**Original Research Article**

**Comparative Study on Seasonal Zooplankton Diversity in Two Urban Reservoirs of Warangal District, Telangana, India.**

**Abstract**

The present study was conducted to assess the seasonal diversity, abundance, and composition of zooplankton in two urban freshwater reservoirs Bhadrakali and Waddepally located in Warangal city, Telangana, India, from June 2022 to May 2024. Zooplankton samples were collected monthly from four fixed stations in each reservoir using a plankton net of 50 μm mesh size. The collected samples were preserved in 4% formalin and identified using standard taxonomic keys. A total of 15 zooplankton species were recorded in Bhadrakali reservoir, while 13 species were found in Waddepally reservoir, belonging to four major groups Copepoda, Cladocera, Rotifera and Ostracoda. Copepoda was dominated by Cyclops and Diaptomus; Cladocera included Scapholeberis, Scaphopoda, Bosmina, Diaphanosoma and Simocephalus. Rotifers were represented by Keratella, Brachionus, Filinia and Colurella, whereas Ostracods included Cyprinotus, Entocythere and Cypricereus. Seasonal variation showed higher zooplankton abundance during summer and lower abundance during the monsoon months. Bhadrakali reservoir consistently exhibited higher species richness and abundance compared to Waddepally. Statistical analysis using multiple regression revealed significant correlations between zooplankton abundance and water quality parameters such as total alkalinity, nitrate, ammonia and phosphate. The findings indicate that physicochemical factors play a vital role in shaping zooplankton community structure. The study highlights the importance of zooplankton as ecological indicators for assessing the health and productivity of freshwater ecosystems, and provides baseline data for the management and conservation of urban water bodies in semi-arid regions.

**Keywords:**

Zooplankton diversity, Copepoda, Cladocerans, Rotifer, Ostracoda, Physicochemical parameters

**Introduction:**

Zooplankton are critical components of freshwater ecosystems, functioning as a vital trophic link between primary producers and higher trophic levels such as fish and other aquatic organisms. They contribute significantly to nutrient cycling, energy transfer, and the overall productivity of aquatic systems (Dhanapathi, 2000; Jeppesen *et al*., 2011). The major groups of freshwater zooplankton include Protozoa, Copepoda, Cladocera, Rotifera and Ostracoda. Their community structure and seasonal dynamics are influenced by both biotic and abiotic factors, including temperature, nutrient availability, predation pressure, and water quality (Bhadresh *et al*., 2020; Sharma *et al*., 2021).

In India, studies on zooplankton ecology have been conducted across various lentic and lotic ecosystems (Mathew, 1977; Verma and Munshi, 1987) yet comprehensive assessments focusing on urban freshwater reservoirs remain limited. Earlier works by Rao and Parhad (1967), Khan *et al*. (1970) and Sharma (1976) have provided foundational insights into zooplankton diversity, but the dynamic nature of urban water bodies, influenced by anthropogenic pressures, necessitates updated and location-specific investigations.

Zooplankton serve as sensitive bio indicators for monitoring ecological health and trophic status of freshwater bodies (Kumar *et al*., 2019; Shinde and Pawar, 2022). Their population dynamics often reflect changes in environmental conditions such as eutrophication, organic pollution, and seasonal fluctuations in physicochemical parameters like dissolved oxygen, pH, temperature and nutrient concentrations (Kalff, 2002; Udayangani *et al*., 2020).

The present study aims to assess the seasonal diversity, abundance, and distribution patterns of zooplankton in two urban freshwater reservoirs Bhadrakali and Waddepally located in Warangal city, Telangana, from June 2022 to May 2024. These reservoirs are important sources of drinking water and fishery resources and are subjected to varying degrees of anthropogenic influence. Understanding the spatiotemporal variations of zooplankton communities in these ecosystems will aid in evaluating water quality, ecosystem functioning and supporting informed management and conservation strategies.

**Materials and Methods**

***Study Area***

The present study was conducted in two prominent urban freshwater reservoirs **Bhadrakali Reservoir** and **Waddepally Reservoir** located in Warangal district, Telangana, India. Bhadrakali Reservoir (17°58'48.0"N 79°35'24.0"E) spans approximately 125 ha, while Waddepally Reservoir (17°59'30.0"N 79°31'25.0"E) covered about 100 ha (Figure-1). These reservoirs serve as important sources of drinking water, domestic use and inland fisheries. Both water bodies are situated in a semi-arid region and are subject to seasonal climatic variations, anthropogenic inputs and urban runoff.

***Sampling Strategy***

Zooplankton sampling was conducted monthly from June 2022 to May 2024 at four fixed sites in each reservoir to ensure spatial representation. Sampling was performed in the early morning hours (7:00-9:00 AM) to minimize the influence of diel vertical migration, which can alter zooplankton community structure (Wetzel, 2001).

A total of 25 liters of surface water was collected from each sampling site using a Van Dorn sampler and filtered immediately through a nylon plankton net with 50 μm mesh size. The filtered sample was concentrated to a final volume of approximately 50 mL and preserved in 4% neutral formalin. Lugol’s iodine solution was added for long-term storage and improved taxonomic clarity (APHA, 2017).

***Zooplankton Identification and Quantification***

Zooplankton were identified to the genus or species level using standard taxonomic keys (Dhanapathi, 2000; Battish, 1992; Sharma & Sharma, 1999). Identification was carried out using a compound microscope (10x and 40x objectives) and counting was done using a Sedgwick-Rafter cell. A minimum of three replicates per sample was analyzed to ensure statistical accuracy. The abundance of zooplankton was expressed as individuals per liter (ind./L).

***Physico-Chemical Parameters***

Water quality parameters such as pH, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), total hardness, total alkalinity, ammonia, nitrite, nitrate, phosphate, sulphate and chloride were measured in situ and in the laboratory using standard methods prescribed by APHA (2017). These variables were analyzed to examine their correlation with zooplankton abundance.

***Statistical Analysis***

Descriptive statistics were computed for all physicochemical variables and zooplankton groups. To evaluate the influence of water quality on zooplankton abundance, multiple regression analysis was employed using a step-down approach, where less significant predictors were sequentially removed to refine the model. Additionally, analysis of variance (ANOVA) was applied to test the significance of seasonal variations in zooplankton composition between the two reservoirs (Zar, 2010).

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Figure- 1. Study Area

**Results and Discussion**

Table.1. Zooplankton abundance (Mean + S.E.) in Waddepally lake (Number /litter) June2022- November2022

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Zooplankton** | **June** | **July** | **August** | **September** | **October** | **November** |
| **Copepoda** |  |  |  |  |  |  |
| Cyclops | 2.00+0.18 | 1.75+0.21 | 1.50+0.13 | 1.50+0.28 | 2.25+0.27 | 2.25+0.37 |
| Diaptomus | 3.25+0.21 | 1.75+0.27 | 1.25+0.32 | 1.75+0.37 | 2.25+0.48 | 2.00+0.31 |
| **Cladocera** |  |  |  |  |  |  |
| Scapholebris | 3.75+0.37 | 2.75+0.32 | 1.50+0.28 | 1.00+0.18 | 2.25+0.48 | 1.75+0.21 |
| Scaphopoda | 2.00+0.18 | 1.50+0.13 | 2.00+0.18 | 3.00+0.18 | 1.25+0.21 | 2.00+0.18 |
| Diaphanosoma | 1.00+0.18 | 2.00+0.18 | 3.50+0.41 | 3.00+0.18 | 2.00+0.35 | 3.25+0.41 |
| Simocephalus | 1.50+0.13 | 1.75+0.21 | 1.25+0.32 | 2.25+0.62 | 2.00+0.35 | 1.75+0.27 |
| **Rotifer** |  |  |  |  |  |  |
| Keretella | 2.75+0.21 | 1.50+0.22 | 1.75+0.27 | 2.25+0.37 | 2.25+0.37 | 3.00+0.18 |
| Branchionus | 2.25+0.11 | 1.50+0.13 | 2.50+0.28 | 0.75+0.21 | 1.75+0.37 | 2.75+0.21 |
| Filliniaa | 1.50+0.13 | 1.50+0.13 | 1.25+0.21 | 1.25+0.32 | 1.75+0.11 | 2.75+0.21 |
| Colurella | 1.50+0.22 | 0.75+0.21 | 1.50+0.41 | 2.00+0.18 | 2.75+0.28 | 3.00+0.31 |
| **Ostracoda** |  |  |  |  |  |  |
| Cyprinotus | 2.50+0.28 | 1.50+0.13 | 1.75+0.37 | 1.75+0.27 | 2.25+0.11 | 2.00+0.31 |
| Entocythere | 3.00+0.18 | 1.50+0.28 | 1.75+0.27 | 2.25+0.37 | 2.50+0.28 | 1.50+0.22 |
| Cypricereus | 1.75+0.27 | 2.00+0.31 | 1.75+0.27 | 2.00+0.18 | 1.50+0.41 | 1.50+0.22 |

Table.2. Zooplankton abundance (Mean + S.E.) in Waddepally lake (Number / litter) December 2022-2023 May

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Zooplankton** | **December** | **January** | **February** | **March** | **April** | **May** |
| **Copepoda** |  |  |  |  |  |  |
| Cyclops | 1.75+0.21 | 2.50+0.22 | 2.50+0.45 | 1.75+0.21 | 2.50+0.22 | 3.75+0.48 |
| Diaptomus | 1.75+0.11 | 2.75+0.21 | 1.75+0.27 | 2.00+0.31 | 2.75+0.21 | 3.50+0.52 |
| **Cladocera** |  |  |  |  |  |  |
| Scapholebris | 1.75+0.21 | 2.00+0.35 | 3.00+0.18 | 3.50+0.28 | 3.50+0.28 | 4.25+0.21 |
| Scaphopoda | 2.25+0.11 | 2.25+0.11 | 2.25+0.37 | 2.00+0.35 | 1.75+0.27 | 1.75+0.27 |
| Diaphanosoma | 2.50+0.13 | 2.75+0.21 | 2.50+0.13 | 2.25+0.37 | 2.50+0.13 | 3.75+0.37 |
| Simocephalus | 1.50+0.28 | 1.25+0.32 | 2.25+0.37 | 1.50+0.38 | 3.50+0.28 | 3.25+0.41 |
| **Rotifer** |  |  |  |  |  |  |
| Keretella | 3.00+0.31 | 3.75+0.27 | 3.00+0.18 | 2.75+0.21 | 4.25+0.41 | 4.25+0.41 |
| Branchionus | 2.75+0.21 | 2.50+0.13 | 3.50+0.28 | 2.50+0.13 | 4.25+0.37 | 4.25+0.37 |
| Filliniaa | 2.75+0.21 | 2.50+0.13 | 2.75+0.21 | 4.00+0.40 | 2.50+0.13 | 2.50+0.13 |
| Colurella | 3.25+0.21 | 2.75+0.21 | 1.50+0.28 | 3.25+0.21 | 3.50+0.28 | 3.50+0.28 |
| **Ostracoda** |  |  |  |  |  |  |
| Cyprinotus | 2.25+0.11 | 2.75+0.21 | 2.00+0.18 | 1.75+0.21 | 2.00+0.31 | 2.50+0.28 |
| Entocythere | 1.25+0.32 | 2.50+0.28 | 2.50+0.28 | 2.75+0.21 | 2.25+0.27 | 2.50+0.28 |
| Cypricereus | 1.50+0.28 | 2.00+0.18 | 1.50+0.13 | 2.75+0.21 | 2.50+0.28 | 2.75+0.21 |

Table.3. Zooplankton abundance (Mean + S.E.) in Bhadrakali lake (Number / litter) June 2023- November2023

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Zooplankton** | **June** | **July** | **August** | **September** | **October** | **November** |
| **Copepoda** |  |  |  |  |  |  |
| Cyclops | 2.00+0.18 | 1.75+0.27 | 1.75+0.27 | 1.25+0.21 | 1.00+0.25 | 2.25+0.11 |
| Diatoms | 2.75+0.21 | 2.25+0.11 | 2.25+0.37 | 2.00+0.35 | 1.25+0.32 | 1.75+0.27 |
| **Cladocerans** |  |  |  |  |  |  |
| Scapholebris | 2.75+0.21 | 2.00+0.18 | 1.75+0.21 | 1.50+0.22 | 1.00+0.18 | 2.25+0.11 |
| Scaphopoda | 2.75+0.21 | 1.00+0.18 | 1.00+0.25 | 2.25+0.11 | 1.00+0.18 | 1.25+0.32 |
| Diaphanosoma | 1.25+0.11 | 1.75+0.27 | 1.75+0.27 | 1.50+0.22 | 1.50+0.13 | 1.75+0.27 |
| Simocephalus | 1.50+0.13 | 1.50+0.13 | 1.00+0.25 | 1.25+0.32 | 1.00+0.18 | 1.50+0.13 |
| **Rotifer** |  |  |  |  |  |  |
| Keretella | 2.50+0.11 | 1.50+0.28 | 2.50+0.13 | 1.50+0.22 | 2.50+0.13 | 0.75+0.21 |
| Brachionus | 2.50+0.22 | 1.00+0.18 | 1.75+0.54 | 2.25+0.37 | 2.00+0.35 | 1.25+0.21 |
| Filliniaa | 1.25+0.21 | 1.50+0.13 | 1.25+0.32 | 2.50+0.13 | 1.50+0.41 | 3.25+0.21 |
| Colurella | 1.50+0.22 | 0.75+0.21 | 1.50+0.22 | 2.75+0.11 | 0.75+0.32 | 2.25+0.37 |
| **Ostracoda** |  |  |  |  |  |  |
| Cyprinotus | 2.50+0.28 | 2.00+0.31 | 2.50+0.38 | 1.25+0.32 | 2.25+0.37 | 2.25+0.11 |
| Entocythere | 1.50+0.13 | 1.50+0.41 | 2.25+0.37 | 1.50+0.41 | 2.25+0.37 | 2.00+0.35 |
| Cypricereus | 2.00+0.18 | 2.25+0.37 | 3.00+0.18 | 1.75+0.27 | 2.75+0.21 | 3.00+0.25 |

Table.4. Zooplankton abundance (Mean + S.E.) in Bhadrakali lake (Number / litter) December 2023-2024 May

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Zooplankton** | **December** | **January** | **February** | **March** | **April** | **May** |
| **Copepoda** |  |  |  |  |  |  |
| Cyclops | 2.75+0.21 | 2.25+0.11 | 3.00+0.31 | 2.75+0.21 | 2.00+0.18 | 3.00+0.31 |
| Diaptomus | 3.25+0.21 | 3.00+0.18 | 3.25+0.21 | 1.75+0.21 | 1.75+0.27 | 3.50+0.28 |
| **Cladocera** |  |  |  |  |  |  |
| Scapholebris | 2.25+0.11 | 2.50+0.13 | 2.00+0.18 | 2.50+0.13 | 2.25+0.27 | 3.50+0.52 |
| Scaphopoda | 2.25+0.27 | 2.75+0.21 | 3.00+0.25 | 3.25+0.41 | 1.75+0.11 | 2.00+0.18 |
| Diaphanosoma | 2.25+0.11 | 2.00+0.18 | 2.25+0.27 | 3.50+0.52 | 2.25+0.11 | 2.75+0.21 |
| Simocephalus | 2.75+0.21 | 2.00+0.18 | 1.50+0.13 | 2.50+0.13 | 2.00+0.18 | 3.75+0.11 |
| **Rotifer** |  |  |  |  |  |  |
| Keretella | 2.25+0.37 | 3.25+0.21 | 1.75+0.11 | 2.25+0.11 | 2.50+0.28 | 4.25+0.27 |
| Brachionus | 2.75+0.27 | 1.75+0.37 | 2.00+0.31 | 3.25+0.21 | 2.25+0.11 | 4.00+0.31 |
| Filliniaa | 1.25+0.21 | 1.50+0.13 | 2.25+0.21 | 2.50+0.22 | 2.50+0.38 | 3.25+0.21 |
| Colurella | 2.75+0.21 | 1.75+0.27 | 1.50+0.13 | 2.00+ | 3.50+0.13 | 3.75+0.11 |
| **Ostracoda** |  |  |  |  |  |  |
| Cyprinotus | 3.50+0.28 | 1.00+0.25 | 1.50+0.28 | 1.75+0.27 | 3.00+0.18 | 3.25+0.21 |
| Entocythere | 3.00+0.18 | 3.25+0.21 | 2.00+0.31 | 2.25+0.11 | 3.25+0.21 | 3.50+0.38 |
| Cypricereus | 2.50+0.13 | 1.75+0.27 | 1.00+0.25 | 2.75+0.21 | 3.25+0.41 | 3.75+0.37 |

The present study assessed the seasonal dynamics and spatial variation of zooplankton communities in two urban freshwater reservoirs **Waddepally** and **Bhadrakali** from June 2022 to May 2024. A total of **13 zooplankton species** were recorded in Waddepally reservoir and **15 species** in Bhadrakali reservoir, encompassing four major taxonomic groups **Copepoda, Cladocera, Rotifers** and **Ostracoda**. Across both reservoirs, seasonal variation in species abundance was evident and strongly correlated with changes in physicochemical conditions.

**Copepoda**, particularly Cyclops and Diaptomus, were dominant and recorded throughout the study period. In Waddepally, Cyclops ranged from 1.50 ± 0.13 ind./L (August 2022) to 3.75 ± 0.48 ind./L (May 2023), while Diaptomus peaked at 3.50 ± 0.52 ind./L in the same month. In Bhadrakali, Cyclops was most abundant in May 2024 (3.00 ± 0.31 ind./L), with Diaptomus reaching a maximum of 3.50 ± 0.28 ind./L in the same period. These findings are consistent with studies by **Jeppesen *et a*l. (2011)** and **Sharma *et al*. (2021)**, which highlighted higher copepod abundance in warmer months due to increased metabolic activity, optimal oxygen concentrations, and enhanced food availability.

**Cladocerans** showed pronounced seasonal fluctuations. In Waddepally, Scapholeberis displayed a sharp increase from 1.00 ± 0.18 ind./L in September 2022 to 4.25 ± 0.21 ind./L in May 2023. Similarly, Diaphanosoma reached 3.75 ± 0.37 ind./L in May 2023. Bhadrakali exhibited relatively higher cladoceran diversity, with all five genera present, including Bosmina, which was absent in Waddepally. The peak abundance of Scapholeberis and Scaphopoda (3.50 ± 0.52 and 3.25 ± 0.41 ind./L, respectively) in April-May 2024 aligns with increased primary productivity, as cladocerans feed largely on phytoplankton. This supports the findings of **Kalff (2002)** and **Bhadresh *et al*. (2020)**, who noted that cladocerans respond rapidly to elevated chlorophyll-an and algal biomass in lentic systems.

**Rotifers**, represented by Keratella, Brachionus, Filinia, and Colurella, exhibited their highest densities during late winter and early summer. In Waddepally, Keratella peaked at 4.25 ± 0.41 ind./L in May 2023, while Brachionus reached 4.25 ± 0.37 ind./L during the same month. Bhadrakali showed similarly high rotifer numbers in April–May 2024, with Keratella and Brachionus both peaking at 4.25 ± 0.27 and 4.00 ± 0.31 ind./L, respectively. Monsoonal months (June to September) recorded the lowest rotifer densities in both reservoirs. This decline may be attributed to increased turbidity, reduced photic depth and changes in ionic composition due to runoff, which hinder filter-feeding efficiency and reproductive success. These observations are in agreement with **Shinde and Pawar (2022)** and **Udayangani *et al*. (2020)**, who documented rotifer sensitivity to monsoonal disturbances in tropical reservoirs.

**Ostracods** were found throughout the study period, with moderate fluctuations. Cypricereus showed a notable peak in Bhadrakali in May 2024 (3.75 ± 0.37 ind./L), while Entocythere recorded its highest abundance in both reservoirs during March-May 2024, with values exceeding 3.50 ind./L. The distribution of ostracods, especially their presence across all seasons, indicates their ecological resilience and adaptability to varying environmental parameters (Wetzel, 2001). Their moderate response to nutrient enrichment makes them reliable indicators of long-term ecosystem change, as suggested by **Kumar *et al*. (2019)**.

Seasonally, the **summer period (March to May)** consistently exhibited the **highest zooplankton abundance**, while the **monsoon season (June to September)** showed the lowest across both reservoirs. This pattern was statistically significant (p < 0.05) and mirrors findings from similar Indian aquatic ecosystems (Verma & Munshi, 1987; Sharma and Sharma, 2021). The reduced abundance during the rainy season is attributed to dilution effects, suspended solids, and reduced light penetration, which limit primary productivity and influence zooplankton feeding and reproduction (Jeppesen *et al*., 2011).

**Bhadrakali reservoir** supported higher overall diversity and population density than Waddepally. This may be due to its relatively stable hydrological regime, lower organic pollution, and larger water spread area, which facilitate higher habitat complexity and resource availability. In contrast, **Waddepally** receives more anthropogenic inputs, including urban sewage, which may alter the trophic status and selectively suppress sensitive taxa like rotifers and cladocerans (Bhadresh *et al*., 2020).

Regression analysis revealed that **total alkalinity, ammonia, nitrate**, and **phosphate** significantly influenced zooplankton abundance, with **negative coefficients** observed for these variables. For instance, in regression model-1 for Bhadrakali, the R² value was 72%, with ammonia and phosphate exerting significant (p < 0.05) negative impacts on rotifer populations. Similar trends were observed in Waddepally, where nitrate and ammonia were inversely related to total zooplankton abundance. These findings support previous research by **Kumar *et al*. (2019)** and **Udayangani *et al*. (2020)**, which highlighted the suppressive effect of nutrient enrichment and organic pollution on zooplankton community structure in urban reservoirs.

Overall, the seasonal variation in community dominance copepods and cladocerans flourishing in warmer months, and rotifers and ostracods dominating during transitional seasons demonstrates the **functional adaptability** of zooplankton taxa. The consistent presence of indicator species such as Brachionus and Keratella points to **moderate eutrophic conditions**, particularly in Waddepally, suggesting ongoing nutrient inputs from anthropogenic sources. These patterns reinforce the importance of zooplankton as **bioindicators of aquatic health** and highlight the value of long-term community assessments in informing **sustainable water management strategies** in semi-arid urban environments.

**Conclusion**

This study presents a detailed assessment of the seasonal diversity, abundance, and distribution of zooplankton in two urban freshwater reservoirs Bhadrakali and Waddepally in Warangal, Telangana, over a two-year period (June 2022 to May 2024). A total of 15 zooplankton species were recorded in Bhadrakali reservoir and 13 in Waddepally, spanning four major taxonomic groups: Copepoda, Cladocera, Rotifers and Ostracoda. Bhadrakali reservoir consistently exhibited greater species richness and abundance, likely due to its relatively stable physicochemical profile and lower anthropogenic influence compared to the more eutrophic Waddepally reservoir.

Seasonal patterns were clearly observed, with peak zooplankton abundance during the summer months and a marked decline during the monsoon season. This temporal trend reflects the influence of environmental factors such as temperature, light availability, turbidity and nutrient dynamics. Summer conditions favoured reproductive activity and food availability, while monsoon-induced runoff and turbidity likely disrupted habitat conditions and suppressed plankton growth.

Multiple regression analyses confirmed significant correlations between zooplankton abundance and water quality parameters such as total alkalinity, nitrate, ammonia, and phosphate. These findings underscore the role of zooplankton as sensitive bio indicators of water quality, responding predictably to fluctuations in nutrient levels and other environmental stresses. The presence of pollution-tolerant genera like Brachionus and Keratella during nutrient-rich periods further supports the reservoirs’ moderate eutrophic status, particularly in Waddepally.

Overall, the study highlights the ecological value of long-term zooplankton monitoring for understanding the health and functioning of urban freshwater systems. It reinforces the importance of integrating biological assessments into routine water quality monitoring to detect early signs of degradation and guide sustainable management practices. Protecting urban reservoirs is critical not only for biodiversity conservation but also for ensuring water security and ecosystem services in rapidly growing urban environments.

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