YUGATO

ISSN: 0387-5695, eISSN: 0387-5695
Vol. 76 No. 1 (2024)

Received: January 09, 2023 / Revised: January 23, 2023 / Accepted: February 18, 2024 / Published: March 02, 2024

ZOOPLANKTON DIVERSITY- A SEASONAL STUDY IN FRESH WATER HABITAT.

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ABSTRACT:

Background:

The quality of an aquatic habitat is measured by species diversity. This study was conducted to analyze the impact of seasonal changes on the zooplankton biodiversity of Tavarekere Lake (latitude 12.4555° N, Longitude 75.9570° E.) in Kodagu, Karnataka, India.

Results:

This study was conducted between June 2020 and May 2021. Sixteen species belonging to Rotifera, Cladocera, Copepods, and Nematodes were documented. At this site, 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> Cladocera> Nematodes, with the highest population in the pre-monsoon season (summer) and the lowest population recorded in the monsoon season. The CCA plot showed a positive correlation between zooplankton and surface water temperature.

Conclusion:

This study shows that zooplankton diversity is seasonal and changes in response to environmental parameters, as it was observed that, with increasing temperature, the species diversity varies, which will impact the balance of the food chain and can be utilized as a potential tool to monitor and maintain water quality.

Key words; Zooplanktons, Bioindicators, Canonical Correspondence Assay, fresh water, Physicochemical analysis

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 bioindicators of pollution, such as phytoplankton and zooplankton, play important roles in protecting freshwater habitats (Altshner et al., 2011). Zooplankton are heterotrophic plankton that range in size from microscopic to large species. 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,& 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 (DO, BOD, TDS, surface water temperature, pH) and biotic factors(nutrient availability, algal bloom toxins) etc.(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, & Unkovskaia, 2021). in Rotifera Branchionus sp., Keratella sp., and Cladocera Ceriodaphnia sp., which have algal toxins that are detrimental to the survival of zooplankton (Pawlick &Bownick, 2021).

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

The study was conducted to 1) analyze the zooplankton abundance, diversity, and distribution at the sampling site. 2) To evaluate the physical and chemical parameters responsible for eutrophication and their impact on zooplankton distribution. This study hypothesizes that zooplankton diversity is based on changing environmental parameters and that some taxa can be used as potential bioindicators to understand the trophic state of freshwater habitats.

2. Materials and Methods:

2.1Study area:

Samples were collected from Tavarekere Lake in Kodagu District, Karnataka State, India (Fig1)(.12.4555° N, 75.957° E). Sample sites were selected based on the influence of anthropogenic activities in and around the region.

Furthermore, water levels and nutrient sources of the lakes were considered as parameters. The geographical locations of the sites were noted using GPS, and the depths of the lakes were measured using a weighted line.

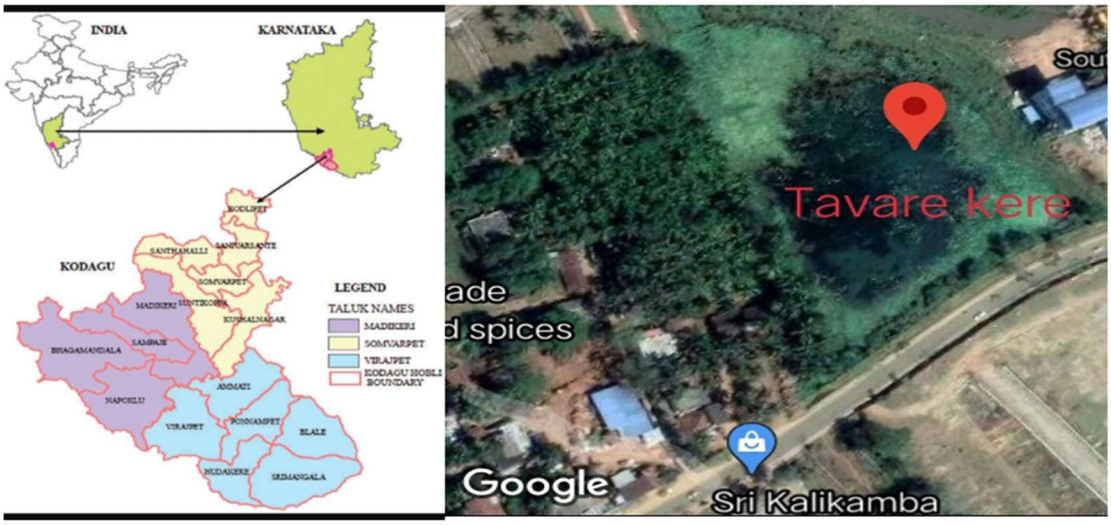


Fig 1: The sampling site

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 were measured on-site. Parameters such as pH, TDS, and EC were measured immediately upon reaching the laboratory. Parameters such as D.O. 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 iodone 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 methods (Dhanpathi, 2000; Battish, 1992; Goswami, 2004).

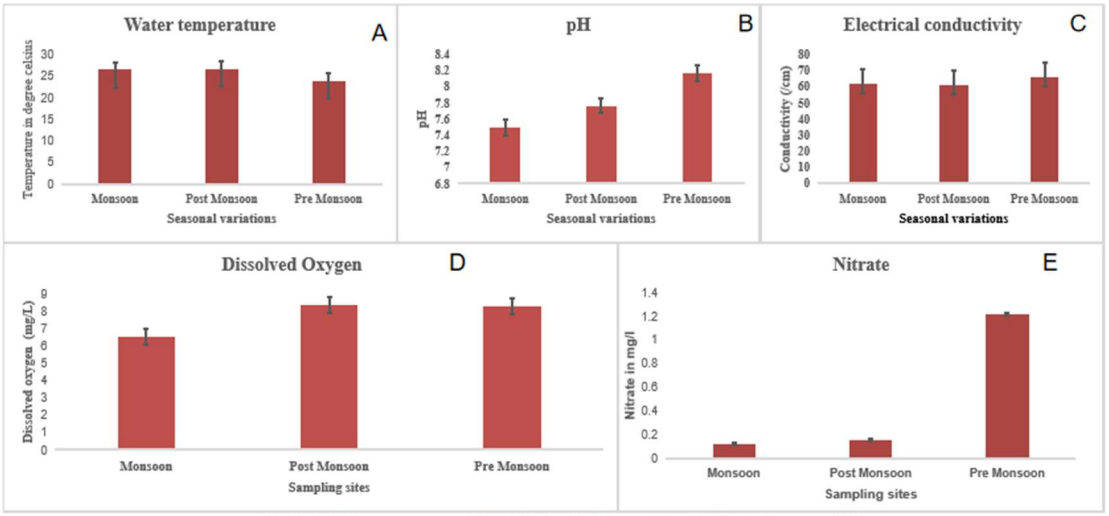
2.4 Statistical analysis

The physicochemical water parameters were calculated using Microsoft Excel, and the graph was plotted using GraphPad Prism 10. Diversity indices, Pearson Correlation Analysis and Canonical Correspondence Assay were calculated using PAST 4.03.

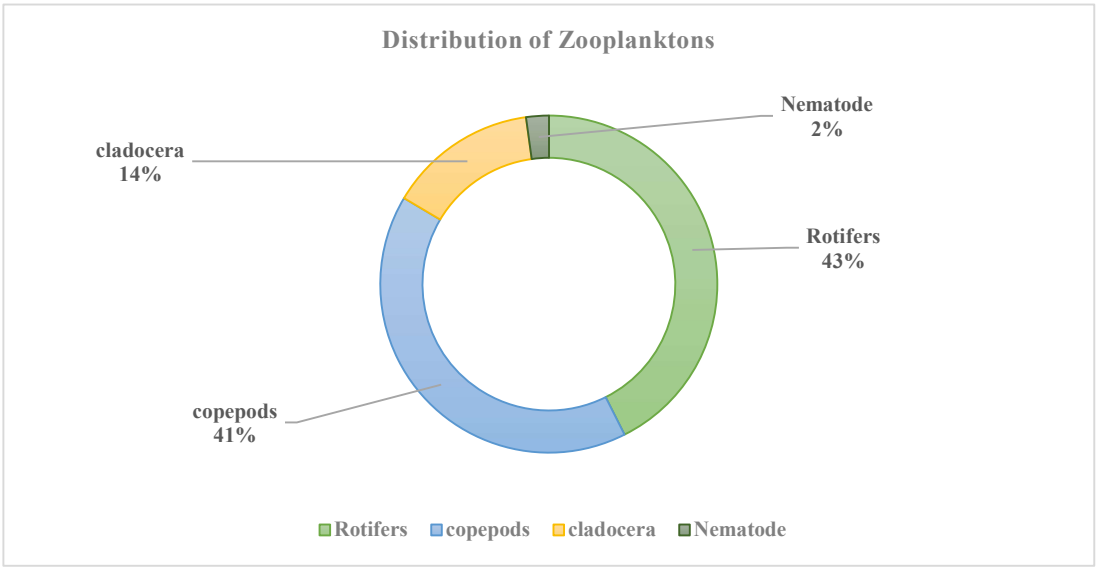
3.Results:

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 30.1^0C 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 on nitrate was highest in the pre-monsoon period and lowest in monsoon period.

The zooplanktons were collected using plankton nets. During the study a total of 16 taxa were recorded (Table 1). The 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. The documented species are as follows *Branchionus falcatus, Branchionus angularis, Diphanosoma sarsi Keratella cochlearis ,Monostyla bulla ,Philodena citrina ,Philodena roseola ,Ptygura pilula*
Ceriodaphina chorata,Moina brachyata,Maxillopoda sp.,Mesocyclops leukarti
Cyclops sp.,Diaptomus castor ,Naupilis sp., and *Nematode.*The distribution of zooplankton is rotifers with 43%, followed by copepods with 41%, cladocera with 14% and nematodes with 2%(graph 2).



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



Graph 2 : Distribution of zooplanktons

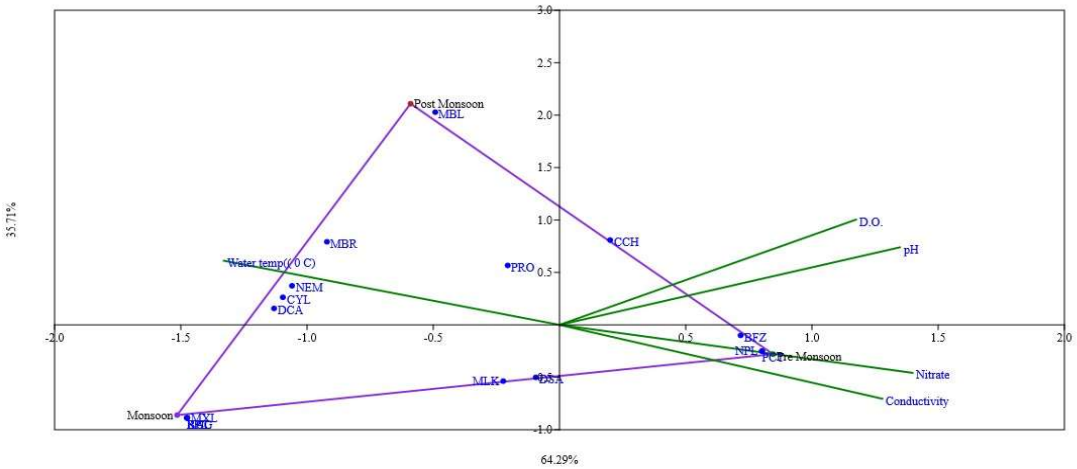
The diversity indices of the sampling site are stated in Table 1.The Shannon diversity index (Shannon_H) value is 2.66, the Simpson diversity index (Simpson_1-D) value is 0.92, wheras, the Pieolous evenness index is 0.89, the magarleif index is 1.58, the Menhinick index is 0.14.

Diversity index	Values
Taxa_S	16
Individuals	12970
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
Chao-1	16

Table 1 The different diversity index values

Canonical Correspondence analysis plot showing the relation between the environmental parameters like Temperature, EC, pH, TDS and nitrate with zooplankton species diversity (**Graph 3**). 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) determines their significance and is equal to the rate of change of variables. The positions of species distribution 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, Cyclops sp., Diaptomus castor, and Monostyla bulla*), 3 species (*Branchionus falcatu*s, *Philodena citrina* and *Naupilis sp.,*) showed a preference to moderate pH and nitarte concentration. The remaining 9 species preferred the moderate concentration of environmental parameters.



Graph 3: Canonical Correspondence Analysis plot shows a correlation between the phyico chemical water parameters and distribution of zooplanktons.

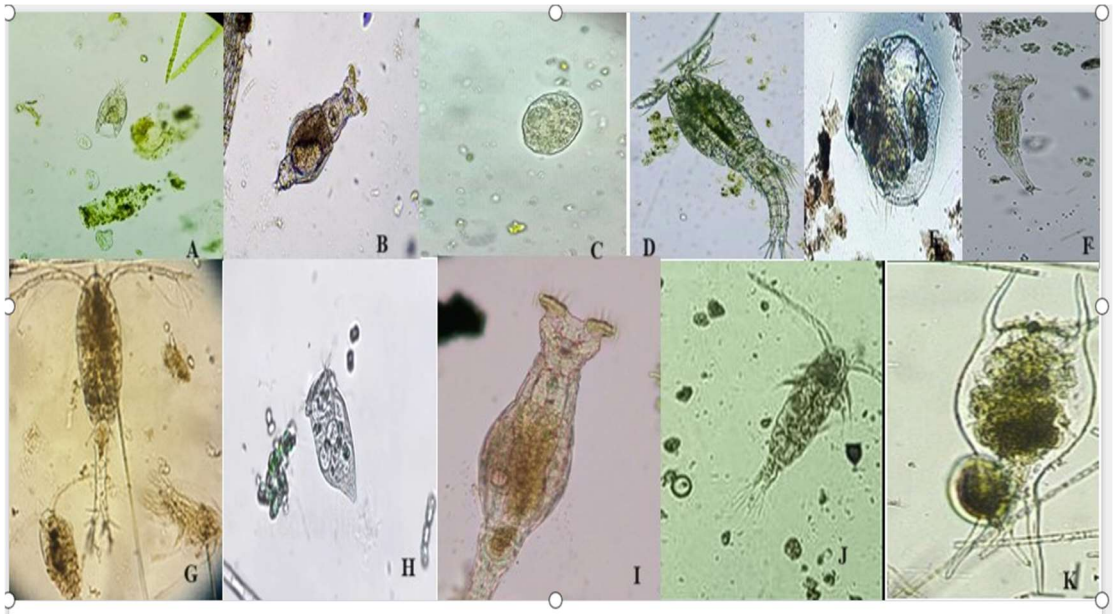


Fig : **A**. *Branchionus falcatus,* **B.** *Philodena citrina,***C.** *Ptygura pilula* , **D.** *Diaptomus castor*, **E.** *Moina brachiyata* **F.** *Diapanosomus sarsi*, **G.** *Maxillopoda* sp., **H.** *Monostyla bulla*, **I.** *Philodena roseola* ,**J.** *Cyclops* sp., **K.** *Keratella cochliaris.*

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). 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).

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).The amount of Dissolved oxygen reported in the lake is in accordance to parameters like temperature, salinity, amount of water flow, salinity, sedimentation, and photosynthesis rate of phytoplankton and macrophytes (George et al. 2004; Abowei 2010).

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). Zooplanktons 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 zooplanktons 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). Similar species have been reported by workers in

fresh water habitats with similar physicochemical measurements, rotifers (Manivelu et al 2016; Adhikari et al 2017;Sarkar et al 2016;Shiv et al 2017), Cladocera (Shiv et al 2017; Kadam 2016; Das et al., 2016;Manivelu et al 2016; Rao 2017; Adhikari et al 2017; Manickam et al 2015).

Sr.No		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
	Rotifera													
1	*Branchionus falcatus* Zacharis 1898	0	0	0	0	0	500	0	0	0	0	240	480	1220
2	*Branchionus angularis*Gosse, 1851	0	680	0	0	0	0	0	0	0	0	0	0	680
3	*Diplaxanosoma zarri* Richard, 1894	0	0	0	480	0	0	0	0	0	0	460	280	1220
4	*Keratella cochlearis* Gosse, *1851*	260	0	0	0	0	0	0	0	0	0	0	0	260
5	*Monostyla bulla* Gosse, 1851	0	0	0	0	0	0	0	880	0	0	0	0	880
6	*Philodina citrina* Ehrenberg, 1832	0	0	0	0	0	0	0	0	0	380	0	0	380
7	*Philodina roseola* Ehrenberg, 1830	140	0	0	0	280	0	0	0	260	0	0	0	680
8	*Pygura pithila* Gubitt 1872	0	0	260	0	0	0	0	0	0	0	0	0	260
	Cladocera													
9	*Ceriodaphinia chorata*Sars 1885	0	0	0	0	0	460	0	0	0	540	0	0	1000
10	*Moina brachyata* Jusiae 1820	0	0	360	0	0	0	0	480	0	0	0	0	840
	Copepoda													
11	*Mastillopoda* sp.	0	0	0	0	0	280	640	0	0	0	0	0	920
12	*Mesocyclops leukarti* Claus	0	0	0	360	0	0	0	0	440	0	0	0	800
13	*Cyclops* sp.	280	0	0	280	0	0	0	360	0	0	0	0	920
14	*Diaptomus castor* Jurine, 1828	430	260	0	0	380	0	0	0	0	0	0	0	1070
15	*Naupilia* sp.	0	0	0	0	0	0	0	0	380	460	240	180	1560
	Nematode													
16	Nematode	100	60	0	0	0	0	0	120	0	0	0	0	280

Table 2: Distribution of zooplanktons from June 2020- May 2021.

Conclusion:

This study shows that zooplankton diversity is seasonal and changes in response to environmental parameters. The results indicate that zooplankton species are vulnerable to environmental changes and can be used as a prospective bio-monitoring tool, to predict the water quality. It was observed that, with increasing temperature, the species diversity varies, which will impact the balance of the food chain.

To conclude, the water body contains bio indicators of eutrophication, giving anticipation of deterioration in the forthcoming days. Hence, regular monitoring, assessment, and remediation measures are needed to prepare and protect the water body. However, standardised protocols are necessary to conclude the biomonitoring tools. Furthermore, this study also establishes a baseline data for documentation of the study area, more spatio temporal work needs to be conducted, to elaborate on the biomonitoring species.

Acknowledgement:
The authors are thankful to P.G.Department of Botany, Jnana Kaveri Campus, Mangalore University for providing the assistance with laboratory facilities.

Funding:
The authors declare that no funding was received to carry out this study

Authors contribution:
The concept formulation and correction of paper was done by AGD and carrying out of the work and writing the paper was done by TGN.

Ethics approval:
The authors declare no animal ethics report is required for this work

Consent for publication:
Authors provide their consent for publication

Competing interests:
The authors declare no conflict of interests in publishing the paper.

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