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Zooplankton diversity and seasonal variations in Thandava reservoir, Visakhapatnam, India

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Abstract

Zooplankton diversity and seasonal variations were studied at three stations of Thandava reservoir to provide new insights into reservoir ecology and water quality. The study was carried out during the study period from Nov 2015 to Oct 2016. A total number of forty four zooplanktons both micro and macro species were identified in this reservoir at three stations. Among eight zooplankton groups, the diversity of rotifera comprise of 17 species (24.38%), cladocera 8 (17.63%), copepoda 5 (17.08%), ostracoda 2 (14.63 %), protozoa 3 (12.03%), crustacea 7 (11.18%), fish larvae and eggs 2 (03.08%). The number and percentage of zooplankton monthly population was highest 9.96% in during May 2016 and lowest 7.11% in November 2016. The group wise and season wise zooplankton mean diversity index was analysed and calculated, rotifera were highest (37.14%) in summer lowest (26.46%) in winter. Followed by cladoceran were highest (36.96%) and lowest (30.01%) in monsoon, followed by copepoda highest (39.40%) and lowest (28.61%), ostracoda highest (35.93%) and lowest (34.26%) in monsoon periods. Protozoa highest (41.80%) and lowest (27.77%), crustacea highest (41.01%) in monsoon and lowest (21.47%) in summer and Fish larvae and eggs highest (57.91%) in monsoon and lowest (16.02%) in summer. Shannon-Wiener index and Margalef's richness index (R1) results were calculated for zooplankton diversity in this reservoir.

Keywords: Zooplankton, seasonal variation, Shannon-Wiener index, and Margalef's richness index (R1)

1. Introduction

Zooplankton is the free floating and microscopic animal found in aquatic ecosystem. Freshwater zooplankton is dominated by protozoans, rotifers, crustacea, cladocerans and copepods. The planktonic protozoans have limited locomotion, but the rotifers, cladocerans and copepod micro crustaceans and certain immature insect larvae often move extensive in quiescent water. The zooplankton assemblage inhabiting freshwater, mostly comprises representative of protozoa, Coelenterata, Rotifera, Gastrotricha, Bryozoa and Arthropoda^[1-2]. 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 the rapidly emerging concepts in environmental management like Environmental Impact Assessment (EIA). Zooplankton is good indicators of the changes in water quality because they are strongly affected by environmental conditions and respond quickly to changes in water quality. The study of zooplankton is necessary to evaluate the fresh water reservoir in respect to their ecological and fishery status. The Zooplankton community fluctuates according to physicochemical parameters of the environment, especially Rotifer species change with biotic factors^[3]. Earlier there was no report on the zooplankton in the Thandava reservoir.

2. Materials and Methods

2.1 Study area

Thandava reservoir is near G.K. Gudem village in Natavaram of Visakhapatnam District. The total extent of ayacut contemplated is 20,828 Hectares (51,465 Acres) with breakup 13060 Hectares in Visakhapatnam and 7768 Hectares in East Godavari District. This reservoir Longitude: 82°-15'-20", Latitude 17° - 45' - 50" and the earth dam was completed during 1974. The samples were collected from four stations i.e., S1: Jalaripeta, S2: Gadampalem, S3: Ammapeta

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2.2 Collection of sample, preservation and identification

Water samples were collected randomly in three selected sites of the reservoir on monthly basis for a period of one year from Nov 2015 to Oct 2016. Collection of Zooplankton was carried out by using plankton net (25µ). Sampling was made between 9.30 to 10.30 am. by Plankton net (bolting silk mesh size 25µ) swept through surface water. 100 litres of surface water was sieved through the plankton net and filtered sample were transferred to plastic containers and 4% formalin was added for sample preservation and then brought to laboratory for further analysis. The remaining concentrate (100 ml) was used for estimation of plankton density [4] and diversity of zooplankton was studied by Lackey’s drop count method and species observed under light microscope. The systematic identification of plankton was made by using standard keys of various authors [5-10]. The total number of zooplankton present in a litre of water sample calculated by using following formula:

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

Where,

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

2.3 Zooplankton Biodiversity: The statistical calculation on biodiversity of zooplankton was studied using the formula of Shannon- Wiener diversity index [11] and Margalef’s richness index (1964) which was calculated as follows.

1. Shannon - Wiener diversity index

Shannon-Wiener index denoted by $H = -\text{SUM} [(p_i) \times \ln(p_i)]$

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}

2.4 Margalef’s richness index: $R1 = \frac{S-1}{\ln(n)}$

Where, S is the number of species and

n is the total number of individuals observed in the sample.



Fig 1: Thandava reservoir

3. Results

In the present investigation attempts on the water quality parameters, diversity of zooplankton and its seasonal fluctuations in the Thandava reservoir were summarized. The

seasonal variations of average physico-chemical parameters i.e water temperature (26.50±0.33 °C); pH (7.43±0.14), Dissolved oxygen (5.97±0.2643mg/lit), alkalinity (263.33±1.78ppm), hardness (57.33±1.21mg/lit), BOD (2.81±0.25mg/lit), COD (14.23±0.43mg/lit) and transparency (50.06±1.80cm) of water were noted at three stations (Table1). A total number of forty four zooplankton species were identified in the reservoir at three stations are Jalaripeta (S1), Gadampalem (S2), Ammapeta (S3) (Table 2) (Fig 1).

Among this diversity, the macro and micro zooplankton species consist of rotifera, cladocera, copepoda, ostracoda and protozoa (Micro), crustacea, fish larvae and eggs (Macro). The monthly variation of zooplankton density (nos/ lit) at three stations found that the mean and standard value is the maximum number of rotifera (232.45 ±18.85 nos/lit) recorded during May 2016 and minimum (132.56 ± 9.74 nos/lit) November 2015. Followed by the maximum number of cladocera (173.65 ±11.22 nos /lit) recorded in May 2016 and the minimum (119.41±8.45 nos /lit) in October 2016. The maximum number of copepoda (188.62±9.42 nos /lit) recorded in May 2016 and minimum (102.54±5.59 nos/lit) in October 2016. The maximum number of ostracoda (145.22±12.48 nos /lit) recorded in May 2016 and minimum (101.75±7.58 nos /lit) in January 2016. The maximum number of protozoa (131.82±11.46 nos /lit) recorded in May 2016 and minimum (075.21±7.74 nos /lit) in January 2016. The maximum number of crustacea (128.55±9.56 nos /lit) recorded in October 2016 and minimum (049.25±6.35 nos /lit) May 2016. The maximum number of fish larvae and eggs (52.22±2.12 nos /lit) recorded in July2016 and the number was minimum (09.65±2.44 nos /lit) at in April 2016 (Table 3). The group wise mean value of zooplankton diversity observed from Nov 2015 to Oct 2016 at three stations (Table 4 & Fig. 3). Rotifera group in the present study observed to show a numeric superiority over other group of zooplankton and occupied with 2400.27 and comprises 24.38%, followed by cladocera with 1736.07 and comprises 17.63%, copepod with 1681.5 and comprises 17.08%, ostracoda with 1440.99 and comprises 14.63%, protozoa with 1184.14 and comprises 12.03%, crustacea with 1101.3 and comprises 11.18%, fish larvae and eggs with 302.87 and comprises 3.08%.

The seven groups of macro and micro zooplankton monthly mean diversity in the distribution was represented in the present investigation (Tab 5 and Fig. 4). In the total monthly population the maximum number of zooplankton are 980.25 in May 2016 and comprises 9.96%, followed by the month of April 2016 the number is 910.35 and comprises 9.24%, June 2016 the number is 905.99 and comprises 9.20%, July 2016 the number is 885.97 and comprises 9.00%, August 2016 the number is 843.34 and comprises 8.56%, March 2016 the number is 826.70 and comprises 8.40%, September 2016 the number is 820.69 and comprises 8.33%, February 2016 the number is 786.04 and comprises 7.98%, October 2016 the number is 756.15 and comprises 7.69%, January 2016 the number is 729.68 and comprises 7.41%, December 2015 the number is 709.93 and comprises 7.21% and November 2015 the number is 700.05 and comprises 7.11%.

In the present investigation, the group wise seasonal diversity of zooplankton is represented as the maximum rotifera were recorded in summer season is 37.14% followed by monsoon 36.39% and winter 26.46%. The maximum cladocera were recorded in summer season is 36.96% followed by monsoon 33.03% and winter 30.01%. The maximum copepoda were recorded in summer season is 39.40% followed by monsoon

31.40% and winter 28.61%. The maximum ostracoda were recorded in summer season is 35.93% followed by monsoon 34.26% and winter 29.81%. The maximum protozoa were recorded in summer season is 41.80% followed by monsoon 30.44% and winter 27.77%. The maximum crustacea were recorded in monsoon season is 41.01% followed by winter 37.52% and summer 21.47%. The maximum fish larvae and eggs were recorded in monsoon season is 57.91% followed by winter 26.07% and summer 16.02% (Table 6 & Fig. 4, 5).

The total number of macro and micro zooplankton in the reservoir represented that the highest zooplankton numbers were recorded during the study period. The following order noticed during monsoon is rotifera (25.28%) > cladocera (16.59%) > copepod (15.28%) > ostracoda (14.29%) > crustacean (13.07%) > protozoa (10.43%) > fish larvae and eggs (5.08%). Followed by winter season the rotifera (21.99%) > cladocera (18.04%) > copepoda (16.66%) > ostracoda (14.83%) > crustacea (14.31%) > protozoa (11.39%) > fish larvae and eggs (2.34%) and summer season the rotifera (25.45%) > copepoda (19.20%) > cladocera (18.32%) > ostracoda (14.78%) > protozoa (14.13%) > crustacea (6.75%) > fish larvae and eggs (1.39%) Tab 7and Fig 8. It is represented that the seasonal biodiversity was maximum in summer season (36%) followed by monsoon (35%) and winter (29%) fig 7.

The monthly biodiversity of zooplankton was calculated by using Shannon -Wiener diversity index (H) represented that 1.88 maximum during Nov 2015 and May2016, minimum 1.72 in May 2016. Maximum diversity possible (H_{max}) represents that 3.47 in May 2016 and minimum is 3.18 in January 2016. Evenness (E) maximum was noticed 0.58 in January 2016 and minimum 0.51 in April 2016. Species richness (S) is maximum 32 in May 2016 and minimum in 24 in January 2016 Tab 8 & Fig. 8.

The season wise Shannon-Wiener diversity index (H) is 2.52 in monsoon, 2.51 in winter and 2.47 in summer season at all three stations. The maximum diversity possible (H_{max}) is represented 2.49 in monsoon, 2.57 in winter and 2.64 in summer season. The evenness (E) is noted 1.01 in monsoon, 0.98 in winter, and 0.94 in summer season. Species richness (S) was noted 12 in monsoon, 13 in winter, and 14 in summer season Table 9 and Fig 9.

The Menhinick's index (d1) was represented as the maximum rotifera diversity 16.77 in May 2016 and minimum 11.51 in Nov 2015 followed by cladocera maximum 13.18 in May 2016 and minimum 10.93 in Oct 2016, copepoda maximum 13.73 in May 2016 and minimum in 10.13 Oct 2016, ostracoda maximum12.05 in May 2016 and minimum10.09 in Jan 2016, protozoa maximum 11.48 May 2016 and minimum in 8.67 Jun 2016, crustacean maximum 11.34 in Oct 2016 and minimum 7.02 May 2016, fish larvae and eggs maximum 7.22 Jul 2016 and minimum 3.11 Apr 2016. These results represented that the diversity indices were more or less similar in all months in the Thandava reservoir (Table 10).

Margalef's richness index (R1) was represented as the maximum rotifera diversity 2.46 in Nov 2015 and minimum 1.53in Sep 2016 followed by cladocera maximum 1.37 in Apr 2016 and minimum 0.62 in Sep 2016, copepoda maximum 0.58 in Apr 2016, ostracoda maximum10.22 in Nov 2015, protozoa maximum 0.46 Jun 2016 and minimum 0.21in Feb, Mar and Apr 2016, crustacean maximum 1.05 in Jul and Aug 2016 and minimum 0.25 Mar and Apr 2016, fish larvae and eggs maximum 0.36 Feb 2016. (Table 10).

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

Parameter	Seasons		
	Summer	Monsoon	Winter
Water Temp (°C)	33.25± 0.32	25.04±0.32	21.22 ± 0.35
pH	7.72±0.12	7.36 ±0.15	7.22 ± 0.16
Dissolved Oxygen (mg/l)	5.32± 0.32	6.82 ± 0.24	5.76 ± 0.21
Alkalinity (ppm)	282 ± 2.82	264 ± 1.09	244 ± 1.42
Hardness mg/lit	62.23± 1.32	53.23 ± 1.56	56.52 ± 0.74
BOD mg/lit	3.68 ± 0.18	2.52 ± 0.15	2.22 ± 0.42
COD mg/lit	8.15± 0.52	6.2 ± 0.42	7.0 ± 0.36
Transparency cm	49.7 ± 1.50	56.12± 2.35	44.36± 1.56

Table 2: Check list of Zooplankton species at Thandava reservoir

Group	Family	Species	
Rotifera (17)	Brachionidae	<i>Brachionus angularis</i>	
		<i>Brachionus calyciflorus</i>	
		<i>Brachionus caudatus</i>	
		<i>Brachionus diersicornis</i>	
		<i>Brachionus plicatilis</i>	
		<i>Brachionus quadridentata</i>	
		<i>Keratella cochlearis</i>	
		<i>Keratella tropica</i>	
		<i>Lecane lunaris</i>	
		<i>Lecane monostyla</i>	
Gastropodidae	<i>Gastropus minor</i>		
	<i>Asplanchnidae</i>	<i>Ascomorpha ovalis</i>	
		<i>Asplanchna sp</i>	
	<i>Synchaetidae</i>	<i>Polyarthra vulgaris</i>	
		<i>Synchaeta sp</i>	
	<i>Philodinidae</i>	<i>Philodina citrine</i>	
Cladocera (8)	<i>Testudinellidae</i>	<i>Filinia longiseta</i>	
	<i>Daphnidae</i>	<i>Daphnia pulex</i>	
		<i>Daphnia carinata</i>	
		<i>Monia micrura</i>	
		<i>Monia brachiata</i>	
	<i>Bosminidae</i>	<i>Bosmina longirostris</i>	
	<i>Chydoridae</i>	<i>Alona pulchella</i>	
		<i>Alona intermedia</i>	
		<i>Alonella. Sp</i>	
	Copepoda (5)	<i>Diaptomidae</i>	<i>Cyclopoid copepodite</i>
			<i>Diaptomus pallidus</i>
		<i>Cyclopidae</i>	<i>Cyclops sp</i>
		<i>Mesocyclops sp</i>	
		<i>Nauplius larva</i>	
	<i>Cyprididae</i>	<i>Cypris sp</i>	
Ostracoda (2)		<i>Stenocypris sp</i>	
	<i>Parameciidae</i>	<i>Paramecium caudatum</i>	
Protozoa (3)	<i>Vorticellidae</i>	<i>Vorticella campanula</i>	
		<i>Epistylis sp</i>	
Crustacea (7)		<i>Chironimid larva</i>	
		<i>Damselfly nymph</i>	
		<i>Dragonfly nymph</i>	
		<i>Mayfly nymph</i>	
		<i>Mosquito larva</i>	
		<i>Stonefly nymph</i>	
		<i>Water beetle</i>	
Fish larvae (2)		Fish larvae and eggs	

Table 3: Monthly variation of zooplankton density (No./ Lit) the mean and standard deviation value of three stations at Thandava reservoir

Group/ Months	Rotifera	Cladocera	Copepoda	Ostracoda	Protozoa	Crustacea	Fish larvae and eggs
Nov-15	132.56 ± 9.74	128.22 ± 8.12	118.47 ± 6.35	104.79 ± 5.62	076.22 ± 8.22	114.44 ± 7.75	25.35 ± 3.54
Dec-15	156.05 ± 11.56	131.14 ± 6.94	122.81 ± 8.48	107.53 ± 5.11	081.39 ± 4.55	085.76 ± 8.65	17.25 ± 2.55
Jan-16	164.27 ± 10.24	142.24 ± 8.32	137.25 ± 5.96	101.75 ± 7.58	085.56 ± 6.47	084.50 ± 5.77	14.11 ± 4.62
Feb-16	176.22 ± 14.58	147.10 ± 7.16	142.22 ± 6.42	115.55 ± 9.42	112.55 ± 10.23	076.25 ± 6.45	16.15 ± 3.22
Mar-16	201.65 ± 23.32	152.15 ± 7.65	157.34 ± 7.35	122.62 ± 10.31	122.33 ± 12.32	058.36 ± 5.55	12.25 ± 2.45
Apr-16	232.45 ± 18.85	168.78 ± 8.46	184.33 ± 5.84	134.35 ± 8.96	128.25 ± 9.57	052.54 ± 5.63	09.65 ± 2.44
May-16	281.21 ± 22.54	173.65 ± 11.22	188.62 ± 9.42	145.22 ± 12.48	131.82 ± 11.46	049.25 ± 6.35	10.48 ± 2.12
Jun-16	251.26 ± 21.52	161.33 ± 14.12	142.22 ± 9.12	133.44 ± 8.22	075.21 ± 7.74	096.21 ± 6.45	46.32 ± 2.36
Jul-16	221.33 ± 16.35	152.16 ± 9.76	133.46 ± 7.63	124.52 ± 11.54	086.45 ± 9.23	115.83 ± 10.44	52.22 ± 2.12
Aug-16	214.62 ± 18.21	133.66 ± 11.46	129.58 ± 8.11	114.55 ± 7.65	092.23 ± 5.34	116.36 ± 8.44	42.34 ± 2.22
Sep-16	186.32 ± 11.46	126.23 ± 14.95	122.66 ± 8.67	121.22 ± 5.32	106.51 ± 8.24	123.25 ± 6.33	34.50 ± 3.12
Oct-16	182.33 ± 15.67	119.41 ± 8.45	102.54 ± 5.59	115.45 ± 6.41	085.62 ± 6.66	128.55 ± 9.56	22.25 ± 4.33

S1: Jalaripeta, S2: Gadampalem, S3: Ammapeta

Table 4: Group wise percentage of zooplankton diversity in Thandava Reservoir

Group	Rotifera	Cladocera	Copepoda	Ostracoda	Protozoa	Crustacea	Fish larvae and eggs
Number of organisms	2400.27	1736.07	1681.5	1440.99	1184.14	1101.3	302.87
Percentage (%)	24.38	17.63	17.08	14.63	12.03	11.18	3.08

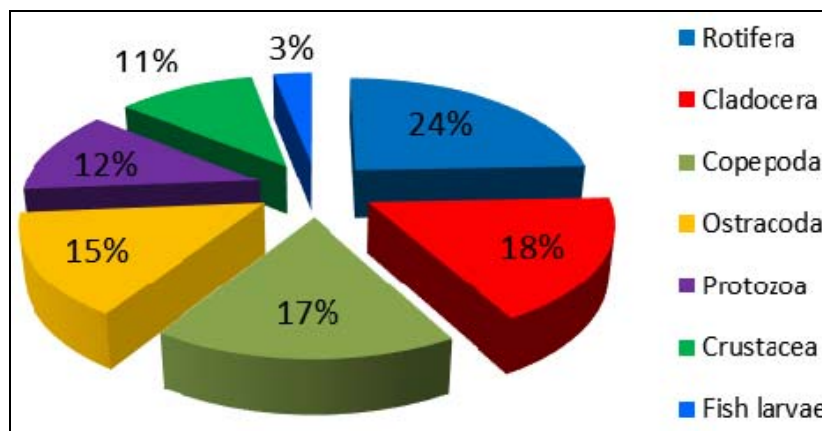


Fig 2: Percentage of group wise zooplankton diversity

Table 5: Monthly variations of zooplankton species density in Thandava Reservoir

Month	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Density	700.05	709.93	729.68	786.04	826.70	910.35	980.25	905.99	885.97	843.34	820.69	756.15
%	7.11	7.21	7.41	7.98	8.40	9.24	9.96	9.20	9.00	8.56	8.33	7.68
Sps.	31	27	24	26	28	32	31	31	30	28	28	29

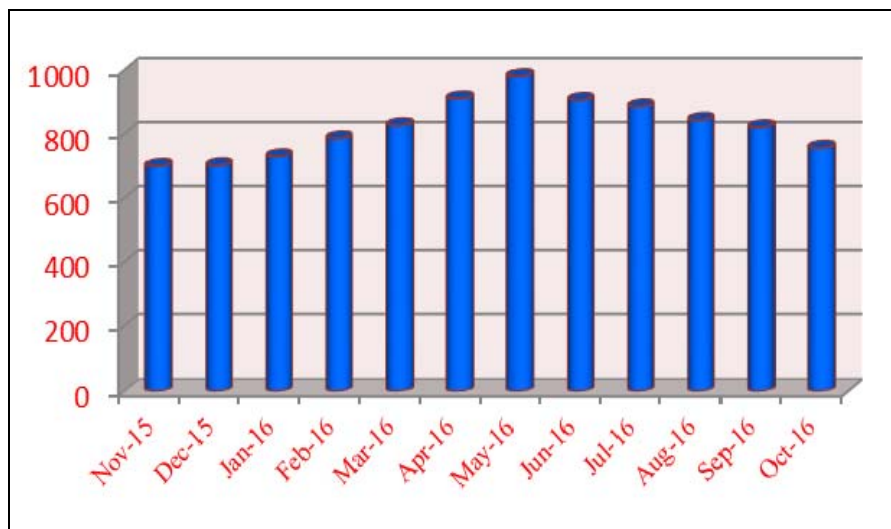


Fig 3: Monthly variation of zooplankton density

Table 6: Group wise seasonal mean diversity of zooplankton in Thandava reservoir

Group	Seasons						Total
	Monsoon	%	Winter	%	Summer	%	
Rotifera	873.53	36.39	635.21	26.46	891.53	37.14	2400.27
Cladocera	573.38	33.03	521.01	30.01	641.68	36.96	1736.07
Copepoda	527.92	31.40	481.07	28.61	672.51	39.40	1681.50
Ostracoda	493.73	34.26	429.52	29.81	517.74	35.93	1440.99
Protozoa	360.40	30.44	328.79	27.77	494.95	41.80	1184.14
Crustacea	451.65	41.01	413.25	37.52	236.40	21.47	1101.30
Fish larvae	175.38	57.91	078.96	26.07	048.53	16.02	302.87

Monsoon: Rotifera > Cladocera > Copepoda > Ostracoda > Crustacea > Protozoa > Fish larvae and eggs

Winter: Rotifera > Cladocera > Copepoda > Ostracoda > Crustacea > Protozoa > Fish larvae and eggs

Summer: Rotifera > Copepoda > Cladocera > Ostracoda > Protozoa > Crustacea > Fish larvae and eggs

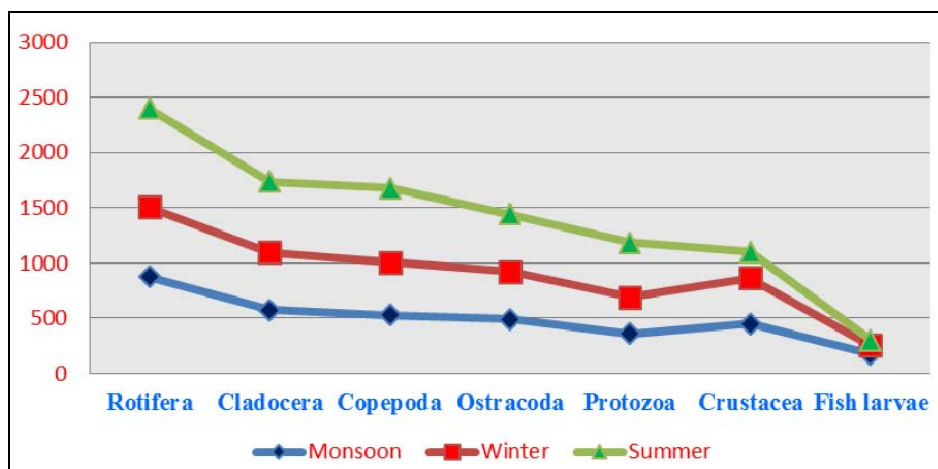


Fig 4: Group wise seasonal diversity

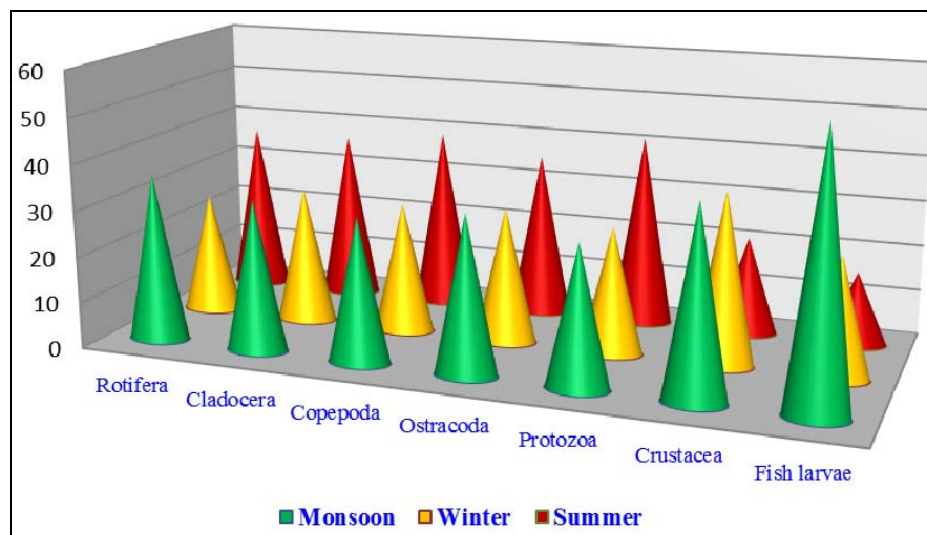


Fig 5: Group wise percentage of seasonal diversity

Table 7: Seasonal mean diversity of zooplankton in Thandava reservoir during

Group	Monsoon	%	Winter	%	Summer	%
Rotifera	873.53	25.28	635.21	21.99	891.53	25.45
Cladocera	573.38	16.59	521.01	18.04	641.68	18.32
Copepoda	527.92	15.28	481.07	16.66	672.51	19.20
Ostracoda	493.73	14.29	429.52	14.83	517.74	14.78
Protozoa	360.40	10.43	328.79	11.39	494.95	14.13
Crustacea	451.65	13.07	413.25	14.31	236.40	6.75
Fish larvae	175.38	5.08	078.96	2.34	048.53	1.39
Total	3455.99		2887.81		3503.34	

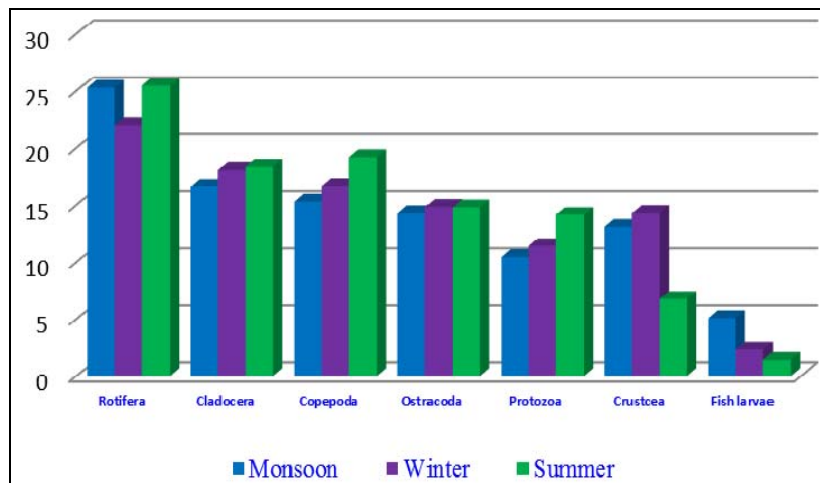


Fig 6: Seasonal mean diversity of zooplankton

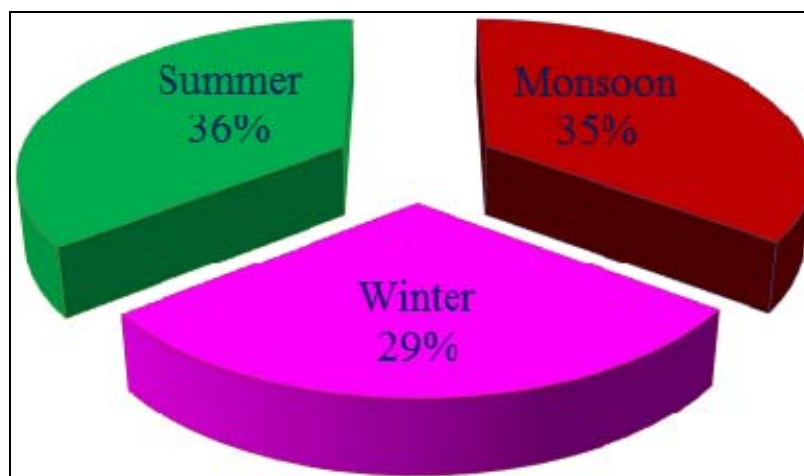


Fig 7: Seasonal diversity of zooplankton

Table 8: Shannon-Wiener diversity index of Zooplankton at Thandava Reservoir

Month/ Diversity Index	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16
H= Shannon-Wiener Index	1.88	1.84	1.83	1.83	1.79	1.76	1.72	1.84	1.88	1.86	1.88	1.84
H _{max} = Max. diversity possible	3.43	3.30	3.18	3.26	3.33	3.47	3.43	3.43	3.40	3.33	3.33	3.37
E = Evenness	0.55	0.56	0.58	0.56	0.54	0.51	0.50	0.54	0.55	0.56	0.57	0.55
S= sps. richness	31	27	24	26	28	32	31	31	30	28	28	29

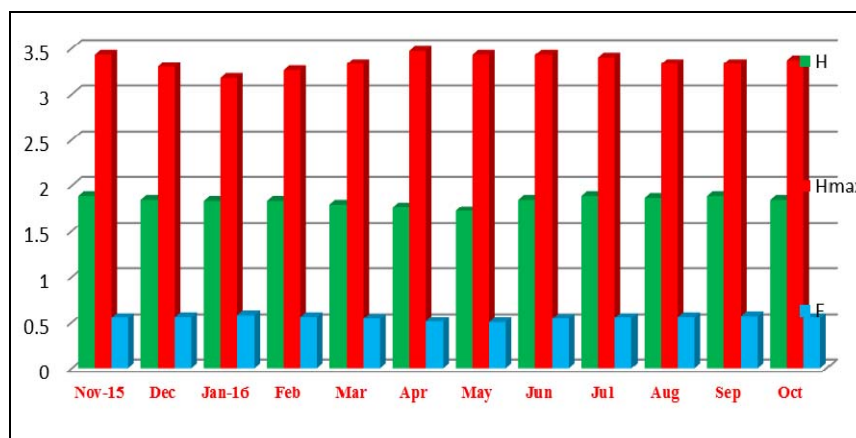


Fig 8: Shannon-Wiener diversity index

Table 9: Season wise Shannon-Wiener diversity index

Biodiversity Index	Monsoon	Winter	Summer
H= Shannon-Wiener Index	2.52	2.51	2.47
H _{max} = Maximum diversity possible	2.49	2.57	2.64
E = Evenness	1.01	0.98	0.94
S= species richness	12	13	14

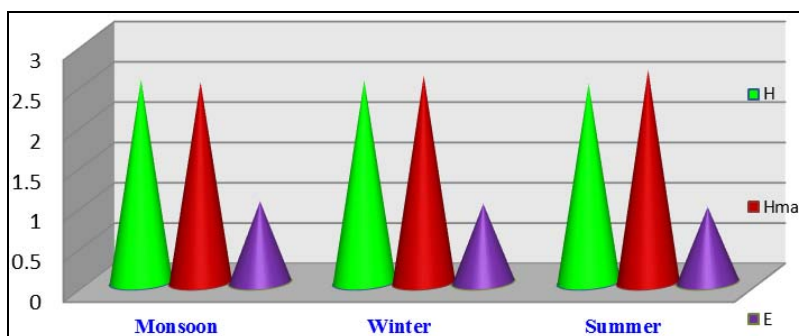


Fig 9: Season wise Shannon-Wiener diversity index

Table 10: Margalef’s richness index of Zooplankton diversity at Thandava Reservoir

Group/ Months	Rotifera	Cladocera	Copepoda	Ostracoda	Protozoa	Crustacea	Fish larvae and eggs
Nov-15	2.46	0.82	0.42	0.22	0.23	0.63	0.31
Dec-15	1.98	0.82	0.42	0.21	0.23	0.45	0
Jan-16	1.57	1.01	0.20	0	0.23	0.45	0
Feb-16	1.75	1.00	0.20	0	0.21	0.46	0.36
Mar-16	2.07	0.96	0.40	0.21	0.21	0.25	0
Apr-16	2.39	1.37	0.58	0.21	0.21	0.25	0
May-16	2.31	1.16	0.19	0.20	0.41	0.26	0
Jun-16	1.81	0.98	0.40	0	0.46	0.88	0.27
Jul-16	2.04	0.80	0	0	0.45	1.05	0.25
Aug-16	1.86	0.82	0	0	0.22	1.05	0.27
Sep-16	1.53	0.62	0.21	0.21	0.43	1.04	0.28
Oct-16	1.92	0.84	0.43	0	0.23	0.82	0.32

4. Discussion

The physico-chemical parameters variations were found during the study period at three selected sites at different seasons of Thandava reservoir. Sehgal. K. *et al* [12] reported the similar results in different seasons in the selected Dimbhe reservoir. The physico-chemical parameters of zooplankton communities together form a comprehensive ecosystem and there is interaction between the zooplankton and phytoplankton. These interactions are directly or indirectly subjected to the complex influences [13-16].

In the present work, we provide quantitative information on the diversity of zooplankton from Thandava reservoir, a study was conducted by Basawarajeshwari *et al* [17] and they have recorded 23 genera of zooplankton, of which 13 genera belong to rotifera, 5 genera belong to cladocera, 4 genera belong to copepod and 2 genera were belong to ostracoda. Among zooplankton, particularly rotifer was the dominant group throughout the study period and highest count was recorded in the northeast monsoon season, followed by summer and winter season. This pattern is common in lakes, ponds, reservoirs and rivers [18]. George [19] and Adoni [8] also reported maximum of zooplankton population during summer. Similar results have also been reported to various seasonal fluctuation of zooplankton at various water bodies at different districts in India [20- 22].

Rajkumar T. Pawar [19] studied a total of 23 species were found in Majalgaon reservoir, among these, rotifers comprise of 8 species (28.92%), Cladocera 6 (19.638%), Copepods 5 (20.09%), Ostracoda 2 (19.317%) and Protozoa 2 (12.02).

The season wise zooplankton analysis showed that the number of population was highest during summer, followed by monsoon and lowest during winter. In the present study the average group of organisms at three stations were more similar except fish larvae and eggs. Khare [14] observed an increasing trend in the months of winter season with peak during summer months - March to June.

In the present study the Shannon -Wiener diversity index (H) represented that 1.88 maximum during Nov 2015 and May2016, minimum 1.72 in May 2016. The season wise diversity index (H) resulted 2.52 in monsoon, 2.51 in winter and 2.47 in summer season at all three stations. H represents the moderate water quality in the Thandava reservoir. In Shannon Wiener legislation, the aquatic environment (soil/water) is classified as – very good when H’ is > 4, good quality 4- 3, moderate quality 3-2, poor quality 2-1 and very poor quality <1. A scale of pollution in terms of species diversity (3.0-4.5 slight, 2.0-3.0 light, and 1.0-2.0 moderate and 0.0 - 1.0 heavy pollution) has been described by Staub *et al.* [23]. Ashutosh mishra *et al* [24] reported that the Margalef and Menhinik richness indices maximum in March, 2007 in Dhaura and November, 2006, Shannon’s diversity index was in November and October, 2006. The Margalef and Menhinick richness indices ranged from 1.132 to 1.924 and from 0.0145 to 0.0203, respectively which indicate moderate richness of the organisms. Margalef’s richness index (R1) was represented as the maximum rotifera diversity 2.46 in Nov 2015 and minimum 1.53in Sep 2016 which indicate moderate richness of the organisms.

5. Conclusion

In the present investigation the seasonal variation in the diversity and distribution of zooplankton at Thandava reservoir in all seven 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 Margalef's richness index (R1) biodiversity indices has been indicated that the zooplankton was evenly distributed and moderate richness of the organisms in all seasons in Thandav reservoir. It provides more information than simply the number of species present in three stations by revealing the abundance of common species in different seasons.

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7. References

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