



Species Composition and Diversity of Zooplankton in Chackferi Stream, Tarai Region, Uttarakhand, India

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Present study deals with the analysis of species composition and diversity of zooplankton in Chackferi stream. For this investigation samples were collected by monthly intervals for a period of September 2020 to August 2022. A total of 28 species of zooplankton, belonging to 25 genera across 5 groups were identified such as Protozoa (6 species of 6 genera), Rotifera (10 species of 9 genera), Copepoda (7 species of 5 genera), Cladocera (3 species of 3 genera) and Ostracoda (2 species of 2 genera). Rotifera was the dominant group, comprising (36%) of the zooplankton community in Chackferi stream, followed by Copepoda (25%), Protozoa (21%), Cladocera (11%) and Ostracoda (7%). It was noticed that seasonal composition of zooplankton was highest during summer, moderate in winter and autumn and least in monsoon season. Zooplankton are also

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considered as a good bio-indicator to assess the pollution status of a stream. Presence of indicator species like *Brachionus calyciflorus*, *Brachionus falcatus* and *Mesocyclops leuckarti* reveals that the stream gets organically polluted and rapidly moving toward a eutrophic condition. Therefore, frequent monitoring and proper treatment should be applied for conservation of the stream and its ecosystem.

Keywords: Ecosystem; eutrophication; pollution; species; stream; Zooplankton.

1. INTRODUCTION

Stream habitats generally have three tropical components as phytoplankton, zooplankton and consumers such as large fishes. Zooplankton are minute, microscopic and free floating organism that play an important role in various aquatic ecosystem. They have some locomotory structures but are not capable of moving against water currents. It occupies an intermediate position in food web in between primary producers and higher consumers like phytoplankton and large fishes (Mahajan 2018). Many of them feed upon bacteria, diatoms and algae and in turn fed by numerous large invertebrates and fishes. It also maintains proper equilibrium between biotic and abiotic components of the water ecosystem. The freshwater zooplankton are comprised of five major groups of invertebrate animals as Protozoa, Rotifers, Copepoda, Cladocera and Ostracoda occurring abundantly in all types of aquatic habitats and plays a vital role in energy transfer in an stream ecosystem.

In present days, the aquatic biodiversity is in danger due to pollution and human activities. Deterioration and degradation of water quality is a serious threat to all aquatic life including human beings. Human activities such as domestic, sewage, municipal and industrial waste and agricultural runoff are the primary reasons of deterioration of stream water quality especially in urban areas (Kumar and Khare,2015). This kind of organic load in stream water is the main cause of eutrophication. The

zooplankton community structure and composition is also affected by eutrophication. Some species of rotifers, copepods and cladoceran groups can be used as the indicator of changing trophic status of a stream ecosystem (Ochang et al., 2015). They serve as warning signals to detect excessive algal growth develops in highly enriched water, mainly that collecting sewage water (Babare et al. 2019). The conservation of aquatic biodiversity is an important task because day to day pollution is increasing and their direct effect is on aquatic life.

Zooplankton diversity reflects the water quality and they are the good indicators of changes taking place in the water resources. Physico-chemical factors like water discharge, nutrient concentration and light condition etc. are regulate zooplankton abundance in water body (Sharma and Dube, 2018). Various researchers who have thoroughly examined several facets of zooplankton include (Joshep and Yamakanamardi, 2011), (Ramesha and Sophia 2013), (Dutta and Patra, 2013), (Pradhan, 2014), (Bhavimani et al. 2016), (Bhosale, 2019) etc. The present study has been undertaken to determine the species composition and diversity of zooplankton in Chackferi stream. Till date no work has been carried out on this concern. With this view in background, a study was carried out to understand the status of zooplankton diversity of Chackferi stream at Tarai region of Uttarakhand.

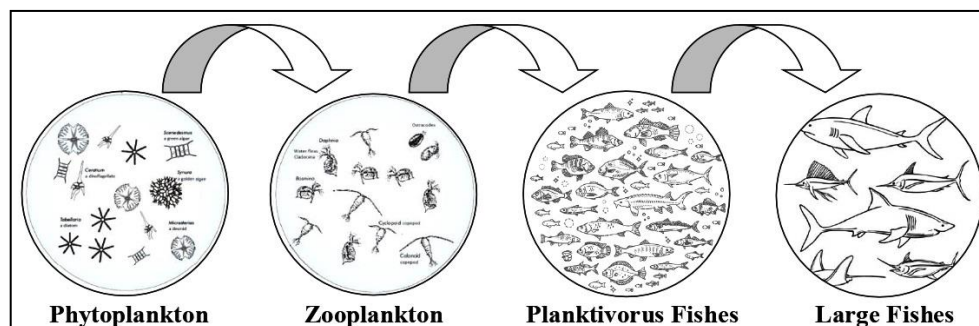


Fig. 1. Figure showing zooplankton play a vital role in food chain and transferring energy from phytoplankton (producer) to large fishes (consumer) in a stream ecosystem

2. MATERIALS AND METHODS

2.1 Study Area

The district Udham Singh Nagar belongs to the Tarai region of the Kumaon Division. The Rivers of the district are part of the Ganges drainage system. Among them, the Gaula, Kosi, Ramganga and Sharda river drain the area of the district. The Chackferi stream is one of the tributaries of the Gaula river that originate from Tanda forest near hilly region of Nainital district and flowing through north-west to south-west direction across the agricultural fields before drain into the Gaula river (Fig. 2). It is located between 29° 01' 58" N latitude and 79° 24' 30" E longitudes. Its major water utilized for agriculture, irrigation, domestic and industrial purpose.

2.2 Collection and Identification of Zooplankton Sample

The present study was carried out for a time period from Sept. 2020 to Aug. 2022 to explore composition and diversity of zooplankton in Chackferi stream at Tarai region, Uttarakhand. Zooplankton samples were collected during at monthly intervals from the stream. For the collection of zooplankton, water samples were filtered through plankton net with a mesh size of 25 µm. The filtrate was then transferred into 100 ml of polyethylene bottle and preserved with 4% formalin for zooplankton analysis. Sample bottle was gradually shaken in the lab to ensure that the specimen was evenly distributed. Then 1 ml of sample was taken on a Sedgewick-Rafter counting cell chamber with the help of a pipette. A coverslip was used to prevent the formation of air bubbles. Then the samples were observed under a compound microscope with 10X and 20X magnifications. Systematic identification of zooplankton was made by with the help of standard books and taxonomic keys (Edmondson, 1959), (Pennak, 1978), (Battish, 1992).

3. RESULTS

Zooplankton is one of the most important biotic components in an aquatic ecosystem that influencing all the functional aspects of it such as food web, energy flows and cycling of nutrients (Fig.1). A total 28 species of zooplankton belonging to 25 genera, 18 families, 12 order and 9 classes of zooplankton were recorded in

Chackferi stream qualitatively. These species are belonging across 5 groups as Rotifera, Protozoa, Copepoda, Cladocera and Ostracoda (Table 1). Rotifera was the dominant group, comprising 36% of the zooplankton community in Chackferi Stream, followed by Copepoda at 25%, Protozoa at 21%, Cladocera at 11%, and Ostracoda at 7%. (Fig. 3 and Fig. 4)

3.1 Rotifera

Out of 28 species, Rotifera composed 10 species of 9 genera such as *Brachionus calyciflorus*, *Brachionus falcatus*, *Keratella sp.*, *Monostyla sp.*, *Lecane sp.*, *Cephalodella auriculata*, *Asplanchna sp.*, *Trichocera sp.*, *Lepadella sp.* and *Roteria rotatoria* belonging to 7 family as Brachionidae, Lecanidae, Notommatidae, Asplanchnidae, Trichoceridae, Lepadellidae, Philodinida, 2 order and 2 class respectively. Among these *Brachionus calyciflorus* was the dominant species. Rotifers appears throughout autumn and summer seasons but some species like *Lecane sp.* and *Asplanchna sp.* were absent in monsoon and winter season (Table 2).

3.2 Protozoa

Protozoa comprises 6 species of 6 genera i.e. *Arcella discoides*, *Trinema sp.*, *Paramecium cudatum*, *Vorticella campanula*, *Dileptus sp.* and *Colpodium sp.* belonging to 6 family as Arcellidae, Trinematidae, Parameciidae, Vorticellidae, Tetrahymenidae, Dileptidae, 6 order and 4 class. During the observations *Arcella discoides* species was found dominant. Protozoa found all over in summer, winter and monsoon but species *dilaptus sp.* was absent in autumn season.

3.3 Copepoda

Copepoda composed 7 species of 5 genera such as *Cyclops strenuus*, *Cyclops vicinus*, *Eucyclops sp.*, *Mesocyclops leuckarti*, *Macrocyclops sp.*, *Macrocyclops albidus* and *Thermocyclops sp.* belonging to 1 family as Cyclopidae, 1 order and 1 class respectfully. During investigation *Mesocyclops leuckarti* was the dominant species of group Copepoda. Copepod presents throughout winter and summer season while species *Macrocyclops sp.* and *Thermocyclops sp.* were absent in autumn and monsoon season.

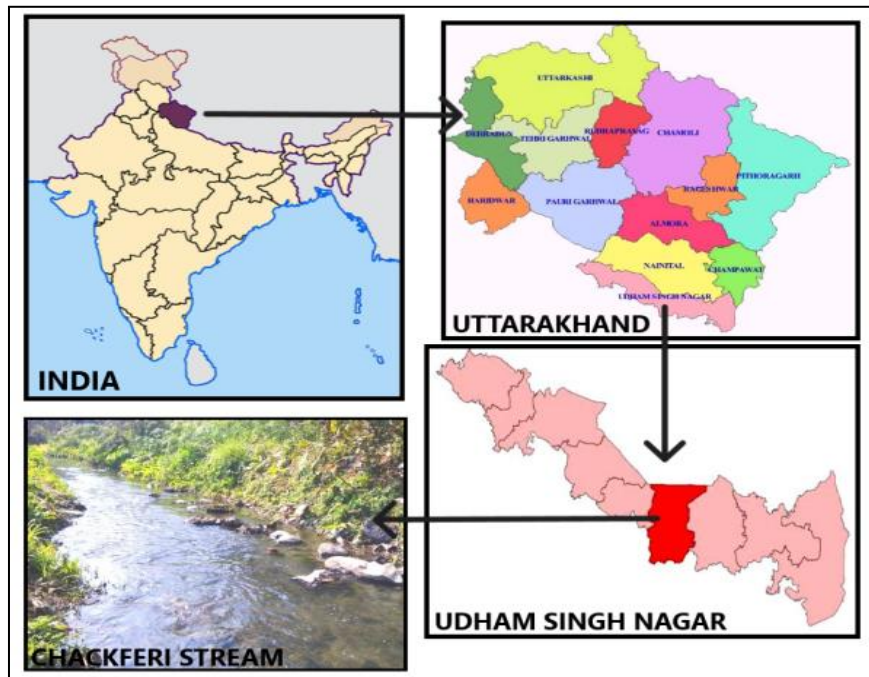


Fig. 2 Map of study area and sample site

Table 1. Species diversity of zooplankton in Chackferi Stream, Uttarakhand

Groups	Class	Order	Family	Genera & Species				
Rotifera	Monogononta	Ploima	Brachionidae	<i>Brachionus calyciflorus</i> <i>Brachionus falcatus</i> <i>Keratella sp.</i>				
			Lecanidae	<i>Monostyla sp.</i> <i>Lecane sp.</i>				
			Notommatidae	<i>Cephalodella auriculata</i>				
			Asplanchnidae	<i>Asplanchna sp.</i>				
			Trichoceridae	<i>Trichocera sp.</i>				
			Lepadellidae	<i>Lepadella sp.</i>				
			Bdelloidea	Bdelloida	Philodinidae	<i>Rotaria rotatoria</i>		
Protozoa	Tubulinea Silicofilosea Oligohymenophorea	Arcellinida	Arcellidae	<i>Arcella discoides</i>				
			Euglyphida	<i>Trinema sp.</i>				
			Parameciidae	<i>Paramecium cudatum</i>				
			Vorticellidae	<i>Vorticella campanula</i>				
			Hymenostomatida	<i>Colpodium sp.</i>				
Litostomatae	Dileptida	Dileptidae	<i>Dileptus sp.</i>					
Copepoda	Maxillopoda	Cyclopoida	Cyclopidae	<i>Cyclops vicinus</i> <i>Cyclops strenuous</i> <i>Eucyclops sp.</i> <i>Mesocyclops leuckarti</i> <i>Macrocyclus sp.</i> <i>Macrocyclus albidus</i> <i>Thermocyclops sp.</i>				
				Cladocera	Branchiopoda	Anomopoda	Daphniidae	<i>Daphnia sp.</i>
							Moinidae	<i>Moina micrura</i>
				Ostracoda	Podocopa	Diplostraca	Chydoridae	<i>Pleuroxus sp.</i>
								Cyprididae

3.4 Cladocera

Cladocera comprises 3 species of 3 genera i.e. *Daphnia sp.*, *Moina micrura* and *Pleuroxus sp.* belonging to 3 family as Daphniidae, Moinidae, Chydoridae, 2 order and 1 class. *Moina micrura* was four dominant species during investigation. Cladocera appears throughout in autumn, winter and summer while species *Pleuroxus sp.* absent in monsoon season.

3.5 Ostracoda

Ostracoda composed 2 species of 2 genera such as *Cypris sp.* and *Cyclocypris sp.* belonging to 1 family as Cyprididae, 1 order and 1 class respectively. Ostracoda presents all over in autumn, winter, summer and monsoon season.

4. DISCUSSION

Rotifers are the important components in aquatic ecosystem. They play a critical role in nutrient cycle within streams and river. Among the collected zooplankton, highest 10 species of Rotifer were identified in the current study representing 2 order, 7 families and 9 genus respectively. Rotifer have been the most dominant group throughout the study period due to its adaptive behaviour, small body size, fast reproducing nature and different feeding ability. Their abundance found highest during summer and winter season due to moderate flow of water and high availability of food (Phytoplankton). These observations also found by (Jose and Sanalkumar, 2012), (Sharma 2020).

Table 2. Seasonal qualitative composition of zooplankton in Chackferi stream during study period 2020-22

S.No.	Zooplankton Groups	Species	Season			
			Autumn	Winter	Summer	Monsoon
1.	Rotifera	<i>Brachionus calyciflorus</i>	+	+	+	+
		<i>Brachionus falcatus</i>	+	+	+	+
		<i>Keratella sp.</i>	+	+	+	+
		<i>Monostyla sp.</i>	+	+	+	+
		<i>Lecane sp.</i>	+	+	+	-
		<i>Cephalodella auriculata</i>	+	+	+	+
		<i>Asplanchna sp.</i>	+	-	+	+
		<i>Trichocera sp.</i>	+	+	+	+
		<i>Lepadella sp.</i>	+	+	+	+
		<i>Roteria rotatoria</i>	+	+	+	+
2.	Protozoa	<i>Arcella discoides</i>	+	+	+	+
		<i>Trinema sp.</i>	+	+	+	+
		<i>Paramecium cudatum</i>	+	+	+	+
		<i>Vorticella campanula</i>	+	+	+	+
		<i>Colpodium sp.</i>	+	+	+	+
		<i>Dileptus sp.</i>	-	+	+	+
3.	Copepoda	<i>Cyclops vicinus</i>	+	+	+	+
		<i>Cyclops strenuous</i>	+	+	+	+
		<i>Eucyclops sp.</i>	+	+	+	+
		<i>Mesocyclops leuckarti</i>	+	+	+	+
		<i>Macrocyclops sp.</i>	-	+	+	+
		<i>Macrocyclops albidus</i>	+	+	+	+
		<i>Thermocyclops sp.</i>	+	+	+	-
4.	Cladocera	<i>Daphnia sp.</i>	+	+	+	+
		<i>Moina micrura</i>	+	+	+	+
		<i>Pleuroxus sp.</i>	+	+	+	-
5	Ostracoda	<i>Cypris sp.</i>	+	+	+	+
		<i>Cyclocypris sp.</i>	+	+	+	+

Note: Presence of a species denoted by +; Absence of a species denoted by -

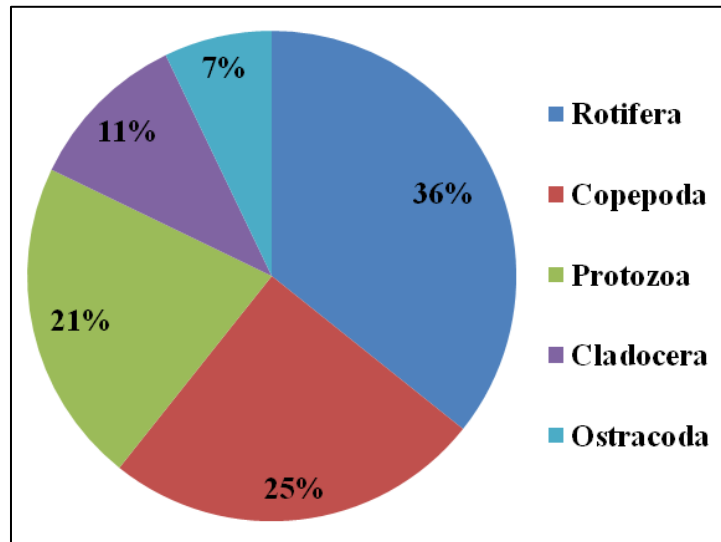


Fig. 3. Species composition of zooplankton in Chackferi stream

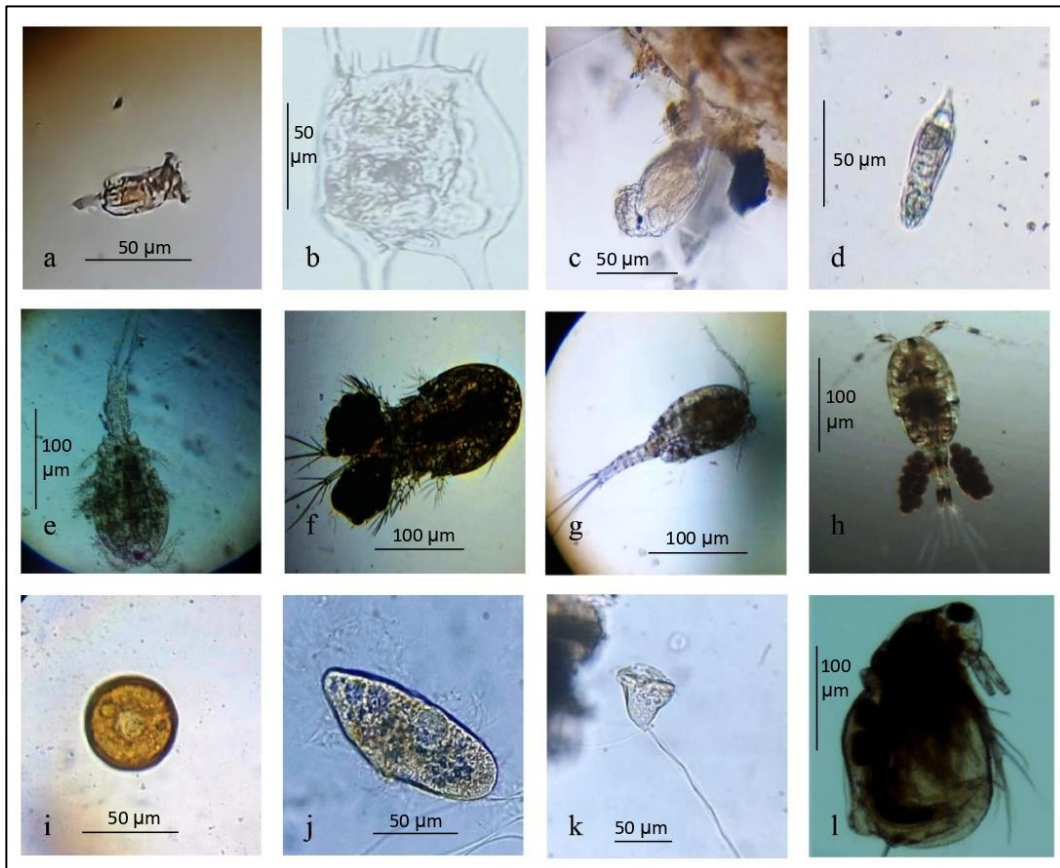


Fig. 4. Some photographs of identified Zooplankton in Chackferi stream

a. *Brachionus calyciflorus*, b. *Brachionus falcatus*, c. *Cephalodella auriculata*, d. *Rotaria rotatoria*, e. *Cyclops vicinus*, f. *Cyclops strenuus*, g. *Mesocyclops leuckarti*, h. *Macrocyclus albidus*, i. *Arcella discoides*, j. *Paramecium cudatum*, k. *Vorticella campanula*, l. *Moina micrura*

Copepods are small crustaceans and feed on micro algae, protozoan, detritus and organic matters. They are then preyed upon by larval fishes and transfer energy to higher trophic

levels. Copepoda was identified with 7 species, 1 order, 1 family and 5 genus in the current investigation. They also appear highest during summer and winter season may be due to dense condition of water column and favourable environmental condition which results have more food availability. Similar results were earlier made by Suresh, et al., 2009 in Tungabhadra river.

Cladocerans also known as 'water flea' are an important component in stream ecosystem. They are the major source of natural food for large fishes. Cladocera was found with 3 species, 2 order, 3 families and 3 genera during the study time period. They were most appearing in summer and autumn season this is may be due to low turbidity and settling of rain water and similar observation also found by (Kumar, 2014), (Marwa and Adel, 2018).

Protozoa play crucial role in aquatic food chain. They are the main source of food for micro and macro invertebrates. As predators they prey upon bacteria, algae and fungi. Protozoa was identified with 6 species, 6 order, 6 families and also 6 genera during the investigation. They were most appearing in summer and winter seasons, it may be due to presence high phytoplankton density in the stream water. Similar results also found by (Sarwade and Kamble, 2014) in Krishna river.

Ostracods have seed like appearance and found almost in all kind of aquatic environment. They actively prey upon algae, bacteria, diatoms, organic detritus and other small zooplankton and in turn serve itself as food source for many small and large fishes. Ostracoda was comprised with 2 species, 1 order, 1 family and 2 genera during the entire study period. They were mostly appearing during summer and winter season may be due to favourable environmental conditions for survival. Similar observation was earlier made by (Watkar and Barbate, 2013).

Among these, rotifers are considered key species for reflecting the water quality of the Chackferi stream due to their resilience in harsh conditions and adaptability. The seasonal composition of rotifer tends to dominated throughout the study because of their ability to thrive in nutrient-rich waters and it indicating that the stream is experiencing eutrophication. Zooplankton are sensitive to pollutants, including pesticides and chemical runoffs. Cladocerans

and ostracods decline in these conditions, as they are more sensitive to oxygen depletion and increased algal blooms, which are typical consequences of eutrophication. Seasonal changes in temperature also impact zooplankton composition. For instance, warmer temperatures often favor rotifers, copepods and protozoans while colder conditions support larger species like cladocerans and ostracods as shown in results. Hence these zooplankton communities act as early warning systems for the stream water quality. By continuously monitoring them, we can gain insights into the overall health of stream ecosystems and take necessary actions to address environmental stressors affecting water quality.

5. CONCLUSION

The presence and dominance of zooplankton species played significant role in the functioning of freshwater ecosystem. They exist in a wide range of environmental conditions and also considered as a good bio indicator to assess the pollution of freshwater body. As per the finding of this investigation zooplankton diversity of the Chackferi stream was found to be dominated by Rotifers followed by Copepods, Protozoans, Cladocerans and Ostracods. Species composition of zooplankton was highest during summer and winter, moderate in autumn and least in monsoon season. In this present investigation in Chackferi stream, the occurrence of *Brachionus calyciflorus*, *Brachionus falcatus* and *Mesocyclops leuckarti*, species reveals that the stream water gets organically polluted. Due to high effect of anthropogenic activities and agricultural runoff from surrounding agricultural fields the stream get highly eutrophicated. Thus, keeping in view the importance of the study, steps should be taken for the conservation, maintenance and restoration of this stream ecosystem.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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