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Research paper

Seasonal Distribution of Zooplankton Diversity in Tavarekere Lake of Kodagu District, Karnataka

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ABSTRACT

The quality of an aquatic habitat is measured by its species diversity. The study was carried out to document the zooplankton diversity in Tavare kere Lake of Kodagu, Karnataka.The water samples were collected from June 2020- May 2021. 16 species belonging to Rotifers, Cladocerans, Copepods, and Nematodes were documented. Rotifers were abundant at 50%, followed by Copepods at 31%, Cladocera at 13%, and Nematodes at 6%. The population density followed the order; Rotifers> Copepods> Cladocerans> Nematodes, with the highest population in the pre-monsoon season (summer) and the lowest population recorded in the monsoon season. The Canonical Correspondense Analysis plot showed a positive correlation between zooplankton and surface water temperature. This work is a baseline data of zooplankton diversity in Lakes of Kodagu district.

1. Introduction

Freshwater ecosystems have been significantly affected in the past few decades because of habitat degradation, water pollution, and invasive species (Agostinho et al., 2009). Natural bio indicators of pollution like phytoplankton and zooplankton, play an important role in protecting freshwater habitats (Altshner et al., 2011).

Zooplankton are nutrient and energy transmitters between primary producers and consumers of aquatic communities (Almeda et al., 2020). Zooplankton are important to ecosystems as each organism performs a set of functions (nutrient cycling, an integral part of food chains) in the ecosystem, and any variation can lead to ecosystem imbalance (Jeelani Kaur and Kumar 2008).

Zooplankton are sensitive to environmental change (Kehayias et al., 2014). Any variation in their abundance and diversity is an indicator of changes in the trophic state and water quality (Munoz et al., 2021). The distribution of zooplanktons majorly depends upon its ability to adjust with abiotic factors like dissolved oxygen (DO), biological oxygen demand

(BOD), total dissolved solids (TDS), surface water temperature, pH and biotic factors like nutrient availability, algal bloom toxins (Umi et al., 2018; Pinto et al., 2023). The growth of zooplankton is also dependent on the phytoplankton abundance in the community (Liu et al., 2023).

Eutrophication in lakes severely affects the zooplankton habitats(Cabarel et al. 2020; Le Quesne et al. 2020). Increased eutrophic conditions lead to small species in a community (Derevenskaia, Borisova, and Unkovskaia 2021).

Species diversity of any community consists of two factors: species richness and species evenness. Species richness is the ratio of different species (S) to the total number of species (N) in the community. Species evenness is the measure of species distribution. Mathematical indices are employed to calculate these parameters, including Shannon's diversity index, Simpson's diversity index, and Pielou's eveness index.

The study was conducted to

1) To analyze the zooplankton abundance, diversity, and distribution at the sampling site.
1. To evaluate the physico chemical parameters of Lake water and their impact on zooplankton distribution.

This study hypothesizes that zooplankton diversity is influenced by environmental parameters.

2. Materials and Methods

2.1 Study area

Samples were collected from Tavarekere Lake in Kodagu District, Karnataka State, India (Fig. 1) (12.4555° N, 75.957° E). Sample sites were selected where anthropogenic activities are more. The geographical locations of the sites were noted using GPS, and the depths of the lake was measured using a weighted line.

2.2 Physicochemical analysis of the water

Water samples were collected monthly during the morning period from 7 AM to 9 AM from June 2020 to May 2021. Parameters such as water temperature was measured on-site. Parameters such as pH, TDS, and EC were measured immediately upon reaching the laboratory. DO and nitrates were measured according to the guidelines of the APHA (1998).

2.3 Sampling method

Water samples were collected using a zooplankton net. The collected samples were immediately preserved in 4% formalin and Lugol's iodine solution (John 2000) and then transferred to the laboratory for further analysis. The samples were concentrated by centrifugation and observed under a microscope for identification. The Sedgewick rafter method was used to enumerate the number of cells, which was recorded as org/L. The counting was performed in triplicate. The formula used was;

$$N = nxv/V$$

where N= Total number of zooplankton per liter, n is the average number of plankton in 1 ml of sample, v is the volume of plankton concentrated, and V is the volume of water sample (Goswami 2004). Zooplankton were identified using standard references (Dhanpathi 2000; Battish 1992; Goswami 2004).

2.4 Statistical analysis

The physicochemical data of the samples were calculated using Microsoft Excel, and the graphs were plotted using GraphPad Prism 10. Diversity indices, Pearson Correlation Analysis and Canonical Correspondence Assay were calculated using PAST 4.03.

3. Results

The study was carried out from June 2020- May 2021. To analyse the relation of physicochemical analysis of water with zooplankton diversity, few water parameters were chosen. The water temperature is shown in Fig 1. The surface temperature varied from 21.5^0 C to 30.1^{0}C in post monsoon season. The values of pH varied from 6.2 to 8.1 through the season. The conductivity varied from 52.28 to 70.94 µS cm^{-1}.The value of dissolved oxygen varied from 5.8 to 8.9 mg l^{-1}. The concentration of nitrate varied from 0.11 to 2.4 mg l^{-1}. The concentration of dissolved oxygen was highest during post monsoon period and lowest during monsoon period. The concentration of nitrate was highest in the pre-monsoon period and lowest in monsoon period.

During the study, a total of 16 taxa were recorded (Table 1). Zooplanktons belonging to 4 classes were recorded, namely Rotifers, Cladocerans, Copepods and Nematodes. The species number and diversity varied seasonally with lowest taxon number (one taxon) in December, the highest taxon (five taxon) in the month of June. Rotifers comprises of 8 species belonging to 5 genus.Seasonally the number was highest in in pre monsoon (2100 org/L) and lowest in Post monsoon (1660 org/L). In Cladocera, 2 species were recorded namely *Ceriodaphina chorata, Moina brachyata.* The seasonal distribution was 1830 org/L in Monsoon period and 940 org/L in the post monsoon period. Copepoda comprises of 5 species namely, *Maxillopoda* sp*., Mesocyclops leukarti, Cyclops* sp*., Diaptomus castor,* and *Naupilis* sp*.* The seasonal distribution was 1610 org/L in monsoon period, 1560 org/L in pre monsoon, and 1460 org/L in post monsoon period.

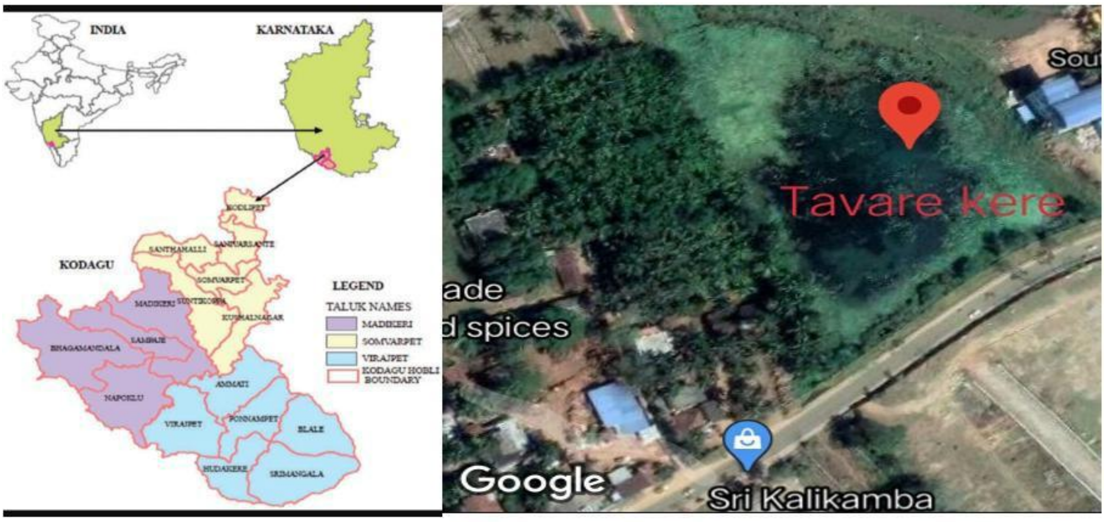
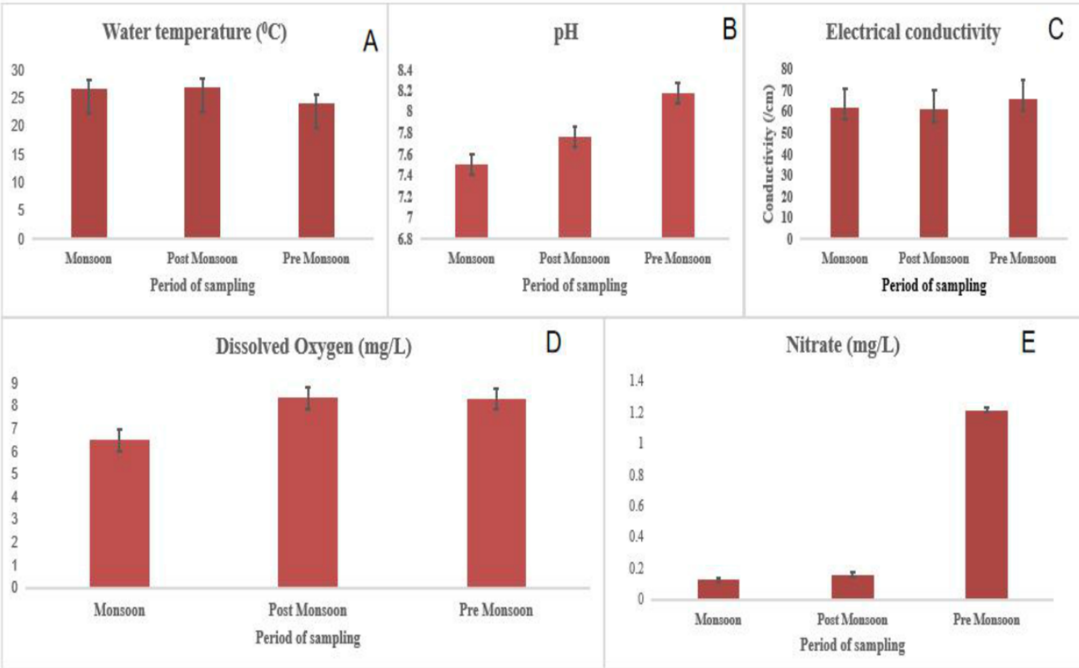
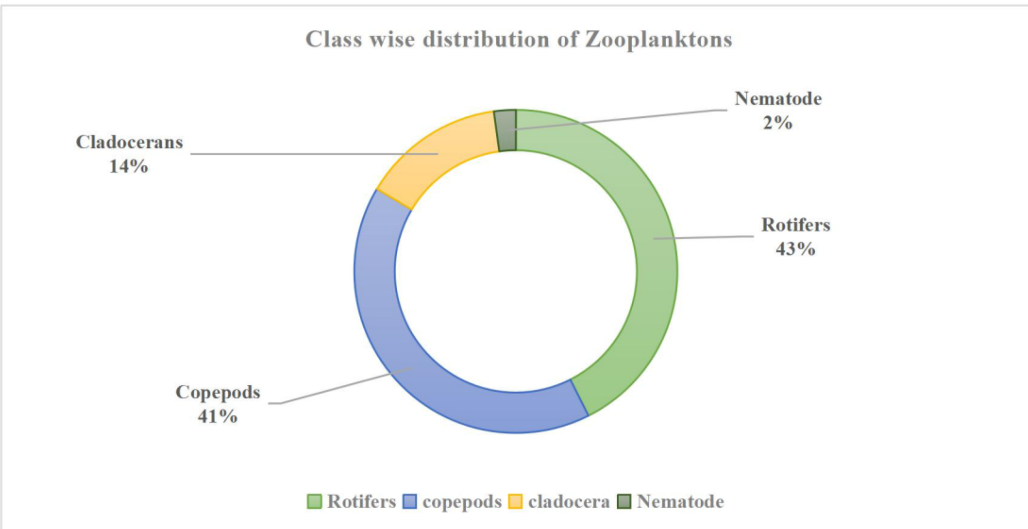


Fig 1: The sampling site



Graph 1: A. Water temperature , B. pH, C. Electrical Conductivity, D. Dissolved oxygen, E.Nitrate



Graph II Class wise distribution of zooplanktons

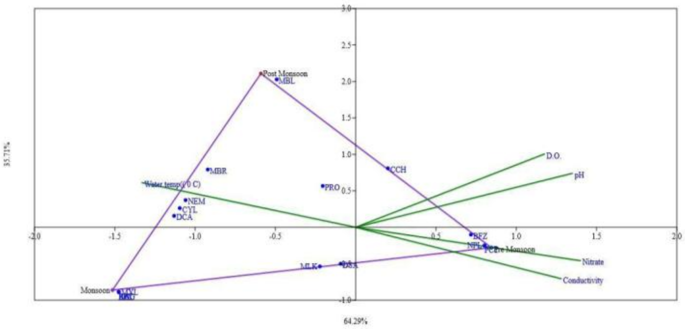
Nematode was documented, with seasonal distribution of 160 org/L in monsoon period and 120 org/L in post monsoon. The distribution of zooplankton is Rotifers with 43%, followed by Copepods with 41%, Cladocera with 14% and Nematodes with 2% (Graph II).

The diversity indices of the sampling site are stated in Table1. The Shannon diversity index (Shannon_H) value is 2.66, the Simpson diversity index (Simpson_1-D) value is 0.92, whereas, the Pieolou's evenness index is 0.89, the magarleif index is 1.58, the Menhinick index is 0.14.

Table 1 The different diversity index values of zooplankton in Tavarekere lake (June 2020-May 2021)

Diversity indexex	Values obtained
Dominance_D	0.0752
Simpson_1-D	0.9248
Shannon_H	2.662
Evenness_e^H/S	0.8953
Brillouin	2.657
Menhinick	0.1405
Margalef	1.584
Equitability_J	0.9601
Fisher_alpha	1.801
Berger-Parker	0.1203

Canonical Correspondence analysis plot showing the relation between the environmental parameters like Temperature, EC, pH, TDS and nitrate with zooplankton species diversity (Graph III). The axis 1 shows a correlation of 64.29% and axis 2 shows a correlation of 35.71%. In CCA plots, the length of variable (Physicochemical water parameters) determ-ines their significance and is equal to the rate of change of variables. The positions of species distribut-ion shows their preferred habitats. In our study all the 5 parameters chosen shows a spatial distribution, which corresponds to their significance to the study. However, out of 16 species, 4 preferred a higher temperature condition(Nematodes (NEM), *Cyclops* sp. (CYL), *Diaptomus castor* (DCA), *and Monostyla bulla* (MBR)), 3 species (*Branchionus falcatus* (BFZ) , *Philodena citrina* (PCL) and Naupilis sp. (NPL)) showed a preference to moderate pH and nitrate concentration. The remaining 9 species preferred the moderate concentration of enviro-nmental parameters.



Graph III Canonical Correspondence Analysis plot showing a correlation between the phyico chemical water parameters and distribution of zooplanktons

4. Discussion

The importance of assessing water parameters to understand the quality of fresh water habitats has been established by many workers (Mitra 1995; Kataria *et al.*1996; Kudesia 2000; Sunkad 2008) The water surface temperature values were found to be within the permissible limit set by WHO (2008). However, it has been reported that, increasing rate of temperature, influences the increase of chemical and biological parameters of a water body (Murugesan *et al.*, 2004). Zoopalnkton are reported to be poikilotherms, and depend on water temperature for their physiological processes. As reported by Ishfaq and Khan (2013) they multiply in doubles or triples with increase in water temperature up to 10^0C . The same was observed in our study with three zooplanktons, with Nematode, *Cyclops* sp., and *Diaptomus castor* preferring a habitat with high water temperature.

pH is one of the important water parameter to be assessed to understand the trophic state of any water body, as low pH indicates to an corrosive nature of water, and pH also has a positive correlation with electrical conductivity (Gupta et al., 2009; Bhalla and Waykar 2012). Suárez-Morales (2015), have classified Cyclops sp., of Copepods as mesoionic group, based on their pH tolerance, and found that these species prefers a pH range of 6.5-8 which was observed in the month of June (Table 2).

Electrical conductivity is the measure of a solutions ability to conduct electricity. It's the measure of quality and quantity of ions, and its valency.Workers have found measuring Electrical conductivity of water bodies is a good parameter to understand the water quality (Gaikwad et al., 2008).

Zooplankton diversity is considered as an bio indicator by many workers, its found that the zooplankton diversity varies with the water quality (Litchman et al., 2013; Perbiche-Neves et al., 2016; Sultana and Balamurugam et al., 2016).

Zooplankton are reported to be significantly affected by increase of nutrient load in water bodies due to agriculture runoffs, pharmaceuticals, and personal care products (Vargas et al., 2015; Xiong et al., 2020). Several workers have reported that, diversity and population of zooplankton is correlated to the biotic and abiotic factors (pH, temperature, dissolved oxygen) (Vagas et al., 2015; Ismail, 2016; Sultana and Balamurugam et al., 2016; Vaidya, 2017; Xiong et al., 2020).

The status of an ecological system can be determined by the values of their diversity indices (Cardoso et al., 2012). The Shannon- diversity index value is 2.662, and as reported by Wilham and Dorri's (1968), this indicates the water to be mildly polluted. The 0.89 value of Eveness index shows that there is a frequent variation in the communities and the species distribution. The 0.92 value of Simpson index shows a greater sample diversity in the ecosystem. It has been widely discussed that species richness and their diversity will invariably contribute to formation of conservation strategies. According to diversity indices, the lake water is moderate in respect to water quality.

Similar species have been reported by workers in fresh water habitats with similar physicochemical values, Rotifers (Manivelu et al., 2016; Adhikari et al., 2017; Sarkar et al., 2016; Shiv et al., 2017), Cladocerans (Manickam et al., 2015; Kadam 2016; Das et al., 2016; Manivelu et al., 2016; Shiv et al 2017; Rao, 2017; Adhikari et al., 2017).

Table 2 Seasonal distribution of zooplankton from June 2020- May 2021 (Ind./L)

Zooplankton	Monsoon	Post Monsoon	Pre Monsoon	Total
Rotifera				
Branchionus falcatus Zacharis 1898	0	500	720	1220
Branchionus angularis Gosse, 1851	680	0	0	680
Diphanosoma sarsi Richard, 1894	480	0	740	1220
Keratella cochlearis Gosse, 1851	260	0	0	260
Monostyla bulla Gosse, 1851	0	880	0	880
Philodena citrina Ehrenberg, 1832	0	0	380	380
Philodena roseola Ehrenberg, 1830	140	280	260	680
Ptygura pilula Cubitt 1872	260	0	0	260
Cladocera				
Ceriodaphina chorata Sars 1885	0	460	540	1000
Moina brachyata Jusine 1820	360	480	0	840
Copepoda				
Maxillopoda sp.	0	920	0	920
Mesocyclops leukarti Claus	0	0	440	440
Cyclops sp.	560	360	0	920
Diaptomus castor Jurine, 1828	690	380	0	1070
Naupilis sp.	0	0	1260	1260
Nematode				
Nematode	160	120	0	280

5. Conclusion

This study shows that zooplankton diversity is seasonal and changes with physicochemical charac-terristics of the water. The zooplankton distribution is influenced by water parameter like pH and surface water temperature. Seasonally higher number of zooplanktons were documented in pre monsoon period. This study establishes a Zooplankton baseline data for documentation in the study area. The diversity indices shows that the Tavare kere is moderately polluted. Regular monitoring, assessment, and remediation measures are needed to prepare and protect the water quality.

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Conflict of interest

The authors declare no conflict of interest

Author's Contribution

This work is carried out in collaboration between three authors.
First author: Thrupthi G.N. - Managed the analysis and wrote the first draft and performed the statistical analysis
Second author - A.G.Devi Prasad - Designed the study, and finalized the manuscript.

Data Availability Statement

The manuscript incorporates all data sets produced or examined throughout the study.

Ethics Approval Statement

The study did not involve an experiment on humans or animals.

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