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Density and Diversity of Zooplankton in Ashtamudi estuary of Kerala, India

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***Abstract*-- The Thekkumbhagam creek of Ashtamudi estuary is facing the problem of degradation due to increasing eco-tourism ,domestic wastes industrial effluents, organic and agricultural wastes. The purpose of this work was to document the seasonal availability of the zooplankton population encountered in this creek during a study period of two years. The plankton samples were collected from selected four stations of the creek and were analysed following standard methods. The present analysis revealed that the Cladocerans exhibited the highest mean value during the monsoon period in station 1. Copepods attained its peak in station 1 during the pre-monsoon period. Station 3 exhibited the Rotifer peak during post monsoon period. Station 4 was dominated by Crustacean larvae during the pre- monsoon period. Protozoa exhibited its highest mean value during the post-monsoon period. Molluscs reached its maximum value during pre-monsoon period in station 4. Station 2 recorded the maximum mean value of Ostracods during pre-monsoon period. The evaluation of the dynamics of zooplankton population with remarkable seasonal variations is an effective and appropriate method of estimating the fishery potential of an area .So, there is an urgent need of first educating the people of the importance of the estuary than the laws could be effectively implemented.**

Key words - Cladocerans, Copepods, Rotifers, Protozoa, Ostracods

I. INTRODUCTION

Planktons are small organisms that constitute the basic link of the food chain of the aquatic system. Zooplanktons provides fish with nutrients, since fish requires proteins, fats, carbohydrates, mineral salts and water in the right proportion as they make up an invaluable source of protein, amino acids, lipids, fatty acids, minerals and enzymes and are therefore an inexpensive ingredient to replace fish meal for cultured fish (Fernando, 1994 and Kibria *et al*., 1997). The zooplankton study is of necessity in fisheries, aquaculture and paleolimnological research. They are also globally recognized as pollution indicator organisms in the aquatic environment. Therefore, plankton population observation may be used as a reliable tool for biomonitoring studies to assess the pollution status of aquatic bodies.

Zooplankton encompasses an array of macro and microscopic animals and comprises representatives of almost all major taxa particularly the invertebrates. They play a vital role in the marine food chain. The herbivores zooplankton feed on phytoplankton and in turn constitute an important food item to animals in higher trophic levels including fish. Zooplankton supports the economically important fish populations. They are the major mode of energy transfer between phytoplankton and fish. (Howick and Wilhm, 1984). The zooplankton in the surface water of a fresh water lake is those which are caught in a fine meshed net towed slowly through the water column and consists mainly of Protozoans, Rotifers, Cladocerans, Copepods and a great variety of larval forms(Odum,1971). Although zooplanktons are usually considered to be good indicators of environmental changes and have a fundamental role in energy flow and nutrient cycling in aquatic ecosystem. Zooplankton study is a prerequisite for water quality study since it forces for scientific research on the mechanism of eutrophication and its adverse impact on an aquatic ecosystem.

The nature and distribution of plankton varies considerably with respect to seasons and alterations in water quality. Their dominance also leads to qualitative changes of aquatic systems. Information pertaining to the nature, type and distribution of these organisms, provide clues regarding the prediction of water quality and the environmental conditions

prevailing in the habitat with respect to the fishery of the area. In the present chapter, seasonal variation and diversity of zooplankton community of four selected stations of Thekkumbhagam creek of Ashtamudi estuary had been discussed since it serves as ecological indicators of estuarine habitats.

II. MATERIALS & METHODS

Monthly collections of plankton samples were made from four selected stations for a period of two years from June 2008 to May 2010(Fig1).Water was collected from the surface early morning with minimal disturbances with a plankton net of mesh size of 55µ m (bolting silk no 25) and the planktons were then transferred to a storage bottle using 100 ml distilled water. The samples were immediately preserved in 5% formalin. Physicochemical analysis was done following standard methods APHA (1985).Drop count method was adopted for plankton's enumeration (Adoni, 1985Identification and enumeration were done with a compound microscope. Identification of planktons was done following Adoni (1985), APHA (1985), Prescott (1969,1982),Ward and Whipple(1992), Battish (1992).

III. RESULTS

In station 1, zooplankton ranged from 7 units /l to 5000 units/l in 2008-2009 and 14 units/l to 7000 units/l in 2009-2010. About 17 genera of zooplankton were recorded: 2 genera of Cladocera, 3 genera of Copepods, 3 genera of Rotifers 3, genera of Crustacean larvae, 2 genera of Protozoa, 2 genera of Molluscs, 1 genus of Bryozoa and Ostracod . Copepods found the dominant group (36.35%) followed by Protozoa (22.53%), Cladocera (22.49%), Rotifers (17.12%), Crustacean larvae (1.31%), Ostracods (0.14%), Bryozoa (0.04%), Molluscs (0.03%) in 2008-2009. Copepoda the dominant group (42.02%) followed by Cladocera (29.13%), Protozoa (16.2%), Rotifers (10.78%), Crustacean larvae (1.72%), Ostracods (0.08%), Molluscs (0.06%) in 2009-2010.The annual mean ± SE of Cladocera , Copepoda ,Rotifers, Crustacean larvae, Protozoa ,Molluscs ,Bryozoa and Ostracods were 775.25 ± 469.99,1252.92 ± 518.47, 590.25 ± 397.25, 45.08 ± 21.35, 776.5 ± 505.97, 1 ± 0.99, 1.25 ±1.25 and 4.75 ± 3.45 respectively in the first year and 846.08 ± 540.29, 1220.42 ±512.87, 313 ± 290, 50 ± 23.04, 470.5 ± 309.08, 2 ± 2, 0 and 2.67 ± 2.67 respectively in the second year. Besides this, insect larvae called Crane fly larvae, Annelid called *Chaetogaster langi* were also obtained from this station (Table 1,2,3,4,5, 6, 10, and Fig , 1a, 1b, 2a, 2b, 3a, 3b, 4a,4b,5a, 5b, 6a,6b, 7a, 7b, 8a, 8b, 9a, 9b).

In station 2, zooplankton ranged from 4 units /l to 4000 units/l in 2008-2009 and 5 units/l to 4000 units/l in 2009-2010. About 19 genera of zooplankton were recorded: 1 genus of Cladocera, 5 genera of Copepods, 4 genera of Rotifers, 3 genera of Crustacean larvae ,3 genera of Protozoa, 1 genus of Mollusc ,1 genus of Bryozoa and Ostracod . Rotifers found the dominant group (51.09%) followed by Copepods (43.28%), Crustacean larvae (2.47%), Cladocera (2.24%), Protozoa (0.85%), Bryozoa (0.04%), Molluscs (0.03%) in 2008-2009. Protozoa the dominant group (55.65%) followed by Copepoda (23.4%), Cladocera (11.43%), Rotifers (7.04%),Crustacean larvae (2.35%), Coelenterates (0.1%),Molluscs (0.03%) in 2009-2010.The annual mean ± SE of Cladocera , Copepoda ,Rotifers, Crustacean larvae, Protozoa ,Molluscs, Bryozoa and Ostracods were 43.08 ± 20.21, 769.5 ± 381.92, 431 ± 270.54, 78.5 ±28.97, 768.75 ± 305.41, 4.5 ± 1.98, 0.34 ± 0.33 and 1.5 ± 1.5 respectively in the first year and 922.5 ± 290.42, 629.5 ± 409.64, 189.25 ± 126, 63.33 ± 20.95, 1497.0 ±452.75, 0.75 ± 0.75, 429.17 ± 376.71 and 1891.61 ± 354.4 respectively in the second year. Besides all these, there were *Obelia medusae* of Coelenterate, *Nematode worm*, *Polychaete larvae*, *Oikopleura* species coming under chordate. (Table1, 2,4,5,7, 11& Fig 1a, 1b, 2a, 2b, 3a, 3b, 4a,4b,5a, 5b, 6a,6b, 7a, 7b, 8a, 8b, 9a, 9b).

In station 3, zooplankton ranged from 5 units /l to 4000 units/l in 2008-2009 and 12 units/l to 3000 units/l in 2009-2010. About 19 genera of zooplankton were recorded: 1 genus of Cladocera, 7 genera of Copepods, 3 genera of Rotifers, 3 genera of Crustacean larvae, 3 genera of Protozoa, 1 genus of Molluscs, 1 genus of Bryozoa. Copepoda found the dominant group (36.69%) followed by Protozoa (36.66%), Rotifers (20.55%), Crustacean larvae (3.74%), Cladocera (2.05%), Molluscs (0.21%), Ostracods (0.07%), Bryozoa (0.02%) in 2008-2009. Copepoda (51.35%) followed by Rotifers (38.1%), Cladocera (4.88%),Crustacean larvae (2.83%), Protozoa (2.65%), Insect larvae (0.16%) in 2009-2010.The annual mean ± SE of Cladocera, Copepoda ,Rotifers, Crustacean larvae, Protozoa ,Molluscs ,Bryozoa and Ostracods were 35.25 ± 17.97, 680.75 ± 415.48, 803.58 ± 430.87, 38.83 ± 19.21,13.34 ± 5.79, 0.42 ± 0.42, 0.67 ± 0.67 and 0 respectively in the first year and 33.33 ±20.32, 351 ± 242.21, 260.42 ± 249.1, 19.33 ± 5.46, 18.42 ± 5.73, 0, 0 and 1.09 ± 0.75 respectively in the second year. Besides all these may fly larvae, Spicules of sponges, *Polychaete worm*, *Turbellaria* etc were found in the station (Table1,2, 3,4,5,8, 12, & Fig , 1a, 1b, 2a, 2b, 3a, 3b, 4a,4b,5a, 5b, 6a,6b, 7a, 7b, 8a, 8b, 9a, 9b).

In station 4, zooplankton ranged from 9 units /l to 6000 units/l in 2008-2009 and 8 units/l to 2000 units/l in 2009-2010. About 18 genera of zooplankton were recorded: 1 genus of Cladocera, 6 genera of Copepods, 3 genera of Rotifers, 5 genera of Crustacean larvae, 1 genus of Protozoa, 1 genus of Molluscs, 1 genus of Bryozoa . Cladocera found the dominant group (59.63%) followed by Rotifers (20.31%), Copepoda (11.52%), Crustacean larvae (7.41%), Molluscs (0.61%), Protozoa (0.48%), Bryozoa (0.03%) in 2008-2009. Cladocera formed the dominant group (30.46%),Protozoa (22.03%), Copepoda (19.23%), Crustacean larvae (16.09%), Rotifers (7.8%), Phyllopoda (2.86%), Molluscs (1.44%) in 2009-2010.The annual mean ± SE of Cladocera , Copepoda, Rotifers, Crustacean larvae, Protozoa, Molluscs, Bryozoa and Ostracods were 523.25 ± 337.93, 634.92 ± 308.74, 20.42 ± 3.78, 152.17 ± 40.97, 9.92± 5.18, 12.59 ± 5.69,0,0 respectively in the first year and 33.33 ± 20.32, 351 ± 242.21,260.42 ± 249.1, 19.33 ± 5.46, 18.42 ± 5.73, 0, 0 and 1.09 ± 0.75 respectively in the second year. Besides all these may fly larvae, Spicules of sponges, Polychaete worm,

Turbellaria etc were found in the station (Table1,2,3,4,5, 9, 13, & Fig , 1a, 1b, 2a, 2b, 3a, 3b, 4a,4b,5a, 5b, 6a,6b, 7a, 7b, 8a, 8b, 9a, 9b).

TABLE 1
Abundance of zooplankton genera at the stations (2008-2010)

Sl no:	Zooplankton	Station 1	Station 2	Station 3	Station 4
	Cladocerans				
1	*Daphnia*	+	+	+	+
2	*Diaphanosoma*	+	-	-	-
	Copepods				
3	*Harpacticoid*	-	+	+	+
4	*Pseudocalanus*	-	-	+	-
5	*Calanus*	-	-	+	+
6	*Eucalanoid*	+	-	+	-
7	*Paradiaptomus*	+	+	-	+
8	*Mesocyclops*	+	+	-	-
9	*Cyclops*	-	+	-	-
10	*Phyllodiaptomous*	-	-	+	-
11	*Acartia*	-	+	-	-
12	*Diaptomous*	-	-	-	+
13	*Spirodiaptomous*	-	-	+	-
14	*Temora*	-	-	-	+
15	*Neodiaptomous*	-	-	-	+
16	*Heliodiaptomus*	-	-	+	-
	Protozoa				
17	*Amoeba*	+	-	+	-
18	*Ophryoglena*	-	-	+	-
19	*Colpoda*	-	+	-	-
20	*Euglena*	+	-	-	-
21	*Lacrymaria*	-	+	-	-
22	*Globigerina*	-	+	-	+
23	*Discorbis*	-	-	+	-
	Coelenterata				
24	*Obelia*	-	+	-	+
25	*Actinula*	-	+	-	+
	Crustacean larvae				
26	*Candacia*	-	+	-	+
27	*Parenchaeta*	-	-	+	-
28	*Sergestes*	-	-	-	+
29	*Nauplius larva*	+	+	+	+
30	*Megalopa larva*	+	+	+	+
31	*Syncaris*	+	-	-	-
32	*Euphausid*	-	-	-	+
33	Nematode worms	-	+	-	+
	Phyllopoda				
34	*Estheria mexicana*	-	-	-	+
	Insect larva				
35	*Crane fly larva*	+	-	-	-
36	*May fly larva*	-	-	+	-
	Molluscs				
37	*Musculium*	+	+	-	+
38	*Sphaerium*	+	-	-	-
39	*Zoo-bivalve veliger larvae*	-	-	+	-
	Annelid				
40	*Chaetogaster langi*	+	-	+	+
	Ostracod				
41	*Cypris*	+	+	-	-
	Invertebrate				
42	*Macrobiotics*	-	-	+	-
	Bryozoa				
43	*Cyphonautes larvae*	-	+	-	+
44	*Lophophore of Cristatella mucedo*	+	-	+	-
	Rotifers				
45	*Brachionus*	-	-	-	+
46	*Notholca*	+	+	-	+
47	*Ploesoma*	-	-	-	+
48	*Synchaeta*	-	-	+	-
49	*Notops*	-	+	+	-
50	*Keratella*	-	+	+	-
	Chaetognathae				
51	*Sagitta*	-	-	-	+
	Spicules of sponges				
52	*Spongilla biopinosa*	-	-	+	-
	Turbellaria				
53	*Planaria*	-	-	+	-
	Polychaete larvae				
54	*Trochophore*	-	+	+	+
	Chordata				
55	*Oikopleura sp*	-	+	-	+
56	*Fritellaria sp*	-	-	+	-

+' = present, '-' = absent

Fig. 1. Map of Thekkumbhagam Creek

TABLE 2
Percentage distribution of zooplankton in the stations (2008-2010)

Percentage abundance of Zooplankton(%)								
	2008-2009				2009-2010			
Cladocerans	22.49	2.05	2.24	59.63	29.13	11.43	4.88	30.46
Copepods	36.35	36.69	43.28	11.52	42.02	23.4	51.35	19.23
Rotifer	17.12	20.55	51.09	20.31	10.78	7.04	38.1	7.8
Crustacean larvae	1.31	3.74	2.47	7.41	1.72	2.35	2.83	16.09
Protozoa	22.53	36.66	0.85	0.48	16.2	55.65	2.65	22.03
Molluscs	0.03	0.21	0.03	0.61	0.07	0.03	-	1.44
Bryozoa	0.04	0.02	0.04	0.03	-	-	-	-
Ostracod	0.14	0.07	-	-	0.08	-	-	-
Coelenterate	-	-	-	-	-	0.1	-	-
Insect Larvae	-	-	-	-	-	-	0.16	-

The two genera of the group Cladocera recorded were *Daphnia* and *Diaphanosoma*. *Daphnia* was seen in all stations while *Diaphanosoma* was seen only at station1.The members of Copepods recorded were *Harpactoid, Pseudocalanus,Calanus, Eucalanoid, Paradiaptomous, Mesocyclops, Cyclops, Phyllodiaptomus, Acartia,Diaptomus ,Spirodiaptomous, Temora, Neodiaptomous, Heliodiaptomous*.The members recorded under Rotifera were *Brachionus, Notholca, Ploesoma, Synchaeta, Notops ,Keratella*. The Crustacean larvae includes *Candacia, Parenchaeta, Sergestis, Nauplius larvae, Megalopa larvae, Syncaris, Euphausid.* Protozoans recorded were *Amoeba, Ophryoglena, Colpoda, Euglena, Lacrymaria, Globegerina, and Discorbis.* Molluscs include *Musculium, Spherium, and Zoo-bivalve veliger larvae*. Bryozoa included *Cyphonautes larvae, Lophophore of Cristella mucido*. Ostracod was represented by *Cypris*(Table 1). It was seen only in station 1 and station 2. Copepods were the dominant group in all stations except station 4 and station 3 of first year. Rotifer showed its maximum abundance in station 3 during the first year. Cladocera dominated in station 4 during both years. Protozoa attained the highest number in station 2 during 2009-2010.

ANOVA comparing zooplankton species between stations revealed that Cladocera showed significant variations between seasons (at 1% level) for the entire period and for periods within seasons (at 5% level) for 2009-2010. Copepoda exhibited significant variations for period within seasons (at 5% level) for the two years. Rotifers exhibited significant variations between seasons (at 1% level) for the first year and for periods within seasons (at 5% level) for 2009-2010. The Crustacean larvae showed variations significant between stations (at 5% level) for the two years and between seasons (at 5% level) for the first year. Protozoans exhibited significant variations between stations (at 1% level) for the second year. Molluscs exhibited significant variations between stations (at 5% level). (Table 14, 15, 16,17,18,19).

TABLE 3
Mean and SE values of Cladocerans, Copepods, Rotifers at Stations 1 - 4 (2008-2010)

Stations	Year 2008-09	Season	Cladocerans Mean & SE Values a	Copepods Mean & SE& Values b	Rotifer Mean & SE Values c
	a) 775.25	1	2158.75a	833.5	758a
	469.99		1211.76	722.99	747.37
1	b) 1252.92	2	116.25b	757.25	1008.5b
	518.47		40.23	747.59	997.2
	c) 590.25	3	50.75c	2168	4.25c
	397.25		44.95	1206.51	4.25
	a) 43.08	1	61.75a	764	15.5a
	20.21		44.85	578.68	11.32
2	b) 769.5	2	63a	1026.5	1241.25b
	381.92		41.43	991.19	689.47
	c) 431	3	4.5b	518	36.25c
	270.54		4.5	494.06	36.25
	a) 35.25	1	49.75a	918.75	875a
	17.97		34.09	861.4	875
3	b) 680.75	2	51.25a	25.75	1511.25b
	415.48		43.62	7.85	951.56
	c) 803.58	3	4.75b	1097.97	24.5c
	430.87		4.75	967.97	8.29
	a) 523.25	1	1427.5a	94.75	16.75a
	337.93		918.7	40.84	4.87
4	b) 634.92	2	72.25b	605.25	26.75b
	308.74		41.17	465.22	7.74
	20.42	3	70b	1204.75	17.75a
	3.78		40.17	790.34	7.32
Stations	2009-2010	Season			
	a) 846.08	1	2458.75a	927.25	875a
	540.29		1382	857.77	875
1	1220.42	2	24.75b	1013.25	56b
	512.87		21.85	995.62	32.92
	c) 313	3	54.75c	1720.75	8c
	290		15.27	1019.78	4.64
	a) 922.5	1	922.5a	870	45.5a
	290.42		859.46	810.11	35.05
2	b) 629.5	2	0b	15	388.5b
	409.64		0	10.79	370.56
	c) 189.25	3	0b	1003.5	133.75c
	126		0	998.84	122.36
	a) 33.33	1	100a	757.5	754.25a
	20.32		48.18	747.53	748.59
3	b) 351	2	0b	130	10.5b
	242.21		0	30.62	10.5
	c) 260.42	3	0b	165.5	16.5b
	249.1		0	52.28	9.74
	a) 234.08	1	700a	59.5	86.5a
	137.14		313.58	25.25	35.26
4	b) 147.83	2	2.25b	296.25	88.75a
	78.95		2.25	235.63	27.08
	c) 59.92	3	0c	87.75	4.5b
	17.92		0	35.61	4.5

TABLE 4
Mean and SE values of Crustacean larvae, Protozoa, Molluscs at Stations 1 - 4 (2008-2010)

Stations	Year 2008-09	Season	Crustacean Larvae Mean & SE	Protozoa Mean & SE	Molluscs Mean & SE
	d) 45.08d1	1	14.75a	49.5	0
	21.35		8.48	35.19	0
1	e) 776.5	2	21.5a	2258.75	0
	505.97		8.97	1309.99	0
	f) 1.0f1	3	99b	21.25	3
	0.99		58.32	6.7	3
	d) 78.5d2	1	53a	836.25	5.75
	28.97		53	724.27	3.47
2	e) 768.75	2	36.75b	549.5	7.75
	305.41		36.75	485.75	4.48
	f) 4.5f1	3	145.75c	920.5	0
	1.98		52.63	490.2	0
	d) 38.83d1	1	103.5a	8	1.25
	19.21		42.53	8	1.25
3	e) 13.34	2	11.75b	8	0
	5.79		11.75	4.69	0
	f) .42f1	3	1.25c	24	0
	0.42		1.25	15.06	0
	d) 152.17d3	1	76.5a	9.5	0
	40.97		48.89	9.5	0
4	e) 9.92	2	86.25a	20.25	13.5
	5.18		71.28	11.69	13.5
	f) 12.59f2	3	293.75b	0	24.5
	5.69		30.85	0	8.68
Stations	2009-2010	Season			
	d) 50d1	1	4.25a	31.25	6
	23.04		4.25	31.25	6
1	e)470.5	2	68.5b	1375	0
	309.08		52.49	800.39	0
	f)2f1	3	77.25b	5.25	0
	2		44.81	5.25	0
	d) 63.33d2	1	55.5a	882.75	0
	20.95		51.58	511.04	0
2	e) 1497.0	2	52.25a	1625	0
	452.75		13.39	746.52	0
	f) .75f1	3	82.25b	1983.25	2.25
	0.75		42.5	1107.39	2.25
	d) 19.33d3	1	39.25a	7.25	0
	5.46		9.53	7.25	0
3	e) 18.42	2	15b	11.5	0
	5.73		1.78	6.94	0
	f) 0f2	3	3.75c	36.5	0
	0		3.75	9.68	0
	d) 123.67d4	1	61.75a	0	0
	33.67		54.48	0	0
4	e) 169.33	2	136.75b	508	12.75
	166.44		75.41	497.39	12.75
	f) 11.09f3	3	172.5c	0	20.35
	4.79		41.05	0	4.35

TABLE 5
Mean and SE values of Bryozoa, Ostracod, Total Zooplankton at Stations 1 - 4 (2008-2010)

Stations	Year 2008-09	Season	Bryozoa Mean & SE	Ostracod Mean & SE	Total Zooplankton Mean & SE
	g) 1.25	1	0	14.25	3828.76a
	1.25 h) 4.75		0	9.28	384.6
1	3.45	2	0	0	4162.27a
	i) 3447i1		0	0	446
	463.56	3	3.75	0	2350b
			3.75	0	1181.8
	g) .34	1	1	0	1737.26a
	0.33		1	0	721.03
2	h) 1.5	2	0	0	2924.76b
	1.5		0	0	471.29
	i) 2097.17i2	3	0	4.5	1629.51a
	338.89		0	4.5	420.64
	g) .67	1	0	0	1956.26a
	0.67		0	0	1018.66
3	h) 0	2	0	0	1608.02b
	0		0	0	940.45
	i) 1572.84i3	3	2	0	1154.26c
	523.03		2	0	989.54
	g) 0	1	0	0	3865.51a
	0		0	0	1236.84
4	h) 0	2	0	0	1887.27b
	0		0	0	1040.75
	i) 2054.1i2	3	0	0	409.52c
	647.92		0	0	18.1
Stations	2009-2010	Season			
	g) 0	1	0	0	2776.26a
	0		0	0	997.32
1	h)2.67	2	0	8	2088.76a
	2.67		0	8	541.23
	i)2690.01i1	3	0	0	3205.01b
	472.31		0	0	977.19
	g) 429.17	1	1050	1925	2.41a
	376.71		494.97	580.41	1.47
2	h) 1891.67	2	1137.5	1575	2.9b
	354.4		220.2	175	1.2
	i) 2.65i2	3	2100	2175	2.65a
	0.85		1020.42	976.49	2.06
	g) 0	1	0	2100	1661.51a
	0		0	820.82	862.35
3	h) 1.09	2	0	0	167.82b
	0.75		0	0	33.51
	i) 683.6i3	3	0	0	222.27b
	344.12		0	0	67.75
	g) .67	1	2	0	909.75a
	508.77		2	0	278.77
4	h) 22	2	0	0	1044.76a
	17.2		0	0	417.01
	i) 768.59i4	3	0	66	351.26b
	176.49		0	47.82	30.32

ANOVA comparing zooplankton species between the years of study was as follows. Cladocera showed significant variations between seasons (at 1% level) for station 1 and station 4 and for periods within seasons (at 1% level) for station 1. Copepods exhibited significant variations between seasons (at 1% level) for station 1 and for periods within seasons (at 1% level) for station 1 and (at 5% level) for station2 and station 3. Rotifers showed significant variations for periods within seasons (at5% level) at station 1, station 3 and between seasons (at 5 % level) for station 2. Crustacean larvae exhibited significant variations between seasons (at 5% level) for station 1 and station 3 (at1% level) for station 4 and for periods within seasons (at 5% level) for station 1 and station 4. Protozoa showed significant variations between seasons (at 1% level) for station 1, station 3, station 4 and (at 5% level) for station 1 and station 3. Molluscs exhibited significant variations between seasons and for periods within seasons (at 1% level) for station 4. Ostracods showed significant variations between seasons (at 1% level) for station 1 and for periods within seasons (at 5% level) for station 1. It revealed that Cladocera exhibited significant variations only for station 1 and station 4. Only station 4 showed significant variations for Molluscs and only station 1 showed significant variations for Ostracods.(Table 4,5).

TABLE 6
Distribution of zooplankton in(units/l) station 1(2008-2009)

	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Cladocerans	4000	35	4500	100	135	185	145	-	-	-	18	185
Copepods	174	3000	145	15	11	-	18	3000	132	4000	4500	40
Rotifer	-	-	32	3000	4000	34	-	-	-	17	-	-
Crustacean larvae	9	6	4	40	36	7	38	5	6	8	132	250
Protozoa	15	155	11	17	19	4000	5000	16	12	38	26	9
Molluscs	-	-	-	-	-	-	-	-	-	12	-	-
Bryozoa	-	-	-	-	-	-	-	-	-	15	-	-
Ostracod	39	-	18	-	-	-	-	-	-	-	-	-

TABLE 7
Distribution of zooplankton in (units/l) station 2(2008-2009)

	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Cladocerans	29	195	23	-	32	35	185	-	-	-	18	-
Copepods	194	2500	175	187	4000	17	45	44	15	45	2000	12
Rotifr	14	-	-	48	165	2000	2800	-	-	-	-	145
Crustacean larvae	-	-	-	212	-	-	-	147	250	178	155	-
Protoza	300	45	3000	-	-	198	-	2000	147	1500	35	2000
Molluscs	-	9	-	14	15	-	16	-	-	-	-	-
Bryozoa	-	-	4	-	-	-	-	-	-	-	-	-
Ostracod	-	-	-	-	-	-	-	-	-	-	-	18

TABLE 8
Distribution of zooplankton in (units/l) station 3 (2008-2009)

	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Cladocerans	14	152	15	18	24	181	-	-	-	-	19	-
Copepods	-	3500	-	175	14	11	35	43	154	196	4000	41
Rotifer	-	-	-	3500	4000	28	2000	17	36	29	33	-
Crustacean larvae	165	9	185	55	47	-	-	-	-	-	-	5
Protozoa	-	32	-	-	-	100	18	14	12	16	68	-
Molluscs	-	-	5	-	-	-	-	-	-	-	-	-
Bryozoa	-	-	-	-	-	-	-	-	-	8	-	-
Ostracod	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 9
Distribution of Zooplankton in(units/l) Station 4(2008-2009)

	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Cladocerans	4000	4500	6000	16	150	-	-	18	14	-	-	-
Copepods	26	185	178	28	31	2000	17	44	-	-	175	156
Rotifer	-	-	40	145	4500	164	145	-	-	-	13	-
Crustacean larvae	52	18	15	221	19	17	9	300	325	365	250	235
Protozoa	-	38	-	-	-	41	40	-	-	-	-	-
Molluscs	-	-	-	-	-	-	-	54	26	30	-	41
Bryozoa	-	-	-	-	-	-	-	-	-	-	-	8
Ostracod	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 10
Distribution of Zooplankton in (units/l) station 1(2009-2010)

	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Cladocerans	4700	35	5000	100	9	-	90	-	74	18	85	42
Copepods	90	3500	100	19	39	14	-	4000	198	4500	2000	185
Rotifer	-	-	-	3500	154	27	31	12	-	-	17	15
Crustacean larvae	-	17	-	-	25	225	-	24	29	18	52	210
Protozoa	-	125	-	-	-	2500	3000	-	-	-	21	-
Molluscs	24	-	-	-	-	-	-	-	-	-	-	-
Bryozoa	-	-	-	-	-	-	-	-	-	-	-	-
Ostracod	14	-	15	-	-	-	-	-	-	-	-	-

TABLE 11
Distribution of Zooplankton in(units/l) station 2(2009-2010)

	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Cladocerans	90	100	3500	-	-	-	-	-	-	-	-	-
Copepods	43	3300	98	39	8	47	-	5	9	-	4000	5
Rotifer	18	14	-	150	25	-	1500	29	500	35	-	-
Crustacean larvae	-	-	12	210	55	14	75	65	55	60	9	205
Protozoa	2000	31	1500	-	1000	2000	-	3500	3800	4000	63	70
Molluscs	-	-	-	-	-	-	-	-	-	9	-	-
Bryozoa	-	-	-	-	-	-	-	-	-	-	-	-
Ostracod	-	-	-	-	-	-	-	-	-	-	-	-
Coelenterate	-	-	-	-	-	-	32	-	-	-	-	-

TABLE 12
Distribution of Zooplankton in (units/l) station 3(2009-2010)

	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Cladocerans	185	180	35	-	-	-	-	-	-	-	-	-
Copepods	-	3000	-	30	145	160	175	40	152	165	300	45
Rotifer	-	17	-	3000	42	-	-	-	-	38	28	-
Crustacean larvae	25	21	52	59	20	15	13	12	15	-	-	-
Protozoa	29	-	-	-	-	-	28	18	30	36	63	17
Molluscs	-	-	-	-	-	-	-	-	-	-	-	-
Bryozoa	-	-	-	-	-	-	-	-	-	-	-	-
Ostracod	-	-	-	-	-	-	-	-	-	-	-	-
Insect Larvae	5	-	8	-	-	-	-	-	-	-	-	-

TABLE 13
Distribution of zooplankton in (units/l) station 4 (2009-2010)

	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Cladocerans	500	800	1500	-	9	-	-	-	-	-	-	-
Copepods	30	33	135	40	42	123	1000	20	17	36	145	153
Rotifer	185	35	36	90	125	38	145	47	-	-	-	18
Crustacean larvae	-	12	10	225	230	9	8	300	50	210	205	225
Protozoa	-	-	-	-	-	2000	32	-	-	-	-	-
Molluscs	-	-	-	-	-	-	-	51	22	8	28	24
Bryozoa	-	-	-	-	-	-	-	-	-	-	-	-
Ostracod	-	-	-	-	-	-	-	-	-	-	-	-
Insect Larvae	-	-	-	8	-	-	-	-	-	-	-	-
Phyllopoda	-	-	-	-	-	-	-	-	205	53	6	-

TABLE 14
ANOVA comparing Cladocera, Copepods and Rotifers between the stations, year 2008-2009

		Cladocerans			Copepods			Rotifer		
Source	DF	Sum of squares	Mean Sum of squares	F	Sum of squares	Mean Sum of squares	F	Sum of squares	Mean Sum of squares	F
Total	47	95816790.00			87226340.00			74387410.00		
Between stations	3	12292490.00	4097496.00	2.90	6248486.00	2082829.00	1.50	1167184.00	389061.30	0.40
Between seasons	2	21919990.00	10960000.00	7.78**	1329538.00	664769.00	0.49	12429870.00	6214937.00	6.92**
Periods within seasons	9	15124293.00	1680477.00	1.19	34594128.00	3843792.0	2.82*	32769009.00	3641001.00	3.85**
Error	33	46480020.00	1408485.00		45054180.00	1365278.18		29641340.00	89822.42	

TABLE 15
ANOVA comparing Cladocera, Copepods, Rotifers between the stations, year 2009-2010

		Cladocerans			**Copepods**			**Rotifer**		
Source	DF	Sum of squares	Mean Sum of squares	F	Sum of squares	Mean Sum of squares	F	Sum of squares	Mean Sum of squares	F
Total	47	56542500.00			73256320.00			21861590.00		
Between stations	3	4338109.00	1446036.00	1.90	7819032.00	2606344.00	2.30	432366.80	144122.30	0.40
Between seasons	2	11428860.00	5714428.00	7.46**	1265500.00	632750.00	0.56	1394223.00	697111.50	2.04
Periods within seasons	9	15501744.00	1722416.00	2.25*	26896878.00	2988542.00	2.65*	8744237.00	971581.90	2.84*
Error	33	25273790.00	765872.42		37274810.00	1129542.73		11290770.00	342144.55	

* denote significance (p < .05) ** denote significance (p < .01)

TABLE 16
ANOVA comparing Crustacean larvae, Protozoa, Molluscs between the stations, year 2008-2009

		Crustacean Larvae			**Protozoa**			**Molluscs**		
Source	DF	Sum of squares	Mean Sum of squares	F	Sum of squares	Mean Sum of squares	F	Sum of squares	Mean Sum of squares	F
Total	47	538635.00			53062360.00			6072.30		
Between stations	3	97401.00	32467.20	3.6*	6949845.00	2316615.00	2.00	1130.40	376.80	3.1*
Between seasons	2	80236.20	40118.10	4.44*	2413684.00	1206842.00	1.06	216.40	108.20	0.89
Periods within seasons	9	62798.06	6977.56	0.77	6058013.00	673112.60	0.59	711.75	79.08	0.65
Error	33	298199.10	9036.34		37640820.00	1140630.91		4013.72	121.63	

TABLE 17
ANOVA comparing Crustacean larvae, Protozoa, Molluscs between the stations, year 2009-2010

		Crustacean Larvae			**Protozoa**			**Molluscs**		
Source	DF	Sum of squares	Mean Sum of squares	F	Sum of squares	Mean Sum of squares	F	Sum of squares	Mean Sum of squares	F
Total	47	350587.70			59289940.00			4590.70		
Between stations	3	69019.70	23006.60	4.2*	15961360.00	5320453.00	5.5**	954.50	318.20	3.6*
Between seasons	2	15704.50	7852.30	1.42	3400893.00	1700447.00	1.77	142.00	71.00	0.81
Periods within seasons	9	83731.13	9303.46	1.69	8255914.00	917323.80	0.96	611.06	67.90	0.78
Error	33	182132.30	5519.16		31671780.00	959750.91		2883.22	87.37	

* denote significance (p < .05) ** denote significance (p < .01)

TABLE 18
ANOVA comparing Bryozoa, Ostracod, Total Zooplankton between stations, year 2008-2009

		Bryozoa			Ostracod			Total Zooplankton		
Source	DF	Sum of squares	Mean Sum of squares	F	Sum of squares	Mean Sum of squares	F	Sum of squares	Mean Sum of squares	F
Total	47	343.20			2051.30			194633.80		
Between stations	3	5.20	1.70	0.30	180.50	60.20	1.40	23809.50	7936.50	4.6**
Between seasons	2	35.50	17.80	2.77	106.00	53.00	1.21	26648.10	13324.50	7.69**
Periods within seasons	9	90.01	10.11	1.58	318.70	35.41	0.81	870230.33	9668.93	5.58**
Error	33	211.48	6.41		1446.04	43.82		57154.92	1732.97	

TABLE.19
ANOVA comparing Bryozoa,Ostracod,Total Zooplankton between the stations, year 2009-2010

		Bryozoa			Ostracod			Total Zooplankton		
Source	DF	Sum of squares	Mean Sum of squares	F	Sum of squares	Mean Sum of squares	F	Sum of squares	Mean Sum of squares	F
Total	47	62.60			44021.80			3421708.00		
Between stations	3	4.00	1.30	1.00	3596.70	1198.90	1.30	287293.10	95764.40	3.00
Between seasons	2	2.70	1.30	0.99	2150.40	1075.20	1.14	468490.50	234245.30	7.29**
Periods within seasons	9	11.99	1.32	1.00	7166.86	796.32	0.84	160574.00	178417.10	5.55**
Error	33	43.97	1.33		31107.79	942.66		1060170.00	32126.37	

* denote significance (p < .05) ** denote significance (p < .01)

TABLE 20
Rain fall data of Kollam district 2008-2010

Rain fall (mm) - 2008-2009											
Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
207.1	454.8	265.1	247	360.8	122.7	25.6	2.2	3	105.7	121.9	136.4
Mean ± SE (2008-2009)											
Monsoon				Post monsoon				Pre monsoon			
293.5 ± 63.64				127.825 ± 94.59				91.75 ± 34.91			
Rain fall (mm) - 2009-2010											
Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
272.3	369.7	185.5	272.6	325.9	317	15.7	11.5	0	59.1	221.1	203.5
Mean ± SE (2009-2010)											
Monsoon				Post monsoon				Pre monsoon			
275.025 ± 43.45				167.525 ± 102.64				120.925 ± 62.62			

Source : Meteorological Station , Thiruvananthapuram

Results of Tukey Test presented using Subscripts a, b , c etc for Seasons
Results of Tukey Test presented using Subscripts a1 etc, b 1 etc, c1 etc etc for Stations

TABLE 21 A
Correlation Coefficient " r " values between Zooplankton parameters and hydrographic parameters at station 1 (2008-2009)

Parameters	Cladocerans	Copepods	Rotifer	Crustacean Larvae	Protozoa	Molluscs	Bryozoa	Ostracod	Total Zooplankton
Air temperature	0.0955	0.3188	0.1852	0.2087	-0.7786	-0.0155	-0.0153	0.2747	-0.2227
Surface water temperature	0.3100	0.1987	-0.3039	0.4108	-0.3961	-0.0294	-0.0295	0.4537	-0.1341
Bottom water temperature	0.3260	0.1741	-0.2768	0.2898	-0.2298	0.1576	0.1572	0.4658	0.0548
pH surface	0.2066	-0.4796	-0.1126	0.1520	0.3685	-0.8082	-0.8084	0.1107	-0.0173
pH bottom	0.0288	-0.3640	0.0716	-0.7712**	0.5098	-0.0837	-0.0839	-0.0325	0.2036
Salinity surface	-0.1705	0.1321	-0.2105	-0.0336	0.3814	0.4848	0.4843	-0.1244	0.2108
Salinity bottom	-0.2017	-0.1262	0.0152	0.1006	0.2682	0.0149	0.0149	-0.0876	-0.0358
Dissolved oxygen surface	0.4771	-0.1262	0.2243	-0.0574	-0.3230	-0.2404	-0.2400	0.2313	-0.1014
Dissolved oxygen bottom	-0.2089	-0.3799	0.7553**	0.1059	-0.0674	-0.1372	-0.1375	-0.3305	-0.0463
CO_2 surface	-0.5503	-0.3664	-0.2409	-0.1743	0.2588	0.2424	0.2424	-0.5552	-0.3056
CO_2 bottom	-0.4447	0.1673	0.0821	-0.2636	-0.1426	0.1503	0.1506	-0.4342	-0.1823
Nitrite surface	-0.1167	0.3295	-0.0607	-0.2478	0.0439	0.8426**	0.8423**	-0.1054	0.1374
Nitrite bottom	-0.4693	0.2395	0.1560	-0.2613	-0.0466	0.7311**	0.7317**	-0.4311	-0.0414
Nitrate surface	-0.0521	0.3249	-0.0914	-0.2926	0.4865	0.0657	0.0666	-0.1050	0.1971
Nitrate bottom	-0.1303	-0.1688	-0.5942	0.1046	-0.1081	0.3826	0.3830	-0.1055	0.0461
Phosphate surface	-0.1663	-0.7147	0.4352	-0.2460	0.2066	-0.0648	-0.0642	-0.1317	0.0831
Phosphate bottom	-0.1710	-0.2987	0.2439	-0.2178	0.1490	-0.3272	-0.3264	-0.0418	-0.0886
Silicate surface	0.3628	-0.2458	0.5297	0.1951	-0.2418	-0.2589	-0.2599	0.3042	-0.0127
Silicate bottom	0.8064**	-0.5190	-0.1927	0.1092	-0.1359	-0.2580	-0.2849	0.7491**	-0.0021
Gross primary productivity	-0.0628	-0.4608	-0.0328	-0.2146	-0.2552	-0.1412	-0.1409	0.0586	-0.2029
Net primary productivity	-0.2686	0.1587	-0.0342	-0.1772	0.2820	-0.2380	-0.2380	0.0922	-0.1878
Transparency	-0.2693	-0.1657	0.2397	-0.1298	0.2090	-0.3467	-0.3464	-0.4393	-0.1823

* denote significance ($p < .05$) ** denote significance ($p < .01$)

TABLE 21 B
Correlation Coefficient " r " values between Zooplankton Parameters and hydrographic parameters at station 1 (2009-2010)

Parameters	Cladocerans	Copepods	Rotifer	Crustacean Larvae	Protozoa	Molluscs	Bryozoa	Ostracod	Total Zooplankton
Air temperature	0.2291	-0.1209	-0.0515	0.2922	-0.4546	0.2318	0.1144	0.2313	-0.1692
Surface water temperature	0.1952	0.0283	-0.2399	0.2533	-0.4585	0.1882	0.1892	0.1966	-0.1665
Bottom water temperature	0.2871	0.0743	-0.1455	0.2498	-0.5009	0.3129	0.2001	0.2892	0.1160
pH surface	0.0648	-0.5950	0.0149	0.3766	0.3142	-0.1044	-0.5866*	0.0565	-0.3146
pH bottom	-0.3135	-0.4472	0.3497	0.5088	0.5988*	-0.3945	-0.4588	-0.3181	-0.2001
Salinity surface	-0.2072	0.0883	0.0005	-0.1369	0.6642	-0.0870	-0.0945	-0.2123	0.2654
Salinity bottom	-0.2084	-0.2454	0.5082	-0.0512	0.5826	0.0308	-0.5601	-0.2209	0.1720
Dissolved oxygen surface	0.4450	-0.3789	0.2428	-0.1039	-0.2668	-0.1006	0.3886	0.4457	0.0633
Dissolved oxygen bottom	-0.2087	-0.2755	0.3671	-0.1893	-0.2426	-0.3602	0.4441	-0.2095	-0.4480
CO_2 surface	-0.5027	0.4746	-0.0543	-0.1532	-0.0712	-0.4619	-0.1603	-0.5049	-0.1400
CO_2 bottom	-0.4547	0.5294	0.2975	-0.1991	-0.1116	-0.3849	-0.1116	-0.4557	0.1405
Nitrite surface	-0.0002	0.2985	-0.2981	-0.0224	0.1389	-0.0972	0.3411	0.0049	0.2136
Nitrite bottom	-0.4942	0.3235	0.3299	0.0299	-0.2690	-0.3302	0.1936	-0.4899	-0.1756
Nitrate surface	-0.0266	0.2882	0.6313*	-0.0717	-0.0393	-0.1769	0.1128	-0.0251	0.594*
Nitrate bottom	0.4509	0.0399	0.0998	-0.2513	-0.2368	0.3000	-0.0852	0.4445	0.4230
Phosphate surface	-0.1221	-0.2141	0.943**	-0.2994	0.0272	-0.1393	-0.0956	-0.1312	0.1939
Phosphate bottom	-0.0231	-0.1889	0.7079	-0.2945	-0.1774	-0.0195	-0.1873	-0.0291	0.0673
Silicate surface	0.5524	-0.5580	-0.2154	-0.0248	-0.2735	0.4629	0.1697	0.5536	-0.2623
Silicate bottom	0.3148	-0.0204	-0.2337	0.1380	-0.3310	-0.3180	0.2008	0.3165	-0.0146
Gross primary productivity	-0.1509	0.2221	-0.3404	0.1447	0.2250	0.1124	0.2235	-0.1419	0.0129
Net primary productivity	-0.1913	-0.1004	-0.0397	-0.1367	0.2443	0.4676	-0.6022	-0.1987	-0.1836
Transparency	-0.2305	-0.3931	0.0151	0.3716	0.2641	-0.4831	0.1314	-0.2253	-0.4577

* denote significance ($p < .05$) ** denote significance ($p < .01$)

TABLE 22 A
Correlation Coefficient " r " values between Zooplankton parameters and hydrographic parameters at station 2 (2008-2009)

Parameters	Cladocerans	Copepods	Rotifer	Crustacean Larvae	Protozoa	Molluscs	Bryozoa	Ostracod	Total Zooplankton
Air temperature	-0.4242	-0.1812	-0.2490	0.3481	0.0749	-0.3591	-0.3832	0.1578	-0.3328
Surface water temperature	-0.3366	-0.0932	-0.4791	0.4532	0.2000	-0.1484	-0.1090	0.1689	-0.2888
Bottom water temperature	-0.3638	-0.1717	-0.4375	0.5074	0.2038	-0.1814	-0.0819	0.0983	-0.3381
pH surface	0.4340	0.3920	0.4782	-0.5204	-0.4223	0.2512	-0.4819	0.2956	0.4267
pH bottom	-0.1620	0.4232	0.1321	-0.1736	-0.2328	-0.0508	-0.3955	0.3100	0.3488
Salinity surface	-0.2506	-0.4875	-0.0625	0.6285	0.2131	-0.1169	-0.2774	0.1523	-0.3687
Salinity bottom	-0.3765	-0.5410	-0.0364	0.7253	-0.0360	-0.0848	-0.2096	0.1342	-0.6318
Dissolved oxygen surface	0.6945**	0.3430	0.3364	-0.5227	-0.3766	0.5736	0.1448	-0.3303	0.3145
Dissolved oxygen bottom	0.2978	0.4489	0.1629	-0.4125	-0.0960	0.5672	0.4061	-0.1374	0.5350
CO_2 surface	-0.1053	-0.3975	0.0422	0.1403	-0.0325	-0.4771	-0.0745	0.1204	-0.4401
CO_2 bottom	0.0796	-0.3924	0.2203	0.4943	-0.0131	-0.0471	-0.2119	0.0043	-0.2316
Nitrite surface	0.8912**	0.2414	0.2443	-0.2863	-0.2882	0.4693	-0.2071	-0.1312	0.2381
Nitrite bottom	0.6383**	-0.1139	0.8626**	-0.2598	-0.2942	0.5875*	-0.1584	-0.1223	0.3141
Nitrate surface	0.9097**	0.2572	0.2052	-0.3597	-0.1811	0.4772	0.0356	-0.2510	0.3156
Nitrate bottom	0.6149*	-0.3055	0.7948	-0.2265	-0.2420	0.4686	-0.0316	-0.2592	0.0910
Phosphate surface	-0.1642	-0.3557	0.0585	0.4370	-0.2641	0.4019	-0.1104	-0.1126	-0.5629
Phosphate bottom	-0.1601	-0.2634	0.1277	0.3108	-0.2735	0.4115	-0.0842	-0.1331	-0.4227
Silicate surface	-0.3473	0.2675	-0.2359	0.1987	0.0158	-0.1090	0.1862	0.1846	0.1241
Silicate bottom	-0.3031	0.1954	-0.2030	0.0690	-0.0763	-0.1789	0.1069	0.1057	-0.0232
Gross primary productivity	0.2197	0.2000	-0.2119	0.3129	-0.1834	0.0664	-0.2120	-0.2341	-0.0700
Net primary productivity	-0.2549	0.1642	-0.0331	0.3698	-0.3640	-0.1078	-0.4465	-0.0750	-0.1544
Transparency	-0.0086	-0.0717	0.2909	0.1711	-0.0674	0.0481	0.0654	-0.3672	0.1035

* denote significance ($p < .05$) ** denote significance ($p < .01$)

TABLE 22 B
Correlation Coefficient " r " values between Zooplankton parameters and hydrographic parameters at station 2 (2008-2009)

Parameters	Cladocerans	Copepods	Rotifer	Crustacean Larvae	Protozoa	Molluscs	Bryozoa	Ostracod	Total Zooplankton
Air temperature	-0.1368	0.2414	-0.3246	-0.1533	0.2023	0.3731	0.0191	-0.2383	0.2251
Surface water temperature	0.0300	-0.3100	-0.2515	0.3565	0.4213	0.7525**	0.1320	-0.2357	0.1020
Bottom water temperature	0.1615	0.3362	-0.3277	0.2170	0.5388	0.6707**	0.1449	-0.3206	0.2456
pH surface	-0.4407	0.3469	0.1475	-0.1853	-0.3870	0.0294	-0.1854	0.2973	-0.3082
pH bottom	-0.3456	-0.0044	-0.0659	-0.1910	0.0402	0.1668	-0.1653	0.0000	-0.2037
Salinity surface	-0.3847	-0.2830	0.1719	0.3299	0.4799	0.3858	0.3268	0.1237	0.0398
Salinity bottom	-0.2628	-0.2235	0.3838	0.4844	0.1855	0.0854	-0.1715	0.1999	-0.0525
Dissolved oxygen surface	0.1342	-0.0803	0.3154	-0.4346	-0.2093	-0.4362	-0.0972	0.3262	-0.1218
Dissolved oxygen bottom	0.2380	-0.0675	0.7349**	0.0754	-0.5420	-0.4793	-0.3011	0.7545**	-0.2288
CO_2 surface	0.0930	0.1351	-0.0094	-0.0721	0.3940	0.2433	-0.3432	-0.2356	0.5453
CO_2 bottom	-0.2205	-0.0001	0.3266	0.2462	0.2348	-0.2597	0.0091	0.1302	0.1877
Nitrite surface	-0.2248	0.3280	0.3318	-0.2228	-0.0830	-0.2408	0.2520	0.2416	0.1463
Nitrite bottom	-0.1616	-0.2282	0.8429	0.0779	0.1188	-0.2502	-0.2510	0.65*	0.0482
Nitrate surface	0.1169	0.2167	0.2413	-0.2432	0.1935	0.0419	0.1461	0.0677	0.4993
Nitrate bottom	-0.0051	-0.2102	0.6421*	-0.0426	0.2560	-0.1316	-0.3915	0.3785	0.2314
Phosphate surface	-0.0131	-0.1483	0.1360	0.5494	-0.2125	-0.1028	0.1905	-0.0072	-0.2799
Phosphate bottom	-0.1013	-0.1682	0.0754	0.6194*	-0.3017	-0.0947	0.2906	0.0009	-0.4500
Silicate surface	0.2332	0.3704	-0.2818	0.1834	-0.4674	-0.2612	-0.1159	-0.1760	-0.0519
Silicate bottom	0.2287	0.1485	-0.2138	0.1693	-0.4661	-0.4862	-0.6555*	-0.1262	-0.2284
Gross primary productivity	-0.1910	0.0771	0.0508	-0.2181	0.4092	-0.1550	0.1402	-0.1560	0.3445
Net primary productivity	-0.4929	-0.1963	0.5619	0.1719	0.1855	-0.2004	-0.3107	0.3465	-0.1363
Transparency	0.0608	-0.3142	0.1187	-0.1599	0.4114	-0.2898	0.2940	-0.0117	0.1833

* denote significance ($p < .05$) ** denote significance ($p < .01$)

TABLE 23 A
Correlation Coefficient " r " values between Zooplankton parameters and hydrographic parameters at station 3 (2008-2009)

Parameters	Cladocerans	Copepods	Rotifer	Crustacean Larvae	Protozoa	Molluscs	Bryozoa	Ostracod	Total Zooplankton
Air temperature	-0.3501	-0.5825	0.1098	0.4126	-0.5623	-0.1710	0.1816	-0.1931	-0.3753
Surface water temperature	-0.5670	0.1286	-0.3334	-0.0932	0.4240	-0.1175	0.2020	-0.2737	-0.1942
Bottom water temperature	-0.6652*	0.0736	-0.1930	-0.2120	0.3846	-0.1070	0.2307	-0.1186	-0.1268
pH surface	0.0995	-0.2329	-0.0140	0.2373	-0.2456	-0.1927	0.2254	-0.3033	-0.1870
pH bottom	-0.1844	-0.1761	0.1447	-0.1611	-0.0179	-0.1457	0.3743	-0.1583	-0.0328
Salinity surface	-0.3282	0.2268	-0.1744	-0.3514	0.4578	-0.4489	0.0751	0.0021	0.0172
Salinity bottom	-0.4845	-0.1742	-0.1543	-0.4033	0.1335	-0.3773	0.1200	0.1647	-0.2956
Dissolved oxygen surface	0.3330	-0.1547	0.3811	-0.2308	-0.2398	-0.5217	-0.0865	0.1834	0.0908
Dissolved oxygen bottom	0.2239	-0.2037	0.4976	-0.3736	-0.1846	-0.5593	-0.3940	0.2041	0.2391
CO_2 surface	0.4180	-0.0610	-0.4595	-0.1244	-0.0822	-0.0920	-0.4939	-0.2814	-0.4188
CO_2 bottom	0.1534	-0.1988	0.1344	0.4239	-0.3749	0.5227	-0.4273	0.3711	-0.0306
Nitrite surface	-0.4647	-0.1855	-0.2940	0.1078	0.1123	0.5592	0.2796	0.4910	-0.3995
Nitrite bottom	-0.2931	-0.0242	-0.0440	-0.0789	0.1443	-0.3143	0.5563	-0.3972	-0.0664
Nitrate surface	0.0485	0.0091	0.1805	-0.2533	-0.0071	-0.1929	0.3336	0.4398	0.1485
Nitrate bottom	-0.0714	-0.0933	-0.4840	0.6436*	-0.1836	0.6263*	0.3500	-0.3072	-0.4527
Phosphate surface	-0.0448	-0.0078	0.7535**	0.2338	-0.2455	-0.0847	-0.3735	0.0539	0.6184*
Phosphate bottom	0.7439**	0.0025	-0.2016	0.4535	-0.2751	0.3249	-0.1073	-0.0847	-0.1248
Silicate surface	-0.1104	0.5526	-0.0331	-0.3439	0.5828	-0.2687	-0.3580	-0.0474	0.4011
Silicate bottom	-0.0362	-0.1213	0.1201	0.5320	-0.2636	0.1194	-0.4143	0.3814	0.0176
Gross primary productivity	-0.1688	0.0207	0.0948	-0.0753	0.0355	-0.2747	0.8368**	-0.1956	0.0872
Net primary productivity	-0.2288	-0.1516	-0.1427	-0.2595	0.0624	0.0361	-0.0375	-0.1611	-0.2547
Transparency	0.1582	-0.3930	0.1547	-0.3139	-0.2485	-0.0760	-0.2924	0.2953	-0.1940

* denote significance ($p < .05$) ** denote significance ($p < .01$)

TABLE 23 B
Correlation Coefficient " r " values between Zooplankton parameters and hydrographic parameters at station 3 (2008-2009)

Parameters	Cladocerans	Copepods	Rotifer	Crustacean Larvae	Protozoa	Molluscs	Bryozoa	Ostracod	Total Zooplankton
Air temperature	0.0238	-0.3907	0.1768	-0.0976	-0.0261	0.3706	-0.6265	-0.0701	-0.1522
Surface water temperature	-0.1336	-0.6053*	-0.3023	-0.4267	0.5824	-0.2921	0.0494	0.1659	-0.6688
Bottom water temperature	-0.2604	-0.7104**	-0.2895	-0.3999	0.5399	-0.3368	0.1294	0.1525	-0.7436**
pH surface	-0.3894	-0.4472	0.5028	0.1518	0.0874	0.2364	-0.1998	-0.0482	0.0309
pH bottom	-0.3558	-0.4339	0.1128	-0.1800	0.2062	0.0510	-0.0533	-0.0922	-0.2517
Salinity surface	-0.1364	-0.1469	-0.2255	-0.6829**	0.7729	0.0202	-0.1766	-0.3928	-0.2817
Salinity bottom	-0.2877	-0.2857	-0.2417	-0.5493	0.6601*	-0.2565	0.2523	-0.3190	-0.4032
Dissolved oxygen surface	0.0208	0.0026	-0.3360	-0.0373	-0.5807*	0.0247	-0.1317	0.0249	-0.2579
Dissolved oxygen bottom	-0.1873	-0.0339	-0.0835	-0.4030	0.0688	0.2326	-0.1895	-0.5352	-0.1048
CO_2 surface	0.2341	-0.0203	0.0777	0.2052	0.1658	-0.1173	-0.0311	0.2240	0.0641
CO_2 bottom	0.1300	0.1120	0.3638	0.7039	-0.2215	-0.3679	0.4146	0.4340	0.3692
Nitrite surface	-0.4542	-0.3354	-0.1946	0.1865	-0.1132	-0.3425	0.5782	0.3851	-0.4138
Nitrite bottom	-0.2917	-0.2525	-0.0365	-0.4441	0.2408	0.4963	-0.4827	-0.4530	-0.2322
Nitrate surface	0.8781**	0.5763*	-0.2037	0.0835	0.1573	-0.1460	-0.1837	0.2806	0.3186
Nitrate bottom	-0.2122	-0.2199	-0.3177	0.0469	0.1279	-0.2296	0.3479	0.5146	-0.4050
Phosphate surface	0.0162	-0.1049	0.6107	0.4856	-0.5038	0.0319	-0.1125	-0.0991	0.3792
Phosphate bottom	0.7444**	0.2258	-0.1442	0.5105	-0.2773	-0.3201	-0.2200	0.7427	0.1812
Silicate surface	0.0947	-0.0461	-0.3323	-0.4904	0.4823	-0.2643	0.1137	-0.1422	-0.2755
Silicate bottom	0.2475	-0.1781	-0.4266	-0.9030	0.0569	-0.5893	0.3254	0.3323	-0.4318
Gross primary productivity	0.1307	0.3255	-0.1555	-0.2924	-0.0979	0.5145	-0.4877	-0.2888	0.1209
Net primary productivity	-0.1603	0.0725	0.0337	0.0995	-0.0195	0.1161	0.0458	-0.1001	0.0690
Transparency	-0.5692	-0.3676	0.0280	-0.0041	-0.1735	0.0497	0.1459	-0.3118	-0.2839

* denote significance ($p < .05$) ** denote significance ($p < .01$)

TABLE 24 A
Correlation Coefficient " r " values between Zooplankton parameters and hydrographic parameters at station 4 (2008-2009)

Parameters	Cladocerans	Copepods	Rotifer	Crustacean Larvae	Protozoa	Molluscs	Bryozoa	Ostracod	Total Zooplankton
Air temperature	-0.2215	-0.3972	0.1076	0.4473	-0.8151	0.0321	0.2392	-0.0294	-0.2344
Surface water temperature	-0.2888	-0.5419	-0.0016	0.6423*	-0.8322**	0.3691	0.2913	-0.1802	-0.3845
Bottom water temperature	-0.2777	-0.5448	0.0493	0.5949	-0.8112	0.3613	0.2594	-0.2574	-0.3479
pH surface	-0.5210	-0.2593	0.1143	0.3058	-0.2108	-0.0272	0.1881	0.1907	-0.4972
pH bottom	-0.5284	-0.1735	0.4228	0.2648	-0.2499	0.1058	0.4335	0.0106	-0.3076
Salinity surface	-0.2562	-0.2098	-0.2643	0.4122	-0.0207	0.5224	-0.0046	0.2822	-0.4270
Salinity bottom	-0.5075	-0.2811	-0.2516	0.6104*	-0.1867	0.7632	0.0308	-0.0565	-0.6729
Dissolved oxygen surface	-0.0992	0.0810	0.3123	-0.2471	0.3464	-0.1026	-0.4977	0.0419	0.0869
Dissolved oxygen bottom	-0.3936	0.0692	0.0590	0.1201	0.0846	-0.0353	-0.3758	0.1544	-0.3308
CO_2 surface	0.0097	-0.0616	-0.2179	0.1110	0.3714	-0.0726	-0.1111	0.5713	-0.1215
CO_2 bottom	-0.2081	-0.0734	-0.3649	0.5931*	-0.1973	0.3911	0.3360	-0.0297	-0.3938
Nitrite surface	0.6154*	-0.1194	-0.1251	-0.4051	0.2386	-0.2964	-0.1253	0.0611	0.4810
Nitrite bottom	0.5684	0.0670	-0.1101	-0.5456	0.4030	-0.4184	-0.1062	0.0808	0.4810
Nitrate surface	0.6541*	-0.0621	-0.1575	-0.4009	0.3435	-0.3024	-0.1359	0.1535	0.5161
Nitrate bottom	0.5797*	-0.0619	-0.1509	-0.3681	0.0413	-0.2944	-0.1599	-0.1609	0.4460
Phosphate surface	0.3710	-0.2639	-0.0772	-0.2144	-0.0743	-0.4151	-0.0912	0.3401	0.2391
Phosphate bottom	0.7991**	-0.0998	-0.4544	-0.3861	0.1513	-0.2636	0.2194	0.0987	0.4800
Silicate surface	-0.3027	-0.1189	0.3296	0.2240	-0.3915	0.2260	0.4805	-0.0650	-0.1265
Silicate bottom	-0.0059	-0.1789	-0.0580	0.0931	-0.3517	0.0430	0.5217	-0.0802	-0.0798
Gross primary productivity	-0.2057	-0.0737	0.2915	0.0940	-0.2506	0.3408	-0.2903	-0.3142	-0.0481
Net primary productivity	-0.0297	-0.4021	-0.1174	0.2243	-0.2500	0.4722	-0.1095	-0.1029	-0.1809
Transparency	-0.4057	0.4043	0.3027	-0.1769	0.3390	-0.0723	-0.4285	0.0368	-0.1365

* denote significance ($p < .05$) ** denote significance ($p < .01$)

TABLE 24 B
Correlation Coefficient " r " values between Zooplankton parameters and hydrographic parameters at station 4 (2008-2009)

Parameters	Cladocerans	Copepods	Rotifer	Crustacean Larvae	Protozoa	Molluscs	Bryozoa	Ostracod	Total Zooplankton
Air temperature	0.0276	0.0640	0.3921	0.1995	-0.2147	-0.0999	0.3786	-0.4592	-0.1206
Surface water temperature	-0.3208	-0.1781	-0.3450	0.5193	-0.2336	0.2859	-0.0499	0.0843	-0.4695
Bottom water temperature	-0.1818	-0.1964	-0.2357	0.3273	-0.1149	0.0327	0.1544	0.0708	-0.2906
pH surface	-0.7544**	0.1087	-0.0607	0.4407	-0.1959	0.0052	0.2121	0.3142	-0.6128
pH bottom	-0.4523	0.0465	-0.2404	0.4949	-0.0922	0.1553	0.2615	-0.0680	-0.3510
Salinity surface	-0.2740	0.0752	-0.3170	-0.0763	-0.0248	0.6325*	0.4373	0.7016**	-0.1655
Salinity bottom	-0.5390	0.1323	-0.1893	0.4701	-0.0607	0.7954**	-0.2061	0.1461	-0.3113
Dissolved oxygen surface	-0.0387	0.1589	0.1548	-0.1197	0.5410	-0.3197	0.2306	-0.1636	0.5204
Dissolved oxygen bottom	-0.2340	0.2712	0.1272	0.1619	-0.0054	-0.1911	0.5923	0.1602	-0.0091
CO_2 surface	-0.0403	-0.0465	-0.2734	-0.3902	-0.0499	-0.2096	-0.0827	0.7015**	-0.1390
CO_2 bottom	-0.3150	-0.1850	-0.4785	0.2303	-0.1061	0.3267	-0.3561	0.2112	-0.4041
Nitrite surface	0.1459	-0.1062	0.6505*	-0.3461	-0.0607	-0.1876	-0.1282	-0.1176	-0.0084
Nitrite bottom	0.2184	-0.1388	0.5494	-0.4239	-0.0960	-0.2609	-0.0129	-0.1861	-0.1235
Nitrate surface	0.2419	-0.1271	0.6297	-0.3587	-0.1109	-0.2324	-0.0833	-0.1189	0.0039
Nitrate bottom	0.3886	-0.2630	0.3389	-0.4400	-0.1612	-0.1047	-0.1513	0.0859	-0.0123
Phosphate surface	0.1229	-0.3394	0.3544	-0.1607	-0.1136	-0.5490	-0.7074**	0.0253	-0.1679
Phosphate bottom	0.6131*	0.0252	0.3481	-0.5621	-0.2851	-0.3938	-0.1429	-0.1777	0.1183
Silicate surface	-0.1241	-0.1198	-0.0785	0.1882	0.0639	0.3370	-0.2445	-0.2381	-0.0768
Silicate bottom	0.0911	-0.0817	0.4355	-0.2202	0.1559	0.0163	-0.2791	-0.3401	0.1488
Gross primary productivity	-0.2142	-0.1136	0.3300	0.3720	0.0539	0.3869	0.3068	-0.1828	-0.0681
Net primary productivity	-0.2497	0.2336	0.4686	0.0982	-0.3479	0.4471	-0.1331	-0.0132	-0.3504
Transparency	-0.3706	0.0946	0.2388	0.0759	0.4700	-0.0459	0.3230	0.0224	0.2385

* denote significance ($p < .05$) ** denote significance ($p < .01$)

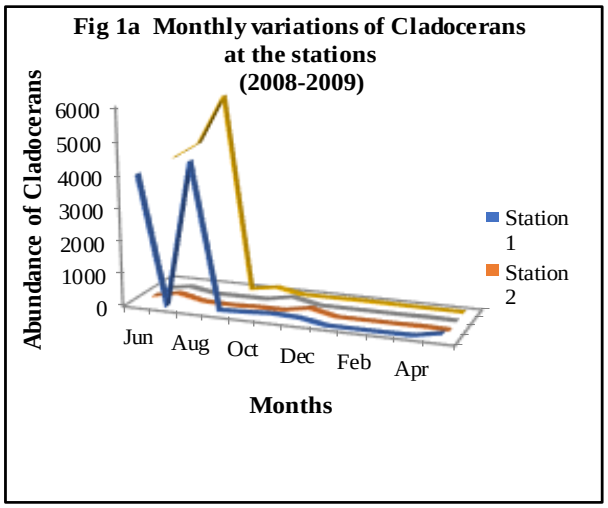
Fig 1a Monthly variations of Cladocerans at the stations (2008-2009)
Abundance of Cladocerans
6000
5000
4000
3000
2000
1000
0
Jun
Aug
Oct
Dec
Feb
Apr
Months
Station 1
Station 2

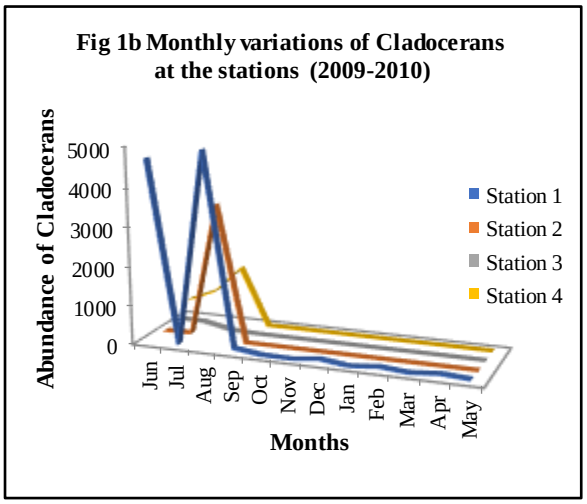
Fig 1b Monthly variations of Cladocerans at the stations (2009-2010)
Abundance of Cladocerans
5000
4000
3000
2000
1000
0
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Months
Station 1
Station 2
Station 3
Station 4

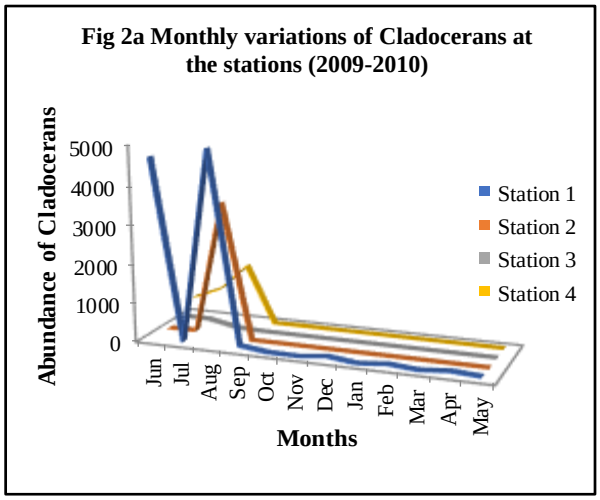
Fig 2a Monthly variations of Cladocerans at the stations (2009-2010)
Abundance of Cladocerans
5000
4000
3000
2000
1000
0
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Months
Station 1
Station 2
Station 3
Station 4

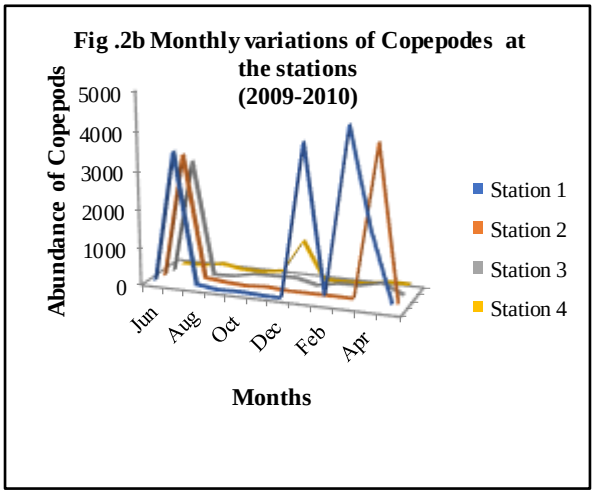
Fig .2b Monthly variations of Copepodes at the stations (2009-2010)
Abundance of Copepods
5000
4000
3000
2000
1000
0
Jun
Aug
Oct
Dec
Feb
Apr
Months
Station 1
Station 2
Station 3
Station 4

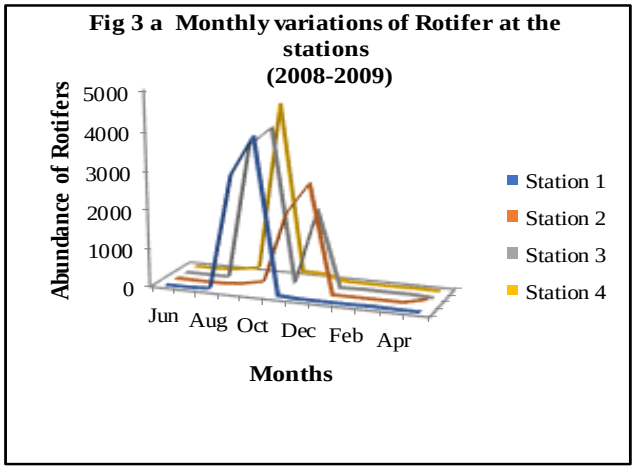
Fig 3 a Monthly variations of Rotifer at the stations (2008-2009)
Abundance of Rotifers
5000
4000
3000
2000
1000
0
Jun
Aug
Oct
Dec
Feb
Apr
Months
Station 1
Station 2
Station 3
Station 4

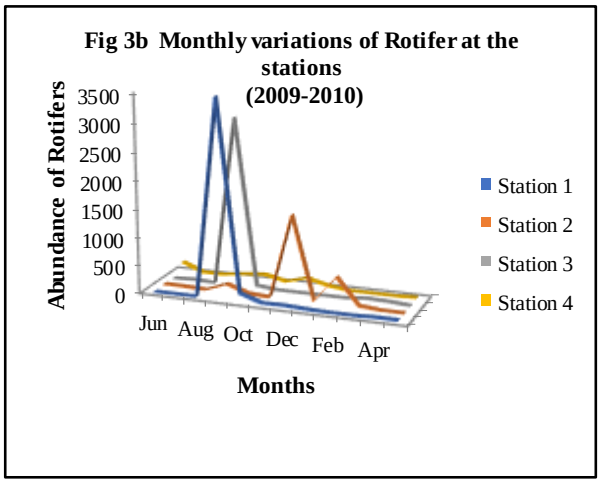
Fig 3b Monthly variations of Rotifer at the stations (2009-2010)
Abundance of Rotifers
3500
3000
2500
2000
1500
1000
500
0
Jun
Aug
Oct
Dec
Feb
Apr
Months
Station 1
Station 2
Station 3
Station 4

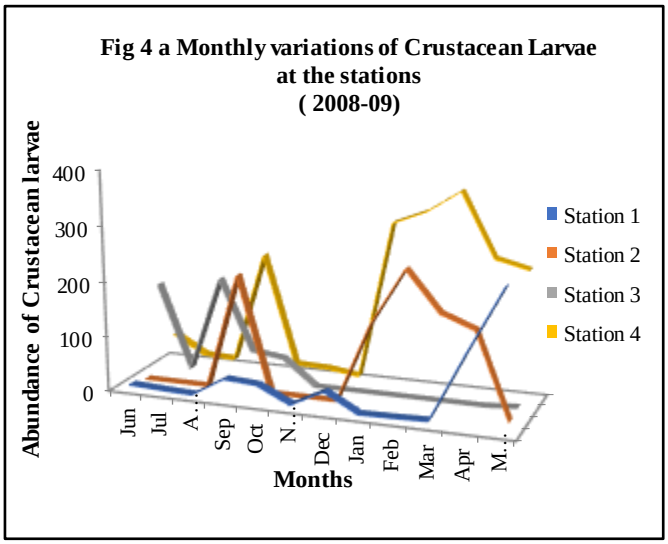
Fig 4 a Monthly variations of Crustacean Larvae at the stations (2008-09)
Abundance of Crustacean larvae
400
300
200
100
0
Jun
Jul
A...
Sep
Oct
N...
Dec
Jan
Feb
Mar
Apr
M...
Months
Station 1
Station 2
Station 3
Station 4

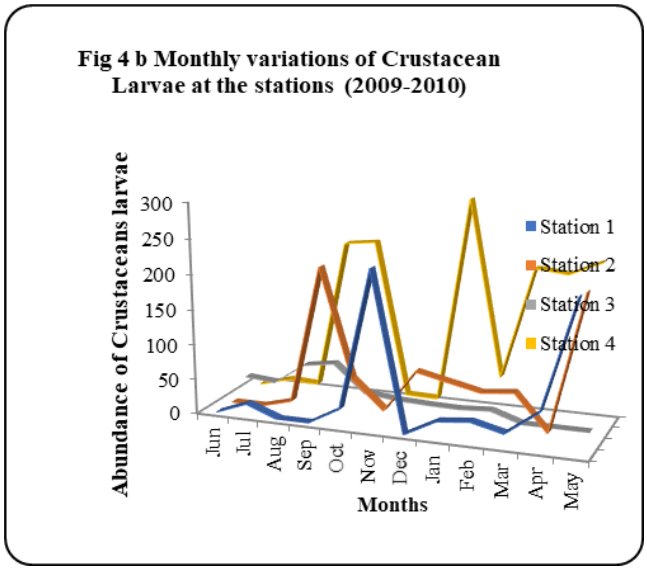
Fig 4 b Monthly variations of Crustacean Larvae at the stations (2009-2010)
Abundance of Crustaceans larvae
300
250
200
150
100
50
0
Jun
Jul
Aug
Sep
Oct
Now
Dec
Jan
Feb
Mar
Apr
May
Months
Station 1
Station 2
Station 3
Station 4

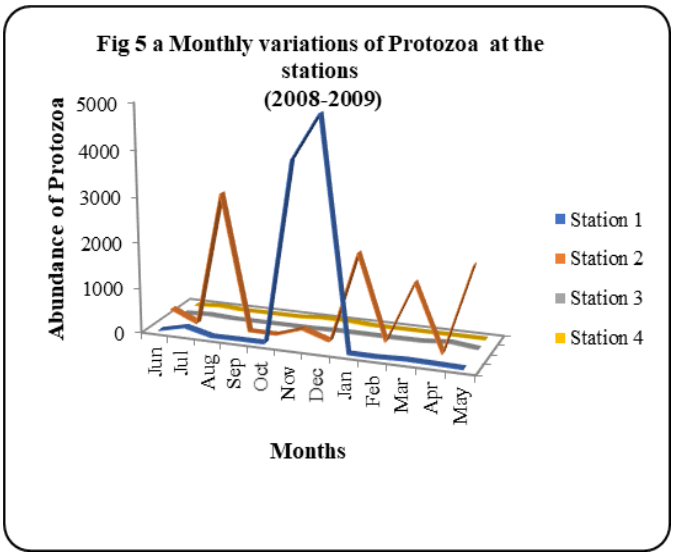
Fig 5 a Monthly variations of Protozoa at the stations (2008-2009)
Abundance of Protozoa
5000
4000
3000
2000
1000
0
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Months
Station 1
Station 2
Station 3
Station 4

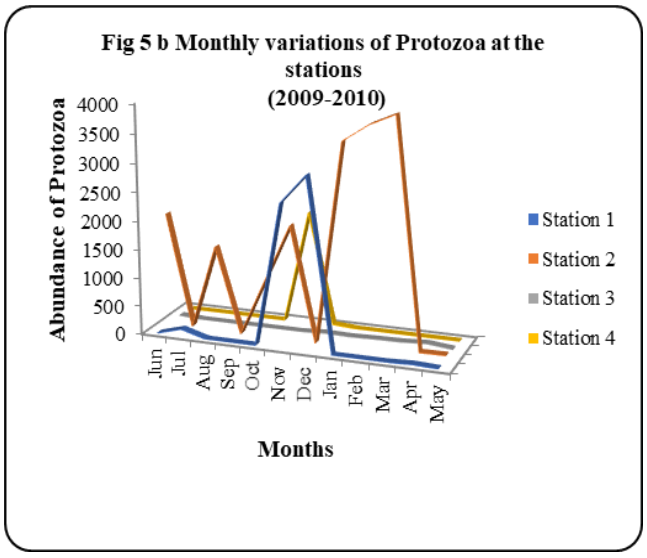
Fig 5 b Monthly variations of Protozoa at the stations (2009-2010)
Abundance of Protozoa
4000
3500
3000
2500
2000
1500
1000
500
0
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Months
Station 1
Station 2
Station 3
Station 4

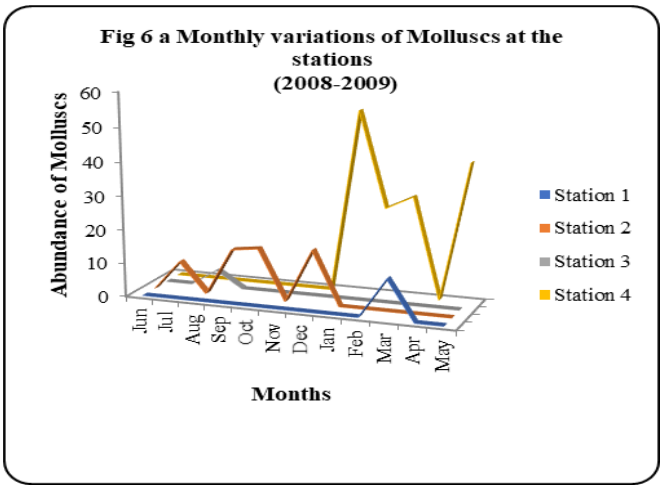
Fig 6 a Monthly variations of Molluscs at the stations (2008-2009)
Abundance of Molluscs
60
50
40
30
20
10
0
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Months
Station 1
Station 2
Station 3
Station 4

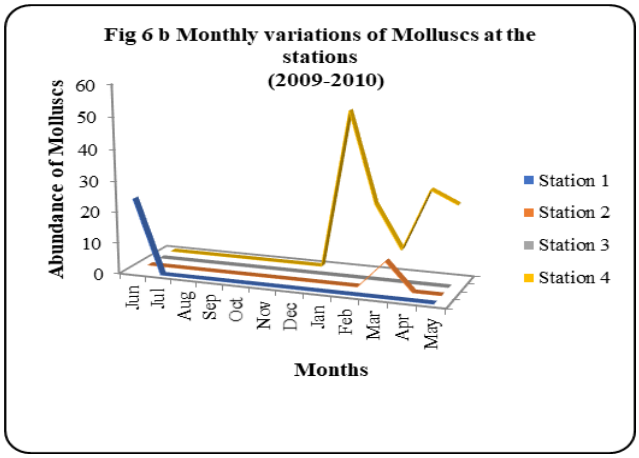
Fig 6 b Monthly variations of Molluscs at the stations (2009-2010)
Abundance of Molluscs
60
50
40
30
20
10
0
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Months
Station 1
Station 2
Station 3
Station 4

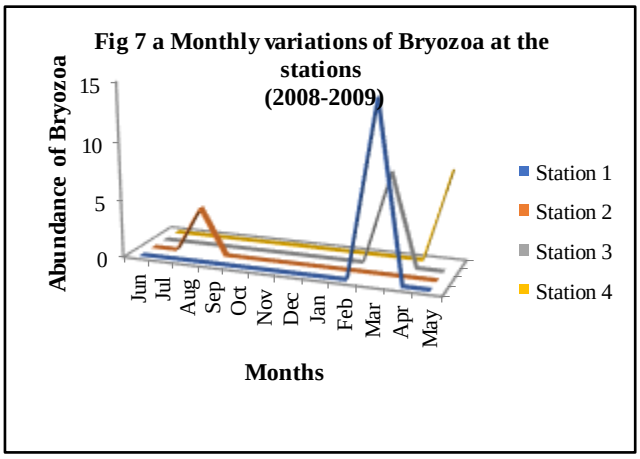
Fig 7 a Monthly variations of Bryozoa at the stations (2008-2009)
Abundance of Bryozoa
15
10
5
0
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Months
Station 1
Station 2
Station 3
Station 4

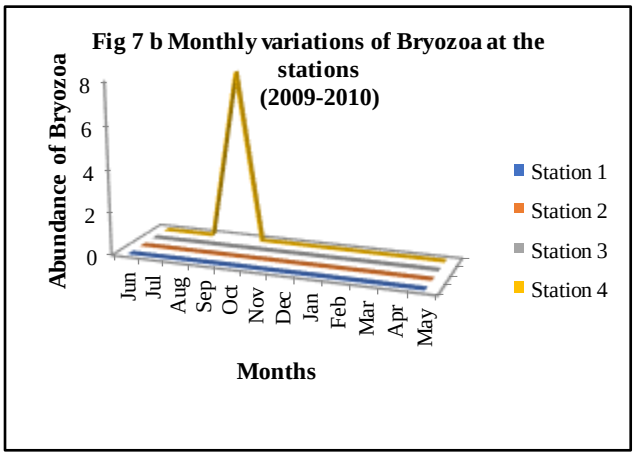
Fig 7 b Monthly variations of Bryozoa at the stations (2009-2010)
Abundance of Bryozoa
8
6
4
2
0
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Months
Station 1
Station 2
Station 3
Station 4

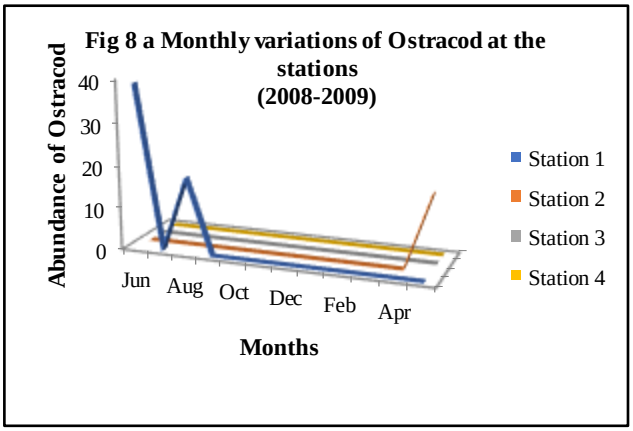
Fig 8 a Monthly variations of Ostracod at the stations (2008-2009)
Abundance of Ostracod
40
30
20
10
0
Jun
Aug
Oct
Dec
Feb
Apr
Months
Station 1
Station 2
Station 3
Station 4

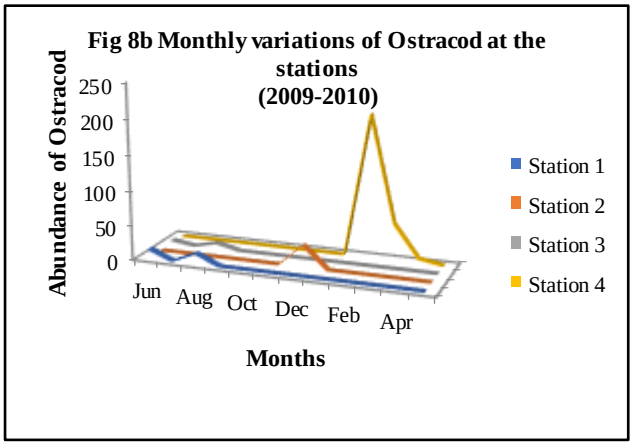
Fig 8b Monthly variations of Ostracod at the stations (2009-2010)
Abundance of Ostracod
250
200
150
100
50
0
Jun
Aug
Oct
Dec
Feb
Apr
Months
Station 1
Station 2
Station 3
Station 4

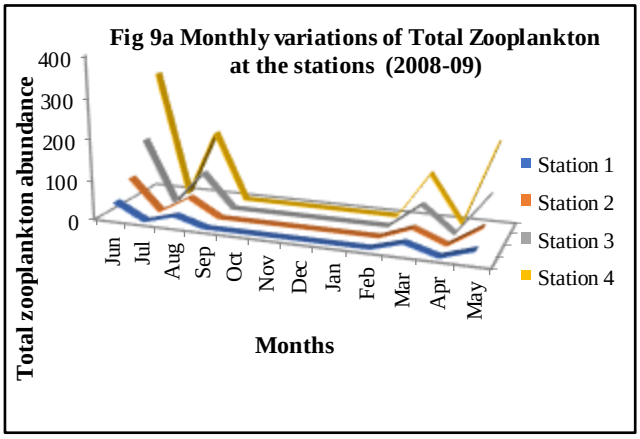
Fig 9a Monthly variations of Total Zooplankton at the stations (2008-09)
Total zooplankton abundance
400
300
200
100
0
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Months
Station 1
Station 2
Station 3
Station 4

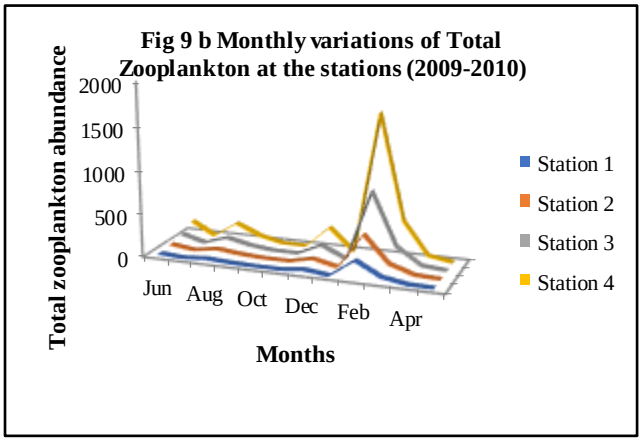
Fig 9 b Monthly variations of Total Zooplankton at the stations (2009-2010)
Total zooplankton abundance
2000
1500
1000
500
0
Jun
Aug
Oct
Dec
Feb
Apr
Months
Station 1
Station 2
Station 3
Station 4

Correlation of zooplankton revealed that Cladocera showed a significant positive relationship with Ostracods (at 1% level) in station 1, and with Copepods (at 5% level) in station 3 during the second year. Copepods exhibited as significant positive relationship Crustacean larvae (at 5% level).Crustacean larvae recorded a significant negative relationship (at 5% level) with Protozoa. Protozoa showed a significant positive relationship with Bryozoa (at 5% level) in station 2 during 2008-2009. Crustacean larvae showed a significant positive relationship with Molluscs (at 1% level) in station 4. A significant positive relationship was exhibited. between Molluscs and Ostracods, while a significant negative relationship (at 1% level) between Molluscs and Bryozoa. (Table 21a, 21b, 22a, 22b, 23a, 23b, 24a, 24b).Significant positive correlation of surface water temperature with Crustacean larvae and Molluscs were noticed. At the same time a significant inverse correlation of water temperature with Protozoa, Copepods, Cladocera was also observed. pH surface showed a significant negative correlation (at 1% level) with Cladocera. Similar type of significant inverse correlation between pH and Crustacean larvae was identified. Rotifers were positively correlated with pH and negatively correlated with dissolved oxygen and salinity. Maximum diversity of Rotifers was recorded during the pre-monsoon period which could between due to favourable environmental factors, food abundance with least disturbance. Minimum diversity during the monsoon season could between due to influx of fresh water from land run off caused by monsoon with more disturbances by tidal variations etc. Significant positive relationship between all plankton's groups except with Bryozoa (Table 21a, 21b, 22a, 22b, 23a, 23b, 24a, 24b). From the results it was clear that various physico chemical characters were closely related to the availability of different types of plankton's groups. In aquatic habitats, environmental factors including various physical properties (light penetration, temperature and density) and chemical properties (salinity, pH, hardness, phosphates and nitrates) of water and rainfall availability (Table 20) are very important for growth and dispersal of phytoplankton on which zooplankton depend for their existence. Thus, the correlation analysis revealed the dependence of each planktons group with the hydrographical parameters of the Thekkumbhagam creek.

IV. DISCUSSION

Nutrient enrichment resulting in eutrophication leading to algal bloom can have negative effects, causing severe economic laws to aquaculture, fisheries and tourism operations that cause major environmental disturbances and significant human health impacts. Few species have the ability to produce potent toxins which can find their way through fish and shellfish to humans. These toxins accumulate in shellfish while feeding on this alga, resulting in poisonous syndromes like Paralytic Shell fish Poisoning (PSP), Diarrhoeic Shell fish Poisoning (DSP), Amnesic Shellfish Poisoning(ASP) and neurotoxin shell fish poisoning in human consumers were earlier reported by Padmakumar (2010). Thus, the fishes may also be contaminated as well as causing Ciguatera Fish Poisoning (CFP) that result in human illness or death followed by the consumption of the contaminated fish (Richardson *et al.*, 1978). Thus, the study of zooplankton composition, distribution and abundance is a necessary requirement of a sustainable fishery management.

Thus, the present study deals with the diversity of zooplankton, which will form an index to measure the fertility of the water body. Hence it is needed for monitoring a sustainable fishery potential. Thus, this chapter focuses on different types of zooplankton in all the four stations. The types of zooplankton encountered during the present study belonged to groups namely the Cladocera, Copepods, Rotifers, Crustacean larvae, Protozoa, Molluscs, Bryozoa, Ostracods etc. Among the four stations Cladocera showed the highest mean value during the monsoon period in station 1. Station1 showed the highest mean value of Copepods during the pre-monsoon period. Rotifers exhibited its peak during the post-monsoon period in station 3. Crustacean larvae dominated on station 4 during the pre-monsoon period. Protozoa showed its highest mean value during the post-monsoon season in station 1 of the first year and pre-monsoon period. Molluscs recorded the maximum during the pre-monsoon season in station 4 during the two years. Ostracods reached its maximum mean value during the pre-monsoon period in station 2. Total zooplankton mean maximum was seen on station 1 during post-monsoon period.

In summer season, the absence of inflow of water brings stability of the water body. The availability of food is more due to production of organic matter and decomposition. These factors might contribute for high density in that season. From the observation of the present study it is evident that zooplankton showed distinct seasonal variations. Thus, each group of zooplankton showed their own maximal and minimal peaks.

The summer season zooplankton population was found to be higher; it might be attributed to favourable environmental conditions and availability of food (phytoplankton) in the lake ecosystem. Also, rich nutrient loading may support the high phytoplankton production which can ultimately support to zooplankton abundance/population (Manickam *et al.*, 2015). The increased level of temperature led to increased water evaporation, followed by rich nutrients and elevated level of zooplankton abundance in the lake during the summer season, whereas zooplankton falls during the monsoon due to dilution of lake by rainfall.

Studies on zooplankton communities, especially copepods are very important in assessing the health of coastal ecosystems (Ramaiah and Vijayalakshmi, 1997). The abundance and variations in distribution of zooplankton of estuaries are mainly related with salinity regime. The peak in Copepods during pre-monsoon season could be attributed to massive ingression of sea water in to the estuary. Many Copepod species disappears during monsoon and species composition also changed, since they are mostly stenohaline. This agrees with the reports of Eswari and Ramanibai,(2004).

The population of zooplankton falls during the monsoon due to dilution of lake by rainfall. The zooplankton population of lake showed an increasing trend during the winter because of favourable environmental conditions which include temperature, dissolved oxygen and the availability of rich nutrients in the form of bacteria, nano-plankton and suspended detritus. The elevated level of zooplankton in winter seasons due to favourable environmental factors has also been reported (Baker, 1979; Edmondson, 1965).

Studies on zooplankton communities especially copepods are very important in assessing the health of coastal ecosystems (Ramaiah and Vijayalakshmi, 1997). The growth of O*scillatoria* species indicated a high level of organic pollution as reported by Arivazhagan and Kamalaveni (1997). Species composition and seasonal variation in zooplankton abundance has been studied in other regions of Indian coastal waters by Govindasami & Kannan(1996); Gopinathan *et al.,* (2001); Ashok Prabhu *et al.,*(2008); Mathivanan *et al.,*(2007). According to Palmer (1980), *Euglena, Chlorella, Chlamydomonas, Oscillatoria, Ankistrodesmus* species are representatives of polluted water. Information on species diversity, richness, evenness and dominance evaluation on the biological components of the ecosystem is essential to understand detrimental changes in environments (Krishnamoorthy and Subramanian,1999;AshokPrabhu *et al*., 2005). Cyanophyceae, Bacillariophyceae shows dominance over Chlorophyceae in sewage polluted water. At the same time Green Algae was considered as the indicators of highly polluted water as per the findings of Rama Rao *et al*., (1978).

Copepods usually predominate in marine zooplankton communities and they hold a key position in marine food webs as the major secondary producers of the world's oceans. (Parsons *et al.,*1974). They feed primarily on phytoplankton and also are consumed by marine organisms of higher trophic levels. The distribution patterns of Copepods are often influenced by environmental factors especially in estuaries like rain fall, river discharge and decreased phytoplankton abundance. Thus, salinity is a key factor influencing the distribution of zooplankton.

The abundance of Cladocera during the monsoon period may between due to the low temperature, high nutrients and flooding of the lake. Low water temperature and other environmental conditions are pre- requisites to the hatching of resting Cladocerans eggs in natural water (Okechukwu and Okogevu, 2010). Under optimum environmental conditions, Cladocera tend to outcompete the Rotifers. As water quality deteriorated temperature and acidity increased during the dry season, the population of Cladocera declined. This relieved the suppressed Rotifer population leading to their predominant during the dry season. Predation by juvenile fishes might have contributed to the decline of zooplankton. *Keratella* species and *Brachionus* species was found to be most dominant during the course of study. Saksena and Sharma (1981) found that various species of *Brachionus* are greater in polluted water. Rotifers exhibit an interesting phenomenon that is cyclic variation in their morphology according to seasonal changes. Ali *et al.,* (1989) reported Rotifers as one of the most sensitive indicators of water quality. Prasad (2003) also reported Brachionus species and *Keratella* species as indicators of eutrophication.

Ostracods, bivalves, crustaceans are found in both freshwater and marine water. They inhabit a wide variety of fresh waters like lakes, swamps, streams, pools and heavily polluted areas. In the present study, other types of zooplankton encountered are insect larvae, fish eggs, nematodes, sponge spicules, polychaete larvae etc which belong to the 'rare' category. An idea about the productive nature of a water body is obtained as a result of understanding the variations in the phytoplankton and zooplankton community. The zooplankton, an important index of secondary production and a natural source of food, for higher organisms including fishes in an aquatic medium that constitutes potentially functional and dynamic community in aquatic ecosystem.From the present study a knowledge regarding the zooplankton abundance and the seasonal variations of the Thekkumbhagam creek will be helpful in planning and successful fishery management.

V. CONCLUSION

Considering the biodiversity values of the Thekkumbhagam creek and its economic role in providing livelihood to thousands of people and contributing significantly to the economy of Kollam district. Fishery resources are composed of both estuarine and marine species having great commercial importance. The estuarine beds also form the cradle for post larvae of shrimps, crabs, fry, and finger lings of marine and brackish water fishes, clams, and oysters etc which add significantly to the fishery export of Kerala. Plankton serves as the foundation stone of the fisheries associated with this area. Zooplankton encountered in the present study, its diversity and relationship with various physico-chemical parameters that will form an index to measure the fertility of the water body required for sustainable fishery potential. The zooplankton collected were classified under the groups namely the Cladocerans, Copepods, Rotifers, Crustacean larvae, Protozoa, Molluscs, Bryozoa, Ostracods etc. Besides these major groups, there were insect larvae, fish eggs, nematodes, sponge spicules, polychaete larvae etc that was in a 'rare' category. Cladocerans exhibited the highest mean value during the monsoon period in station 1. Copepods attained its peak in station 1 during the pre-monsoon period. Station 3 exhibited the Rotifer peak during post monsoon period. Station 4 was dominated by Crustacean larvae during the pre- monsoon period. Protozoa exhibited its highest mean value during the post-monsoon period. Molluscs reached its maximum value during pre-monsoon period in station 4. Station 2 recorded the maximum mean value of Ostracods during pre-monsoon periods. Thus, maintaining the hydrological regime of a wetland and its natural variability is necessary to maintain the ecological characteristics of this creek including its biodiversity. The primary necessity of today is to protect these wetlands from deterioration. Water quality monitoring is needed to understand the dynamics of the aquatic ecosystem.

This scientific knowledge will help in understanding the economic, social, cultural, aesthetic values and to create awareness among the general public.

VI. Acknowledgement

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