservation of zooplankton have been carried out in India as compared to other parts of the world (Jhingran and Tripathy, 1969).

In the present study, diversity, seasonal fluctuations and correlation coefficients of zooplankton were determined from July 2008 to June 2009 at Harsool Dam in Aurangabad (M.S.), India.

Materials and Methods

The plankton net (25 µm mesh size) was rinsed in the surface water (Secchi disk transparency zone) and the plankton collected from the net was quickly transferred to a separate plastic bottle/container. 100 liters of surface water were sieved through the plankton net to obtain plankton.They were stored in 4% formalin. The formalin-fixed plankton samples were spun at 1500-2000 rpm for 10-12 min. The zooplankton was settled at the bottom and diluted to the desired concentration so that they could be easily counted individually under the binocular compound microscope, and the zooplankton was measured and multiplied by the dilution factors using the Edgonson cell (Sedgwick Rafter, 1963; Battish, 1992; APHA, 2005).

Species diversity, species richness, and species evenness were calculated by Ludwick and Reynold (1988).

Shannon and Weaver (1949) diversity index values were obtained by using the following equation:

$$H' = -\sum n=1n(pi*\ln pi)$$

where H' is the diversity index, p_i is the proportion of each species in the sample, and ln p_i is the natural logarithm of this proportion.

Species equitability or evenness was determined by using the following expression:

Evenness index (E_1):

$$E_1 = \text{In}\ (N_1) / \text{In}\ (N_0)$$

Results and Discussion

Detailed microscopic examination of zooplankton revealed that 4 groups consisting of 25 genera of zooplankton belonging to orders Cladocera (8 genera), Copepoda (5 genera), Rotifera (10 genera) and Ostracoda (2 genera). The species observed were --*Ceriodaphni cornuta, Alona pulchella, Diaphanosoma excisum, Chydorus reticulates, Chydorus barroisi, Macrothrix goeldi, Biapertura karua,* and *Pleuroxus denticulatius,* among the group of Cladocera (8 species); *Paracyclops fimbriatus, Tropocyclops parasinus, Mesocyclops leuckarti, Mesocyclops hylinus* and *Copepod larvae* among the group Copepoda (5 species); *Brachionus caudatus, Brachinous falcatus, Brachionus forficula, Keratella tropica, Keratella cochlearis, Trichocera sylindrica, Brachionus calyciflorus, Filinia longiseta, Brachionus plicatilis,* and *Brachionus diversicomis* among the group Rotifera (10 species); and *Llyocypris gibba* and *Hemicypris fossulate* among the group Ostracoda (2 species).

The highest species diversity of Harsool dam was that of the Cladocera in December, Copepoda in October, Rotifera in January, and Ostracoda in January and August during the year 2008-09.

Order-wise average seasonal variation and seasonal total population density of zooplanktons recorded were-- maximum Cladocera 60.31±88.24 (organisms/liter) and 1930 (organisms/liter) in summer, minimum Cladocera recorded were 21.56±38.86 (organisms/liter) and 690 (organisms/liter) in monsoon and Grand Total 3440 (organisms/liter)(Table 1); maximum Copepoda recorded were 87.50±75.45 (organisms/liter) and 1750 (organisms/liter) in summer, minimum Copepoda recorded were 43.50±49.01 (organisms/liter), and 870 (organisms/liter) in winter and a Grand Total 3680 (organisms/liter); maximum Rotifera recorded were 42.25±57.88 (organisms/liter) and 1690 (organisms/liter) in summer, minimum Rotifera recorded were 16.55±33.41 (organisms/liter) and 730 (organisms/liter) in monsoon and Grand Total 3220 (organisms/liter); maximum Ostracoda recorded were 32.50±23.14 (organisms/liter) and 260 (organisms/liter) in winter, minimum Ostracoda recorded were 12.50±16.69 (organisms/liter) and 100 (organisms/liter) in monsoon and Grand Total 520 (organisms/liter) (Table 1). A total of 10,860 (organisms/liter) zooplankton was noticed in Harsool dam that constituted 31.67% of Cladocera, 33.88% of Copepoda, 29.65% of Rotifera and 4.78% Ostracoda (Table 1; Fig. 1).

In Harsool dam, during (2008-09) the Cladocera group was positively correlated with Rotifers ($r=0.878$, $P<0.01$) and Ostracoda ($r=0.794$, $P<0.01$) and no negative correlation was observed. Copepod population showed strong positive correlation with air temperature ($r=0.644$, $P<0.05$), water temperature ($r=0.854$,$P<0.01$), free carbon dioxide ($r=0.582$, $P<0.05$), total hardness ($r=0.855$, $P<0.01$), Ostracods ($r=0.746$, $P<0.01$), and negative correlation with magnesium ($r=0.799$, $P<0.01$), chloride ($r=0.685$, $P<0.05$) and sulphate ($r=0.785$, $P<0.01$). Rotifera population showed positive correlation with free carbon dioxide ($r=0.585$,$P<0.05$), total hardness ($r=0.594$, $P<0.05$), Cladocera ($r=0.861$, $P<0.01$), Ostracoda ($r=0.813$, $P<0.01$) and negatively correlated with chlorides ($r=0.585$, $P<0.05$). Ostracods population was positively correlated with water temperature ($r=0.594$, $P<0.05$), free carbon dioxide ($r=0.646$, $P<0.05$), total hardness ($r=0.701$, $P<0.05$) and Rotifera ($r=0.823$, $P<0.01$), and negatively correlated with sulphate ($r=0.715$, $P<0.05$) (Table 2).

During summer time, growing temperature enhanced the rate of composition because of which the water has become nutrient-rich. In addition due to evaporation in summer season the nutrient content increased and plentiful food was available in form of phytoplankton and micro-organism for zooplankton that is why excessive zooplankton populace density occurred at some point of the summer season which could be related to stable hydrological factors and low water stage, while low density during monsoon season can be attributed to heavy flood and

Table 1: Order-wise average and total seasonal variations of zooplanktons (organisms/liter) in Harsool dam during 2008-09

Order	**Average**			**Total**			**Grand total**	**Total percentage %**
	Summer	**Monsoon**	**Winter**	**Summer**	**Monsoon**	**Winter**		
Cladocera	60.31±88.24	21.56±38.86	25.62±32.62	1930	690	820	3440	31.67
Copepoda	87.50±75.45	53±54.58	43.50±49.01	1750	1060	870	3680	33.88
Rotifera	42.25±57.88	16.55±33.41	20±24.49	1690	730	800	3220	29.65
Ostracoda	32.50±23.14	12.50±16.69	20±19.27	260	100	160	520	4.78
Total				**5630**	**2580**	**2650**	**10860**	

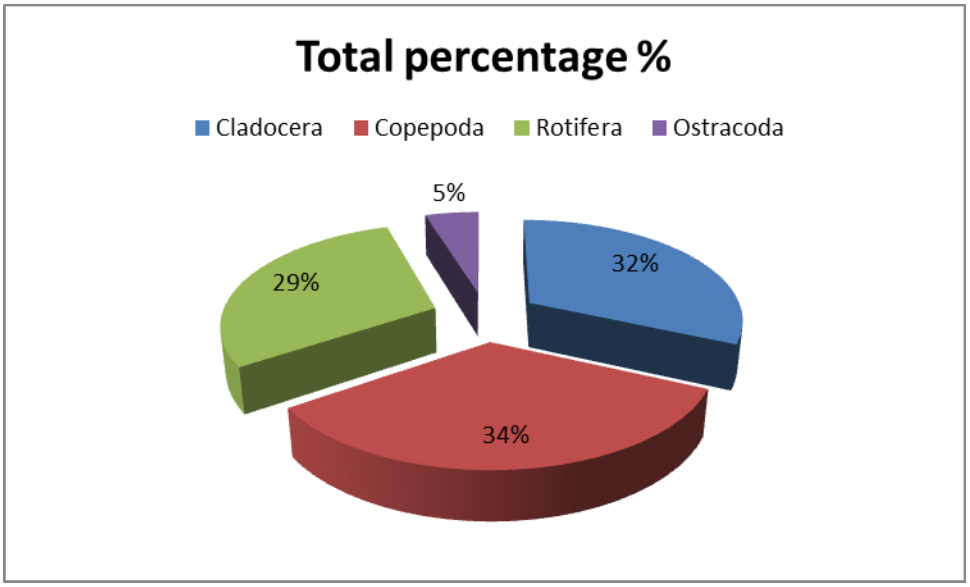

Fig. 1: Order-wise percentage of zooplanktons (organisms/liter) in Harsool dam during 2008-09.

freshwater inflow (Krishnamoorthy *et al*., 2007). They have resumed again in monsoon due to dilution and high water levels (Jayabhaye and Madlapure, 2006; Krishnamoorthy *et al*., 2007; Pejaver and Gurav, 2008; Mulani *et al*., 2009; Rajagopal *et al*., 2010).

The species richness was high in February and March and it was low in June and July. Hence the maximum zooplankton was recorded in the months of peak summer and the minimum recorded in pre-monsoon months (Table 3).

The zooplankton biodiversity index, the Shannon Index (H'), combines biodiversity and spice uniformity components as a general index of diversity. The ZSDI value of zooplankton was higher in summer. The highest value in the Shannon Index (H') indicated the highest biodiversity. More extraordinary biodiversity means a broader food chain and more cases of interspecific interactions and more significant opportunities to control negative feedback that reduces vibrations and increases community stability (Ludwick and Reynold, 1988).

These diversity indices showed that the ponds examined have a balanced zooplankton community that establishes a uniform representation of different species, which indicates the dynamic nature of this aquatic ecosystem. However, corrective action must be taken to minimize pollution, as shown by the ecological indicators. Uniformity was relatively high during the rainy season, indicating a decrease

Table 2: Correlation of zooplankton groups with physico-chemical variables and other zooplankton in Harsool dam during 2008-09

Parameters	**Air Temp**	**Water Temp**	**pH**	**TDS (mg/l)**	**DO (mg/l)**	**Free CO_2 (mg/l)**	**Ca+ (mg/l)**	**Mg+ (mg/l)**	**TH (mg/l)**	**Chloride (mg/l)**	**PO_4 (mg/l)**	**SO_4 (mg/l)**
Cladocera	0.349	0.344	-514	-162	-413	0.654	-169	-274	0.351	-326	-390	-458
Copepoda	**0.644***	**0.854****	-521	-039	-091	**0.582***	0.569	**-799****	**0.855****	**-685***	0.356	**-785****
Rotifera	0.651	715	-405	0.078	-206	**0.585***	0.244	0.564	**0.594***	**-585***	0.021	-540
Ostracoda	0.568	**0.594***	-581	0.041	-378	**0.646***	0.265	-511	**0.701***	-507	0.131	**-715***

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

Table 3: Species diversity (H) and uniformity (E) of Cladocera, Copepoda, Rotifera and Ostracoda in Harsool dam during 2008-09.

Groups/Months	JULY	AUG	SEPT	OCT	NOV	DECE	JAN	FEB	MAR	APR	MAY	JUNE
CLADOCERA												
Shannon-Weaver index (H)	1.48	1.434	2.101	1.610	2.283	1.500	1.655	1.789	2.00	2.00	1.900	1.504
Evenness (E)	0.752	0.821	0.974	0.722	0.99	0.840	0.800	0.700	0.887	0.810	0.778	0.946
Total No. of Species	2	4	4	5	3	6	5	6	3	5	6	3
COPEPODA												
Shannon- Weaver index (H)	1.449	1.01	1.442	1.303	1.110	0.725	1.450	1.558	0.70	0.900	0.910	0.910
Evenness (E)	0.780	0.770	0.872	0.667	0.779	0.650	0.800	0.830	0.840	0.912	0.900	0.884
Total No. of Species	3	4	4	5	3	2	4	4	4	5	4	3
ROTIFERA												
Shannon- Weaver index (H)	1.776	1.30	1.958	1.600	1.881	1.550	2.110	2.400	2.100	1.800	1.779	1.800
Evenness (E)	0.880	0.840	0.779	0.775	0.880	0.842	0.748	0.810	0.759	0.775	0.840	0.567
Total No. of Species	2	6	6	5	4	5	8	7	3	7	3	2
OSTRACODA												
Shannon- Weaver index (H)	0.120	0.432	0.883	0.878	1.000	0.448	0.550	0.049	1.010	1.200	0.821	_
Evenness (E)	0.770	0.842	0.710	0.862	0.884	0.749	0.772	0.882	0.775	0.772	0.796	_
Total No. of Species	1	2	1	2	1	1	1	2	2	1	2	_

in plankton diversity during this period (Adesalu and Nwankwo, 2008).

The homogeneity indices indicated whether all species are equally common in a sample. This means that the species uniformity has decreased with the increasing size of the zooplankton population (Shinde *et al*., 2012).

Conclusion

It can be concluded that Cladocera was the dominant group of zooplankton during the study period. The zooplankton population density of the Harsool dam was highest in summer and lowest in monsoons. The essential factors for zooplankton growth are temperature, free CO_2, total hardness, chloride, and sulfate. Uniformity indices indicated whether all species are equally common in a sample. This means that the uniformity of the species decreases as the zooplankton population increases. The existence of species depends on their environmental sustainability. When competition or predator decreases or food supply or good habitat increases, the species becomes more common. This study provided background information on the distribution and frequency of zooplankton which would be a valuable tool for further ecological assessment and monitoring of ecosystems at the Harsool Dam.

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