European Journal of Biotechnology and Bioscience
Online ISSN: 2321-9122, Impact Factor: RJIF 5.44
www.biosciencejournals.com
Volume 5; Issue 1, January 2017; Page No. 04-11

Zooplankton diversity indices and Seasonal variations in Meghadrigedda reservoir, Visakhapatnam, Andhra Pradesh, India

*** Sharmila Sree J, Shameem U**

Department of Zoology, Andhra University, Visakhapatnam, Andhra Pradesh, India

Abstract
A study was carried out to examine the seasonal diversity and density of zooplankton in Meghadrigedda reservoir during the study period from September 2014 to August 2015. Various physico-chemical parameters supporting the diversity and production of zooplankton were studied at three stations of the reservoir. A total of 46 species of zooplankton belonging to 16 species of rotifer in 7 families, 8 species of cladocera in 3 families, 6 species of copepod in 2 families, 3 species of ostracoda in one family, 3 species of protozoa in 2 families, 7 species of crustacea in 2 families, one species of mollusca and 2 species of fish larvae were identified. Species diversity (H-), evenness (E), species richness (S), Margalef's richness index (R1) and Menhinik diversity index(d1) were calculated in the three seasons.

Keywords: zooplankton diversity, species diversity (H-), evenness (E) and species richness (S), margalef's richness index (R1) and menhinik diversity index (d1)

1. Introduction

Zooplankton species are one of the most important biotic components influencing all the functional aspects of an aquatic ecosystem, such as food chains, food webs, energy flow and cycling of matter. They play an important role in the conservation of energy from primary to secondary level. The biomass abundance and species diversity of zooplankton are used to determine the conditions of aquatic environment. Zooplankton diversity and density refers to variety within community and their diversity is one of the most important ecological parameters as these are the intermediate link between phytoplankton and fish. They are also useful indicators of future fisheries health because they are a food source for organisms at higher trophic levels. The distribution of Zooplankton community depends on a complex of factors such as change of climatic conditions, physical and chemical parameters and vegetation cover. Zooplankton plays an integral role as it serves as a bio- indicator and is well suited for understanding water pollution status.

The study aims to record the biodiversity of zooplankton by employing various diversity parameters like Shannon-Wiener index, Margalef's richness index and Menhinick's index. The results of the study indicated specific seasonal variations in the distribution of various specific species of zooplankton. The study was supported by the analysis of physico-chemical parameters of water environment, which indicated a suitable survival habitat for species like rotifers, cladocerans and copepods, etc.

Fig 1: Meghadrigedda Reservoir (Google courtesy)

2. Materials and Methods

Study Area: Meghadrigedda Reservoir is a perennial water body located at Visakhapatnam District, Andhra Pradesh, India. Zooplankton samples were collected from three stations i.e. Jerripotulapalem: S1, Porlupalem: S2, Pedagadi:S3 during the study period. It lies between North latitude 18º.38' and East longitude 79º.12'. The total area of the reservoir is about 8,103 hectare and maximum depth is 21.9m Fig. 1. The study extended for a period of one year from September, 2014 to August, 2015.The region gets much rainfall from south-west monsoon. The place gets most of its rainfall from June to September during the monsoon.

2.1 Collection of zooplankton sample

Zooplankton were collected monthly from three different stations of the Meghadrigedda reservoir from September 2014 to August, 2015 Table 2. Samplings were made between 9.00 am to 11.00 am. Each sample was collected by filtering 20 litres of water through plankton net. Filtrate was stored in 20 ml plastic bottles and 5% formalin was added for sample preservation. These samples were then brought to laboratory for further studies. Zooplankton diversity was studied by Lackey's drop count method and species observed under light microscope. The systematic identification of zooplankton was made by using standard keys of various authors [1-6]. The Population density was quantified by Drop count method of Lackey (1938) and was calculated using the following formula:

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

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

3. Statistical calculation

Biodiversity of zooplankton was studied using the formula of Shannon- Wiener diversity index; Margalef's richness index and Menhinick's index [7-9] were calculated as follows.

3.1 Shannon - Wiener diversity index

This is widely used method of calculating biotic diversity in aquatic and terrestrial ecosystems and is expressed as:
$H=-SUM\ [(p_i) \times \ln(p_i)]$ 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}

3.2 Margalef's richness index

$$\mathbf{R1}= \frac{S-1}{In\ (n)}$$

Where, S is the number of species and n is the total number of individuals observed in the sample.

3.3 Menhinick's index

$$\mathbf{d1 = S / \sqrt{N}}$$

Where; d1 = Menhinick's index
S = total number of species.
$\sqrt{N}$ = total number of organism (density).

The physico-chemical parameters like water temperature, pH, DO, Total alkalinity; Hardness and Free CO_2 were estimated from the samples collected from the fixed stations during summer, monsoon and winter periods respectively and the average data of one year is depicted in table 1. For the qualitative and quantitative analysis, the plankton samples were collected using bolting silk (20 µ aperture) conical shape plankton net from the selected sites following standard methods [10] during the three seasons for each site. Using the given statistical calculations, evaluations were done for the collected samples and results shown.

4. Results

In the present investigation the physico-chemical parameters were recorded in the three seasons at the selected stations of Meghadrigedda Reservoir; the mean and standard deviation values are analysed. The average water temperature was 32.68± 0.45°C in summer, 26.56±0.38°C in monsoon and 22.14±0.42 °C in winter season as recorded during study period at three stations followed by pH 7.62±0.05 in summer, 7.45±0.08 in monsoon and 7.12±0.12 in winter season. Dissolved Oxygen concentrations (mg/lit) were observed as 4.57±0.52 in summer, 6.35± 0.46 in monsoon and 5.23± 0.32 in winter season. Alkalinity concentrations (ppm) were observed as 265 ± 2.04 in summer, 245 ± 1.86 in monsoon and 252 ± 1.92 in winter season. Hardness concentrations (mg/lit) were observed as 53.68± 1.32 in summer, 48.22 ± 1.56 in monsoon and 49.62 ± 0.89 in winter season. BOD concentrations (mg/lit) were observed as 3.84 ± 0.08 in summer, 2.72 ± 0.05 in monsoon and 2.47 ± 0.05 in winter season. COD concentrations (mg/lit) were observed as 9.1± 0.62 in summer, 7.2 ± 0.48 in monsoon and 8.3 ± 0.52 in winter season. Transparency values (cm) were observed as 53.8 ± 2.80 in summer, 43.06± 2.50 in monsoon and 47.25± 2.53 in winter season Table-1.

The present study revealed 46 species of zooplankton belonging to 18 families and 8 groups in Meghadrigedda reservoir, including 16 species of rotifera, 8 species of cladocera, 6 species of copepoda, 3 species of ostracoda, 3 species of protozoa, 7 species of crustacea, 1species of mollusca, 1 species of fish larva and fish eggs; (Table-2). Monthly macro and micro zooplankton variations were observed at three stations and the values were provided as mean values in different groups and are presented in Table 3, figure-2. The maximum number (187.36) of rotifera were recorded in May 2015 and minimum number (125.5) were recorded in October 2014. Cladocera were recorded at a maximum number (153.25) in May 2015 and minimum number (122.25) in month of August 2015. In case of copepod, maximum number (143.25) was recorded in April 2015 and minimum number (120.67) in August 2015. Ostracoda recorded maximum number (142.25) in May, 2015 and minimum number (112.25) in month of August, 2015. In protozoa maximum number (135.25) of species recorded in May, 2015 and minimum number (112) recorded in November, 2014. Crustacea recorded maximum number (132.55) in December, 2014 and February, 2015 and minimum number (112.25) in the month of August, 2015. Mollusca recorded maximum number (22.33) in March, 2015 and minimum number (14) in the month of October, 2014. Fish larvae and fish eggs were maximum number (16.32) in July,

2015 and minimum number (1.33) in the month of June, 2015 (Table 3, Fig. 2).

The percentage of various zooplankton groups are viz. rotifera 18.23%, cladocera 16.80%, copepoda 16.45%, ostracoda 15.53%, protozoa 13.78%, crustacea 15.27%, mollusca 03.15% and fish larvae 0.79% during September,2014 to August, 2015 (Table 4, Fig. 3). The number of organisms was enumerated annually in each group and the mean and standard deviation values were calculated. Rotifera recorded maximum number (1769.6 ± 16.63/annum) and fish larvae were minimum number (76.74 ± 5.13) at all the three stations. The seasonal deviations of zooplankton organisms were recorded as summer (850.72 ± 28.69), winter (794.26 ± 16.49) and monsoon (780.95 ± 25.14) months Table 5, Fig. 4. The dominance of various zooplankton groups in the decreasing order during the three seasons is as follows:

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

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

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

Shannon- Weiner diversity index (H-) indicated the highest diversity of 1.93 in July 2015 and lowest of 1.79 in February 2015. The annual mean value of the H- is 1.89 and it was deviated by ± 0.04 at the three sampling stations in the reservoir (Table 7, Fig. 6). Zooplankton diversity evenness index (E) represented the highest evenness of 0.55 in August, 2015and lowest value of 0.51 in May, 2015. The annual mean value of the E is 0.53 and it was deviated ± 0.02 at the three sampling stations (Table 7). Zooplankton richness (S) was presented highest in May, 2015 and lowest in September, 2014. The annual mean value of S is 3.56 and deviated by ± 0.08 at the three sampling stations (Table 7). The group wise Shannon- Weiner diversity index (H-) values are more or less similar for all groups except for mollusca and fish larvae.

The order of organisms are protozoa > crustacea > cladocera & copepoda > rotifera > ostracoda > fish larvae > mollusca. Evenness index (E) represented more variations in fish larvae and crustacean group and other group results were indicated as rotifera > cladocera > copepoda > ostracoda > protozoa. Richness (S) indicated more variations in mollusc and fish larvae and other group results indicated as rotifera > cladocera > crustacea > copepoda > ostracoda & protozoa (Table 8, Fig. 7). Margalef's richness index (R1) and Menhinick's index (d1) were calculated group wise and the results showed a highest richness of 2.14 (R1) and 0.38 (d1) for rotifers and lowest richness for mollusc group at 0.18 (R1) and 0.06 (d1). The slight variations in mean and standard deviation values of Margalef's richness index and Menhinick's diversity index (d1) are provided in Table 9. The month wise diversity indices of Margalef's richness index (R1) results exhibited highest value of 6.03 in May 2015 and lowest value of 4.52 in September, 2014. Menhinick's index (d1) diversity results show highest 1.40 in May, 2015 and lowest in September, 2014 showing similar index results in the same months (Table 10).

5. Discussions

The composition and biomass of zooplankton species were evenly distributed in the reservoir at three stations and the physical parameters are of suggestible range in the reservoir. In the similar studies conducted [11, 12, 13] by various authors, it was shown that zooplankton depends on a complex combination of factors, such as temperature, dissolved oxygen, and availability of nutrients. It is the most fluctuating parameter in the freshwater environment and exerts different ecological and physiological effects depending on the interaction with temperature, oxygen and ionic compounds (Odum, 1971). Aquatic organisms are affected by pH because most of their metabolic activities are pH dependent [14, 15, 16, 17, 18, 19].

In the present study rotifers were observed to show a numeric superiority over other groups of Zooplankton. Generally the fish larvae showed minimum density during summer months, while the Rotifers, Copepoda and Cladocerans exhibited maximum density during summer months. Basawarajeshwari *et al* [20] also noted that rotifer was the dominant group throughout the study period and highest count was recorded in the north-east monsoon season, followed by summer and winter season. Mahor [21] reported that ostracoda was of maximum population in summer months and minimum in monsoon months and Protozoa were recorded maximum in summer and winter months and minimum in monsoon months. The taxonomic dominance has been reported in several water bodies [22], common in lakes, ponds, reservoirs and rivers [23]. The number of Rotifers increased in summer, which may be due to the higher population of bacteria and organic matter of dead and decaying vegetation [24]. Segers [25] highlighted the dominance of rotifer population which was due to its preference for warm waters. The seasonal variations and Zooplankton diversity in Thigra Reservoir, Gwalior (M.P.) reported that a total of 20 species were recorded during the study, 10 belonged to rotifera, 4 each to copepod and cladocera and 2 to protozoa. Rotifera was the most dominant group throughout the study period. Seasonal variations were observed in the distribution of zooplankton. Seasonally, the number was highest during summer, followed by monsoon and lowest during winter [26].

In the present study, a total of 8 species of cladocera were recorded at all stations and the population densities of cladocera were higher in summer season (556.29 org/lit) and lower in monsoon (505.12 org/lit.). Abundance has also been earlier reported in summer season and lower in winter in Thigra Reservoir, Gwalior (M.P.) [26]. Cladocera is an order of small crustaceans commonly called as "water fleas". It has been reported that the density and biomass of cladocerans were primarily determined by food supply [27]. Seven species of crustacea were observed at the population densities are higher in winter season (503.95 org/lit) and lower in monsoon (475.18 org/lit.). The similar observations have also been observed by Khare [28] with an increasing trend in the months of winter season and showing a peak during summer months (March to June). He recorded a minimum population during rainy season.

Six species of copepoda were observed at three stations and the population densities of copepoda were higher in summer season (556.29 org/lit) and lower in monsoon (505.12 org/lit.). Similar results were noticed by Kedar *et al* [29]. in Rishi freshwater lake of Washim district. The occurence of some species of ostracods in Dharwad district [30] there are three species of ostracoda were observed at all the three stations and the population densities of ostracoda were higher in summer season (542.00 org/lit) and lower in monsoon (468.48 org/lit.).

Three species of protozoa were observed at three stations and the population densities of protozoa were higher in summer season (498.83 org/lit) and lower in monsoon (462.34 org/lit.). Similar observations have also been observed in Fort Lake of Belgaum and Rishi freshwater lake of Washim district [25, 31]. During the present study, diversity indices represented maximum in rotifers and minimum in molluscan groups in the month of May 2015, indicating less pollution in these water bodies. A similar study conducted by Mishra *et al* [32] during different months indicated variations in the taxa of plankton varied from 12 to 29 in Dhaura and Baigul reservoirs. The Margalef's and Menhinick's richness indices were maximum in March, 2007 in Dhaura and November, 2006 in Baigul. The maximum values (2.947 in Baigul and 2.801 in Dhaura) of Shannon's diversity index were in November and October, 2006 [33].

6. Tables and Figures

Table 1: Seasonal variations in physico-chemical parameters (Mean and slandered values) of water at three stations in Meghadrigedda reservoir

Parameter	Season		
	Summer	Monsoon	Winter
Water Temp (°C)	32.68± 0.45	26.56±0.38	22.14±0.42
pH	7.62±0.05	7.45±0.08	7.12±0.12
Dissolved Oxygen (mg/l)	4.57±0.52	6.35± 0.46	5.23± 0.32
Alkalinity (ppm)	265 ± 2.04	245 ± 1.86	252 ± 1.92
Hardness mg/lit	53.68± 1.32	48.22 ± 1.56	49.62 ± 0.89
BOD mg/lit	3.84 ± 0.08	2.72 ± 0.05	2.47 ± 0.05
COD mg/lit	9.1± 0.62	7.2 ± 0.48	8.0 ± 0.52
Transparency cm	53.8 ± 2.80	43.06± 2.50	47.25± 2.53

Table 2: Checklist of Zooplankton from Meghadrigedda reservoir

Groups	Family	Species
Rotifera	Brachionidae	*Brachionus angularis* (Gosse,1851)
		Brachionus calyciflorus (Pallas, 1766)
		Brachionus caudatus aculeatus(Haner, 1937)
		Brachionus diersicornis(Daday, 1883)
		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.* Sp
	Chydoridae	*Alona pulchella* (King)
		Alona intermedia (Sars)
		Alonella. Sp
Copepoda	Diaptomidae	*Cyclopoid copepodite*
		Diaptomus pallidus
		Neodiaptomus sp
	Cyclopidae	*Cyclops* sp
		Mesocyclops sp
		Nauplius larva
Ostracoda	Cyprididae	*Cypris globosa*
		Hemicypris fossulata (Baird, 1845)
		Stenocypris sp
Protozoa	Parameciidae	*Paramecium caudatum*
	Vorticellidae	*Vorticella campanula*
		Epistylis sp
Crustaceans	Decapoda	*Zoea larvae*
	Insecta	*Nymphs*
		Trichoptera
		Damselfly Nymph

		Dragonfly Nymph
		Deronectes sps (Water beetles)
		Mosqito larvae
Molluscans	Pelecipoda	*Veliger*
Fish larvae		*Embryonated eggs*
		Fish larvae

Table 3: Mean Diversity indices and percentage of Zooplankton at three stations in Meghadrigedda Reservoir from September 2014 to August 2015

Group	Sep14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	%
Rotifera	136.36	125.5	138.25	131.55	142	148.33	154.25	162.5	187.36	163.25	148	132.25	18.23
Cladocera	128.25	133.25	132.5	135.25	137.25	133.67	138.5	142.25	153.25	142.33	122.25	131.32	16.80
Copepoda	121.5	126.75	138.36	132.05	137.67	139.25	135.12	143.25	138.67	136.45	126.5	120.67	16.45
Ostracoda	112.55	118.66	122.25	125.25	130.12	128.75	132.33	138.67	142.25	125.36	118.32	112.25	15.53
Protozoa	119.67	123.25	112	122.75	118.25	120	125.25	118.33	135.25	112.5	111.67	118.5	13.78
Crustacea	121.33	119.45	125.25	132.25	127	132.25	124.55	119.25	126.55	123.25	118.35	112.25	15.27
Mollusca	16.25	14	15.67	16.25	20.75	18.55	22.33	20.25	12.25	18.36	15.25	15.25	03.15
Fish larvae	11.25	10.25	06.75	02.25	04.25	02.25	02.5	2.25	02.67	01.33	16.32	14.67	0.79

S1: Jarripotulapalem, S2: Porlupalem, S3: Pedagadi

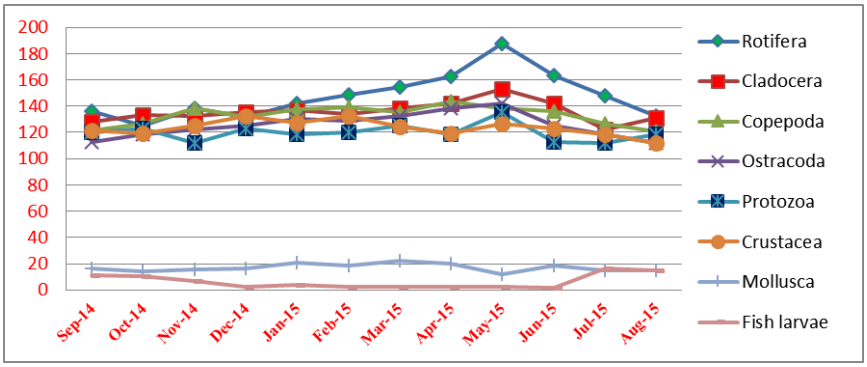

Fig 2: Mean Diversity indices of Zooplankton

Table 4: Number of organisms in each group mean and Standard deviation value

Group	No. of org/anu
Rotifera	1769.6 ± 16.63
Cladocera	1630.07 ± 7.53
Copepoda	1596.24 ± 7.13
Ostracoda	1506.76 ± 9.06
Protozoa	1337.42 ± 6.30
Crustacea	1481.73 ± 5.56
Mollusca	305.16 ± 2.85
Fish larvae	76.74 ± 5.13

Table 5: Seasonal mean deviations of zooplankton

Season	organisms of mean and SD values
Summer	850.72 ± 28.69
Monsoon	780.95 ± 25.14
Winter	794.26 ± 16.49

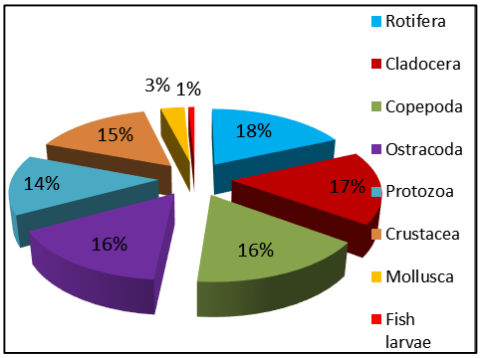

Fig 3: Group wise zooplankton percentage

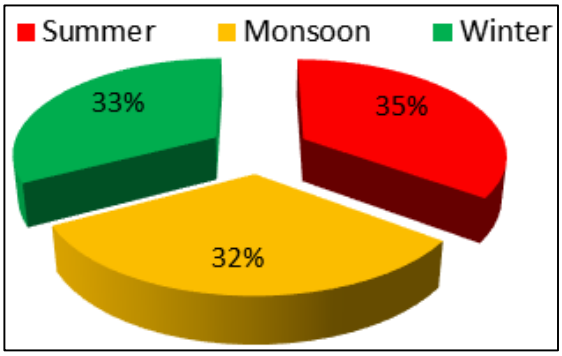

Fig 4: Seasonal deviation

Table 6: Group wise seasonal variations at three stations

Group	Summer	Average	Monsoon	Average	Winter	Average
Rotifera	652.44	163.11	579.86	144.97	537.30	143.33
Cladocera	567.67	141.9	524.15	131.04	538.25	134.56
Copepoda	556.29	139.07	505.12	126.28	534.83	133.71
Ostracoda	542.00	135.50	468.48	117.12	496.28	124.07
Protozoa	498.83	124.71	462.34	115.56	476.25	119.06
Crustacea	502.60	125.65	475.18	118.80	503.95	125.99
Mollusca	073.38	018.35	065.11	016.28	066.67	016.67
Fish larvae	009.67	002.42	043.57	010.90	023.50	005.88

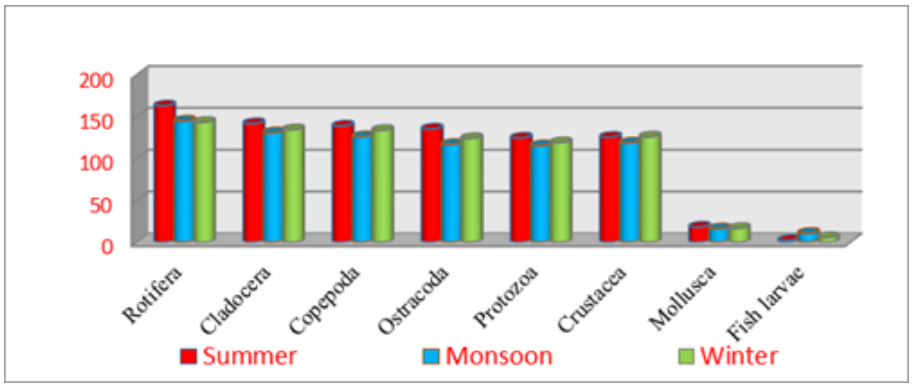

Fig 5: Group wise seasonal variations

Table 7: Shannon-Weiner diversity index of month wise zooplankton variations

	Sep14	Oct-	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	SD
H	1.90	1.91	1.89	1.88	1.88	1.79	1.90	1.89	1.92	1.86	1.93	1.92	1.89+0.04
E	0.55	0.54	0.54	0.53	0.53	0.50	0.53	0.52	0.51	0.52	0.54	0.55	0.53+0.02
S	3.43	3.52	3.52	3.58	3.56	3.61	3.56	3.64	3.74	3.58	3.56	3.47	3.56+0.08

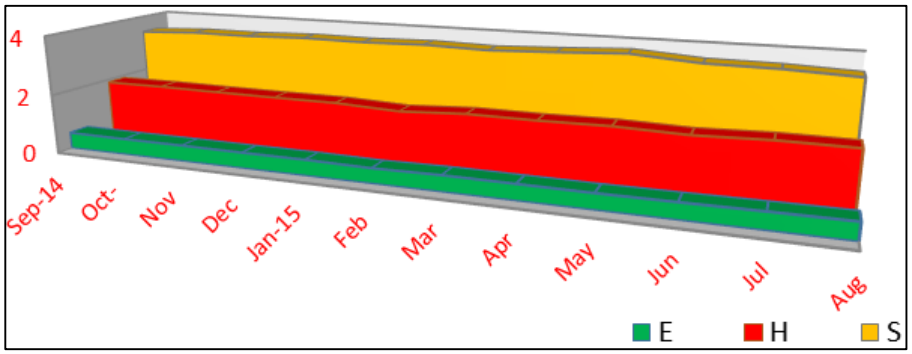

Fig 6: Shannon-Weiner diversity index

Table 8: Shannon-Weiner index of group wise zooplankton variations

Group	Hmax	E	S
Rotifera	2.48	0.90	2.77
Cladocera	2.49	0.83	2.08
Copepoda	2.49	0.72	1.79
Ostracoda	2.47	0.45	1.10
Protozoa	2.62	0.42	1.10
Crustacea	2.50	1.28	1.95
Mollusca	1.93	0	0
Fish larvae	2.15	3.12	0.69

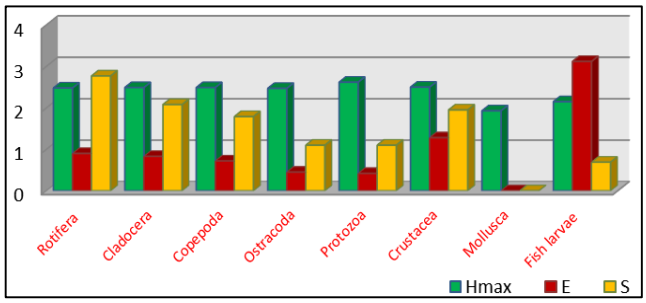

Fig 7: Shannon-Weiner index of group wise zooplankton variations

Table 9: Group- wise diversity of Margalef's richness index (R1) and Menhinick's index (d1)

Group	R1= $\frac{S-1}{In\,(n)}$	d1 = $\frac{S}{\sqrt{n}}$
Rotifera 16	2.14	0.38
Cladocera8	0.95	0.20
Copepoda6	0.68	0.15
Ostracoda3	0.41	0.08
Protozoa3	0.42	0.08
Crustacea7	0.96	0.18
Mollusca1	0.18	0.06
Fish larvae2	0.46	0.23
Mean and SD value	0.78±0.58	0.17 ±0.10

Table 10: Month- wise diversity of Margalef's richness index (R1) and Menhinick's index (d1)

Month	R1= $\frac{S-1}{In\,(n)}$	d1 = $\frac{S}{\sqrt{n}}$
Sep-14	4.52	1.12
Oct	4.96	1.22
Nov	4.95	1.27
Dec	5.24	1.28
Jan-15	5.07	1.22
Feb	5.37	1.29
Mar	5.05	1.21
Apr	5.49	1.31
May	6.03	1.40
Jun	5.23	1.26
Jul	5.11	1.26
Aug	4.68	1.16
Mean and SD value	5.13 ± 0.37	1.25±0.07

7. Conclusion

The present study reveals seasonal variations in the diversity indices and distribution of zooplankton in Meghadrigedda Reservoir. All eight groups of zooplankton were recorded throughout the study period. The number was highest during summer and lowest during winter. The study indicates that temperature has an important role in the distribution of zooplankton in a fresh water habitat. The Shannon- Wiener diversity index (H-), Margalef's richness index (R1) and Menhinick's diversity index (d1) indicated a huge diversity of zooplankton in Meghadrigedda Reservoir and there is no pollution in the aquatic ecology and water is a suitable source for drinking.

8. Acknowledgement

The authors are thankful to the Head, Department of Zoology, Andhra University for providing necessary facilities to carry out the present work.

9. Reference

1. Adoni AD. Work book on limnology. Pratibha Publishers C-10 Gour Nagar, Sagar-470 003, India, 1985, 216.
2. Edmondson WT. Freshwater biology 2nd Ed. USA. John Wiley and Sons, Ins New York 1993.
3. IAAB. Methodology for water Analysis, IAAB Editorial Board. 1998.
4. Battish SK. Freshwater Zooplankton of India, Oxford and IBH Publishing Co.Ltd, New Delhi. 1992, 1-194.
5. Dhanapathi MV. S.S.S., Taxonomic notes on the rotifers from India, *IAAB*, Hyderabad. 2000, 1-78.
6. Altaff K. A manual of Zooplankton University Grants commission, New Delhi, 2004.
7. Shannon CE, Weaver W. The Mathematical Theory of Communication. University of Illinois Pres, Urbana. 1998, 144.
8. Margalef R. Information theory in ecology. *Gen Syst.* 1958; 3:36-71.
9. Menhinick Edward F. A Comparison of Some Species-Individuals Diversity Indices Applied to Samples of FieldInsects. Ecology. 1964; (45):859-861.
10. APHA. Standard methods for examination of water and waste water. 20th edn., American Public Health Association, Washington, D.C. 1998.
11. Chowdhury SH, Mazumder A. Limnology of Lake Kaptai. I. Physico-chemical features. Bang. J. Zool, 1981; 9(2):59-72.
12. Choubey U. Studies on physico-chemical and biological parameters of Gandhisarar reservoir, Mandsaur district, Madhya Pradesh [dissertation]. India. 1990, 1-244.
13. Pandey BN, Jha AK, Pandey K. Zooplankton community in relation to certain physico-chemical factors of Kosi, Purnes, Bihar, Environ. Ecol. 1994; 12:563-567.
14. Singh SP, Pathak D, Singh R. Hydrobiological studies of two ponds of Satna (M. P.), India. Ecology, Environment and Conservation. 2002; 8:289-292.
15. Rajagopal T, Thangamani A, Sevarkodiyone SP, Sekar M, Archunan G. Zooplankton diversity and physico-chemical conditions in three perennial ponds of Virudhunagar district, Tamilnadu. J Environ Biol. 2010; 31:265-272.
16. Veerendra DN, Thirumala Manjunatha h, Aravinda hB. Zooplankton diversity and its relationship with Physico-chemical parameters in mani reservoir Of western ghats, region, hosanagar taluk, Shivamoga district karnataka, india. Journal of urban and environmental Engineering, 2012; 6(2):74-77.
17. Balakrishna D, Reddy TR, Reddy KV, Samatha D. Physico-Chemical Parameters and Plankton Diversity of Ghanpur Lake, Warangal, A.P. India. Inter J Zoo Res. 2013; 3:44-48.
18. Bazmi Shaukat Hussain Md, Shahabuddin Md. Alam Mumtaz and Sayeed Akhtar S.M., Seasonal fluctuation of zooplankton community in relation to certain physico-chemical parameters of river Bagmati of Darbhanga, Bihar, Environ. Ecol. 2011; 29(2A0):922-925.
19. Michael RG. A guide to the study of freshwater organism, 2.Rotatoria, J.Madurai University. Suppl. 1973; 1:23-36.
20. Basawarajeshwari Indur, ramakrishna Reddy, 1vijaykumar K. Zooplankton diversity in freshwater reservoir of Yadigir district, karnataka state. International Journal of Current Innovation Research. 2015; 1(1):19-22.
21. Mahor RK. Diversity and seasonal fluctuation of zooplankton in fresh water reservoir Tighra Gwalior (M.P), International Reseach Journal. 2011; 2(19):24-25.
22. Kanagasabhapati V, Rajan MK. A Preliminary survey of plankton in Irrukkangudi reservoir, Virudhnagar District, T.N. Journal of Phytology. 2010; 2(3):63-72.
23. Neves IF, Recha O, Roche KF, Pinto AA. Zooplankton community structure of two marginal lakes of the river Cuiaba (Mato Grosso, Brazil) with analysis of Rotifera and Cladocera diversity, Braz. J. Biol. 2003; 63:1-20.
24. Majagi G, Vijaykumar K. Ecology and abundance in

Karanja reservoir. Environ. Monit. Asses. 2009; 152:137-144.
25. Segers H. A biogeographical analysis of rotifers of the genus Trichocerca Lamarck, 1801 with notes on taxonomy, Hydrobiologia. 1973; (5):103-114.
26. Dushyant kumar Sharma, RP Singh. Seasonal variation in zooplankton diversity in Tighra Reservoir Gwalior (M.P.) Indian Journal of Science and Research. 2012; 3(2):155-161.
27. Smitha PG, Byrappa K, Ramaswamy SN. Physico chemical characteristics of water samples of bantwal Taluk, South-estern Karnataka, India. Journal of Environmental Biology. 2007, 595.
28. Khare PK. Physico-chemical characteristics in relation to Abundance of plankton of Jagat Sagar Pond, Chattapur, India. Advances in Limnology Edited by. S.R. Mishra, (Daya Publishing House), New Delhi, 2005, 162-174.
29. Kedar GT, Patil GP, Yeole SM. Effect of physicochemical factors on the seasonal abundance of zooplankton population in Rishi Lake. The 12th world lake conference, 2008, 88-91.
30. Patil CS, Gouder BYM. Freshwater invertebrates of Dharwad (Karnatak State, India), Prasaranga Karnatak University, Dharwad, India, 1989, 144.
31. Sukand BN, Patil HS. Water quality assessment of Fort Lake of Belgaum (Karnataka) with special reference to zooplankton. J.Environ. Biol, 2004, 99-102.
32. Ashutosh Mishra SK, Chakraborty1 a, Jaiswar1 aK, Sharma2 P, Geetanjali deshmukhe1, madan mohan. Diversity in dhaura and baigul reservoirs of uttarakhand. indian j. Fish. 2010; 57(3):19-27.
33. Avinash Gholap B. Species diversity indices of zooplankton from Sadatpur reservoir, Ahmednagar, Maharashtra Scholars Research Library, Annals of Biological Research, 2014; 5(4):58-61.