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Diversity of Rotifers in Two Eutrophic Lentic Freshwater Bodies of Lakhandur, District Bhandara, Maharashtra, India

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Abstract: Rotifers are vital for nutrient cycling, water purification, and supplying food for higher trophic levels. The study of species biodiversity provides insight into the resilience and health of ecosystems by revealing patterns of species distribution, variation, and adaptability across a variety of freshwater settings. Understanding rotifer diversity is crucial for tracking environmental changes and protecting freshwater ecosystems in the face of increasing human demands. Freshwater Rotifera variety is crucial for maintaining the health of aquatic environments. These small organisms play a crucial role in the nutrition cycle by helping to break down organic matter and transport energy through the food chain. Rotifers are a crucial source of food for larger species, such as fish larvae, which are necessary for their survival and growth. A large diversity of rotifers, which help freshwater environments adapt to shifting environmental conditions, is typically indicative of a strong and resilient ecosystem. The goal of the current study was to investigate the cultural eutrophication of two lentic water bodies in Maharashtra's Lakhandur district of Bhandara. Anthropogenic pressure is present in these ponds. The current study documented 52 Rotifer species from 20 genera and 14 families in the orders Ploima, Flosculariaceae, and Bdellaoidea. The current study discusses the rotifer's diversity and function in determining these ponds' trophic state. Their key role and availability in the water with reference to indicator role of pollution are also covered. This research is essential to our comprehension of nature and sheds light on intricate ecological interactions and ecosystem dynamics.

Keywords: Rotifer diversity, Brachionus, Eutrophication, Lentic freshwater, Lakhandur

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Introduction

Significant alterations in rotifer diversity may result from altered environmental conditions in eutrophied freshwater bodies. Rotifer communities are directly impacted by eutrophi-

cation, which is frequently brought on by elevated nutrient levels, such as those of nitrogen and phosphorus, which increase organic waste and algal blooms. Although there may be more rotifers overall if there is more food available, species diversity typically decreases. This is explained by the tendency of some opportunistic species, such as Brachionus and Keratella, to take over in environments that are nutrient-rich and to replace other species that are less able to adjust to changing conditions. Because of this, the more sensitive and specialised species vanish, homogenising the rotifer community and lowering biodiversity in general. This alteration impacts the biological balance of the freshwater ecosystem and is indicative of a general environmental stress caused by eutrophication. Rotifer variety often shows distinct patterns in eutrophic water bodies, which are influenced by the elevated nitrogen levels and ensuing ecological shifts. Studies have indicated that certain rotifer species, particularly those better suited to the nutrient-rich environment, have a tendency to dominate these types of environments. For instance, the presence of organic matter and algae in eutrophic waters allows a number of species, such as *Brachionus calyciflorus*, *Keratella cochlearis, and Polyarthra vulgaris*, to thrive (Sharma, 2001). These species thrive in the nutrient-rich but frequently oxygen-depleted waters (Gannon and Stemberger, 1978). Rotifer abundance and size distribution in plankton are impacted by greater food availability in more nutrient-rich environments because body size increases food concentration thresholds and reproductive capacity (Stemberger and Gilbert, 1985). Eutrophication causes the loss of shelter that submerged macrophytes provide (Basiǹska, 2010) also have their consequences. Collectively, these mechanisms lead to significant differences in the species composition, assemblage structure, and functional properties of planktonic rotifer communities in lakes and ponds with turbid phytoplankton dominance and clear phyto-plankton-poor freshwaters. According to Arora and Mehra (2003), rotifer diversity in the eutrophic Yamuna River can serve as an indicator of water quality, with certain species growing in response to nutrient enrichment and deteriorating water quality. As a result of shifting nutrient availability and environmental conditions, rotifer diversity in freshwater habitats varies greatly throughout trophic status grades. With species like *Keratella quadrata* and *Polyarthra dolichoptera* frequently seen, rotifer communities are typically diversified in oligotrophic environments, which are defined by low levels of nutrients and high oxygen concentrations. According to Pourriot and Rougier (1997), these species have adapted to the clear, nutrient-poor conditions and are frequently found in stable, less productive environments. Rotifer diversity often increases when the trophic status shifts towards mesotrophic conditions, which are defined by a more balanced availability of food sources and a reasonable amount of nutrients. According to Gulati *et al*. (2001), species such as *Asplanchna priodonta* and *Filinia longiseta* become more frequent because they benefit from the increased algal production without encountering with the severe competition or hypoxia that arise in conditions with greater nutrient concentrations. Taxonomical and distribution study enables the scientific identification, classification, and interpretation of the relationships between different species. These studies facilitate the handling of ecosystems, the safeguarding of biodiversity, and the understanding of the geographical distribution of species. They also influence ecological regulations and conservation programs. They also provide insight into the evolutionary history of creatures and help predict how species may respond to environmental changes. Aquatic ecosystems depend on rotifers, a significant type of microscopic aquatic organism.

In India, the diversity of rotifers and the impact of eutrophication on their populations have been the subject of numerous studies. A comprehensive review of the diversity of rotifers found in India's varied freshwater ecosystems is provided by Sharma's (2005) notable studies on rotifer species diversity and eutrophication in India, which list over 300 species. According to

Fig. 1: S-1 (Shastri Nagar Pond).

Fig. 2: S-2 (Kinhala Pond).

Sharma (2005), rotifer communities are significantly impacted by eutrophication. Changes in species composition favour populations that are more tolerant and often less diverse in nutrient-rich environments. Rotifer populations in a number of Indian lakes are impacted by eutrophication, according to Dhanapathi and Rao (2010), Eutrophic conditions have been found to produce a decline in species richness and an increase in the number of some eutrophic-tolerant species, such as *Lecane* and *Brachionus*. Focussing on the Ganges River, Arora and Mehra (2003) discovered that eutrophication significantly altered the structure of the rotifer population. The dominance of eutrophic species like *Brachionus calyciflorus* led to a decline in total diversity. Sinha and Khan (2015) examined how the diversity of rotifers in many Indian wetlands, including Kolleru Lake, is impacted by ongoing eutrophi-cation. Due to ongoing eutrophication, the rotifer community became simpler, with fewer species and an abundance of individuals such as *Brachionus plicatilis*.

Within the phylum Rotifer, there are over 2500 species spread across 200 genera. Sharma and Michael (1980) provided the first taxonomic report, reporting 241 species from India, whereas Anderson (1889) recorded 47 species of Indian rotifers. Dhanapathi (2000) organised the taxonomic notes. Sharma (1998) recognized 330 species of rotifers. The majority of rotifers in India are tropicopoliton, which is found in tropical and sub-tropical latitudes but can also occasionally be found in temperate locations with suitable habitats (Dhanapathi, 2000). The faunal richness of phylum Rotifera from eastern Maharashtra, Central India, is not well documented in Indian literature. The biodiversity of rotifers in Indian waters is still not fully understood, despite the fact that taxonomic research on Indian rotifers started more than a century ago. The present study helps to identify the diversity of rotifers with the help of existing available literature.

Materials and Methods

Study Sites:

Site I (S-1) (Shastri Nagar Pond; 20°44'39.9"N 79°53'04.8"E): This site (Fig. 1) is located in the Shastri Nagar, near Ashirvad Talkies near Sakoli-Wadsa road, Lakhandur. This moderate size aged eutrophied water body is surrounded by crowded human inhabitancy as well as agriculture land on one side. Abundant anthropogenic activities were also observed frequently.

Site II (S-2) (Kinhala Pond; 20°44'25.6"N 79°53'06.5"E): This site (Fig. 2) is located behind the YC College, Lakhandur. This water body is surrounded by agricultural land on one side while on the other side scattered human residency causes many anthropogenic activities are observed. This water body has abundant vegetation like shrubs and tree in the basin of

pond. It is observed primarily that it is culturally etrophied.

Plankton samples were hauled of bolting cloth plankton net with a mesh size of 25 µm every month for two years throughout the winter, summer, and monsoon seasons from two distinct places. Intensive samples are obtained by repeating the hauling process. The concentrated samples were gathered in sampling bottles labeled S1, S2, and included the date and time of the sampling. Samples were preserved by adding a small amount of glycerin to improve preservation and stop the samples from evaporating. An equal volume of hot water and 4% formalin were added to the set samples. Plankton clumping were avoided by adding a few drops of detergent. Using Edmondson (1959) and more identification keys, Rotifera can be identified. The specimens were shot using the Metzer-M-Co-axial trinocular digital research microscope vision plus-5000 DTM, and their identification was based on keys provided by Edmondson (1959), Battish (1992), and Dhanapathi (2000). With the aid of earlier research publications, taxonomy databases, and scientific journals that record the ranges of rotifer species in diverse geographic areas, the distribution range was established.

Results and Discussion

A total of 52 Rotifer species belonging to orders Ploima, Flosculariaceae and Bdellaoidea comprises in 20 genera and 14 families were recorded, taxonomic list of Rotifers of two freshwater lentic ecosystem is given in the Table 1 and images of the identified rotifers are given in Figure 1. 52 species belongs to class Monogonanta. The order Ploima comprises of 45 species which is divided into the 12 families, among which 27 species of rotifer belongs to the family Brachionidae, 3 species belongs to Asplanchnidae, 3 species to Lecanidae, 2 species belongs to each of Notommatidae, Mytilinidae and Trichocercidae while 1 species belongs to each of Trichosphaeridae, Gastropodidae, Scaridiidae, Epiphanidae, Lepadellidae and Synchaetidae. The order Flosculariaceae comprised of 4 species which is divided into 2 families Testudinellidae and Trochosphaeridae each comprised 2 species. The order Bdelloidae comprised of 3 species which belongs to family Philodinidae. Among all the species found during the study, the most dominant species belongs to the family Brachionidae with 27 species with representative genus like *Brachionus* with 24 species, while *Platyas* with 1 and *Keratela* with 2 from Brachionidae family. 2 species of Asplanchna and 1 species of *Asplanchnopus* belongs to the family Asplanchnidae. The family Lecanidae with 3 species which belongs to genus *Lacane*. The family Trichosphaeridae, Gastropodidae and Scaridiidae comprise 1 genus each. The family Notommatidae comprises 2 different genera and species while Mytilinidae with 2 species belongs to genus *Mytilina*. Epiphanidae, Leadellidae and Synchaetidae with 1 genus each while family Trichocercidae with 2 species with single genus *Trichocerca*. The order Flosculariaceae comprises two families; Testudinellidae and Trochosphaeridae, the family Testudinellidae with 2 species with 1 genus *Testudinella* while Family Trochosphaeridae also have 2 species with 1 genus Filinia. The order Bdelloidea comprises 3 species from 2 genera. In the present investigation, from site I (Shastrinagar Pond) 38 species of Rotifers were recorded with highest species diversity while fromsite II (Kinhala Pond) 34 species of Rotifers were recorded. Site I is dominated by Brachionidae with 20 species of genera *Brachionus* while site II was also dominated by Brachionidae with 16 species of *Brachionus*. Rotifer diversity dominance is as--family Brachionidae> Asplanchidae~ Lecanida~ Philodinidae>Notomatidae~Mytilinidae~Trichcercidae~ Testudinellidae~ Trochosphaeridae> Trichsphaeridae ~ Gastropodidae ~ Scarididae~ Epiphanidae~ Synchaetidae.

In the present investigation, *Brachionus* formed the dominant and diversified genus among the rotifers throughout the study period. the numbers of species of rotifer are considered as bioindicator of pollution. Bioindicator is the organism whose presence in the water indicates the type and degree of pollution. As and when the

Table 1: List of Rotifera in two freshwater eutrophic pond in Lakhandur dist. Bhandara

PHYLUM: ROTIFERA; CLASS: MONOGONONTA					
S.No.	**Order**	**Family**	**Species Name**	***S I**	***S II**
1	Ploima	Brachionidae	*Brachionus calyciflorus,* Pallas, 1766	+	+
2	Ploima	Brachionidae	*B. calyciflorus v. hymani,* Dhanapathi, 1974	+	-
3	Ploima	Brachionidae	*B. calyciflorus f borgerti,* Apstein, 1907	+	-
4	Ploima	Brachionidae	*B. calyciflorus f. amphicerous,* Ehrenberg, 1838	+	+
5	Ploima	Brachionidae	*B. calyciflorus f dorcus,* Gosse, 1851	+	+
6	Ploima	Brachionidae	*B. falcatus,* Zacharias, 1898	+	+
7	Ploima	Brachionidae	*B. falcatus long spined,* Zacharias, 1898	+	+
8	Ploima	Brachionidae	*B. quadridentatus,* Hermann, 1783	+	+
9	Ploima	Brachionidae	*B. quadridentatus v.brevispinus,* Ehrenberg, 1832	+	-
10	Ploima	Brachionidae	*B. quadridentatus v. melhini,* Barrois and Daday, 1894	+	+
11	Ploima	Brachionidae	*B.quadridentatus v. entzii,* France, 1894	+	-
12	Ploima	Brachionidae	*B. angularis,* Gosse, 1851	-	+
13	Ploima	Brachionidae	*B. plicatilis,* Muller, 1786	+	+
14	Ploima	Brachionidae	*B. durgae,* Dhanapathi, 1974	+	+
15	Ploima	Brachionidae	*B. forficula f. typicus urawensis,* Sudzuki, 1955	-	+
16	Ploima	Brachionidae	*B. diversicornis,* Daday, 1883	-	+
17	Ploima	Brachionidae	*B. budapestinesis,* Daday,1885	-	+
18	Ploima	Brachionidae	*B. caudatus,* Barrois and Daday, 1894	+	+
19	Ploima	Brachionidae	*B. caudatus f. apsteini,* Ahlstrom, 1940	+	-
20	Ploima	Brachionidae	*B. caudatus valgates,* Barrois and Daday, 1894	+	-
21	Ploima	Brachionidae	*B. mirabilis,* Daday, 1897	+	-
22	Ploima	Brachionidae	*B. rubens,* Ehrenberg, 1838	+	+
23	Ploima	Brachionidae	*B. bidentata,* Anderson, 1889	+	+
24	Ploima	Brachionidae	*B. urceolaris,* Muller, 1773	+	-
25	Ploima	Brachionidae	*Platyas quadricornis,* Ehrenberg, 1832	+	-

26	Ploima	Brachionidae	*Keratella tropica,* Apstein,1907	+	+
27	Ploima	Brachionidae	*Keratella cochlearis,* Gosse, 1851	+	-
28	Ploima	Asplanchnidae	*Asplanchna brightwelli,* Gosse, 1850	+	+
29	Ploima	Asplanchnidae	*Asplanchna intermedia,* Hudson, 1886	-	+
30	Ploima	Asplanchnidae	*Asplanchnopus bhimavaramensis,* Dhanapathi, 1975	-	+
31	Ploima	Lecanidae	*Lecane leontina,* Turner, 1892	+	-
32	Ploima	Lecanidae	*Lacane hamata,* Stokes, 1896	+	+
33	Ploima	Lecanidae	*Lecane decipiens,* Murray, 1913	+	-
34	Ploima	Trichosphaeridae	*Horaella brehmi,* Donner, 1949	-	+
35	Ploima	Gastropodidae	*Ascomorpha ecaudis,* Perty, 1850	-	+
36	Ploima	Scaridiidae	*Scaridium langicaudatum,* Muller, 1786	-	+
37	Ploima	Notommatidae	*Cephalodella catellina,* Muller, 1786	+	-
38	Ploima	Notommatidae	*Eosphora anthadis,* Harring and Myers, 1922	-	+
39	Ploima	Mytilinidae	*Mytilina ventralis,* Ehrenberg, 1830	+	+
40	Ploima	Mytilinidae	*Mytilina ventralis f. brevispinus,* Ehrenberg, 1830	+	-
41	Ploima	Epiphanidae	*Microcadides chlaena,* Gosse, 1886	+	-
42	Ploima	Lepadellidae	*Colurella adriatica,* Ehrenberg, 1831	-	+
43	Ploima	Synchaetidae	*Polyarthra indica,* Segers and Babu, 1999	+	+
44	Ploima	Trichocercidae	*Trichocerca tigris,* Muller, 1786	-	+
45	Ploima	Trichocercidae	*Trichocerca similis,* Wierzejski, 1893	+	-
46	Flosculariaceae	Testudinellidae	*Testudinella patina,* Hermann, 1783	+	+
47	Flosculariaceae	Testudinellidae	*Testudinella dendradena,* de Beauchamp, 1955	-	+
48	Flosculariaceae	Trochosphaeridae	*Filinia pejleri,* Hutchinson, 1964	+	-
49	Flosculariaceae	Trochosphaeridae	*Filinia longiseta,* Ehrenberg, 1834	+	+
50	Bdelloidea	Philodinidae	*Macrotrachela quadricornifera,* Milne, 1886	+	-
51	Bdelloidea	Philodinidae	*Rotaria rotatoria,* Pallas, 1766	+	+
52	Bdelloidea	Philodinidae	*Rotaria neptunia,* Ehrenberg, 1830	-	+

*Site I (Shastrinagar Pond), *Site II (Kinhala Pond)

pollutant gets mixed with any water body the residential delicate organism are eliminated, whereas the tolerant species survive and flourish. Some species flourish in highly eutrophic waters while others are very sensitive to organism or chemical wastes (El Enany, 2009). Rotifers, especially *Brachionus*, constitute an important link in the food chains of inland waters. They are considered preferred food for many fish larvae (Guerguess, 1993). *Brachionus plicatilis*, formed the most dominant species in the eutrophic water body which referred to the influence of eutrophication. Most of the genera and species are found extensively in eutrophic waters. *Brachionus* species has cosmopolitan distribution in India and during the present study; it was represented by twenty three species viz. *Brachionus calyciflorus, B. calyciflorus v. hymani, B. calyciflorus f borgerti, B. calyciflorus f. amphicerous, B. calyciflorus f dorcus, B. falcatus, B. falcatus long spined, B. quadridentatus, B. quadridentatus v. brevispinus, B. quadridentatus v. melhini, B.quadridentatus v. entzii, B. angularis, B. plicatilis, B. durgae, B. forficula f. typicus urawensis, B. diversicornis, B. budapestinesis, B. caudatus, B. caudatus f. apsteini, B. caudatus valgates, B. mirabilis, B. rubens, B. bidentata,* and *B. urceolaris.* Out of these species of Genus *Brachionus*, *B. angularis, B. forficula f. typicus urawensis, B. diversicornis,* and *B. budapestinesis* were not recorded from the study site I during the study period while from the site II, the *Brachionus* species viz. *B. calyciflorus v. hymani, B. calyciflorus f borgerti, B. quadridentatus v. brevispinus, B.quadridentatus v. entzii, B. caudatus f. apsteini, B. caudatus valgates, B. mirabilis,* and *B. urceolaris* were not recorded during the study period.

Among the rotifers during the research period, *Brachionus* emerged as the most prevalent and diverse genus. According to Berzines and Pejler (1989) and Sampio *et al.* (2002), these species are widely distributed in eutrophic waterways. According to Mageed (2008) and Uzma (2009), the presence of more than five species of *Brachionus* indicates eutrophication of water bodies. Hutchinson (1967) noted that *Brachionus* species are highly prevalent in temperate and tropical waters with an alkaline pH. *Brachionus* has also been found to be abundant in a number of central Indian water bodies by Kaushik and Saxena (1995). *Brachionus* is abundant in tropical regions, and in warmer parts of the Indian peninsula, several species of this genus predominate in the plankton community (Fernando, 1980; Hillbritch-Ilkowska, 1983; Gulati, 1990; Erbern *et al*., 2002; Yildiz *et al*., 2007). In the current investigation, the most prevalent genera isBrachionides. The biotic community structure, water quality, pollution concentrations, and nutrient contents are all strongly connected with the health of aquatic ecosystems. The number and species composition of rotifers are thought to be closely related to the health of the ecosystem, and the degree of eutrophication may be reflected in the species (Rogozin, 2000). Increased abundance of tolerant rotifer species and alterations in species composition might result from eutrophication (Spoljar *et al*., 2011). According to Nogueira (2001), the abundance of these species is a biological indication of eutrophic water, while Sladecek (1983) also proposes that this genus is the index of eutrophic water. *Brachionus* species have been shown to be present in typical tropical settings by Mulani et al. (2009), while Sampaio *et al.* (2002) found that they are an indication of eutrophication.

Brachionus species are much resistant in adverse condition (Davis, 1968). Arora (1966) reported that *B. calyciflorus, B. angularis* and *Filinia longiseta* are common forms predominantly occurring in eutrophic water and he used rotifers as bioindicators of water quality and classified water in to clean, polluted and heavily polluted. He also considered *B. falcatus* indicating relatively clear water species, same observation wisas found in the present study. Rotifers were found in Lake Kacharali, and their relationship to water quality was examined by Somani *et al*. (2012). They detected 13 different species of rotifers during their investigation, with Branchionus and Keratella species being the most prevalent. Similar

findings have been recorded in this study. In many central Indian waterways, several species of the Branchionidae family serve as markers of mesotrophic and eutrophic conditions (Unni, 1985; Bhandarkar and Paliwal, 2012, 2019; Bhandarkar, 2015). Manikandan (2016) investigated the seasonal change and zooplankton diversity of three lakes in Coimbatore, Tamil Nadu, India. They examined 30 genera of zooplanktons in three lakes, including 8 genera of protozoa, 9 genera of rotifers, 7 species of cladocera, and 6 genera of copepods. They claim that a high concentration of *Branchionus* and *Keratella* species is a sign of alkalinity and organically achieved conditions. The pond is considered organically contaminated since *Brachionus calyciflorus, B. forficula,* and *B. caudatus* are known to have a high tolerance to organic enrichment (Grajner and Gladysz, 2010; Chitra, 2013). In this study, the impact of micro-habitats, such as the zone of macro-vegetation, on rotifer abundance was observed. Arora (1961) collected a large number of *Rotaria rotaria* from Nagpur's polluted water. According to him, the fact that *R. rotaria* is completely absent from clear, pure water suggests that it only lives in contaminated water. Likewise, there are no examples of this species in the current investigation, indicating that it is clean.

Conclusion

Rotifers make up the majority group during the investigation. One possible explanation for the overall rich diversity of rotifers found in these ponds is their high tolerance to salinity, parthenogenic reproduction, and ease of adoption and enrichment of nutrients. According to the current study, the varied rotifer fauna of the two study locations in the Lakhandur and Bhandara districts may be related to the favorable environmental conditions and copious amounts of food in the form of bacteria, macrophytoplankton, nanoplankton, animal waste, and suspended detritus in the lake water. Shastrinagar and Kinhala ponds are rich in nutrients, and home to a variety of rotifer fauna.

Ethical Statement

The authors confirm that all ethical issues have been dealt with the research ethics guidelines provided by the Rashtrasant Tukdoji Maharaj Nagpur University Nagpur, Maharashtra, India.

Author Contributions

Each author has contributed equally to the study's planning, analysis, writing, and editing. All authors have read and agreed to the published version of the manuscript.

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Conflict of Interest

The authors declare no conflicts of interest.

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