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STUDIES ON THE HYDROBIOLOGY OF RIVER CAUVERY AND ITS TRIBUTARIES ARASALAR FROM KUMBAKONAM REGION (TAMILNADU, INDIA) WITH REFERENCE TO ZOOPLANKTON

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ABSTRACT : The present investigation was an attempt to examine the composition, abundance, frequency of occurrence and diversity of net zooplankton species inhabiting in river Cauvery and its tributaries Arasalar at Kumbakonam, Tamil Nadu, India. From the selected 6 stations of river Cauvery and its tributaries Arasalar water samples were collected at monthly intervals. Qualitative and quantitative analysis of zooplankton were carried out during the year 2010 January to December. In the river Cauvery 45 species of zooplankton were identified. Rotifera species was dominant (34.97%); followed by Cladocera (29.92%), Copepoda (18.27%), Protozoa (12.2%) and Ostracoda (8.72%). Throughout the study, six species of Protozoa, 13 species of Rotifera, 12 species of Cladocera, 11 species of Copepoda and two species of Ostacoda were identified in the river Cauvery. Similarly, in the river Arasalar 38 species of zooplankton were identified. Rotifera species was dominant (37.87%); followed by Cladocera (26.32%), Copepoda (19.74%), Protozoa (9.17%) and Ostracoda (6.43%). During the study period, 5 species of Protozoa, 12 species of Rotifera, 11 species of Cladocera, 9 species of Copepoda and one species of Ostacoda were identified in the river Arasalar. During the winter and summer season maximum zooplankton diversity was recorded which was mainly dominated by Rotifer population. High turbidity observed as a major factor which restricts growth of the planktonic population during monsoon season. Not all of the identified species were found in all six sites, thus indicating different types of pollution across the sites. There was no significant difference in the quantity of phytoplankton across the sites; however the quality differs as a result of the various stressors. These findings indicate that the effect of anthropogenic stressors, brewery effluent and refuse impact the water body, albeit minimally.

Key Words: Seasonal variations; Zooplankton; River Cauvery; River Arasalar

INTRODUCTION

Zooplanktons are the central trophic link between primary producers and higher trophic levels. The freshwater zooplankton comprise of Protozoa, Rotifers, Cladocerans, Copepods and Ostracods. Zooplanktons constitute an important link in food chain as grazers (primary and secondary consumers) and serve as food for fishes directly or indirectly. According to Suontama (2004), an advantage of zooplankton as fish food is that they contain lower amounts of environmental toxins than organisms higher up the food chain. This is because environmental toxins accumulate as they move up the food chain. Nearly all fish depend on zooplankton for food during their larval phases, and some fish continue to eat zooplankton in their entire lives (Madin *et al.*, 2001). The rate of zooplankton production can be used as a tool to estimate the exploitable fish stock of an area (Twari and Nair 1991). It has been reported that in many countries the failure of fishery was attributed to the reduced zooplankton especially copepod population (Scottrup 2000). According to Nasser et al. (1998), some fishes are exclusively zooplankton feeder and therefore their abundance is directly linked to their presence (Mishra and panigraphy). Therefore any adverse effect to them will be indicated in the wealth of the fish populations. Thus, monitoring them as biological indicators of pollution could act as a forewarning for the fisheries particularly when the pollution affects the food chain (Mahajan, 1981).

Water quality is at present a global issue, especially when considering its implications to humanity in terms of water borne diseases. The deterioration of water quality has led to the destruction of ecosystem balance, contamination and pollution of ground and surface water resources. Water quality degradation world-wide is due mainly anthropogenic activities which release pollutants into the environment thereby having an adverse effect upon aquatic ecosystems. Water quality can be regard as a net work of variables (pH, oxygen concentration, temperature etc.,) that are linked and co linked; any changes in these physical and chemical variables can affect aquatic biota in a variety of ways. More often an issue raised by the public, concerning the deteriorating quality of a particular water body, forms the basis for water quality assessment. Thus water quality assessments is done to understand the quality of water, to show the causes of impacts, the level of impact, to verify the suitability for the current use and finally if the interpretation reveals the polluted status, outlining the restoration measures and alternatives for implementation by the decision makers. The decline in water quality and quantity has a great bearing on the social, economic and environmental status of a region. This necessitates restoration of degraded ecosystems as a part of conservation and sustainable management of aquatic ecosystems.

Furthermore many zooplankton species are used as indicators of water quality and pollution, (Mishra and Panigrahy 1999). They respond more rapidly to environmental changes than fishes, which have been traditionally used as indicators of water quality. Zooplankton used in the pollution assessment and monitoring studies in various ways which include change in community structure, species diversity, species preference and biological toxicants. Thus, the use of zooplankton for ecological biomonitoring of the water bodies helps in the analysis of water quality trends, development of cause-effect relationships between water quality and environmental data and judgments of the adequacy of water quality for various uses.

Zooplankton is rarely important in rivers and streams because they cannot maintain positive net growth rates in the face of downstream losses. Zooplankton communities respond to a wide variety of disturbances including nutrient loading (e.g.McCauley and Kalff 1981; Pace 1986; Dodson 1992), acidification (e.g. Brett, 1989; Keller and Yan 1991; Marmorek and Kormann 1993), contaminants (e.g. Yan *et al.*1996), fish densities (Carpenter and Kitchell 1993), and sediment inputs (Cuker 1997). Zooplankton density has also been reported to vary depending on the availability of nutrients and the stability of the water (Redmond, 2008). This study was therefore designed to determine if various anthropogenic stressors actually impact the water body and if they do, in what way and to determine if there is any significant difference in the abundance and diversity of the zooplankton population at different stations as a result of these stressors.

MATERIALS AND METHODS

A. Study area

Cauvery originates in Karnataka at Talakaveri, in Kodagu and flows down through Kushal Nagar, Srirangapatna, and Shivanasamudram before reaching Hogennikal and Srirangam in Tamilnadu. In Erode in Tamilnadu two more tributaries join it – Noyyal and Amaravathi. In Trichirapalli, it branches out in to Coleroon and Cauvery. Cauvery again divides in to Arasalar and Cauvery at Papanasam, near Kumbakonam. Kumbakonam in Tanjore district is located at 10º 59' north latitude and 79º 23' longitudes. India, along the certain holy river-edge settlements have grown into religious centers or holy cities. Kumbakonam is one such city in Tamilnadu, along the Cauvery River; located in the delta between the Cauvery and its

tributary Arasalar. The city has developed in the delta between the Cauvery River to the north and the Arasalar River, to the south and has a gentle slope from north-west to south-east. In the present context, there are vast agricultural wetlands to the north and south of planning area; with the rivers Cauvery and Arasalar as the main source of irrigation. The mighty Cauvery River in Tamil Nadu is reduced to a number of unused channels and falls into the Bay of Bengal at the historical place of Poompuhar or Kaveripoompatinam about 13kms north of Tharangampadi.

B. Sampling and Analysis of water

Each river (Cauvery and Arasalar) three sampling station designated as station1 (upstream of the river) station2 (midstream of the river) and station3 (downstream of the river) were established for sampling purpose. Sampling was done in the mornings before 8.00 am. Water samples were collected from six stations on monthly basis using a standard water sampler for a period of one year (Jan 2010 to Dec 2010). Surface water samples were analyzed according to standard method (APHA, 1998) for physicochemical parameters namely, temperature, transparency, total solids, pH, dissolved oxygen (DO), and biological oxygen demand (BOD).

C. Sampling of Zooplankton:

Water was collected from the surface with minimal disturbance and filtered in a No. 25 bolting silk cloth net of mesh size 63 mm and 30 cm diameter. The final volume of the filtered sample was 125ml. The sample was transferred to another 125ml plastic bottle and labeled mentioning the time, date and place of sampling. The samples collected in 125ml plastic bottles were preserved by adding 5ml of 4% formalin. The preserved samples were kept for 24 hours undisturbed to allow the sedimentation of plankton suspended in the water.

After 24 hours, the supernatant was discarded carefully without disturbing the sediments and the final volume of concentrated sample was 50ml. The preserved samples were brought to the laboratory for quantitative and qualitative analysis. Counting of the planktons was done by using a Sedgwick-rafter cell method (Welch, 1952). The abundance and diversity of Zooplankton at the six stations were determined by counting and identifying using standard identification keys.

D. Qualitative and Quantitative analysis of Zooplankton:

The qualitative and quantitative analysis of zooplankton was done by using Sedgwick-Rafter cell (for standardization) and by Lackey's drops method. Six strips were counted in Sedgwick-Rafter cell with dimensions of 50mm * 20mm * 1mm. In Lackey's drop method, the cover slip was placed over a drop of water in the slide and whole of the cover slip was examined by parallel overlapping strips to count all the organisms in the drop. About 20 strips were examined in each drop. Number of subsamples to be taken was dependent on the examining 2 to 3 successive subsamples without any addition of unencountered species when compared to the already examined subsamples in the same sample. The species belonging to each group were noted down and number of individuals in each species was counted. The number of organisms was expressed in Total organisms per liter using the formula,

$$\text{Organisms per liter (N)} = \frac{R * 1000\text{mm}^3 * 10^3}{L * D * W * S}$$

Where R = number of organisms counted per subsample, L = length of each strip, mm D = depth of a strip, mm W = width of a strip, mm S = number of strips counted. Therefore, Total organisms per liter = N * 1/C

$$\text{Where concentration factor, } C = \frac{\text{Volume of original sample (ml)}}{\text{Volume of concentrated sample (ml)}}$$

RESULTS

The total number of zooplankton and monthly average zooplankton n/L were shown in the Table 1and 2 while abundance and annual percentage of zooplankton components has been shown in Fig 1 and 2. It was noted that the total number of zooplankton in the river Cauvery recorded was 1266-5578 n/L, 933-5575 n/L and 793-5435 n/L for S1, S2 and S3 respectively. Similarly, in the river Arasalar recorded were 664-4540 n/L, 646-4370 n/L and 781-4538 n/L for S1, S2 and S3 respectively**.** The zooplankton in the six stations of both the river showed variations because of their diverse physico-chemical conditions. The effects of temperature, transparency, total solids, pH, dissolved oxygen and biological oxygen demand on zooplankton dynamics in the River Cauvery and its tributaries Arasalar during the study period are presented in Table 3 and 4. The zooplankton component of Cauvery River and Arasalar River consisted of the members of Protozoa, Rotifera, Cladocera, Copepod and Ostracoda are presented in table 5.

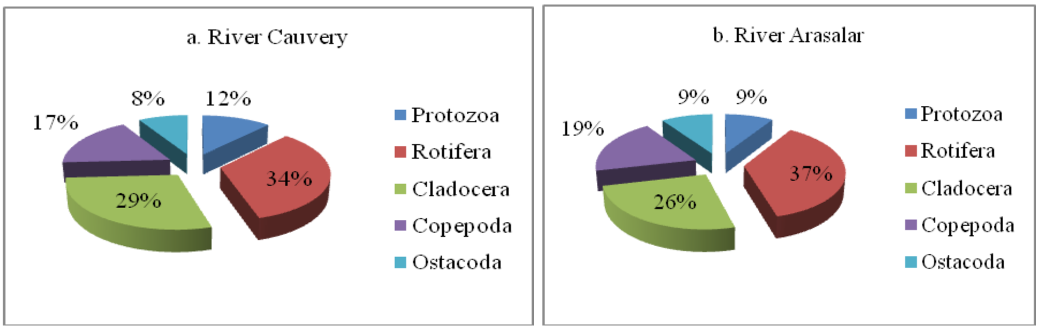

Fig. 1 Distribution of zooplankton genera in River Cauvery and Arasalar

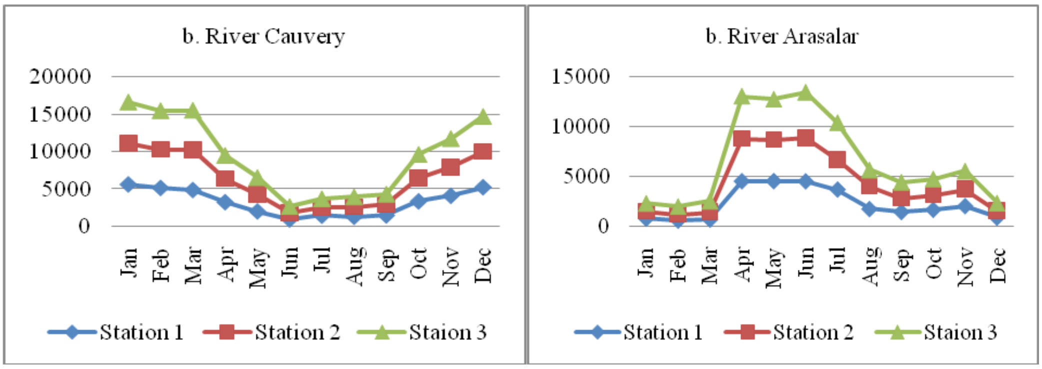

Fig. 2 Abundance of zooplankton at three stations in River cauvery and River Arasalar

River Cauvery

Forty four zooplankton species were identified from the Cauvery River (Table 5) and they were composed of protozoa (6), rotifers (13), cladocera (12), copopoda (11) and ostrocoda (2). The zooplankton fauna of Cauvery River were dominated by the Rotifers and followed by Cladocera, Copepoda, Protozoa and Ostacoda. The percentage of total annual zooplankton of the river Cauvery consisted of 12.26% Protozoa, 34.97% Rotifera, 29.92% Cladocera, 18.27% Copepoda and 8.72% Ostracoda (Fig.1.a). An annual average of Protozoa was 371.72 n/L, Rotifera was 1059.917 n/L Cladocera was 915.33 n/L, Copepoda was 553.80 n/L and Ostracoda was 264.41 n/L (Table.5). Annual averages revealed that Rotifera were the dominant group.

Table 1: Zooplankton species composition (n/L) from Cauvery River (2010)

Components	Jan 2010	Feb 2010	Mar 2010	Apr 2010	May 2010	June 2010	Jul 2010	Aug 2010	Sept 2010	Oct 2010	Nov 2010	Dec 2010	Annual Total
Station - I Protozoa	753	606	496	428	304	206	166	158	152	164	383	688	4504
Rotifera	1972	1959	1907	1313	506	144	137	62	164	1270	1560	1732	12726
Cladocera	1478	648	379	500	298	298	902	850	896	1660	1728	1544	10883
Copepoda	943	1193	1468	649	616	124	130	102	162	156	200	1056	6799
Ostracoda	432	706	588	328	262	136	84	94	78	73	196	182	3159
Monthly Total	**5578**	**5112**	**4838**	**3218**	**1986**	**908**	**1419**	**1266**	**1452**	**3323**	**4067**	**5202**	**38369**
Station - II Protozoa	723	666	558	398	274	176	136	128	122	134	353	466	4134
Rotifera	2106	2036	2073	1181	702	267	176	88	161	1228	1383	1592	12993
Cladocera	1497	636	454	599	362	224	650	896	992	1566	1718	1877	11471
Copepoda	912	1264	1499	724	710	124	136	124	68	152	232	744	6689
Ostracoda	337	624	810	291	280	142	96	138	142	76	202	162	3300
Monthly Total	**5575**	**5226**	**5394**	**3193**	**2328**	**933**	**1194**	**1374**	**1485**	**3156**	**3888**	**4841**	**33746**
Station - III Protozoa	773	726	608	448	324	226	186	178	172	184	403	516	4744
Rotifera	2056	1986	2023	1131	652	217	126	83	111	1178	1333	1542	12438
Cladocera	1397	536	354	499	262	124	550	796	892	1566	1618	1706	10300
Copepoda	892	1244	1479	704	690	104	116	104	58	132	212	714	6449
Ostracoda	317	604	790	271	260	122	76	118	122	56	182	142	3060
Monthly Total	**5435**	**5096**	**5254**	**3053**	**2188**	**793**	**1054**	**1279**	**1355**	**3116**	**3748**	**4620**	**36991**

Table 2: Zooplankton species composition (n/L) from Arasalar River (2010)

Components	Jan 2010	Feb 2010	Mar 2010	Apr 2010	May 2010	June 2010	Jul 2010	Aug 2010	Sept 2010	Oct 2010	Nov 2010	Dec 2010	Annual Total
Station - I Protozoa	158	132	170	328	404	306	383	118	102	99	65	164	2429
Rotifera	185	154	147	1713	1562	1870	1402	740	564	670	860	264	10131
Cladocera	142	78	109	1030	1098	1198	1002	450	396	560	628	152	6843
Copepoda	160	92	78	990	916	724	830	302	262	256	301	140	5001
Ostracoda	117	104	160	471	560	422	76	118	112	66	172	142	2620
Monthly Total	**762**	**560**	**664**	**4532**	**4540**	**4520**	**3693**	**1728**	**1436**	**1651**	**2026**	**862**	**26974**
Station - II Protozoa	128	102	230	298	370	276	353	108	112	109	95	134	2315
Rotifera	265	234	207	1513	1362	1670	1202	640	464	570	760	164	9051
Cladocera	112	84	119	950	1048	1098	952	350	356	460	428	132	6089
Copepoda	110	102	82	1090	866	924	110	702	362	256	252	122	4978
Ostracoda	107	124	148	421	500	402	396	122	142	85	152	160	2759
Monthly Total	**722**	**646**	**786**	**4272**	**4146**	**4370**	**3013**	**2272**	**1436**	**1480**	**1687**	**712**	**25542**
Station - III Protozoa	117	97	202	293	340	271	308	124	122	125	130	105	2234
Rotifera	315	284	257	1563	1412	1720	1252	690	514	620	810	194	9631
Cladocera	152	144	129	1050	1188	1298	1152	400	406	510	478	182	7089
Copepoda	130	142	182	910	766	824	750	302	362	266	275	132	5041
Ostracoda	107	114	302	421	342	425	220	122	142	90	125	145	2055
Monthly Total	**821**	**781**	**1072**	**4237**	**4048**	**4538**	**3682**	**1638**	**1546**	**1611**	**1818**	**758**	**26550**

Monthly fluctuation of zooplankton showed four peaks in December (5202 n/L), January (5578 n/L), February (5112 n/L) and March (4838 n/L) (Table1). Three peaks of Protozoa were observed in December (688 n/L) January (753 n/L), and February (606 n/L). Four peaks of Rotifera were observed in December (1732n/L), January (1972 n/L), February (1959 n/L) and March (1907n/L).

Three peaks of Cladocera were observed in October (1660n/L), November (1728 n/L) and December (1544 n/L). The Copepoda showed two peaks, one in March (1468 n/L) and another in December (1056 n/L). Similarly, the Ostracoda showed two peaks, one in February (706 n/L) and another in March (810 n/L). During the twelve months of collection the Rotifers were the dominant forms. Cladocera and Copepods were seen throughout the year.

On the basis of qualitative study, species of *Arcella, Difflugia* and *Vorticella* were the most common species which occurred throughout the study period among the class Protozoa while as among the Rotifera class*Brachionus angularis, Brachionus falcatus, Keratella tropica, Lecane lunaris* and *Testudinella patina* were the dominant species. *Bosmina* sp., *Chydorus sphaericus, Daphnia pulex, Diaphanosoma excisum* were dominant among Cladocera. *Mesocyclops leuckarti and Thermocyclops crassus* were recorded during all the seasons among Copepoda. Ostracoda occupied fifth position of zooplankton and represented very low population diversity compared to other groups. Two species were identified *Cypridopsis spp* and *Crpris spp* (Table 5).

Table. 3 Water quality parameters of river Cauvery

Water quality Parameters	Range value			Mean value ± Standard Deviation		
	S1	S2	S3	Station 1	Station 2	Station 3
Water Temperature-ºC	25-31	26-32	26-31	28.23±1.96	28.65±1.88	28.23±1.96
Transparency -cm	40-28	42-160	45-140	111 ± 54.76	96.53 ± 43.03	91.61 ± 34.07
Total Solis-mg/L	420 -680	370 -670	320 -660	536.15±91.51	487.69±113.95	472.30±103.53
pH	7.5 -8.1	7.6 -8.3	7.4 -8.1	7.74±0.20	7.85±0.22	7.74±0.20
Dissolved Oxygen-mg/L	5.1 -8.0	4.3 -7.6	5.1 -7.8	6.51±1.03	6.35±1.02	6.51±1.03
BOD-mg/L	7.2 -14.1	9.2 -14.5	8.4 -13.1	10.46±2.17	10.61±1.91	10.56±1.46

Table. 4 Water quality parameters of river Arasalar

Water quality Parameters	Range value			Mean value ± Standard Deviation		
	S1	S2	S3	Station 1	Station 2	Station 3
Water Temperature-ºC	26-32	26-32	27-32	29 ± 1.58	28.84 ± 1.62	29 ± 1.47
Transparency- cm	26 -115	29 - 121	30-160	62.61±24.56	70.61±30.48	105.84±58.17
Total Solis mg/L	480-750	580-780	570-775	610.76±83.21	655.38 ± 77.20	646 ± 75.56
pH	7.5-8.2	7.6-8.4	7.6-8.3	7.79 ± 0.21	7.93 ± 0.26	7.88 ± 0.26
Dissolved Oxygen- mg/L	5.4-7.4	5.1-7.5	5.2-7.7	6.46 ± 0.59	6.36 ± 0.76	6.42 ± 0.80
BOD-mg/L	8.7-14.2	9.7-14.4	9-14	11.9 ± 1.60	12.40 ± 1.60	11.84 ± 1.67

The highest water temperature was 31ºC and the least 25ºC while the transparency ranged between 40 and 140. The highest total solids were 660 mg/L and the least 320 mg/L while the pH ranged between 7.5 and 8.3. The highest DO value was 7.8 mg/L and the lowest was 5.1 mg/L while the highest BOD value was 14.1 mg/L and the least 7.2 mg/L. The mean and standard deviation values are given in Table 3.

River Arasalar

Thirty eight zooplankton species were identified from the Arasalar River (Table 5) and they were composed of protozoa (5), rotifers (12), cladocera (11), copopoda (9) and ostrocoda (1). The zooplankton fauna of Cauvery River were dominated by the Rotifers and followed by Cladocera, Copepoda, Protozoa and Ostacoda. The percentage of total annual zooplankton of the river Arasalar consisted of 9.17 % Protozoa, 37.87% Rotifera, 26.32 % Cladocera, 19.74 % Copepoda and 9.74 % Ostracoda (Fig.1.a). An annual average of Protozoa was 196.08 n/L, Rotifera was 800.36 n/L Cladocera was 556.13 n/L, Copepoda was 418.61 n/L and Ostracoda was 217.61 n/L (Table.5). Annual averages revealed that rotifera were the dominant group.

Table 5: Occurrence and diversity of zooplankton species at three sites in River Cauvery and Arasalar

SPECIES COMPOSITION	STATION 1	STATION 2	STATION 3
PROTOZOA			
1. *Amoeba spp*	+++	+	+
2. *Paramecium spp*	+	-	+++
3. *Verticella spp*	+	+++	++
4. *Arcella spp*	-	++	-
5. *Actinosparium spp*	+	-	+
6. *Ceretium focus spp*	+	-	+
ROTIFERA			
1. *Branchionus spp*	+++	+++	+++
2. *Notholca spp*	++	+++	+++
3. *Trichocerca spp*	++	+++	+++
4. *Asplanchna spp*	++	+++	+
5. *Testudinella spp*	+++	++	-
6. *Rotaria spp*	-	+	++
7. *Eosphora spp*	+	+	+
8. *Lepadella spp*	+++	++	+
9. *Cephalodella spp*	+++	+	+
10. *Monostyla spp*	+	-	+
11. *Searridium spp*	+	-	+
12. *Filinia spp*	+	++	+
13. *Keratella spp*	+	+	+++
CLADOCERA			
1. *Branchinella spp*	+++	+++	++
2. *D.longipinna*	+++	-	+
3. *D.similis*	-	+	-
4. *Alona spp*	-	+	+
5. *Moina spp*	+	-	+
6. *Mysis spp*	+++	+++	+
7. *Zoea spp*	+	+	+
8. *Nauplius spp*	+	++	++
9. *Simocephalus spp*	+	++	++
10. *Camptocercus spp*	++	+	++
11. *Chydorus spp*	++	+	-
12. *Ceriodaphnia spp*	-	+	+
COPEPODA			
1. *Cyclops spp*	+++	++	++
2. *Mesocyclops spp*	++	+	+
3. *Ectocyclops*	+++	++	+
4. *Eucyclops*	++	-	+
5. *Microcyclops*	++	+	++
6. *Paracyclops*	-	+	++
7. *Heliodiaptomus viduur*	+	-	+
8. *Diaptomus spp*	++	+	+
9. *Neodiaptomus spp*	-	+	-
10. *Paradiaptomus spp*	++	++	-
11. *Metacyclops spp*	++	++	++
OSTRACODA			
1. *Cypridopsis spp*	++	+	+
2. *Crpris sp.*	++	+++	++

NOTE: - Absent; + = Occurs less often, 1-10; ++ = Occurs often, 11-20; +++ = Occurs more often, 21-30

Monthly fluctuation of zooplankton showed four peaks in April (4532 n/L), May (4540 n/L), June (4520 n/L) and July (3693 n/L) (Table1). Two peaks of Protozoa were observed in April (328 n/L) May (404 n/L). Three peaks of Rotifera were observed in April (1713 n/L), May (1562 n/L) and June (1870 n/L). Three peaks of Cladocera were observed in April (1030 n/L), May (1098 n/L) and June (1198 n/L). The Copepoda showed two peaks, one in April (990 n/L) and another in May (916 n/L). Similarly, the Ostracoda showed two peaks, one in April (471 n/L) and another in May (560 n/L). During the twelve months of collection the Rotifers were the dominant forms. Cladocera and Copepods were seen throughout the year.

Qualitative zooplanktonic analysis has shown irregular presence of various groups of zooplankton in this river. Species of *Arcella, Difflugia* and *Vorticella* were the most common species which occurred throughout the study period among the class Protozoa Among rotifera *Branchionus spp Notholca spp Trichocerca spp Asplanchna spp and Testudinella spp* were dominated in the present investigation. In the cladocera *Nauplius spp Simocephalus spp Camptocercus spp Chydorus spp* group were dominant in the present study. Among copepods *Mesocyclops haylinus Metacyclops, Diaptomus* and *Neodiaptomus strigilipes* were dominant and only one species of class Ostracoda namely *Stenocypris malcolmsoni* was found throughout the study period (Table 5). The highest water temperature was 32ºC and the least 26ºC while the transparency ranged between 26 and 160. The highest total solids were 780 mg/L and the least 480 mg/L while the pH ranged between 7.5 and 8.4. The highest DO value was 7.7 mg/L and the lowest was 5.1 mg/L while the highest BOD value was 14.4 mg/L and the least 8.7 mg/L. The mean and standard deviation values are given in Table 4.

DISCUSSION

A marked seasonal variation in zooplankton population was recorded during the present investigation. In general, the maximum density was observed in winter season and summer season, while low density was observed in monsoon season. The winter season is most favorable period for the growth and multiplication of zooplankton species. The same finding has been also reported by Abdus and Altaff, (1995) and Kumar, (2001). Less zooplankton population during monsoon season in on account of high turbidity which restricts growth of the planktonic population. Choudhary and Singh (1999) studied zooplankton population of Boosra lake at Muzaffarpur, Bihar State of India, and reported that the abundance of zooplankton were more during winter months and less during rainy months. Kumar (2001) studied the fresh water zooplankton of some lake in Dharmapuri District, Tamil Nadu state of India and reported that the abundance of Ostracods was maximum during winter months and minimum during rainy months.

During the present investigation class Rotifera was dominated among all the zooplanktonic groups in both the rivers. In the river Cauvery the diversity of zooplankton varied from season to season and the maximum diversity was recorded in winter season while minimum was observed in monsoon season (Table 1 and). The results indicates that the maximum number of genera occurred during winter season than summer and monsoon season which also reported by Abdus et al (1995) and Kumar (2001). The less number of genera might be attributed to the fewer nutrients in the river which consequently result in less productivity or might be due to the depletion of important factors such as dissolved oxygen and pH. However, in the river Arasalar the diversity of zooplankton varied from season to season and the maximum diversity was recorded in summer season while minimum was observed in monsoon season (Table 2). The results indicates that the maximum number of genera occurred during summer season than winter and monsoon season which also reported by (Jhingran 1982). The reduction in the number of genera (species) may be due to predation, variation in the pH of water is always associated with the genera (species) composition of Zooplankton inhibiting among them (Jhingran 1982). In winter, it is biotic interaction operating through feeding pressure rather than water quality it seems to affect the zooplankton diversity and density particularly the stocked fish species play an important role in harvesting species of copepoda and cladocera, thereby reducing their predatory pressure on other groups. The rotifers and particle feeder cladocera were higher in winter can be linked to favorable temperature and availability of abundant food in the form of bacteria, nanoplankton and suspended detritus (Edmondson, 1965 and Baker, 1979).

The observed high density of zooplankton in Station 1 could be attributed to the accumulated wastes like human activities mostly the refuse dumping, domestic sewage, detergent run-off as a result of washing activities, cow dung and poultry droppings constantly washed into the stream at this station of river Cauvery and Arasalar. These high organic materials enhance phytoplankton growths that support the zooplankton community. The low density of zooplankton observed in Station 2 could be linked to low dissolved oxygen and high biological oxygen demand (BOD) in this station. The low dissolved oxygen and high biological oxygen demand levels were caused by the influx of enormous domestic and industrial effluents from Station 2.

There was marked difference in the density of total zooplankton in the two rivers. In the river Cauvery, minimum number of zooplankton was 908 n/L in June and maximum 5578 n/L in January whereas, in river Arasalar minimum number of zooplankton was recorded 560 n/L in February and maximum was recorded 4540 n/L in May. From the observation, it is obvious that zooplankton showed their peak in January (a winter month). Bhuiyan & Nessa (1998a, b) and Islam *et al*. (2000) recorded highest density of zooplankton in January (442213units/L and1350units/L respectively). The peak of zooplankton in winter may be due to the favorable conditions of the physico-chemical parameters and the availability of nutrients in the rivers. Mainly five groups of zooplankton Protozoa, Rotifera, Cladocera, Copepoda and Ostacoda were identified in the present study. Similar findings were found with Shankaran & Varghese (1981) and Hossain *et al*. (1999). Comparatively higher concentration of zooplankton was found with Cauvery River than that of Arasalar River. This might be due to the effect of fertilizer and subsequent water quality changes in the rivers. These results were more or less agreed with Nayar (1965), Knud-Hansen *et al*. (1994) and Edwards *et al*. (1994). Singh *et al.* (2002) reported that higher rotifer population occur during summer and winter might be dominant due to hyper tropical condition of the river at high temperature and low level of water. The dominance of rotifers was reported in winter (Kulshreshtra and Joshi, 1999). This is confirmed in the present study. Chandraseker (1996) showed that the water temperature, turbidity and transparency and dissolved oxygen were favor for rotifer population. In rainy rotifers were lower might be due to neutral pH. At the alkalinity, pH and temperature above 290C the rotifers disappears (Dhanapathi, 1995). The differences in seasonal density might be the nutrition and biotic interactions (Power and Pulle, 2005). Rotifer species showed marked difference in their tolerance and adaptability to change in physicochemical and biological events. They play important roles as grazers, suspension feeders and predators in the zooplankton community. Higher rotifer population indicates pollution from organic matter. Density and diversity of cladocera depend on water temperature, DO, turbidity and transparency (Pawar and Pulle, 2005). During the winter period cladocera species were maximum can be attributed to the favorable water temperature and food (Edmondson, 1965; Baker, 1979) and organic matter. It indicates that minimum temperature was favor for cladocera. This is confirmed in the present study.

In the river Arasalar net zooplankton species increased their abundance during summer (April-May), probably corresponding to the water quality, decaying vegetation, increased levels of organic matter in the sediment and higher abundance of bacteria in the lake during this time (Jacoby and Greenwood, 1989; Srivastava *et al*., 1990; Coman *et al*., 2003). In contrast, the abundance of net zooplankton species decreased in winter (November-January), probably corresponding to low water temperature and high alkalinity (pH 7.6-9.8) of this water body (Chattopadhyay and Banerjee, 2007). In contrast, the river Cauvery net zooplankton species increased their abundance during winter and decreased in summer. Sarkar and Chaudhuri, (1999) noticed that the fluctuation of abiotic factors as dissolved oxygen, temperature, total alkalinity, phosphate, nitrogen, and pH can influence the growth of zooplankton. Das *et al,* (1996) showed relationship between zooplankton and physico-chemical parameters such as densities, pH, alkalinity, nitrate and phosphate. Nutrient availabilities influence the abundance of rotifer and copepoda (Kumar *et al.* 2004).

In the river Arasalar the transparency was found more when compare to the river Cauvery. This may be due to the more turbid condition of the river due to the mixing of the effluents. Moreover, the transparency appeared to be extremely low, which might be largely responsible for the very low zooplankton densities recorded during the study period as Dejen et al., (2004) had earlier reported that silt held in suspension in turbid water interferes with filter feeding mechanisms of crustaceans and this affects their reproduction success. Arasalar River appeared to have a low diversity of zooplankton species with relatively low densities perhaps primarily due to low transparency level among other factors that strongly limit light penetration and thus photosynthesis. Similarly, Hart (1986) reported that transparency values above 0.30 - 0.35M appeared to be necessary for the development of sufficient and suitable zooplankton to benefit fishery. The reason for the minimum transparency in the river Cauvery due to the dilution of the sewage and effluents and also the water flow is more when compare to the river Arasalar. Transparency or light penetration depends on the intensity of sunlight, suspended soil particles, turbid water received from catchment area and density of plankton etc. (Mishra and Saksena, 1991; Kulshrestha and Sharma, (2006).

The zooplankton population dynamics might have been influenced by agricultural runoff and other human activities in the river Cauvery. In this study the primary sources for elevated.

TDS level in river water are agricultural runoff, particulate matter of cement and other raw material used in construction of river front, leaching of soil contamination and non point source of water pollution i.e. discharge from industrial and sewage treatment plants particularly during dry season with low water level and relatively low values during wet season might due to dilution effect (Moniruzzaman, 2009). River Cauvery show a lower TDS value than Arasalar. The reason for the minimum total solids in the river Cauvery due to the dilution of the sewage and effluents and also the water flow is more when compare to the river Arasalar. The same is reported by Subbarao *et al*. (1997). The pH value was ranged 6.9 to 7.4. It indicates alkalinity nature. High pH was recorded during rainy. Tenner *et al*. (2005) noticed that the range of pH from 6 to 8.5 indicates medium production of reservoir. Present study indicates that the river is medium production of zooplankton population because pH in the range of 6.9 to 7.4.

Dissolved oxygen (DO) is an important aquatic parameter whose presence is vital to aquatic fauna. It plays crucial role in life processes of animals. It is ranged from 3.23 to 3.98 ppm. High concentration of DO was recorded during winter. This may be due to low solubility at low temperature and high degradation of organic substances. Singh and Singh (1993) drew a conclusion that DO value may be favor or not to the zooplankton. Estimation of biological oxygen demand (BOD) is an important factor to the oxygen required for the degradation of organic matter. Rajagopal *et al,* (2010) noticed BOD was favorable to zooplankton. At both the rivers, the BOD values were high during the study period. The results indicate that the water body had suffered deterioration and degradation due to agricultural runoff and continuous discharge of domestic and municipal sewage. High BOD value is unflavored with zooplankton. In general, in all the stations, richness and evenness of zooplankton were comparatively low in pre-monsoon and post monsoon periods. During this periods the phytoplankton abundance also low due to rain. Due to rain water causes strong currents which wash away the phytoplankton, Ramanujan (1994) the depletion of phytoplankton naturally affects the population of zooplankton.

CONCLUSION

Overall it is concluded that, the diversity and density of zooplankton depends upon the nutrient condition of water body, abiotic factors, DO, BOD, food chain, soil-water chemistry and web with life cycle. Hence theirs is needed to conserve biotic and abiotic of water body. There was evidence from this study that human activities mostly the refuse dumping, domestic sewage, detergent run-off as a result of washing activities and changing environmental conditions might be responsible for the fluctuation of zooplankton abundance and seasonal succession in these rivers. It can be concluded that the present findings indicated that the Cauvery River showed better result than that of the Arasalar River regarding zooplankton production. This study showed that community size of zooplankton was the highest in summer and winter while the lowest density in rainy. Thus, the quality and quantity of zooplankton have fluctuated monthly, seasonally and altitudinal in the river Cauvery and its tributaries Arasalar besides many physico-chemical factors in the rivers.

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