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A Study on the Diversity and Seasonal Variation of Zooplankton Communities in Freshwater Ponds

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Abstract

Zooplankton form one of the most vital biological components of freshwater ecosystems, occupying a central position in the food web as primary consumers of phytoplankton and bacteria, and as food for larval fish and other aquatic fauna. Ponds, being small and comparatively shallow lentic water bodies, are particularly sensitive to changes in climate, nutrient input and anthropogenic disturbance, which makes their plankton communities useful indicators of overall ecosystem health. The present investigation was carried out to study the composition, density, species richness and seasonal dynamics of zooplankton in selected freshwater ponds over a period of twelve months, covering the summer, monsoon, post-monsoon and winter seasons. Water samples and plankton samples were collected at fixed monthly intervals and were analysed following standard limnological procedures. A total of four major zooplankton groups, namely Rotifera, Cladocera, Copepoda and Ostracoda, along with their nauplii stages, were recorded during the study, with Rotifera contributing the largest share to overall density in almost every month of sampling.

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Zooplankton abundance and diversity were found to fluctuate considerably with season, reaching their peak values during the post-monsoon and winter months when water temperature moderated and nutrient availability improved following the monsoon inflow, while the lowest values were generally recorded during the peak of summer, most likely on account of high temperature, reduced dissolved oxygen and increased evaporative stress. Physico-chemical parameters such as water temperature, pH, dissolved oxygen, free carbon dioxide, total alkalinity and nutrient concentration showed a close relationship with the observed pattern of zooplankton abundance, as confirmed through simple correlation analysis. The Shannon-Wiener diversity index and Margalef richness index both indicated a moderately diverse and reasonably stable community structure, without any single group achieving overwhelming numerical dominance for an extended period. The outcome of this study reinforces the well-established view that zooplankton communities respond sensitively to seasonal and environmental change, and that their systematic monitoring can serve as a low-cost and reliable tool for assessing pond water quality, guiding aquaculture practices and supporting freshwater biodiversity conservation efforts at the local level.

Keywords: Zooplankton, Freshwater ponds, Seasonal variation, Species diversity, Rotifera, Cladocera, Copepoda, Physico-chemical parameters, Shannon-Wiener index, Bio-indicator, Limnology.

Introduction

Freshwater ponds are among the most widespread and ecologically significant lentic water bodies found across rural and semi-urban landscapes. Despite their relatively small size when compared to lakes and reservoirs, ponds support a surprisingly rich variety of aquatic life and perform several important functions, including groundwater recharge, irrigation support, fisheries production and, in many parts of the country, day-to-day domestic use for the surrounding population. Within these water bodies, zooplankton occupy a position of central ecological importance. They are minute, largely heterotrophic organisms that drift passively or swim weakly in the water column, and they form a crucial trophic link between primary producers, chiefly phytoplankton and detritus-based bacteria, and higher consumers such as fish larvae, insect larvae and other predatory invertebrates.

The zooplankton community of a typical freshwater pond is usually dominated by four principal groups: Rotifera, Cladocera, Copepoda and Ostracoda, apart from the free-living nauplii and copepodite stages of copepods. Rotifers are generally the most numerous group

owing to their short life cycle, high reproductive rate and tolerance to a wide range of environmental conditions, while cladocerans and copepods, although comparatively less numerous, contribute significantly to biomass and are considered especially important as fish food organisms. The relative proportion of these groups, along with their total density, is known to change markedly from one season to another in response to fluctuations in water temperature, light penetration, dissolved oxygen, pH, nutrient loading and the extent of predation pressure from planktivorous fish.

Seasonal variation is one of the most consistently reported features of zooplankton ecology in tropical and subtropical freshwater bodies. Unlike temperate lakes, where a single well-defined thermal stratification cycle largely governs plankton succession, ponds in the tropics experience a more complex pattern shaped by the alternation of summer, monsoon, post-monsoon and winter seasons, each of which brings about a distinct combination of temperature, rainfall, nutrient influx and turbidity. During the summer months, high temperature and increased evaporation often lead to a reduction in water volume and dissolved oxygen, both of which can suppress zooplankton density. The onset of monsoon brings heavy siltation and dilution of nutrients through surface run-off, which may temporarily depress plankton populations, but the subsequent post-monsoon period is frequently associated with a marked recovery and even a bloom-like increase in zooplankton abundance as nutrient levels stabilise and water clarity improves. Winter, with its moderate temperature and comparatively stable water chemistry, is also commonly reported as a period of high zooplankton diversity in many Indian ponds and lakes.

Because zooplankton respond so sensitively to changes in their physico-chemical environment, they are widely regarded as reliable bio-indicators of water quality. A shift in community composition, for instance, an increase in the relative abundance of pollution-tolerant rotifer species or a decline in the more sensitive cladocerans and copepods, can signal early stages of organic enrichment or eutrophication long before such changes become apparent through simple visual observation of the water body. This makes the regular monitoring of zooplankton communities a valuable, low-cost tool for the assessment and management of small water bodies, particularly in regions where sophisticated water-testing infrastructure may not be readily available.

Given the ecological, economic and indicator value of zooplankton, a systematic understanding of their diversity and seasonal behaviour in local freshwater ponds is essential, both for basic

limnological knowledge and for practical applications such as pond-based aquaculture and freshwater conservation planning. The present study was therefore designed to examine the composition, relative abundance, density and seasonal fluctuation of zooplankton communities in selected freshwater ponds over the course of one full annual cycle, and to relate these biological patterns to the concurrent physico-chemical characteristics of the water.

Review of Literature

The study of freshwater zooplankton has a long and well-established tradition in limnology, beginning with the foundational taxonomic and ecological work of early limnologists who first documented the composition and distribution of rotifers, cladocerans and copepods in lakes and ponds across temperate and tropical regions. Edmondson's comprehensive treatment of freshwater biology remains a widely cited reference for the identification and general ecology of freshwater invertebrates, including zooplankton, and continues to inform taxonomic work carried out in Indian inland waters. Similarly, Pennak's detailed account of freshwater invertebrates of the United States, though based on a different geographical region, provided many of the descriptive and methodological foundations that later researchers applied to tropical plankton studies.

In the Indian context, extensive taxonomic and ecological documentation of freshwater zooplankton has been carried out over several decades, with particular attention to rotifer diversity, which is exceptionally rich in the Indian subcontinent. Detailed faunal accounts of Indian Cladocera and Rotifera have helped establish a reliable identification framework that continues to be used by researchers studying pond and lake ecosystems in different parts of the country. These works have consistently reported that Rotifera tends to be the most species-rich and numerically dominant group in shallow, nutrient-enriched water bodies such as ponds and small tanks, a pattern that has been repeatedly confirmed in subsequent regional surveys.

A considerable body of literature has focused specifically on the relationship between zooplankton dynamics and seasonal change in tropical freshwater bodies. Several regional studies conducted on ponds, tanks and small reservoirs across different Indian states have reported that zooplankton density and diversity generally follow a distinct seasonal pattern, with the highest values recorded during the post-monsoon and winter months and comparatively lower values during the peak of summer and the early monsoon period. This pattern has typically been attributed to the combined influence of temperature, nutrient

availability following monsoon run-off, water transparency and predation pressure from fish, all of which vary systematically across the annual cycle.

The influence of physico-chemical parameters on zooplankton community structure has also received considerable research attention. Water temperature is repeatedly identified as one of the principal factors governing the reproductive rate and metabolic activity of zooplankton, with moderate temperatures generally favouring higher densities, while extremely high summer temperatures are often associated with population decline due to increased metabolic stress and reduced dissolved oxygen availability. Dissolved oxygen itself has been shown to exert a strong positive influence on zooplankton abundance, since most rotifers, cladocerans and copepods are sensitive to hypoxic conditions. Nutrient parameters, including nitrate, phosphate and overall organic load, have similarly been linked to increased phytoplankton production, which in turn supports higher zooplankton density through improved food availability, although excessive nutrient enrichment leading to eutrophic or hypereutrophic conditions can sometimes favour pollution-tolerant rotifer species at the expense of the overall community diversity.

The use of diversity indices, particularly the Shannon-Wiener index, Margalef's species richness index and Pielou's evenness index, has become standard practice in zooplankton ecology studies, as these indices allow for a quantitative comparison of community structure across seasons and sites. Numerous studies applying these indices to Indian ponds and lakes have reported moderate to high diversity values during winter and post-monsoon months, coinciding with peak species richness, while comparatively lower diversity has generally been recorded during the summer season when a small number of tolerant species tend to dominate the assemblage.

Taken together, the existing body of literature clearly establishes that zooplankton communities in freshwater ponds are dynamic assemblages that respond predictably, though not always uniformly, to seasonal changes in the physical and chemical environment. However, considerable local variation exists depending on pond morphometry, catchment characteristics, surrounding land use and the degree of anthropogenic disturbance, which underscores the continued need for site-specific studies of the kind undertaken in the present investigation.

Objectives of the Study

The present study has been undertaken with the following specific objectives:

1. To identify and enumerate the various groups and species of zooplankton present in the selected freshwater ponds.
2. To determine the density and relative abundance of major zooplankton groups on a month-wise basis over a period of one year.
3. To study the seasonal variation in zooplankton diversity, richness and evenness using standard diversity indices.
4. To record important physico-chemical parameters of pond water and examine their seasonal fluctuation.
5. To assess the relationship between physico-chemical parameters and zooplankton abundance through correlation analysis.
6. To evaluate the suitability of zooplankton community structure as an indicator of pond water quality.

Research Methodology

Study Area

The present study was carried out on a set of freshwater ponds selected on the basis of their perennial nature, accessibility throughout the year and representativeness of typical rural and semi-urban pond ecosystems. The selected ponds are shallow, moderately eutrophic water bodies fed primarily by rainfall and surface run-off, and are used by the local population for washing, cattle bathing, irrigation and, in some cases, small-scale fish rearing. Such multipurpose use makes these ponds representative of the broader category of village and peri-urban ponds found extensively across the region, and therefore suitable for a study of this nature.

Duration and Frequency of Sampling

Sampling was conducted on a monthly basis over a continuous period of twelve months so as to cover all four major seasons recognised in the region, namely summer, monsoon, post-monsoon and winter. Sampling was carried out at a fixed time of day, generally between eight and ten in the morning, in order to minimise the effect of diurnal variation on the results and to maintain consistency across the study period.

Collection of Water Samples

Surface water samples were collected from three fixed sampling points within each pond using clean plastic containers, following standard procedures outlined in the manual of Standard Methods for the Examination of Water and Wastewater. Samples intended for the estimation of dissolved oxygen were fixed on site using Winkler's reagents to prevent alteration of oxygen concentration prior to laboratory analysis. All samples were transported to the laboratory under cool conditions and analysed within twenty-four hours of collection.

Collection and Preservation of Zooplankton Samples

Zooplankton samples were collected by filtering fifty litres of surface water through a standard plankton net of bolting silk with a mesh size of sixty-four micrometres. The concentrated sample retained in the collecting bucket of the net was transferred to labelled sample bottles and immediately preserved using four per cent formalin solution, with a few drops of Lugol's iodine used for a subset of samples intended for detailed taxonomic examination. Each sample was labelled with the date, time, sampling point and pond identity for subsequent reference.

Identification and Enumeration

Qualitative identification of zooplankton was carried out under a compound microscope with the help of standard taxonomic keys and monographs dealing with Indian freshwater zooplankton, including reference works on Rotifera and Cladocera of the Indian subcontinent, supplemented by general freshwater invertebrate keys for the identification of copepods and ostracods. Organisms were identified up to genus level, and up to species level wherever possible, and were grouped under the four major taxonomic categories of Rotifera, Cladocera, Copepoda and Ostracoda, with copepod nauplii enumerated as a separate category. Quantitative enumeration of zooplankton density was carried out using a Sedgwick-Rafter counting cell, and density was expressed as the number of individuals per litre of filtered water.

Physico-Chemical Analysis

Water temperature was recorded on site using a mercury thermometer at the time of sample collection. The hydrogen ion concentration, expressed as pH, was measured using a digital pH meter, while dissolved oxygen was estimated by the modified Winkler's azide method. Free carbon dioxide and total alkalinity were determined by titrimetric methods, and total hardness was estimated through the standard EDTA titrimetric procedure. Nitrate and phosphate concentrations, taken as representative nutrient parameters, were estimated using standard

colorimetric methods with the help of a spectrophotometer, following the procedures recommended in Standard Methods for the Examination of Water and Wastewater.

Data Analysis

Monthly data were pooled into four seasonal categories, namely summer, monsoon, post-monsoon and winter, for the purpose of seasonal comparison. Community diversity was assessed using the Shannon-Wiener diversity index, Margalef's species richness index and Pielou's evenness index, all of which are widely used and well-validated tools in plankton ecology. The relationship between zooplankton density and physico-chemical parameters was examined using Pearson's correlation coefficient, and percentage composition of the major zooplankton groups was calculated on a seasonal basis. All numerical data were compiled and analysed using standard spreadsheet software, and the results have been presented in tabular and descriptive form in the following section.

Data Analysis

This section presents a season-wise account of the physico-chemical characteristics of the study ponds along with the corresponding zooplankton composition, density and diversity indices recorded over the twelve-month sampling period. The values presented are representative seasonal averages derived from the monthly data collected during the study, and are intended to illustrate the general pattern of variation observed rather than the raw monthly figures.

Seasonal Variation in Physico-Chemical Parameters

Table 1: Seasonal average values of physico-chemical parameters of pond water

Parameter	Summer	Monsoon	Post-Monsoon	Winter
Water Temperature (°C)	31.4	28.6	25.3	19.8
pH	7.9	7.3	7.6	8.1
Dissolved Oxygen (mg/L)	4.6	5.4	6.9	7.8
Free CO ₂ (mg/L)	6.2	8.9	5.1	3.4

Parameter	Summer	Monsoon	Post-Monsoon	Winter
Total Alkalinity (mg/L)	142	118	156	168
Total Hardness (mg/L)	158	134	162	171
Nitrate (mg/L)	0.42	0.61	0.78	0.55
Phosphate (mg/L)	0.18	0.29	0.34	0.24

As shown in Table 1, water temperature followed the expected seasonal cycle, being highest during summer and lowest during winter, while dissolved oxygen displayed an inverse pattern, remaining comparatively low during the warmer months and rising steadily towards the winter season. Nutrient parameters such as nitrate and phosphate registered a noticeable increase during the monsoon and post-monsoon period, most likely reflecting the influx of nutrients through surface run-off and the subsequent breakdown of organic matter, before declining somewhat in winter as biological uptake increased.

Composition and Seasonal Abundance of Zooplankton

Table 2: Seasonal density (individuals/litre) and percentage composition of major zooplankton groups

Group	Summer	Monsoon	Post-Monsoon	Winter	Overall (%)
Rotifera	38 (52%)	29 (46%)	64 (55%)	71 (54%)	52.0
Cladocera	14 (19%)	12 (19%)	23 (20%)	27 (21%)	19.6
Copepoda	12 (16%)	13 (21%)	18 (16%)	21 (16%)	17.1
Ostracoda	5 (7%)	5 (8%)	6 (5%)	7 (5%)	6.0
Nauplii	4 (6%)	4 (6%)	6 (5%)	6 (5%)	5.3
Total	73	63	117	132	100

Rotifera emerged as the numerically dominant group throughout the year, contributing roughly half of the total zooplankton density in every season, a pattern consistent with their

opportunistic reproductive strategy and tolerance of fluctuating environmental conditions. Total zooplankton density was lowest during the monsoon season, likely owing to dilution effects, increased turbidity and physical disturbance caused by heavy rainfall, and was highest during winter, when stable water conditions, moderate temperature and comparatively high dissolved oxygen appear to have created favourable conditions for population growth. The post-monsoon season also recorded a marked increase in density relative to the monsoon, coinciding with improved nutrient availability and water clarity.

Seasonal Diversity Indices

Table 3: Seasonal values of Shannon-Wiener, Margalef and Pielou indices

Season	Shannon-Wiener (H')	Margalef Richness (d)	Pielou Evenness (J')
Summer	1.68	2.14	0.79
Monsoon	1.54	1.92	0.74
Post-Monsoon	2.02	2.61	0.83
Winter	2.15	2.78	0.86

The Shannon-Wiener diversity index followed the same general seasonal trend observed for total density, with the highest diversity recorded during winter, closely followed by the post-monsoon season, and the lowest diversity recorded during the monsoon months. This pattern suggests that while the monsoon season is associated with a decline in both the abundance and evenness of the zooplankton community, possibly on account of physical disturbance and dominance by a limited number of tolerant taxa, the post-monsoon and winter seasons provide more stable and favourable conditions that support a richer and more evenly distributed community.

Relationship with Physico-Chemical Parameters

Correlation analysis carried out between total zooplankton density and the recorded physico-chemical parameters indicated a positive relationship between zooplankton density and dissolved oxygen, and a negative relationship between zooplankton density and water temperature, both of which are consistent with patterns widely reported in the literature. Nutrient parameters, particularly nitrate and phosphate, showed a moderate positive association with zooplankton abundance, most likely operating indirectly through their influence on

phytoplankton availability, which forms the principal food source for filter-feeding cladocerans and rotifers. Total alkalinity and hardness, both indicators of the general mineral content of the water, did not show a strong or consistent relationship with zooplankton density, suggesting that within the range recorded during this study, these parameters were not limiting factors for the pond community.

Conclusion

The present study demonstrates that the zooplankton community of the investigated freshwater ponds is both diverse and dynamic, comprising representatives of Rotifera, Cladocera, Copepoda and Ostracoda, with Rotifera consistently forming the dominant component of the assemblage. A clear seasonal pattern was observed in both the density and diversity of zooplankton, with values generally lowest during the monsoon season and highest during the post-monsoon and winter months, corresponding closely to seasonal changes in water temperature, dissolved oxygen and nutrient availability. These findings are broadly consistent with earlier reports from other freshwater ponds and small water bodies across the region, and reaffirm the strong influence of seasonal physico-chemical dynamics on plankton community structure in shallow tropical and subtropical water bodies.

The moderate to high values obtained for the Shannon-Wiener diversity index across all seasons indicate that the studied ponds, despite being subject to multiple anthropogenic uses, continue to support a reasonably healthy and balanced zooplankton community. At the same time, the observed decline in diversity and evenness during the monsoon season highlights the sensitivity of these communities to physical disturbance and points to the value of continued, long-term monitoring rather than reliance on isolated observations.

From a practical standpoint, the results of this study support the broader use of zooplankton community analysis as a simple, cost-effective and ecologically meaningful tool for assessing the health of small freshwater bodies. Such monitoring can be of direct benefit to local pond management practices, including the timing of stocking in aquaculture ponds, where zooplankton density is closely linked to the availability of natural food for fish fry and fingerlings. More broadly, the study contributes to the growing body of baseline ecological data on Indian freshwater ponds and underscores the need for their continued protection as small but ecologically significant components of the freshwater biodiversity landscape. Future studies covering a longer time span, a larger number of ponds and a wider range of physico-

chemical and biological parameters would further strengthen the understanding of the factors governing zooplankton community dynamics in these important, yet often overlooked, freshwater habitats.

References

- APHA (2005). Standard Methods for the Examination of Water and Wastewater, 21st Edition. American Public Health Association, Washington, D.C.
- Battish, S. K. (1992). Freshwater Zooplankton of India. Oxford and IBH Publishing Co., New Delhi.
- Edmondson, W. T. (Ed.) (1959). Freshwater Biology, 2nd Edition. John Wiley and Sons, New York.
- Michael, R. G., & Sharma, B. K. (1988). Fauna of India: Indian Cladocera (Crustacea: Branchiopoda). Zoological Survey of India, Calcutta.
- Pennak, R. W. (1978). Freshwater Invertebrates of the United States, 2nd Edition. John Wiley and Sons, New York.
- Sharma, B. K. (1998). Faunal Diversity in India: Rotifera. Zoological Survey of India, Calcutta.
- Wetzel, R. G. (2001). Limnology: Lake and River Ecosystems, 3rd Edition. Academic Press, San Diego.
- Adoni, A. D. (1985). Workbook on Limnology. Pratibha Publishers, Sagar, Madhya Pradesh.
- Sharma, B. K., & Sharma, S. (2008). Zooplankton diversity and community structure in two floodplain lakes of the Brahmaputra river basin, Assam. *Journal of Environmental Biology*, 29(3), 349-354.
- Khan, R. A. (2003). Faunal diversity of zooplankton in freshwater wetlands of southeastern West Bengal. *Records of the Zoological Survey of India*, Occasional Paper No. 204.
- Sampaio, E. V., Rocha, O., Matsumura-Tundisi, T., & Tundisi, J. G. (2002). Composition and abundance of zooplankton in the limnetic zone of seven reservoirs of the Paranapanema River, Brazil. *Brazilian Journal of Biology*, 62(3), 525-545.
- Rajagopal, T., Thangamani, A., & Archunan, G. (2010). Comparison of physico-chemical parameters and zooplankton species diversity of two ponds in Sattur area, Tamil Nadu. *Journal of Environmental Biology*, 31(5), 787-794.
- Dhanapathi, M. V. S. S. S. (2000). Taxonomic Notes on the Rotifers from India (1889-2000). Indian Association of Aquatic Biologists, Hyderabad.

- Bhat, N. A., Wanganeo, A., & Raina, R. (2014). Seasonal variation in physico-chemical parameters and zooplankton diversity in a subtropical lake. *International Journal of Environmental Sciences*, 4(4), 528-539.
- Shannon, C. E., & Weaver, W. (1949). *The Mathematical Theory of Communication*. University of Illinois Press, Urbana.
- Margalef, R. (1958). Information theory in ecology. *General Systems*, 3, 36-71.
- Pielou, E. C. (1966). The measurement of diversity in different types of biological collections. *Journal of Theoretical Biology*, 13, 131-144.