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SPECIES DIVERSITY AND PROTOZOOPLANKTON ABUNDANCE IN KONAM RESERVOIR, VISAKHAPATNAM, ANDHRA PRADESH

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Background:
Protozooplankton plays a crucial role in aquatic ecosystems as primary grazers of phytoplankton and links to higher trophic levels. Their growth rates, abundance, biomass, and diversity serve as indicators of ecosystem health and pollution. A study was conducted in six stations of Konam Reservoir, during the period from July, 2015 to June, 2016 to investigate protozooplankton communities. During the study, two flagellate assemblages were identified: *Cryptomonas-Peridinium* (predominant at all stations) and Euglenids (seasonal occurrence). Ciliates formed three assemblages: *Vorticella-Coleps* (stagnant waters), *Pelagostrombidium-Holophrya*(catchment area), and *Halteria-Strobilidiumgyrans* (stations 2-4). These species were found to be more nutrient-dependent than water quality-dependent. The abundance of flagellates showed a gradual increase in their abundance from station 1 to 5 but the ciliates were more abundant at station 3 than at other locations. The gradual rise in ciliate composition from 1 to 3 and fall in 4 to station 6 may be attributable to the rich anthropogenic activity at station 3 than at other points of reservoir. In addition to the above, the flagellates cyanophycean and filamentous diatoms also occur in the reservoir waters playing significant role in the trophic levels of the aquatic ecosystems.

***Keywords*:** Protozooplankton, Flagellates, Cilitaes, Euglenids, Species Diversity

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Introduction

India's reservoirs have been instrumental in driving social and economic growth over the past five decades, storing precious rainfall to enable irrigation for agricultural lands, electricity generation, drinking water supply, and flood and drought protection, thereby transforming India's landscape and ensuring a more secure and prosperous future [1]. In reservoir ecosystems, planktonic protozoans encompass a diverse range of taxa, including foraminifera, radiolarians, flagellates, and ciliates. While the first three groups dominate deep-sea environments, flagellates and ciliates prevail in freshwater and coastal waters. The significance of these microorganisms in marine environments has been recognized by Lohmann[2], highlighting the importance of heterotrophic protozoans. Subsequent research has underscored their crucial role in the plankton microbial community [3], energy flow, and nutrient cycling[4]. Studies have further emphasized their impact on microbial community productivity, biomass, and diversity [5]. Protozoa function as both a food source and a regulator of microbial populations of higher trophic levels, they also play a significant role in aquatic settings as nutrient recyclers and remineralizers [6]. Their small size, short generation times, sensitivity to stress, and ability to occur in a variety of environments make them excellent biological indicators [7]. They also effectively reflect the physical, chemical, and biological environmental aspects [8]. Since plankton productivity is particularly crucial for a healthy ecosystem, studies on this issue measured ecologically significant in aquatic habitats. Their diversity has developed as a result of their evolution to take use of the variety of microbial food sources that exist on all permanent and transient aquatic environments, even if some of them are capable of photosynthesis [9]. The importance of protozoans in trophic systems, underscoring their significance in aquatic ecosystems in Brazilian freshwater bodies has been illustrated by Bagatini et al. [10].

Numerous studies have investigated various aspects of phytoplankton and zooplankton ecology in Indian reservoirs. Researchers have explored topics such as plankton population dynamics in NagarjunSagar Reservoir [11], phytoplankton productivity fluctuations in Gandhi Sagar Reservoir [12], and the impact of abiotic factors on phytoplankton in Kohargaddi Dam [13]. Additional studies have examined phytoplankton diversity and seasonal fluctuations in Pahuj Reservoir [14], and Riwada Reservoir [15]. Further, limnological studies in Indian Reservoirs in relation to plankton productivity have been investigated by [16-20]. However, research on reservoirs in Andhra Pradesh's eastern ghats and Bay of Bengal coast has been limited. The region's low-lying areas are prone to flooding during the monsoon season. Reservoirs in Andhra Pradesh's coastal districts (Visakhapatnam, Vizianagaram, and parts of East Godavari) play a crucial role in supporting domestic use, agriculture, farming, and irrigation.

Hence, the taxonomic composition and abundance of protozooplankton in Indian freshwater reservoirs are still poorly understood.The main objective of the study is to evaluate and identify the plankton communities at group level for phytoplankton, zooplankton and at species level in regard to protozooplankton. The study also intended to find out the seasonal changes in species composition and identify faunal assemblages as this is a pioneering study on the reservoir located in the western part of Eastern Ghats.

Material and Methods

The present study on protozoan plankton is carried out at a freshwater reservoir called Konam Lake, located in ChidikadaMandal, Visakhapatnam district, Andhra Pradesh, near the Eastern Ghats (latitude 180 -52'-0"N and longitude 820 - 50'- 0"E). It is a small irrigation project constructed on the Bodderu river which originates in the Eastern Ghats and flows southwards for 16 km, passing through Konam village and turning south-eastwards for another 16 km to join another river Pedderu near Lakshmipuram. The catchment area is 170-94 km2, mainly covered by hilly and forested areas. The average monsoon rainfall is 893 mm and the maximum flood discharge is 1260 m3/s and the spread area at the FRL is 807 acres. The study area and sampling sites are displayed at Figure No.1.

The phytoplankton samples were collected monthly from six (6) sampling sitesto cover all intrusions and influxes of the reservoir area. Reservoir water for plankton sampling was collected for fresh observations was subjected to filtration of 100 litres through suction

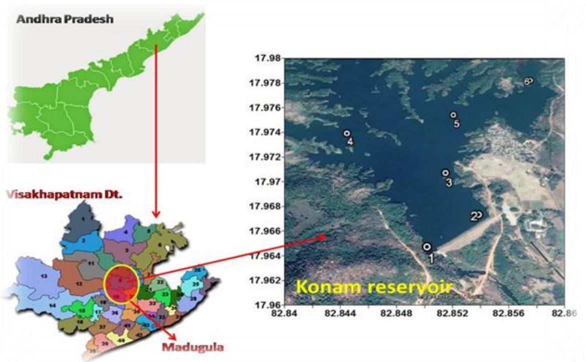


Figure: 1- Konam Reservoir and 6 sampling locations

apparatus (Millipore Company) by using GF/C paper to collect the supernatant in small beakers. The unfiltered supernatant was then collected into the beakers and subjected to vital staining techniques with methyl green, Neutral red, or Nigrosin; flagellates were stained with Giemsa, and ciliates were stained with methyl green and Neutral red. In some cases, Lugol's Iodine was also used to observe the fresh sample by adding a drop of it to the sample. The observations were examined under a Labomed digital microscope from Labomed company at magnifications of 40x and 100x for very small organisms like green flagellates (Monads).

To determine the species composition, photos of a few significant, often observed organisms were captured under a microscope. Protozoa observations by famous taxonomists [21, 22] were followed in order to study the taxonomic observations. While studying taxonomy, we measured the size using an ocular micrometer. One milliliter of Lugol's iodine-fixed sample was placed in a Sedgwick rafter counting chamber, and three aliquots of each sample were examined in order to determine the amount. The quantity was expressed in terms of numbers per 1L.

Results and Discussion

A common class of free-living microorganisms, the protozooplankton plays a vital role in the general economy and productivity of aquatic environments. The two main classifications of planktonic protozoa are ciliates and flagellates. Their sizes vary from 0.2 μm to >200 μm, and they have a broad range of life strategies that allow them to react swiftly to changes in their environment [23]. The composition and distribution of plankton species are significantly influenced by physicochemical parameters and nutrient patterns, which shape their ecological niches and determine their presence and abundance in aquatic environments [24].

The present studies on the protozoan faunal composition was carried out during the one-year period in Konam Reservoir. Two major planktonic groups noticed namely flagellates and ciliates. The flagellates consisted of 5 diverse groups namely Dinoflagellida, Euglenida, Cryptomaonadida, Choanoflagellida and Chrysomonadida and were represented 17 important species. The most common genera were Euglena (4 species), Peridinium (3), Phacus (3 species), Cryptomonas and Trachelomonas. They formed 85% of flagellate population. The other species namely *Peranema, Spumella, Codosiga, Petalomonas, Notosolenus*sp are insignificant and rare species.Similarly, for one year period at 5 sampling locations at Riwada Dam, Visakhapatnam District, Andhra Pradesh, phytoplankton analysis revealed a diverse assemblage of 57 genera, representing four major groups: Chlorophyceae (27 genera), Bacillariophyceae (14 genera), Cyanophyceae (13 genera) and Euglenophyceae (three genera) [15], corroborating phytoplankton seasonal diversity earlier findings by [25-28].

Another major group namely ciliates represented by 35 species belonging to 25 families and 6 major taxonomic groups namely *Karyorelictea, spirotrichea, prostomatia, phyllopharyngia, nassophorea*and*oligohymenophoria* were recorded. Of 35 species noticed only 12 species contributing to nearly 85% of total ciliate population (based on numerical abundance). They are *Strobilidiumgyrans, Halteriagrandinella, Colepshirtus, Cyclidium glaucoma, Stombidiumsulcatum, Vorticella companula, Podophrya sp., Holophrya sp., Prorodon sp., Vorticella natans, Pelagostrombidiumfallax, Tetrahymenathermophila*. The other species are insignificant and occasionally noticed. Thus, in the reservoir there were some commonly occurring protozooplankton and few are occasional and rare species.

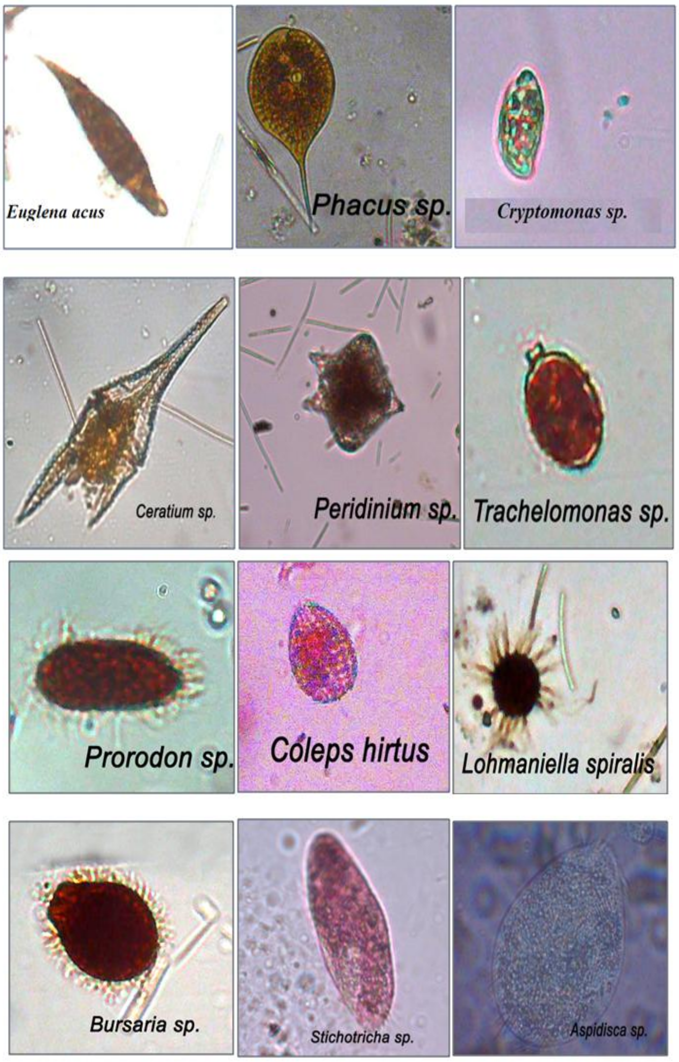
Flagellates play a crucial role in microbial food webs across various ecosystems, contributing significantly to biomass and ecosystem function. This diverse group encompasses unicellular and colonial organisms, ranging in size from 2-2000 µm, and characterized by the presence of one, two, four, or eight flagella [29]. The dynamics of flagellate communities are significantly influenced by a range of hydro-biological factors, encompassing climatic conditions, phytoplankton, zooplankton, and bacterial populations [30]. Station wise species composition of flagellates showed very meager variations in their distribution along the transects. Station 1 for instance, there are 16 species mostly represented by *Peridinium*sp., Station 2 & 3 represented by 14 species mostly predominated by *Cryptomonas*, station 4, 5 & 6 represented by 16, 12 and 15 species respectively and the most commonly observed genera are *Cryptomonas* and *Peridinium*. Some flagellate species are seasonal occurring genera. Euglenoids were observed more during pre-monsoon periods and hot month seasons but dinoflagellates were commonly seen at all stations during all observations irrespective of the seasons.

The other major group of protozoan ciliates representing 35 species. At station I there were 24 species mostly represented by Prostomatians and Peritrichs (*Colepshirtus, Vorticella companula*). In Station 2, there were 27 species represented by choreotrichs and oligotrichs ciliates namely *Halteriagrandinella, Strobilidiumgyrans, Strombidiumsulcatum*. Station 3 has 31 species of which *Halteriagrandinella* and *Strobilidiumgyran*s are very significant. Station 4 and Station 5 are represented by 29 and 28 species mostly represented by *Strobilidiumgyrans.*Station 6 represented by 24 species of which *Halteriagrandinella* and *Pelagostrombidumfallax*. The species which are recorded in reservoir areas were more predatory on flagellates and bacteria. The percentage composition of flagellates and ciliates were calculated and the observation showed gradual increase in the percentage composition of flagellates from station 1 to station 5 the values being 14.2 % at station 1 to 20.4% at station 5. (Table). Station 6 is main catchment area which showed fall in flagellate composition than other catchment locations of the reservoir (Stations 4 and 5).The ciliates showed a raise in the percentage composition from station 1 to station 3(Table) and slight fall in their composition from station 4 to station 6. The middle section of the reservoir showed quantitative enrichment of ciliates than at the catchment areas and dam gates areas.

Overall 72 samples were fixed in lugol's iodine subjected for studying abundance patterns in the reservoir. One ml of the sample is taken in Sedgwick-Rafter counting chamber and the organisms were counted for three similar aliquots under microscope and the abundance expressed in nos/ml. The studies on total numerical abundance of flagellates and ciliates revealed that flagellates outnumbered (13476 nos/ml) ciliates (3390nos/ml).Species Composition wise ciliates were showing variety than flagellates (35 species of ciliates and 17 species of flagellates) but numerically they are low than flagellates following classical microbial food chain. The overall protozooplankton abundance at Six Selected Stations of Konam Reservoir (nos/ml) is displayed at Table 1.Station I near to the dam gates the total flagellate abundance is 1916 nos/ml with minimum abundance 33/ml noted during February 2016 and maximum abundance during April 2016 with 311 nos/ml. The most commonly occurring predominant genera of staion I are *Peridinium*sp and It was also observed that the station I has a greater number of *cynophysian*filamentous algae along with protozoan's indicative of eutrophic environment. Similar

Ciliates are highly adaptable organisms that can thrive in a wide range of environments, due to their ability to tolerate and adjust to varying physical and chemical conditions [31]. When faced with unfavorable conditions, they can form protective cysts that allow them to survive and be transported to new locations through wind, water, insects, and animals [32]. This adaptability enables them to respond to changes in water quality, including fluctuations in temperature, dissolved organic matter, pH, conductivity, and oxygen levels [33]. As a result, ciliates are valuable indicators of water quality and are increasingly used in biomonitoring studies [34]. Additionally, ciliates play a key role in the purification of wastewater, particularly in activated sludge systems, where they contribute significantly to the degradation of organic matter [35].

Glimpses of Protozooplankton identified at different stations



Total Ciliates at Station I recorded was 528nos/ml and the minimum abundance noticed were 16 nos /ml during April 2016 and 18 nos/ml during November 2015. Maximum abundance recorded was 76 nos/ml during January 2016. The most dominant genera were *Strobilidiumgyrans* and *Vorticella companula*. In Station 2, the total flagellate abundance is 2263 nos/ml. Minimum abundance 41 nos/ml were noticed during February 2016 and maximum numbers 416/ml observed in October 2015. The dominant genera were *Cryptomonas* sp. The total ciliate abundance at station 2 is 634 nos/ml with minimum abundance during November 2015 (19 nos/ml) to maximum of 81 nos/ml during June 2015 and during December 2015. The dominant species *Halteriagrandinella, Strobilidiumgyrans*.At station 3 the flagellate total abundance is 2186 nos/ml with minimum abundance recorded 56 nos/ml during February 2016 and maximum of 351 nos/ml during October 2015. The dominant genera *Cryptomonas* sp.similar to station 2.

Ciliate quantitative enumeration revealed total abundance of 713 nos/ml with minimum of 26 nos/ml in November 2015 and maximum numbers 126/ml during march 2016. The numerically predominant ciliate is *Halteriagrandinella* (119 nos/ml).Station 4 is part of catchment area near foot hills of eastern ghats. The flagellate's total abundance is 2417 nos/ml with minimum numbers 113 nos/ml during june 2015 and maximum during 437 nos/ml in May 2016. The abundantly occurring species is same as 2&3 stations *Cryptomonas* sp. The ciliate total abundance 556 nos/ml with minimum of 32 nos/ml and maximum of 81 nos/ml. The most abundant ciliate of station 4 is *Strobilidiumgyrans*.Similarly, previous research indicates that ciliate populations tend to surge in spring (May) and late summer (July, August) [36, 37]driven by the abundance of nutrients that fuel phytoplankton and bacterial growth, ultimately supporting the expansion of planktonic ciliate communities [38].

In case of Station 5, another point of catchment area where the total flagellates encountered were 2517nos/ ml with minimum abundance 70 nos/ml during February 2016 and maximum abundance of 409 nos/ml during May 2016. The predominant flagellate recorded is *Cryptomonas* sp. The other major group ciliates total abundance is 552 nos/ml with minimum of 9 nos/ml during April 2016 and maximum of 73 nos/ml during May 2016. The most commonly abundant species being *Halteriagrandinella* and *Strobilidiumgyrans*. At Station 6, also a transect of catchment area in the reservoir noted a total of 1940 nos/ ml flagellates with minimum of 79/ml during August 2015 and maximum abundance being 394 nos/ml during November 2015. The ciliates abundance ranged from minimum of 21 nos/ml during December 2015 to maximum of 74 nos/ml during July 2015 and May 2016. The dominant ciliate species being *Halteriagrandinella, Pelagostrombidiumfallax*.

Overall observations revealed that the abundance of flagellates showed a gradual increase in their abundance from station 1 to 5 but the ciliates were more abundant at station 3 than at other locations. The gradual rise in ciliate composition from 1 to 3 and fall in 4 to station 6 may be attributable to the rich anthropogenic activity at station 3 than at other points of reservoir.In addition to the above-mentioned flagellates cyanophycians and filamentous diatoms also occur in the reservoir waters playing significant role in the trophic levels of the aquatic ecosystems. The seasonal abundance of flagellates and ciliates at Konam reservoir are shown at Figure:2.

Table:1. Overall Protozooplankton Abundance at Six Selected Stations of Konam Reservoir (nos/ml)

Area	Total flagellates	% composition	Total ciliates	% composition
Station 1	1916	14.2	528	15.6
Station2	2263	16.8	634	18.7
Station3	2186	16.2	713	21.0
Station4	2417	17.9	556	16.4
Station5	2754	20.4	522	15.4
Station6	1940	14.4	437	12.9
Total	**13476**	**100.0**	**3390**	**100**

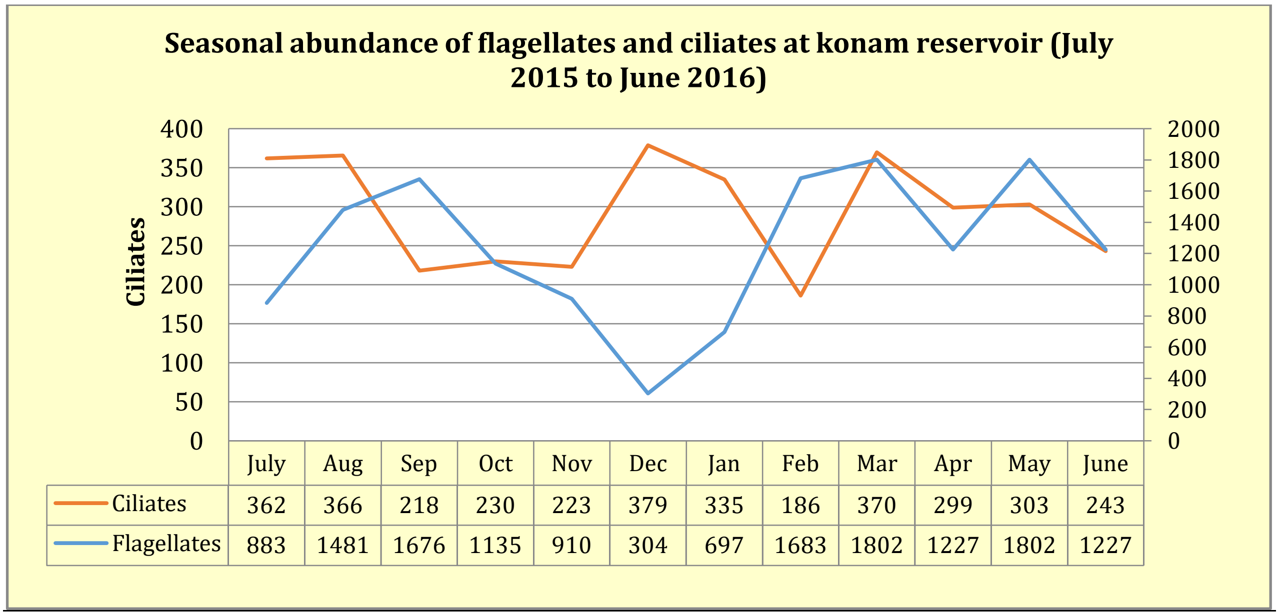


Figure: 2. Seasonal abundance of flagellates and ciliates at Konam reservoir (July 2015 to June 2016)

Faunal assemblages

The mean abundance of the flagellates and ciliates were subjected to statistical analysis in Primer a package mostly used for biological calculations. The Bray Curtis similarity index with Eucledian distances were calculated for flagellates and ciliates separately. During the study the flagellates formed two assemblages. *Cryptomonas- Peridinium* assemblage most predominant at all stations and the other assemblage is dominated by Euglenids. During the study the first assemblage is most common in all observations but the second assemblage showed seasonal occurrence. Ciliates formed three assemblages. *Vorticella – Coleps*assemblage; *Pelagostrombidium- Holophrya* assemblage; *Halteria- Strobilidiumgyrans* assemblage. The first assemblage is characteristic of stagnant waters near station 1 the third assemblage is most commonly found in 2,3 & 4 stations where as the second assemblage is characteristic of station 5&6 near catchment area. These species are more of nutrient dependent than the water quality dependent. The Faunal assemblages of Flagellates and Ciliates are visible at Figure: 3 &4.

In the current investigation, seasonal fluctuations in protozooplankton populations were observed, with high productivity during summer season and a decline during the monsoon season. The summer season witnessed an increase in plankton growth, likely driven by increased water temperature, nutrient availability, and photosynthetic activity [39].These findings align with previous studies, which reported similar declines in phytoplankton density during the monsoon season due to flooding and freshwater influx [40]. Comparable patterns noticed in other investigations of Hassan et al. [41] and Devika et al. [42], who also highlighted the significance of physical factors, such as water temperature and transparency, in regulating phytoplankton populations.

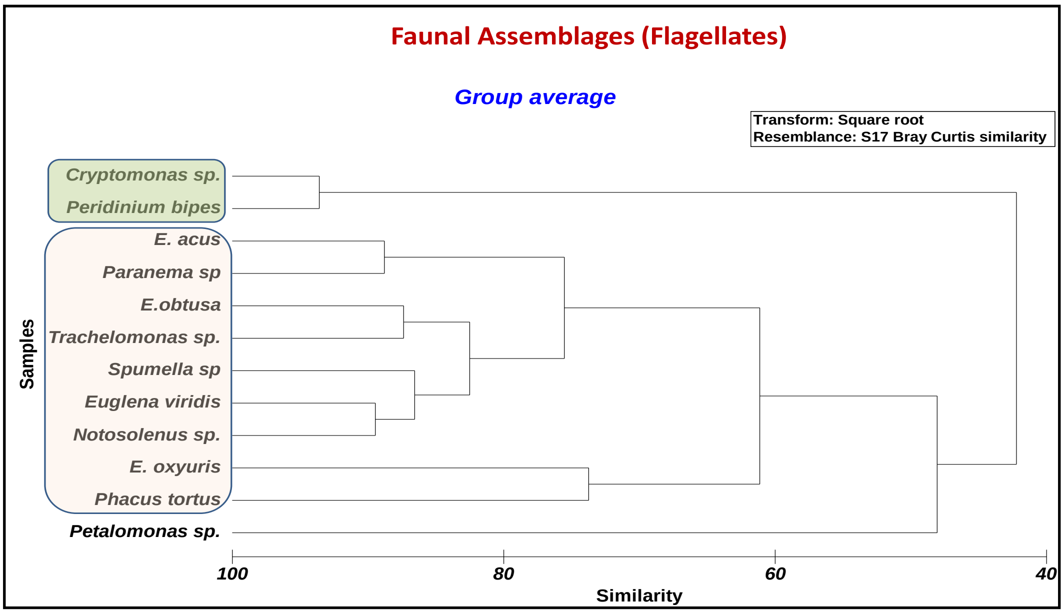


Fig 3: Faunal Assemblages (FLAGELLATES)

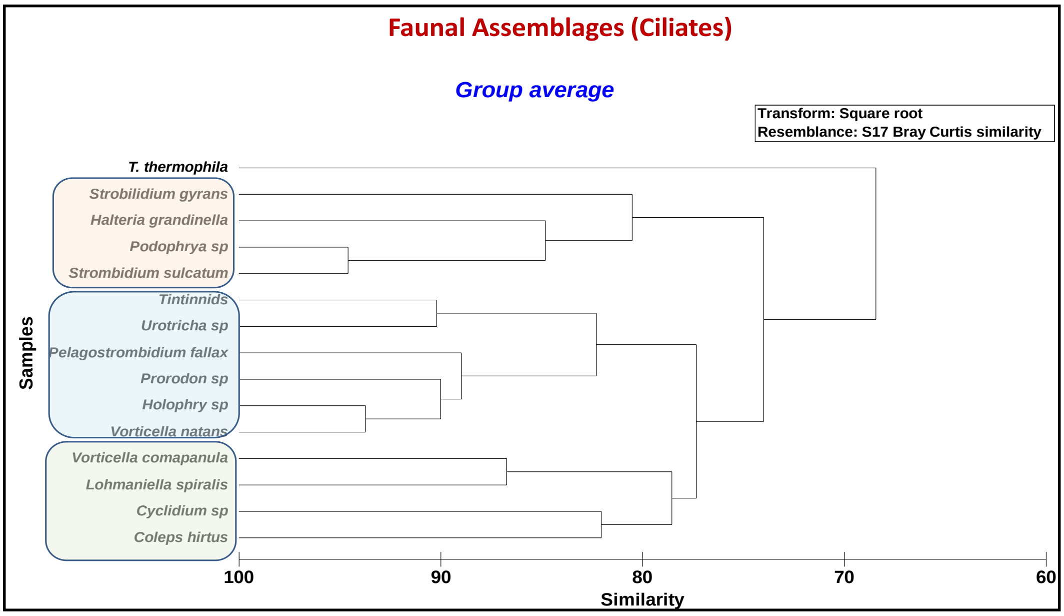


Fig 4: Faunal Assemblages (Ciliates)

Conclusion

Protozooplankton in fresh water bodies like reservoirs form the backbone of aquatic food webs, and their growth and metabolism are closely tied to the physical and chemical properties of their environment. As a result, these populations can be used as a sensitive indicator of water quality, providing insights into the overall health and productivity of aquatic ecosystems.The study identified two flagellate and three ciliate assemblages, each with distinct distribution patterns. The flagellate assemblages were *Cryptomonas-Peridinium* and Euglenids, while the ciliate assemblages were *Vorticella-Coleps, Pelagostrombidium-Holophrya,* and *Halteria-Strobilidiumgyrans*. Notably, these assemblages were more influenced by nutrient availability than water quality. Seasonal variations in species richness and diversity were pronounced. The growth rates, abundance, biomass, and diversity of these organisms serve as sensitive indicators of ecosystem health, reflecting the impact of pollution and environmental changes.

References

1. Kadam SU, Kadam SS, Babar M. Phytoplankton diversity of reservoirs in Parbhani district, Maharashtra, India. International Journal Current Microbiology Applied Sciences. 2014;3(8):459-466.
2. Lohmann H. Über das Nannoplankton und die ZentrifugierungkleinsterWasserprobenzurGewinnungdesselben in lebendemZustande. Internationale revue der gesamtenhydrobiologie und hydrographie. 1911;4(1-2):1-38.
3. Beaver JR, Crisman TL. Seasonality of planktonic ciliated protozoa in 20 subtropical Florida lakes of varying trophic state. Hydrobiologia. 1990 Feb;190:127-35.
4. Azam F, Fenchel T, Field JG, Gray JS, Meyer-Reil LA, Thingstad FJ. The ecological role of water-column microbes in the sea. Marine ecology progress series. Oldendorf. 1983 Nov;10(3):257-63.
5. Corno G, Caravati E, Callieri C, Bertoni R. Effects of predation pressure on bacterial abundance, diversity, and size-structure distribution in an oligotrophic system. Journal of Limnology. 2008 Aug 1;67(2):107.
6. Beaver JR, Crisman TL. The role of ciliated protozoa in pelagic freshwater ecosystems. Microbial ecology. 1989 Mar;17:111-36.
7. Lee JJ, Hutner SH, Bovee EC, editors. Illustrated guide to the protozoa. 1985 Oct 28.
8. Cairns J, Dickson KL, Maki AW. Estimating the hazard of chemical substances to aquatic life. Hydrobiologia. 1979 Jun;64:157-66.
9. Finlay BJ. The global diversity of protozoa and other small species. International Journal for Parasitology. 1998 Jan 1;28(1):29-48.
10. Bagatini IL, Spínola AL, Peres BD, Mansano AD, Rodrigues MA, Batalha MA, Lucca JV, Godinho MJ, Tundisi TM, Seleghim MH. Protozooplankton and its relationship with environmental conditions in 13 water bodies of the Mogi-Guaçu basin-SP, Brazil. Biota Neotropica. 2013 Oct;13:152-63.
11. Sugunan VV. Seasonal fluctuations of plankton of Nagarjunasagar reservoir, AP, India. J. Inland Fish. Soc. India. 1980;12(1):79-91.
12. Rao KS, Choubey U. Studies on phytoplankton dynamics and productivity fluctuations in Gandhi Sagar Reservoir. InNational workshop on reservoir fisheries, Special Publication. AFSI Branc 1990 (Vol. 3, pp. 103-106).
13. Mishra BB, Chaturvedi GB, Tewari DD. Phytoplankton fluctuatuations under the stress of abiotic factors at Kohargaddi Dam, Balrampur. J. Exp. Sci. 2010;1(5):22-4.
14. Ahmad Y, Hussain G, Tharani M, Hussain A. Diversity and Seasonal Fluctuation of Phytoplankton of Pahuj Reservoir, Jhansi (U.P). International Journal of Pharmaceutical & Biological Archives. 2013;4(1):66-69.
15. Kaparapu J, Geddada MN. Seasonal Distribution of Phytoplankton in Riwada Reservoir, Visakhapatnam, Andhra Pradesh, India. NotulaeScientiaBiologicae. 2013 Aug 1;5(3):290-5.
16. Mustapha MK. Seasonal influence of limnological variables on plankton dynamics of a small, shallow, tropical African reservoir. Asian Journal of Experimental Biological Sciences. 2010;1(1):60-79.
17. Thirupathaiah M, Samatha CH, Sammaiah C. Analysis of water quality using physico-chemical parameters in lower manair reservoir of Karimnagar district, Andhra Pradesh. International Journal of Environmental Sciences. 2012;3(1):172-80.
18. Shivashankar P, Venkataramana GV. Zooplankton diversity and their Seasonal varation in Bhadra Reservoir Karnatka, India. IntRes.J.Environment Sci., 2013 Vol.2(5), 87-91.
19. Mohammad MJ, Krishna PV, Lamma OA, Khan S. Analysis of water quality using Limnological studies of Wyra reservoir, Khammam district, Telangana, India. Int. J. Curr. Microbiol. App. Sci. 2015 Mar 11;4(2):880-95.
20. Mansano AS, Hisatugo KF, Leite MA, Luzia AP, Regali-Seleghim MH. Seasonal variation of the protozooplanktonic community in a tropical oligotrophic environment (IlhaSolteira reservoir, Brazil). Brazilian Journal of Biology. 2013 May;73(2):321-30.
21. Lee RE, Kugrens P. Relationship between the flagellates and the ciliates. Microbiological reviews. 1992 Dec;56(4):529-42.
22. Corliss JO. An aspect of morphogenesis in the ciliate Protozoa. The Journal of Protozoology. 1967 Feb;14(1):1-8.
23. Leakey RJ, Burkill PH, Sleigh MA. Planktonic ciliates in Southampton Water: abundance, biomass, production, and role in pelagic carbon flow. Marine Biology. 1992 Sep;114:67-83.
24. Horne AJ, Goldman CR. Limnology;vol. 2. New York. McGraw-Hill; 1994.
25. Tiwari A, Chauhan SV. Seasonal phytoplanktonic diversity of Kitham lake, Agra. Journal of Environmental Biology. 2006;27(1):38-38.
26. Balasingh GS, Shamal VP. Phytoplankton diversity of a perennial pond in Kanyakumari District. Journal of Basic and Applied Biology. 2007;1(1):23-6.
27. Laskar HS, Gupta S. Phytoplankton diversity and dynamics of Chatla floodplain lake, Barak Valley, Assam, North East India-A seasonal study. Journal of Environmental Biology. 2009 Nov 1;30(6):1007-12.

28. Adesalu TA. Phytoplankton dynamics of river Oli in Kainji Lake National Park, Nigeria during dry season. International Journal of Botany. 2010 Oct 20;6(2):112-6.
29. Arndt H, Dietrich D, Auer B, Cleven EJ, Gräfenhan T, Weitere M, Mylnikov AP. Functional diversity of heterotrophic flagellates in aquatic ecosystems. The flagellates: unity, diversity and evolution. 2000;1:240-68.
30. Begum M, Jewel MA, Haque MA, Khatun MS. Hydrobiological variables as a regulatory factor on the abundance of heterotrophic flagellates in an urban pond. Journal of Oceanology and Limnology. 2019 May;37:1030-6.
31. Sleigh, M. Protozoa and other Protists New York: Chapman and Hall, 1988, 399 p.
32. Finlay BJ. Global dispersal of free-living microbial eukaryote species. Science. 2002 May 10;296(5570):1061-3.
33. Madoni P, Braghiroli S. Changes in the ciliate assemblage along a fluvial system related to physical, chemical and geomorphological characteristics. European Journal of Protistology. 2007 Jul 2;43(2):67-75.
34. Debastiani C, Meira BR, Lansac-Tôha FM, Velho LF, Lansac-Tôha FA. Protozoa ciliates community structure in urban streams and their environmental use as indicators. Brazilian Journal of Biology. 2016 May 17;76(04):1043-53.
35. Madoni P. Protozoa in wastewater treatment processes: a minireview. Italian Journal of Zoology. 2011 Mar 10;78(1):3-11.
36. Zingel P. The role of planktonic ciliates in lake ecosystems. Tartu University Press; 2001.
37. Zou Q, Lu Z, Li C, Li Y, Huang P. Seasonal pattern of planktonic ciliates in a subtropical shallow urban Lake. Current Research Journal of Biological Sciences. 2013 Sep 20;5(5):210-9.
38. Velho LF, Pereira DG, Pagioro TA, Santos VD, Perenha MC, Lansac-Tôha FA. Abundance, biomass and size structure of planktonic ciliates in reservoirs with distinct trophic states. ActaLimnologicaBrasiliensia. 2005;17(4):361-71.
39. Santhanam P, Perumal P. Diversity of zooplankton in Parangipettai coastal waters, southeast coast of India. J. mar. biol. Ass. India. 2003;45(2):144-51.
40. Krishnamoorthy G, Rajalakshmi S, Sakthivel D. Diversity of Zooplankton in mangrove Areas of Puducherry. India Jouranal of Aquatic Biology. 2007;22:45-8.
41. Hassan FM, Taylor WD, Al-Taee MM, Al-Fatlawi HJ. Phytoplankton composition of Euphrates river in Al-Hindiya barrage and Kifil city region of Iraq. Journal of Environmental Biology. 2010 May 1;31(3):343.
42. Devika R, Rajendran A, Selvapathy P. Variation studies on the physico-chemical and biological characteristics at different depths in model waste stabilsation tank. Pollution Research. 2006;25(4):771.