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Density and Diversity of Planktonic Rotifers in Nandipur Canal

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ABSTRACT

Density and diversity of planktonic rotifers were assessed with respect to seasonal variations in Nandipur canal. Sampling was done at three sites on monthly basis from October 2011 to September 2012. In total, 28 rotifer species belonging to 10 families and 14 genera were recognized. ANOVA showed a significant difference in population density of rotifers in different seasons. Highest (42.34±13.24 ind/ml) population density of rotifers was in June while the lowest (12.01±6.80 ind/ml) in January. Temperature, pH, conductivity, total hardness and turbidity reflected positive correlations with rotifers whereas there was negative correlation with D.O and transparency. Shannon-Weaver diversity index ranged between 2.409 to 3.092 that showed high diversity of planktonic rotifer species. Species evenness ranged from 0.99 to 0.957 that reflected even distribution of rotifers.

Key Words: planktonic rotifers, dissolved oxygen, temperature, conductivity

INTRODUCTION

There are three major groups of freshwater zooplanktonic invertebrates i.e., Rotifers, Cladocerans and Copepods. The members of the phylum Rotifera are found in freshwater bodies (Wallace & Snell, 1991; Papa & Zafaralla, 2011). Fresh water habitats have 95% rotifer species and remaining 5% are marine. Rotifers are important members of the littoral and limnetic invertebrates (Wallace & Snell, 2010; Sulehria *et al*., 2013). Phylum Rotifera has about 2200 identified species and is divided into three classes, i.e., Monogononta, Bdelloidea and Seisonidea (Barnes *et al*., 2011). New rotifer species are being identified from different regions of the world. Rotifers have 300 years old history and their taxonomic studies are still going on. A few rotifer species are very specialized, but most of them are opportunistic pseudocoelomates that consume various types of food such as bacteria, ciliates and algae while some are detritivorous (Wallace & Snell, 2010; Sulehria & Malik, 2013).

Due to high protein content, larvae of most planktivorous species of fish use rotifers as a source of nutrients for rapid growth (Clarke *et al*., 2013). Distribution of rotifers is influenced more by ecological barriers rather than geographical barriers (Pejler, 1995; Sulehria *et al*., 2012). Temperature, potential food resources, nutrients, abundance of predators and competitors are the major factors that affect the structure of rotifer community (Ekhande *et al*., 2013). They can respond more abruptly and quickly to the changes in water bodies as compared to other zooplanktons. The study of rotifers may be important to assess the quality of a water body (Kumar *et al*., 2011).

Several studies of planktonic rotifers and their interactions with abiotic parameters have been done in a few freshwater bodies in Pakistan (Mahar *et al.,* 2000; Malik & Sulehria, 2003, 2004; Baloch *et al*., 2004, 2008; Sulehria *et al*., 2009a, 2009b; Sulehria & Malik, 2012, 2013; Sulehria *et al*., 2012, 2013). The present study is the first research work on rotifers in lotic waters of Gujranwala (Nandipur canal) and is aimed at identification of rotifer species, determination of seasonal variations of rotifer fauna, abiotic parameters of lotic water and correlation between rotifers and abiotic parameters.

MATERIALS AND METHODS

Study area

Nandipur is 15 Km away from Gujranwala city on eastern side at Gujranwala-Sialkot Road at Latitude: 32° 15' 10" North and Longitude: 74° 15' 30" East (Fig., 1). The Upper Chenab Canal near Nandipur is named Nandipur Canal. In March 1963, a small hydroelectric power plant started producing electricity (14MW) at Nandipur Canal. Presently a new thermal power station is under construction at

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the bank of Nandipur Canal to compensate the shortage of electricity.

Rotifer Sampling

Three sampling sites i.e., site-I (NS1), site-II (NS2) and site-III (NS3) were selected in the Nandipur Canal. Each site was further subdivided into three sub-sites. Rotifers were collected monthly from October 2011 to September 2012 by standard plankton net of 37µm mesh size (Wisconsin net). The net was towed horizontally for about 2 to 3 minutes so that 50 litres of water might pass through it. Three samples were collected from each sampling site. Water samples collected from sub-sites of each site were mixed to have a composite sample. Sampled volume was calculated after Perry, (2003). Rotifers were preserved in 4-5% formaldehyde solution in 50 ml plastic bottles (Koste, 1978). An additional sample of rotifer was taken from each site in order to study live organisms.

Rotifer Counting and Identification

Rotifers were identified on the basis of different morphological characters, size, shape and behavior (Ward & Whipple, 1959; Koste, 1978; Pennak, 1978; Segers, 2007). Sedgewick-Rafter chamber was used to count the rotifers (APHA, 2005) at 60-100x using an inverted Olympus microscope. Live rotifers were also studied after staining with vital stain (1% neutral red) under the microscope. Photographs of rotifers were taken by using microscope LEICA HC 50/50 microscope, with 5 megapixel camera, fitted on it.

Water Sampling and Physico-chemical Parameters

Physico-chemical characteristics of water were monitored from October 2011 to September 2012. Water samples were taken between 9.0 A.M. to 1.0 P.M., usually, in 1st week of every month. Before sampling the sample bottles (BOD bottles as well as 1.5 L plastic bottles) were first soaked in 2-5 % HCl solution and then rinsed with distilled water and dried by inverting them on dry place. Samples were taken slightly below (20-25 cm) the water surface.

Water and atmospheric temperature (°C), dissolved oxygen (mg/l), pH, total hardness (mg/l), electrical conductivity (µS/cm) and turbidity (NTU) were measured in the field using their respective metres such as thermometer (HANNA HI-8053), D.O metre (YSI-Eco Sense DO 200), pH metre (YSI-Eco Sense pH 100), conductivity metre (YSI-Eco Sense EC300) and turbidity metre (HANNA HI-93703). To measure transparency (cm) a Secchi disc was used. Total hardness was determined by the method described in APHA (2005).

Diversity Indices

Shannon–Weaver and Simpson diversity indices were applied to compute the rotifer diversity in the Canal. Species richness (SR) and evenness (E) were also recorded (Sulehria *et al*., 2013).

Shannon Weaver Index (H) was determined by the equation:

$$H= -\sum P_i(\ln P_i)$$ (Shannon & Weaver, 1949)

Where P_i represents the percentage of each species; Pi = ni/N; ni shows the number of a particular species and N indicates the total number of members of all the species.

Simpson equation was used to estimate the **Simpson's Index of Dominance (D).**

$$D= \Sigma\, n\,(n-1) / N\,(N-1)$$ (Simpson, 1949):

Where D designates Simpson's Index of Dominance; N indicates Total No. of individuals of all species and n represents No. of members of particular species per samples; and Σ = sum

Simpson's Index of Diversity and **Simpson's Reciprocal Index** were similarly estimated by the following equations

SID=1-D and SRI=1/D

Species richness (SR), i.e., No. of species found in an area, was calculated by Margalef's formula:

$$SR = (S - 1) / \log_n N,$$ (Margalef, 1951)

Where S represents total number of species and N denotes total number of individuals in a sample.

Species evenness (E) was calculated by Pielou's equation:

$$E= H / \log_n S,$$ (Pielou, 1966)

Where S shows total No. of species and H is the Shannon-Weaver diversity index.

Statistical Analysis

Pearson's correlation was executed to consider the relationships between rotifer species and physico-chemical factors of water that may regulate rotifer population. ANOVA was applied to the data of the various months to find the difference among rotifer density. Software MINITAB 2013 was utilized for Pearson's correlation and ANOVA. Graphs were drawn with the help of MS Excel 2010.

Cluster analysis

Hierarchical Cluster analysis of rotifer species was done by software PAST version 2.08.

RESULTS AND DISCUSSION

In the present work twenty eight rotifer species of 10 families and 14 genera had been identified (Table I). Physico-chemical parameters of water affected the abundance and composition of rotifer fauna both positively and negatively (Chittapun *et al*., 2007; Sulehria *et al*., 2012). There was positive correlation between temperature and rotifers. During this study the highest temperature (31±0.06) was recorded in June while the lowest (11.33±0.26) in January (Fig., 2). Population density of rotifers was highest (**42.34**) in June while the lowest (**12.01**) in January (Fig., 3). Similar results were also found in other studies by Baloch *et al*. (2008); Schöll & Kiss (2008); Sulehria *et al.* (2009a); Sulehria & Malik (2012). This positive relationship shows that increase in temperature proportionately increases the rate of growth of rotifer population.

Rotifers prefer to live in the pH that ranges from 6.5 to 8.5 (Neschuk *et al*., 2002). pH is the total of proton activities. The highest mean pH (8.6±0.06) was observed during the month of June while the lowest mean pH (7.17±0.01) was found during the month of January. Increase in pH started from January to June. During this study Pearson correlations indicated that density and diversity of rotifers were positively influenced by pH. Similar results were also noted by Dai *et al*., 2014.

Dissolved oxygen is a critical factor for the survival of aquatic life. The highest DO (11.2±0.01) was noted in January and the lowest (7.31±0.01) in June (Fig., 2). This decline in DO during hot months might be due to increased decomposition of organic matter and decreased solubility of oxygen displaying negative correlation between rotifers and dissolved oxygen (Table 3). These findings agreed with the results of Saler & Sen (2002); Sulehria & Malik (2012, 2013); Sulehria *et al*. (2013).

The highest (689.33±0.88) electrical conductivity was in June and the lowest (300.67±5.93) in January (Fig., 2). Conductivity is believed to be a vital sign of trophic situations. Highest conductivity in summer might be because of lower solubility, high temperature and high degradation of organic substances. Positive correlation was shown by conductivity with rotifer density and diversity (Table III). Similar results had also been obtained in other studies in Pakistan (Sulehria *et al*., 2009a; Sulehria & Malik, 2012).

Total hardness was maximum (120.27 ±0.15) in June and minimum (135.47±0.15) in January (Fig., 2). Total hardness was positively correlated with rotifer population in Nandipur water (Table III). Similar results were also noted by Malik & Sulehria (2004) in the river Ravi. However, many species showed that either they had no effect of various chemicals e.g., Mg^{+2} and Ca^{+2}, (Tamas & Horvarth, 1978; NACA ADCOM Report, 1983) or they had wide range of tolerance. Transparency ranged between 27±0.15 and 15.03±0.24 and was negatively correlated with the density and diversity of rotifers. Turbidity reflected positive correlation with rotifers (Table III).

Brachionus calyciflorus was found to be the most dominant species with 23.67±6.07 ind/ml (mean density). *Lecane ungulate* had the lowest (2.0±.58 ind/ml) population density, found only in January and May (Fig., 4).

During this study the following rotifer genera indicated relative (%) composition in decreasing order: *Brachionus* (11.5%), *Keratella* (11.2%), *Lecane* (9.16%), *Trichocerca* (8.74%), *Rotaria* and *Polyarthra* (7.63%), *Euchlanis* (7.44%), *Cephalodella* (7.34%), *Filinia* (6.83), *Lepadella* (6.63%), *Dicranophorus* (4.81%), *Colurella* (4.42%), *Platyias* (4.22%) and *Notholca* (2.41%) (Fig., 6). Similar results were also noted in Balloki Headworks by Sulehria & Malik (2013).

ANOVA (F=42.01, DF=23, P=0.000) showed that there was a significant difference in population density of rotifers (Table II).

Values of Shannon weaver index ranged from 2.409 to 3.092 being lowest in January and highest in June. Simpson index of dominance found between 0.047 and 0.096 being minimum in June and maximum in January reflecting lowest diversity of planktonic rotifer in June and highest in January respectively. The value of Species Richness ranged between 1.171 and 2.065, indicating high species richness in June and lowest in January. Species Evenness ranged from 0.957 to 0.99 showing even distribution of planktonic rotifers (Fig., 5).

The highest diversity of rotifers was noted in June and lowest in January. Rotifer species showed increasing trend from February to June and decreasing trend from July to January. This trend of

diversity might be credited to the production of new rotifer species in summer months due to availability of food and temperature.

For comparative analysis of twenty eight planktonic rotifer species a dendrogram was plotted. At eucladian distance 6 four clusters were formed. Six clusters were formed at eucladian distance 3. Cluster 1 consists of *Colurella uncinata, Lepadella patella, Platyias quadricornis, Dicranophorus epicharis, Lepadella ovalis, Euchlanis dilatata, Cephalodella gibba, Cephalodella forficula*. Cluster 2 comprises of *Lecane ungulata, Trichocerca pusilla, Lecane curvicornis, Notholca acuminata*. Cluster 3 has only *Brachionus calyciflorus* and cluster 4 consist of *Brachionus quadridentatus, Keratella tropica*. Cluster 5 includes *Lecane lunaris, Brachionus caudatus, Euchlanis lyra, Filinia longiseta*. Cluster 6 contains *Polyarthra vulgaris, Brachionus angularis, Rotaria rotatoria, Brachionus falcatus, Brachionus leydigii, Lecane quadridentata, Brachionus bidentatus, Trichocerca porcellus,* and *Lecane luna*. At eucladian distance 26 all the clusters merged into a single cluster (Fig., 7).

CONCLUSION

This is the first survey of planktonic rotifers of Nandipur Canal. Our knowledge on the fauna of rotifers of lotic waters is still very scanty. This work is a contribution to the present knowledge on the distribution of planktonic rotifers and more work needs to be done to get a reliable picture of rotifer fauna of lotic waters and ecology of this group.

Table I: List of Rotifer species identified from Nandipur Canal.

S. No	Family	Genus	Species
1	Brachionidae	*Brachionus*	*Brachionus angularis*
2			*Brachionus bidentatus*
3			*Brachionus calyciflorus*
4			*Brachionus caudatus*
5			*Brachionus falcatus*
6			*Brachionus leydigii*
7			*Brachionus quadridentatus*
8		*Keratella*	*Keratella tropica*
9		*Notholca*	*Notholca acuminata*
10		*Platyias*	*Platyias quadricornis*
11	Dicranophoridae	*Dicranophorus*	*Dicranophorus epicharis*
12	Euchlanidae	*Euchlanis*	*Euchlanis dilatata*
13			*Euchlanis lyra*
14	Filinidae	*Filinia*	*Filinia longiseta*
15	Lecanidae	*Lecane*	*Lecane ungulata*
16			*Lecane curvicornis*
17			*Lecane luna*
18			*Lecane lunaris*
19			*Lecane quadridentata*
20	Lepadellidae	*Lepadella*	*Lepadella patella*
21			*Lepadella ovalis*
22		*Colurella*	*Colurella uncinata*
23	Notommatidae	*Cephalodella*	*Cephalodella gibba*
24			*Cephalodella forficula*
25	Philodinidae	*Rotaria*	*Rotaria rotatoria*
26	Synchaetidae	*Polyarthra*	*Polyarthra vulgaris*
27	Trichocercidae	*Trichocerca*	*Trichocerca porcellus*
28			*Trichocerca pusilla*
Total	10	14	28

Table II: Analysis of Variance of rotifers (p<0.05)

Source	DF	SS	MS	F	P
Factor	1	2059.6	2059.6	42.01	0.000
Error	22	1078.5	49.0		
Total	23	3138.1			

DF=Degree of freedom, SS=Sum of square, MS=Mean of square, F=f- ratio, P= probability, significance level=0.05

Table III: Correlations (Pearson) between Rotifers and physico-chemical parameters

	Rotifers	Temp	pH	DO	E.C	T.H	Trans
Temp	0.842						
pH	0.797	0.739					
DO	-0.862	-0.974	-0.655				
E.C	0.952	0.810	0.693	-0.861			
T.H	0.884	0.869	0.620	-0.928	0.884		
Trans	-0.691	-0.801	-0.312	0.902	-0.751	-0.830	
Turb	0.650	0.835	0.368	-0.898	0.703	0.797	-0.960

Temp= Temperature, D.O= Dissolved oxygen, E.C= Conductivity, T.H= Total Hardness, Trans= Transparency, Turb= Turbidity

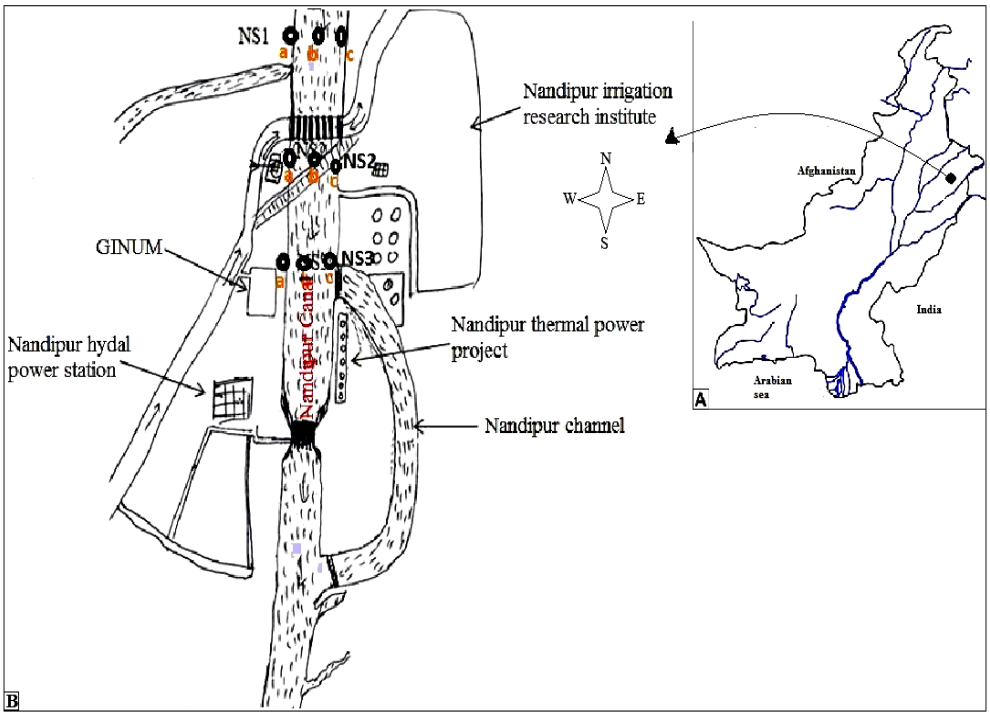
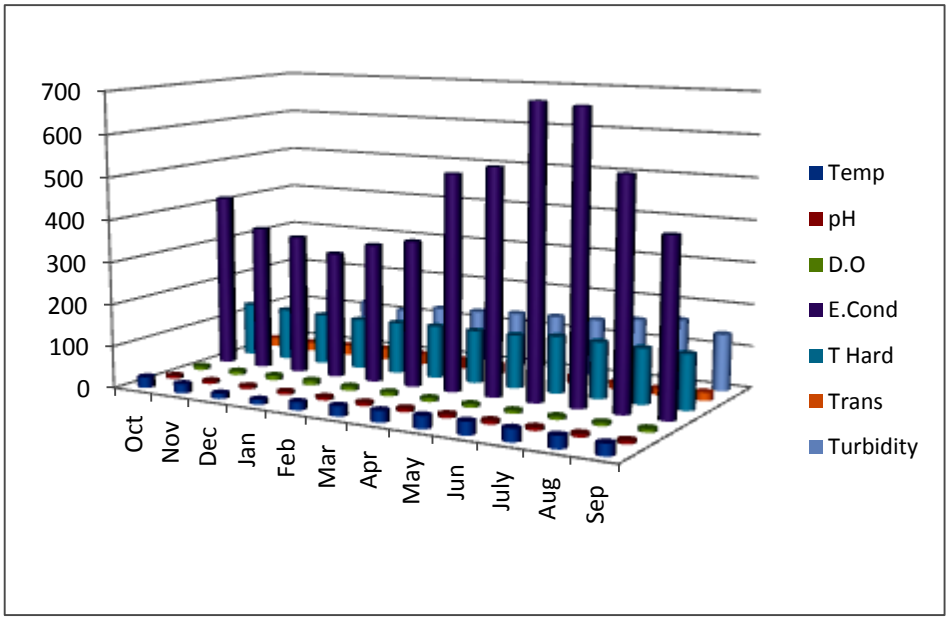


Fig., 1: Map of study area. A) Map of Pakistan. B) Nandipur Canal



Temp= Temperature, D.O= Dissolved oxygen, E.Cond= Electrical conductivity, T.Hard= Total Hardness, Trans= Transparency

Fig., 2: Variations of different physico-chemocal parameters (Temperature (^{0}C), pH, Dissolved oxygen (mg/L), Electrical conductivity (µs/cm), Total hardness (mg/L), Transparency (cm), Turbidity (NTU), in Nandipur Canal.

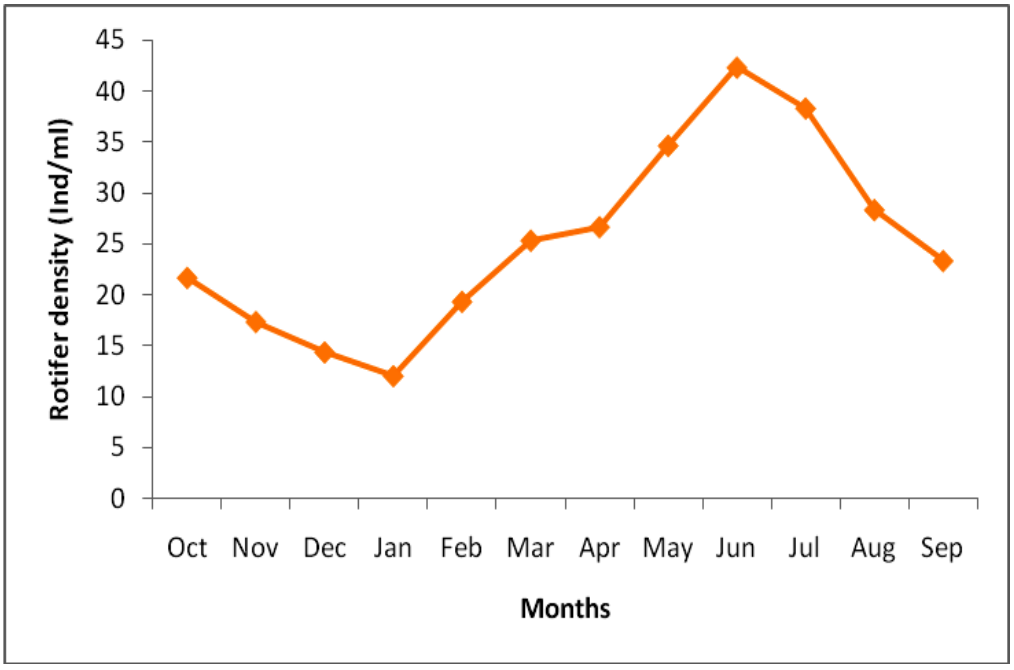


Fig., 3: Density of rotifers isolated from Nandipur Canal

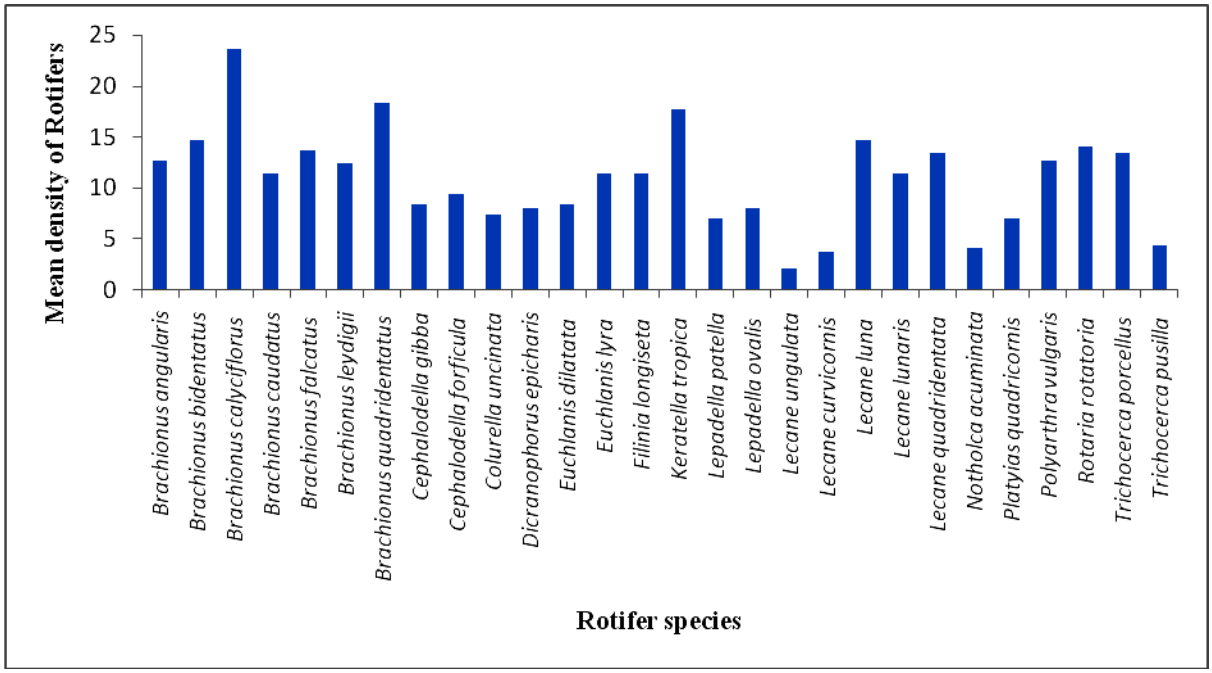
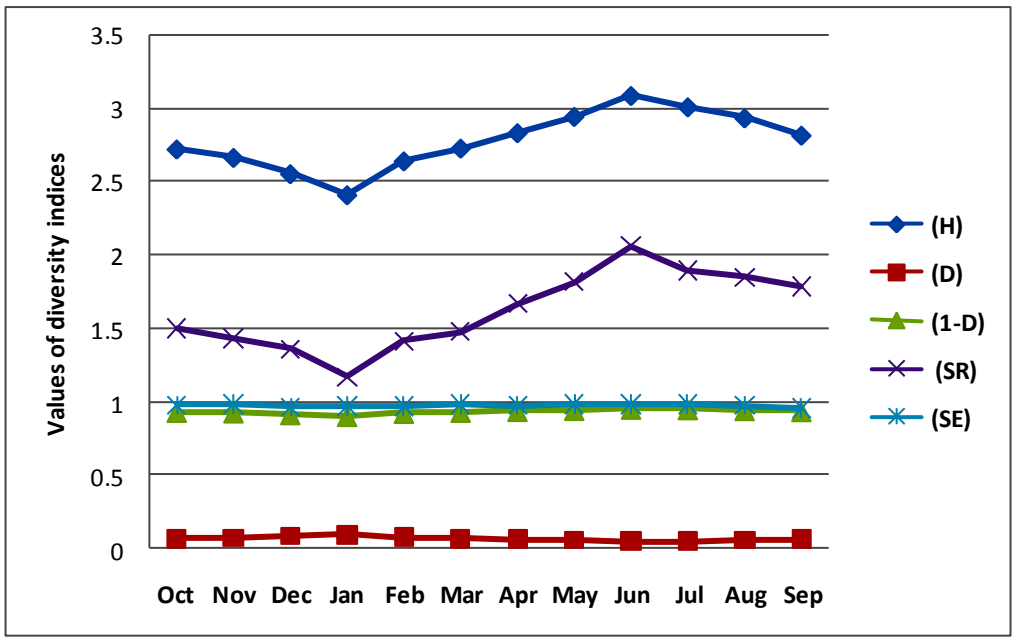


Fig., 4: Rotifer species with their mean diversity isolated from Nandipur Canal.



H (Shannon-weaver diversity index), D (Simpson index of dominance),
1-D (Simpson index of diversity), SR (Species richness), SE (Species evenness)

Fig., 5: Variations of diversity indices of rotifers isolated from Nandipur Canal

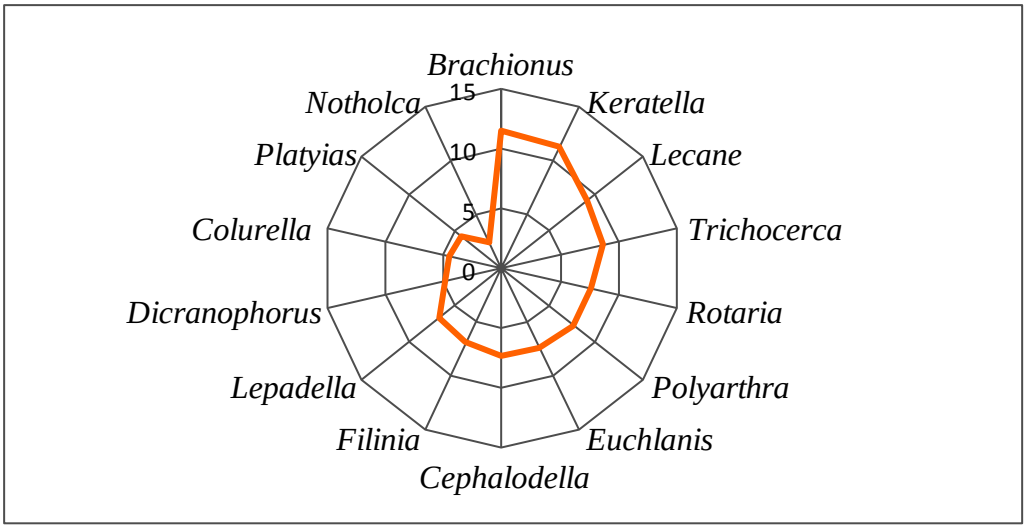


Fig., 6: Percent representation of rotifer genera isolated from Nandipur Canal.

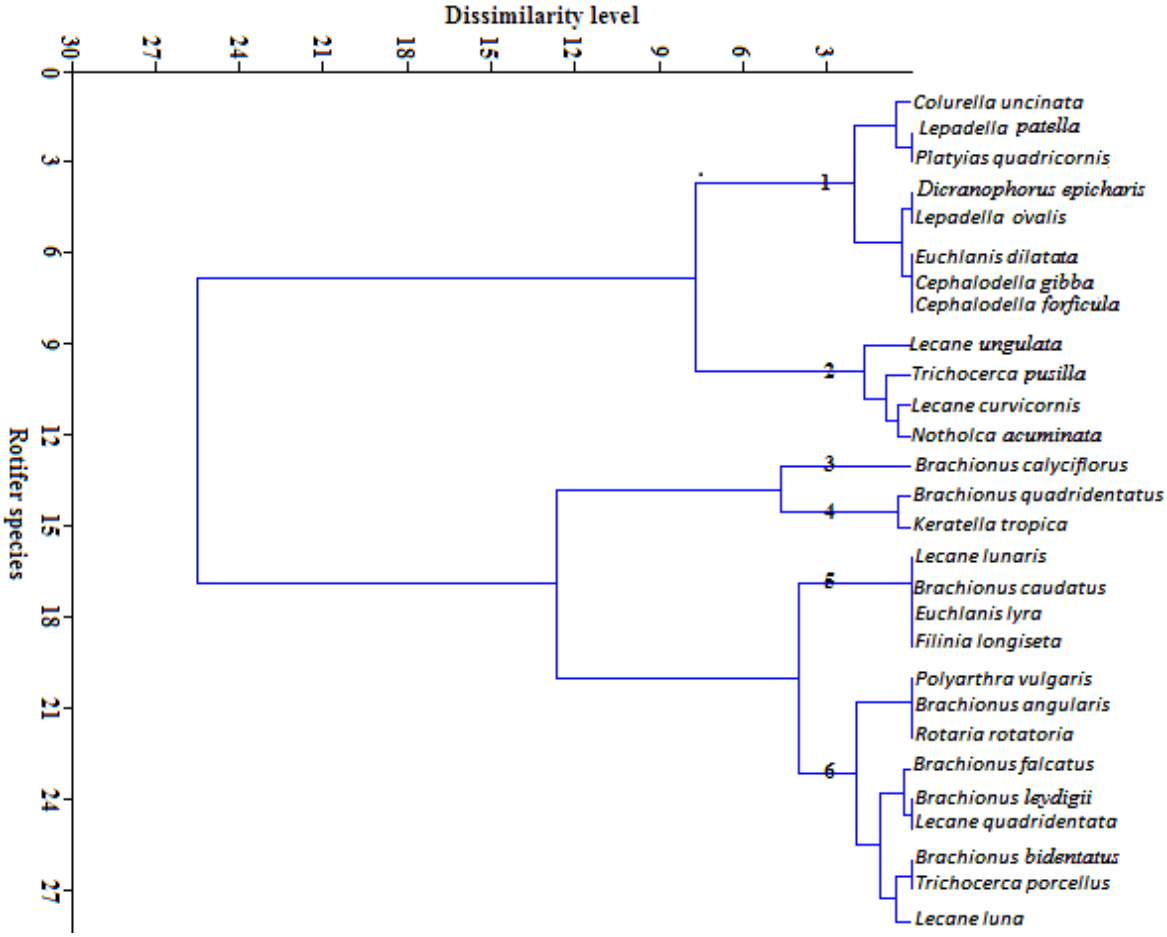


Fig., 7: Cluster analysis of rotifer species isolated from Nandipur Canal.

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