



Studies on Seasonal and Spatial Distribution of Zooplankton Communities and Their Diversity Indices at Chashma Lake, Pakistan

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ABSTRACT

The study was conducted to investigate the seasonal and spatial distribution of zooplankton species at Chashma Lake during June 2014 to May 2015. The samples were collected from three partially separated stations of the Chashma Lake on a monthly basis. A total 42 species of zooplankton were identified from the Chashma Lake belonging to three taxa viz.; copepoda, rotifera and cladocera. The diversity of the zooplankton species in the lake was determined by richness and evenness indices, which were found as follows; Margalef Index 1.30 to 3.87, Shannon's Index 2.54 to 3.68, Simpson Index 0.92 to 0.97, Simpson's Reciprocal Index 12.25 to 37.69 and Pielou's Evenness Index 0.94 to 1.0. The zooplankton community was found abundant in summer as compared to winter. The copepods were found dominant followed by rotifers and cladocerans for entire study period. The spatial distribution of zooplankton was not found prominent as compared to their seasonal distribution. However, rotifers showed spatial difference among sampling stations (ANOVA, p -value < 0.05). The present study provides a first detailed spatial and seasonal distribution of zooplankton in Chashma Lake, which may be a road map for further studies on zooplankton diversity in other freshwater lakes in the region.

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Authors' Contribution

MQ planned the research project. HA Collected samples, performed laboratory work and wrote the article. IA and MZB helped in sampling. SLS provided laboratory facilities at Pakistan Museum of Natural History, Islamabad and identified zooplankton species. NS Proofread the manuscript and helped in data analysis.

Key words

Zooplankton, Chashma Lake, Diversity, Seasonal, Spatial.

INTRODUCTION

Zooplankton play an important role in aquatic environment. They actively participate in food chain and are responsible for nutrients recycling and energy transfer from producers to secondary and tertiary consumers (Datta, 2001; Park and Shin, 2007). They are also used as a direct prey for fish and large invertebrates. Influence of various physicochemical parameters, geographical features and complex diversity of zooplankton result in difficulty in zooplankton examination. They are considered as an important component of aquaculture and are also used as indicators of water quality, pollution level and status of eutrophication in freshwater bodies (Saler, 2009; Thor *et al.*, 2005; Hwang *et al.*, 2009). In Pakistan, some studies have been carried out on various aspects of zooplankton (Mahar *et al.*, 2000, 2008; Baloch, 2000; Baloch and Soomro, 2004; Baloch *et al.*, 2004,

2005; Kazmi, 2004; Shelly *et al.*, 2011; Naz *et al.*, 2012; Shah *et al.*, 2013; Maqbool *et al.*, 2014; Saddozai *et al.*, 2015). However, no study on the zooplankton communities of Chashma Lake has so far been conducted.

The present study was conducted to determine the zooplankton species composition and distribution in Chashma Lake, which may be helpful in aquaculture management especially in fish hatchery sector, as the zooplankton are the main source of food for aquatic animals particularly for fish fry in freshwater ecosystem.

MATERIALS AND METHODS

Study site

Chashma Lake is a manmade lake and is situated on Indus River at 32° 25' N, 71° 22' E. This is a shallow lake and a wetland of international importance and is also a RAMSAR Site (Akbar *et al.*, 2009). In order to obtain a comparative report of zooplankton distribution from the different sites, three stations S1, S2 and S3 were selected for study and marked by GPS.

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Sampling

Zooplankton samples were collected on a monthly basis from June 2014 to May 2015. Five liters of water was filtered through a zooplankton net (mesh size 80 μm) from 1 to 2 feet depth at each site for the zooplankton population and preserved in 5 % formalin and shifted to Pakistan Museum of Natural History, Islamabad, Pakistan. In laboratory, zooplankton samples were analyzed and counted under light microscope (BH2 OLYMPUS, Japan with rotator eyepiece 10x) with the help of counting chamber. Various magnifications of 20x, 30x, 40x and 100x were also used for examination of specimens. Identification of zooplankton was made with the help of different taxonomic keys (Ward and Whipple, 1959; Pennak, 1978; Yunfang, 1995; Mizuno and Takahashi, 1991; Battish, 1992).

Table I.- List of zooplankton species observed at Chashma Lake during June 2014-May 2015.

S Species name No.	S Species name No.
Cladocerans	Rotifers
1 <i>Bosmina longirostris</i>	22 <i>Skistodiaptomus pallidus</i>
2 <i>Alona guttata</i>	23 <i>Hexarthra mira</i>
3 <i>Alona reticulata</i>	24 <i>Filinia longiseta</i>
4 <i>Chydorus poppie</i>	25 <i>Asplanchna brightwelli</i>
5 <i>Ceriodaphnia cornuta</i>	26 <i>Asplanchna priodonta</i>
6 <i>Ceriodaphnia reticulata</i>	27 <i>Brachionus angularis</i>
7 <i>Daphnia lumholtzi</i>	28 <i>Brachionus clycflorus</i>
8 <i>Scapholeberis kingi</i>	29 <i>Brachionus havanaensis</i>
9 <i>Simocephalus exspinosus</i>	30 <i>Brachionus patulus</i>
10 <i>Macrothrix rosea</i>	31 <i>Brachionus quadridentatus</i>
Copepods	32 <i>Keratella cochlearis</i>
11 <i>Diacyclops bicuspidatus</i>	33 <i>Keratella tropica</i>
12 <i>Eucyclops agilis</i>	34 <i>Keratella valga</i>
13 <i>Eucyclops macrurus</i>	35 <i>Notholca foliacea</i>
14 <i>Ectocyclops phaleratus</i>	36 <i>Notholca squamula</i>
15 <i>Macrocyclus albidus</i>	37 <i>Platytias quadricornis</i>
16 <i>Macrocyclus fuscus</i>	38 <i>Euchlanis triquetra</i>
17 <i>Mesocyclop edax</i>	39 <i>Lecane arcula</i>
18 <i>Mesocyclop leukarti</i>	40 <i>Lepadella species</i>
19 <i>Microcyclus varicans</i>	41 <i>Notommata tripus</i>
20 <i>Diaptomus species</i>	42 <i>Polyarthra species</i>
21 <i>Onychodiaptomus mohammad</i>	

Statistical analysis

The data for spatial difference was analyzed through Box-plot by using R Studio (3.2.5 version) and ANOVA test to see the difference between sites, whereas, the

relative occurrence was measured to know the abundance of zooplankton. Diversity indices were measured by using R Statistical VEGAN package (3.4.0 version). The indices used for the measurement of diversity and richness were; a) Shannon Index, b) Evenness or Pielou Index, c) Simpson Index, and d) Margalef Index.

RESULTS AND DISCUSSION

The present study reveals that a total 42 species of zooplankton were found in Chashma Lake belonging to three taxa *viz.*; rotifers, cladocerans and copepods. Of these, 20 species belong to rotifers, 12 species to copepods and 10 species to cladocerans (Table I). On the basis of percent occurrence throughout the year, the copepods were found more abundant (47.93%) followed by rotifers (33.67%) and cladocerans (18.38%). The physical characteristics of three sampling sites in Chashma Lake are given in Table II.

Table II.- Physical characteristics of Chashma Lake.

Parameters	Name of station		
	S1 Main Basin	S2 Hajji Basin	S3 Dera Basin
Latitude	N32°26.110	N32°26.229	N32°27.141
Longitude	E071°25.571	E071°23.664	E071°20.919
Average depth (m)	4.14	4.29	5.15
Flow velocity (cm/2 min)	44.41	51.66	108.91
Color	Dark green	Dark green	Grey green

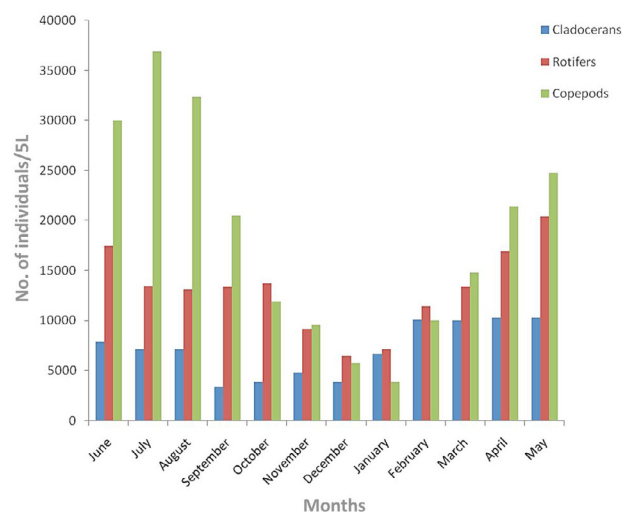


Fig. 1. Average monthly abundance of major zooplankton groups in Chashma Lake between June 2014 and May 2015.

Regarding seasonal variation in zooplankton species, it was found that the copepods were dominant in summer (March to September), followed by rotifers. Whereas, in winter rotifers were prominent in occurrence as compared to copepods. The cladocerans were dominant from early spring to summer and less in winter (Fig. 1).

Table III.- Values of diversity indices for different sites and months at Chashma Lake during June 2014-May 2015.

Months and sites	Margalef	A	B	C	D
June.S1	3.61	3.59	0.97	33.69	0.97
June.S2	3.71	3.63	0.97	35.63	0.98
June.S3	3.15	3.45	0.97	29.07	0.98
July.S1	3.16	3.47	0.97	30.09	0.98
July.S2	3.68	3.58	0.97	32.97	0.97
July.S3	3.01	3.36	0.96	26.17	0.97
Aug.S1	3.29	3.52	0.97	31.74	0.98
Aug.S2	3.60	3.58	0.97	33.05	0.98
Aug.S3	3.10	3.44	0.97	29.40	0.98
Sep.S1	3.21	3.48	0.97	30.56	0.99
Sep.S2	3.34	3.54	0.97	33.39	0.99
Sep.S3	3.06	3.44	0.97	29.88	0.99
Oct.S1	3.26	3.52	0.97	33.11	1.00
Oct.S2	3.43	3.53	0.97	32.47	0.98
Oct.S3	2.44	3.17	0.96	22.85	0.99
Nov.S1	3.45	3.57	0.97	35.36	1.00
Nov.S2	1.99	3.00	0.95	20.00	1.00
Nov.S3	2.16	3.08	0.95	21.16	0.99
Dec.S1	2.64	3.30	0.96	27.00	1.00
Dec.S2	1.41	2.64	0.93	14.00	1.00
Dec.S3	1.30	2.54	0.92	12.25	0.99
Jan.S1	2.53	3.24	0.96	25.14	1.00
Jan.S2	1.49	2.67	0.93	13.76	0.99
Jan.S3	1.97	2.97	0.95	18.62	0.99
Feb.S1	3.49	3.56	0.97	32.81	0.99
Feb.S2	2.64	3.12	0.94	16.35	0.94
Feb.S3	2.71	3.28	0.96	25.62	0.99
Mar.S1	3.62	3.60	0.97	33.78	0.98
Mar.S2	3.66	3.62	0.97	35.53	0.99
Mar.S3	2.78	3.33	0.96	26.56	0.99
Apr.S1	3.83	3.68	0.97	37.69	0.98
Apr.S2	3.81	3.66	0.97	36.63	0.99
Apr.S3	3.56	3.59	0.97	34.13	0.99
May.S1	3.59	3.59	0.97	33.84	0.97
May.S2	3.70	3.61	0.97	34.04	0.98
May.S3	3.87	3.65	0.97	35.08	0.98

A, Shannon's Diversity; B, Simpson's Diversity; C, Inverse Simpson's Diversity; D, Pielou's Evenness.

The values of diversity, richness and evenness indices of zooplankton in the Chashma Lake are presented seasonally and spatially (Table III). It was found that the Margalef value ranged from 1.30 to 3.87, lowest in December at S3 and highest in May at S3. The Shannon's Diversity ranged from 2.54 (in December at S3) to 3.68 (in April at S1), whereas, the Simpson's Diversity value varied from 0.92 (in December at S3) to 0.97 (in April at S1) and the Simpson's Reciprocal Index ranged from 12.25 to 37.69 in December at S3 and in April at S1, respectively. The Pielou's Evenness value ranged from 0.94 in February at S2 to 1.0 in November at S2, and in December at S1 and S2 (Table III).

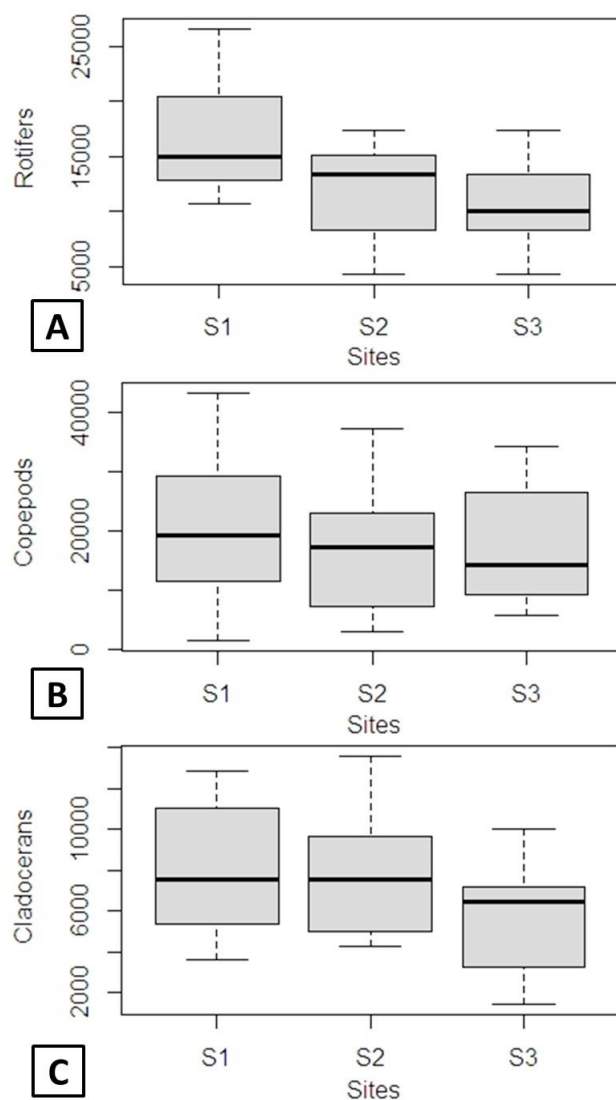


Fig. 2. Spatial comparison of zooplankton abundance through Box-plot: A, Rotifers; B, Copepods; C, Cladocerans at Chashma Lake.

These values reveal that the species diversity, richness and proportion were high in April at S1 and low in December at S3. However, interestingly, the evenness value demonstrates that the species were less evenly distributed in February and November at S2 and the species frequencies were remained similar in December at S1 and S2. When this difference was examined spatially by Box-plot (Fig. 2), no significant difference was found between all the sites for copepods and cladocerans (ANOVA, p -value >0.05). Whereas, the significant difference for rotifers was found between S1 and S3 and between S1 and S2 (ANOVA, p -value <0.05); however, no significant difference found between S2 and S3 (ANOVA, p -value >0.05).

The abundance of zooplankton community in Chashma Lake was found throughout the year and almost at all stations, however, it was more prominent in summer months. Sulehria *et al.* (2009), Salve and Hiware (2010) and Devaraju (2015) have reported similar findings in their work. Altindag *et al.* (2007) observed dominance of rotifers in their study in Mogan Lake. In current study, for zooplankton species, Shannon's Diversity, Margalef value, Simpson's Diversity and Simpson's Reciprocal index values were also found. Shannon diversity is used to determine the diversity of a particular habitat and also for a comparison of various habitats for the abundance of the species (Clarke and Warwick, 2001). Evenness is a vital factor of diversity indices which presents the relation between the frequencies of species (Pielou, 1969) and it evaluates the relative abundance of different species which make richness of a habitat (Leinster and Cobbold, 2012). The Simpson index is used not only for counting the number of species, but also to find out the ratio of each species (Simpson, 1949). Simpson describes the possibility of any two individuals randomly caught belonging to different species (Bibi and Ali, 2013). Margalef index accounts for species richness of a habitat by the Gleason coefficient (Margalef, 1958). The index values rely on the number of species and not on the species frequencies.

In current study, the values for all measured indices were high in summer months and are in agreement with Maqbool *et al.* (2014). The values for diversity indices reveal that the zooplankton communities were heterogeneous by diversity index values especially when the difference between maximum and minimum values was high. During this study, it was also found that among three taxa of zooplankton, the copepods were dominant in occurrence from March to April, and were masked by rotifers in winter. Whereas, the cladocerans followed the same pattern as of copepods but were least abundant. Similar results have been reported by Mwaluma *et al.* (2003), Mahar *et al.* (2008), Maqbool *et al.* (2014) and

Sulehria *et al.* (2009).

Among rotifers, *Asplancha priodonta* was more prevailing in winter season, while other species like *Lecane arcua*, *Polyarthra* species, *Euchlanis triquetra*, *Keratella tropica* and *Brachionus havanaensis* were found abundant in summer. Similar findings have been reported by many researchers (Nogueira, 2001; Sampaio *et al.*, 2002; Sulehria and Malik, 2012). Saddozai *et al.* (2015) found that *Keratella* spp. were dominant in April and July. Yağcı (2014) also observed more *Keratella* from Lake Gölhisar, Turkey. It is also observed that *Asplancha priodonta* and *Keratella valga* were more prevalent at S3, while other species like *Polyarthra* spp., *Brachionus* spp., *Keratella tropica* and *Euchlanis triquetra* were more abundant at S1. Among cladocerans, the *Cerodaphnia cornuta*, *Daphnia* and *Alona* were found more prominent in late winter and early spring at Chashma Lake. This may be due to low population of Cyanophyta in winter as compared to summer, which is not favored by *Daphnia* species, as reported by Kiss (2002). The *Chydorus poppie* and *Cerodaphnia reticulata* were found more prevailing in May and June whereas, *Scapholeberis kingi* and *Macrothrix rosea* were found abundant in May, June and July. This finding is in agreement with Mahar *et al.* (2008). *Bosmina longirostris* and *Scapholeberis kingi* showed their preference towards S1 and *Cerodaphnia cornuta* were higher at S3, while *Alona guttata* and *Alona reticulata* were more prevalent at S2. Whereas, all species of copepods were more abundant in summer as compared to winter. Furthermore, *Macrocyclus fuscus*, *Diacyclops bicuspidatus* and *Eucyclops species* were more prevalent at S1, whereas, *Mesocyclop leukarti* was more abundant at S3. Yildiz *et al.* (2007) and Ergonul *et al.* (2016) also observed the abundance of *Keratella* spp. and *Bosmina longirostris* in Anatolian lakes. The copepods found from Chashma Lake were abundant in summer and this finding is in agreement with Jhoshi (2011), Maqbool *et al.* (2014) and Devaraju (2015).

CONCLUSION

It is concluded that the Chashma Lake is very rich in zooplankton diversity in summer than in winter. The values of diversity indices reflect that zooplankton are more prevalent and rich in summer, whilst in terms of evenness, zooplankton community in the lake was found equitable.

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Statement of conflict of interest

The authors declare that there is no conflict of interests regarding the publication of this article.

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