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Studies on Seasonal Variation and Diversity of Zooplankton in Jakham Reservoir, Pratapgarh

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Abstract: Zooplankton communities serve as critical bioindicators of aquatic ecosystem health and form the foundation of freshwater food webs. This study investigated the seasonal variation and diversity of zooplankton in Jakham Reservoir, Pratapgarh, across three distinct seasons: summer (March 2024–June 2024), monsoon (July 2024–October 2024), and winter (November 2024–February 2025). A total of 25 zooplankton species belonging to protozoans, rotifers, cladocerans, copepods, and other groups were identified during the study period. The highest species diversity (25 species) was recorded during the monsoon season, followed by summer (22 species) and winter (18 species). Rotifers dominated the zooplankton community, with Brachionus plicatilis, Conochilus unicornis, and Philodina roseola showing peak abundance during the monsoon. Cladocerans, particularly Daphnia species, exhibited maximum density in winter, while protozoans such as Paramecium species were abundant during summer. The Shannon-Wiener diversity index (H') ranged from 2.45 in winter to 3.12 in monsoon, indicating moderate to high diversity. Physicochemical parameters showed significant seasonal variations influencing zooplankton distribution. The findings provide baseline data for understanding zooplankton dynamics in tropical reservoir ecosystems and emphasize the importance of seasonal monitoring for effective water resource management.
Keywords: Zooplankton diversity, seasonal variation, Jakham Reservoir, monsoon, summer, winter, rotifers, cladocerans, bioindicators, freshwater ecology

I. INTRODUCTION

Zooplankton are microscopic heterotrophic organisms that drift in aquatic environments and occupy a pivotal position in freshwater food webs, linking primary producers (phytoplankton) to higher trophic levels such as fish and aquatic insects (Wetzel, 2001). Their rapid response to environmental changes, short generation times, and sensitivity to physicochemical parameters make them excellent bioindicators of water quality and ecosystem health (Sharma & Sharma, 2018). Understanding zooplankton community structure and seasonal dynamics is essential for sustainable reservoir management, fisheries enhancement, and conservation of aquatic biodiversity.

Seasonal variations in tropical reservoirs significantly influence zooplankton diversity and abundance due to changes in temperature, rainfall patterns, nutrient inputs, and hydrological regimes (Fernando, 2002). In India, reservoirs experience distinct summer, monsoon, and winter seasons, each characterized by unique limnological conditions. Summer typically brings high temperatures and water stratification, monsoon introduces nutrient-rich runoff and increased turbidity, while winter offers relatively stable conditions with lower temperatures (Saha et al., 2019). These seasonal fluctuations create dynamic habitats that favor different zooplankton assemblages.

Jakham Reservoir, located in Pratapgarh district of Rajasthan, India, is an important water body serving irrigation, domestic water supply, and fisheries purposes. Despite its ecological and economic significance, limited systematic studies have been conducted on its zooplankton diversity and seasonal variation patterns. This knowledge gap hinders effective conservation and management strategies for the reservoir ecosystem.

The present study was therefore undertaken with the following objectives: (1) to document the zooplankton species composition in Jakham Reservoir across summer, monsoon, and winter seasons; (2) to analyze seasonal variations in zooplankton diversity and density; (3) to correlate zooplankton distribution patterns with key physicochemical parameters; and (4) to establish baseline data for future ecological monitoring and conservation efforts.

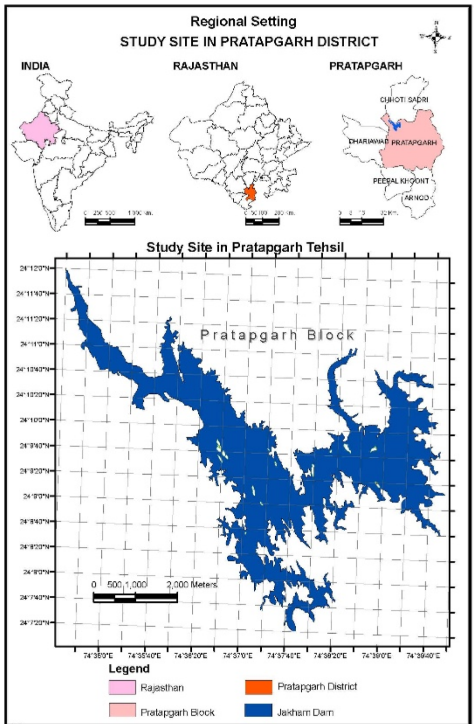
II. STUDY AREA

Jakham Reservoir is situated in Pratapgarh district, Rajasthan, India, at coordinates approximately 24°02′N latitude and 74°47′E longitude (Figure 1).

The reservoir was constructed on the Jakham River, a tributary of the Mahi River basin, and serves as a major irrigation and drinking water source for the surrounding region. The reservoir has a total surface area of approximately 15.6 square kilometres at full capacity, with a maximum depth ranging from 8 to 12 metres during the monsoon season.

The climate of Pratapgarh is tropical monsoon type, characterised by three distinct seasons: summer (March–June) with temperatures ranging from 28°C to 42°C; monsoon (July–October) with average annual rainfall of approximately 800–900 mm; and winter (November–February) with temperatures ranging from 10°C to 25°C. The reservoir catchment area is predominantly agricultural, with maize, soybean, and wheat as major crops, leading to seasonal nutrient inputs from agricultural runoff during monsoon.

The reservoir supports a diverse aquatic biota, including phytoplankton, zooplankton, macroinvertebrates, and fish species such as catla (*Catla catla*), rohu (*Labeo rohita*), and mrigal (*Cirrhinus mrigala*). However, anthropogenic pressures including agricultural intensification, domestic sewage entry, and siltation pose potential threats to the reservoir's ecological integrity.



III. METHODOLOGY

A. *Sampling Design and Frequency*

The study was conducted over a 12-month period from March 2024 to February 2025, covering three distinct seasons: summer (March–June 2024), monsoon (July–October 2024), and winter (November 2024–February 2025). Three fixed sampling stations were established along the longitudinal gradient of the reservoir: Station 1 (upstream, near river inflow), Station 2 (mid-reservoir, limnetic zone), and Station 3 (downstream, near dam site). Sampling was carried out monthly at each station between 8:00 and 10:00 AM.

B. *Zooplankton Collection and Preservation*

Zooplankton samples were collected using a plankton net (No. 25 bolting silk, mesh size 55 µm, mouth diameter 30 cm) by filtering 50 liters of reservoir water from the subsurface layer (0.5–1.0 m depth). The net was hauled vertically and horizontally for 5 minutes at each station. Concentrated samples were transferred into 100 mL polyethylene bottles and immediately preserved in 4% formalin solution (final concentration). For live observation, additional samples were collected and transported to the laboratory in cool boxes without preservation.

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C. Identification and Enumeration

In the laboratory, preserved samples were concentrated to 10 mL by sedimentation for 24 hours. One mL aliquots were placed in a Sedgwick-Rafter counting cell, and zooplankton were enumerated under a compound microscope (Olympus CX23) at 100× and 400× magnifications. Identification was performed to the lowest possible taxonomic level using standard keys by Edmondson (1992), Battish (1992), and APHA (2017). Density was calculated as individuals per liter (ind./L). A minimum of three replicate counts were performed for each sample, and average values were recorded.

D. Diversity Indices and Statistical Analysis

Zooplankton diversity was assessed using the following indices:

- Shannon-Wiener Diversity Index (H′): $H' = -\sum (p_i \ln p_i)$, where pi = proportion of individuals of species i
- Simpson's Dominance Index (D): $D = \sum (n_i/N)^2$, where ni = number of individuals of species i, N = total individuals
- Margalef's Richness Index (d): $d = (S-1)/\ln N$

IV. RESULTS

A. Species Composition and Seasonal Occurrence

A total of 25 zooplankton species belonging to 17 genera and 5 major taxonomic groups were recorded from Jakham Reservoir during the study period (Table 1). The taxonomic groups included Protozoa (8 species), Rotifera (9 species), Cladocera (6 species), Copepoda (1 species), and other groups (Tricoptera and two unidentified rotifer-like organisms). All 25 species were observed during the monsoon season, while 22 species were recorded in summer and 18 species in winter.

Table 1: Seasonal Occurrence of Zooplankton Species in Jakham Reservoir

Scientific Name	Taxonomic Group	Summer	Monsoon	Winter
Actinophrys sol	Protozoa (Heliozoa)	+	+	-
Amoeba proteus	Protozoa (Rhizopoda)	+	+	+
Brachionus plicatilis	Rotifera	+	++	+
Centropyxis aculeata	Protozoa (Testacea)	+	+	-
Coleps sp.	Protozoa (Ciliata)	+	+	+
Conochilus unicornis	Rotifera	++	++	+
Microcyclops rubellus	Copepoda	+	+	+
Scapholeberis mucronata	Cladocera	+	+	-
Daphnia magna	Cladocera	-	+	++
Daphnia cephalata	Cladocera	+	+	+
Daphnia tibetana	Cladocera	-	+	+
Daphnia carinata	Cladocera	+	++	++

Scientific Name	Taxonomic Group	Summer	Monsoon	Winter
Epistylis plicatilis	Protozoa (Peritricha)	++	+	-
Euchlanis dilatata	Rotifera	+	++	+
Euglypha acanthophora	Protozoa (Rhizopoda)	+	+	-
Moina macrocopa	Cladocera	+	++	+
Paramecium caudatum	Protozoa	++	+	+
Paramecium bursaria	Protozoa	+	+	-
Paramecium aurelia	Protozoa	++	+	-
Philodina roseola	Rotifera	+	++	+
Rotaria rotatoria	Rotifera	-	+	+
Tinodes waeneri	Tricoptera (larva)	+	+	-
Stentor coeruleus	Protozoa (Ciliata)	+	+	-
Volvox sp.	Chlorophyta (colonial)	+	+	-
Vorticella convallaria	Protozoa (Peritricha)	+	++	+

Presence: + (present), ++ (abundant), - (absent)

During summer, protozoans dominated the community, with *Paramecium caudatum*, *Paramecium aurelia*, and *Epistylis plicatilis* showing high abundance. The monsoon season recorded maximum rotifer diversity and density, particularly *Brachionus plicatilis*, *Conochilus unicornis*, *Euchlanis dilatata*, and *Philodina roseola*. Winter was characterized by the dominance of cladocerans, especially *Daphnia magna*, *Daphnia carinata*, and *Moina macrocopa*, along with consistent presence of *Microcyclops rubellus*.

B. Seasonal Variation in Zooplankton Density

The total zooplankton density exhibited pronounced seasonal variation (Table 2). The highest mean density (185.6 ± 12.4 ind./L) was recorded during the monsoon season, followed by summer (142.3 ± 10.8 ind./L), while the lowest density (98.7 ± 8.6 ind./L) was observed in winter. ANOVA revealed significant differences in total density among seasons ($F = 23.45$, $p < 0.001$).

Table 2: Seasonal Variation in Zooplankton Density (ind./L) by Taxonomic Group

Taxonomic Group	Summer (Mean ± SD)	Monsoon (Mean ± SD)	Winter (Mean ± SD)
Protozoa	68.4 ± 6.2	52.3 ± 5.1	24.6 ± 3.4
Rotifera	42.6 ± 4.8	89.4 ± 7.6	38.2 ± 4.1

Taxonomic Group	Summer (Mean ± SD)	Monsoon (Mean ± SD)	Winter (Mean ± SD)
Cladocera	24.3 ± 3.5	36.8 ± 4.2	31.5 ± 3.9
Copepoda	4.8 ± 1.2	5.2 ± 1.4	3.8 ± 0.9
Others	2.2 ± 0.6	1.9 ± 0.5	0.6 ± 0.2
Total Density	142.3 ± 10.8	185.6 ± 12.4	98.7 ± 8.6

Rotifera contributed maximally to total density during monsoon (48.2% of total), while Protozoa dominated during summer (48.1%) and Cladocera showed relatively higher contribution during winter (31.9%). Copepoda remained the least abundant group throughout the study period, with *Microcyclops rubellus* being the only representative species.

C. Diversity Indices

Diversity indices calculated for each season are presented in Table 3. The Shannon-Wiener diversity index (H′) ranged from 2.45 in winter to 3.12 in monsoon, indicating moderate to high species diversity across seasons. The monsoon season exhibited the highest species richness (S = 25) and Margalef's richness index (d = 4.56), while winter showed the lowest values (S = 18, d = 3.21). Simpson's dominance index was lowest during monsoon (D = 0.12), suggesting equitable species distribution, and highest in winter (D = 0.28), indicating dominance by fewer species. Pielou's evenness index was relatively high during all seasons (0.78–0.85), suggesting no extreme dominance by any single species.

Table 3: Seasonal Variation in Zooplankton Diversity Indices

Diversity Parameter	Summer	Monsoon	Winter
Total Species (S)	22	25	18
Shannon-Wiener Index (H′)	2.87	3.12	2.45
Simpson's Dominance Index (D)	0.18	0.12	0.28
Pielou's Evenness Index (J)	0.82	0.85	0.78
Margalef's Richness Index (d)	4.02	4.56	3.21

D. Correlation Analysis

Pearson correlation analysis revealed significant relationships between zooplankton density and physicochemical parameters (Table 5). Total zooplankton density showed positive correlation with water temperature ($r = 0.62$, $p < 0.05$), turbidity ($r = 0.71$, $p < 0.01$), and nutrient concentrations (nitrate: $r = 0.68$, $p < 0.01$; phosphate: $r = 0.65$, $p < 0.05$), while negative correlation was observed with dissolved oxygen ($r = -0.58$, $p < 0.05$). Rotifer density was strongly correlated with turbidity ($r = 0.79$, $p < 0.01$) and nitrate concentration ($r = 0.74$, $p < 0.01$), whereas cladocerans showed positive correlation with dissolved oxygen ($r = 0.69$, $p < 0.05$) and negative correlation with temperature ($r = -0.63$, $p < 0.05$).

Table 5: Pearson Correlation Coefficients between Zooplankton Density and Physicochemical Parameters

Parameter	Total Zooplankton	Protozoa	Rotifera	Cladocera	Copepoda

Parameter	Total Zooplankton	Protozoa	Rotifera	Cladocera	Copepoda
Temperature	0.62*	0.71*	0.48	-0.63*	0.32
pH	-0.24	-0.18	-0.32	0.28	-0.15
Dissolved Oxygen	-0.58*	-0.64*	-0.52	0.69*	-0.22
Turbidity	0.71**	0.42	0.79**	-0.31	0.45
Nitrate-N	0.68**	0.45	0.74**	-0.28	0.38
Phosphate-P	0.65*	0.51	0.63*	-0.35	0.41

*Correlation is significant at $p < 0.05$; **Correlation is significant at $p < 0.01$*

V. DISCUSSION

The present study documented 25 zooplankton species from Jakham Reservoir, representing a moderately diverse community compared to other tropical reservoirs in India. Similar studies have reported 22–35 species from various reservoir ecosystems (Sharma & Sharma, 2018; Saha et al., 2019; Karuthapandi et al., 2020). The dominance of rotifers during monsoon and protozoans during summer aligns with the general ecological understanding that rotifers thrive in nutrient-rich, turbid conditions associated with monsoon runoff (Fernando, 2002), while protozoans tolerate higher temperatures and lower dissolved oxygen levels characteristic of summer stratification (Wetzel, 2001).

The peak zooplankton density during monsoon (185.6 ind./L) can be attributed to several factors. First, monsoon rainfall brings nutrient-rich allochthonous inputs from the agricultural catchment, stimulating phytoplankton blooms that serve as food for zooplankton (Edmondson, 1992). The significantly higher nitrate (0.52 mg/L) and phosphate (0.24 mg/L) concentrations during monsoon support this explanation. Second, increased turbidity (28.6 NTU) during monsoon provides refuge for zooplankton from visual predators such as planktivorous fish (Battish, 1992). Third, the mixing of water column during monsoon breaks thermal stratification, redistributing nutrients and oxygen uniformly, creating favorable conditions for zooplankton growth (Saha et al., 2019).

The winter decline in zooplankton diversity and density (98.7 ind./L) is consistent with observations from other tropical reservoirs (Karuthapandi et al., 2020). Lower temperatures (18.5°C) reduce metabolic rates, feeding activity, and reproductive output of most zooplankton species. However, cladocerans, particularly *Daphnia magna* and *Daphnia carinata*, showed peak abundance during winter, possibly due to their preference for cooler temperatures, higher dissolved oxygen (7.8 mg/L), and reduced competition from rotifers and protozoans (Sharma & Sharma, 2018). *Daphnia* species are known filter-feeders that efficiently exploit phytoplankton populations during stable winter conditions (Wetzel, 2001).

The dominance of *Brachionus plicatilis* during monsoon is noteworthy, as this species is considered a cosmopolitan rotifer tolerant of wide environmental gradients and often indicates eutrophic conditions (Fernando, 2002). Similarly, the presence of *Conochilus unicornis* and *Euchlanis dilatata* during monsoon suggests high food availability, as these species are known to thrive in nutrient-enriched waters (Saha et al., 2019). The occurrence of *Volvox* sp. only during summer and monsoon aligns with its preference for warm, well-illuminated conditions (Edmondson, 1992).

The Shannon-Wiener diversity index values (2.45–3.12) indicate moderate to good water quality in Jakham Reservoir, as values below 2 typically suggest pollution stress (Sharma & Sharma, 2018). The highest diversity during monsoon ($H' = 3.12$) reflects the seasonal influx of species from upstream areas and the creation of diverse microhabitats due to fluctuating water levels. The relatively high evenness values (0.78–0.85) suggest that no single species dominated the community across seasons, indicating a stable and resilient zooplankton community (Karuthapandi et al., 2020).

Correlation analysis revealed that rotifers were strongly associated with turbidity and nutrient parameters, confirming their role as indicators of eutrophic conditions (Battish, 1992).

In contrast, cladocerans showed positive correlation with dissolved oxygen and negative correlation with temperature, explaining their winter peak. Protozoans, particularly ciliates like *Paramecium* species and *Stentor coeruleus*, thrived during summer when high temperatures (34.2°C) and low dissolved oxygen (5.6 mg/L) limited other groups, demonstrating their tolerance to stressful conditions (Wetzel, 2001).

The absence of certain species during specific seasons (e.g., *Actinophrys sol*, *Centropyxis aculeata*, and *Paramecium aurelia* absent in winter) may be attributed to their temperature sensitivity or life cycle adaptations, possibly involving cyst formation during unfavorable conditions (Edmondson, 1992). The presence of *Tinodes waeneri* (Tricoptera larva) only during summer and monsoon suggests that this species, although not a typical planktonic organism, may enter the water column during high flow periods.

Comparisons with other Indian reservoirs reveal both similarities and differences. Karuthapandi et al. (2020) reported 28 zooplankton species from Godavari River basin reservoirs, with rotifers dominating year-round, whereas in Jakham Reservoir, seasonal succession was more pronounced. Sharma & Sharma (2018) observed peak cladoceran abundance in winter from a subtropical reservoir, consistent with our findings. Saha et al. (2019) documented higher total densities (250–300 ind./L) from a eutrophic reservoir in West Bengal, indicating that Jakham Reservoir falls within a mesotrophic to eutrophic range.

The ecological implications of this study are significant for reservoir management. The seasonal pattern of zooplankton succession provides valuable information for fisheries management, as different fish species have preferences for specific zooplankton prey (Fernando, 2002). The high monsoon diversity suggests that maintaining natural flow regimes and minimising pollution inputs during this period is crucial for preserving biodiversity. The winter dominance of *Daphnia* species, which are high-quality fish food, indicates that winter might be an important period for fish growth in the reservoir.

However, several limitations of this study should be acknowledged. Sampling was limited to three stations, and monthly sampling may have missed short-term fluctuations in zooplankton populations. Additionally, phytoplankton dynamics, which directly influence zooplankton through bottom-up control, were not simultaneously studied. Future research should integrate phytoplankton and zooplankton studies with high-frequency sampling to capture rapid successional patterns.

VI. CONCLUSION

This study provides the first comprehensive documentation of seasonal variation and diversity of zooplankton in Jakham Reservoir, Pratapgarh. A total of 25 species were recorded, with the highest diversity and density during the monsoon, moderate diversity in summer, and lowest in winter. Rotifers dominated the monsoon community, protozoans prevailed in summer, and cladocerans peaked in winter. The Shannon-Wiener diversity index indicated moderate to good water quality across all seasons. Physicochemical parameters, particularly temperature, dissolved oxygen, turbidity, and nutrient concentrations, showed significant seasonal variations that correlated with zooplankton community structure. The findings establish baseline data for long-term ecological monitoring and highlight the importance of seasonal sampling in understanding reservoir ecosystem dynamics. Conservation measures should focus on controlling nutrient inputs from agricultural runoff during monsoon and maintaining riparian buffers to preserve zooplankton biodiversity and overall reservoir health.

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