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Seasonal fluctuation of physico-chemical parameters with correlation of zooplankton density in "Virla reservoir" West Nimar (Khargone)

Dr. D S Waskel, Pratibha Pahade, Dr. B S Patel
Assistant professor, Department of Zoology, Maharaja Bhoj Govt. P. G. College, Dhar, Madhya Pradesh, India

Abstract
The present study investigates the seasonal fluctuation of physico-chemical parameters and their correlation with zooplankton density in Virla reservoir, West Nimar (Khargone), during 2022–2023. Zooplankton, as primary consumers, play a crucial role in aquatic food webs and serve as bioindicators of water quality. A total of 24 species belonging to five groups were recorded: Rotifera (8 species), Cladocera (5 species), Protozoa (4 species), Copepoda (4 species), and Ostracoda (3 species). Rotifera dominated the community, followed by Cladocera, Protozoa, Copepoda, and Ostracoda. Seasonal variations revealed maximum zooplankton density in summer and minimum in rainy seasons, correlating with fluctuations in temperature, pH, dissolved oxygen (DO), and nutrient availability. The study highlights the ecological significance of zooplankton diversity and emphasizes the need for biodiversity conservation in freshwater ecosystems.

Keywords: Virla reservoir, physico-chemical parameter, zooplankton

Introduction

Biodiversity is the shortened form of "biological diversity." It refers to all the variety of life that can be found on earth (plants, animals, fungi, and microorganisms) as well as the communities and habitats in which they live. Biodiversity is not only the sum of all ecosystems, species, and genetic materials.

Zooplankton constitutes a vital link in the food chain of an ecosystem, and fish yield depends greatly on their abundance. Their abundance is governed by physical, chemical, and biological processes. Plankton is important in freshwater ecosystems as the main source of energy and nutrition (Mishra & Joshi, 2003) [8].

The aim of the present study was to investigate species composition, distribution, and biodiversity of zooplankton in Virla reservoir (Khargone) during two consecutive years (2022–2023). Zooplankton serves as a bioindicator and is a useful tool for understanding water pollution status (Ahmed, 1996; Contreras *et al*., 2009) [2, 4].

Zooplankton density was identified up to genus level, and seasonal fluctuation of total zooplankton was studied. The group accounted for a contribution: Rotifers 61.11% (2022) and 61.04% (2023), Cladocerans 15.12% (2022) and 15.21% (2023), Protozoa 12.01% (2022) and 12.06% (2023), Copepods 11.10% (2022) and 10.35% (2023), Ostracoda 5.05% (2022) and 5.02% (2023).

This dominance pattern (Rotifera > Cladocera > Protozoa > Copepoda > Ostracoda) reflects the ecological balance of the reservoir. Rotifers, with their high reproductive potential, were consistently the most abundant group, while Ostracoda remained the least represented. Seasonal fluctuations showed maximum densities in summer and minimum in rainy seasons, correlating with physico-chemical parameters such as temperature, pH, dissolved oxygen, and nutrient availability.

Thus, the study highlights the importance of zooplankton diversity as a key indicator of freshwater ecosystem health, and emphasizes the need for conservation strategies to mitigate anthropogenic pressures on Virla reservoir.

Material and Methods

Virla reservoir is situated near Virla village on the Khargone–Julwania road, 28 km west of Khargone district. It is located at latitude 21°50′30″ N and longitude 75°23′30″ E, at an elevation of 309 meters above mean sea level (MSL). The reservoir was constructed during the Holkar rule and has a catchment area of about 50 km² with a maximum depth of 16.29 m.

The present study was carried out in Virla reservoir during 2022–2023. Water samples were collected seasonally from five sites. Plankton samples were collected following the methods of Welch (1953) [14] and Lind (1979) [7] by filtering 40 liters of water through a plankton net (64 µm mesh size). Samples were preserved in 5% formalin and Lugol's solution.

Zooplankton were identified using taxonomic keys provided by Edmondson (1959) [6] and Adoni (1985) [1]. Counting of individual zooplankton was performed using a Sedgwick–Rafter cell (APHA, 2005).

The density of zooplankton was calculated using the formula:

$$\text{Density} = \text{Mean} + (SD \times 10^2)$$

Where:

- X = individual reading of the parameter
- $\text{Mean} = \frac{\sum X}{n}$
- $SD = \sqrt{\frac{\sum (X - \text{Mean})^2}{n}}$
- n = number of samples

This formula accounts for both the average abundance and the variability (standard deviation) of zooplankton across seasons.

Results and Discussion

The present study of Virla reservoir during 2022–2023 revealed five major groups of zooplankton: Rotifera, Cladocera, Protozoa, Copepoda, and Ostracoda. A total of 24 species were identified, with Rotifera comprising 8

species, Cladocera 5 species, Protozoa 4 species, Copepoda 4 species, and Ostracoda 3 species. Seasonal sampling showed clear fluctuations in abundance, with maximum densities observed in summer and minimum in the rainy season.

Annual totals (Tables 1 and 2) indicated that Rotifera consistently dominated the zooplankton community, contributing 1038 individuals in 2022 and 1055 in 2023. Cladocera followed with 629 individuals in 2022 and 586 in 2023, while Protozoa contributed 508 and 421 individuals respectively. Copepoda showed moderate abundance with 365 individuals in 2022 and 372 in 2023, whereas Ostracoda remained the least represented group with 264 individuals in 2022 and 158 in 2023. The grand totals were 2804 individuals in 2022 and 2592 in 2023.

When expressed as raw percentages (Table 3A), Rotifera contributed 37.0% in 2022 and increased to 40.7% in 2023, confirming its dominance in the reservoir. Cladocera contributed 22.4% in 2022 and 22.6% in 2023, while Protozoa accounted for 18.1% and 16.2% respectively. Copepoda showed a slight increase from 13.0% in 2022 to 14.4% in 2023, whereas Ostracoda declined from 9.4% to 6.1%, suggesting possible sensitivity to environmental changes.

In addition to raw counts, the statistical density index (Mean + SD × 100) was applied (Table 3B). This method highlighted seasonal variability and confirmed the dominance of Rotifera across both years, with values of 61.11 ± 3.104 in 2022 and 61.04 ± 3.11 in 2023. Cladocera contributed 15.12 ± 2.345 in 2022 and 15.21 ± 2.33 in 2023, while Protozoa contributed 12.01 ± 2.43 and 12.06 ± 2.35 respectively. Copepoda showed values of 11.10 ± 1.41 in 2022 and 10.35 ± 1.28 in 2023, and Ostracoda contributed 5.05 ± 1.22 and 5.02 ± 1.20.

Seasonal fluctuations in zooplankton density were closely correlated with physico-chemical parameters (Table 4). Maximum densities were observed in summer when temperature (45.32–45.22 °C), pH (9.13–9.21), and total alkalinity (256–251 mg/L) were highest, providing favorable conditions for reproduction and growth. Minimum densities occurred in the rainy season when dilution effects reduced transparency and nutrient availability, with lower values of temperature (33.18–34.21 °C), pH (8.4–8.1), and dissolved oxygen (5.81–5.91 mg/L). Winter showed intermediate densities, supported by higher dissolved oxygen (9.89–9.94 mg/L) and moderate nutrient levels.

The comparative analysis of raw percentages and statistical indices confirmed Rotifera as the dominant group, followed by Cladocera and Protozoa, while Copepoda maintained a stable presence and Ostracoda showed a decline. The dominance of Rotifera can be attributed to their high reproductive potential, adaptability, and tolerance to varying physico-chemical conditions. The decline of Ostracoda in 2023 may indicate sensitivity to habitat disturbance or changes in sediment composition. Thus, zooplankton diversity in Virla reservoir reflects a balanced ecosystem, with Rotifera acting as the primary bioindicator of water quality

Table 1: Seasonal Variation of zooplankton density (no./litre) in Virla reservoir during 2022

S.N.	Name of the groups and genera	Season															Annual Total
		Rainy					Winter					Summer					
		I	II	III	IV	V	I	II	III	IV	V	I	II	III	IV	V	
I	Rotifera																
1	*Asplanchna*	2	0	3	2	4	0	2	1	2	0	3	5	2	7	4	37
2	*Filinia opolensis*	1	2	4	3	5	2	0	5	8	6	5	0	10	15	12	78
3	*Filinia longiseta*	3	5	0	4	6	4	7	3	5	8	0	15	20	14	18	112
4	*Brachionus sp.*	10	11	8	7	9	15	12	13	20	8	18	21	22	20	21	215
5	*Brachionus caudatus*	4	7	8	7	11	2	5	9	6	7	8	7	8	9	6	104
6	*Brachionus rubens*	12	10	13	8	7	15	12	18	20	21	12	15	17	20	25	225
7	*Keratella tropica*	15	13	17	18	16	10	11	18	12	13	10	12	10	11	18	204
8	*Lecane bulla*	3	0	2	3	2	0	5	3	7	8	0	6	5	8	11	63
	Total Species	50	48	55	52	60	48	54	70	80	71	56	81	94	104	115	1038
II	Cladocera																
1	*Moniabra*	0	2	5	4	3	0	3	5	8	9	3	5	12	18	15	92
2	*Ceriodaphnia sp.*	3	5	0	2	1	2	7	10	8	5	8	7	12	20	18	108
3	*Diaphanosoma sp.*	4	3	10	11	8	3	4	7	6	15	20	22	16	18	17	164
4	*Alona retangul*	0	2	3	2	5	2	0	15	20	16	3	7	9	6	15	105
5	*Daphnia sp.*	10	8	10	12	17	0	12	18	15	19	5	7	3	4	20	160
	Total Species	17	20	28	31	34	7	26	55	57	64	39	48	52	66	85	629
III	Protozoa																
1	*Arcella vulgaris*	0	1	2	0	3	11	0	10	12	8	18	12	10	8	17	112
2	*Actinophrys sp.*	4	5	2	1	4	4	5	0	10	12	21	25	20	22	10	145
3	*Vorticella sp.*	6	7	3	4	6	13	10	12	8	7	10	12	13	10	8	129
4	*Ceratium*	5	3	7	0	9	6	3	15	8	9	3	7	9	13	25	122
	Total Species	15	16	14	5	22	34	18	37	38	36	52	56	52	53	60	508
IV	Copepoda																
1	*Phyllodiaptomus*	2	0	1	3	2	0	3	0	2	5	6	8	10	12	10	64
2	*Cyclops*	0	2	0	1	2	2	3	7	5	8	3	2	15	20	18	88
3	*Mesocyclops*	0	1	2	3	3	3	2	5	2	7	20	13	18	20	23	122
4	*Microcyclops*	0	0	1	2	1	0	2	1	3	5	7	18	19	15	17	91
	Total Species	2	3	4	9	8	5	10	13	12	25	36	41	62	67	68	365
V	Ostracoda																
1	*Cypris sp.*	3	0	2	0	1	2	0	3	5	0	18	20	10	11	15	90
2	*Cyprinotus sp.*	3	5	2	7	0	0	3	7	9	0	8	10	13	9	8	84
3	*Cypridopsio sp.*	0	3	2	2	1	0	3	2	0	8	7	7	20	22	13	90
	Total Species	6	8	6	9	2	2	6	12	14	8	33	37	43	42	36	264

Table 2: Seasonal Variation of zooplankton density (no./litre) in Virla reservoir during 2023

S.N.	Name of the groups and genera	Season															Annual Total
		Rainy					Winter					Summer					
		I	II	III	IV	V	I	II	III	IV	V	I	II	III	IV	V	
I	Rotifera																
1	*Asplanchna*	2	0	4	2	4	0	2	1	2	0	3	5	2	8	4	39
2	*Filinia opolensis*	5	2	7	4	5	2	0	6	8	6	8	0	9	17	15	94
3	*Filinia longiseta*	3	5	0	7	6	4	8	3	5	9	0	17	21	16	20	124
4	*Brachionus sp.*	12	4	8	7	9	15	12	13	20	8	18	21	22	23	21	213
5	*Brachionus caudatus*	4	7	8	7	11	2	9	9	6	7	8	7	8	10	6	109
6	*Brachionus rubens*	12	10	13	8	7	15	12	18	13	21	12	15	17	20	28	221
7	*Keratella tropica*	16	13	17	12	16	10	11	18	7	13	10	12	10	11	18	194
8	*Lecane bulla*	3	1	12	3	4	0	1	3	7	5	0	6	5	2	9	61
	Total Species	57	42	69	50	62	48	55	71	68	69	59	83	94	107	121	1055
II	Cladocera																
1	*Moniabra*	0	2	5	3	3	0	1	5	7	9	3	5	10	18	12	83
2	*Ceriodaphnia sp.*	4	5	0	3	1	4	7	9	8	5	5	7	12	12	9	91
3	*Diaphanosoma sp.*	4	3	3	11	8	3	4	7	6	15	20	22	16	18	17	157
4	*Alona retangul*	0	2	3	1	5	2	0	15	20	16	3	7	9	6	15	104
5	*Daphnia sp.*	10	8	10	12	17	0	12	18	15	11	5	7	3	3	20	151
	Total Species	18	20	21	30	34	9	24	54	56	56	36	48	50	57	73	586
III	Protozoa																
1	*Arcella vulgaris*	0	1	1	0	3	11	3	10	12	4	18	12	10	8	17	110
2	*Actinophrys sp.*	4	5	2	1	4	4	5	0	10	12	21	25	20	21	10	144
3	*Vorticella sp.*	6	7	4	4	6	12	8	12	5	3	10	1	2	10	8	98
4	*Ceratium*	5	2	7	0	9	6	2	2	7	9	3	1	9	3	4	69
	Total Species	15	15	14	5	22	33	18	24	34	28	52	39	41	42	39	421
IV	Copepoda																
1	*Phyllodiaptomus*	2	0	1	3	2	0	3	2	2	5	6	8	12	12	10	68
2	*Cyclops*	0	2	0	1	2	2	3	7	6	8	3	2	15	20	18	89
3	*Mesocyclops*	2	1	2	4	4	3	2	10	2	7	10	15	18	12	23	115
4	*Microcyclops*	2	3	1	4	1	1	4	3	4	7	7	12	19	15	17	100
	Total Species	6	6	4	12	9	6	12	22	14	27	26	37	64	59	68	372
V	Ostracoda																
1	Cypris sp.	3	0	2	0	1	2	0	3	5	0	4	4	6	8	4	42
2	Cyprinotus sp.	3	5	2	7	4	0	3	7	9	0	8	4	5	9	8	74
3	Cypridopsio sp.	0	3	3	2	1	0	3	2	0	8	7	2	3	3	5	42
	Total Species	6	8	7	9	6	2	6	12	14	8	19	10	14	20	17	158

Table 3A: Yearly Raw Percentage Contribution of Zooplankton Groups in Virla Reservoir (2022–2023)

S.No	Zooplankton Group	Year 2022 (%)	Year 2023 (%)
1	Rotifera	37.0	40.7
2	Cladocera	22.4	22.6
3	Protozoa	18.1	16.2
4	Copepoda	13.0	14.4
5	Ostracoda	9.4	6.1

Table 3B: Yearly Variation of Zooplankton Density in Virla Reservoir (Mean + SD × 10^2)

S.No	Group	Year 2022	Year 2023
1	Rotifera	61.11 ± 3.104	61.04 ± 3.11
2	Cladocera	15.12 ± 2.345	15.21 ± 2.33
3	Protozoa	12.01 ± 2.43	12.06 ± 2.35
4	Copepoda	11.10 ± 1.41	10.35 ± 1.28
5	Ostracoda	5.05 ± 1.22	5.02 ± 1.20
	Total	104.39 ± 10.50	103.68 ± 10.22

Table 4: Seasonal Fluctuation of Physico-Chemical Parameters in Virla Reservoir Year 2022–2023

Parameter	2022 Rainy	2022 Winter	2022 Summer	2023 Rainy	2023 Winter	2023 Summer
Temperature (°C)	33.18	22.23	45.32	34.21	20.10	45.22
pH	8.4	7.31	9.13	8.1	7.42	9.21
TDS (mg/L)	238	234	246.6	249	241	265.1
Total Alkalinity	143	138	256	142	133	251
DO (mg/L)	5.81	9.89	7.23	5.91	9.94	7.83
BOD (mg/L)	5.38	5.31	5.49	5.42	5.37	5.56
Phosphorus (mg/L)	3.2	2.78	3.55	3.0	2.88	3.43

Conclusion

The present investigation of Virla reservoir during 2022–2023 revealed that zooplankton diversity is composed of five major groups: Rotifera, Cladocera, Protozoa, Copepoda, and Ostracoda, with a total of 24 species recorded. Among these, Rotifera consistently dominated both in raw percentages and statistical density indices, reflecting their high reproductive potential and adaptability to varying

physico-chemical conditions. Cladocera and Protozoa contributed moderately, while Copepoda maintained a stable presence across seasons. Ostracoda, however, showed a marked decline in 2023, suggesting sensitivity to environmental stress or habitat changes.

Seasonal fluctuations in zooplankton density were closely correlated with physico-chemical parameters. Maximum densities were observed in summer, coinciding with higher temperature, alkalinity, and nutrient availability, whereas minimum densities occurred in the rainy season due to dilution effects and reduced transparency. Winter values were intermediate, supported by higher dissolved oxygen levels.

The study highlights that zooplankton serve as reliable bioindicators of water quality in Virla reservoir. The dominance of Rotifera and the seasonal variability of other groups reflect the ecological balance of the system. The observed decline in species richness and the reduced contribution of Ostracoda emphasize the need for continuous monitoring and conservation strategies to mitigate anthropogenic pressures and maintain biodiversity in freshwater ecosystems.

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