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Zooplankton Diversity in Madduvalasa Reservoir, India

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ABSTRACT- The zooplankton diversity was studied in four stations at the Madduvalasa reservoir from June 2014 to May '15 and forty five species were identified. Among eight groups, the diversity of Rotifera comprises of 17 species (21.37%), Cladocera 8 (16.44%), Copepoda 5 (17.28%), Ostracoda 2 (15.21 %), Protozoa 3 (12.24%), Crustacea 9 (11.26%), Mollusca 1 species (01.60%) respectively along with fish larvae and eggs (04.61%). The monthly and group wise zooplankton density analyzed and found that the number was higher during summer, followed by monsoon and lowest during winter.

Key-words: Copepoda, Madduvalasa reservoir, Monthly variation, Rotifera, Zooplankton

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INTRODUCTION

Plankton is one of the most favourable food items for many aquatic organisms; almost all the fishes at their larval stages depend on it and some of them exclusively feed on zooplankton. They invariably form an integral component for fresh water communities and contribute to biological productivity [1]. In the last two decades, much attention has been paid in tropical countries towards the study of biology, ecology and toxicology of zooplankton due to their important role in rapidly emerging concepts in environmental management like Environmental Impact Assessment (EIA). Zooplankton is good indicator of the changes in water quality because they are strongly affected by environmental conditions and respond quickly. The study of zooplankton is necessary to evaluate the fresh water reservoir in respect to their ecological and fishery status [2]. The Zooplankton community fluctuates according to physicochemical parameters of the environment, especially Rotifer species change with biotic factors [3]. Zooplankton is the link between phytoplankton and fish; hence, their qualitative and quantitative studies are of great importance.

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MATERIALS AND METHODS

Study Area: Sri Gorle Sriramulu Naidu Madduvalasa reservoir is present in the Madduvalasa village of Srikakulam district, Andhra Pradesh, India (Fig. 1). Samples were collected from four stations of the above reservoir i.e., S1: Narendra puram, S2: Vangara, S3: Kottisa and S4: Gudivada agraharam.

Fig. 1: Madduvalasa reservoir (18° 35' 30"N Latitude and 83° 37' 20" E longitude)

Collection of sample, preservation and identification- Zooplankton samples were collected randomly with plankton net (bolting silk mesh size 25µ) on monthly basis from June 2014 to May 15, between 9.00 to 10.00 am. 100 lit of surface water was sieved through the plankton net and transferred to plastic containers and 4%

formalin was added for preservation; density [4] and the diversity of zooplankton was studied by Lackey's drop count method under light microscope. The total number of zooplankton present in a litre of water sample calculated by using the following formula:

$$N = n \times v / V$$

Whereas,
N = Total no. of organisms/ lit of water filtered,
n = Number of organisms counted in 1 ml of sample,
v = Volume of concentrate plankton sample (ml),
V= Volume of total water filtered through (L)

The systematic identification of plankton was made by using standard keys of various authors [5-10].

Biodiversity: The statistical calculation on biodiversity of zooplankton was studied using the formula of Shannon- Wiener diversity index and Menhinick's index [11-12] which was calculated as follows:

1: Shannon - Wiener diversity index
Shannon-Wiener index denoted by
$$H = SUM [(p_i) \times ln(p_i)]$$

Whereas, SUM = summation
p_i = proportion of total sample represented by species *i*
Divide no. of individuals of species *i* by total number of samples
S = number of species = species richness
H_{max} = ln(S) Maximum diversity possible
E = Evenness = H/H_{max}

2: Menhinick's index

$$\text{Menhinick's index (d1)} = S / /\sqrt{N}$$

Where,
d1 = Menhinick's index
S = total number of species.
√N = total number of organism (density)

RESULTS

In the present study, diversity and monthly availability of zooplankton in Madduvalasa reservoir were analyzed and given in Table 1. Forty five species were identified in four stations, which consist of rotifera, cladocera, copepoda, ostracoda, protozoa, crustacea, mollusca along with fish larvae and fish eggs.

Table 1: Check list of Zooplankton species at Madduvalasa reservoir, Srikakulam dt.

Group	Family	Species
Rotifera	Brachionidae	*Brachionus angularis* (Gosse,1851)
		Brachionus calyciflorus (Pallas, 1766)
		Brachionus caudatus (Haner, 1937)
		Brachionus diersicornis (Daday, 1883)
		Brachionus plicatelis
		Brachionus quadridentata (Hermann, 1783)
		Keratella cochlearis (Gosse,1851)
		Keratella tropica (Apstein, 1907)
	Lecanidae	*Lecane lunaris* (Ehrenberg,1982)
		Lacane monostyla (Daday, 1897)
	Gastropodidae	*Gastropus minor* (Rousselet 1892)
	Asplanchnidae	*Ascomorpha ovalis* (Begendal, 1892)
		Asplanchna sp
	Synchaetidae	*Synchaeta* sp
		Polyarthra vulgaris (Carlin, 1943)
	Philodinidae	*Philodina citrine* (Ehrenberg)
	Testudinellidae	*Filinia longiseta* (Ehrenberg)
Cladocera	Daphnidae	*Daphania pulex*
		Daphania carinata
		Monia micrua (Kurz)
		Monia brachiata
	Bosminidae	*Bosmina longirostris*
	Chydoridae	*Alona pulchella* (King)
		Alona intermedia (Sars)
		Alonella. Sp
Copepoda	Diaptomidae	*Cyclopoid copepodite*
		Diaptomus pallidus
	Cyclopidae	*Cyclops* sp
		Mesocyclops sp
		Nauplius larva
Ostracoda	Cyprididae	*Cypris* sp
		Stenocypris sp
Protozoa	Parameciidae	*Paramecium caudatum*
	Vorticellidae	*Vorticella campanula*
		Epistylis sp
Crustacea		*Prawn nauplius larva*
		Zoea larva
		Chironimid larva
		Dragonfly nymph
		Mayfly nymph
		Damselfly nymph
		Stonefly nymph
		Waterbeetle nymph
		Mosquito larva
Mollusca		*Velligar larva*
Fish larvae		Fish larva
Fish eggs		Fish eggs

The monthly variation of zooplankton density (nos/lit) at four stations found that the maximum number of rotifera (262 nos/lit) recorded at station 1 during May 2015 and minimum (142 nos/lit) at station 3 in November 2014. Followed by the maximum number of cladocera (186 nos /lit) recorded at station 1 occurred during May 2015 and the minimum (112 nos /lit) at station 2 in January 2015. The maximum number of copepoda (224 nos /lit) recorded at station 1 during May 2015 and minimum (120 nos/lit) at station 2 in December 2014. The maximum number of ostracoda (162 nos /lit) recorded at station 1 during May 2015 and minimum (104 nos/lit) at station 4 in January 2015. The maximum number of protozoa (142 nos/lit) recorded at station 1 during May 2015 and minimum (75 nos /lit) at station 2 in January 2015. The maximum number of crustacea (132 nos /lit) recorded at station 2 during August 2014 and minimum (54 nos /lit) at station 4 in January 2015. The maximum number of mollusca (36 nos/lit) recorded at station 3 during August 2014 and the nil at summer season and the maximum number of fish larvae (66 nos /lit) recorded at station 2 during August 2014 and the number was minimum (18 nos/lit) at station 3 in May 2015 (Table 2).

Table 2: Monthly variation of zooplankton density (no./lit) during June 2014–May 2015

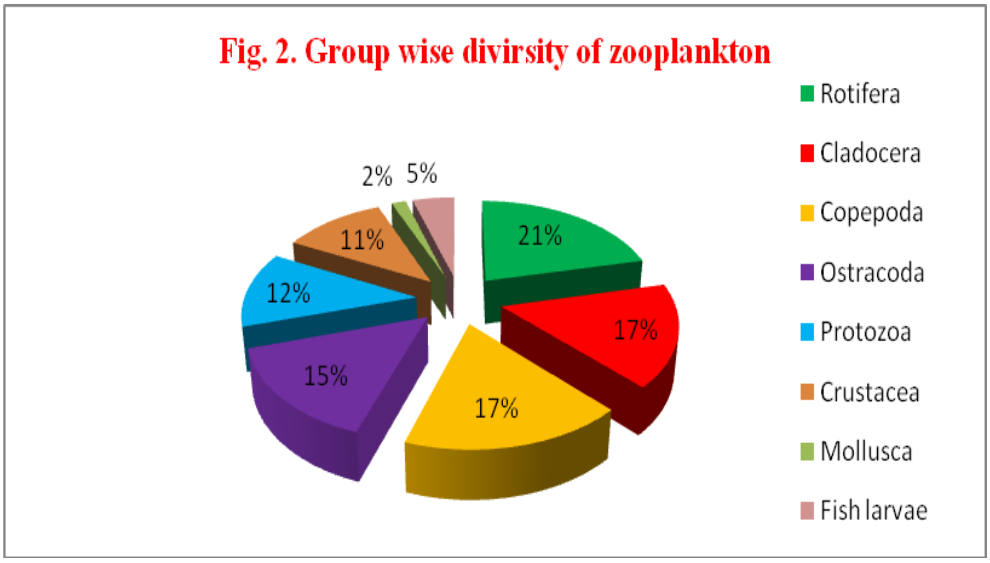
Stations/	Rotifera				Cladocera				Copepoda				Ostracoda			
Months	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
JUN-14	236	204	222	216	162	152	158	148	158	145	152	155	158	142	148	142
JUL	215	195	201	198	145	142	136	146	158	133	128	142	148	138	144	143
AUG	195	181	187	196	136	128	138	122	146	138	135	138	136	132	138	136
SEP	172	169	159	178	125	118	127	116	143	142	138	142	132	128	132	138
OCT	163	172	168	158	122	115	120	122	128	126	132	124	128	125	126	128
NOV	150	146	142	148	132	130	125	134	138	134	128	134	122	112	126	125
DEC	178	153	163	169	144	125	132	138	124	120	134	128	112	108	115	118
JAN-15	186	168	176	174	138	112	124	128	142	135	132	141	118	121	108	104
FEB	180	175	177	168	152	145	149	149	167	152	145	158	125	135	118	115
MAR	197	177	181	178	164	158	168	156	184	164	155	174	142	142	130	125
APR	205	196	188	204	178	166	172	175	202	187	164	192	158	158	142	136
MAY	262	244	254	237	186	175	178	184	224	198	188	198	162	156	155	146
TOTAL	2339	2180	2218	2224	1784	1666	1727	1718	1914	1774	1731	1826	1641	1597	1582	1556
MEAN	2240.25				1723.75				1811.25				1594.00			
	S1	**S2**	**S3**	**S4**	**S1**	**S2**	**S3**	**S4**	**S1**	**S2**	**S3**	**S4**	**S1**	**S2**	**S3**	**S4**
JUN-14	126	115	122	118	077	122	092	078	022	032	026	028	058	062	048	055
JUL	131	112	125	124	122	126	115	098	032	025	032	028	042	057	045	064
AUG	118	106	105	108	124	132	124	112	025	033	036	024	064	066	038	068
SEP	102	108	100	115	122	128	118	121	028	034	025	022	052	060	046	052
OCT	090	092	085	102	105	122	122	104	025	022	024	022	048	056	033	047
NOV	082	085	092	096	102	113	108	096	012	016	021	019	042	056	032	042
DEC	095	098	086	091	102	108	110	086	0	009	014	017	038	053	025	035
JAN-15	096	075	084	085	096	106	094	054	0	0	009	010	033	042	028	038
FEB	106	082	102	102	085	112	094	076	0	0	0	0	028	035	026	027
MAR	112	096	113	122	075	095	085	078	0	0	0	0	025	038	022	025
APR	135	102	126	131	062	077	082	065	0	0	0	0	022	032	021	019
MAY	142	118	135	138	065	082	077	072	0	0	0	0	022	027	018	022
TOTAL	1335	1189	1275	1332	1137	1323	1221	1040	144	171	187	170	474	584	382	494
MEAN	1282.75				1180.25				168.00				483.50			

S1: Narendra puram, S2: Vangara, S3: Kottisa, S4: Gudivada Agraharam

The monthly group wise zooplankton diversity observed from June 2014 to May 15 at four stations (Table 3 & Fig. 2). Rotifera group in the present study observed to show a numeric superiority over other groups of zooplankton and occupied with 21.37%. Followed by copepod groups with 17.28%, cladocera with 16.44%, ostracoda with 15.21%, protozoa with 12.24%, crustacea with 11.26%, fish larvae and eggs with 4.61%, and mollusca with 1.60%.

Table 3: Group wise zooplankton diversity during June 2014 – May 2015

S. No	Groups	Number of organisms	Percentage (%)
1	Rotifera	2240.25	21.37
2	Cladocera	1723.75	16.44
3	Copepoda	1811.25	17.28
4	Ostracoda	1594.00	15.21
5	Protozoa	1282.75	12.24
6	Crustacea	1180.25	11.26
7	Mollusca	168.00	01.60
8	Fish larvae	483.50	04.61

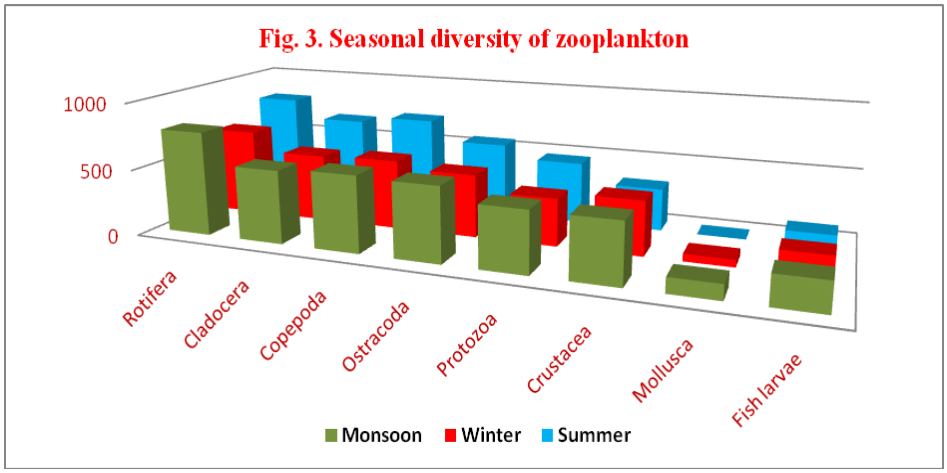


The group wise diversity in the distribution of macro and micro zooplankton are represented in Table 4 and Fig. 3. Rotifera, cladocera and copepoda were found in maximum number during summer, followed by monsoon and minimum during winter. In case of crustacea, mollusca, fish larvae and fish eggs maximum number was recorded during monsoon, followed by winter and minimum in summer. In the total population, maximum number of rotifera was 805.75 and comprised 35.97%, followed by the second largest number of copepoda was 713.00 and comprises 39.37%, cladocera was 663.75 and comprises 38.51%, ostracoda was 561.25 and comprises 35.21%, protozoa was 465.5 and comprises 36.29% during summer season. The maximum number of crustacea was 452.75 and comprises 38.36%, followed by the secon largest number of mollusca is 113.00 and comprises 67.26% and fish larvae and fish eggs the number was recorded i.e. 215.25 and comprised 45.35% during monsoon period.

Table 4: Monthly diversity of zooplankton during June 2014 to May 2015

Group	Seasons					
	Monsoon	Percentage (%)	Winter	Percentage (%)	Summer	Percentage (%)
Rotifera	781.00	34.86	653.50	29.17	805.75	35.97
Cladocera	549.75	31.89	510.25	29.60	663.75	38.51
Copepoda	573.25	31.65	525.00	28.99	713.00	39.37
Ostracoda	558.75	35.05	474.00	29.74	561.25	35.21
Protozoa	458.75	35.76	358.50	27.95	465.50	36.29
Crustacea	452.75	38.36	407.00	34.48	320.50	27.16
Mollusca	113.00	67.26	055.00	32.74	0	0
Fish larvae	219.25	45.35	162.00	33.51	102.25	21.15

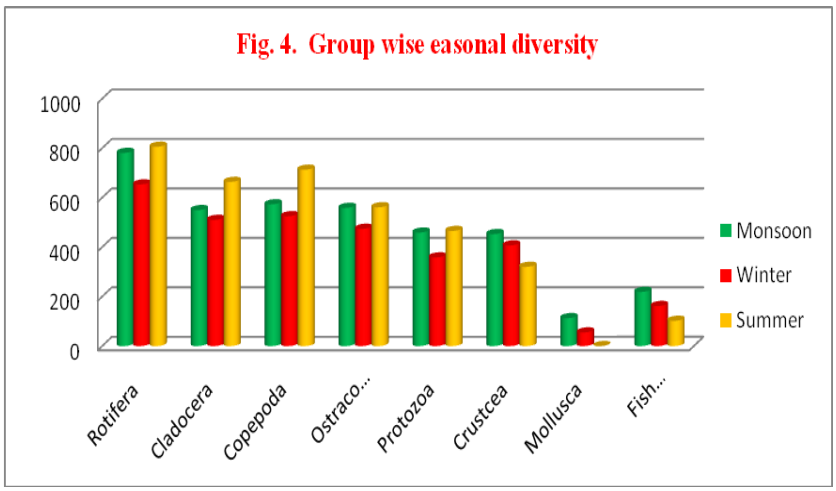
Monsoon: Rotifera > Copepoda > Ostracoda > Cladocera > Protozoa > Crustacea > Fish larvae > Mollusca
Winter: Rotifera > Copepoda > Cladocera > Ostracoda > Crustacea > Protozoa > Fish larvae > Mollusca
Summer: Rotifera > Copepoda > Cladocera > Ostracoda > Protozoa > Crustacea > Fish larvae> Mollusca



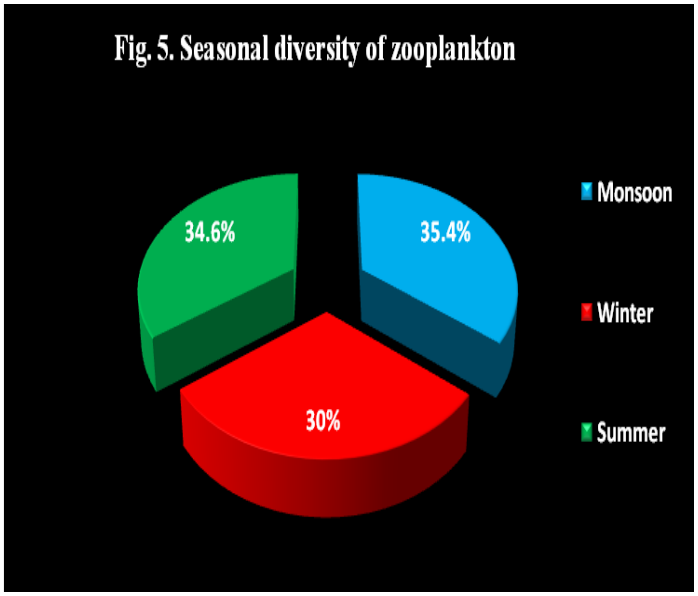
In the present investigation, the group-wise seasonal diversity of zooplankton is represented as the maximum rotifera were recorded in summer season was 22.19% followed by monsoon 21.07% and winter 20.78%. The maximum copepoda were recorded in summer season was 19.63%, followed by winter 16.69% and monsoon 15.47%. The maximum cladocera were recorded in summer season is 18.28%, followed by winter 16.22% and monsoon 14.83%. The maximum ostracoda were recorded in summer season was 15.45%, followed by monsoon 15.08% and winter 15.08%. The maximum protozoa were recorded in summer season was 12.82%, followed by monsoon 12.38% and winter 11.40%. The maximum crustacea were recorded in winter season was 12.94%, followed by monsoon 12.22% and winter 8.82%. The maximum mollusca were recorded in monsoon season was 3.05%, followed by winter 1.75%. The maximum fish larvae and eggs were recorded in the monsoon season was 5.92%, followed by winter 5.15% and summer 2.82% (Table 5 & Fig. 4).

Table 5: Group wise seasonal diversity of zooplankton during June 2014 to May 2015

Group	Monsoon	Percentage (%)	Winter	Percentage (%)	Summer	Percentage (%)
Rotifera	781.00	21.07	653.50	20.78	805.75	22.19
Cladocera	549.75	14.83	510.25	16.22	663.75	18.28
Copepoda	573.25	15.47	525.00	16.69	713.00	19.63
Ostracoda	558.75	15.08	474.00	15.07	561.25	15.45
Protozoa	458.75	12.38	358.50	11.40	465.50	12.82
Crustcea	452.75	12.22	407.00	12.94	320.50	08.82
Mollusca	113.00	03.05	055.00	01.75	0	0
Fish larvae	219.25	05.92	162.00	05.15	102.25	2.82
Total	3706.50		3145.25		3632.00	



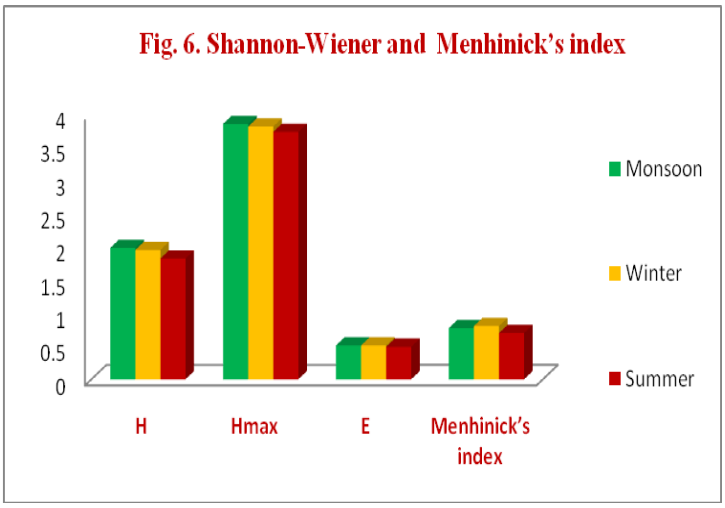
The total number of macro and micro zooplankton in this reservoir showed that the highest zooplankton numbers were noted during monsoon period (35.36%) followed by summer season (34.64%) and lowest during winter season (30.00%) (Fig. 5).



The biodiversity of zooplankton was calculated by using Shannon-Wiener diversity index represented that 1.98 in monsoon, 1.95 in winter and 1.82 in summer season at all four stations. The maximum diversity possible is represented 3.85 in monsoon, 3.81 in winter and 3.73 in summer season. The evenness noted 0.51 both in monsoon and winter and 0.49 in summer season. The Menhinick's index was represented as 0.772 in monsoon, 0.802 in winter and 0.697 in summer. These results represented that the diversity indices were more or less similar in all seasons in the reservoir (Table 6 & Fig. 6).

Table 6: Shannon-Wiener and Menhinick's diversity index

Biodiversity Index	Monsoon	Winter	Summer
H= Shannon-Wiener Index	1.98	1.95	1.82
Hmax= Maximum diversity possible	3.85	3.81	3.73
E = Evenness	0.51	0.51	0.49
Menhinick's index	0.772	0.802	0.697



DISCUSSION

Madduvalasa reservoir is used for irrigation and fisheries where plankton is important for fishes as a food source. The fish diversity in this reservoir was reported by Ramachandrarao and Mukundarao [13]. Taxonomic dominance has been reported in several water bodies [1, 14].

During the present study period, the concentration of zooplankton was recorded to be minimum in November and maximum in June. This pattern is common in lakes, ponds, reservoirs and rivers [15]. Adoni [7] and George [16] also reported maximum of zooplankton population during summer. In the present work, overall view revealed that the fluctuation of zooplankton diversity occurs distinctly in four study areas and normally in monsoon, there was less population due to dilution factors in the reservoir. Vasanth [17] recorded a total of 61 species of zooplanktion in three ponds in Karwar district, Karnataka with rorifera being the dominant group.

In the present study, a total of 17 species of rotifer recorded from seven families on the whole rotifera exhibited higher density in summer season. Rotifera play a vital role in the trophic tiers of fresh water impoundments and serve as living capsule of nutrition [18]. Sharma and Diwan [19] reported rotifera to form a dominant group during summer in Yeswinisagar reservoir; similar results were occurred at various fresh water bodies in India [20-24]. In the present investigation the population density of rotifera found rich in summer season (805.75 nos/lit) and less in winter season (653.50 nos/lit). A similar study was conducted on the number of rotifera which increased in summer may be due to the higher population of bacteria and organic matter of dead and decaying vegetation [7,25,26]. According to Hutchinson [27], *Brachionus* species are very common in temperate and tropical water, indicating alkaline nature of water and excess growth of rotifera and reservoirs indicate the eutrophic conditions.

In the present study period, a total of 8 species of cladocera was recorded in three families. The population densities of cladocera were highest in summer season (663.75 nos/lit) followed by monsoon (549.75 nos/lit) and lowest in winter (510.25 nos/lit.). Diversity had also been reported higher in summer and lower in winter in Thigra Reservoir Gwalior [28] and in Majalgaon reservoir [24], cladocera is an order of small crustacea commonly called as "water fleas". It has been reported that the density and biomass of cladocera were primarily determined by food supply [29]. Jhingran [30] recorded cladocera population to be

most abundant in February, followed by July and Oct. in Ramgarh reservoir in Rajasthan. Sharma and Diwan [19] studied plankton dynamics of Yeshwantsagar reservoir in which the cladocera showed maximum density in June. Khare [31] observed an increasing trend in the months of the winter season with a peak during summer months March to June. He recorded minimum population during rainy season. Five species of copepoda from two families were recorded during the present study period. Copepoda showed higher population density in summer season (713 nos/lit) and lowest in winter (525 nos/lit). The similar result has also been reported to various seasonal fluctuation of zooplankton [24,32-34]. In the present investigation two species of ostracoda were recorded from one family showing higher population diversity in summer season (561.25 nos/lit) and lowest in winter (474 nos/lit). Rajkumar [24] also reported 2 species of ostracoda a very low diversity and population density as compared to other groups of zooplankton. The population density was higher in summer season (851 org/lit) and less in Monsoon (637 org/lit). The similar results had also been observed various water bodies at different districts in India [35-37].

Three species of protozoa from two families were recorded during the present study. The density of population was highest during summer season (465.50 nos/lit) and lowest in winter season (358.5 nos/lit). Rajkumar [24] reported two species of protozoa and population density was higher in summer season (590.333 org/lit) and less in monsoon (379.333 org/lit). A similar observation was made by Shivashankar [38] at Bhadra reservoir, Karnatka. In the present investigation crustacea, mollusca, fish larvae and fish eggs play a vital role in the reservoir. The crustacea leads to sixth position in total number of organisms which comprises nine species like prawn nauplius larva¸ zoea larva, chironimid larva, dragonfly nymph, stonefly nymph, waterbeetle nymph, mosquito larva contain 11.26% in the total population. Importance of phytoplankton in Kalyanapulova reservoir was reported by Sasikala [39].

CONCLUSIONS

In the present study the seasonal variation in the diversity and distribution of zooplankton in Madduvalasa reservoir in all eight groups of zooplankton were recorded throughout the study period. The number was highest during summer and lowest during winter seasons in this reservoir. Shannon-wiener and Menhinicks biodiversity indices had been indicated that the zooplankton was evenly distributed in all seasons in Madduvalasa reservoir. It provides more information than simply the number of species present in four stations by revealing the abundance of rare and common species in different seasons.

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