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Statistical approaches for computing diversity and density of zooplankton with water factors in Mula Dam, Rahuri, MS, India

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ABSTRACT

This paper tended the seasonal density and diversity of zooplankton in Mula dam a freshwater body during 2007-09. Zooplankton showed seasonal variations. Over all density was higher in rainy (35.3%) > summer (34.1%) > and lowest in winter (30.7%). The zooplankton distribution constitutes rotifer (48.9%), cladocera (18.9%), copepoda (13.1%), decapoda (10.9%) and protozoa (8.2%). The rotifer dominated among the zooplankton organisms. Also statistical parameters such as standard deviation, sum of error, covariance, etc documented. The density and diversity of zooplanktons was also discussed with physico-chemical parameters of water. The diversity and density of zooplankton depends upon the nutrient condition of water body, abiotic factors, food chain and web with life cycle.

Key words: Zooplankton, diversity, density, seasons, statistics, Rahuri dam,

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INTRODUCTION

Zooplankton is minute aquatic animals. They play an important role in food web by linking the primary producers and higher tropical level. The freshwater zooplankton comprises protozoa, rotifers, cladocera, copepods, microscopic crustaceans and microinvertibrates suspended in water. They have their own peak periods of density, also affected by local environmental conditions prevailing at the time. Their density and diversity depend upon biotic and abiotic factors of their habitat. Their heterotrophic activity plays a key role in the cycling of organic materials in aquatic ecosystems.

Water is essential natural source for sustaining life and environment (Pethe *et al.* 2011). Ground water is the chief source of water in India and only 0.61% of total available water on the earth

(Kamble *et al.* 2011). Only 4% of fresh water available in India inhibiting 14% of world population and also aquatic organisms (Pavendan *et al*. 2011). Pollution of ground water is major concern in now days due to prolonged discharged industrial effluents, domestic sewage and other waste it become polluted and creates health problems to human and aquatic organisms (Sayyed and Bhosale, 2011).

Although last decade data are available on zooplankton composition and seasonal dynamics from lake (Dhembare, 2005; Kamble and Meshram, 2005; Pawar and Pulle, 2005; Kiran, 2007; Tijare and Thosar, 2008; Rajashekar *et al*. 2009; Rajagopal *et al*, 2010) and rivers (Mulani *et al*, 2009) from India and (Nevels *et al*. 2003, Ozbay and Altindag, 2009, Leunda *et al*. 2009) from overseas. The data received showed little attention on dam zooplankton. Indian data on zooplankton work also concentrate more on lake than rivers and dam. This study therefore describes the seasonal density and diversity of zooplankton in the Mula dam. The effects of physico-chemical parameters on the zooplankton community were also monitored.

MATERIALS AND METHODS

Study area: The present study was conducted in rural habitat. The study was conducted in three seasons (rainy, winter and summer) during 2007-09. Mula dam was the study area situated between $19^0$20' to $19^0$35' N latitude and $74^0$25' to $74^0$36' E longitude. The dam is constructed (1971) on river Mula a tributary of river Godavari at Rahuri, district Ahmednagar. Catchments area is about 2275 sq km and experiences 58 mm annual rainfalls and capacity of dam is 26,000 TMC. The basin is semi-agriculture and semi-arid with cultivated topsoil bank.

Collection of samples: The dam survey was carried out from January 2007 to December 2009. Water and plankton samples were collected from ten sites bimonthly from the reservoir (<1m depth) during the early hours between 7 to 9 am. The plankton samples were collected by filtering 50 liters of water through standard planktonic net (75µm mesh) and the concentration samples were fixed in 5% formalin.

Biological identification: The zooplanktons were identified with standard taxonomic books up to generic level with the help of standard literature of rerspective groups. For identification of rotifer was done with Dhanapathi (2000). Copepod was done with key provided by Battish (1992) and Dussart and Defaye (1995). Cladocera was identified following the taxoniomic key provided by Sharma and Micheal (1987) and Muragan *et al.* (1998). The quantative analysis of organisms was carried out using Sedwick-Rafter counter and pesented in Table1 and statistical variables computed and presented in Table 2. The density of zooplankton was expressed as number of organisms/L using formula by APHA (1998).

Physico-chemical analysis: The pH of water samples was noted on the spot with the help of gun (pen) pH meter. The analysis of filtered water samples was carried out for the parameters, as Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Hardness (TH), Major Constituents [Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K)–Cationic and Chloride (Cl), Total Alkalinity (TA), Sulphates (SO_4)–Anionic], Minor Constituents [Phosphate (PO_4) and Nitrate (NO_3)], indicator parameter [Dissolved Oxygen (DO), Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD)] of the samples were done according to

standard methods APHA, (1998). The results of analyses were averaged out seasonally and statistical variables computed using Window™/Excel/2007and presented in Table 3.

RESULTS AND DISCUSSION

Data obtained from the study indicates that a total of 26 zooplankton species were recorded in Mula dam water, comprising 9 species of rotifers, 6 species of protozoa, 5 species of cladocera and 3 each species of copepoda and decapoda. High number of zooplankton species were recorded during rainy (35.3%) followed by summer (34.1 %) and lowest in winter (30.7%).

It is apparent from the study that, five species of cladocera such as *Alona* sp., *Chydorus* sp., *Dapnia* sp. a *Monia* sp and *Monocylopnia* sp. were observed in varied level. The monthly average of cladocera varied from 0.98 ind/l in rainy to 2.43ind/l in summer. The seasonal density was higher in summer (7.06 %) followed by winter (6.41 %) and lower in rainy (5.42 %). It is second largest group having density 18.89 % in zooplankton.

In the study three species of copepoda was noticed such as *Eucyclope* sp., *Mesocyclopes* sp. and *Nauplius* sp. in varied frequencies. The seasonal density was in order as 4.8 %, 4.34 % and 3.9 % in winter, summer and rainy respectively. It is third largest group having density 13.04 % in zooplankton.

According to Micheal and Sharma (1987) 90 species and Sharma (1991) 109 species were known to India. Density and diversity of cladocera depend on water temperature, DO, turbidity and transparency (Pawar and Pulle, 2005). During the winter period cladocera species were maximum can be attributed to the favorable water temperature and food (Edmondson, 1965; Baker, 1979) and organic matter. It indicates that minimum temperature was favor for cladocera. This is confirmed in the present study.

Perusal of data revealed that monthly average and density of decapoda varied from 0.73 to 2.98 ind/L. In the study three species of decapoda was reported such as *Zoaea* larva, *Cardona* sp. and *Cyclocypria* sp. in varied frequencies. Thus the seasonal density of decapoda was in order such as winter (2.7 %) < rainy (3.6 %) < summer (4.6 %) respectively.

Rotifer is richest group with 9 species which accounts 48.9% of total zooplankton population. The seasonal density of rotifers was in following order: rainy (19.32 %), winter (14.30 %) and summer (15.31 %). Over all 2500 species of rotifers belonging 200 genera are known form all over the world. However, 300 and more species are being noticed in India (Dhanapathi, 2000).

Rajagopal *et al.* (2010) reported 51% population of rotifer to total population. Singh *et al.* (2002) reported that higher rotifer population occur during summer and winter might be dominant due to hypertropical condition of the pond at high temperature and low level of water. The dominance of rotifers was reported in winter (Kulshreshtra and Joshi, 1999). Chandraseker (1996) showed that the water temperature, turbidity and transparency and dissolved oxygen were favor for rotifer population. In rainy rotifers were lower might be due to neutral pH. At the alkalinity, pH and temperature above 29^0C the rotifers disappears (Dhanapathi, 1995). The differences in seasonal density might be the nutrition and biotic interactions (Power and Pulle, 2005).

Table 1. Showing population density of zooplankton from Mula dam reservoir during 2007-09.

Zooplankton species		Seasons (Month)											
		Rainy				Winter				Summer			
		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Cladocera	1. *Eucylope* sp.	+			+	+		+	+	+	+		+
	2. *Chydorus* sp.		+	+		+		+	+	+		+	+
	3. *Daphnia* sp.	+		+	+	+	+		+		+	+	
	4. *Monia* sp.			+	+	+	+	+		+	+	+	+
	5 *Monoclaphnia* sp.	+	+		+	+	+		+	+		+	+
Decapoda	1. *Eucyclope* sp.		+	+	+	+	+	+	+		+		+
	2. *Mesocylopes* sp.	+	+	+			+	+	+	+	+	+	
	3. *Naupilus* sp.	+	+	+	+	+	+		+	+	+	+	+
Copepod	1. *Zoaea* Larva	+	+	+			+	+	+		+	+	
	2. *Cardona* sp	+	+		+	+	+	+	+	+	+		+
	3. *Cyclocypria* sp.	+	+		+	+	+	+	+	+		+	+
Rotifer	1. *Brancionous* sp.	+	+	+	+	+	+			+	+	+	+
	2. *Cristaluta* sp.	+			+		+	+	+		+	+	
	3. *Cupelopagis* sp.	+	+	+		+			+	+	+	+	+
	4. *Rotaria* sp.	+	+		+	+	+	+	+	+	+		+
	5. *Keratella* sp.	+	+	+		+	+	+			+	+	
	6. *Asplanchuna* sp.		+	+	+	+		+	+	+	+	+	+
	7. *Tophrocauna* sp.	+	+	+	+	+	+		+	+	+	+	
	8. *Trichoreca* sp.	+		+	+		+	+	+	+		+	+
	9. *Lecane* sp.	+	+	+	+	+	+		+	+	+	+	+
Protozoa	1. *Arcella* sp	+	+	+		+	+	+		+	+	+	+
	2. *Balantidium* sp.		+	+	+	+	+		+	+	+	+	+
	3. *Ceratium* sp.	+	+	+	+	+		+	+		+	+	+
	4. *Rugipe* sp.	+	+	+	+		+	+	+	+		+	
	5. *Stentor* sp.	+		+	+	+	+	+		+	+		+
	6. *Euglina* sp.	+	+		+	+	+		+	+	+	+	+

Number of organisms / liter of water.

Table 2. Showing seasonal mean and statistical characteristics of zooplankton in Mula dam during 2007-09.

	Zooplankton species	Seasons			Statistical parameters					
		R	W	S	Mean	Mn	Mx	SE	SD	CV%
Cladocera	1. *Eucylope* sp.	1.85	2.25	2.43	2.18	1.30	2.9	0.14	0.52	23.85
	2. *Chydorus* sp.	0.98	1.63	1.70	1.43	0.0	2.3	0.14	0.54	37.76
	3. *Daphnia* sp.	1.30	1.48	1.78	1.52	1.2	2.2	0.09	0.33	21.71
	4. *Monia* sp.	1.38	1.48	1.73	1.58	0.0	2.7	0. 17	0.66	41.77
	5 *Monoclaphnia* sp.	1.80	1.80	1.88	1.83	1.2	2.7	0.14	0.55	30.05
Copepoda	1. *Eucyclope* sp.	1.85	2.25	2.20	2.18	1.3	2.9	0.14	0.52	23.85
	2. *Mesocylopes* sp.	1.58	2.15	1.90	1.88	1.1	2.5	0.12	0.42	22.34
	3. *Naupilus* sp.	1.83	2.08	1.75	1.88	1.3	2.8	0.14	0.53	28.19
Decapoda	1. *Zoaea* Larva	1.60	1.28	1.90	1.59	0.0	2.2	0.17	0.62	38.99
	2. *Cardona* sp	1.85	1.68	2.25	1.93	1.2	2.9	0.12	0.46	23.83
	3. *Cyclocypria* sp.	1.50	0.73	0.98	1.07	0.0	1.9	0.17	0.62	57.94
Rotifer	1. *Brancionous* sp.	3.45	1.95	1.93	2.42	1.3	3.9	0.23	0.86	35.54
	2. *Cristaluta* sp.	3.43	2.78	2.53	2.91	2.1	3.9	0.14	0.52	17.86
	3. *Cupelopagis* sp.	3.08	2.55	2.47	2.81	2.1	3.1	0.14	0.51	18.15
	4. *Rotaria* sp.	2.75	2.35	2.40	2.50	1.5	3.5	0.14	0.57	202.80
	5. *Keratella* sp.	2.60	2.70	2.68	2.66	1.6	3.4	0.12	0.49	18.42
	6. *Asplanchuna* sp.	2.98	2.58	2.23	2.59	1.5	3.4	0.17	0.61	23.55
	7. *Tophrocauna* sp.	2.68	1.73	2.45	2.28	1.3	3.2	0.17	0.63	32.30
	8. *Trichoreca* sp.	2.53	1.15	2.18	1.95	0.0	3.1	0.26	0.91	46.67
	9. *Lecane* sp.	2.55	1.45	1.78	1.93	0.0	3.4	0.26	0.94	48.70
Protozoa	1. *Arcella* sp	0.6	0.25	0.50	0.45	0.0	0.9	0.0.9	0.33	73.33
	2. *Balantidium* sp.	0.40	0.38	0.48	0.42	0.0	0.8	0.09	0.30	71.43
	3. *Ceratium* sp.	0.60	0.25	0.40	0.42	0.0	0.9	0.08	0.27	64.29
	4. *Rugipe* sp.	0.45	0.40	0.42	0.43	0.0	0.7	0.07	0.24	55.81
	5. *Stentor* sp.	0.90	0.15	1.13	0.73	0.0	3.2	0.26	0.90	12.33
	6. *Euglina* sp.	1.08	1.18	0.85	1.03	0.0	2.6	0.23	0.81	78.64

Number of organisms / L of water.
R = Rainy, S = Summer, W = Winter, Mn = Minimum, Mx = Maximum, SD = Standard deviation, SE = Sum of Error and CV = Covariance.

Table 3. Showing seasonal mean and statistical characteristics of water from Mula dam during 2007-09..

Water Parameters			Seasonal Mean			Statistical Parameters					
			R	S	W	Mean	Mn	Mx	SE	SD	CV%
Physical Properties	PH		7.4	7.1	6.3	6.9	6.8	7.5	0.05	0.17	2.39
	EC		632	710.3	686.3	673.2	550.0	810.0	20.61	35.5	13.77
	TDS		412.3	508.0	565.8	498.0	338.0	664.0	43.03	14.89	28.75
	TH		420.0	310.8	370	366.3	180.0	532.0	32.25	11.6	28.89
Major Constituents	Cationic	Ca	37.0	111.0	80.8	75.9	30.0	208.0	15.86	54.9	63.39
		Mg	60.3	45.5	87.3	64.7	23.0	97.5	8.70	30.1	47.25
		Na	52.0	69.3	30.5	50.6	27.0	86.0	0.17	0.60	1.28
		K	2.15	2.30	3.15	1.87	0.7	4.5	14.02	48.5	31.76
	Anionic	Cl	33.8	45.0	68.8	49.2	27.0	98.0	12.86	44.5	30.50
		TA	180.8	167.5	210.2	186.2	110.0	165.0	2.66	9.21	5.05
		SO_4	40.3	47.8	30.5	39.5	30.0	58.0	0.1	0.33	8.06
Minor constituent		PO_4	0.48	0.88	0.70	0.68	0.3	1.2	0.44	1.50	19.48
		NO_3	1.58	0.90	1.25	1.24	0.3	3.8	0.26	0.89	60.14
Indicator parameters		DO	3.31	3.23	3.98	3.51	2.0	4.9	0.26	0.89	27.34
		BOD	3.4	2.10	1.85	2.45	1.7	4.4	4.51	15.6	75.80
		COD	20.3	29.8	22.0	24.0	11.1	31.1	5.90	20.4	46.68

R = Rainy, S = Summer, W = Winter, Mn = Minimum, Mx = Maximum, SD = Standard deviation, SE = Sum of Error and CV = Covariance.

Rotifer species showed marked difference in their tolerance and adaptability to change in physicochemical and biological events. They play important roles as grazers, suspension feeders and predators in the zooplankton community. Higher rotifer population indicates pollution from organic matter.

The present study enclave six species of protozoan, as *Arcella* sp., *Balanidium* sp., C*eratium* sp., *Rugipe* sp., *Stentor* sp. and *Euglina* sp. The density of protozoa was varied from 0.25 to 1.18 no. ind/L of water. The seasonal density of protozoa was recorded as rainy (2.99 %), winter (2.4 %) and summer (2.8 %). The occurrence of these organisms depends upon organic matter and water chemistry. About 39,000 species of protozoan have already been known and probably thousand more are yet to be known to science.

The physico-chemical parameters of water at Mula dam have been given in Table 3. The pH value was ranged 6.9 to 7.4. It indicates alkalinity nature. High pH was recorded during rainy. Tenner *et al*. (2005) noticed that the range of pH from 6 to 8.5 indicates medium production of reservoir. Present study indicates that water is medium production of zooplankton population because pH in the range of 6.9 to 7.4.

In the present work Electrical Conductivity (EC) value was ranges from 632 to 710.3 µmho cm^{-1}. The higher EC was recorded during summer and lower during rainy. EC value showed good indicators of the water quality (Abbassi *et al.* 1999, Gaikwad *et al.* 2008). According to Gaikwad *et al,* (2008) the dilution of solid substances reduces the EC value, alkalinity and zooplankton for production.

Total alkalinity (TA) ranged from 167.5 to 210.2 ppm. Maximum value was recorded in winter (210.2 ppm) followed by rainy (180.8 ppm). The high value of TA would be due to reduction of alkalinity. Alkalinity is favor for zooplankton population (Singh *et al*. 2002, Kiran *et al*. 2007). The value of Total Hardness (TH) fluctuation ranged from 310.8 to 420 ppm. The high value of TH was recorded during rainy (420 ppm) whereas low during summer (310.8 ppm). High range of hardness might be due to high loading organic substances, detergents, chlorides and other pollutants. The hardness is favors to zooplankton production, alkalinity and phosphate. Meshram (2005) has noticed that calcium hardness is essential for normal growth of aquatic ecosystem.

Dissolved oxygen (DO) is an important aquatic parameter whose presence is vital to aquatic fauna. It plays crucial role in life processes of animals. It is ranged from 3.23 to 3.98 ppm. High concentration of DO was recorded during winter. This may be due to low solubility at low temperature and high degradation of organic substances. Singh and Singh (1993) drew a conclusion that DO value may be favor or not to the zooplankton.

Estimation of biological oxygen demand (BOD) is an important factor to the oxygen required for the degradation of organic matter. The BOD value ranged from 1.85 to 3.4 ppm. High BOD value is unflavored with zooplankton. Rajagopal *et al,* (2010) noticed BOD was favorable to zooplankton.
To monitor the aquatic ecosystems and integrity of water the zooplankton has been used recently as bioindicators. This study showed that community size of zooplankton was the highest in rainy while the lowest density in winter. Among the zooplankton rotifer (48.9 %) forming dominant group followed by cladocera (18.9 %) and copepoda (13.1 %). Sukumaran and Das (2002) studied plankton abundance in relation to physico-chemical features of Manchribele reservoir in Bangalore, India and reported high chloride content and optimal temperature were favor for zooplankton in different seasons. In the studied groups of zooplankton rotifer was largest group and cladocera was second larger group followed by copepoda. Similar ranking was noticed in the present study.

Sarkar and Chaudhuri, (1999) noticed that the fluctuation of abiotic factors as dissolved oxygen, temperature, total alkalinity, phosphate, nitrogen, and pH can influence the growth of zooplankton. Das *et al,* (1996) showed relationship between zooplankton and physico-chemical parameters such as densities, pH, alkalinity, nitrate and phosphate. Nutrient availabilities influences the abundance of rotifer and copepoda (Kumar *et al.* 2004).

Many scientists worked with dominant and densities of zooplankton to show differences. The water quality of Fort lake Belgaum, Karnataka was evaluated for density of zooplankton by Sunkad and Patil (2004). Four groups of zooplankton were recorded as rotifer, cladocera, copepoda, and ostracods. In his study rotifers were 52.38 %, copepoda 26.5 %, cladocera 16.45 % and Ostracoda 4.67 %. Higher level of phosphate (7.2-13.6 mg L^{-1}) leaded to eutrophication in the lake and growth of rotifer.

Overall it is concluded that, the diversity and density of zooplankton depends upon the nutrient condition of water body, abiotic factors, DO, food chain, soil-water chemistry and web with life cycle. Hence theirs is needed to conserve biotic and abiotic of water body.

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