

A review of the zooplankton in Kashmir waters

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Limnology as a distinct subject is now almost 140 years old. Starting with the works of Forel, A.F. (1885) on Swiss lakes (Geneva), a voluminous literature is available on almost all aspects of limnology of inland waters of the world. Consolidating on the research done in the first half of the twentieth century, there occurred a boom in the limnological studies during the latter part of the twentieth century, more so because of alarming situation about the pollution levels in these waters world over. Overall, this review paper summarizes the current state of knowledge and creates an understanding of the ecology of Zooplankton in aquatic bodies of Kashmir, for the readers by discussing the findings presented in recent research papers.

Limnological studies in Kashmir were initiated during Yale North India Expedition by Hutchinson and his associates by publishing preliminary reports on different Zooplankton groups as well as fish (Edmondson & Hutchinson, 1934; Brehm, 1936; Keifer, 1939; Hutchinson, 1937). However, detailed round the year studies were only initiated in 1960s by Kaul and Das and their co-workers (Kaul & Zutshi, 1967; Das *et al.*, 1969). Since then many workers have reported on the limnology of various types of aquatic habitats of the region.

The Cladocera community structure in the Lake Manasbal was studied by Qadri and Yousuf (1980) and described that littoral zone contained higher density of the group. The group showed strong seasonal patterns that appear to be related primarily to temperature and pH. Subla and Vishin (1981) reported maximum density of Zooplankton during spring in surface water and during Summer at bottom water. Seasonal distribution and abundance of *Diaphanosoma brachyurum* in Lake Manasbal was discussed by Yousuf and Qadri (1981a) and found the species to prefer water having temperature > 20°C and pH > 8.0. It preferred the upper layers of the water column and concentrated generally at a depth of 3m. The population recorded two maxima, first in July and second in September. The population decline was reported to be related to destratification process which involved decrease in temperature, transparency, pH and dissolved oxygen and increase in carbon dioxide and bicarbonate content. Same authors (1981b) studied seasonal abundance of Rotifera in Lake Manasbal and recorded 38 species of the group. The abundance of group was closely governed by environmental conditions. Zutshi and Vass (1982) gave a descriptive account on limnology of Dal lake and reported 93 Zooplankton species out of which 37 belonged to Rotifera, 27 to Cladocera, 12 to Rhizopoda, 9 to Ciliophora and 8 to Copepoda. Rotifera was dominant group of Zooplankton in Boulevard basin. Copepods and Cladocerans remained numerically low in the Nishat basin. The main representatives of Rotifers were *Ascomorpha*, *Asplanchna*, *Brachionus*, *Conochilus*, *Monostyla*, *Keratella*, *Polyarthra*, *Philodina*, *Filinia* and *Notholca*. In Hazaratbal basin maximum rotifer population density was noticed during autumn and minimum in winter. But at other three basins maximum Rotifer density was recorded in spring and late summer. *Alonella*, *Alona*, *Bosmina*, *Ceriodaphnia* and *Daphnia* were the main contributors of Cladocera found in the lake. Their populations depicted low and was recorded for a short duration. Peak values were encountered during spring. The time of appearance of maximum Zooplankton in the Dal lake differed at various sites. It was recorded in March in Boulevard, during late February in Bod Dal, in April at Nishat and during October in Hazaratbal basin. The authors attributed that the limnological features of the Dal lake differ significantly and justified that a single trophic status can not be assigned to the entire lake system.

Qadri and Yousuf (1982) have studied relationship between *Anuraeopsis fissa* Gosse and *Notholca acuminata* Ehrn. with some physico-chemical factors in Lake Manasbal. The thermal structure of the lake seemed to control the distribution of both the species, *Anuraeopsis* constituted the warm stenothermal and *Notholca* a cold stenothermal form. It was emphasised that *Anuraeopsis fissa* prefer water rich in carbonates and poor in bicarbonates, free carbon dioxide and high pH while as *Notholca acuminata* prefers water with high bicarbonate content and free carbon dioxide and with no carbonates and low pH. Pandit and Koul (1982) recorded

147 Zooplankton species from five wetlands of Kashmir. Protozoans formed the dominant group with 61 species, Cladocera 35, Rotifera 29, Copepoda 13 and Ostracoda 3.. Naqash (1982) studied the hydrobiological characteristics of Wular lake and reported that rotifers constituted most dominant group followed by Copepoda and Cladocera. These three groups were reported to show a bimodal pattern of seasonal distribution and the total Zooplankton were more abundant in deeper zones than the shallow regions.

Yousuf *et al.* (1984) gave the most extensive descriptive account of Cladoceran communities of the Anchar lake and recorded 31 taxa of Cladocera of which 13 were eurythermal, 14 warm stenothermal and four cold stenothermal. *Graptolebris testudinaria* was the most dominant eurythermal Cladoceran. During summer it penetrated deeper layers but in winter large quantities of carbon dioxide in bottom waters prevented its entry into deep layers. Dominant warm stenothermal species were *Illyocryptus sordidus*, *Ceriodaphnia reticulata*, *C. quadrangula* and *Bosmina longirostris*. Cold stenothermal species were *Alonopsis elongate*, *Chydorus carolinae*, *Daphnia* sp. and *Macrothrix* sp. Subla *et al.* (1984) described the distribution and ecology of Zooplankton communities from Kashmir and reported Rotifers to be the most dominant group followed by Cladocera. They also reported meso- and eutrophic waters containing more number of species, while oligotrophic water showed less plankton. Zutshi and Wanganeo (1984) reported Zooplankton to be having Cladocera as the predominant group with *Daphnia* sp being the main contributor unlike lakes of Kashmir where Rotifera was dominant. Thirty three taxa of Rotifera in summer and winter seasons in Anchar Lake were reported by

Balkhi *et al.* (1984). Population was found mainly concentrated in surface layers and only a few species of rotifers penetrated the deeper layers. Shannon diversity index was found to have higher value in Summer than Winter. Subla *et al.* (1985) provided the general seasonal variation and abundance of Zooplankton in Hokarsar. The author showed high density of Zooplankton of which the Crustacean population was low, population density of Rotifera was reported high which indicated high trophic level of Kashmir Himalayan Valley lakes. Yousuf and Qadri (1985) provided the seasonal fluctuations of Zooplankton in Manasbal lake and showed that more than half of the total population was represented by Copepoda. During stratification Zooplankton was reported to have a well marked preference for thermocline zone. Zutshi (1987) while studying the impact of human settlement on the ecology of rural lakes of Kashmir, recorded *Keratella cochlearis*, *Brachionus angularis* and *Brachionus caudatus* and designated them as eutrophic indicators. Limnological features of Anchar Lake was studied by Balkhi *et al.* (1987) and reported 41 species of Rotifera, 33 species of Cladocera and 13 species of Copepod. The primary peak of total Zooplankton was recorded during summer. Parveen (1988) studied the ecology of Zooplankton of Dal lake Kashmir and found qualitative as well as quantitative variation from basin to basin due to the variation in physico – chemical environment. Yousuf (1989) reviewed the literature available on the Zooplankton research in North India and concluded that the taxonomy of the Zooplankton of region needs to be evaluated

properly so as to make use of these organisms as indicators of trophic status of different water bodies. The author concluded that large gaps exist in the knowledge regarding the different aspects of the Zooplankton associations.

A detailed study on the limnological features of the lake with special reference to the plankton population in different basins was made by Yousuf and Parveen (1992). A total of 72 species of Zooplankton were recorded, of which 44 belonged to Rotifers, 21 to Cladocera and 7 to Copepod. In most

parts of the lake Rotifer plankton was found to be dominated by *Keratella cochlearis*, *Polyarthra vulgaris*, *Anuraeopsis fissa*, *Lepadella ovalis* and *Asplanchna priodonta*. However in Brarinumbal basin the group was dominated by *Hexarthra* sp, *Filinia longiseta* and *Brachionus angularis*. Among Cladocerans *Ceriodaphnia reticulata*, *Chydorus sphaericus*, *Bosmina longirostris* and *Acroperus harpae* were found as chief contributors of the total population in all parts of the lake except in Brarinumbal basin where *Moina micrura* was the main constituent of the Cladoceran fauna and *Cyclops* sp among the Copepod was dominant which formed blooms at times. When the population density of three Zooplankton groups in different parts of the lake was compared, it was seen that the density of the group was much higher at Brarinumbal basin. It was quite evident that the plankton community of Brarinumbal basin has been affected by the change in the physico chemical limnology as a result of introduction of large quantities of the untreated municipal sewage. Balkhi *et al.*(1992) while working on 100 water bodies belonging to nine different categories of aquatic systems of Kashmir, viz, lakes (high and valley altitudes), wetlands, ponds /pools, roadside ditches, water flows / fountains, streams, springs, reservoirs and puddles reported that the number of Copepod species in a sample was less than five. In Anchar and Wular lakes eight Copepod species were recorded from each in a single collection. Fourteen species of Copepod in a single collection from a small puddle, Shala Dob during spring season were collected. The authors revealed that the abiotic features of this water body showed not much difference from most of other water bodies. However this water body had rich submerged macrophytes which might be providing a good habitat for the various species.

Yousuf and Farooq (1994) reported 23 species of Rotifera from the limnetic zone of the Lake Manasbal. *Polyarthra vulgaris* and *Keratella cochlearis* were recorded the dominant forms. During stagnation period, the Rotifers were found to be mainly concentrated in the metalimnetic zone (thermocline zone) due to the availability of higher quantities of food (detritus etc) in this layer as a result of appreciable density variations due to abrupt fall in temperature with depth.

Pandit and Yousuf (2002) while studying six Himalayan lakes, reported that the best chemical indicator of the trophic status of these aquatic systems was total phosphorus and total dissolved inorganic nitrogen in the epilimnetic layers. They placed the two mountain lakes, viz, Gangabal and Nundkoul under oligotrophic, two rural lakes Manasbal and Malpursur under mesotrophic, semi urban Anchar lake under eutrophic and urban Khushalsar lake under hypertrophic category. Same authors in 2003 reported on the rotifer community in six Kashmir Himalayan lakes of varied trophic status. Ninety eight species of rotifers were recorded during the investigation. It was observed that the rotifer community increased qualitatively as well as quantitatively from oligotrophic to mesotrophic waters and then fell towards eutrophy. *Asplanchna priodonta* and *Kellicotia longispina* were found to dominate the oligotrophic waters, while *Brachionus calyciflorus* and *B. quadridentata* were significant in hypertrophic waters. The authors developed a trophic state index based on the occurrence and abundance of different rotifer species for determining the trophic status of the lakes of the Himalayan region .

Ufaq and Yousuf (2005) while studying the ecology of Khushalsar lake revealed that the Zooplankton population was dominated by Rotifera. They compared the dominance pattern of different Zooplanktons reported by Pandit in 1992 with their work and described that although most of the Zooplanktons reported by Pandit were still present in the lake, only sequence of dominance has changed significantly. It was concluded that the Zooplankton of the lake were represented by typical eutrophic and hypertrophic taxa and the changes recorded in the dominance pattern of various taxa are attributable to the ecological set up of the water body which has been continuously receiving domestic sewage from the catchment and its area is decreasing day by day due to human encroachment

Impact of floating gardens on the water quality and Zooplankton community in the Dal lake Kashmir was analyzed by Siraj *et al.* (2006) and found that the water near the floating gardens was more enriched with nutrients due to increased levels of chloride, phosphorus, nitrogen and conductivity. The Zooplankton community around these gardens also revealed difference in species composition and abundance from the open water areas of the lake.

While studying the Cladoceran community in Wular lake Mir *et al.* (2010) reported 35 species represented by seven families. Shallow sites supported more Cladoceran members in comparison to other sites and all the sites contained almost the same species. Chydoridae was the prominent group with maximum number of species followed by Daphnidae and the groups were present at all sites but vary in population density on account of variations in the physico chemical characteristics of the lake. Ahangar *et al.* (2011) studied Zooplankton community structure of Anchar lake. The zooplankton community was found to be composed of 8 species of Rotifera, 6 species of Protozoa, 7 species of Cladocera, 2 species of Copepod and 1 species of Ostracoda. *Centropyxis aculeate*, *Keratella cochlearis*, *K. valga*, *Alona affinis*, *Daphnia magna*, *Chydorus sphaericus*, *Macrothrix rosea* and *Cyclops bicuspidatus* were common at all stations.

The ability of certain Rotifer species to dominate a macrophyte infested littoral zone is because of favourable life conditions to them (Jamila.*et.al* 2013 , 2014). Family Brachionidae was reported dominant in the concerned water bodies. According to the study of the Dal Lake conducted by same authors , in 2017 , Family Brachionidae was dominant in terms of genera . In addition it was stated that most of the species recorded by earlier authors are still present in the lake but some have been disappeared completely . It was stated that change in trophic status of the investigated water body during last three or four decades has led to change in species composition of the water concerned .

Data on Zooplankton diversity and distribution in the area of Kashmir have been mostly obtained at the beginning and the middle of the last century. It is only recently, at the beginning of the 2000s, that investigations in this field have restarted in Kashmir . This review was therefore necessary to update the information available to detect possible trends associated with physico chemical parameters or anthropogenic events.

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