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Species composition and abundance of rotifers (Rotifera: Eurotatoria) in Thrissur Kole wetland, Kerala, India.

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ABSTRACT

Kole Wetlands are the major freshwater wetlands of Kerala, which spread over Thrissur and Malappuram districts of Kerala. They are the most productive and threatened wetlands in Kerala. Zooplanktons are heterotrophic animals; floating in the water and act as indicators for water quality. The Rotifers form a major portion of the freshwater zooplankton, serve as an important source of food for many larger aquatic organisms, and an integral part of the aquatic food web. In this context, the study on biodiversity and the abundance of rotifers was carried out from November 2017 to October 2019 from different stations of Trissur Kole wetlands. The physical and chemical parameters of the water were checked regularly for getting the data on the influence of these parameters on the rotifer's population. The highest diversity and density of rotifers recorded during the pre-monsoon season (H= 3.194, D= 0.954) followed by post-monsoon and lowest during monsoon season (H= 2.658, D= 0.898). A total of 40 species of rotifers belonging to 15 genera and 10 families were recorded. Rotifers of Thrissur Kole wetlands are dominated by Brachionidae (12 species)> Lecanidae (11 species)> Trichocercidae (5 species). Keratella cochlearis (29%) and Brachionus falcatus (25%) of the family Brachionidae are the dominant species seen during all seasons. In conclusion, Rotifers represented the important group of zooplankton throughout the current study, about 50% of the collected Rotifers were new to this area and the species richness and abundance of Rotifer shows a significant relationship with the physical and chemical parameters of the water**.**

INTRODUCTION

The Rotifers also called wheel animalcules (because of the presence of a wheel like organ) belong to the phylum Rotifera, form an essential part of the freshwater zooplankton and great consumer of protozoans and bacteria (**Arndt, 1993**). Thus rotifers have the power to manage the bacterial number (**Sanders, 1989**) and act as an important food sources for the majority of the fish larva (**Howell, 1973**) and cladocerans (**Burns and Gilbert, 1986**). The majority of the rotifers are microscopic and few of them having approximately 2mm can see with naked eye like rods or dots (**Sharma, 1998**). Live feeds may improve the digestion of fish larvae, therefor rotifer feeds fulfils the need for digestive and nutritional requirement for their favorable growth (**Govoni *et al.*, 1986; Lubzens, 1989**). Demolition of rotifer community indirectly upsets fish community (**Pérez-Legaspi and Rico-Martínez, 2001**). Rotifers have an important role in the aquatic ecosystem as bioindicator of water quality (**Błedzki and Ellison, 2003; Casanova, 2009**), therefore world's researchers give importance to the study about the rotifers in all aspects (**Coulon, 1983**). They are extensively used as a model organism to study the aquatic toxicology because of their small size, high sensitivity to toxins and easily growth in laboratory (**Snell and Janssen, 2018**), especially the genus *Brachionus* (**Grosell *et al.*, 2006; Janssen *et al.*, 1993; Preston *et al.*, 2000)** and *Lecane* **(Pérez-Legaspi and Rico-Martínez, 2001**). Rotifer shows sexual dimorphism, that males act like pockets of sperm. Phylum Rotifera comprises of three groups Monogononta, Seisonida (completely marine) and Bdelloidea (uniquely parthenogenetic). Of these, more than 77% of the global Rotifers (**H Segers, 2007**) and above 90% of the Indian rotifers (**Sharma, 1998**) are belonging to the subclass Monogononta.

Kole wetland is a unique wetland ecosystem recently designated under the wetlands of international importance and has a high diversity of fauna and flora. As the name "Kole" indicates this gives a bumper yield to the farmers even if they only cultivate once a year possibly December to May. Even so, human interference continues to affect the ecosystem by building construction, mining, dumping of wastes, fishing, and reclamation for cultivation. This kind of anthropogenic activities intern alters the biodiversity and declines the ground water availability in the future. There are only few studies conducted on the Ramsar sites in India. The present work aimed to measure the diversity and abundance of Rotifers of Thrissur kole wetland and to determine the influence of physical and chemical factors on the species composition of the Rotifera.

MATERIALS AND METHODS

Study area

The Kole wetlands, recently designated as a Ramsar site, spread over Thrissur and Malappuram districts of Kerala is one of the largest, most productive and unique wetland lies between 10° 20' and 10° 40' N latitudes and 75° 58' and 76° 11' E longitudes and lies between the Chalakkudy river in the south and Bharatapuzha in the North, Kruvannur and kecheri river drain the Kole lands and finally discharge into the Arabian sea (**Thomas, 2003**). The Kole wetlands run parallel to the sea and are low lying tracts located 0.5 to 1m below mean sea level and remain submerged for about six months in a year (**Johnkutty and Venugopal, 1993**). There is an alternative culture of fish and paddy practice in some of the area of Kole lands. Herbs and shrubs are the major vegetation type. Kole wetlands are dominated by *Salvinia molesta, Ludwigia adcscendens, Eichhornia crassipes* among the 75 species of aquatic macrophytes (**Jyothi and Sureshkumar, 2014**), of these *Salvinia molesta* and *Eichhornia crassipes* are non-native species. The massive growth of these non-native weeds interrupts the water flow.

Methodology

Collection and analysis of water samples: The water and plankton samples were collected early in the morning between 6 am to 9 am from different stations of Trissur Kole wetlands (Fig. 1), monthly from November 2017 to October 2019. For the determination of physical and chemical parameters the surface water samples were collected from each sampling station. Air temperature, Water temperature and field pH were measured in the field itself. Water pH, Conductivity, Turbidity, TDS, DO, CO_2, BOD, COD, Calcium, Chloride, Hardness, Acidity, Alkalinity, Magnesium, Fluoride, Iron, Nitrate and Sulphate were determined separately for all the samples in the laboratory by employing standard methods described in **APHA (1992)** and **Trivedy and Goel (1984)**.

Quantitative and qualitative analysis of Rotifers:

For qualitative analysis of Rotifer, samples were collected from the different stations of Trissur Kole wetlands by towing the plankton net horizontally at a depth of 40cm for about 10 minutes. For the quantitative analysis of Rotifer, 100 L of water were filtered through a plankton net (made up of bolting silk- 60μm mesh). Plankton samples were preserved in 4% formalin and subjected to stereo microscopic analysis.

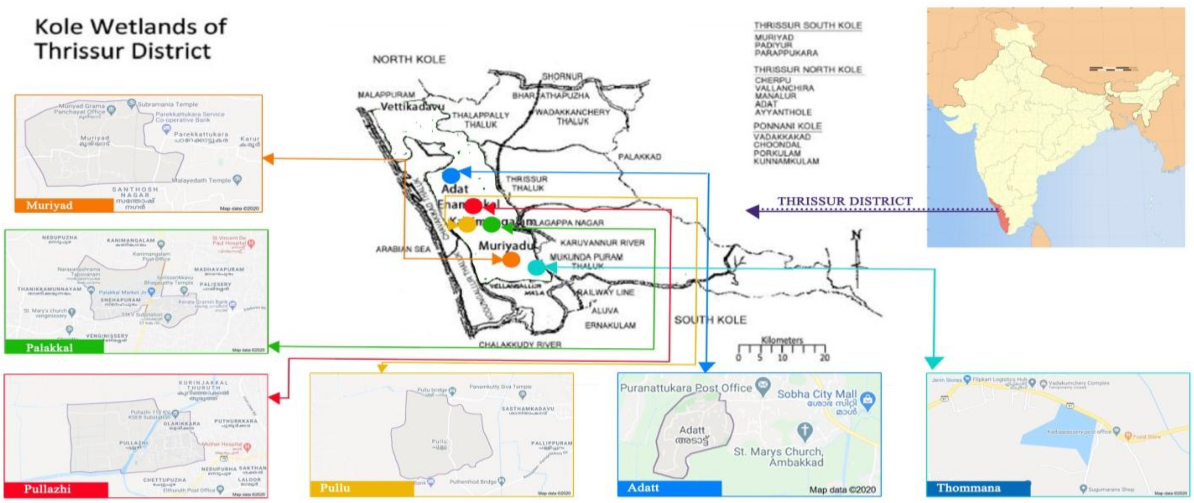

Fig. 1. Location of the study area

Identification of Rotifers: The Rotifers were identified by using conventional taxonomic keys (**Battish, 1992; Shiel, 1995**; **Altaff, 2004**) and classic morphological methods mentioned in the Rotifer world Catalogue under a compound microscope. An ml of plankton sample was taken with a wide mouthed pipette and poured into the Sedgwick Rafter counting chamber and the count was made. Rotifers sort out separately from the chamber to a clean glass slide and observed under a binocular microscope in 10/40X for species level identification.

Statistical analysis: In order to analyze the data statistically, the IBM SPSS software package (version 24.0) was used. The correlation between physical and chemical parameters of water with the diversity and abundance of rotifers were done by using Pearson's correlation analysis. Diversity was estimated by using Shannon-Weiner (**Shannon and Weaver, 1948**)) and Simpson Index (**Simpson, 1949**).

RESULTS

1. Physical and chemical parameters of water

A summary of the physical and chemical parameters of the study area is given in the Table 1. The physical and the chemical parameters of water showed seasonal fluctuation. The highest temperature recorded during the pre-monsoon season and the lowest was during the monsoon season. The water temperature is higher during pre-monsoon season and lowers during monsoon season. The relationship between the physical and chemical parameters is shown in the Table 2. The atmospheric temperature showed a significant positive correlation with water temperature, electrical conductivity, fluoride, sulphate, CO_2 and BOD of the water and significant negative correlation with the dissolved oxygen content of the water. The water temperature correlated positively with atmospheric temperature, alkalinity, magnesium, fluoride, sulphate and CO_2 content of the water. Turbidity and dissolved oxygen content of the water showed a significant negative correlation. The mean field pH is slightly acidic in all the season; small change is noted in the laboratory pH. The pH showed a significant positive correlation with the total hardness, calcium and COD and negative correlation with the iron content of the water. The mean electrical conductivity is high during the pre-monsoon season and shows significant positive correlation with atmospheric temperature, magnesium, fluoride, sulphate, BOD and significant negative correlation with dissolved oxygen of the water. Conductivity is a rapid measure of TDS, the mean TDS value in the pre-monsoon and the post-monsoon season are almost similar and it show a significant positive correlation with chloride and total anions in strong acids. The mean turbidity value is above the acceptable limit of drinking water during pre-monsoon season and above the permissible limit during the monsoon and the post-monsoon season. Turbidity shows significant negative relation with the water temperature and alkalinity of the water.

Table 1: Summary of the physical and chemical parameters of Thrissur Kole wetlands, Oct 2017-Sep 2019.

Physical/chemical parameter	**Mean ±SD**	**Range**	**CV (%)**
Air temp (^{0}C)	27.37 ±2.66	24-33	9.7
Water temp (^{0}C)	26.58 ±1.72	24.3-30	6.5
Field pH	6.67 ±0.27	6.2-7.4	4.0
Lab pH	6.68 ±0.29	6.3-7.5	4.4
Turbidity (NTU)	10.81 ±6.26	4.0-25	57.9
Electrical conductivity (µS-cm)	150.53 ±37.49	101-232	24.9
TDS (mg/L)	90.35 ±41.05	32.5-188	45.4
Acidity (mg/L)	11.93 ±3.13	6.7-19	26.2
Alkalinity (mg/L)	31.87 ±9.01	15-48	28.3
Total hardness (mg/L)	34.54 ±16.45	2.0-72	47.6
Calcium (mg/L)	10.45 ±4.53	4.0-22.4	43.4
Magnesium (mg/L)	3.63 ±1.17	1.9-5.5	30.8
Chloride (mg/L)	32.39 ±14.44	13-75.5	44.6
Fluoride (mg/L)	0.09 ±0.04	0.02-0.17	50.7
Iron (mg/L)	0.98 ±0.17	0.81-1.5	17.4
Nitrate (mg/L)	4.57 ±0.95	6.0-3.2	20.8
Sulphate (mg/L)	8.2 ±.02	4.5-13.1	36.7
CO2 (mg/L)	10.61 ±3.03	4.0-20	28.6
DO (mg/L)	5.98 ±1.4	4.0-8	23.5
BOD (mg/L)	1.43 ±0.58	0.7-2.7	40.1
COD (mg/L)	6.83 ±2.57	3.0-11	37.5
TASA (mg/L)	42.4 ±15.17	24.5-84.9	35.8

The mean acidity and alkalinity are significantly similar during all the seasons and acidity shows significant correlation only with the nitrate content of the water, alkalinity is positively correlated with water temperature, total hardness, and magnesium and negatively correlated with turbidity and chloride content of the water. The mean DO show seasonal variation, DO was low during pre-monsoon season and high during monsoon season. DO shows significant negative correlation with atmospheric temperature, water temperature, electrical conductivity, fluoride, sulphate, BOD and significant positive correlation with iron. Mean BOD was high during the pre-monsoon season and show a significant correlation with atmospheric temperature, electrical conductivity, total hardness, calcium, fluoride, iron, sulphate, CO_2 and DO. The COD value is significantly similar in pre-monsoon and post-monsoon season and monsoon season shows low COD value. The mean nitrate was below 5.5 mg/L in all the seasons, this shows a significant positive correlation with acidity and a negative correlation with fluoride.

The Mean sulphate value high during pre-monsoon season and that of monsoon and post-monsoon season is significantly similar and show a significant correlation with atmospheric temperature, water temperature, electric conductivity, magnesium, fluoride, DO and BOD. The mean chloride concentration is significantly similar in pre-monsoon and the post-monsoon season and shows a significant correlation with TDS, alkalinity, iron and TASA. The mean hardness value ranges between 2 to 47, which is low during pre-monsoon and significantly similar in both monsoon and post-monsoon season and show a correlation with pH, calcium and BOD. The mean calcium level is significantly higher during post-monsoon and monsoon season and low during the pre-monsoon season. The mean value of magnesium shows variation in all the season, which was high during pre-monsoon season with and low during the post-monsoon season. The mean fluoride value is similar during pre-monsoon and the post-monsoon season and low during the monsoon season. The mean value of iron is high during the monsoon season and low during post-monsoon season. The mean TASA value does not show any significant difference among the seasons, TASA was high during the pre-monsoon season and low during monsoon season. The TASA value depends on magnesium and TDS.

Table 2: Pearson's correlation coefficient between physical and chemical parameters of water monitored in six stations of Thrissur Kole wetland, Oct 2017-Sep 2019.

	AT	WT	FpH	LpH	TUR	EC	TDS	ACD	ALK	TH	Ca	Mg	Cl	F	Fe	NO3	SO4	CO2	DO	BOD
AT		.789**	0.119	0.196	-0.351	.613**	0.296	0.016	0.326	-0.117	-0.229	0.362	0.085	.541**	-0.337	0.052	.814**	.546**	-.760**	.466*
WT			0.012	0.159	-.485*	.565**	0.196	-0.103	.424*	-0.011	-0.269	.526**	0.071	.438*	-0.295	0.033	.652**	.473*	-.676**	0.216
FpH				.931**	0.025	0.2	0.142	-0.026	-0.053	0.364	.535**	-0.129	0.319	0.315	-.497*	-0.265	0.084	0.146	-0.372	0.131
LpH					-0.088	0.232	0.165	-0.019	0.099	.409*	.535**	0.03	0.286	0.285	-.429*	-0.202	0.169	0.265	-0.398	0.112
TUR						-0.146	-0.047	-0.081	-.675**	-0.166	-0.112	-0.377	0.221	-0.129	0.043	0.147	-0.295	-0.145	0.335	0.336
EC							0.331	-0.355	0.177	-0.033	-0.205	.488*	0.356	.685**	-.439*	-0.074	.631**	0.258	-.659**	.520**
TDS								-0.373	-0.125	0.296	0.103	0.005	.544**	0.337	-0.324	-0.306	0.065	0.177	-0.174	0.107
ACD									0.21	-0.126	0.189	-0.009	-0.26	-0.342	0.039	.465*	-0.049	0.186	0.101	-0.04
ALK										.442*	0.225	.493*	-.448*	0.003	0.023	0.12	0.175	0.274	-0.104	-0.318
TH											.592**	0.018	0.015	-0.122	-0.054	-0.117	-0.373	0.077	0.233	-.454*
Ca												-0.073	0.079	-0.206	-0.051	-0.023	-0.234	-0.126	0.166	-.456*
Mg													0.063	-0.057	0.164	0.363	.462*	-0.074	-0.294	-0.038
Cl														0.22	-.419*	-0.075	0.09	-0.01	-0.26	0.241
F															-.505*	-.561**	.438*	.421*	-.618**	.424*
Fe																0.194	-0.187	-.447*	.539**	-.432*
NO3																	0.146	0.015	0.17	0.047
SO4																		0.345	-.827**	.446*
CO2																			-0.397	.425*
DO																				-.465*
BOD																				
COD																				
TASA																				

COD	0.271	0.108	**.509***	**.444***	0.19	0.293	-0.028	-0.091	-0.044	0.138	0.086	-0.278	0.26	**.474***	**-.563****	-0.375	0.1	0.39	-0.394	**.454***		
TASA	0.007	-0.001	0.32	0.286	0.244	0.321	**.426***	-0.167	-0.18	0.365	0.309	0.054	**.808****	0.19	-0.29	-0.064	-0.048	0.045	-0.045	-0.019	0.365	

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

2. Diversity and Abundance of Rotifers

A total of 40 species of Rotifera belonging to 15 genera and 10 families were recorded, taxonomic list of Rotifers of the Thrissur kole wetland is given in the Table 3 and images of the identified rotifers were given in figure 2. All the species were coming under sub class Monogonanta. Rotifer of thrissur Kole wetlands is dominated by Brachionidae (12 species)> Lecanidae (11 species)> Trichocercidae (5 species). The diversity and abundance of rotifers of Thrissur kole wetlands showed seasonal fluctuations. Highest species richness was found during the pre-monsoon season (35 species) and lowest during monsoon season (19 species).

Table 3: A list of Rotifer taxa of Thrissur Kole wetland collected during Oct 2017- Sep 2019.

Order	Family	Species	Pre-monsoon	Monsoon	Post-monsoon
Ploima	Brachionidae	*Anuraeopsis fissa*	+	+	+
		Anuraeopsis navicula	-	+	+
		Brachionus angularis	+	-	-
		Brachionus calyciflorus	+	+	+
		Brachionus dichotomous	+	-	-
		Brachionus falcatus	+	+	+
		Brachionus forficula	-	+	-
		Brachionus sessilis	+	-	-
		Platyias patulus	+	+	+
		Platyias quadricornis	+	+	-
		Keratella cochlearis	+	+	+
		Keratella tropica	+	+	-
	Asplanchnidae	*Asplanchna brightwelli*	+	+	+
		Asplanchna herricki	+	+	+
		Asplanchna priodonta	+	-	+
	Mytilinidae	*Mytilina* sp.	+	-	+
	Lecanidae	*Lecane bulla*	+	+	+
		Lecane cornuta	+	-	+
		Lecane aculeate	+	-	+
		Lecane furcate	+	-	+
		Lecane monostyla	+	+	-
		Lecane luna	+	-	+
		Lecane lateralis	-	-	+
		Lecane inopinata	+	-	+
		Lecane pyriformis	+	-	+
		Lecane sp1.	+	-	+
		Lecane sp2.	_	_	+
	Trichocercidae	*Trichocerca cylindrica*	+	+	-
		Trichocerca kostei	+	-	+
		Trichocerca longiseta	+	-	+
		Trichocerca similis	+	+	+
		Trichocerca rattus	-	+	-
	Synchaetidae	*Synchaeta* sp.	+	-	-
		Polyarthra vulgaris	+	+	+
		Polyarthra sp.	+	-	-
Flosculariacea	Conochilidae	*Conochilus unicornis*	+	+	+
		Conochilus hippocrepis	+	+	-
	Filinidae	*Filinia opoliensis*	+	-	-
	Testudinellidae	*Testudinella patina*	+	-	+
	Trichosphaeridae	*Horaella brehmi*	+	-	+

Keratella cochlearis (29%) and *Brachionus falcatus* (25%) of the family Brachionidae were the dominant species and seen during all the seasons, whereas *Brachionus angularis, platyias patulus, Brachionus forficula, Lecane lateralis, Lecane* sp2., *Trichocerca rattus, Synchaeta* sp., *Polyarthra* sp. and *Filinia opoliensis* were restricted to the single season only.

Table 4: The Pearson's correlation coefficient between family abundance of Rotifers with respect to physical and chemical parameters of Thrissur Kole wetland.

Parameters	Brachionidae	Asplanchnidae	Lecanidae	Mytilinidae	Trichocercidae	Synchaetidae	Conochilidae	Filinidae	Testudinellidae	Trichosphaeridae	Total abundance
AT	**.464***	**.464***	0.271	0.140	-0.095	0.149	-0.271	**.415***	0.021	0.169	0.379
WT	0.294	0.294	0.094	-0.055	-0.273	0.002	-0.195	0.237	-0.088	0.208	0.196
FpH	0.172	0.172	0.391	0.339	-0.133	0.396	**-.531****	0.244	0.380	0.080	0.127
LpH	0.187	0.187	0.356	0.283	-0.166	0.328	**-.466***	0.228	0.301	0.024	0.133
TUR	-0.304	-0.304	0.058	0.173	-0.203	0.038	0.038	-0.148	0.173	0.010	-0.240
EC	0.242	0.242	0.316	0.190	-0.349	0.138	-0.371	0.171	0.165	**.443***	0.167
TDS	-0.267	-0.267	0.187	0.248	-0.332	-0.070	-0.238	-0.139	0.144	0.306	-0.258
ACD	0.163	0.163	-0.056	-0.162	0.188	-0.037	-0.044	0.079	-0.167	-0.374	0.111
ALK	0.018	0.018	-0.187	-0.200	0.002	-0.270	0.034	-0.139	-0.204	-0.252	-0.045
TH	**-.452***	**-.452***	-0.194	-0.128	-0.195	-0.305	-0.021	**-.458***	0.027	-0.200	**-.456***
Ca	-0.101	-0.101	0.061	0.122	0.042	0.008	-0.102	-0.093	0.076	-0.270	-0.097
Mg	0.038	0.038	-0.292	**-.428***	-0.154	**-.408***	0.122	-0.133	**-.433***	-0.253	-0.061
Cl	-0.128	-0.128	0.378	0.230	-0.320	0.300	-0.330	0.017	**.459***	**.502***	-0.093
F	0.352	0.352	**.583****	**.559****	-0.119	**.479***	**-.412***	**.407***	0.393	**.659****	0.357
Fe	-0.204	-0.204	**- 626****	**-.503***	**.549****	**-.505***	**.881****	-0.264	**-.608****	**-.593****	-0.110
NO3	-0.046	-0.046	**-.478***	**-.515***	-0.076	**-.439***	0.194	-0.213	**-.492***	**-.484***	-0.147
SO4	**.749****	**.749****	0.324	0.146	0.134	0.308	-0.173	**.673****	-0.031	0.176	**.674****
CO2	0.316	0.316	**.431***	0.279	-0.046	0.293	-0.317	0.352	0.247	0.384	0.301
DO	**-.707****	**-.707****	**-.575****	-0.358	0.050	**-.528****	**.480***	**-.700****	-0.294	**-.420***	**-.633****
BOD	0.304	0.304	**.493***	0.360	-0.207	0.380	-0.301	0.342	0.383	0.344	0.297
COD	0.185	0.185	**.717****	**.597****	-0.201	**.616****	**-.461***	0.339	**.794****	**.508***	0.238
TASA	-0.241	-0.241	0.288	0.155	-0.288	0.170	-0.248	-0.103	**.405***	**.426***	-0.195

*Correlation is significant at the 0.05 level (2-tailed).
**Correlation is significant at the 0.01 level (2-tailed).

The Pearson's correlation coefficient between family abundance and the physical and chemical parameters of the water is shown in the Table 4. The dominant species *Brachionus falcatus* shows significant correlation with atmospheric temperature (r=0.560; P<0.01), water temperature (r= 0.475; P<0.05), total hardness (r= -0.430; P<0.05), SO_4 (r=0.871; P<0.01) and dissolved oxygen (r= -0.701; P<0.01). *Keratella cochlearis* abundance also showed a correlation with atmospheric temperature (r=0.452; P<0.05), fluoride (r= 0.482; P<0.05), total hardness (r= -0.450; P<0.05), SO_4 (r=0.650; P<0.01) and dissolved oxygen (r= -0.656; P<0.01). The Brachionidae and Lecanidae were the most frequent rotifer family (53% of total). *Lecane* is the most diversified genus (28%).

Species richness varied with the season and showed a significant positive correlation with air temperature (r=0.77; P<0.01), water temperature (r=0.666; P<0.001), electrical conductivity (r=0.742; P<0.001), fluoride (r= 0.726; P<0.01), SO_4 (r= 0.789; P<0.001), CO_2 (r= 0.534; P<0.01), BOD (r=0.651; P<0.01), COD (r= 0.549; P<0.01) and significant negative correlation with Fe (r= -0.598; P<0.01) and with DO (r= -0.916; P<0.01). Species diversity was higher during pre-monsoon season (H= 3.194, D= 0.954) and lower during monsoon season (H= 2.658, D= 0.898). The abundance of rotifers is mainly controlled by total hardness, sulphate and dissolved oxygen in the water, sulphate is positively correlated (r= 0.674 P<0.01) total hardness (r= -0.456 P<0.05) and dissolved oxygen (r= -0.633 P<0.01) shows negative correlation.

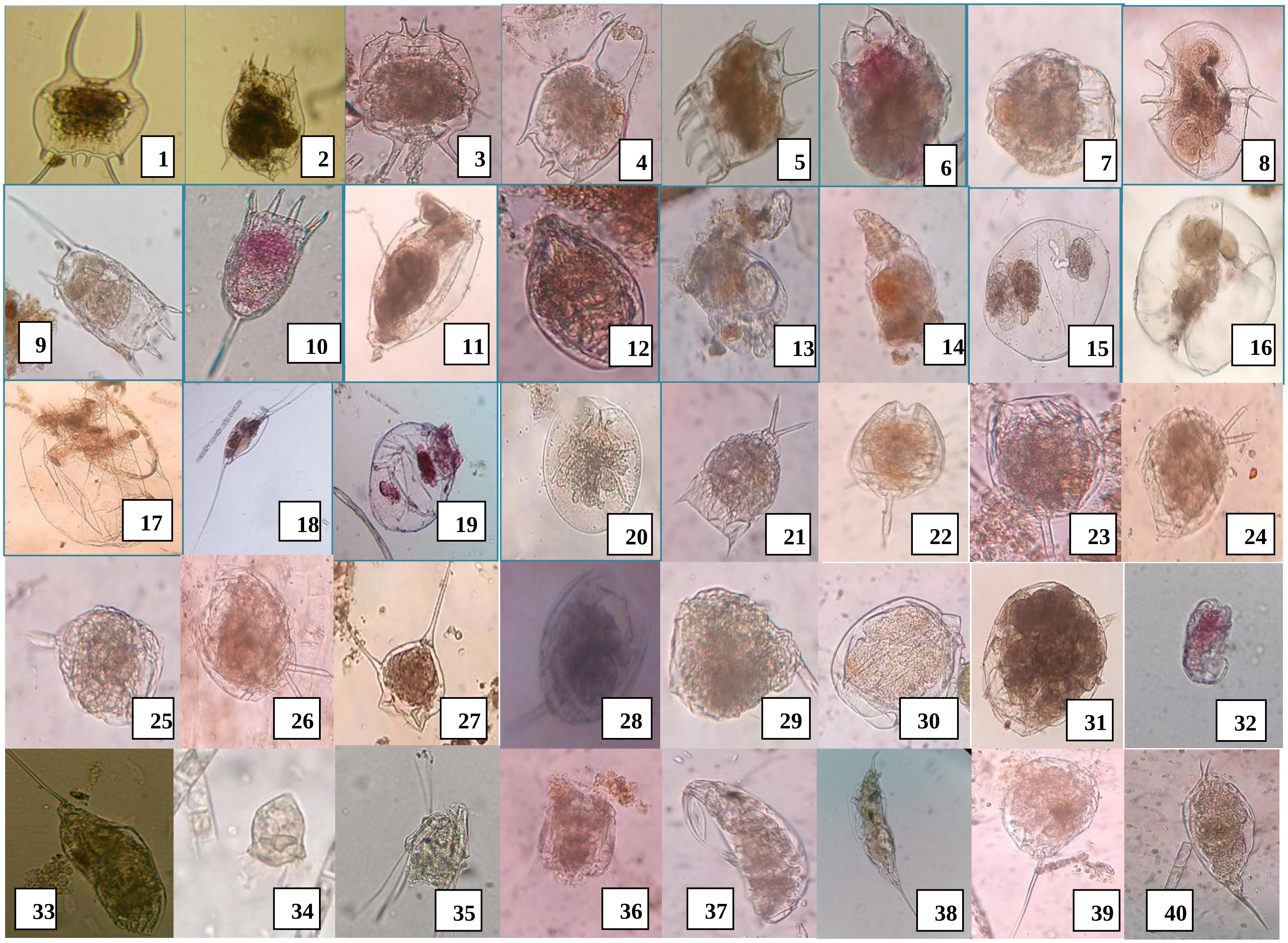

Fig. 2. Rotifers of Thrissur Kole wetland; 1. *B. falcatus,* 2. *B.calyciflorus,* 3. *B. dichotomous,* 4. *B. forficula,* 5. *P.patulus,* 6. *B. sessilis*, 7. *B. angularis*, 8. *P. quadricornis*, 9. *K. tropica*, 10. *K. cochlearis*, 11. *A. fissa*, 12. *A. navicula*, *13. C. unicornis*, 14. *C. hippocrepis*, 15. *A. brightwelli*, 16. *A. herricki*, 17. *A. priodonta*, 18. *F. opoliensis*, 19. *H. brehmi*, 20. *T. patina*, 21. *L. aculeate*, 22. *L. bulla*, 23. *L. furcata*, 24. *L. luna*, 25. *L. inopinata*, 26. *L. lateralis*, 27. *L. monostyla*, 28. *L. cornuta*. 29. *L.* sp1., *30. L.* sp2., 31. *L. unguitata*, 32. *M.* sp., 33. *T. cylindrica*, 34. *S.* sp., 35. *P. vulgaris*, 36. *P.* sp., 37. *T. kostei*, 38. *T. longiseta*, 39. *T. rattus*, 40. *T. similis.*

DISCUSSION

Water temperature is an important parameter that influences the physiology of all the aquatic organisms, the higher temperature increases the metabolic activity of organisms and decreases the solubility of oxygen in water, this may lead to the prominent stress (**Heinle, 1969**). The water temperature is higher during pre-monsoon season due to the higher atmospheric temperature and lowers during monsoon season due to the decreased solar radiation, cloudy sky, and rainfall (**Vijayakumar, 2000**). The mean field pH is slightly acidic in all the season, small change is noted in the laboratory pH this may due to the exposure to the air, biological activity and change in the temperature. The lower value of pH during pre-monsoon season is due to the utilization of CO_2 by phytoplankton similar pH variation is noticed by (**Thomas, 2003**). The alkalinity is an important parameter; it balances the pH changes occur due to the photosynthetic activity of vegetation. The mean electrical conductivity is high during the pre-monsoon season due to the presence of the higher amount of salts and contamination. This higher turbidity value is may be due to the clay, organic matter, silt, and microscopic organisms and this makes the water unfit for domestic purposes. The mean DO showed seasonal variation, DO was low during pre-monsoon season because of the higher temperature and may be due to the presence of oxygen requiring wastes and high mean DO was recorded during monsoon season due to mixing of surrounding waters. The measurement of BOD and COD is important to state the pollution status of the water. According to WHO drinking water standard, less than 5 mg/L BOD considered as clean water.

Rotifers represented the important group of zooplankton throughout the current study and showed monthly variation. About 50% of the collected rotifers were new to this Kole wetland, **Thomas (2003)** reported 20 species of rotifers belongs to 9 genera and 7 families from the Muriyad kole. The rotifer population of Thrissur kole wetland shows seasonal fluctuations. Seasonal variation in the rotifer population is also noticed by **Arora (2003)**, **Contreras *et al.* (2009)**, **El-Shabrawy and Dumont (2003)**, **Okogwu *et al.* (2010)** and **Viayeh and Spoljar (2012). Kaya (2010)** stated that there is no change in the species composition based on the season, only the site difference act as the reason for the variation. The rotifer of the river Achenkovil, Kerala (**Jose and Sanalkumar, 2012**) reported the similar seasonal occurrence that higher richness and abundance recorded during the premonsoon season and low during the monsoon season. The highest species diversity during these months was also noticed by **Nogueira (2001)** and **Sulehria *et al*. (1995).** *Brachionus falcatus* and *Keratella cochlearis* were dominant species seen in all the seasons (**Ejsmont-Karabin, 2001**).

Brachionus dichotomous, Brachionus forficula, Brachionus sessilis, Brachionus angularis, Anuraeopsis fissa, Anuraeopsis navicula, Conochilus unicornis, Conochilus hippocrepis, Asplanchna brightwelli, Asplanchna herricki, Asplanchna priodonta, Horaella brehmi, Lecane furcate, Lecane luna, Lecane monostyla, Lecane cornuta, Lecane sp1., *Lecane* sp2., *Lecane unguitata, Mytilina* sp., *Synchaeta* sp., *Polyarthra vulgaris, Polyarthra* sp., *Trichocerca cylindrica, Trichocerca kostei, Trichocerca longiseta, Trichocerca rattus* and *Trichocerca similis* were new to this area (**Thomas, 2003**). The nine species (*Brachionus caudatus, Brachionus qudridentatus, Euchalanis dilatata, Macrochetus collinsi, Lepadella patella, Lecane ludwigii, Lecane papuana, Lecane quadridentata* and *Lecane ungulate*) previously reported rotifers are absent in our study. *Brachionus caudatus* seems to prefer eutrophic water, physical and chemical properties of water influence its population regulation more seriously than other rotifers (**PahariI, 2002**). Life span and fecundity of the *Brachionus caudatus* is depending on the temperature (**Athibai, 2008**). The number of offspring was more during the high temperature as compared to the lower temperature. The reason behind the absence of *Brachionus caudatus* and another 8 species in two years regular sampling is unknown even when other species show higher abundance, which needs further investigation.

The Brachionidae and Lecanidae were the most frequent rotifers in line with similar findings of **Arora (2003)** and **Kudari (2005).** *Lecane* was the most diversified genus of this *L. bulla, L. furcate, L. luna* are cosmopolitan species *and L. aculeata, L. inopinata, L. monostyla, L. papuana* are tropicopolitan species (**Segers, 1996**).

The abundance of Rotifer during pre-monsoon season is due to the stable environment and the availability of food (**Thirupathaiah *et al.*, 2012**). Temperature is the main factor that influences the occurrence of rotifer **(Devetter, 1998; Kaya, 2010 and May, 1983)**. The high abundance of the genera *Brachionus* indicates pollution **(Perbiche-Neves et al., 2013)**. The presence of *Brachionus calyciflorus, B. angularis, Anuraeopsis fissa,* and *Trichocerca cylindrica* are an indicator of eutrophication **(Bhat, 2013; Mola, 2011; PahariI, 2002; Pal, 2015; Sampaio et al., 2002; Shei, 2012; Radwan, 1983 and Maemets, 1983)**, *Keratella cochlearis, conochilus hippocrepis, asplanchna herricki* and *Plationus patulus* are oligotrophic species (**Hillbricht-Ilkowska, 1983; Mäemets, 1983**). Dissolved oxygen of the water is the major influencing factor for the existence of rotifers (**Aoyagui and Bonecker, 2004; Bonecker, 1996**).

Arora (2003) noticed that the rotifer diversity is more pronounced when the BOD level is lower, but **De Zwart (1991)** reported the opposite. The total hardness, sulphate and dissolved oxygen are the important factors influencing the occurrence of rotifers. Sulphate is positively correlated, total hardness and dissolved oxygen shows negative correlation with the abundance of rotifers (**Govindasamy and Kannan 1991; Sulehria and Malik 2012**), **Malik and Sulehria (2003)** repoted Contrary result (positive correlation with water temperature, dissolved oxygen and negative correlation with total hardness).

The present study revealed that Rotifers are completely depending on the physical and chemical parameters of the water either positively or negatively on all aspects. Water temperature, sulphate, dissolved oxygen, BOD, COD are reported as the limiting factor throughout the study period. Highest diversity and abundance of rotifers were seen in the pre-monsoon season and least during the monsoon season. This may be due to the stable environment and the availability of food during pre-monsoon season. Family Brachionidae reported as the richest family followed by Lecanidae. *Brachionus falcatus* and *Keatella cochlearis* were the dominant species throughout the study period. We can clearly realize the effect of anthropogenic activity on Kole wetland only by studying the top-down effect and negative interactions within and between the species along with this study.

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