DIVERSITY AND SEASONAL VARIATION OF ZOOPLANKTON IN LALIYA LAKE (GUJARAT, INDIA)

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ABSTRACT

Plankton are a fundamental component of aquatic ecosystems, serving as primary producers and bioindicators of environmental health. This study investigated zooplankton diversity and its seasonal variation in the Laliya Lake (Gujarat, north-west India) over a one-year period. In total, 24 zooplankton species were recorded during the study period, of which 12 species (44 % of total fauna) belong to Copepoda, 8 species (30 %) belong to Rotifera, and 4 species (15 %) belong to Cladocera. Zooplankton diversity was highest during the summer, followed by the winter, and lowest in the monsoon season. The relatively lower diversity in the monsoon season was attributed to water dilution effects caused by increased water inflow and other ecological disturbances. The family Cyclopidae showed remarkable species richness and seasonal stability. The diversity of copepods and rotifers indicates a relatively stable zooplankton community, as they were consistently present under different seasonal conditions.

Keywords: *Copepoda, Rotifera, plankton community, freshwater habitat*

INTRODUCTION

Freshwater ecosystems consist of abiotic and biotic components that interact to maintain ecological balance [1]. Freshwater ecosystems include diverse habitats such as rivers, lakes, streams, ponds, and wetlands [2]. These ecosystems support aquatic plants, animals and microorganisms, which play critical roles in food webs, nutrient cycling, water purification, and carbon sequestration [3]. The zooplankton community contributes to freshwater ecosystems by maintaining the aquatic food web through energy transfer from producers to consumers and acting as a bioindicator of environmental changes [4]. Freshwater zooplankton consists primarily of diverse assemblages of Rotifera, Cladocera, Copepoda, and additional groups such as Protozoa, Ostracoda, including and other invertebrate taxa [5]. They act as primary consumers of phytoplankton and bacteria, while also serving as prey for secondary consumers [6]. Their composition, diversity and abundance reflect complex interactions between abiotic and biotic factors, environmental conditions, and resource availability, making them valuable indicators of ecosystem health [7]. Zooplankton diversity and abundance are strongly influenced by physicochemical parameters, such as temperature, pH, dissolved oxygen and nutrient concentrations in the water bodies [8]. Nutrient enrichment, particularly nitrogen and phosphorus, enhance the production of phytoplankton, which affects the composition and population dynamics of the zooplankton communities [9]. Due to their sensitivity to environmental changes, they are used as bioindicators of water quality and freshwater ecosystem [10]. Copepods and rotifers are important components of freshwater zooplankton and often dominant in nutrient-rich environments [11]. Certain rotifer genera, e.g., *Brachionus* and *Keratella,* are recognized as bioindicators of eutrophication and water quality in freshwater ecosystems [12]. Similarly, copepods, particularly members of the family Cyclopidae, are commonly associated with mesotrophic and eutrophic conditions in freshwater ecosystems [13]. Previous studies have documented zooplankton diversity in the wetlands, rivers, and reservoirs of Gujarat [14]. However, many water bodies remain insufficiently documented. Therefore, the present study aims to examine the taxonomic composition and seasonal variation of zooplankton diversity, and to evaluate its potential role as a bioindicator of the water quality in Laliya Lake.

MATERIALS AND METHODS

Study area

Research work was carried out at Laliya Lake (latitude 21°20'15.0" N and longitude 72°45'12.0" E), which is a freshwater body located in Olpad, Surat District, Gujarat (northwest India) (Figure 1). The selected lake is approximately rectangular with a surface area of approximately 4.89 hectares and a maximum depth of 3.5 m.

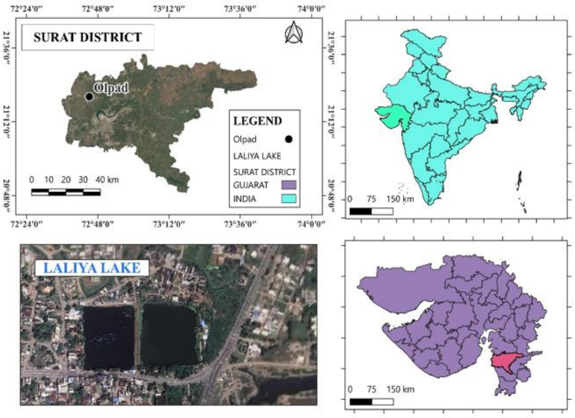

Figure 1. Study area, Laliya Lake, India

Laliya Lake is a man-made freshwater body surrounded by semi-urban areas and agricultural fields. The lake receives surface runoff from the surrounding areas and is relatively stagnant with minimal water circulation. The lake supports aquatic macrophytes, including floating species such as water hyacinth (*Pontederia crassipes*), duckweed (*Lemna* sp.) and water lilies (*Nymphaeaceae*), as well as emergent and semi-aquatic species such as *Ipomoea aquatica* and *Alternanthera philoxeroides*. The lake retains water throughout the year and is used for irrigation, domestic purposes and other local activities. However, it is affected by pollution from plastic debris and domestic waste, which significantly affects water quality.

Sampling design, collection, fixation and laboratory analysis

Zooplankton samples were collected twice a month from August 2024 to July 2025, in the early morning hours between 07:00 and 10:00 during the study period. The samples were collected using a conical plankton net with a mesh size of 25 µm and a mouth diameter of 30 cm. The net was towed horizontally at a depth of approximately 1.0 m, with 45 - 50 tows performed per sampling. The samples were transferred to pre-labelled 500 ml plastic bottles and immediately preserved with a 4 % formaldehyde solution to prevent decomposition and maintain the morphological characteristics of the plankton. The samples were observed under a binocular inverted microscope equipped with a camera and display (LM52-1803 LYNX) at magnifications of 5X, 10X, 45X and 100X. Zooplankton were identified to the lowest possible taxon using standard keys and literature [15, 16].

RESULT AND DISCUSSION

Zooplankton diversity in Laliya Lake

The present study recorded a total 24 zooplankton species from Laliya Lake (Table 1, Figure 2). Similar comparative patterns of zooplankton diversity have been documented in the freshwater bodies of Gujarat, as Chaudhari and Soni (2024) observed similar zooplankton communities in the Kanewal Community Reservoir in Central Gujarat [17]. Jani et al. (2023) described diverse zooplankton species in the wetlands of the Junagadh district [18].

Copepoda emerged as the most diverse and species-rich class, comprising 12 species (44 % of total fauna) presented in Table 1 and Figure 2. This was followed by Rotifera with 8 species (30 %) and Cladocera with 4 species (15 %), as shown in Figures 2 and 3. Along with zooplankton, other groups such as Insecta and Nematoda were also recorded; these included mayfly larvae and chironomid larvae (class Insecta) and Nematoda Rhabditiform. The species diversity gradient of zooplankton and other groups was as follows: Copepoda > Rotifera > Cladocera > Insecta > Nematoda. Similar patterns of diversity and dominance of copepods and rotifers were observed in the wetlands of the Anand and Kheda districts and various reservoirs across Saurashtra in India [19, 20]. These observations suggest that open freshwater systems in Gujarat share comparable environmental conditions, such as moderate nutrient enrichment, temperature, and suitable habitats that support similar taxonomic assemblages. Several studies have reported on copepods and rotifers diversity in tropical freshwater systems in India, where they act as primary consumers and integral components of aquatic food webs. The diversity of copepods, especially members of the family Cyclopidae, indicates mesotrophic to eutrophic conditions in this lake. The dominance of copepod species recorded in this study reflects their adaptability to nutrient-enriched and relatively stagnant freshwater systems, further confirming the eutrophic conditions of the studied water body [21].

Table 1. Seasonal occurrence of zooplankton species in Laliya Lake

	S	W	M		S	W	M
Rotifera				**Copepoda**			
Brachionus forficula (Wierzejski, 1891)	+	+	+	*Diaptomus sp.*	+	-	+
Brachionus calyciflorus (Pallas, 1766)	+	-	-	*Mesocyclops sp.*	+	+	+
Brachionus quadridentatus (Hermann, 1783)	+	+	-	*Mesocyclops leuckarti (Claus, 1857)*	+	+	+
Brachionus diversicornis (Daday, 1883)	+	-	+	*Mesocyclops aspericornis (Daday, 1906)*	+	+	+
Brachionus falcatus (Zacharias, 1898)	+	+	-	*Cyclops sp.*	+	+	+
Brachionus urceolaris (Müller, 1773)	+	-	-	*Cyclops vicinus (Uljanin, 1875)*	+	-	+
Keratella tropica (Apstein, 1907)	+	+	+	*Cyclops scutifer (Sars,1863)*	+	-	-
Keratella cochlearis (Gosse, 1851)	+	+	-	*Acanthocyclops sp.*	+	+	+
Cladocera				*Diacyclops sp.*	+	+	+
Pleuroxus sp.	+	-	-	*Eucyclops sp.*	+	+	+
Daphnia sp.	+	+	+	*Thermocyclops sp.*	+	-	+
Diaphanosoma spinulosum (Herbst, 1967)	+	+	-	Nauplius larvae	-	+	-
Bosmina sp.	+	+	+	**Total: 24**	**23**	**16**	**15**

Note: S - Summer, W - Winter, M - Monsoon; "+" indicates presence, "–" indicates absence

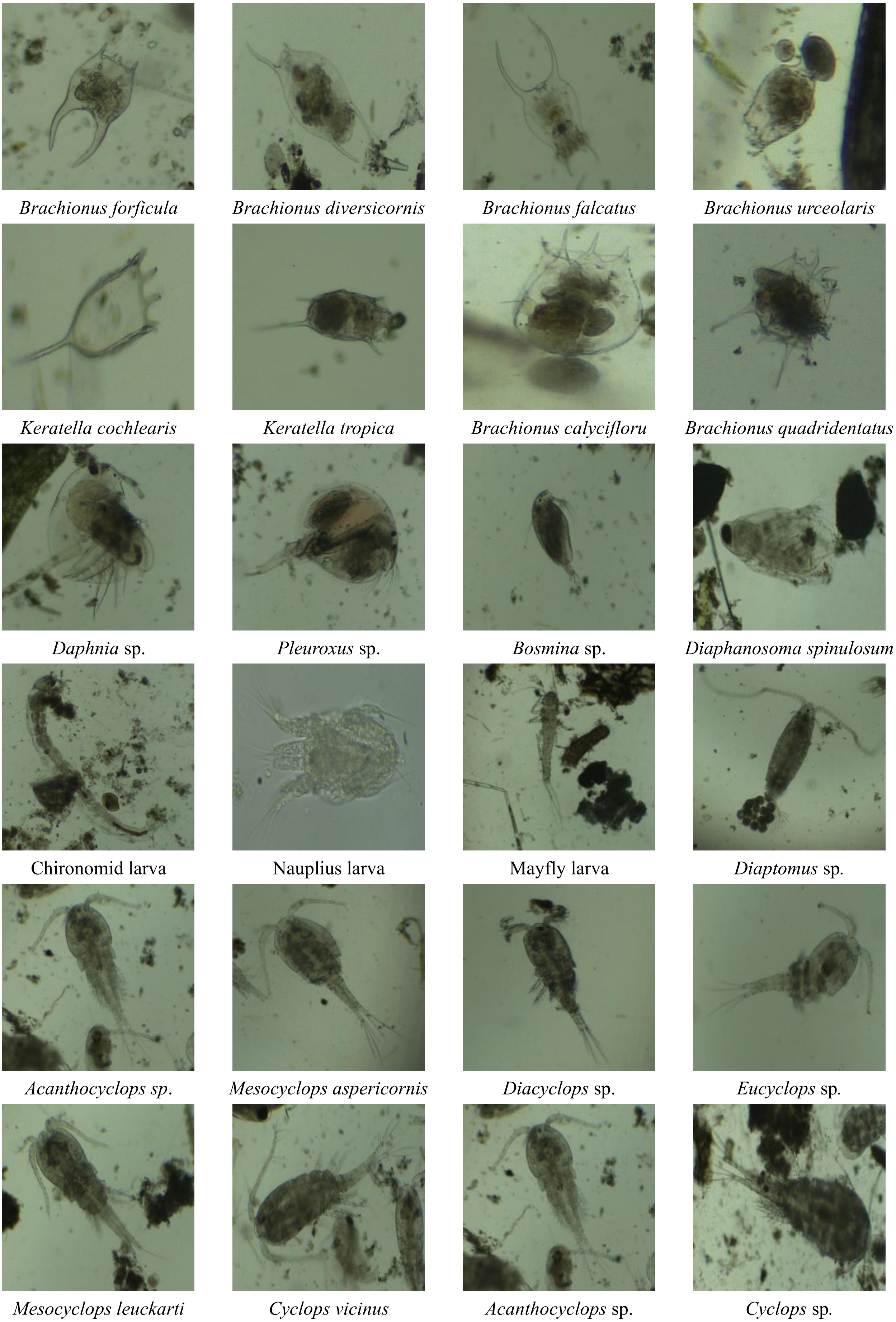

Figure 2. Zooplankton species and other macroinvertebrates

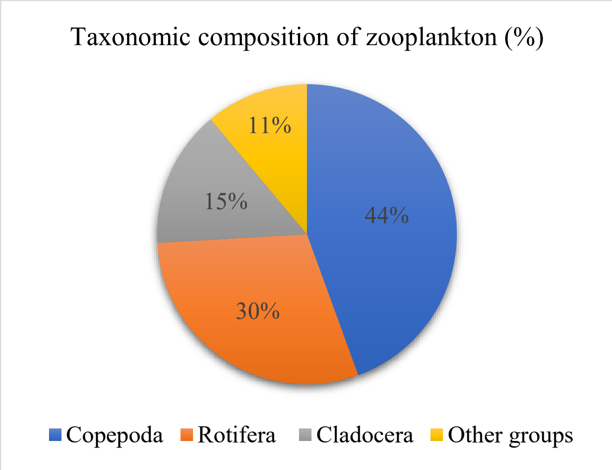

Figure 3. Relative taxonomic composition of zooplankton

Copepoda - ecological significance

In the class Copepoda, the occurrence of the family Cyclopidae across all seasons indicates their persistence and strong trophic interactions within the lake ecosystem (Table 1). Similar diversity and dominance of cyclopoids have been reported in Maharashtra, attributed to their omnivorous feeding habits and ability to tolerate fluctuations in water quality [22]. The copepods promote secondary productivity and affect lower trophic levels through selective predation [23]. The diversity of copepods observed in Laliya Lake likely regulates the lower trophic levels. Cyclopoid copepods exhibit significant feeding plasticity, as they can utilise multiple food types, including filamentous cyanobacteria that often bloom in nutrient-rich conditions associated with many eutrophic water bodies. Furthermore, their high ability to resist environmental changes broadens their distribution across a variety of freshwater habitats [24].

Rotifers as indicators of eutrophication

All rotifer species documented in Laliya Lake belonged to the family Brachionidae. The genus Brachionus was the most dominant, comprising six species as shown in Table 1 and Figure 2. In Laliya Lake, rotifers were the most diverse group after copepods, and their diversity indicates nutrient enrichment and eutrophic conditions. Similar diversity and dominance of rotifers have been reported under moderate eutrophication in other freshwater systems [25]. The composition of the rotifer community indicates that Laliya Lake exhibits eutrophic features typical of freshwater systems influenced by anthropogenic activities. Previous studies have recognised *Brachionus* species as valuable indicators of eutrophication in freshwater systems [26]. The presence of pollutant-tolerant *Keratella* species, particularly *K. cochlearis,* further suggests that the lake is undergoing eutrophic stress, reflecting their value as indicators of water quality [27]. Moreover, the coexistence of *Keratella* species further supports this interpretation of nutrient-rich tropical waters. The high diversity of algal species in eutrophic conditions may also provide a broader range of niches and food resources, thereby supporting greater rotifer diversity [28].

Cladoceran diversity and habitat conditions

The occurrence of cladoceran taxa (Table 1) indicates a moderate level of Cladocera diversity in Laliya Lake. Similar results were reported from the Amaravathi Dam in the Tirupur District, Tamil Nadu, and Lapkaman Pond in Ahmedabad, suggesting that cladoceran assemblages in nature are closely associated with freshwater bodies in India [29, 30]. Cladocerans exhibit species-specific effects on phytoplankton assemblages. In these systems, predatory groups considerably affect microzooplankton population fluctuations, concentrations of soluble nutrients, and algal abundance, as evidenced by extensive investigations conducted in freshwater ecosystems [31]. A previous study concluded that cladocerans are preyed upon by copepods and are less abundant in polluted water [32].

Seasonal variations

Seasonal variations indicated differences in zooplankton composition during the study period. Summer recorded the highest species richness, consisting of 23 species (96 %), followed by winter with 16 species (67 %), while the monsoon season had the lowest diversity with 15 species (62 %) (Figure 4, Table 1). Similar observation has been reported by many researchers, where zooplankton diversity and abundance generally increase during the summer and decrease during the monsoon season [33, 34]. Zooplankton diversity increased due to the high temperatures, food availability and favourable environmental conditions during the summer. Higher temperatures result in increased metabolic and reproductive rates, especially in rotifers, while longer photoperiods promote phytoplankton growth, ensuring that food does not become limiting [35]. This recovery trend following the monsoon has been described in water bodies of West Bengal and lakes of Maharashtra, indicating a broad regional response of monsoon disturbance followed by stabilization during the winter season [36].

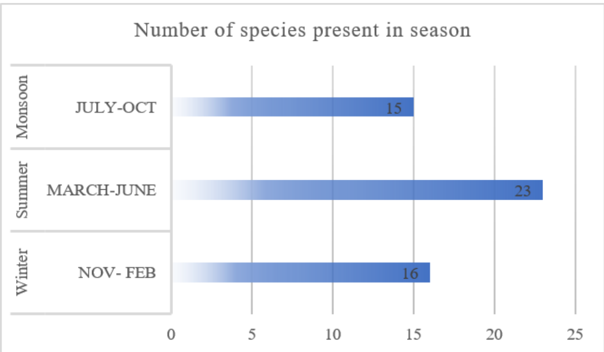

Figure 4. Number of zooplankton species in different seasons

The impact of the monsoon on zooplankton diversity

The monsoon period exhibited a marked decline in zooplankton diversity, with only 15 species documented (63 % of the total) (Figure 4, Table 1). This observation suggests that almost half of the species (38 %) were absent during the monsoon season, reflecting a 6 % reduction in species diversity compared to winter and a 35 % decline relative to summer. The decrease was most evident in Rotifera (62.5 % species loss) and Branchiopoda (50 % species loss), while Copepoda exhibited relatively greater resilience (25 % species loss).

A comparable decline related to the monsoon has been commonly documented in tropical freshwater systems of India. A previous study also noted that monsoon disturbances consistently reduced zooplankton diversity across several Indian lakes [37]. In Laliya Lake, the 35 % decrease in species richness compared to the summer findings is comparable to the results of Yannawar (2022) in the Godavari River, who documented declines in diversity following monsoon disturbances caused by environmental changes [38]. During the monsoon, high turbidity caused by runoff from the surrounding areas negatively affects the zooplankton population [39]. Heavy rainfall increases water turbidity, reducing light and limiting photosynthesis in phytoplankton, which leads to reduced food availability. This turbidity also affects phytoplankton productivity, resulting in reduced food availability and lower zooplankton abundance [40, 41].

CONCLUSION

This study documented 24 zooplankton species in Laliya Lake, with a prevalence of copepods (Cyclopidae) and rotifers (Brachionidae). The observed community structure suggests moderate eutrophication and is affected by urbanization. Seasonal patterns showed maximum diversity in summer, a minimum during the monsoon and a partial recovery in winter, which is characteristic of tropical Indian freshwater systems where differences in taxonomic response indicate the sensitivity of rotifer to ecological disturbance. These findings provide essential baseline information for future monitoring, contextualize Laliya Lake within Gujarat's freshwater biodiversity, and emphasize the management priorities to maintain zooplankton diversity and associated ecosystem services.

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