"Taxonomy And Ecological Distribution Of Ciliated Protozoa (Phylum: Ciliophora) In Freshwater Reservoirs Of Visakhapatnam District, Andhra Pradesh, India

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Abstract
This study delves into the taxonomy and ecological distribution of ciliated protozoa (Phylum: Ciliophora) in freshwater reservoirs, with a specific focus on three reservoirs in Visakhapatnam, Andhra Pradesh, India. Ciliates are crucial players in maintaining the biological balance of aquatic ecosystems, regulating bacterial populations, facilitating organic matter biodegradation, and contributing to the formation of biological flocs. The research aimed to identify and describe cultivable ciliate species within these reservoirs, shedding light on their role in these dynamic environments. A total of 15 ciliate genera were identified, representing various taxonomic classes, including Oligohymenophora, Spirotrichea, Heterotrichea, Prorodontida, Phyllopharyngea, and order Armophorida. The study considered the relative richness of these genera in each reservoir, revealing variations in their distribution patterns. Physico-chemical factors such as substrate composition, temperature, Dissolved Oxygen (DO), alkalinity, ammonia, and pH were found to play crucial roles in shaping the ciliate community structure. Station-II exhibited the highest nutrient levels and consequently hosted the most abundant and diverse ciliate fauna, featuring eight different genera. In contrast, Station-I had fewer nutrients and seven ciliate genera, while Station-III, rich in nutrients, harbored a remarkable 11 genera. These findings underline the significance of physico-chemical factors in shaping ciliate communities within freshwater ecosystems. The specificity of ciliate genera to particular habitats was evident, although their presence was also influenced by various environmental factors. This research contributes valuable insights into the ecology of ciliated protozoa and their role in maintaining the ecological balance of freshwater reservoirs, providing a foundation for further studies in this field.

Keywords: Ciliated protozoa, Freshwater reservoirs, Taxonomy, Ecological distribution, Andhra Pradesh, Biodiversity.

INTRODUCTION:

Earth is the only planet which covers about 75% with water and a small proportion associated with the continental areas. These continental areas are highly confined to Human beings for survival. Despite water associated with this continental zone is the vital resource to support all forms of life. A large amount of freshwater (over 99%) is in the form of ground water or ice, which is difficult for human use. Most often freshwater available in streams, reservoirs, marshes, lakes, and shallow ground waters.

The high rates of reservoir construction throughout the world give evidence of the fact that at the present stage of economic development reservoirs are objectively necessary for solving water resources problems both in industrially-developed and in developing countries. The great achievements in the field of hydraulic construction make it possible to regulate the flow of the largest reservoirs in the world and to create reservoirs with parameters exceeding those of many large natural lakes. The high scales achieved in reservoir construction during the past two decades, and the many-sided effects of reservoirs on the natural surroundings and on the economy call for an intensification of scientific investigations and for the unification of the efforts of scientists in different countries. One of the most fruitful devices for scientific research, widely applied also in reservoir design, is the analogy method. Its utilization and development call for the preparation of different reservoir classifications and typologies, which in turn generates the need for an adequate approach to the use and publication of data on reservoirs. A list of the most desirable reservoir indices should be an object for discussion by specialists in different countries.

The study of ecological changes, fauna and flora in these fresh water bodies are now-a-days creating much attention as the climate change reflects the global warming indications. Correct identification of freshwater organisms is essential to understanding their ecology. Plants, animals, and microbes interact with the environment to alter water quality and perform ecological “services” such as decomposition and nutrient cycling. Identifying species in food webs is an essential part of managing fisheries. Biodiversity of invertebrates, microbes, and fishes can be used to indicate chronic pollution problems. Taxonomic identification of invertebrates and fishes is required for techniques that use species

diversity as an indicator of pollution. Some species of algae are toxic, so identification of these species may be important in maintaining safe water quality. Tracking the invasion and influence of pest organisms also requires taxonomic expertise. Finally, endangered species can have a major influence on management decisions, again requiring taxonomic information.

Ciliated protozoa (Phylum: Ciliophora Doflein, 1901)[1] are free living as well as parasitic which are cosmopolitan (Finlay et al.,1998)[2] in distribution. They are well developed and organized homogenous of protozoan groups. Most of them are found in aquatic habitat like freshwater bodies such as temporary puddles, rivers and reservoirs. small ponds, chloride lakes (Madoni, 1990)[3]; (Dyer, 1989)[4]; Fenchel, 1987)[5]; marine habitats (e.g., Agamaliev, 1974)[6]; hot springs, and in ice flows from the Arctic and Antarctic sea ice as well as in terrestrial habitat; (from temperate and tropical soils) Foissner (1987, 1995b)[7]. Some endemics as well as typical weather depended species are present.

Ciliates are alveolates, unicellular, dikaryotic organisms carrying cilia, as tiny hair like organelles intended for locomotion and food gathering at some stages in their life cycle, recognized as monophyletic. One of the most familiar groups of protozoa, distinguished by usually having many cilia lying in rows on the body and used for movement, sometimes with more cilia around the mouth and used for feeding. These cilia cover the whole cell in some species and in other species, the cilia form compound ciliary organelles called cirri; in some of the sessile species, the cilia are limited to the oral region with body or somatic cilia only appearing when the ciliate disperses, whereas in other sessile species, such as the suctorians, cilia are absent at all stages but the dispersal stage. The often thousands of cilia on the cell surface are coordinated by a hydrodynamic coupling that is manifested in the metachronal waves observed passing along the cell's surface (Guirao & Joanny, 2007)[8]; (Sleigh, 1989)[9].
Ciliates diverged from other microbial eukaryotes quite recently, as part of a monophyletic lineage (alveolates) with apicomplexans (e.g.,Plasmodium) and dinoflagellates (Wright & Lynn 1998)[10], (Baldauf et al., 2000)[11]. Classification includes two major subphyla and twelve major classes based on the features of the kinetid and sequences of genes.

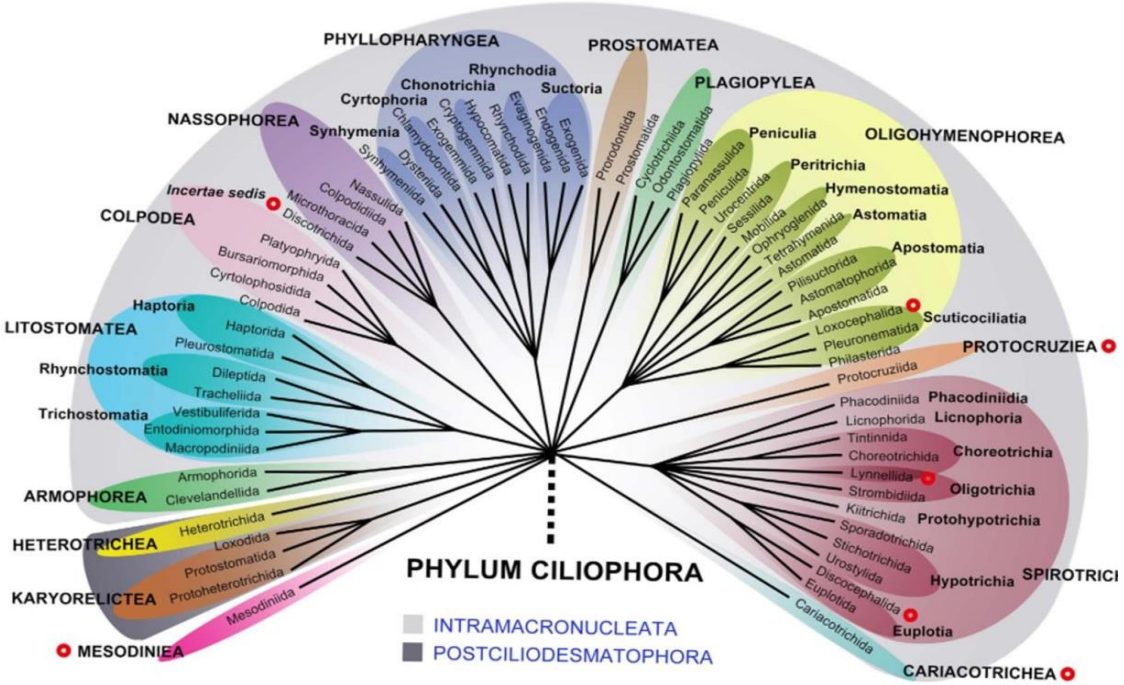

Fig1. Systematic scheme for phylum Ciliophora (Courtesy :Sci Rep 6,24874, 2016)

STUDY AREA:

In India, Andhra Pradesh state has boundaries on west by Karnataka State, on the southeast by Madhya Pradesh and Orissa states, and northwest by Maharashtra state, on the east covering Bay of Bengal and on south by Tamil Nadu State. Andhra Pradesh is one of the 28 states of India, situated in the south-eastern part of the country, covering an area of 162.975 km2 (62,9025 sq.mi). In Andhra Pradesh, especially the major cities are Visakhapatnam and Vijayawada and in Visakhapatnam, India's fourth largest Port is situated. In the financial sector, agriculture plays a vital role and most of the population only works on regions of producing rice and also other major cropping patterns are oil seeds, sugarcane, beans and pulses (edible seeds from crops such as lentils, peas, and beans).. From various places in Andhra Pradesh, samples for the present study were collected:

1. Raiwada Reservoir
2. Thandava Reservoir
3. Thatipudi Reservoir

MATERIALS AND METHODS:

The present work was designed such that to cover as much as freshwater sources like reservoirs for Ciliates. Monoclonal cultures were maintained under laboratory conditions after the isolation of selected cultivable species of ciliates. Investigations were done on the live culture cells along with staining techniques like Feulgen reaction, Harri's hematoxylin and Silver impregnation (Chatton and Lwoff 1930)[12] methods. Most accessible species for the taxonomy study such as Spirostomum, Stentor, Blepharisma, Euplotes, Tetrahymena, Neokeronopsis, Frontonia, and Paramecium were maintained well in laboratory. About 10-15 cells were observed for the main morphological characteristics for each species. Cultures of Stentor, Spirostomum, Paramecium, Euplotes, Blepharisma etc., species is maintained in the laboratory at 22-23°C in a medium made of hay infusion, Cerophyl, Na2HPO4, Stigmasterol and distilled water inoculated with Roultella planticola was added to the medium to promote the growth of bacteria which served as the primary food source for the ciliates. The green algae Dunaliella tertiolecta as employed as food for Euplotes and some Stichotrichs.

OBSERVATION AND RESULTS:

In the present study has reported the occurrence of 15 genera of ciliates, belonging the 15 families and five classes. The 15 different genera, which are Spirostomumsp., Blepharishma sp., Aspidisca sp., Colpoda sp., Epistylis sp., Frantonia sp., Paramecium sp., Chilodonella sp., Colipidium sp., Stentor sp., Vorticella sp., Zoothamnium sp., Metapus sp., Coleps sp., and Euplotes sp. In the present study obtained 15 genera of ciliates species were recorded from three different stations. Hydrographical parameters of the stations, morphological characters of the ciliate species, and ecology of ciliates of selected three reservoirs were carried out.

In the sampling from station–I (Raiwada Reservoir) Seven genera of ciliates were described. They are species Coleps sp.,(Colpodiae), Euplotes sp., (Euplotidae), Blepharishma sp., (Blepharismidae), Spirostomum sp., (Spirostomidae), Frantonia sp., (Frontoniidae), Vorticella sp., (Vorticellidae) and Paramecium sp., (Parameciidae) belonging to families.

During the sampling period from sampling station–II (Thandava Reservoir), Eight genera of ciliates species were collected. These ciliates represented Coleps sp., (Colpodiae), Chilodonella sp., (Chilodonellidae), Spirostomum sp.,(Spirostomidae), Stentor sp.,(Stentoridae), Vorticella sp., (Vorticellidae), Paramecium sp., (Parameciidae), Aspidisca sp., (Aspidiscidae) and Colpidium sp., (Tetrahymenidae) of the families.

In station–III (Thatipudi Reservoir) Eleven genera of ciliate species were collected, they include Coleps sp., (Colpodiae), Chilodonella sp.,(Chilodonellidae), Euplotes sp., (Euplotidae), Spirostomum sp., (Spirostomidae), Stentor sp., (Stentoridae),Vorticella sp., (Vorticellidae), Epistylis sp., (Epistylididae), Colpoda sp., (Tetrahymenidae), Colpidium sp., (Tetrahymenidae), Metapus sp., (Metopidae) and Zoothamnium sp., (Zoothamniidae) of the families.

All the 15 genera were described together with their principal distinct characters and the ranges of physico-chemical factors under which the genera occurred during the period of study. Their relative richness at each station was studied, their specialty to a particular habitation to a particular station was considered.

Table 1: List of ciliates species obtained from three sampling stations in the study period

Serial Number	Station – I	Station - II	Station - III	Total
Number of ciliates Enumerated	976	1696	1452	4124

DISCUSSION:

The present study shows that physico-chemical factors in the three stations varied considerably. In general, station-I is poor in nutrients and has a poor ciliate fauna. Station-II had the maximum amount of nutrients rich in ciliate fauna. Station-III is rich in nutrients and has good ciliate fauna. The ciliates were numerically more in station-II they belong to 8 genera in contrast to what it seen in Station I having 7 only. However station- III has maximum of 11 genera. Oligohymenophora cluster ciliate species are most highly represented. Ciliates were belonging to Classes Phyllopharyngea and Armophorida are poorly represented. It is well documented in the literature that the physico-chemical factors such as the substratum, temperature, Dissolved Oxygen (DO), Alkalinity, Ammonia and Hydrogen Ion contrition (pH) play an important role in the composition, distribution and abundance of microorganisms in nature. These factors vary from place to place and from time to time and may interact in a variety of ways. Hence it is not easy to draw specific conclusions and relate them to specific factors and understand the impact on the distribution of ciliates. However some broad generalization can be made from the present study.

SUMMARY AND CONCLUSIONS:

The present work was designed on the taxonomy of ciliated protozoa (Phylum: Ciliophora) starting from classical methods and up to the Genus level. The main view was to identify the cultivable ciliates species from reservoirs located in Visakhapatnam, Andhra Pradesh. Samples were obtained from Raiwada Reservoir, Thandava Reservoir and Thatipuid Reservoir. The description, of these three study areas, Microbiology, and working procedure were presented in chapter II. The present study of the identification of ciliates in reservoirs is important to maintain the quality of biological system. Ciliates make population control of bacteria, are agents of organic matter biodegradation and influence the agglutination of bacteria in biological flocs. A total of 15 genera belonging to the principal taxonomic classes Oligohymenophora, Spirotrichea, Heterotrichea, Prorodontida, Phyllopharyngea and order Armophorida were considered and their relative richness at each station was studied. The physico-chemical factors in all the stations were

having variations to the abundance of ciliate fauna. There is specificity between the ciliate genera. But the specificity does not play important role when we consider the quantities. When the other physico-chemical factors are similar, ciliates show a preference to certain habitation. The ciliate species richness has been in direct relation to the microbial population abundance.

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