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Seasonal Investigation of Zooplanktonic Diversity in Morvan Dam (Neemuch District), India

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Abstract: An attempt has been made to investigates the Zooplanktonic diversity at the three selected station (station I, II and III)of Morvan dam (Neemuch District), M.P., India through seasonal surveys *viz*; Winter, Summer and Monsoon, during two annual cycle 2010-11 and 2011-2012. The study reveals the occurrence of Protozoans, Rotifers, Cladocerans, Copepods and Ostracods among the zooplanktonic groups of species however, the Rotifers exhibits the numerical dominance among the zooplanktons in all the three selected station of Morvan dam, followed by Cladocerans, Protozoans, Copepods and Ostracods. The seasonal variation in Zooplankton density at station I, station II and station III were ranges between 110 to 155/l, 104 to 138/l and 113 to 144/l respectively during 2010-12. The zooplankton diversity index (based on the Menhinick's index) for the station I, station II and station III of Morvan dam were noticed as 2.441057739, 2.52545659 and 2.491327 respectively whereas, Overall, zooplanktonic diversity of Morvan dam were calculated as 4.30452.

Key words: Morvan Dam · Zooplanktonic Diversity · Rotifers And Menhinick's Index

INTRODUCTION

In natural conditions, the presence of planktonic organisms is related to the optimum ecological ranges that mainly dependent on abiotic environmental factors such as temperature, pH and oxygen concentration and; also on the biotic interactions among various organisms. Zooplankton community is found to be one of the most important components of aquatic systems. It helps in the formation of trophic interrelationships and self-purification processes in aquatic bodies [1, 2]. Zooplanktons are a vital component of freshwater aquatic bodies and were found to be the first biological communities that illustrate the environmental changes towards their immediate habitat [3]. Zooplanktonic species was reported as ecological indicators of aquatic systems and its abundance, biomass and species diversity are used to determine the quality of aquatic systems [4].

Zooplanktonic species mainly consists of rotifers, cladocerans, copepods and ostracods and are found to be most important from population density, biomass production, grazing and nutrient regeneration point of view, in any aquatic habitates. The Zooplanktonic diversity and density is mainly depends upon availability of food and favourable water quality [5]. Zooplanktons in tropical aquatic bodies are mainly consists of Protozoa, Crustacea and Rotifera. However, the plankton's group crustacea includes the orders Copepoda, Cladocera and Ostracoda [6]. Zooplanktons are the intermediate link between phytoplankton and fish, which acts as the secondary producers in aquatic food chains. They are choice food of commercially important fishes and their juveniles. Therefore, the knowledge about freshwater zooplankton is very essential to understand trophic nature and energy transfer in wetlands [7]. Since, Zooplankton plays an important role in indicating the water quality of any aquatic bodies, because they are strongly affected by environmental profiles. In view of this, the attention has been focused on the Zooplanktonic diversity at the three selected station (station I, II and III) through seasonal surveys (Winter, Summer and Monsoon), along with correlation of various physicochemical profile in Morvan dam (Neemuch District), M.P., India during two annual cycle, 2010-11 and 2011-2012 to understand about its nutrient profile, trophic status to improve the quality of dam.

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MATERIALS AND METHODS

Study Area: The Morvan dam is constructed in 1960 and located in village Morvan belonging to Tehsil Jawad which is situated in Neemuch District of Madhya Pradesh with latitude: 27°-37'-06"N and longitude: 75°-03'-30"E. This is a stone masonry dam constructed on Gambhiri sub-river basin of Chambal. The length of the dam is 990 m and width is 12 m, while its total water holding capacity is 16.46 million m^3. Whereas, maximum depth and average depth of the dam were measured as 27.42 m and 13 m, respectively. The water spread area and catchment area of dam is 3.21km^2 and 62.16 km^2 respectively with an average rain fall of 760 mm. This dam is important since it provides drinking water and irrigation facilities to many villages. It covers 267100 ha of total irrigation area. Therefore this dam assures three important benefits as irrigation, drinking water supply and fish production.

Sampling Stations and Plankton Analysis: There are three sampling stations were selected in the Morvan dam (Station-I, II and III). The plankton samples were collected from all the three sampling stations using Hensen's Standard Plankton net made up of bolting silk no. 25. For quantitative estimations: 50 liters of surface water was filtered through small plankton net. Sub sample of small quantities (10 ml) were taken and counting of plankton was done in counting chamber under a C.Z. inverted microscope. Zooplankton numbers were expressed as individuals per liter and were preserved in 70% alcohol. The number of zooplankton were estimated by using following formula:

$$\text{Zooplankton} = A \times (B/C \times 1/d) \times 10$$

where,
A = Total number of individuals (in observed strips).
B = Volume of sample in cell.
C = Volume of observed strips.
d = Concentration factor.

Qualitative analysis of plankton samples were done by standard methods [8-11].

Biodiversity: Biodiversity of zooplankton have been studied using Menhinick's index [12] which was calculated by the following formula:

Menhinick's Index:

$$D = S \sqrt{N}$$

where,
D = Menhinick's index,
S = Total number of species,
N = Total number of organisms

RESULTS AND DISCUSSION

Results of the present investigation has been summarized in various Table (1-8) and depicted by figure 1-3. Zooplanktonic diversity were analysed at the three selected station (station I, II and III) in different seasons *viz*; Winter, Summer and Monsoon of Morvan dam (Neemuch District), M.P., during two annual cycle (2010-11 and 2011-2012) which are depicted by Table 1. There are diverse taxonomic groups of zooplankton representing Protozoa, Rotifera, Cladocera, Copepoda and Ostracoda has been analysed in Morvan dam.

Station I: In present investigation, 7 forms of protozoans (5 families), 23 form of Rotifers (8 families), 22 forms of Cladocerans (7 families), 9 forms of Copepodas (3 families). However, there are 3 forms of Ostracoda were also noticed (Table 1).

The percentage compositions of zooplankton at station I of Morvan dam were noticed as following (Figure 1).

Rotifers (39.56%) > Cladocerans (34.15%) > Protozoans (11.86%) > Copepods (7.47%) > Miscellaneous (3.87%) > Ostracods (3.09%)

The biological diversity (based on Menhinick's index) at station I of Morvan dam were also calculated (Table 5) whereas, the zooplankton diversity index for the station I of Morvan dam was estimated to be 2. 441057739 (Table 8). The rotifers were found to be dominant among the zooplankton followed by cladocerans and protozoans.

Station II: At station II of Morvan dam, there are 7 forms of protozoans (5 families), 26 forms of rotifers (8 families), 21 forms of cladocerans (7 families), 7 forms of copepoda (3 families) and 3 forms of ostracoda were analyzed (Table 1). However, zooplankton like *Nauplii*, insects and their larvae, mites and spiders were also noticed occasionally from station II of Morvan dam.

Table 1: List of Zooplankters occurred at three stations of Morvan dam during 2010-12

		Station I						Station II						Station III					
		2010-11			2011-12			2010-11			2011-12			2010-11			2011-12		
No.	Name of Zooplankter	W	S	M	W	S	M	W	S	M	W	S	M	W	S	M	W	S	M
	Protozoa																		
	Sub phylum – Sarcomastigophora, Super class – Mastigophora																		
	Class – Phytomastigophora, Order – Volvocida																		
	Family – Volvocacae																		
1	*Volvox**	3	4	6	5	5	3	3	–	5	4	–	2	4	5	–	6	–	2
	Family – Nebelidae																		
	Euglenidae																		
2	*Euglena acur*	–	–	5	–	–	4	–	2	–	2	3	–	–	–	5	4	6	–
3	*Euglena* sp.	4	–	4	–	3	5	2	4	–	–	4	3	3	–	–	–	4	–
	Class – Rhizopodea, Order – Amoebida																		
4	*Amoeba* sp.	–	3	–	4	5	–	2	4	–	2	–	5	–	6	–	3	–	5
	Sub–phylum Ciliophora, Class – Ciliata																		
	Family – Paramecidae																		
5	*Paramecium* sp.	–	2	–	2	4	–	–	–	–	2	3	–	5	–	4	–	3	–
	Order – Peritricha, Family – peridiniaceae																		
6	*Peridinium* sp.	3	4	–	3	–	–	5	4	–	3	3	4	–	5	–	2	–	–
	Family – Frontonida																		
7	*Phacus* sp.	2	–	1	1	3	4	–	–	2	2	4	–	4	–	5	–	3	5
	Rotifera																		
	Family – Brachionidae																		
8	*Brachionus angularis*	3	–	5	–	–	6	–	–	–	7	2	–	4	–	4	6	–	6
9	*Brachionus calyciflorus*	4	3	4	–	5	–	3	5	–	–	4	4	5	3	–	–	5	4
10	*Brachionus diversicornis*	–	4	5	3	–	4	–	6	3	–	–	–	–	–	5	–	–	7
11	*Brachionus monospina*							5	–	–	–	–	–	–	–	–	6	–	–
12	*Brachionus falcatus*	–	4	3	4	–	5	–	–	4	–	–	6	–	–	–	–	6	5
13	*Brachionus forficula*	4	5	4	–	6	–	–	5	3	–	6	5	4	6	–	–	–	–
14	*Brachionus caudatus*	–	4	2	–	5	3	5	–	3	4	–	4	–	–	5	–	5	4
15	*Brachionus bidentata*	–	–	5	–	–	–	–	6	–	–	–	5	6	–	–	–	–	–
16	*Keratella tropica*	3	5	4	5	–	3	–	4	6	5	–	–	4	–	3	5	7	6
17	*Keratella tropica heterospina*	3	3	–	4	3	–	5	–	–	4	–	4	–	3	4	–	–	–
18	*Keratella cochleris*	–	–	5	3	–	5	4	–	–	5	7	5	–	–	–	4	–	–
19	*Lopocharissalpina*							6	–	–	–	–	–	5	–	–	–	–	–
20	*Mytilina ventralis*	–	–	3	4	–	5	–	–	–	3	–	3	–	–	3	4	–	5
21	*Anuraeopsis* fissa	–	5	4	–	6	–	7	5	6	–	–	4	–	5	–	–	5	6
	Family – Lecanidae																		
22	*Monostyla bulla*	4	–	–	5	7	6	5	6	4	5	6	–	7	–	5	–	6	7
23	*Monostyla lunaris*							–	3	–	–	4	3	–	3	–	–	–	–
	Family – Calurinae																		
24	*Lepadella ovalis*	–	–	3	4	–	5	–	2	4	–	3	4	–	–	3	–	6	–
25	*Lepadella patella*	–	–	–	–	4	3	–	–	–	2	4	–	–	–	–	–	–	–
	Family – Trichocercidae																		
26	*Tricocerca cylindrico*	–	3	4	–	5	–	4	–	–	–	–	–	–	3	–	–	–	–
27	*Tricocerca longiseta*	3	–	3	–	5	3	–	–	–	2	5	–	6	–	–	–	6	–
	Family – Asplanchnidae																		
28	*Asplanchna brightwelli*	5	5	2	–	–	4	–	–	5	2	–	4	–	5	–	5	–	–
	Family – Synchaetidae																		
29	*Polyarthra vulgaris*	–	3	2	–	6	3	–	–	–	2	–	3	–	–	–	3	–	4
	Family – Testudinellidae																		
30	*Filinia longiseta*	–	4	–	3	–	–	4	3	–	–	–	–	4	6	–	4	6	5
31	*Testudinella patina*	2	–	2	–	4	3	–	–	–	–	4	–	5	–	4	–	5	4

Table 1: Continued

No.	Name of Zooplankter	Station I						Station II						Station III					
		2010-11			2011-12			2010-11			2011-12			2010-11			2011-12		
		W	S	M	W	S	M	W	S	M	W	S	M	W	S	M	W	S	M
32	*Horellamira*	–	2	3	–	–	4	–	5	4	–	6	4	–	5	3	5	–	–
	Family – Hexarthridae																		
33	*Hexarthramira*	–	3	2	–	5	–	–	–	6	–	–	–	–	7	–	–	–	–
	Cladocerans – Family – Sididae																		
34	*Diphonosomabrachyurum*	5	4	–	3	1	3	5	6	–	7	–	6	5	7	–	6	–	5
35	*Diphonosomasarsi*							4	–	3	–	2	–	–	–	4	–	–	–
	Family – Daphnidae																		
36	*Ceriodaphniarigaudi*	7	4	2	6	3	2	4	–	5	6	4	7	6	–	–	6	4	–
37	*Ceriodaphnialaticaudata*	–	–	–	1	–	4	–	–	–	–	–	–	–	–	4	–	–	5
38	*Daphnia lumholtzi*	2	–	–	3	4	–	7	3	–	–	–	–	5	6	–	–	–	–
39	*Daphnia ambigua*	7	3	4	6	5	2	5	4	–	5	–	–	–	–	–	–	–	–
40	*Daphnia dubia*	3	–	–	–	–	–	–	–	3	–	–	–	–	–	–	5	–	4
41	*Simocephalusvetulus*	–	2	–	4	3	–	4	–	–	–	5	–	4	–	5	–	4	3
42	*Scapholeberiskingi*	4	–	3	–	–	2	–	–	–	3	–	–	–	4	–	4	5	–
	Family – Moinidae																		
43	*Moinamicrura*	4	–	–	–	3	–	–	–	4	–	–	–	–	4	3	–	–	–
44	*Moinamacrocopa*	–	3	3	5	–	4	3	5	–	4	–	–	6	–	–	–	–	5
45	*Moinarosea*	3	–	2	4	3	–	3	–	–	5	4	5	–	–	5	–	4	–
	Family – Bosminidae																		
46	*Bosminopsisdeitersi*	5	2	–	5	2	–	–	–	–	–	–	–	–	–	–	–	6	–
47	*Bosminalongirostris*	7	3	3	4	–	3	–	–	–	6	–	–	4	–	–	–	5	–
48	*Bosminacoregoni*	5	2	4	6	3	–	5	3	5	3	–	4	–	7	5	–	–	6
	Family – Macrotpricidae																		
49	*Macrothrixrosea*	5	–	3	3	3	–	–	–	4	–	–	–	5	4	–	5	–	–
	Family – Chydoridae																		
50	*Chydorusgibbus*	–	1	2	4	–	2	4	5	–	4	5	3	–	–	5	3	–	5
51	*Chydorussphaericus*	6	–	–	5	2	4	3	4	–	3	–	–	6	–	4	–	–	2
52	*Chydorusovalis*	–	–	–	–	3	2	3	–	4	5	4	–	–	–	5	5	–	–
	Sub Family – Aloninae																		
53	*Alonellaglobulosa*	–	–	2	2	1	–	3	–	–	–	–	–	–	–	–	–	–	–
54	*Alonella nana*	5	3	–	–	4	–	4	3	–	–	3	–	–	4	–	–	5	–
55	*Alonellaglobosa*	–	–	3	3	1	–	–	–	5	–	4	3	5	–	–	6	–	5
56	*Alonelladentifera*	3	–	–	–	2	1	–	2	–	4	–	2	3	–	–	–	4	–
	Order – Anostraca																		
	Phylum – Arthropoda																		
	Class – Crustacea																		
	Sub–class – Calanoida																		
	Order – Calanoida																		
	Family – Diaptomidae																		
57	*Heliodiaptomusviddus*	5	3	2	2	–	2	3	4	–	2	–	5	6	3	4	–	4	–
58	*Phyllodiaptomus*	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–
59	*Rhinediaptomus*	–	–	–	–	2	–	–	–	2	–	–	–	–	–	–	–	–	3
	Order – Cyclopoida, Family – Cyclopidae																		
60	*Cyclops leuckarti*	2	–	3	–	2	2	2	–	3	3	2	–	3	2	–	4	4	2
61	*Mesocylopshyalinus*	2	2	–	2	–	2	2	3	–	–	–	3	2	3	–	2	–	–
62	*Paracyclopsaffinis*	–	2	–	–	2	–	–	–	–	–	–	–	–	–	2	–	–	–
63	*Microcyclops bicolor*	2	–	–	–	3	–	2	–	–	–	–	–	2	–	–	–	–	–
64	*Mesocyclopsleuckartii*	–	–	–	–	2	2	–	–	3	2	–	4	2	–	2	–	–	3
	Family – Canthocamptidae																		
65	*Nauplii*	2	2	1	3	1	–	–	–	2	–	3	2	1	–	2	–	–	3
	Ostracoda																		

Table 1: Continued

		Station I						Station II						Station III					
		2010-11			2011-12			2010-11			2011-12			2010-11			2011-12		
No.	Name of Zooplankter	W	S	M	W	S	M	W	S	M	W	S	M	W	S	M	W	S	M
66	*Heterocypris*	1	1	2	2	5	–	–	5	–	–	4	3	–	–	2	1	–	1
67	*Stenocypris*	–	2	–	–	2	3	5	–	2	4	–	–	2	1	–	3	2	3
68	*Eucypris*	3	–	–	2	1	–	–	2	1	3	–	–	5	3	3	–	1	–
	Arthropodainsecta																		
69	Insects				1		1	2	3	–	–	–	–	3	1	–	1	2	–
70	Insects larva	4	3	–	1	3	–	–	1	1	1	2	3	1	1	2	2	–	2
	Hemiptera																		
	Corixidae																		
71	Water mites	3	–	–	3	3	1	2	1	2	2	1	3	–	2	3	–	2	1
	Natonectidae																		
72	Arachnids water spiders	3	2	–	–	2	–	3	–	–	–	-	–	2	1	–	3	1	1

* = Considered both as phytoplankton as well as zooplankton but counting was made differently

Table 2: Seasonal variation in density of zooplanktonic groups (no. /l) at station I of Morvan dam during 2010 – 12

Year	Season	Protozoans	Rotifers	Cladoceras	Copepods	Ostracods	Insects	Misc.	Total Density
2010-11	Winter	12	31	71	13	4	4	6	141
	Summer	13	53	27	9	3	3	2	110
	Monsoon	16	65	31	6	2	0	0	120
2011-12	Winter	15	35	64	7	4	2	3	130
	Summer	20	61	43	15	8	3	5	155
	Monsoon	16	62	29	8	3	1	1	120

Table 3: Sesonal variation in density of zooplanktonic groups(no. /l) at station II of Morvan dam during 2010-12

Year	Season	Protozoans	Rotifers	Cladoceras	Copepods	Ostracods	Insects	Misc.	Total Density
2010-11	Winter	12	48	57	9	5	2	5	138
	Summer	14	50	35	7	7	5	1	119
	Monsoon	7	48	33	10	3	1	2	104
2011-12	Winter	15	41	55	7	7	1	2	128
	Summer	17	51	31	5	4	2	1	111
	Monsoon	14	58	30	14	3	3	3	125

Table 4: Sesonal variation in density of zooplanktonic groups (no. /l) at station III of Morvan dam during 2010-12

Year	Season	Protozoans	Rotifers	Cladoceras	Copepods	Ostracods	Insects	Misc.	Total Density
2010-11	Winter	16	50	49	16	7	4	2	144
	Summer	16	46	36	8	4	2	3	115
	Monsoon	14	39	40	10	5	2	3	113
2011-12	Winter	15	42	40	6	4	3	3	113
	Summer	16	57	37	8	3	2	3	126
	Monsoon	12	63	40	11	4	2	2	134

Table 5: Bio diversity of zooplanktonic groups Menhinick's index at station I of Dam

Year	Season	Protozoans	Rotifers	Cladoceras	Copepods	Ostracods	Insects	Misc.
	Winter	1.154700538	1.616447718	1.780172487	1.386750491	1	0.5	0.816496581
2010-11	Summer	1.109400392	1.923047895	1.924500897	1.333333333	1.154700538	0.577350269	0.707106781
	Monsoon	1	2.356659957	1.975658322	1.224744871	0.707106781	0	0
	Winter	1.290994449	1.521277659	2	1.133893419	1	1.414213562	0.577350269
2011-12	Summer	1.118033989	1.536442559	2.439977125	1.807392228	1.060660172	0.577350269	0.894427191
	Monsoon	1	1.905001905	2.04264872	1.414213562	0.577350269	1	1

Table 6: Biological diversity of zooplanktonic groups based on Menhinick's index at station II of Morvan dam.

Year	Season	Protozoans	Rotifers	Cladoceras	Copepods	Ostracods	Insects	Misc.
	Winter	1. 154700538	1. 443375673	1. 8543453	1. 333333333	0. 447213595	0. 707106781	0. 894427191
2010-11	Summer	1. 069044968	1. 555634919	1. 521277659	0. 755928946	0. 755928946	0. 894427191	1
	Monsoon	0. 755928946	1. 58771324	1. 392621248	1. 264911064	1. 154700538	1	0. 707106781
	Winter	1. 549193338	1. 717911381	1. 61807967	1. 133893419	0. 755928946	1	0. 707106781
2011-12	Summer	1. 212678125	1. 540308092	1. 436842416	0. 894427191	0. 5	0. 707106781	1
	Monsoon	1. 069044968	1. 83829006	1. 278019301	1. 069044968	0. 577350269	0. 577350269	0. 577350269

Table 7. Biological diversity of zooplanktonic groups based on Menhinick's index at station III of Morvan dam

Year	Season	Protozoans	Rotifers	Cladoceras	Copepods	Ostracods	Insects	Misc.
	Winter	1	1.414213562	1.42857142	1.5	0.755928946	1	0.707106781
2010-10	Summer	0.75	1.474419562	1.166666667	1.060660172	1	1.414213562	1.154700538
	Monsoon	0.801783726	1.601281538	1.423024947	1.264911064	0.894427191	0.707106781	0.577350269
	Winter	1.032795559	1.38873015	1.264911064	0.816496581	1	1.154700538	0.577350269
2011-12	Summer	1	1.324532357	1.315191898	0.707106781	1.154700538	0.707106781	1.154700538
	Monsoon	0.866025404	1.511857892	1.423024947	1.206045378	1	0.707106781	1.414213562

Table 8: Total diversity of Zooplanktonic groups based on Menhinick's index at station I, II and III of Morvan dam during 2010-12.

		2010-11			2011-2012				
Plankters	Station	Winter	Summer	Monsoon	Winter	Summer	Monsoon	Total	Over all diversity of Morvan dam
Zooplankton	I	3. 2001773	3. 432465321	3. 46890953	3. 332820473	3. 694808913	3. 377622438	2. 441057739	4. 30452
	II	3. 06452351	2. 841765341	2. 84368396	3. 181980515	2. 752558188	2. 862167011	2. 52545659	
	III	2. 83333333	2. 704263944	2. 82216260	2. 634018431	2. 583525338	2. 850765804	2. 491327	

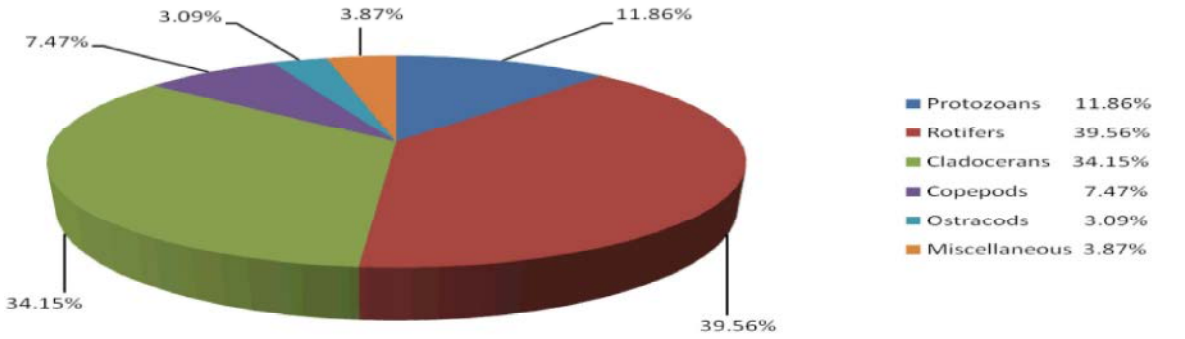

Fig. 1: Group-wise composition of zooplankton at station I of Morvan dam during 2010-12

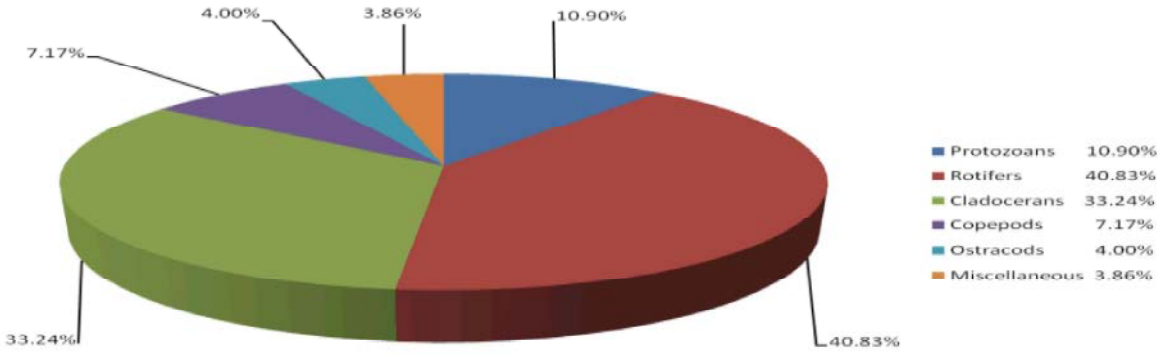

Fig. 2: Group-wise composition of zooplankton at station II of Morvan dam during 2010-12

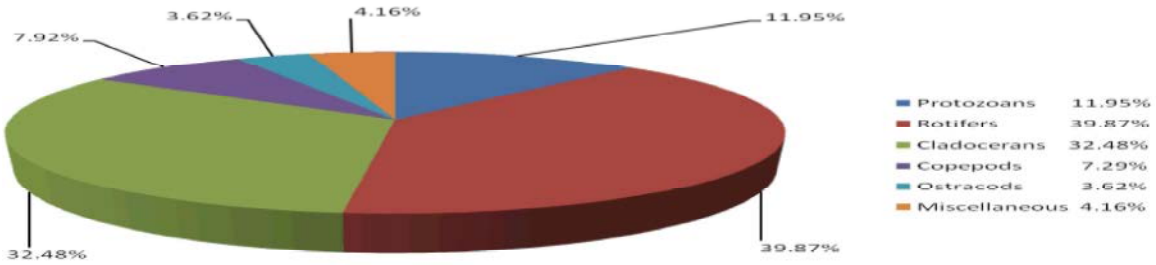

Fig. 3: Group-wise composition of zooplankton in station III of Morvan dam during 2010-12

The percentage compositions of zooplankton at station II of Morvan dam were analyzed as following (Figure 2).

Rotifers (40.83%) >Cladocerans (33.24%) > Protozoans (10.90%) > Copepods (7.17%) >Ostracods (4.00 %) > Miscellaneous (3.86 %).

The biological diversity (based on Menhinick's index) for station II of Morvan dam were also analyzed (Table 6). Furthermore, the zooplankton diversity index for the station II was calculated as 2.52545659 (Table 8). The dominant species were also rotifers followed by cladocerans and protozoans in the station II of Morvan dam.

Station III: In station III, there are 7 forms of protozoans (5 families), 25 forms of rotifers (8 families), 21 forms of cladocerans (7 families), 8 forms of copepoda (3 families) and 3 forms of ostracoda were estimated. However, some zooplankters like *Nauplii,* spiders and mites, insects and their larvae were also noticed at station III of Morvan dam (Table 1).

Following are the percentage composition of zooplankton summarized in station III of Morvan dam (Figure 3).

Rotifers (39.87%) >Cladocerans (32.48 %) > Protozoans (11.95%) > Copepods (7.92 %) >Miscellaneous (4.14 %) >Ostracods (3.62 %).

The biological diversity, based on Menhinick's index (Table 7) and zooplankton diversity index for the station III were also estimated as 2.491327 (Table 8).

The Rotifers were also noticed as a dominant group among zooplanktons at station III of Morvan dam.

In present investigation, there are diverse taxonomic groups of zooplankton representing Protozoa, Rotifera, Cladocera, Copepoda and Ostracoda has been analysed in all the three selected station of Morvan dam during 2010-2012.

Protozoa: In present investigation, protozoans were represented by *Amoeba* sp., *Volvox* sp., Euglena acur, *Difflugia* sp., *Arcelladiscoida*, *Peridinium* sp., *Paramecium* sp. and *Phacus* sp. (Table 1). It has been reported that the protozoans are associated with high amount of organic matter which supply basic source of food [13, 14]. There are a *Euglena, Paramecium, Opercularia, Didinium*, *Vorticella* and *Epistylis* species were documented from Chandigarh industrial effluents [15].

Rotifers: Rotifers are reported to be good indicators of water quality. It has been noticed that they provides an important role as a major planktonic community in waters bodies of Madhya Pradesh [16].

In the present work, the most common species of family Brachionidae has been reported as *B. falcatus, B. calyciflorus, B. forficula* and *Keratella tropica* (Table 1). Similar literature about genus *Brachionus* has been also cited by Sharma and Durve [17], Saksena and Kulkarni [18], Singhal *et al.* [19] and Ali *et al.* [20]. There are a significant decreased in size of *Brachionus calyciflorus* has been noticed in polluted pond of Berach river [21]. The rotifers like *B. caudatus, B. forficula, B. diversicornis, B. angularis, B. falcatus, K. procurva, Keratella tropica, Polyarthra indica Trichotria* sp. and *Asplanchna periodontal* were also identified from Lony dam [16]. However, in Barwani (M.P.), there are a *B. calcyflaorus, B. caudatus, Hexarthra* sp., *Monostyla* sp. *Keratella* sp. and *Notholca* sp. has been reported [22].

Cladocerans: In present investigation Cladocerans were identified as *C. reticulata, C. lacustris, C. acanthine, C. laticaudata, D. brachyurum, C. rigaudi, D. lumholtzi, D. ambigua, D. dubia B. deitersi, B. coregoni, B. longirostrus, C. feviformis, C. sphaericus, C. gibbus, C. ovalis, L. quadrangularis*, *S. vetulus, A. guttata, A. nana, A. dentifera, M. macrocopa* and *M. rosea* (Table 1).

It has been noticed that the occurrence of cladocerans were more in eutrophic waters [23]. In India, theliterature on Cladocerans has been also cited by Michael and Sharma [24], Venkataraman and Das [25] and Sinha and Khan [26]. There are a diversity of cladocerans

has been reported in all littoral zones of lotic and lentic aquatic bodies [27]. The *Moina* are most tolerant Cladocerans species along with*Ceriodaphnia, Moina* and *Daphnia* in sewage polluted ponds [28]. However, the Cladocerans species such as *Ceriodaphnia cornuta, Diaphonosoma excisum, Bosmina longirostris, Bosminopsis deitersi, Sida crystallina, Chydorus sphaericus* and *Daphnia lumholtzi* has been reported from a fresh water pond developed by waste land of Brick-kiln [29]. There are a total of 16 species of cladocera have been identified among the three freshwater bodies (a fishpond, a forest pond and a village pond) in West Midnapore district (West Bengal, India) and dominant family were noticed as Chydoridae (56%) followed by Moinidae (19%). However, the cladoceran species diversity and presence of nutrients are found to be positively correlated [30].

Copepoda and Ostracods: In present study, the Copepods were indicated by both orders, Calanoida and Cyclopoida. However, the occurrence of calanoidsis comparatively more in oligotrophic and clear water bodies [14, 31] but occurrence of cyclops indicate oligotrophic conditions of the water bodies [32]. Furthermore, the dominance of cyclopswas documented more in eutrophic waters [7, 28]. An Ostracods were represented as *Centrocypsis, Heterocypris*, *Cyclocypris, Stenocypris* and *Eucypris* during present work.

Whereas in present investigation, the species which including rotifers were high as compared to Protozoa, Copepoda, Cladocera and Ostracoda. A simmilar results in context of dominance of rotifers has also been documented by Greenwald and Hurlbert [33], Sarwar and Parveen [34], Sarkar and Chaudhary [35], Park and Marshall [36], Halvorsen [37], Sharmaand Singh [38], Bhat *et al.* [39], Pateland Singh [40] and Hayrapetyan *et al.* [41]. Further, the various species of Rotifers, copepods, Cladocerans, protozoan and ostracods were reported during study of the zooplankton diversity in Powai reservoir, Mumbai [42].

In present investigation, the seasonal variation in Zooplankton density at station I of the Morvan dam were found to be ranges between 110 (Summer) to 141/l (Winter) and 120 (Monsoon) to 155/l (Summer)during 2010-11 and 2011-2012 respectively (Table 2). But, these values were fluctuated between 104 (Monsoon) to 138/l (Winter) during 2010-11 and 111(Summer) to 128/l (Winter) during 2011-12 at station II of theMorvan dam (Table 3). However, the seasonal variation in Zooplankton density at station III of theMorvan dam were noticed in the range of 113(Monsoon) - 144/l (Winter) and 113 (Winter) - 134/l (Monsoon) respectively during 2010-11 and 2011-2012 annual cycle (Table 4).

There are a highest density of zooplankton were noticed in the flooded Sambhar Lake during analysis of 27 water bodies which belongs to 14 districts of Rajasthan [17]. A total zooplankton density were estimated in the range from 19/l to 299/l in a high altitude oligotrophic reservoir at the Amarchand (District Rajsamand), Southern Rajasthan. However, there are a total 61 species of Protozoans were reported in five wetlands of Kashmir [14] and an Amoeba and *Volvox* were analyzed in Shiroli reservoir [43]. Further, the zooplanktonic density were analyzed in the range from 10/l to 329/l in sewage fed ponds of Calcutta [28] whereas it was ranges from 450/l to 996/l in a brick-kiln developed pond [29]. There are a 20 species of zooplankton were identified which belongs to Protozoa, Rotifera, Copepoda and Cladocera in Beehar River, Rewa [40] and 23 species of zooplankton has been noticed which belonged to 23 genera and 17 families of Rotifera, Cladoceraand Copepodain the arpa river, armenia [41]. Furthermore, it has been observed a total 81 species of zooplankton, which consists of Rotifera (63), Cladocera (15) and Copepoda (3), during analysis of species diversity and community structure of zooplankton in three different types of water body in Sakarya River Basin, Turkey [44]. There are a total 16 different species of zooplankton were analyzed in Saraswati and Shingoda River and dominant species were represented as *Calanopia minor, Acrocalanus gracilis, Pseudodiaptomus serricaudatus, Tortanus forcipatus, Copepod nauplii, Centropages tenuiremis* and *Tortanus barbatus*. In addition, Authors also analyzed the different physico-chemical profiles of Morvan dam such as air and water temperature, pH, total dissolved solids (TDS), dissolved oxygen, transparency, total alkalinity, total hardness, nitrate and phosphate and also correlated together during the years of 2010-2012 to improve the productivity of the dam from aquaculture point of view [45]. However, there are a 18 species of zooplanktons were noticed which consists of Protozoa Rotifera Cladocera Copepoda and Ostracoda in the number of 6, 4, 3, 4 and 1 in Rapti River at Gorakhpur, India [46]. There are also a total 24 species (8 genera) of zooplankton, including 6 genera of Protozoa (dominant) and 1 genus of Rotifera, were observed in Mixed Water of River Jhelum and Chenab at Head Trimmu (District Jhang, Punjab) Pakistan [47]. Furthermore, there are 18 zooplanktonic groups were recorded and Arthropoda was found to be dominant group which constitute 94.47% of zooplankton density

followed by Rotifera, Cnidaria and Annelida with 5. 00%, 0. 46% and 0. 07% respectively [48]. Whereas, there are a total 57 and 45 species of microzooplanktons were recorded at the two sites, Colva and Arossim (South Goa) respectively during the period of July to December, 2013 [49]. It has been reported a total 15 genera of Zooplankton in order abundance as Cladocera> Copepoda> Rotifera> Ostracoda from the fresh water Pampoo Pond of Madhupur, Jharkhand, India [50]. The crustacean (Copepoda and Cladocera) were recorded in the firstlake whereas Rotifers was found to be most dominant group in the second lake of Wadi El-Rayan [51]. The species composition for Copepoda, Decapoda, Rotifera, Ciliata, Foraminifera, CladoceraandCumacea were reported as 31, 10, 8, 7, 6, 5 and 2 respectively out of a total 69 species of zooplankton identified in the Great Vedaranyam Swamp of the Point Calimere Wildlife Sanctuary [52]. However, the maximum density were also contributed by Rotifers among zooplanktons followed by protozoa, Cladocera, Copepoda and Ostracoda in Maheshara Lake in Gorakhpur, India [53].

The species diversity of zooplankton is high in perennial water bodies illustrates about its low pollution status and therefore plays an important role in the stability of aquatic environment [54]. Eventually, it has been noticed that the results of the present investigation also exhibit conformities to the findings of previous authors that is, in context of seasonal zooplanktonic species diversity in various freshwater ponds.

CONCLUSIONS

Water bodies of three stations of Morvan dam harbour diverse taxonomic groups of zooplankton representing Protozoa, Rotifera, Cladocera, Copepoda and Ostracoda. Whereas, Rotifers were found to be dominant in all the selected three station of Morvan dam followed by Cladocerans, Protozoans, Copepods and Ostracods. Seasonal variation in zooplanktonic density revealed that summer months of the year 2011-12 exhibited highest density values, followed by winter of the year 2010-11. Since, Zooplanktons acts as a critical link between phytoplankton and higher consumers [55], therefore the study provides valuable information about quality of water bodies in context of Zooplanktonic species diversity to know about its nutrients profile, trophic status that help to design the formulation of management to improve the productivity of the dam by forthcoming researchers.

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