Environment Conservation Journal 16(1 &2) 37-46, 2015
ISSN 0972-3099 (Print) 2278-5124 (Online)
Abstracted and Indexed

Studies on rotifer ecology of Lake Mansar (Ramsar site), Jammu, J&K

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Received:02.07.2014 **Revised:11.10.2014** **Accepted:14.12.2014**

Abstract

Rotifers represent microscopic zooplankton fauna, occurring prevalently in freshwater. In the present study, monthly qualitative and quantitative analysis of phylum Rotifera was carried out in lake Mansar, Jammu, during the year 2011-2012 and has been described. The study revealed the presence of fifteen species belonging to two classes viz. Monogononta and Bdelliodea. Qualitatively, Class Monogononta was represented by fourteen species belonging to four families namely Lecanidae, Colurinae, Brachionidae and Notommatidae and Class Bdelliodea by one species belonging to family Philodinidae. The annual average density of the rotifers in the lake varied between 109n/l (January) and 709n/l (March), respectively. Seasonally, class Monogononta observed bimodal peaks viz. March and August with highest and lowest observation in the months of August and January, respectively. Class Bdelloidea showed its presence only during December, March and May with complete absence in rest of the months. The analysis of coefficient of correlation (r) of rotifers with various physicochemical parameters of water has shown strong significant correlation with dissolved oxygen and carbonate. Also, linear regression equations developed for rotifer and water quality parameters which have significant influence on each other (r > .701 at 0.05 significance level; two tailed and n = 12) have confirmed significant correlation between rotifer and DO.

Keywords: Coefficient of correlation, Mansar Lake, physicochemical parameters, Ramsar site, Rotifera, zooplankton

Introduction

Phylum Rotifera belonging to primary freshwater Metazoa consists of two major groups; the heterogonic Monogononta and the exclusively parthenogenetic Bdelloidea. Rotifers, also called as "pioneer organisms" are the first to appear in newly created water bodies and form connecting link between primary producers and consumers in aquatic ecosystems (Kippen, 2005). They commonly occur in densities up to 1,000 individuals per litre, and are important filter-feeders on algae, protozoa, dead bacteria and detritus. Their high population renewal rates distinguish them as an important link in energy flow and nutrient cycling (Esteves, 1998). Rotifers occur almost everywhere in aquatic ecosystems and constitute an important group of zooplankton community in aquatic and semi-aquatic ecosystems of the world. This phylum is highly susceptible to physical and chemical changes in the environment due to their small size and permeable integument (Nogrady *et al*., 1993). Because of their extremely fast reproductive rates and quick response to environmental changes, rotifers are considered as very good indicators of subtle alterations in water quality (Gannon and Stumberger, 1978). The studies on water quality change and seasonal occurrence of planktonic rotifers in lakes have been carried out by workers like Malik and Sulehria (2003), Baloch *et al*. (2008), Slathia and Dutta(2008), Pradhan *et al*.(2011), Sharma and Sharma (2011), Tripathi and Nadim (2012) and Jamila *et al.*(2014).

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Material and Methods

Study Area

Mansar Lake ($75^0 05′11.5″–75^0 5′12.5″$E; $32^0 40′58.25″–32^0 40′59.25″$N) is located 60 km east of Jammu city at an elevation of 666 m above mean sea level in the Siwalik terrain. It is a sub-tropical, sub-oval shaped fresh water body with an area of 0.59 km^2 (Fig.1 a & b) and has been given the Ramsar status along with another important lake- Surinsar in the region. With a small catchment area of 1.67 x 10^6 m^2 and the maximum depth of 38.25 m, the lake has total capacity of 11.57 × 106 m^3 (Rai *et al.*, 2002). Geologically, catchment area of Mansar lake is composed of fine grained sand stone, alternating with silt stone, mud stone and clay of lower Siwalik (Kumar *et al.* 2006).

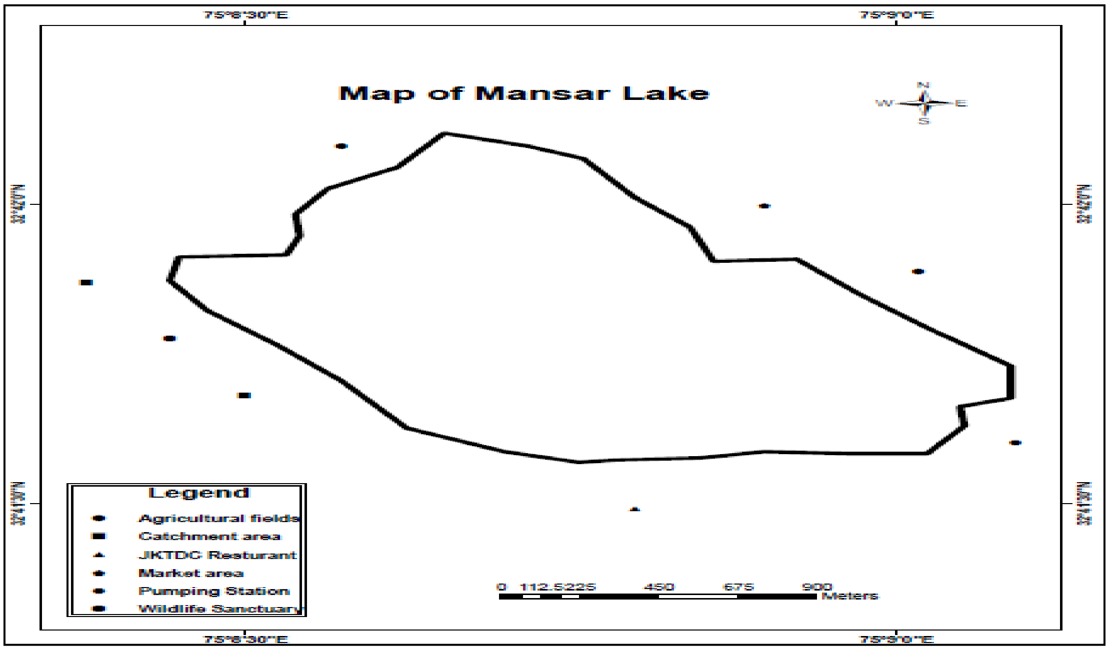


Fig. 1 a. Land use land cover of lake Mansar

Fig. 1 b. Panoramic view of lake Mansar

Climatically, the area is subtropical with an average annual rainfall of 1500 mm. Macrophytic vegetation of the lake is composed of submerged, emergent and floating vegetation viz. *Hydrilla verticellata*, *Najas indica*, *Chara hyaline*, *Vallisneria spirallis*, *Potamageton nodosus*, *Potamageton crispus*, *Nitella* sp., *Nelumbo nuciferum* and *Nymphoides cristatum*. The lake supports two important species of turtles namely *Lissemys punctata* listed in CITES Appendix II and *Trionyx gangeticus* listed in CITES Appendix I and vulnerable in IUCN Redlist (2014). The lake supports very rare Medusae (*Mansariella lacustris*) besides 207 species of algae (www.sites.wetlands.org).

Methodology

Water quality study

Water quality of the lake was determined by carrying out physicochemical analysis of water samples using standard methods given in APHA (1998). Air and water temperature was measured by mercury bulb thermometer (^{0}C); electrical conductivity, TDS, salinity, pH were measured by Century water/ soil analyser kit (model CMK 731); turbidity by turbidity meter (model 331 E); free carbon dioxide, carbonate and bicarbonate, DO, BOD, chloride, calcium, magnesium by titration methods; sodium and potassium by flame photometry and phosphate, silicate, sulphate and nitrate by double beam spectrophotometer.

Rotifer Analysis

Monthly planktonic samples were collected at four experimental station of the lake by filtering 20 litres of water through planktonic net (no. 25) in labelled plastic tubes and were immediately fixed in 5% formaldehyde solution. In the laboratory, plankton were identified (Koste, 1978; Pennak, 1978; Edmondson, 1992; Dhanapathi, 2000; Fernando, 2002; Anitha *et al*. 2004) and counted by drop count method (Welch, 1952). The mean results of all the experimental stations were expressed as number/litre (n/l).

Results and Discussion

Water quality studies

Mean monthly physicochemical data of Mansar lake water is presented in Table 1. The surface water temperature closely followed the air temperature throughout the year and observed distinct seasonal trend of summer increase and winter decline. Electrical conductivity and TDS observed similar pattern of increase and decrease in the lake water. Direct relation of electrical conductivity and TDS is already on record (Wetzel, 2001). Maximum turbidity record during summer (54.1NTU) may be correlated with increased decomposition and water level decrease due to increased evaporation at high temperatures. pH range (7.57-8.50) reflects alkaline nature of lake water. Dissolved oxygen is an important indicator of ability of water to support aquatic life. DO (4.57mg/l – 9.4mg/l) with an annual average of 7.18±1.36mg/l, remained high during most part of the year except during winter. Winter decline of DO may be attributed to lake upwelling in December and January which also results in increase in various other parameters like turbidity, total dissolved solids, free CO_2, sodium, potassium and BOD. BOD, an important pollution indicator fluctuated between 0.3-3.3mg/l in lake water. BOD increase during monsoon (3.3mg/l) may be due to inflow of surface runoff carrying sewage and agricultural discharge from the surrounding area along with rain water. Monsoon increase in BOD has been well documented by workers like Mahadev *et al*.(2010) and Murthuzasab *et al.* (2010). The cationic composition of lake water was dominated by calcium following the order $Ca^{++}>Na^{+}>Mg^{++}>K^{+}$ which indicates marl character of the lake, typical of Himalayan lakes (Siraj *et al.*, 2010). Calcium, magnesium and total hardness almost paralleled in their seasonal pattern of increase and decrease and lake water remained moderately hard throughout the year (TH: 65-139mg/l). Anionic spectrum of the lake water ($HCO_3^{-}>Cl^{-}>CO_3^{2-}>SO_4^{2-}>SiO_2^{-}>PO_4^{3-}>NO_3^{-}$) showed bicarbonate dominance (92.71-263.8mg/l). Bicarbonate dominance in other lakes of the state has been reported by workers like Siraj *et al.(*2010) and Slathia and Dutta(2013). Lake Mansar comes under Class I category of trophic classification based on the ionic concentration (Talling and Talling, 1965). Overall ionic spectrum of Mansar lake is similar to another subtropical lake Surinsar in the region as reported by Slathia and Dutta(2008). All the physicochemical parameters observed well marked seasonal fluctuations.

Table 1. Range, average and standard deviation of water quality parameters of lake Mansar during December 2011-November 2012

Parameters	Minimum	Maximum	Average	SD
A.T (°C)	15	36	28.16	6.50
W.T (°C)	13.14	29.6	23.89	5.24
EC (µS/cm)	145.1	309	218.45	42.45
TDS (mg/l)	73.13	152.1	108.6	20.31
Turbidity (NTU)	7	54.1	19.70	12.89
Salinity(ppt)	Nil	0.10	0.02	0.04
pH	7.57	8.50	8.08	0.32
Free CO_2 (mg/l)	Nil	11.9	4.59	3.82
Carbonate (mg/l)	Nil	31.3	11.97	10.48
Bicarbonate (mg/l)	92.71	263.8	154.34	55.48
D.O (mg/l)	4.57	9.4	7.18	1.36
B.O D (mg/l)	0.53	3.3	1.82	0.93
Chloride (mg/l)	2.99	31.6	12.59	7.74
Calcium (mg/l)	10.64	34.7	24.29	6.49
Magnesium (mg/l)	7.73	16.2	10.88	2.87
TH as $CaCO_3$ (mg/l)	65.04	139	106.15	22.25
Sodium (mg/l)	14.44	42.6	30.36	8.39
Potassium (mg/l)	3.44	9.8	6.24	2.15
Phosphate (mg/l)	0.06	2.7	0.54	0.84
Nitrate (mg/l)	0.09	0.9	0.45	0.21
Silicate (mg/l)	0.47	2.1	1.34	0.54
Sulphate (mg/l)	3. 3	16.3	8.53	4.24

Rotifer Analysis

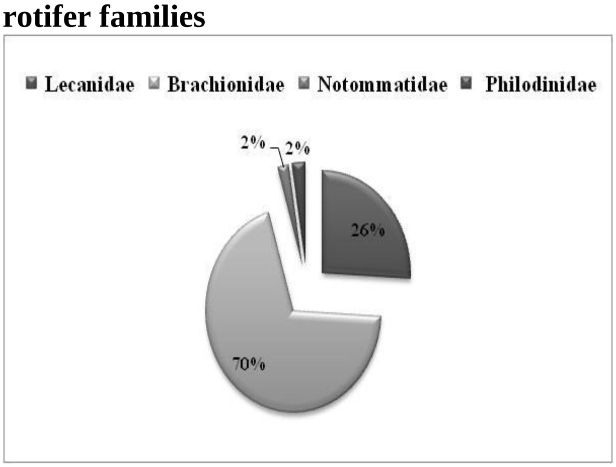
A total of 15 taxa belonging to two classes, four families and seven genera were observed including many represented by few or even a single individual (Table 2). The rotifer diversity as noticed in the present study is low as compared to the findings of earlier workers like Sehgal (1980) from adjoining lake Surinsar (29 species), Jammu ; Sharma, M. (2000) from lake Mansar (21 species), Udhampur; and Slathia and Dutta(2008) from Surinsar lake (40 species), Jammu.Among various rotifer classes, Class Monogononta represented by fourteen species showed qualitative dominance over Bdelloidea represented by only one species only. Family Brachionidae (8 taxa), among the rotifer families showed highest species diversity with maximum population contributed by Brachionidae (70%) followed by Lecanidae (26%) and Philodinidae and Notommatidae (2% each) (Fig. 2). Genus *Lecane* and *Colurella,* among various genera of class Monogonata, showed their maximum presence followed by *Keratella* and *Brachionus*, *Lepadella* and *Cephalodella* (Table 2). Among Bdelloidea, *Philodina* showed its irregular presence during December, March and May. Similar seasonal planktonic associations have been earlier documented by Jhingran(1991) who attributed temporary disappearance of certain planktonic forms at specific periods to the fact that species concerned become too scarce or occur as spores or resting eggs and are not easily detectible. On return of favourable conditions young one hatch

Table-2. Mean monthly variations in Rotifera population(n/l) in lake Mansar during December 2011-November 2012

Name of Species/ Months	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Mean	SD
ROTIFERA														
Class Monogononta														
Order Ploima														
Family Lecanidae														
Lecane(monostyla) bulla Harrings and Myers	**15**	**--**	**108**	**--**	**157**	**46**	**46**	**30**	**108**	**30**	**--**	**47**	**65**	**47.6**
L.(M) quadridentataHarrings and Myers	**--**	**--**	**30**	**30**	**--**	**--**	**--**	**77**	**--**	**--**	**61**	**79**	**55**	**24.2**
L.luna Harrings and Myers	**--**	**--**	**--**	**157**	**15**	**--**	**--**	**--**	**--**	**78**	**31**	**--**	**70**	**63.7**
L.lunaris Harrings and Myers	**47**	**--**	**--**	**30**	**63**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**47**	**16.5**
***Lecane* spp.** Nitzsch	**--**	**--**	**--**	**30**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**30**	
Total Lecane	***62***	**--**	***138***	***247***	***235***	***46***	***46***	***107***	***108***	***108***	***92***	***126***	***120***	***67.3***
Family Brachionidae														
Subfamily Colurinae														
***Lepadella* spp.**Bory de St. Vincent	**78**	**--**	**--**	**154**	**--**	**15**	**--**	**31**	**46**	**15**	**47**	**111**	**62**	**49.3**
Colurella adriatica Carlin	**30**	**46**	**--**	**61**	**79**	**--**	**--**	**--**	**47**	**31**	**78**	**142**	**64**	**36.6**
C.bicuspidata Carlin	**--**	**--**	**--**	**--**	**--**	**--**	**15**	**--**	**61**	**--**	**15**	**--**	**30**	**26.6**
C.obtusa Hauer	**--**	**63**	**--**	**30**	**31**	**111**	**79**	**--**	**202**	**--**	**--**	**109**	**89**	**59.5**
***Colurella* spp.**Bory de St. Vincent	**--**	**--**	**--**	**--**	**--**	**15**	**--**	**46**	**15**	**--**	**--**	**--**	**25**	**17.9**
Total colurella	***30***	***109***	**--**	***91***	***110***	***126***	***94***	***46***	***325***	***31***	***93***	***251***	***186***	***125.6***
Sub family Brachioninae														
***Keratella* spp.**Bory de St.Vincent	**--**	**--**	**92**	**31**	**47**	**125**	**62**	**--**	**157**	**220**	**322**	**79**	**126**	**94.2**
B.quadridentata Ahlstrom	**46**	**--**	**109**	**15**	**31**	**30**	**--**	**--**	**--**	**--**	**--**	**--**	**46**	**36.8**
B.bidentata Ahlstrom	**15**	**--**	**46**	**77**	**--**	**77**	**63**	**46**	**--**	**--**	**15**	**30**	**46**	**25.0**
Total Branchionus	***61***	**--**	***155***	***92***	***31***	***107***	***63***	***46***	**--**	**--**	***15***	***30***	***179***	***94.5***
Total Brachionidae	**169**	**109**	**247**	**368**	**188**	**373**	**219**	**123**	**528**	**266**	**477**	**471**	**294.8**	**144.7**
Family Notommatidae														
Cephalodella gibbaHarrings and Myers	**15**	**--**	**--**	**15**	**--**	**46**	**--**	**--**	**--**	**--**	**30**	**--**	**27**	**14.8**
Total	**15**	**--**	**--**	**15**	**--**	**46**	**--**	**--**	**--**	**--**	**30**	**--**	**27**	**14.8**
Total Monogononta	**246**	**109**	**385**	**630**	**423**	**465**	**265**	**230**	**636**	**374**	**599**	**596**	**413**	**177.3**
Class Bdelloidea														
Order Bdelloida														
Family Philodinidae														
***Philodina* spp.** Ehrenberg	**31**	**--**	**--**	**79**	**--**	**15**	**--**	**--**	**--**	**--**	**--**	**--**	**42**	**33.3**
Total Philodinidae	**31**	**--**	**--**	**79**	**--**	**15**	**--**	**--**	**--**	**--**	**--**	**--**	**42**	**33.3**
TOTAL ROTIFERA	**277**	**109**	**385**	**709**	**423**	**480**	**265**	**230**	**636**	**374**	**599**	**596**	**424**	**185.2**

from the resting eggs and multiply, grow and show their presence in planktonic samples. Seasonally, rotifers observed high diversity in spring(13 species) with winter lowest record (2 species).Quantitatively, Class Monogononta (109n/l-636n/l) showed quantitative dominance over Bdelloidea (nil -79n/l). Family Brachionidae, with total annual population of 3538n/l observed monthly variation between 109 n/l(January) to 528n/l (August) and dominated quantitatively in the present study followed by Lecanidae which recorded total annual population of 1315 n/l with monthly variation of nil (January) to 247n/l (March). Family Notommatidae(December and March 15 n/l each, May 46n/l and October 30n/l) and Philodinidae(December 31n/l, March 79n/l and May 15n/l) showed irregular presence in the present study (Table 2; Fig.3). Among its various genera, *Colurella (*nil-*325n/l)* contributed maximum to the total count followed by *Keratella* (nil-322n/l), *Lecane* (nil-247n/l), *Brachinous* (nil-155n/l), *Lepadella* (nil-154n/l) and *Cephalodella* (nil-46n/l) (Table 2). Seasonally, class Monogononta showed bimodal peaks viz. March and August with August highest record (Table 2; Fig 4). It recorded fall in winter (December-January). Class Bdelloidea showed trimodal peaks with complete absence in the rest of the months. It recorded highest value in the month of March (Fig 4). Quantitatively, overall rotifer population fluctuated between 109n/l (January) to 709n/l (March).

Fig. 2. Percentage dominance of various rotifer families



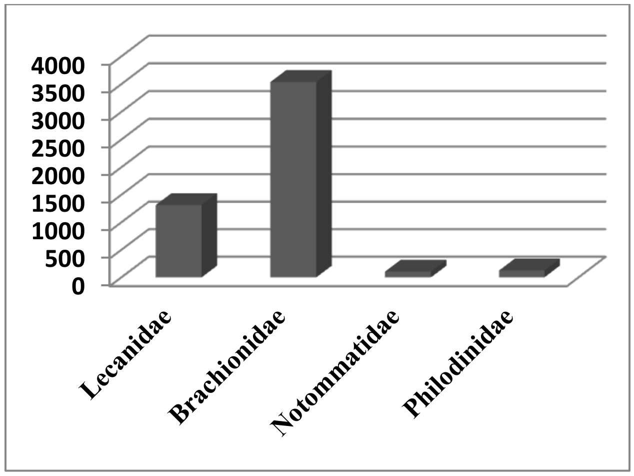


Fig. 3 Rotifera population (n/l) of various families in Mansar lake, Jammu

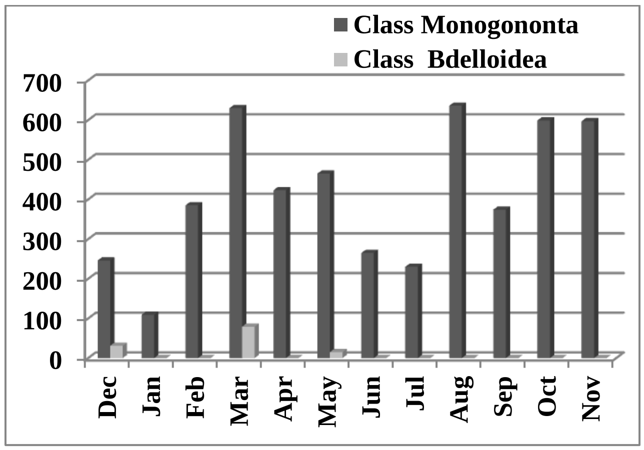


Fig. 4. Mean monthly variations (n/l) of various Classes of Rotifera

Seasonally, rotifers showed bimodal (March and August) peaks with spring (March) highest record (Fig. 5**)**. It observed winter (January) lowest record. Bimodal peak of rotifers with winter least record in lakes have been reported by earlier workers like Jamila *et al.*(2014).from Kashmir. However, these peaks varied for different taxas indicating their seasonal distribution. Spring (March) highest record of rotifers may be attributed to increased availability of food in the form of phytoplankton and stable hydrological factors (Salve and Hiware, 2010; Joshi, 2011; Shashikant, 2012). Also, rapid rate of development due to increased photoperiod and temperature may explain high diversity and density during this period (Slathia and Dutta, 2008).

Similar rotifer peak in spring (March-April) was observed by Wignaraja and Amarasiriwardena (1983) from Bolgoda lake, Sri lanka and Majagi and VijayKumar (2009) from Karanja reservoir, Karnataka. Winter decline in rotifer population may be ascribed to mixing of lake during winter lake overturn resulting in low oxygen concentration and increased carbon dioxide and is in agreement with the findings of Slathia and Dutta (2008). Also, winter low temperatures do not favour rotifer growth and reproduction (Michaloudi *et al.*, 1997). Ecological distribution of rotifers from various lentic and lotic water bodies have been studied by various workers. Influence of temperature on rotifer communities was confirmed by Hessen *et al.* (1995) and Sitre (2012). Echaniz and Vignatti (2011) recorded positive correlations of rotifer abundance with concentration of organic suspended solids and water temperature but negative correlations with salinity and inorganic suspended solids. Sitre and Zade (2012) discussed pH and temperature to be the main factors in the appearance and abundance of different rotifers. Sharma (2005) observed significant direct relationship of the rotifer density with specific conductivity, dissolved oxygen and alkalinity. In the present investigation, coefficient of correlation (r) of rotifer density with various physicochemical parameters of water has shown significant positive correlation with carbonate ($r=0.552; p<0.05$) and dissolved oxygen ($r=0.837$; $p<0.05$) (Table 3). Hofmann (1977) suggested that temperature and oxygen are the main but not the only determinative factors which influence the occurrence and diversity of rotifers. A positive correlation of rotifer density with oxygen was also reported by Sharma (2009) from Loktak lake, Manipur and Jamila *et al.* (2014) from Manasbal lake, Kashmir. The linear regression analysis for Rotifera and DO having significant correlation($r=0.837$, $p<0.05$) has been depicted in Fig. 6 and its summary output has been shown in Table 4. The calculated values for the lake water quality parameters and rotifer, using the regression equations have been compared with the observed values like, rotifer with DO (Table 4; Fig 6.). This equation can be used to calculate the quantitative changes in rotifer population in the lake caused by DO fluctuations by substituting the DO values in the equation.

Table 3. Coefficient of correlation(r) between Rotifera (n/l) and physicochemical parameters of Mansar lake, Jammu during December 2011-November 2012

Parameters	Rotifera
A.T (°C)	0.217
W.T (°C)	0.262
EC (µS/cm)	-0.282
TDS (mg/l)	-0.295
Turbidity (NTU)	-0.126
Salinity(ppt)	-0.450
pH	0.210
Free CO_2 (mg/l)	-0.370
Carbonate (mg/l)	0.553*
Bicarbonate (mg/l)	-0.220
D.O (mg/l)	0.837*
B.O D (mg/l)	0.140
Chloride (mg/l)	-0.154
Calcium (mg/l)	-0.101
Magnesium (mg/l)	-0.295
TH as $CaCO_3$ (mg/l)	-0.253
Sodium (mg/l)	-0.171
Potassium (mg/l)	-0.218
Phosphate (mg/l)	-0.088
Nitrate (mg/l)	0.278
Silicate (mg/l)	0.254
Sulphate (mg/l)	-0.075

*** significant at 0.05 level**

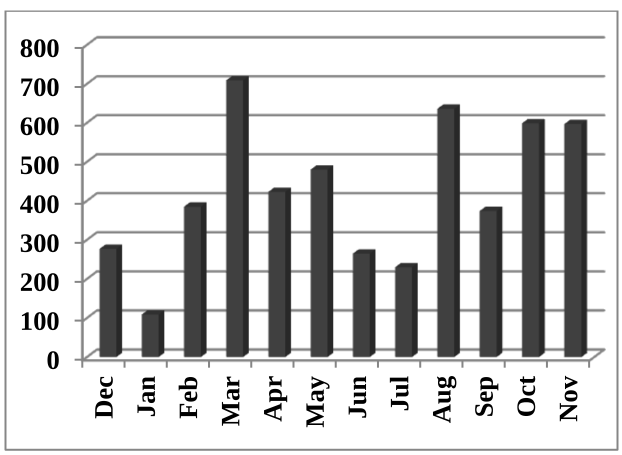


Fig. 5 Mean monthly variation in Rotifer Population (n/l) of Lake Mansar, Jammu

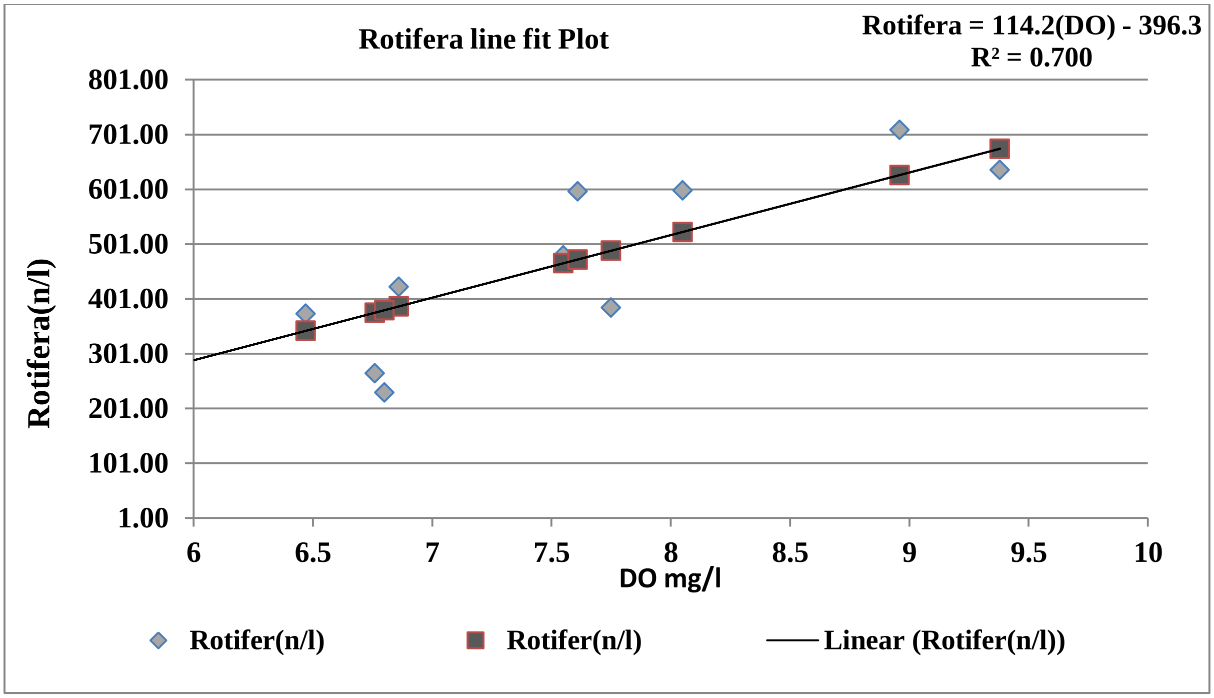


Fig. 6 Regression between DO and Rotifera

Conclusion

Based on the present study, it can be concluded that most of the rotifer species followed seasonal pattern of increase and decrease and is in conformity with the findings of earlier workers. Seasonal variations in rotifer population may be ascribed to availability of food and favourable conditions for their growth and development. Presence of indicator species like *Brachionus* and *Lecane* indicate eutrophic conditions in the lake water. Rotifers observed insignificant coefficient of correlation(r) with most of the physicochemical parameters of water except DO and carbonate. This indicates that no single factor is strong determinant of rotifer distribution in lake Mansar and a sum total of number of factors contribute to their diversity and density in the lake. Also, linear regression equations developed for rotifer and water quality parameters have confirmed significant correlation between rotifer and DO.

Acknowledgements

The authors are thankful to Head, Department of Environmental Science, University of Jammu for providing necessary facilities during the present work. Financial assistance provided by Jammu University is gratefully acknowledged.

References

A.P.H.A.1998. Standard Methods: Examination of water and waste water. **20th Edn.** ***American Public Health Association*** NW Washington, DC. 2005-2605.

Anitha, P.S., George, M. and George, J. P. 2004. ***Identification manual of freshwater Rotifera of peninsular India,*** Central Marine Fisheries institute, Cochin.

Baloch, W.A., Soomro, A.N. and Buledi, G.H. 2008. Zooplankton, especially Rotifer and Cladoceran Communities of the spring and rainwater streams (Nai) in Kirthar range, Sindh, Pakistan. ***Sindh University Research Journal (Science Series).*** 40: 17-22

Dhanapathi, M.V.S.S.S. 2000. Taxonomic notes on the rotifers from India (from 1889-2000). ***Indian Association of Aquatic Biologists (IAAB),*** Hyderabad.

Echaniz, S.A. and Vignatti, A.M. 2011. Seasonal variation and influence of turbidity and salinity on the zooplankton of a saline lake in central Argentina. ***Latin American Journal of Aquatic Research.*** 39(2): 306-315

Edmondson, W.T. 1992. ***Freshwater Biology***. John Wiley and Sons, New York, 1-124

Esteves, F. A. 1998. ***Fundamentos de Limnologia*** (2nd edn.) Intercieˆncia/FINEP. Rio de Janeiro, 602 pp.

Fernando, C.H. 2002. A guide to tropical fresh water zooplankton**:** ***Identification, ecology and impact on fisheries, Balkhuys,*** Publ. Netherlands.

Gannon, J. E. and Stemberger, R. S. 1978. Zooplankton (especially crustaceans and rotifers) as indicators of water quality. ***Trans. am. Microsc. Soc***. 97: 16–35.

Hessen, D.O., Faafeng, B. A. and Anderson, T. 1995. Replacement of herbivore zooplankton species along gradients of ecosystem productivity and fish predation pressure. ***Canadian Journal of Fisheries and Aquatic Sciences***. 52: 733–742.

Hofmann, W. 1977. The influence of abiotic environmental factors on population dynamics in planktonic rotifers. ***Archiv für Hydrobiologie–Beiheft Ergebnisse der Limnologie***. 8: 77–83.

IUCN Redlist (2014) **The IUCN Red list of threatened species (http://www.iucnredlist.org)** accessed on 14-10-14.

Jamila,I., Yousuf, A. R., Parveen,M., Hassan,K., Rehman,M. and Sheikh,B.A. 2014. Rotifer community in Manasbal Lake of Kashmir. ***International Journal of Fisheries and Aquatic Studies***, 1(6): 190-198.

Jhingran,V.J.1991. Fish and fisheries of India. Hindustan Publ. House, India.

Joshi, P.S. 2011. Studies on zooplankton of Rajura lake of Buldhana district, Maharashtra. ***Science Research Reporter***. 1(3):132-137.

Kippen, N. K. 2005. Impact of macrophyte substratum and season on the habitat choice of rotifer communities. ***Hydrobiologia.*** 593: 27-37.

Koste, W., 1978. Rotatoria. Die RaÈdertiere Mitteleuropas, 2 vols (Berlin: Borntraeger), 673 pp., 234 pls.

Kumar, V., Rai, S.P. and Singh, O. 2006. Water quantity and quality of Mansar lake located in the Himalayan foothills. ***Lake and Reservoir Management.*** 22(3):191-198.

Mahadev, J., Hosamani, S.P. and Ahmed, S.A.2010. Statistical multivariate analysis of lakes water quality parameters in Mysore, Karnataka, India. ***World Applied Sciences Journal.*** 8(11):1370:1380.

Majagi, S. and VijayKumar, K. 2009. Ecology and abundance of zooplankton in Karanja reservoir. ***Environmental Monitoring and Assessment***. 152:451-458.

Malik, M. A. and Sulehria, A. Q. K. 2003. Seasonal variation, density and diversity of planktonic rotifers in Jallolake. ***Biologia (Pakistan).*** 49 (1and 2): 77-88.

Michaloudi, E., Zarfdjian, M. & Economidis, P. S. 1997. The zooplankton of lake Mikri Prespa. ***Hydrobiologia.*** 351: 77–94.

Mondall, D. Pal, J.; Ghosh, T.K. and Biswas, A.K. 2012. Rotifer diversity of Mirik Lake in Darjeeling Himalaya. ***European Journal of Experimental Biology.*** 2 (5):1451-1456.

Murthuzasab, M.R., Rajashekhar, M., Vijaykumar, K. and Haliked, N.S. 2010. Seasonal variation in physico-chemical parameters of Hirahalla reservoir Koppal district Karnataka. ***International Journal of System Biology***. 2(2):16-20.

Nogrady, T., Wallace, R. L. and Snell, T. W. 1993. Rotifera, Vol.1. Biology, ecology and systematics. In Nogrady, T. & H. J. Dumont (eds), ***Guides to the Identification of the Microinvertebrates of the Continental Waters of the World***. SPB Academic Publishing BV, The Hague: 142 pp.

Pennak, R.W. 1978. ***Freshwater Invertebrates of the United States***. 2nd Edition, John Wiley and Sons, New York: 803.

Pradhan, V., Patel, R. and Bansode, S.G. 2011. Biodiversity of population dynamics and seasonal variation in Nath Sagar Reservoir at Paithan (M.S), India with reference to rotifers. ***International Journal of Science Innovations and Discoveries***. 1(3): 320:326.

Rai, S. P., Kumar, V., Omkar, Kumar, B. and Jain, S. K. 2002. Limnological study of the Mansar Lake, District Udhampur, J&K. ***Project Report, National Institute of Hydrology, Roorkee, India***.

Salve, B. and Hiware, C. 2010. Zooplankton diversity of Wan reservoir, Nagapur (M.S), India. ***Trends Research in science and Technology***. 2(1):39-48.

Sehgal, H.S.1980. Limnology of lake Surinsar, Jammu with reference to zooplankton and fishery prospects. Ph. D thesis submitted to Deptt. Of Biosciences. University of Jammu.

Sharma, B.K. 2005. Rotifer communities of floodplain lakes of the Brahmaputra basin of lower Assam (N.E. India): biodiversity, distribution and ecology. ***Hydrobiologia***. 533: 209–221.

Sharma, B.K. 2009. Diversity of rotifers (Rotifera, Eurotatoria) of Loktak lake, Manipur, North-eastern India. ***Tropical Ecology.*** 50(2): 277-285, 2009

Sharma, B.K. and Sharma, S. 2011. Zooplankton diversity of Loktak Lake, Manipur, India . ***Journal of Threatened Taxa Communication.*** *3*(5): 1745–1755.

Sharma, M. 2000. Ecology and community structure of zooplankton of lake Mansar (J&K) Ph. D thesis submitted to Department of Biosciences, University of Jammu, Jammu.

Shashikant, R.S. 2012. Studies on the seasonal variation of fresh water zooplankton in a perennial urban lake of Nagpur city, Maharashtra, India. ***Lokavishkar International E. Jr.,*** 1(3):10-16.

Siraj,S. , Yousul,A.R., Bhat, F.A. and Parveen,M. 2010. Ecology of macrozoobenthos in Shallabugh wetland of Kashmir Himalaya, India. ***J. Ecology and Natural Environment***. 2(5):84:91.

Sitre, S.R. 2012. Assessment of biodiversity of rotifers in Ambazari lake of Nagpur city with respect to water quality. ***Interdisciplinary research Journal***. 2(2):104-*110*.

Sitre, S.R. and Zade, S.B. 2012. Studies on biodiversity of rotifers in a freshwater lake of Nagpur city (m.s.) India during different seasons of the year. ***International Journal of Innovations in Bio-Sciences***. 2(3), pp. 109–111.

Slathia, D. and Dutta S.P.S. 2008. Ecology of Rotifers of Lake Surinsar, Jammu. ***Proceedings of TAAL : the 12th world lake conference*.** 74-81.

Slathia, D. and Dutta S.P.S. 2013. Hydrobiological Study of a Subtropical Shiwalik Lake, Jammu, J&K (India) ***International Journal of Chemical, Environmental & Biological Sciences (IJCEBS)***. 1(1):143:149.

Talling, J.F. and Talling,T.B. 1965. The cemical composition of African lake waters. ***Int. Revue ges.Hydrbiol.*** 50(3):421-463.

Tripathi, A. K. and Nadim, C. 2012. Rotifer Diversity in a Semiurban Shallow Perrenial Water Body: A Case Study of Jalaser Tank Mandalgarh, India **.** ***International Research Journal of Environment Sciences.*** 1(1), 42-45.

Welch, P.C. 1952. Limnology, McGraw Hill Book Co. Inc. New York.539 pp.

Wetzel, R.G. 2001. Limnology**.** Lake and River Ecosystems, Third Ed. Academic Press, London.

Wignaraja, S. and Amarasiriwardena 1983. Some aspects of the limnology of Bolgoda lake Sri lanka. ***Journal of the National Science Council***. 11(2):255-268.

www.sites.wetlands.org. Ramsar Information sheet on wetlands (accessed on 10-10- 2014).