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Abundance and Diversity of Zooplankton in Baini Stream at Tarai Region, Uttarakhand, India

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ABSTRACT
The present study analyzes species diversity and seasonal abundance of zooplankton in the Baini stream, Tarai region, Uttarakhand. For this investigation, samples were collected monthly from September 2020 to August 2022 from three selected stream sites. During the study period, about 30 species of zooplankton were identified, representing 27 genera across five groups, including Protozoa (6 species from 6 genera), Rotifera (11 species from 10 genera), Copepoda (7 species from 5 genera), Cladocera (3 species from 3 genera) and Ostracoda (3 species from 3 genera). Among the collected zooplankton, Rotifera was the most dominant group, comprising 37% in the Baini stream, followed by Copepoda at 23%, Protozoa at 20%, and both Cladocera and Ostracoda at 10%. Seasonal abundance was observed to be highest in summer, moderate in autumn and winter, and lowest during the monsoon season. The zooplankton diversity of the concerned habitat was dominated by Rotifers, followed by Copepods, Protozoans, Cladocerans, and Ostracods.

Key words: Conservation, Diversity, Ecosystem, Pollution, Species, Zooplankton.

INTRODUCTION

The word "plankton" refers to organisms that drift on the water surface, which can include both phytoplankton (plants) and zooplankton (animals). Zooplankton are small, microscopic, and heterotrophic animals that freely float in the water column of streams, rivers, lakes, and oceans. The word "zooplankton" comes from Greek, with *zoon* meaning "animal" and *plankton* meaning "drifter" (Sayasrao and Ramabhau 2020). Zooplankton plays a crucial role in balancing biotic and abiotic components of aquatic ecosystems, as they are abundant across all aquatic forms and essential for energy transfer within these habitats (Panpatil and Deshmukh 2021). Freshwater zooplankton comprises five major groups of invertebrates: rotifers, copepods, cladocerans, protozoa, and ostracods.

Zooplankton are essential to aquatic ecosystems and vital in energy flow, food webs, and nutrient cycling. As part of the functional groups within these ecosystems, they help regulate material and energy cycles in water systems. Zooplankton typically shows high species diversity in clean water but is present in smaller numbers. In contrast, heavily polluted water can significantly reduce zooplankton's diversity and survival rates (Chen 2020). They are also a crucial food source for various aquatic species, such as fish, prawns, and shrimp, supplying the protein necessary for their growth and development. Their presence and abundance directly influence fish population dynamics and water quality by controlling oxygen levels, enhancing organic matter decomposition, and moderating algal and bacterial growth (Shil et al. 2013). Therefore, Effective fisheries management depends on sustaining zooplankton diversity and abundance, which supports income, employment, nutrition, and trade within the region.

Many species within the rotifer and crustacean groups are considered reliable indicators of trophic conditions in streams and other aquatic ecosystems. Specifically, rotifer genera such as *Asplanchna*, *Brachionus*, *Keratella*, and *Trichocerca* are commonly found in mesotrophic to eutrophic conditions, signaling elevated nutrient levels in the water (Imoobe and Adeyinka 2009). Their presence indicates a shift towards eutrophic conditions, reflecting changes in water quality and nutrient enrichment. The spatial and temporal distribution of zooplankton is influenced by various factors such as physicochemical parameters, vegetation cover, and climatic changes, making them a valuable tool for assessing pollution in aquatic environments.

Extensive research has been conducted on zooplankton diversity and abundance in freshwater systems, with notable studies by Reddy et al. (2012), Okorafor et al. (2013), Shah et al. (2013), Kumar (2014), Brraich and Akhter (2019), and Kumar and Singh (2023), all of which found significant variations in zooplankton populations in response to environmental factors. Water quality in aquatic habitats, particularly in streams like the Baini near urban areas, is increasingly impacted by pollution and human activities. Understanding how zooplankton communities respond to pollution is essential for effective stream management. Thus, the present study aims to learn about zooplankton diversity and abundance in the Baini stream in the Tarai region of Uttarakhand.

MATERIAL AND METHODS

Study site

Udham Singh Nagar district falls in the Tarai region of Kumaun division and is also known as the "food bowl" of Uttarakhand state. The rivers like Gaula, Sarada, and Kosi are significant rivers that flow from the lower Himalayas into the Tarai region of the district. The Baini stream is one of the tributaries of the Gaula River that originates from the Tanda forest near the hilly region of Nainital district and flows from north-east to south-east direction across the agricultural fields up to Kiccha city before drain into the Gaula River at district Udham Singh Nagar of Uttarakhand (Fig. 1). It is located between 28°01'48"

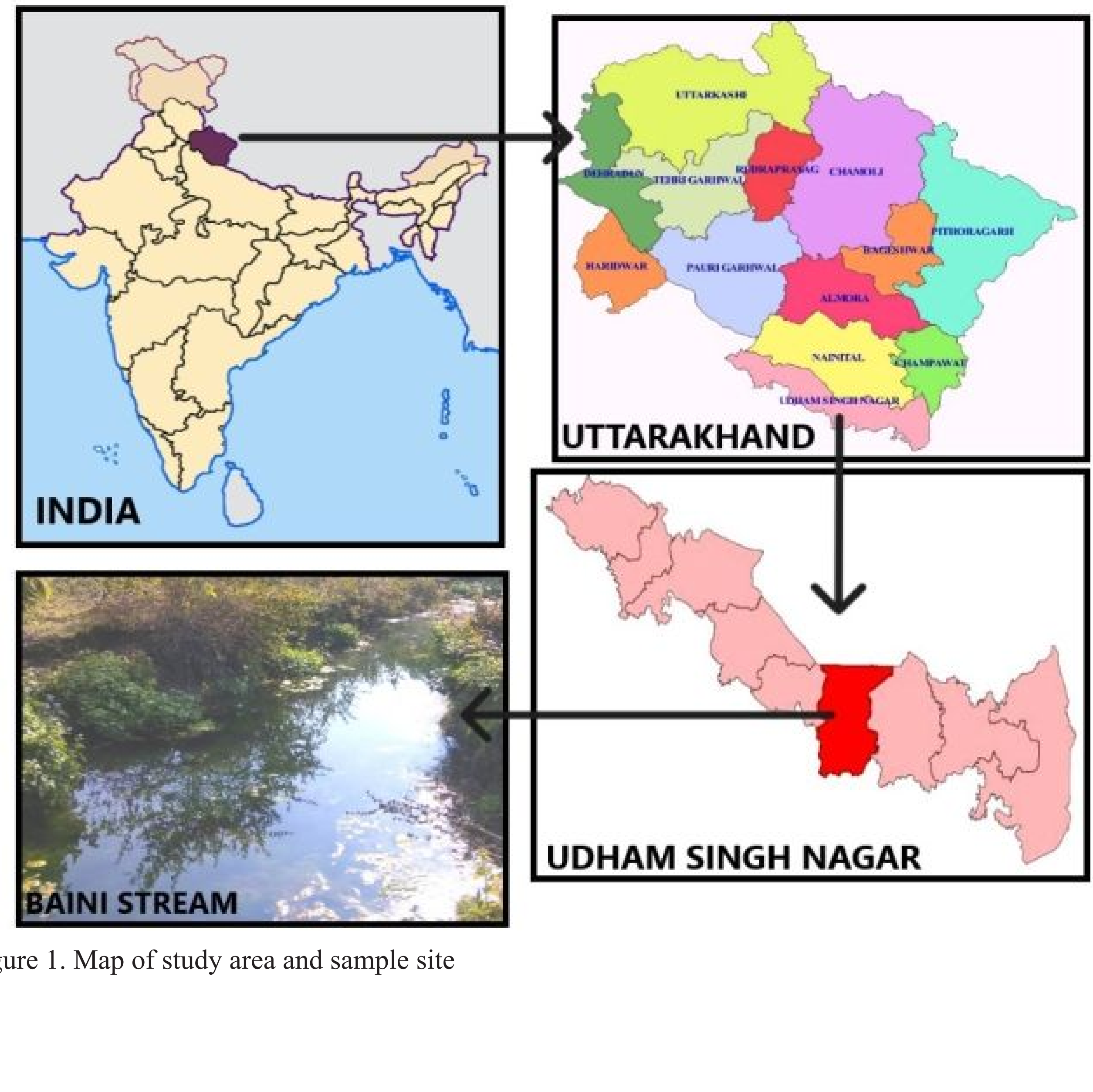

Figure 1. Map of study area and sample site

N latitude and 79°31'24" E longitudes. Its major share of water is utilized for agriculture, irrigation, and industrial purposes. It is also used for domestic and other human activities and is crucial in the uptake of household, municipal, and industrial waste and agricultural field runoff.

Zooplankton collection and identification

This study was conducted from Sept. 2020 to Aug. 2022 to explore zooplankton diversity in the Baini stream in the Tarai region of Uttarakhand. Zooplankton samples were collected monthly from three selected sites along the stream. For zooplankton collection, water samples were filtered through a plankton net with a mesh size of 25 µm. The filtrate was then transferred into a 100 ml polyethylene bottle and preserved with 4% formalin for zooplankton analysis. The sample bottle was gradually shaken in the lab to ensure the specimen was evenly distributed. Then, 1 ml of the sample was taken in 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. With the help of standard books and taxonomic keys of Edomndson 1959, Pennak 1978, and Battish 1992, systematic identification of zooplankton.

RESULTS

A total of 30 zooplankton species from 27 genera, 18 families, 12 orders, and 10 classes were identified in the Baini stream during the study period. These species were categorized into five groups: protozoa, rotifera, copepoda, cladocera, and ostracoda (Table 1, Fig. 2). Of the collected zooplankton, rotifera was the most dominant group, accounting for 37% of the total followed by copepoda (23%), protozoa (20%), and both cladocera and ostracoda at 10% each (Fig. 2).

Rotifera consisted of 11 species across 10 genera, including *Brachionus calyciflorus, Brachionus falcatus, Keratella* sp.*, Monostyla* sp.*, Lecane* sp.*, Cephalodella auriculata, Asplanchna* sp.*, Trichocerca* sp.*, Lepadella* sp.*, Philodina* sp., and *Rotaria rotatoria*, belonging to 7 families, 2 orders, and 2 classes. *Brachionus calyciflorus* was the leading species within this group. Rotifers were present throughout autumn and summer, though

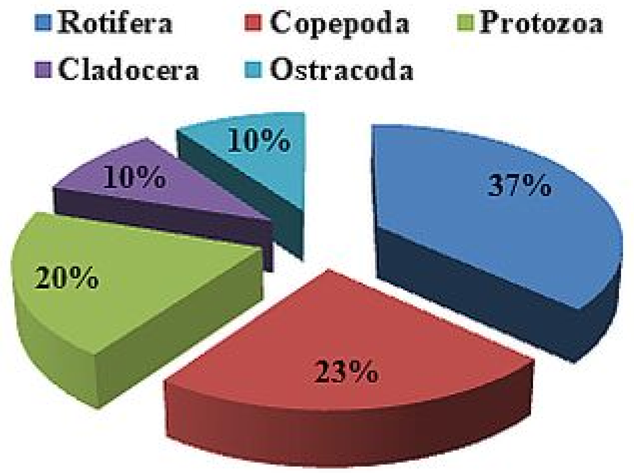

Figure 2. Species composition of zooplankton in Baini stream

certain species like *Brachionus falcatus* and *Asplanchna* sp. were absent in winter and monsoon seasons.

Protozoa comprised 6 species from 6 genera, including *Arcella discoides, Trinema* sp.*, Paramecium caudatum, Vorticella campanula, Dileptus* sp.*,* and *Halteria* sp.*,* spanning 6 families, 6 orders, 5 classes. *Arcella discoides* was the dominant species among protozoa. Protozoans were commonly observed in summer, although species like *Trinema* sp., *Paramecium caudatum*, and *Vorticella campanula* were absent during monsoon, winter, and autumn.

Copepoda consisted of 7 species across 5 genera, including *Cyclops vicinus*, *Cyclops strenuus*, *Eucyclops* sp., *Mesocyclops leuckarti*, *Macrocyclops* sp., *Macrocyclops albidus*, and *Thermocyclops* sp., all belonging to a single family, order, and class. Copepods were present throughout autumn and winter, with *Mesocyclops leuckarti* as the primary species in this group. However, *Eucyclops* sp. was not observed during the monsoon season.

Cladocera included three species from three genera, including *Daphnia* sp., *Moina micrura*, and *Pleuroxus sp.*, each belonging to 3 different family but sharing 2 orders and 1 class. Cladocerans were observed throughout autumn, summer, and monsoon, though *Pleuroxus sp.* was absent in winter. *Moina micrura* was frequently encountered during the study. Ostracoda was represented by three species from three genera, including *Cypris* sp., *Cyclocypris* sp., and *Eucypris* sp., all within a single family, order, and class. Ostracods were generally observed in

Table 1. Diversity and seasonal abundance of zooplankton in Baini stream, Uttarakhand (2020-22)

Groups	Class	Order	Family	Genera & Species	Season			
					A	W	S	M
Rotifera	Monogononta	Ploima	Brachionidae	*Brachionus calyciflorus*	+	+	+	+
				Brachionus falcatus	+	+	+	-
				Keratella sp.	+	+	+	+
			Lecanidae	*Monostyla* sp.	+	+	+	+
				Lecane sp.	+	+	+	+
			Notommatidae	*Cephalodella auriculata*	+	+	+	+
			Asplanchnidae	*Asplanchna* sp.	+	-	+	+
			Trichoceridae	*Trichocera* sp.	+	+	+	+
			Lepadellidae	*Lepadella* sp.	+	+	+	+
	Bdelloidea	Bdelloida	Philodinidae	*Philodina* sp.	+	+	+	+
				Roteria rotatoria	+	+	+	+
Protozoa	Tubulinea	Arcellinida	Arcellidae	*Arcella discoides*	+	+	+	+
	Silicofilosea	Euglyphida	Trinematidae	*Trinema* sp.	+	+	+	-
	Oligohymenophorea	Peniculida	Parameciidae	*Paramecium cudatum*	+	-	+	+
		Sessilida	Vorticellidae	*Vorticella campanula*	-	+	+	+
	Litostomatae	Dileptida	Dileptidae	*Dileptus* sp.	+	+	+	+
	Oligotrichea	Halteriida	Halteriidae	*Halteria* sp.	+	+	+	+
Copepoda	Maxillopoda	Cyclopoida	Cyclopidae	*Cyclops vicinus*	+	+	+	+
				Cyclops strenuous	+	+	+	+
				Eucyclops sp.	+	+	+	-
				Mesocyclops leuckarti	+	+	+	+
				Macrocyclops sp.	+	+	+	+
				Macrocyclops albidus	+	+	+	+
				Thermocyclops sp.	+	+	+	+
Cladocera	Branchiopoda	Anomopoda	Daphniidae	*Daphnia* sp.	+	+	+	+
			Moinidae	*Moina micrura*	+	+	+	+
		Diplostraca	Chydoridae	*Pleuroxus* sp.	+	-	+	+
Ostracoda	Podocopa	Podocopida	Cyprididae	*Cypris* sp.	+	+	+	+
				Cyclocypris sp.	+	+	+	-
				Eucypris sp.	+	+	+	+

Note: *A (Autumn), W (Winter), S (Summer), M (Monsoon); Presence of a species denoted by +, Absence by -*

winter and summer, but *Cyclocypris* sp. was absent during the monsoon season. This diverse zooplankton community reflects each group's seasonal patterns of abundance and environmental preferences in the Baini stream ecosystem.

DISCUSSION

This study highlights the diversity and seasonal abundance of zooplankton, including rotifers, copepods, cladocerans, protozoans, and ostracods, providing valuable insights into the water quality and ecological health of the Baini stream. Rotifers emerged as the most dominant group due to their adaptability, small size, rapid reproduction, and versatile feeding habits. Their flexibility in nutrient-rich, often harsh conditions and their dominance across seasons indicate ongoing eutrophication in the Baini stream. This observation aligns with previous findings (Ismail and Zaidin 2015) that rotifers thrive in environments experiencing nutrient enrichment, suggesting they serve as effective indicators of water quality degradation. Copepods, the second-leading group after rotifers, were abundant during summer, reflecting high-temperature tolerance and food availability (Pandey and Upadhyay 2015), while cladoceran were peak in low-turbidity and warm conditions (Pal and Verma 2016). Protozoans and ostracods also show seasonal abundance patterns, protozoans peak in warmer months with high phytoplankton levels (Dede and Deshmukh, 2015), whereas ostracods, sensitive to oxygen depletion, decrease in eutrophic conditions that favor algal blooms (Kar and Kar 2016, Sharma et al. 2020). The

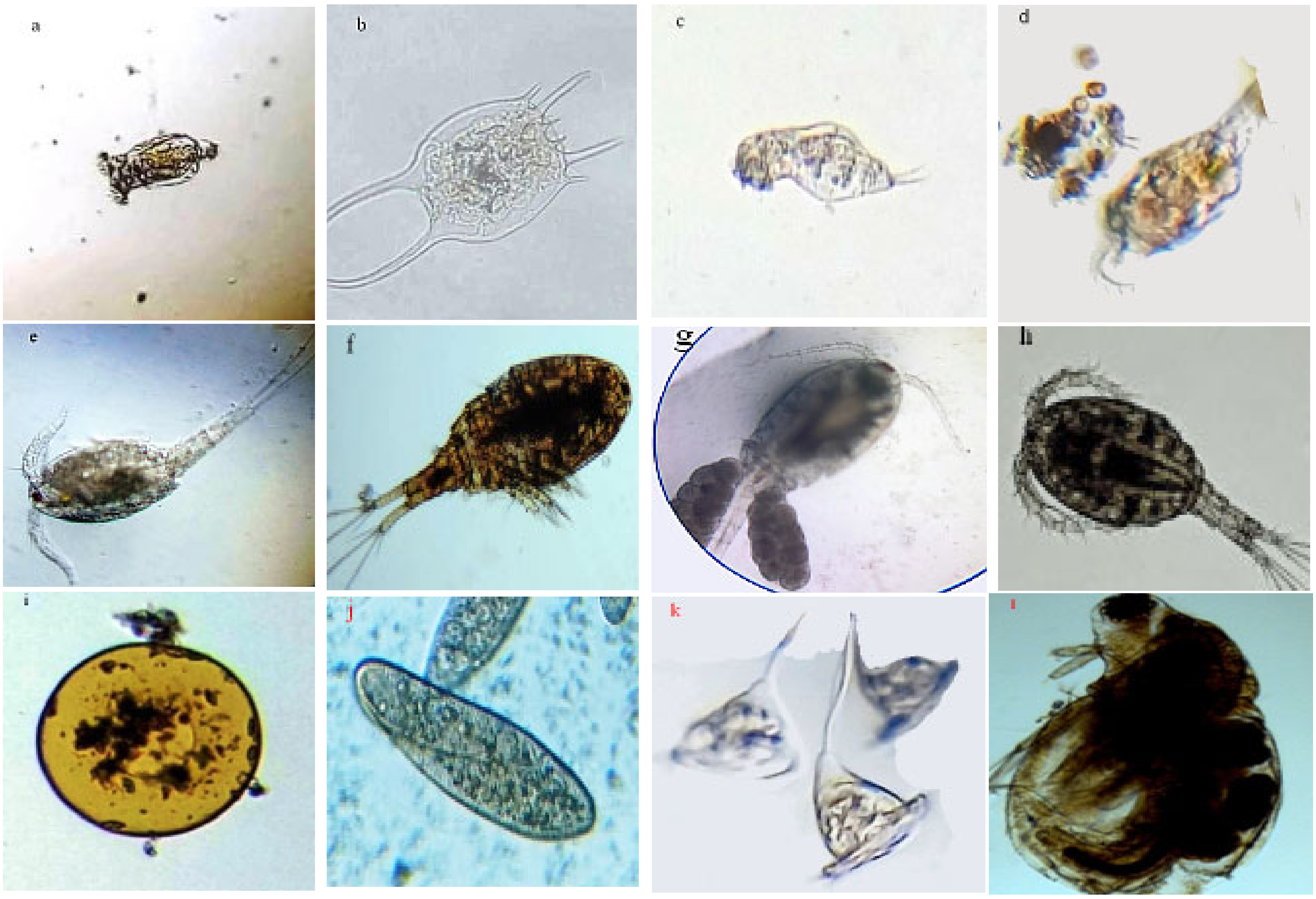

Figure 3. Some photographs of identified Zooplankton in Baini stream: a. *Brachionus calyciflorus*, b. *Brachionus falcatus*, c. *Cephalodella auriculata*, d. *Roteria rotatoria*, e. *Cyclops vicinus*, f. *Cyclops strenuous*, g. *Mesocyclops leuckarti*, h. *Macrocyclops albidus*, i. *Arcella discoides*, j. *Paramecium cudatum*, k. *Vorticella campanula*, l. *Moina micrura*

seasonal patterns also demonstrate how warmer temperatures favor groups like rotifers, copepods, and protozoans, while colder conditions support larger species like cladocerans and ostracods. These zooplankton communities act as early warning systems, sensitive to pollution, chemical runoff, and eutrophic shifts, and highlight how seasonal environmental changes impact stream health. Regular assessment of these zooplankton groups offers a strategic approach to understanding water quality dynamics and taking timely actions to mitigate ecological stressors in freshwater systems.

CONCLUSION

This study highlights the importance of zooplankton diversity as an indicator of the ecological health of the Baini stream. Zooplankton in the stream were predominantly rotifers, followed by copepods, protozoans, cladocerans, and ostracods. Seasonal abundance was highest in summer, moderate in autumn and winter, and lowest in the monsoon season. The dominance of rotifers, particularly *Brachionus calyciflorus*, copepods, and other taxa, reveals seasonal patterns reflecting the stream's water quality. Pollution-tolerant species like *Mesocyclops leuckarti* and *Moina micrura* indicate moderate pollution and signs of eutrophication. Due to the stream's vulnerability to pollution from human activities and agricultural runoff, targeted conservation and management actions are needed to restore ecological balance, enhance biodiversity, and support local fisheries and the broader ecosystem. Continued monitoring and timely interventions are essential to preserve the health and resilience of the Baini stream ecosystem.

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