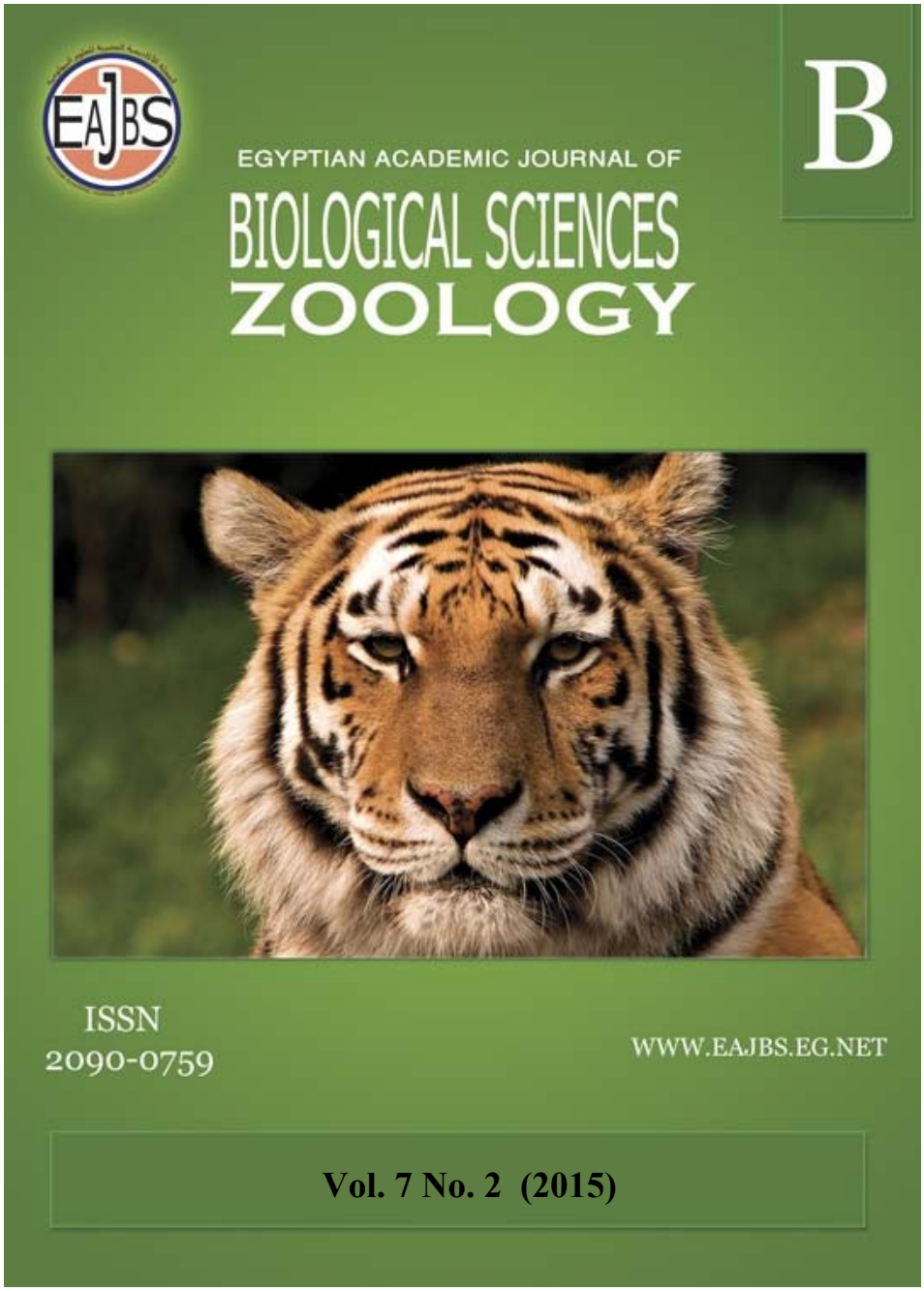


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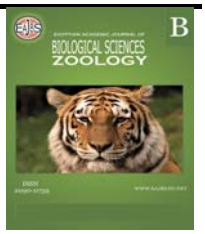


# Diversity and Abundance of Zooplankton in Nigeen Lake of Kashmir Himalaya

**Asma Jan[1], Ashok K. Pandit[1]and Javaid Ahmad Shah[2]***

1- P.G. Department of Environmental Science, University of Kashmir, Srinagar-190006, J&K, India

2- Centre of Research for Development University of Kashmir, Srinagar-190006, J&K, India

*Corresponding author email: javaidshah31@gmail.com

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**ABSTRACT**

The present study was carried out on zooplankton community of the Nigeen lake from June 2014- November 2014. During the study period, a total of 25 taxa of zooplankton were recorded of which Cladocera constituted the most dominating group represented by 12 taxa, Rotifera contributed 10 taxa and Copepoda was the least represented group registering only 3 taxa. Numerically, Cladocera was the dominant group throughout the study period both in terms of density and diversity. Though 25 zooplankton taxa were identified in the Nigeen lake yet, only few like *Alona* sp., *Alonella* sp., *Chydorus* sp., *Bosmina* sp., *Graptoleberis* sp., *Brachionus* sp., *Cephalodella* sp. and *Cyclops* sp. were commonly encountered at all the study sites.The occurrence of these species indicates the general eutrophic nature of the lake.

## INTRODUCTION

Zooplankton are minute heterotrophic organisms present in the diverse water bodies (Majagi and Vijaykumar, 2009). They occupy a central position between the autotrophs and heterotrophs and forms an important link in food web of a freshwater ecosystem (Pandit, 1980, 99) and contribute significantly to aquatic productivity in freshwater ecosystems (Wetzel, 2001). Zooplankton diversity and density refers to variety within community and their diversity is one of the most important ecological parameters as these are the intermediate link between phytoplankton and fish. Zooplankton communities respond to a wide variety of disturbances including nutrient loading (Pace, 1986; Dodson, 1992), acidification (Fuller *et al.,* 1977), contaminants (Murugan *et al.,* 1998) and fish densities (Canfield and Jones, 1996 and Pace, 1986). As a result, change their abundance, species diversity or community composition due to their short generation time (Shah and Pandit, 2013). Keeping in view the importance of these animalcules, an attempt was made to obtain the baseline data on species composition and diversity of various zooplankton groups in the various ecozones of Nigeen lake.

## MATERIALS AND METHODS

**Study area and study sites**

Nigeen lake is situated between the geographical coordinates of 34°7'13"N 74°49'40"E to the east of Srinagar city at an elevation of 1584 m above mean sea level. The lake covers an area of 4.5 $km^2$ with the maximum depth of 6 m in spring.

The lake is of drainage type, fed by a narrow water channel of Dal lake on its Ashaibagh bridge, Saidakadal in the North east while it drains into Khushalsar lake on its northwest side through Nallah Amir khan. A long channel to the south west of the Nigeen lake is present which drains water directly to the river Jhelum. Nigeen lake is a fully urban lake and is subjected to a greater stress on account of more of biotic impact through excessive human activity both within the lake and around the adjacent lake shore.

The area of lake has got reduced to 0.65 $km^2$ in as recorded in 2004 from an area of 0.79 $km^2$ recorded in 1971 due to creation of floating gardens for vegetable cultivation, increased hotels and human habitation. The lake is known for its aquatic sports and has been the focal point of tourist attraction. It supports a rich and diverse macrophytic vegetation of both floating and submerged forms such as *Azolla* sp., *Nelumbo* sp., *Typha* sp. etc.

**Study sites:**

Zooplankton samples were collected from five sampling sites of Nigeen lake differing in vegetation, water and having varied anthropogenic pressures (Fig. 1). The geographical coordinates and other related features of the study sites are given in Table 1.

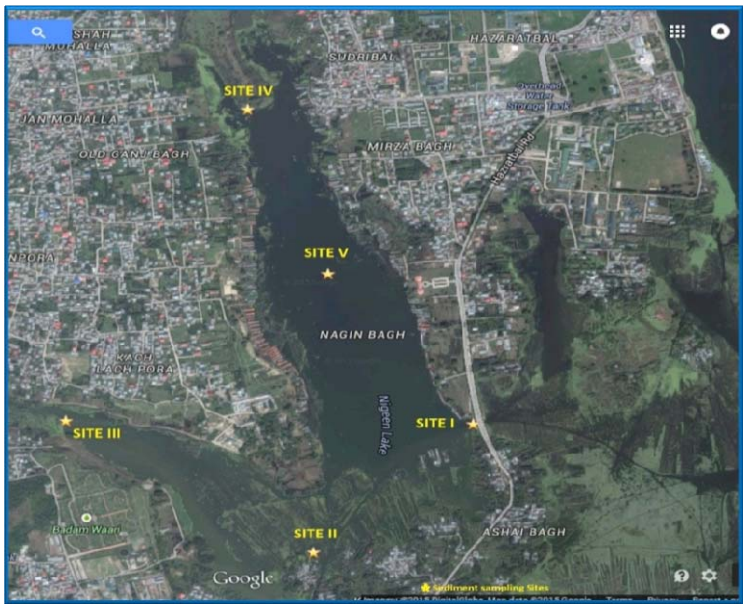


Fig. 1: Map showing various sampling sites at Nigeen lake

Table 1: Location of five study sites in Nigeen lake

| S.NO. | Sites | Latitude (N) | Longitude (E) | Features |
|---|---|---|---|---|
| 1 | Ashaibagh (inlet) | 34°06′53.0″ | 74°50′09.5″ | Good macrophytic growth |
| 2 | Khujyaarbal (outlet) | 34˚06′28.1″ | 74°49′47.3″ | Anthropogenic pressures |
| 3 | Nallah Amir Khan | 34° 06′ 50.2″ | 74° 49′ 13.5″ | Profuse growth of macrophytes |
| 4 | Bottabagh | 4˚07′37.33″ | 74°49′38.2″ | Turbid water |
| 5 | Centre | 34° 07′ 14.2″ | 74° 49′ 49.3″ | Centre of lake |

The sampling of zooplankton was done on monthly basis (June, July, October and November, 2014). Zooplankton samples were procured by filtering 100 liters of the surface lake water through plankton net made of nylon bolting cloth. The content collected in the tube attached to the lower end of the net were transferred to the properly labeled vials and preserved in 4% formalin which acts as a good preservative (Dussart and Defay, 1995). The aliquot in the vials was taken to be 30 ml. The qualitative and quantitative analyses were carried out in the laboratory with the help of microscope and counting was done by a Sedgwick-rafter counting cell. Identification of the specimens was carried with the help of standard work of Edmondson (1992). Diversity indices were calculated by using software PAST(statistical Version 1.93 for Windows 7) and the similarity between various sites were calculated by Sorenson similarity coefficient (Sorenson, 1948).

## RESULTS AND DISCUSSION

A total of 25 zooplankton of which12 belonged to Cladocera, 10 to Rotifera and 3 to Copepoda were encountered during the present study (Table 2). The most common genera found among all the sites were *Alona affinis, Alona* sp., *Alonella* sp., *Bosmina* sp., *Chydorus* sp., *Chydorus sphaericus* and *Graptoleberis* sp. Among the recorded species the maximum number of animalcules were recorded at Khujayarbal site (site II; 24 taxa) whereas minimum taxa were found at Centre of the lake (site V; 15 taxa).

Table 2: Distribution pattern of zooplankton at five sites in Nigeen lake

| Zooplankton | Site | Site II | Site III | Site IV | Site V |
|---|---|---|---|---|---|
| **ROTIFERA** | - | + | + | - | - |
| ***Anuraeopsis* sp.** | + | + | + | + | + |
| ***Brachionus* sp.** | + | + | + | + | + |
| ***Cephalodella* sp.** | + | + | - | - | - |
| ***Filinia longiseta*** | + | + | + | - | - |
| ***Keratella* sp.** | + | + | + | - | + |
| ***Lepadella* sp.** | - | + | + | + | + |
| ***Monostyla* sp.** | + | + | - | - | - |
| ***Platyias* sp.** | - | + | + | + | - |
| ***Testudinella* sp.** | - | + | - | + | - |
| ***Trichocerca* sp.** | - | + | + | - | - |
| **CLADOCERA** | | | | | |
| ***Alona affinis*** | + | + | + | + | + |
| ***Alona* sp.** | + | + | + | + | + |
| ***Macrothrix rosea*** | + | + | + | + | + |
| ***Bosmina longirostris*** | + | + | - | + | + |
| ***Bosmina* sp.** | + | + | + | + | + |
| ***Camptocercus* sp.** | - | + | + | + | - |
| ***Chydorus sphaericus*** | + | + | + | + | + |
| ***Chydorus* sp.** | + | + | + | + | + |
| ***Graptoleberis* sp.** | + | + | + | + | + |
| ***Alonella* sp.** | - | + | + | + | - |
| ***Pleuroxus* sp.** | + | + | - | - | - |
| ***Simocephalus* sp.** | + | + | - | + | - |
| **COPEPODA** | | | | | |
| ***Bryocamptus* sp.** | + | + | + | + | + |
| ***Diaptomus* sp.** | + | - | - | + | + |
| ***Cyclops* sp.** | + | + | + | + | + |
| **Grand total = 25** | **19** | **24** | **18** | **19** | **15** |

+ =Presence of species, -=Absence of species

Rotifera average density was recorded minimum (20.31%) at site V and maximum (31.98%) was observed at site III. Cladocera average population density ranged from a minimum of 55.08% at site III to a maximum of 67.03% at site IV. However, narrow differences were maintained in the average population density of copepods throughout the study period (Table 3). Among zooplankton, Rotifera population density was highest in July (544 ind./ L) at site II and lowest in November (48 ind./L) at site V. Water fleas maintained peak populations in October registering 685 ind./L again at site II, followed by 568 ind./L at site IV, 527 ind./L at site III, 540 ind./L at site I decreasing to lowest 502 ind./L at site V.

Table 3: Monthly variations in density (ind./L) of zooplankton at five different sites during June – November 2014

| S.NO | Taxa | June | July | Oct. | Nov. | Average density |
|---|---|---|---|---|---|---|
| | | **Site I** | | | | |
| Rotifera | | | | | | |
| 1 | *Brachionus* sp. | 50 | 72 | 44 | 24 | |
| 2 | *Cephalodella* sp. | 22 | 42 | 18 | - | |
| 3 | *Filinia longiseta* | 35 | 43 | - | - | |
| 4 | *Keratella* sp. | 32 | 65 | 31 | 33 | 21.93% |
| 5 | *Lepadella* sp. | - | 48 | - | - | |
| 6 | *Platyias* sp. | 43 | 48 | - | - | |
| | **Total** | **182** | **318** | **93** | **57** | |
| Cladocera | | | | | | |
| 7 | *Alona* sp. | 40 | 64 | 91 | 70 | |
| 8 | *Alona affinis* | 38 | 40 | 66 | 37 | |
| 9 | *Alonella* sp. | 28 | 36 | 43 | 32 | |
| 10 | *Bosmina longirostris* | 31 | 42 | 58 | 22 | |
| 11 | *Bosmina* sp. | 60 | 71 | 94 | 58 | |
| 12 | *Chydorus sphaericus* | 51 | 32 | 89 | 67 | |
| 13 | *Chydorus* sp. | 66 | 64 | 99 | 95 | 59.70% |
| 14 | *Graptoleberis* sp. | 56 | 61 | - | - | |
| 15 | *Simocephalus* sp. | 23.66 | - | - | - | |
| 16 | *Pleuroxus* sp. | - | 45 | - | - | |
| | **Total** | 393.66 | 455 | 540 | 381 | |
| Copepoda | | | | | | |
| 17 | *Bryocamptus* sp. | - | - | 66 | 72 | |
| 18 | *Cyclops* sp. | 22 | 57 | 96 | 106 | 18.35% |
| 19 | *Diaptomus sp*. | - | - | 52 | 73 | |
| | **Total** | 22 | 57 | 214 | 251 | |
| | | | **Site II** | | | |
| Rotifera | | | | | | |
| 1 | *Anuraeopsis* sp. | 53 | 82 | 65 | 39 | |
| 2 | *Brachionus* sp. | 38 | 47 | 27 | - | |
| 3 | *Cephalodella* sp. | 61 | 86 | 58 | - | |
| 4 | *Filinia longiseta* | 16 | 37 | - | - | |
| 5 | *Keratella* sp. | 22 | 56 | 16 | 12 | 31.55% |
| 6 | *Lepadella* sp. | 32 | 39 | 20 | - | |
| 7 | *Monostyla* sp. | 72 | 92 | 79 | 30 | |
| 8 | *Platyias* sp. | 19 | 50 | - | - | |
| 9 | *Trichocerca* sp. | 11 | - | 25.33 | 18 | |
| 10 | *Testudinella* sp. | - | 55 | - | - | |
| | **Total** | **324** | **544** | **290.33** | **99** | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Cladocera | | | | | | |
| 11 | *Alona affinis* | 71 | 45 | 83 | 56 | |
| 12 | *Alona* sp. | 63 | 72 | 128 | 113 | |
| 13 | *Alonella* sp. | 34 | 51 | 88 | 48 | |
| 14 | *Bosmina longirostris* | - | - | - | 65 | |
| 15 | *Bosmina* sp. | 81 | 111 | 132 | 70 | |
| 16 | *Camptocercus* sp. | - | 53 | - | - | |
| 17 | *Chydorus* sp. | 88 | 97 | 130 | 70 | |
| 18 | *Chydorus sphaericus* | 68 | 62 | 91 | 51 | 59.40% |
| 19 | *Graptoleberis* sp. | 64 | 90 | - | - | |
| 20 | *Macrothrix rosea* | - | 52 | - | - | |
| 21 | *Pleuroxus* sp. | - | 39 | 33 | - | |
| 22 | *Simocephalus* sp. | 68 | - | - | - | |
| | **Total** | **537** | **672** | **685** | **473** | |
| Copepoda | | | | | | |
| 23 | *Bryocamptus* sp. | 12 | - | 40 | 48 | |
| 24 | *Cyclops* sp. | 41 | 39 | 78 | 102 | 9.03% |
| | **Total** | **53** | **39** | **118** | **150** | |
| | | | **Site III** | | | |
| Rotifera | | | | | | |
| 1 | *Anuraeopsis* sp. | 68 | 82 | 90 | 0 | |
| 4 | *Brachionus* sp. | 41 | 52 | 21 | 15 | |
| 3 | *Cephalodella* sp. | 33 | 68 | 54 | 32 | |
| 4 | *Keratella* sp. | 55 | 61 | 0 | 0 | 31.98% |
| 5 | *Lepadella* sp. | 0 | 36 | 0 | 0 | |
| 6 | *Monostyla* sp. | 58 | 79 | 64 | 40 | |
| 7 | *Testudinella* sp. | 0 | 20 | 0 | 0 | |
| | **Total** | **255** | **398** | **229** | **87** | |
| Cladocera | | | | | | |
| 8 | *Alona affinis* | 20 | 27 | 80 | 56 | |
| 9 | *Alona* sp. | 46 | 63 | 116 | 102 | |
| 10 | *Alonella* sp. | 54 | - | 62 | 32 | |
| 11 | *Bosmina* sp. | 70 | 81 | 96 | 49 | |
| 12 | *Camptocercus* sp. | 29 | 51 | - | - | |
| 13 | *Chydorus* sp. | 66 | 74 | 97 | 68 | |
| 14 | *Chydorus sphaericus* | 37 | 61 | 76 | 51 | 55.80% |
| 15 | *Graptoleberis* sp. | 45 | 50 | - | - | |
| 16 | *Macrothrix rosea* | - | 32 | - | - | |
| | **Total** | **367** | **439** | **527** | **358** | |
| Copepoda | | | | | | |
| 17 | *Bryocamptus* sp. | - | - | 30 | 42 | |
| 18 | *Cyclops* sp. | 52 | 48 | 85 | 113 | 12.21% |
| | **Total** | **52** | **48** | **115** | **155** | |
| | | | **Site IV** | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Rotifera | | | | | | |
| 1 | *Brachionus* sp. | 28 | 38 | 19 | 12 | |
| 2 | *Cephalodella* sp. | 47 | 62 | 53 | 29 | |
| 3 | *Monostyla* sp. | 49 | 78 | 57 | 45 | |
| 4 | *Testudinella* sp. | - | 28 | - | - | 23.76% |
| 5 | *Trichocerca* sp. | 24 | 70 | 14 | 16 | |
| | **Total** | **148** | **276** | **143** | **102** | |
| Cladocera | | | | | | |
| 6 | *Alona affinis* | 60 | - | 78 | 45 | |
| 7 | *Alona* sp. | 52 | - | 114 | 93 | |
| 8 | *Alonella* sp. | 44 | 60 | 82 | 33 | |
| 9 | *Bosmina longirostris* | - | - | 42 | 39 | |
| 10 | *Bosmina* sp. | 70 | 78 | 98 | 62 | |
| 11 | *Camptocercus* sp. | - | 38 | - | - | |
| 12 | *Chydorus* sp. | 46 | 72 | 87 | 91 | |
| 13 | *Chydorus sphaericus* | 59 | 88 | 67 | 75 | 67.03% |
| 14 | *Graptoleberis* sp. | 40 | 74 | - | - | |
| 15 | *Macrothrix rosea* | - | 35 | - | - | |
| 16 | *Simocephalus* sp. | 51 | - | - | - | |
| | **Total** | **422** | **445** | **568** | **438** | |
| Copepoda | | | | | | |
| 17 | *Bryocamptus* sp. | - | - | 29 | - | |
| 18 | *Cyclops* sp. | 17 | - | 74 | 89 | 9.19% |
| 19 | *Diaptomus* sp. | - | - | 48 | - | |
| | **Total** | **17** | **0** | **151** | **89** | |
| | | | **Site V** | | | |
| Rotifera | | | | | | |
| 1 | *Brachionus* sp. | 23 | 32 | 20 | 0 | |
| 2 | *Cephalodella* sp. | 44 | 72 | 47 | 26 | |
| 3 | *Lepadella* sp. | - | 18 | - | - | 20.31% |
| 4 | *Monostyla* sp. | 57 | 64 | 49 | 22 | |
| | **Total** | **124** | **186** | **116** | **48** | |
| Cladocera | | | | | | |
| 5 | *Alona affinis* | 52 | 54 | 84 | 45 | |
| 6 | *Alona* sp. | 49 | 66 | 108 | 51 | |
| 7 | *Alonella* sp. | - | - | 76 | 60 | |
| 8 | *Bosmina longirostris* | - | - | - | 24 | |
| 9 | *Bosmina* sp. | 42 | 65 | 54 | 78 | |
| 10 | *Chydorus* sp. | 68 | 73 | 82 | 59 | 61.03% |
| 11 | *Chydorus sphaericus* | 40 | 55 | 76 | 41 | |
| 12 | *Graptoleberis* sp. | - | - | 22 | - | |
| | **Total** | **251** | **313** | **502** | **358** | |
| Copepoda | | | | | | |
| 13 | *Bryocamptus* sp. | - | - | - | 68 | |
| 14 | *Cyclops* sp. | 21 | 41 | 98 | 128 | 18.64% |
| 15 | *Diaptomus* sp. | - | - | - | 49 | |
| | **Total** | **21** | **41** | **98** | **245** | |

- = species not detected

Copepods were abundant in winter (November) and seem to tolerate harsh environmental conditions of low temperature. Cladocera was the dominated group both qualitatively as well as quantitatively among all the groups contributing 60 % to overall density followed by rotifers with 27 % and copepods contributing 13% (Figs. 2-4).

Table 4: Showing group wise total number of zooplankton forms (Ind./L) at five sites in Nigeen lake, Kashmir

| Groups | Site I | Site II | Site III | Site IV | Site V |
|---|---|---|---|---|---|
| Rotifera | 650 | 1257.33 | 969 | 669 | 474 |
| Cladocera | 1769.66 | 2367 | 1691 | 1873 | 1424 |
| Copepoda | 544 | 360 | 370 | 257 | 405 |

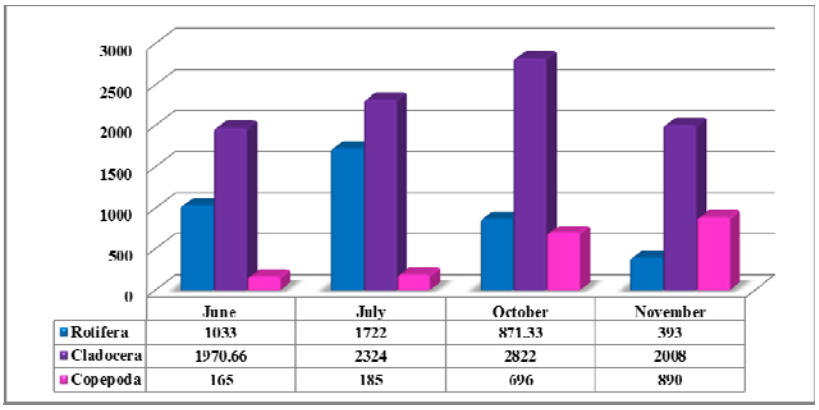


Fig. 2: Monthly variation in total count of zooplankton at five different sites from June-November

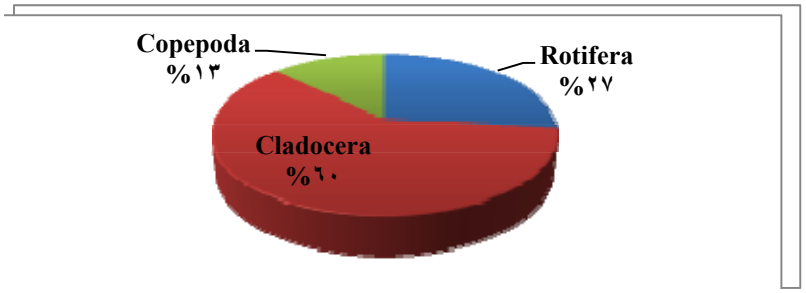


Fig. 3: Overall % composition of three groups of zooplankton in Nigeen lake during study period

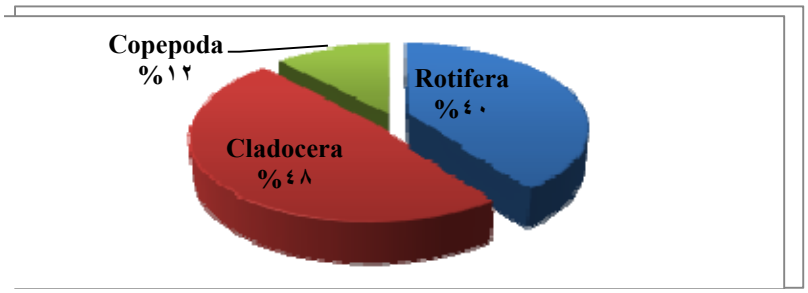


Fig. 4: Group wise percentage diversity composition of zooplankton

In the present study, the population density of Cladocera was found maximum in the month of October which could be attributed to the presence of higher population of bacteria and dead and decayed organisms (Davis, 1964; Tripathy and Nadim, 2012). The dominance of Cladocera in the zooplankton community has been attributed to multiple environmental factors including temperature enhancing rapid hatching of eggs, high nutrient conditions and food availability as maintained by Pandit (1980, 1998). Contrarily, Yousuf and Qadri (1985) reported that the abundance of cladocerans were lowest during summer season. Decline in the number of

Cladocerans during summer months may be due to fish predation and the active competition between Cladocerans and other groups as reported by Pandey *et al.* (2009). The presence of species like *Alona* sp., *Alonella* sp., *Chydorus* sp. and *Bosmina* sp. indicate eutrophic condition as opined by Pandit (1999). These findings are in agreement with those of Swar and Fernando (1980) Baloch (1995). Among water fleas *Chydorus sphaericus* was also the dominant in the lake suggesting that the present water body is organically polluted as maintained by Deneke (2000). Further, during the present study, small sized zooplankton (*Alona affinis*, *Alonella* sp., *Chydorus* sp. and *Bosmina* sp.) encountered in more numbers as compared to large sized zooplankton (*Macrothrix rosea, Simocephalus* sp., *Diaptomus* sp. etc.) indicating that the Nigeen lake is racing towards accelerated eutrophication (Pandit, 1980, 99, 2008; Sampaio *et al.,* 2002).

The Rotifera formed the second dominant group in terms of density. Wheel animalcules were found maximum in the month of July at all the study sites. According to Holz *et al.* (1996) increase in temperature during summer enhances the rate of decomposition due to which the water becomes nutrient rich resulting in increase in rotifer population (Rajashekhar *et al*., 2010; Shah *et al.,* 2015). Further, the abundance of rotifers may also be attributed to its dependence on phytoplankton and detrital matter as food (Bazmi Shaukat Hussain *et al.,* 2011).

Among the rotifers the species like *Keratella*, *Brachionus* and *Monostyla* are considered as pollution tolerant and are typical eutrophic forms (Hutchinson, 1973; Jamila *et al*., 2014). Similar species were found in the present lake thereby indicating eutrophic conditions. Further, *Brachionus* sp. was frequently observed at all sampling sites in the lake. Sampaio *et al.* (2002) are of the opinion that this species is considered to be an indicator of eutrophication. Low population density after July could be assigned to fall in temperature (Bonnecker and Lansac-Toha, 1996) and increased Cladoceran count that bears inverse relationship with these animalcules (Seghal, 1980).

During the study period Copepoda formed the third most abundant group in terms of density and was represented by *Cyclops* sp., *Bryocamptus* sp. and *Diaptomus* sp. Their population density remained again high during November. Similar trend has already been pointed by several workers (Yousuf and Qadri, 1985; Rao and Durve, 1992). Our results are in confirmation with Kumar (2001) who reported maximum number of copepods during winter than summer. Copepods build up their population taking more time than rotifers and other zooplankton. However, once they become dominant, they continue to dominate the habitat till the hydrobiological condition favour their existence (Prabhavathy and Sreenivasan, 1977).

Copepoda during the entire period was mainly represented by *Cyclops* sp. Verma *et al*. (1984) and Ahmad *et al*. (2011) observed that *Cyclops* sp. were sensitive to pollution and increase with an increase in nutrients, a fact also revealed by Pejaver and Somani (2004) in Lake Masunda. Similar results recorded by Kamble *et al.* (2005) and reported the pollution indicator species like *Cyclops* during winter season. Further, Hansson *et al.* (2007) opined Copepoda to be more tolerant to harsh environmental conditions.

Shannon – Weiner index was used to establish the link between the number of species and number of individuals. It may function as a sensitive indicator for pollution (Klemm *et al.,* 1990). The highest Shannon- Weiner index was recorded for Khujeyarbal (site II) (2.95) as this site is subjected to anthropogenic pressures and thus may be related to higher concentration of nutrients due to high organic matter, followed by Ashaibagh (site I) (2.78), Bottabagh (2.71), Nallah Amir Khan (2.69) and

the minimum was recorded for Centre of the lake (2.46) (Fig. 5). McDonald (2003) stated that the value of the index ranging from 1.5 to 3.4 has low diversity and species richness while value above 3.5 has high diversity and species richness. There was lot of similarity at each site as was reflected by high Sorenson similarity coefficient (Table 5). Taxa like *Filinia longiseta, Platyias* sp. and *Pleuroxus* sp. was restricted to site I (Ashaibagh) and site II (Khujeyarbal), while as *Anuraeopsis* sp. was reported in site II( Khujeyarbal site )and site III(NallahAmir Khan).

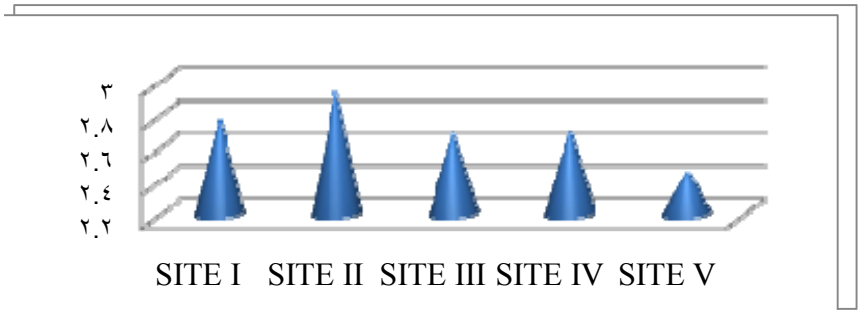


Fig. 5: Shannon – Wiener diversity index of zooplankton at different sites

Table 5: Sorenson's similarity coefficient (%) between different selected sites.

| S. No | Between sites | Similarity Coefficient |
|---|---|---|
| 1 | Inlet and Khujeyarbal | 83.72% |
| 2 | Inlet and Nallah Amir khan | 70.27% |
| 3 | Inlet and Bottabagh | 68.42% |
| 4 | Inlet and centre | 82.35% |
| 5 | Khujeyarbal and Nallah Amir Khan | 85.71% |
| 6 | Khujeyarbal and Bottabagh | 83.72% |
| 7 | Khujeyarbal and centre | 71.79% |
| 8 | Nallah Amir khan and Bottabagh | 81.08% |
| 9 | Nallah Amir khan and centre | 78.78% |
| 10 | Bottabagh and centre | 82.35% |

## CONCLUSIONS

Cladocera appeared to be the most dominant followed by Rotifera throughout the study period. The dominance of rotifers and cladocerans is an indication of eutrophic lake conditions. The presence of species like *Brachionus, Chydorus sphaericus*, *Bosmina* indicate that the lake is approaching towards eutrophication and is organically polluted. Overall zooplankton diversity and abundance in Nigeen lake indicate that the lake water is rich in nutrients. The lake may become polluted and eutrophic if it is not managed properly.

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