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Rotifer Community in Some Kashmir Himalayan Lakes of Varied Trophic Status

Anil K. Pandit and A. R. Yousuf

Centre of Research for Development, The University of Kashmir, Srinagar, India

ABSTRACT

Six Kashmir Himalayan lakes located at different altitudes and depicting different trophic status were investigated for various limnological parameters including plankton. Rotifera was found to be contributing significantly to the total zooplankton population in all the six lakes which depicted trophic status from oligotrophy to hyper(eu)trophy. 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* dominated the oligotrophic waters, while *Brachionus calyciflorus* and *B. quadridentata* were significant in hypereutrophic waters. Trophic State Index based on the occurrence and abundance of the different rotifer species has been developed for determining the trophic status of the lakes of the Himalayan region.

Keywords: Himalayan lakes, rotifera, trophic state index

INTRODUCTION

The gradual increase in the fertility of lakes with a concomitant biological succession is a natural phenomenon and continues slowly throughout their life spread over thousands of years. However, in recent times the exceptionally high human interference in and around aquatic habitats in the form of agriculture, industrialization and urbanization, has greatly accelerated the aging of these ecosystems. The valley of Kashmir has a great array of lakes located at different altitudes and latitudes. Because of varied human interference in and around these water bodies, many of them are showing signs of instability and in some red euglenoid blooms were observed. In order to devise methods for conservation of these natural resources of the region we need to monitor their present status.

Although physico-chemical characteristics of water give an indication of its trophic status (Odum, 1963; Margalef, 1963; Carlson, 1977; Jorgensen, 1980), there are many problems associated with it that may affect its utility (Cairns and Schallie, 1980). It is believed that the biotic characteristics of a water body, including community structure, give a better idea about the trophic status of the water concerned (Tarzel, 1965; Patalas, 1972; Gannon & Stemberger, 1978). Several reports are available on the use of biotic communities as indicators of water quality (Patalas, 1972; McNaught *et al*, 1975; Chapman, 1981; Hakkari, 1977; Sladecek, 1983) but the indices developed are not directly applicable to Kashmir Himalayan lakes as many of the species used in these reports are either totally absent or very rare in our waters. It was, therefore, felt necessary to have a detailed study of the trophic status of Kashmir Himalayan waters based on water chemistry as well as biotic communities living therein. The project was facilitated by the financial assistance from CSIR, New Delhi under Ref. No. 37 (39)/86 - EMR II. Six lakes of the Kashmir Himalayas - Gangabal, Nundakol, Malpursar, Manasbal, Anchar and Khushhalsar - apparently depicting varied trophic level in response to varied human interference in and around their basins were selected for a detailed study. Geographical and morphometric data and the methodology for determining chemical parameters of the lakes are given in Pandit & Yousuf (2002). In the present article community structure of Rotifera in these water bodies is presented.

MATERIAL AND METHODS

For qualitative enumeration of plankton, samples were collected with the help of plankton net fitted with Nylobolt net cloth No. 140 T (Nylobolt Company, Mumbai) by making horizontal as well as vertical hauls. Identification was undertaken under stereoscopic and compound microscopes with the help of standard works on the group (Edmondson & Hutchinson, 1934; Edmondson, 1959; Pennak, 1978; Chengalath, 1976, 1984; Koste, 1978). For quantitative analysis the plankton samples were collected by sieving a fixed volume of water, obtained from different depths with the help of 2 - liter Ruttner type sampler, through the plankton net. The plankton samples were preserved in 4% formalin. At the time of counting the preserved sample was thoroughly shaken and one ml. of it was withdrawn with a wide mouthed glass pipette into Sedgwick rafter cell and studied under microscope. The whole cell was scanned for the rotifers. The counts were made in triplicate or till every species recorded in the qualitative analysis was recorded. The number of rotifers in the sample was then calculated as per APHA (1985). All the values recorded at different collection sites in a lake were pooled to present a single set of data for the statistical analysis in accordance with Zar (1984).

RESULTS AND DISCUSSION

The basic aim of the present investigation was to study the population dynamics of Rotifera in response to changes in the environmental chemistry and to ascertain whether the rotifer community inhabiting the Kashmir Himalayan waters could be utilized for determining the trophic status of the waters of the region. As per the chemical features the lakes studied were clearly of different trophic status (Pandit & Yousuf, 2002). While Gangabal and Nundkol lakes belonged to oligotrophic category, Manasbal revealed mesotrophy, Malpursar meso-eutrophy and Anchar typical eutrophy and Khushhalsar hyper(eu)trophy (Pandit & Yousuf, op. cit.). A total of ninety-eight taxa of rotifers were recorded from the lakes surveyed (Table 1).

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Table 1. List of rotifers (with mean population) recorded from six Kashmir Himalayan lakes.

Name of species	Population density (Mean values based on two years data) Individuals /m^3					
Lakes	Gangabal	Nundkol	Malpursar	Manasbal	Anchar	Khushhalsar
Anuraeopsis fissa	-	-	98	7893	81	3638
Ascomorpha saltans	-	-	-	2	447	10
Asplanchna priodonta	675	2375	-	2317	50	1609
Bdelloid sp	-	100	763	641	1383	1495
Brachionus bidentatus	-	-	2	2	-	47
B. calyciflorus	-	-	-	6	-	2861
B. leydigia	-	-	-	-	89	892
B. plicatilis	-	-	10	29	350	2457
B. quadridentata	-	-	283	95	556	1757
Cephalodella exigua	-	-	4	15	92	-
C. gibba	-	-	159	73	42	14
Colurella adriatica	-	-	-	16	19	12
C. obtusa	-	-	106	46	354	19
C. uncinata	-	-	1067	519	263	86
Dissotocha macrostyle	-	-	-	519	-	5
Dipleuchinis propatula	-	-	-	-	22	21
Ephiphanes senta	-	-	-	-	556	20
Euchlanis calpidia	30	175	-	57	-	-
E. dilatata	-		714	1986	669	473
Filinia longiseta	-	-	15	1339	389	26835
F. terminalis	-	-	-	36	117	214
Gastropus hyptopus	-	-	-	-	122	-
Horaella brehmi	-	-	-	11	11	-
Kellicottia longispina	350	250	-	-	-	-
Keratella cochlearis	-	-	131	64969	333	103
K. quadrata	-	-	2	320	419	57
K. tropica	-	-	-	5	-	-
K. valga	-	-	5	32	237	4275
Lepadella acuminata	-	-	-	-	-	39

L. ehrenbergi	-	-	6	130	17	16
L. ovalis	63	150	386	391	455	181
L. patella	-	-	6	28	128	23
L. priptera	-	-	37	53	17	43
L. (Hemimonostyla) sympoda	-	-	-	7	-	-
Lecane (Lecane) depressa	-	-	-	15	-	3
L. (L.)elasma	-	-	36	21	-	-
L. (L.)flexilis	-	50	27	29	-	-
L (L.) ludwigi	13	-	-	35	-	50
L.(L.) luna	-	-	5	264	881	38
L.(L.) methoria	-	-	-	10	-	-
L.(L) ohioensis	-	-	11	34	56	49
L (L.) angulata	-	-	-	19	-	-
L (L.) verencunda	-	-	-	-	-	2
Lecane (Monostyla) bulla	-	-	612	1168	-	411
L.(M.) closterocerca	31	-	183	1026	1358	204
L. (M.) cornuta	-	-	-	3	-	-
L. (M.) crenata	12	-	411	8	6	40
L. (M.) decipiens	-	-	-	6	-	17
L. (M.) hamata	13	-	-	128	135	71
L. (M.) lunaris	13	-	160	543	298	107
L. (M.) quadridentata	25	-	-	463	744	37
L.(M.) pyriformis	-	-	-	13	-	-
Macrochaetus collinsis	-	-	-	3	22	27
Manfridium eudactylotum	-	-	122	38	283	61
Monommata grandis	-	-	38	10	28	-
Mytilina mucronata	-	-	62	116	58	104
M. ventralis	-	-	69	163	-	130
Notholca acuminata	-	-	521	-	164	12
N. labis	-	-	124	3	36	-
Phylodina roseola	-	-	298	67	778	9277
Platyas patulus	-	-	-	4	-	10
P. polycanthus	-	-	-	-	-	4
P. quadricornis	-	-	-	16	86	169
Polyarthra dolichoptera	-	-	-	2760	353	1998
P. euryptera	-	-	-	63	-	-
P. remata	-	-	-	44	-	18

P. vulgaris	-	-	14	11199	1208	1703
Proales sp.	-	-	-	36	-	-
Proalinopsis sp.	-	-	-	10	64	-
Rotaria neptunia	-	-	-	-	-	70
Scaridium longicaudum	25	-	-	26	83	-
Synchaeta oblonga	-	-	-	602	181	60
S. pectinata	-	-	-	74	-	-
S. stylata	-	-	-	25	6	12
Sphyrias lofuana	-	-	-	-	6	172
Squatinella rostrum	-	-	-	1	622	-
Testudinella patina	-	-	374	259	133	121
Trichotria tetractis	-	-	157	171	192	120
T. pocillum	-	-	135	31	677	85
Trichocerca bicristata	-	-	-	492	-	-
T. cavia	-	-	11	21	31	4
T. cylindrica	-	-	-	31	-	-
T. elongata	-	-	-	12	-	-
T. insignis	-	-	33	2	14	4
T. iernis	-	-	-	-	-	2
T. longiseta	-	-	1283	63	19	5
T. multicrinis	-	-	-	96	-	704
T. platessa	-	-	-	8	-	-
T. porcellus	-	-	21	59	47	82
T. rattus	-	-	-	14	206	62
T. ruttneri	-	-	122	144	-	10
T. similis	-	-	10	2598	64	255
T. tigris	-	-	-	6	-	-
T. vernalis	-	-	-	6	-	-
T. weberi	-	-	-	26	-	-
Trichocerca sp.	-	-	-	14	-	16
Trochosphaera solstitialis	-	-	-	-	-	15
Tripleuchlanis plicata	-	-	-	6	-	-

On an average the group contributed 59.39% to the total number of zooplankton taxa and 60.55% to the total zooplankton population recorded in the lakes under investigation. Least number of six species of rotifers was recordeed in Nundkol lake. Gangabal lake recorded eleven species, while the other four lakes showed considerably higher number in close association with area and habitat complexity of the water body. 43 species were recorded from the shallow Malpursar lake, while in case of the Anchar lake the number was 58. In the Manasbal lake 85 species were recorded, while the Khushhalsar recorded the presence of 69 species. The similarity in the rotifer community (Table 2) of the six lakes was maximum between the Anchar and the Khushhalsar (0.68) followed by Manasbal and Khushhalsar (0.62). The least similarity was recorded between Khushhalsar and Nundkol (0.04).

Table 2. Jaccard Similarity coefficient for Rotifera in the six Kashmir Himalayan Lakes.

Lakes	Gangabal (1)	Nundkol (2)	Malpursar (3)	Manasbal (4)	Anchar (5)
Nundkol (2)	0.31				
Malpursar (3)	0.09	0.07			
Manasbal (4)	0.12	0.06	0.46		
Anchar (5)	0.11	0.05	0.56	0.56	
Khushhalsar (6)	0.12	0.04	0.50	0.62	0.68

Zyblut (1970), Northcote (1972) and Gannon (1981) have reported increased plankton density with advancement of the trophic level of a water body. This is clearly reflected by the population density of rotifera in the present lakes. On the basis of mean population density the mountain lakes recorded very low population density in comparison to the valley lakes. The Gangabal lake recorded a mean population of 1,225 individuals / m^3 and in the Nundkol the mean density was 3350 individuals / m^3. The highest rotifer density of 104,584 individuals / m^3 was recorded in the Manasbal lake (Table 3).

Table 3. Contribution of rotifera in the total zooplankton population of the six Kashmir Himalayan lakes.

Lakes	Gangabal	Nundkol	Malpursar	Manasbal	Anchar	Khushhalsar
No. of zooplankton taxa	20	13	70	133	92	109
No. of rotifer taxa	11	6	43	85	57	69
Contribution of rotifer species (%)	55	60.4	61.4	63.9	61.9	63.8
Mean zooplankton density (ind/m³)	18724	13425	30340	135642	45347	81419
Mean Rotifer density (ind./m³)	1225	3350	7740	104584	16955	62896
Contribution of rotifera in zooplankton density (%)	6.5	24.9	25.5	77.1	37.4	77.3

The diversity index of the biotic communities with respect to different environmental variables has been discussed by a number of workers. Among various indices used the Shannon diversity index has been found to be of great value (Wilhm, 1970; Sanders, 1968; Watt *et al*, 1977). Shannon diversity index (H') and Evenness (E) values for the six lakes varied in close association with the trophic level of the waters. The mountain lakes, which were oligotrophic in nature, recorded low diversity values when compared with the valley lakes. In the latter group the maximum diversity was recorded in the mesotrophic Manasbal lake, while the evenness of the community structure was relatively higher in the Malpursar and the Anchar. It was observed that when there was a bloom of only a few species the H' as well as the 'E' decreased and when the different species were rather equally distributed the two indices showed higher values.

The relative contribution of different planktonic groups in a water body has been shown to be influenced by the trophic level of the water concerned with dominance of rotifer plankton in nutrient rich waters (Mc Naught, 1975; Blancher, 1984; Yousuf, 1989).

However, the present study does not fully support this view. For example the zooplankton community of the Gangabal and Nundkol, which are typical oligotrophic waters as per their water chemistry (Pandit & Yousuf, 2002) should have been dominated by copepods, especially calanoids. But instead rotifers and cladocerans were equally important contributors here.

The habitat complexity, in the form of shoreline characteristics, depth, occurrence and abundance of macrophytes, etc., is one of the factors responsible for the variation in the species composition. The oligotrophic Gangabal and Nundkol lakes are the simplest habitats among the investigated waters, while the maximum habitat complexity was recorded in the Manasbal lake with significant differences in depth, macrophytic infestation, shore line features, bottom characteristics, etc. from place to place. The habitat complexity showed gradual decrease from Manasbal through Anchar , Khushhalsar to Malpursar lake.

The number of zooplankton species has been found to be high in macrophyte - infested waters than in waters without vegetation (Nordlie, 1976; Shireman & Martin, 1978; Fryer & Forshew, 1979). It has also been established that the structure and function of zooplankton is altered by eutrophication (Gannon, 1981). Both the mountain lakes (Gangabal and Nundkol) were oligotrophic , whereas the four valley lakes ranged from mesotrophy to hyper(eu)trophy (Pandit & Yousuf, 2002). The rotifer population in these waters showed close relationship with the changing trophic status, the number of species increasing from oligotrophy to mesotrophy and then declining towards hyper(eu)trophy.

The dominance pattern of rotifera in the six lakes revealed an interesting trend. In the Gangabal and Nundkol lakes the rotifer population was dominated by *Asplanchna priodonta* and Kellicotia longispina. In the other four lakes the dominance pattern showed significant variation not only with season but also from year to year. In the Malpursar *Trichotria tetractis, Testudinella pattina, Lecane (L.) elasma, Lecane (Monostyla) bulla, Anuraeopsis fissa, Trichocerca longiseta, T. rattneri, Notholca acuminata, Keratella cochlearis, Brachionus quadridentata*, and *Colurella uncinata* played the dominant role.

In the Manasbal *A. priodonta, K. cochlearis, Polyarthra vulgaris, P. dolichoptera, A. fissa*, and *T. similis*, were the main contributers of the rotifer population. In the Anchar *N. acuminata, Epiphanes senta, Colurella obtusa, P. vulgaris, P. dolichoptera, A. priodonta* and *L. (L.) luna* were the dominant contributors. In the Khushhalsar lake *Philodina roseola, Filinia longiseta, A. fissa, K. valga, P. vulgaris, Brachionus calyciflorus, B. quadridentata, B. plicatilis*, and *L. (M.) bulla* dominated the rotifer plankton.

The concept of indicator species as proposed by Pejler (1975) and Sladecek (1983) does not seem to hold true for the Himalayan ecosystems as is revealed by overlap of species distribution in the investigated lakes. Keeping this in mind it was thought worthwhile to try Trophic State Index (TSI). Previously TSI based on Eutrophic species (E) / Oligotrophic species (O) ratio (Hakkari ,1977) and *Brachionus* / *Trichocerca* ratio (Sladecek, 1983) have been proposed. However, the E/O ratio could not be used in the Himalayan lakes as the species listed by Hakkari in the O group were completely absent here. Similarly B / T ratio was found to be useless as *Trichocerca* was absent from the oligotrophic waters. Instead some species of this genus (like *T. porcellus*, *T. similis*, *T. rattus* and *T. multicrinis*) were found to dominate even in the hyper(eu)trophic waters of the Khushhalsar lake. Under these circumstances a trophic state index based on the distribution pattern of the species recorded from the lakes investigated by the authors was tried.

The index was developed on the occurrence and relative abundance of different species in different habitats. For this purpose all the 98 species recorded during the present study were classified as per their habitat. On the basis of its preference for a particular habitat each species was assigned an indicator value ranging from one to 10. The species which were restricted to or dominated in oligotrophic Gangabal and Nundkol lakes were assigned an indicator value equal to '1'. Species dominant in Malpursar, but occurring in other waters as well got a value of '3' and those abundant in Manasbal a value of '4'. A species which dominated the scene in Anchar Lake was assigned a value of '7' and the one dominant in Khushhalsar got a value of '10'. The TSI was then estimated by the formula:

TSI =
Sum of indicator value of the species(n) present in a lake /
Number of species present (n)

The value of TSI ranged between one and 10. Values were then distributed in the following manner:

1 - 2.5	=	Oligotrophic
2.6 - 5.0	=	Mesotrophic
5.1. - 7.5	=	Eutrophic
7.6 - 10	=	Hyper(eu)trophic

The index thus developed was applied to the present lakes. It recorded a value of 2.0 and 1.4 in Gangabal and Nundkol respectively. The Manasbal and Malpursar recorded values around 4.5, while Anchar a value of 5.4. The Khushhalsar recorded a value of 6.5.

The values clearly indicate the trophic evolution of the waters concerned as depicted by their water chemistry as well (Pandit & Yousuf, 2002).

For checking its applicability in respect of other lakes of the region, the index was applied to the data presented by Yousuf & Parveen (1992) for the Brarinambal basin of the Dal lake. The value obtained (6.5) clearly indicated the eutrophic nature of the water body as was reflected by the concentration of phosphorus in this water body. It is therefore concluded that although the occurrence and abundance of a particular species may provide information about the water quality , it is better to use the TSI for assessing the trophic status of a water body as it takes care of the distribution as well as abundance of the various species.

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