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Research Article

COMMUNITY ASSEMBLANCE AND SEASONAL DYNAMICS OF ZOOPLANKTON IN A FRESHWATER POND ECOSYSTEM OF MEGHALAYA, NORTHEAST INDIA

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ABSTRACT

Zooplankton is an integral component of freshwater ecosystems and serves as a sensitive indicator of environmental conditions and trophic status. The present study documents the community structure and seasonal abundance of zooplankton in a freshwater pond located within the campus of the University of Science and Technology Meghalaya (USTM), Northeast India. Zooplankton samples were collected seasonally and identified up to the genus level. A total of 29 genera belonging to four major taxonomic groups-Rotifera, Cladocera, Copepoda and Protozoa-were recorded during the study period. Rotifera constituted the dominant group with 12 genera, followed by Cladocera (8 genera), Protozoa (6 genera) and Copepoda (3 genera). Seasonal abundance showed clear temporal variation, with maximum zooplankton density during the monsoon season (810 Ind.L^{-1}), followed by the retreating monsoon (699 Ind.L^{-1}), pre-monsoon (568 Ind.L^{-1}) and winter (449 Ind.L^{-1}). Rotifers such as *Brachionus, Keratella* and *Polyarthra* were the most abundant taxa throughout the study period, while cladocerans, including *Bosmina* and *Ceriodaphnia,* also contributed substantially to total abundance. The observed community structure reflects a moderately productive pond ecosystem influenced by seasonal hydrological and nutrient dynamics. The study provides baseline information on zooplankton diversity and seasonal dynamics in small freshwater ecosystems of Northeast India.

Keywords: Zooplankton diversity, Rotifera, Cladocera, Copepoda, Protozoa, Seasonal variation, Campus pond.

INTRODUCTION

Zooplankton constitute a fundamental component of freshwater ecosystems, playing a crucial role in linking primary producers to higher trophic levels such as fish and other aquatic organisms. They are a vital component of the aquatic ecosystems and significantly contribute to the transfer of energy and nutrients within the food web (Steinberg and Robert, 2009). As primary consumers, they regulate phytoplankton populations and contribute significantly to nutrient recycling and energy transfer within aquatic food webs. Zooplankton communities typically comprise a diverse assemblage of invertebrates, particularly rotifers, cladocerans and copepods (Elmoor-Loureiro *et al*., 2023). These organisms exhibit high sensitivity to environmental changes and are widely recognized as consistent indicators of ecosystem health due to their short life cycles, rapid population turnover and high dispersal abilities (Castilho-Noll *et al.,* 2023). Consequently, zooplankton communities are frequently used as biological indicators for assessing water quality and trophic status in freshwater ecosystems.

Small freshwater ponds often exhibit high biological productivity and support diverse planktonic communities. Such ecosystems are particularly important in tropical and subtropical regions where seasonal variations in rainfall and temperature strongly influence plankton dynamics. In India, the dominant zooplankton groups in freshwater habitats typically include Rotifera, Cladocera and Copepoda, along with several protozoan taxa. Despite the ecological importance of small freshwater bodies, studies focusing on zooplankton diversity in institutional campus ponds remain limited, particularly in Northeast India. The present study aims to investigate the composition and seasonal abundance of zooplankton in the freshwater pond of the University of Science and Technology Meghalaya (USTM), thereby providing baseline ecological information

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on the structure and dynamics of zooplankton communities in such freshwater systems.

MATERIALS AND METHODS

Study Area

The study was conducted in a freshwater pond with coordinates (26°05'57"N 91°50'36"E) located within the campus of the University of Science and Technology Meghalaya (USTM) situated in the Ri-Bhoi district of Meghalaya, Northeast India (Figure 1). The region experiences a humid subtropical climate characterized by heavy monsoonal rainfall and moderate temperature fluctuations throughout the year. The pond receives water mainly from precipitation and surface runoff and supports aquatic macrophytes along its margins, creating suitable habitats for planktonic organisms.

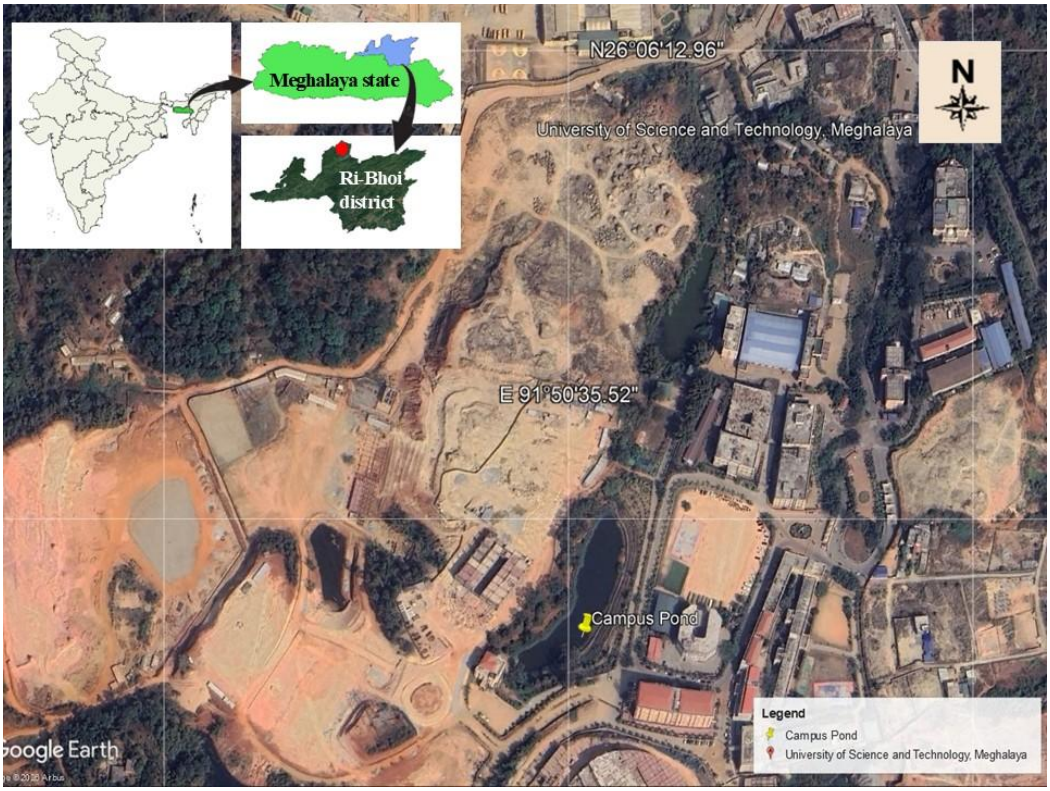

Figure 1. Map of USTM campus in RiBhoi district of Meghalaya, Northeast India, where the present study was conducted.

Collection of Zooplankton

Plankton samples were collected from the pond at regular monthly intervals during the study period, i.e., from December 2023 to November 2024, four seasons of the year, i.e., winter (December to February), pre-monsoon (March to May), monsoon (June to September) and retreating monsoon (October to November) (Borthakur, 1986). For this, 100 liters of water were filtered through a 55 µm mesh bolting silk net (plankton net) for collecting plankton samples (Deka and Goswami, 2015; Basumatary, 2017; Baishya, 2021; Mili, 2023) and the samples were preserved in 5% formalin for further examination.

Identification and Quantification

Plankton identification and counting were performed using a binocular light microscope (Labomed Vision 2000) at the required magnifications of 10X initially, followed by 40X. Zooplankton were identified up to the genus level using standard taxonomic keys following published works by Edmondson (1966), Needham and Needham (1966), Smirnov (1971, 1974, 1996), Ruttner-Kolisko (1974), Pennak (1978), Sharma (1983, 1987a, 1987b, 1998), Koste and Shiel (1987, 1989, 1990), Sharma and Michael (1987), Michael and Sharma (1988), Battish (1992), Shiel and Koste (1992, 1993), Ranga (1994, 2001), Segers (1995), Sharma and Sharma (1999a, 1999b, 2000, 2008, 2012), Korinek (2002), Alekseev (2002), Nogrady and Segers (2002), Chattopadhyay and Das (2003), Ueda and Reid (2004), Kar and Barbhuiya (2004), etc. The quantitative analysis of plankton (Ind.L^{-1}) was conducted by extracting 1 ml of homogenized preserved samples using a wide-mouthed graduated pipette, which was then transferred to a Sedgwick Rafter cell for microscopic examination. The total plankton count per liter of water was determined using the formula (Sarojini and Sarma, 2001; Santhanam *et al.*, 2019):

$$\text{Plankton units/Litre, } N = \frac{(n \times v)}{V}$$

where, N = Number of plankton counted in 1ml concentrate under S-R cell.
v = Total volume of concentrate in ml.
V = Total volume of water filtered for sample in litres

Data analysis

MS Excel software, MEGA and the Bio-Diversity Pro program were used to compute the plankton abundance and diversity. The following formula was used to calculate the relative abundance of each zooplankton species.

$$RA = \frac{\text{Number of samples of a specific zooplankton species X 100}}{\text{Total number of samples}}$$

Diversity indices such as Shannon-Weiner (Shanon and Weiner, 1949) and Simpson Diversity (Simpson, 1949) were also computed.

RESULTS AND DISCUSSION

A total of 29 genera of zooplankton were recorded from the USTM campus pond, belonging to four major taxonomic groups, i.e., Cladocera, Copepoda, Protozoa and Rotifera (Table 1). Rotifera was the most diverse group with 12 genera (41.38%), followed by Cladocera with 8 genera (27.59%), Protozoa with 6 genera (20.69%) and Copepoda with 3 genera (10.34%) (Figure 2). There was a significant variation ($t=3.841$, $p \leq 0.05$) between various zooplankton regarding their distribution in different genera. The overall relative abundance of zooplankton in the campus pond was dominated by Rotifera, representing the highest proportion (39.94%), followed by Cladocera (25.69%), Protozoa (20.11%) and Copepoda (14.25%) (Figure 3). This indicates that the zooplankton community assemblage is primarily led by rotifer genera, while cladocerans, copepods and protozoans play significant roles in creating a well-organized and ecologically balanced community.

Table 1. Diversity and relative abundance of zooplankton in the pond of USTM campus.

Sl. No.	Groups	Genus	Relative Abundance
1	Rotifera	Asplanchna	2.22
2		Brachionus	4.59
3		Keratella	5.86
4		Polyarthra	4.95
5		Trichocerca	4.43
6		Lepadella	3.56
7		Testudinella	3.88
8		Conochilus	3.17
9		Mytilina	2.69
10		Platyias	2.14
11		Pompholyx	1.35
12		Macrochaetus	1.11
13	Cladocera	Alona	2.85
14		Bosmina	5.15
15		Ceriodaphnia	3.09
16		Chydorus	3.56
17		Diaphanosoma	4.20
18		Scapholeberis	3.05
19		Bosminopsis	1.74
20		Karualona	2.06
21	Copepoda	Mesocyclops	4.12
22		Microcyclops	3.56
23		Nauplii	6.57

24	Protozoa	Arcella	3.80
25		Centropyxis	3.25
26		Difflugia	3.56
27		Trinema	4.59
28		Euglypha	2.30
29		Euglena	2.61

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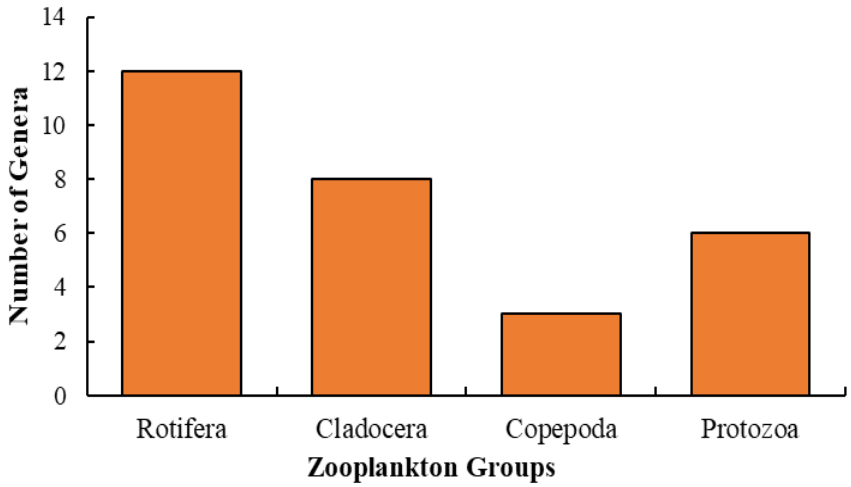

Figure 2. Distribution of zooplankton groups with respect to genera.

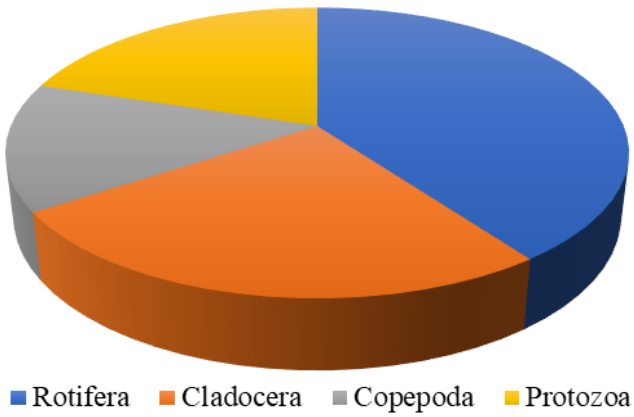

Figure 3. Relative abundance of the major groups of zooplankton.

Dominant rotifer genera included *Brachionus sp., Keratella sp., Polyarthra sp., Trichocerca sp., Testudinella sp.* and *Lepadella sp*. Among cladocerans, *Bosmina sp., Diaphanosoma sp., Chydorus sp., Ceriodaphnia sp.* and *Alona sp*. were prominent. The copepod assemblage was represented primarily by *Mesocyclops sp., Microcyclops sp.* and nauplii. Dominant protozoan taxa included *Trinema sp.*, *Arcella sp., Difflugia sp., Centropyxis sp.* and *Euglena sp*. The highest total abundance was recorded during the monsoon season (810 Ind.L^{-1}), followed by the retreating monsoon (699 Ind.L^{-1}) and pre-monsoon (568 Ind.L^{-1}), while the lowest abundance occurred during winter (449 Ind.L^{-1}) (Figure 4). There was a significant difference among zooplankton in various seasons ($t=.055$, $p \leq 0.05$). Overall, the abundance of zooplankton reaches its peak during the monsoon season due to favorable environmental conditions, followed by a gradual decline as winter approaches, demonstrating a strong seasonal impact on community dynamics.

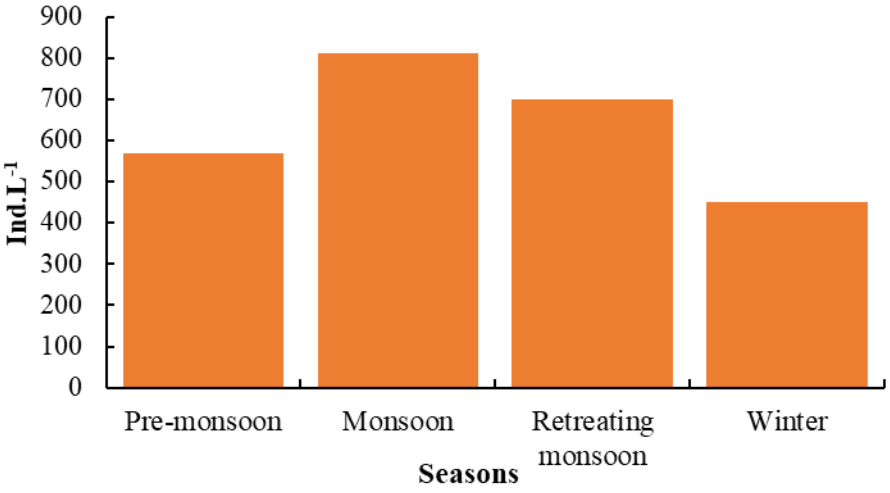

Figure 4. Overall seasonal variation of zooplankton abundance.

Rotifers consistently dominated the zooplankton community across all seasons, contributing the largest share of total abundance. During the monsoon season, rotifer abundance reached 328 Ind.L^{-1}, indicating favorable environmental conditions for their growth. Cladocerans showed moderate seasonal variation, with peak abundance during monsoon (208 Ind.L^{-1}) and post-monsoon (180 Ind.L^{-1}) (Figure 5). The zooplankton showed a significant variation in their abundance during pre-monsoon ($t=4.553$, $p\leq0.05$), monsoon ($t=4.383$, $p\leq0.05$), retreating monsoon ($t=4.393$, $p\leq0.05$) and winter ($t=5.128$, $p\leq0.05$). Further, a very high positive and statistically significant correlation was observed among zooplankton in various seasons (Table 2). Copepods were represented mainly by cyclopoid forms and nauplii stages, which remained present throughout the year. Protozoan taxa also exhibited seasonal fluctuations but maintained moderate abundance across all seasons. This clearly indicates that the zooplankton community is predominantly composed of rotifers, with other groups exhibiting moderate seasonal variations while remaining present throughout the year, indicating a stable yet seasonally adaptive community structure.

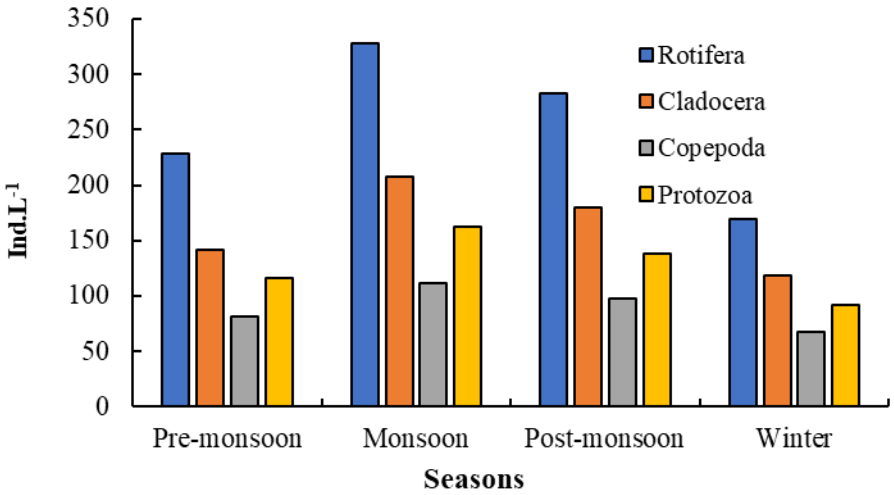

Figure 5. Seasonal variation of zooplankton abundance in different groups

Table 2. Correlation among different season with respect to zooplankton abundance.

Season	Pre-monsoon	Monsoon	Retreating monsoon	Winter
Pre-monsoon	1			
Monsoon	0.999**	1		
Retreating monsoon	0.999**	1.000**	1	
Winter	0.995**	0.998**	0.998**	1

The biodiversity indices indicate that the zooplankton community of the study site exhibits consistently moderate to high species diversity throughout the year. The Shannon-Wiener index (H′) ranged narrowly between 3.23 and 3.31, reflecting a relatively stable community with well-distributed species richness and evenness across seasons. The highest H′ value during the pre-monsoon suggests slightly greater heterogeneity and balanced species composition, likely supported by favorable environmental conditions prior to heavy rainfall. In contrast, the slight decline during monsoon, retreating monsoon and winter indicates minor seasonal shifts but no drastic loss of diversity. The Simpson's index of dominance (D), which varied from 0.032 to 0.041, provides further insight into community structure. The lowest dominance during the pre-monsoon signifies a more even distribution of individuals among species, whereas the highest dominance recorded in winter indicates that a few taxa become relatively more abundant, leading to reduced evenness. The monsoon and retreating monsoon seasons showed intermediate dominance values, suggesting a balanced coexistence of species despite increased productivity. Overall, the combined interpretation of both indices demonstrates that while species diversity remains relatively stable across seasons, community evenness fluctuates, with more even species distribution during the pre-monsoon and increased dominance of certain taxa during winter. This pattern highlights the influence of seasonal environmental factors on the structure and organization of the zooplankton community (Figure 6).

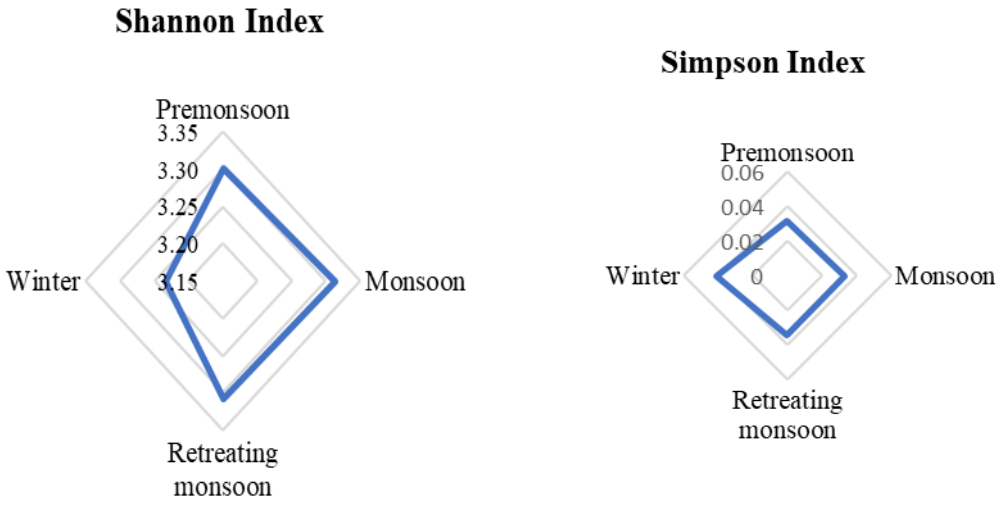

Figure 6. Shannon-Weiner and Simpson diversity indices values for zooplankton in different seasons.

The present study reveals that the zooplankton community in the USTM campus pond is dominated by rotifers, a pattern commonly observed in tropical and subtropical freshwater ecosystems (Phan *et al.,* 2021; Wen *et al.,* 2017; Razak and Sharip, 2023). Rotifers are known for their high reproductive rates and adaptability to fluctuating environmental conditions, enabling them to colonize small water bodies efficiently (Stemberger and Gilbert, 1985; Wallace *et al.,* 2015). The dominance of genera such as *Brachionus sp., Keratella sp.* and *Polyarthra sp*. suggests moderately eutrophic conditions, as these taxa are frequently associated with nutrient-rich freshwater habitats. Similar observations have been reported in several limnological studies conducted in ponds and wetlands of Kashmir (Khan 1987, Raina and Vass 1993, Ahangar *et al.* 2012, Jeelani and Kaur 2014), Andhra Pradesh (Sharmila and Shameem 2017) and even in northeastern states like Mizoram (Sharma and Pachuau 2013), Assam (Pathak *et al*., 2025) and Meghalaya (Sharma 1995, Das *et al.* 1996, Sharma and Lyngdoh 2004, Sharma and Sharma 2020). Cladocerans such as *Bosmina sp., Ceriodaphnia sp.* and *Diaphanosoma sp*. were also important components of the zooplankton community (Karuthapandi and Rao, 2016). These organisms are key grazers of phytoplankton and play

a significant role in transferring energy from primary producers to higher trophic levels. Their relatively high abundance during the monsoon and retreating monsoon may be attributed to increased phytoplankton productivity resulting from nutrient inputs during rainfall. The monsoon exhibited the highest zooplankton density, likely due to increased nutrient inflow, enhanced primary productivity and favorable temperature conditions (Hood *et al*., 2024). In contrast, winter showed the lowest abundance, possibly reflecting reduced metabolic activity (Thomas, 2019). Cyclopoid copepods, namely *Mesocyclops sp*. and *Microcyclops sp. were* consistently present throughout the study period, indicating their adaptability to varying environmental conditions. The presence of copepod nauplii further suggests active reproduction within the pond ecosystem (Frisch and Sante, 2004). Protozoan taxa, including *Arcella sp., Centropyxis sp.* and *Difflugia sp.,* were also recorded in moderate abundance, reflecting the presence of organic matter and microbial activity in the pond environment (El-Tohamy *et al.,* 2024). These organisms contribute to the microbial loop and nutrient cycling, thereby supporting the overall productivity of the ecosystem. Overall, the observed zooplankton community structure reflects the ecological characteristics of a productive subtropical pond influenced by seasonal hydrological dynamics.

The comparative analysis of biodiversity indices across seasons indicates that species diversity remained relatively stable, as reflected by the narrow range of the Shannon-Wiener index (H′ = 3.23–3.31), with slightly higher diversity during the pre-monsoon period. In contrast, Simpson's index of dominance (D) shows a clearer seasonal pattern, with lower dominance (indicating higher diversity) during pre-monsoon and higher dominance during winter. This suggests that although overall diversity does not fluctuate markedly, community evenness declines in winter, leading to the increased dominance of a few taxa during that season. The findings highlight the ecological significance of small freshwater ponds as reservoirs of planktonic biodiversity and provide baseline information for future ecological monitoring and management of freshwater resources in Northeast India.

CONCLUSION

The present investigation recorded 29 genera of zooplankton from a freshwater campus pond at USTM, representing four major groups-Rotifera, Cladocera, Copepoda and Protozoa. Rotifers constituted the dominant component of the zooplankton community, followed by cladocerans and protozoans. Seasonal analysis revealed maximum zooplankton abundance during the monsoon season and minimum abundance during winter. The zooplankton community exhibits stable and moderate species diversity across seasons, with peak abundance and evenness during the monsoon and pre-monsoon, while winter reflects increased dominance of a few taxa. Maintaining water quality and nutrient balance, especially during critical seasonal transitions, is essential to sustain zooplankton diversity and overall ecosystem health.

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CONFLICT OF INTERESTS

The authors declare no conflict of interest

ETHICS APPROVAL

Not applicable

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AI TOOL DECLARATION

The authors declares that no AI and related tools are used to write the scientific content of this manuscript.

DATA AVAILABILITY

Data will be available on request

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