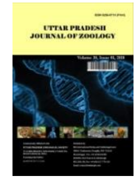
UTTAR PRADESH JOURNAL OF ZOOLOGY

41(8): 52-58, 2020
ISSN: 0256-971X (P)



ZOOPLANKTON DIVERSITY OF KOTTAKAYAL – A WETLAND IN SOUTH KERALA THAT IS UNDER THE THREAT OF SAND AND CLAY MINING

F. JENSY ROSHAN[1*] AND R. SREEJAI[2]
[1]Department of Zoology, St. John's College, Anchal, University of Kerala, India.
[2]Zoology Research Centre, St. Stephen's College, Pathanapuram, University of Kerala, India.

AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration between both authors. Author FJR designed the study, performed the statistical analysis, wrote the protocol and prepared the first draft of the manuscript. Author RS managed the literature survey of the present study. Both the authors have read and approved the final manuscript.

Received: 17 April 2020
Accepted: 22 June 2020
Published: 23 June 2020

Original Research Article

ABSTRACT

Zooplankton play multiple roles in an aquatic ecosystem**.** Nutrient recycling, energy flow, microbial remineralization, carbon cycling and maintenance of the population size of primary producers are some of the vital roles of zooplankton. Zooplankton are great indicators of the ecological status of a water body since their population dynamics changes with environmental changes. This study aims to identify the zooplankton population and its dynamics in a lake that was formerly paddy field. Kottakayal is a wetland lying near the Ittikara-Pallimon confluence. Sand and clay mining that is prevalent in this area has changed it into a water logged area. Zooplankton samples were collected from six sampling stations bimonthly for a period of two years from November 2015 to October 2017. Quantitative and qualitative analyses of the samples were made using standard protocols. Statistically significant seasonal variation in zooplankton population was noticed. Thirty eight species of zooplankton belonging to 7 different classes, 12 orders and 18 families were identified. Zooplankton abundance was maximum (119915±33053 nm^{-3}) during monsoon season and minimum (55212±19637 nm^{-3}) during pre-monsoon season. Rotifers were the dominant group of zooplankton in Kottakayal. Abundance of rotifers which are the chief food for fishes make this wetland suitable for practising aquaculture. Copepods were the second dominant zooplankton. Presence of species like *Keratella, Brachionus, Monostyla, Lecane, Arcella* and *Difflugia* indicated that Kottakayal was subjected to organic pollution.

Keywords: Zooplankton; ecological status; wetland; sand and clay mining; rotifers; copepods; and organic pollution.

1. INTRODUCTION

Zooplanktons play a prime role in the aquatic food chain by controlling phytoplankton production. Zooplanktons via vertical migration transport dissolved and particulate matter to deeper waters. These organisms greatly affect primary producer populations, microbial remineralization and particle export in an aquatic ecosystem through their grazing and metabolism. They are the nutrient recyclers who also play the prime role in carbon cycling, population dynamics, energy flow and trophodynamics. Zooplankton are one of the most important sources of food to aquatic organisms especially planktivorous

**Corresponding author: Email: jensyroshan@gmail.com;*

fishes. Zooplanktons are important elements in the functioning of the aquatic ecosystem due to their major role in energy flux in a plankton based food web [1]. Surface area, depth, trophic level, colour of water and the biological community of the lake characterize zooplankton community structure [2]. Thus zooplanktons make a useful tool in determining ecological status of a lake. The major cause of water pollution is industrialization besides human activities. The contaminant induces algal blooming leading to eutrophication of water bodies. Zooplanktons are potent indicators of water pollution due to the rapid change they exhibit in their population with disturbances in the ecosystem [3]. Curiosity may prompt the question: "Why the choice of such an area for the study?" It is true that such pursuits have been undertaken earlier. But the conspicuous difference between Kottakayal and other water bodies makes this research assume the dimensions of almost pioneer study. No previous study was undertaken in this wetland.

Sand and clay mining which is very rampant here, has effected the transformation of paddy fields into a conglomeration of water logged areas. This facet is one among the factors that lend a special importance to this study.

2. MATERIALS AND METHODS

2.1 Study Area

Kottakayal lies in Grid no. 58D/09 of Survey of India Toposheet, between 8°51'35.236" to 8°54'11.144" North Latitude and 76°40'31.547" to 76°43'4.784" East longitude near Pallimon-Ithikkara confluence. Kottakayal has an area of 2.32 km^2. It flows through Adichanalloor, Thrikovilvattom and Nedumpana panchayats. Kottakayal belongs to Ithikkara block. As Kottakayal is situated at low lying area the chances of ecological degradation is fairly high. 1967 SOI toposheet reveals that the water body now known as Kottakayal was cropland especially paddy field. Sand and clay mining predominant in this area has alchemized these paddy fields to water logged area. Moreover the entire land was debilitated for any sort of cultivation due to intrusion of saline water from the Ittikara River to the great pits that were the outcome of indiscriminate and unethical sand and clay mining. Samples were collected from six sampling sites (Fig. 1).

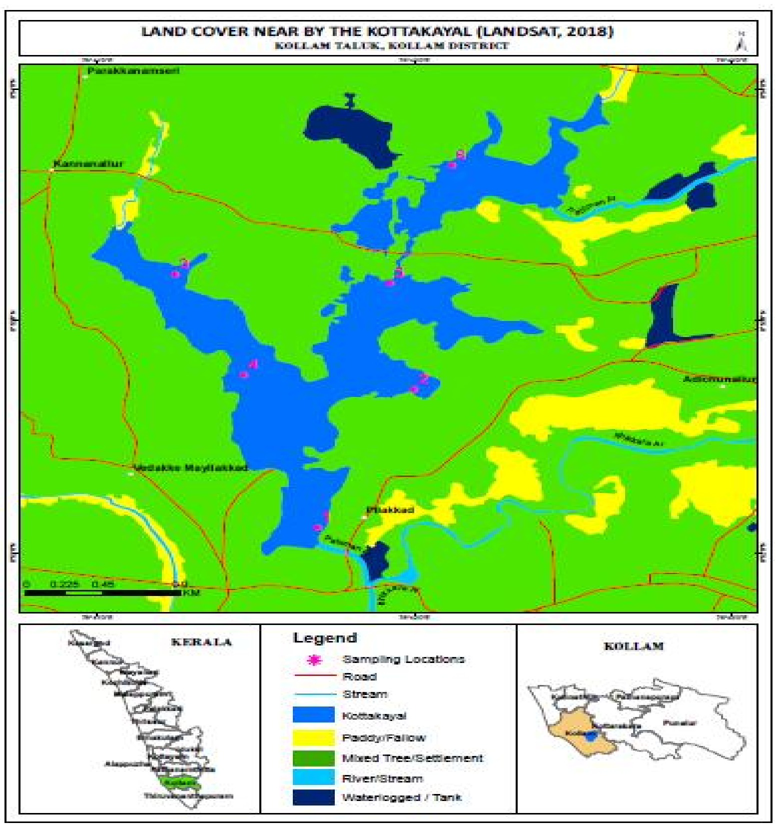


Fig. 1. Study area with sampling sites marked

2.2 Sampling of Zooplankton

Zooplankton samples were collected from six sampling stations bimonthly for a period of two years (November 2015- October 2017). Sampling sites were fixed in such a way that they were almost 1 km apart from one another.Zooplankton samples were collected by filtering 50 liters of sub-surface water through a conical plankton net made of fine blotting silk of mesh size 100 µm [4,5]. Filtered samples were preserved in 4% formalin and kept in good quality polythene bottles. Zooplankton were identified using standard references: [6-8]. Both qualitative and quantitative study of zooplankton were done. Quantitative analyses of plankton samples were done using Sedgewick-Rafter Counting Slide [9]. An average of 5 to 8 counts were made for each plankton samples. The results were expressed as number of organisms per cubic metre of the water sample.

2.3 Statistical Analysis

Multivariate statistical tools have been used to assess the data interpretation.

3. RESULTS

Zooplankton identified from different sites of the study area are mentioned below (Table 1). 38 species of zooplankton belonging to 7 different classes, 12 orders and 18 families were identified. Larval forms of insects like mosquitoes, chironomids and statoblast of plumatella were also observed.

Table 1. Zooplankton identified in different sites of Kottakayal

Sl. No.	Class	Order	Family	Species
1.	Tubulina	Arcellinidae	Difflugiidae	*Difflugia lobostoma*
2.	Tubulina	Arcellinidae	Difflugiidae	*Difflugia globulosa*
3.	Tubulina	Arcellinidae	Difflugiidae	*Difflugia urceolata*
4.	Tubulina	Arcellinidae	Difflugiidae	*Difflugia corona*
5.	Tubulina	Arcellinidae	Difflugiidae	*Difflugia gramen*
6.	Tubulina	Arcellinidae	Arcellidae	*Arcella discoides*
7.	Tubulina	Arcellinidae	Arcellidae	*Arcella vulgaris*
8.	Lobosa	Amoebida	Amoebidae	*Amoeba radiosa*
9.	Imbricatea	Euglyphida	Euglyphidae	*Trinema lineare*
10.	Imbricatea	Euglyphida	Euglyphidae	*Euglypha tuberculate*
11.	Monogononta	Ploima	Brachionidae	*Brachionus calyciflorous*
12.	Monogononta	Ploima	Brachionidae	*Brachionus bidentata*
13.	Monogononta	Ploima	Brachionidae	*Brachionus* sp.
14.	Monogononta	Ploima	Brachionidae	*Agronotholca foliacea*
15.	Monogononta	Ploima	Brachionidae	*Notholca acuminata*
16.	Monogononta	Ploima	Brachionidae	*Notholca labis*
17.	Monogononta	Ploima	Brachionidae	*Notholca sp.*
18.	Monogononta	Ploima	Brachionidae	*Keratella quadrata*
19.	Monogononta	Ploima	Brachionidae	*Keratella valga*
20.	Monogononta	Ploima	Brachionidae	*Keratella cochlearis*
21.	Monogononta	Ploima	Brachionidae	*Keratella* sp 1
22.	Monogononta	Ploima	Brachionidae	*Keratella* sp. 2
23.	Monogononta	Ploima	Trichocercidae	*Trichocerca longiseta*
24.	Monogononta	Ploima	Trichocercidae	*Rattulus* sp.
25.	Monogononta	Ploima	Synchaetidae	*Polyarthra* sp.
26.	Monogononta	Ploimdae	Lacanidae	*Lacane* sp.
27.	Monogononta	Ploimdae	Lacanidae	*Monostyla lunaris*
28.	Monogononta	Flosculariaceae	Filinidae	*Filinia* sp.
29.	Maxillipoda	Calanoida	Calanidae	*Calanus* sp.
30.	Maxillipoda	Calanoida	Eucalanoidea	*Eucalanus* sp
31.	Maxillipoda	Cyclopoida	Cyclopoidae	*Cyclops* sp.
32.	Maxillipoda	Cyclopoida	Cyclopoidae	*Cyclops bicuspidatus*
33.	Branchiopoda	Anostraca	Artemiidae	*Artemia* sp.
34.	Branchiopoda	Anomopoda	Bosminidae	*Bosmina* sp.
35.	Branchiopoda	Diplostraca	Chydoridae	*Chydorus* sp.
36.	Branchiopoda	Diplostraca	Sididae	*Diaphanosoma* sp.
37.	Branchiopoda	Cladosera	Monidae	*Monia* sp.
38.	Malacostraca	Mysida	Mysidae	*Mysis* sp.

Zooplankton abundance was maximum during monsoon season in all study sites. Least abundance was observed during pre-monsoon season. Zooplankton abundance was higher in post-monsoon months than pre-monsoon months. Maximum abundance (119915±33053 nm^{-3}) of zooplankton was observed during monsoon months. Mean zooplankton abundance during pre-monsoon was 55212±19637 nm^{-3}. The mean abundance of zooplankton during post-monsoon was 83039±13095 nm^{-3}. Results of ANOVA reveal that there was significant difference in zooplankton abundance between stations and between seasons (Table 2). Rotifers were the most dominant group observed in the study area. Rotifer abundance was at its peak during post-monsoon and declined during pre-monsoon. The average abundance of rotifers in the study area during the course of study was 457356±114120 n m^{-3}. Copepods were the second dominant (322895±10393 nm^{-3}) zooplankton in Kottakayal. Copepod abundance was maximum during pre-monsoon. Maximum abundance of cladocera (190000±135 nm^{-3}) was recorded during pre-monsoon season. Mean abundance of amoebozoa was high during monsoon and low during post-monsoon months. Cercozoa was the least abundant group of zooplankton (Table 3). Results of ANOVA reveal that there was significant difference in zooplankton abundance between different groups and between different seasons (Table 3).

4. DISCUSSION

The structure and abundance of zooplankton are determined by the availability of nutrients or trophic status of the system [10]. Large herbivorous forms like calanoid copepods and large water fleas dominate modest trophic conditions whereas predatory forms such as cyclopoid copepods, small water fleas, rotifers dominate fecund water [11]. In the present investigation it was found that zooplankton abundance was maximum during monsoon season and minimum during pre-monsoon season. Similar reports were made by Mozumder [12] in his studies on zooplankton abundance in polyculture fish pond of Manikganj, West Bengal.

Copepods were the second dominant (322895 nm^{-3}) zooplankton in Kottakayal. This was in resonance with the results of An et al. [13] in their studies conducted in Lake Hulun, China. The present study has revealed that copepod population was dominated by their young forms especially nauplii, which is a common pattern observed in fresh water bodies [13], [14]. Continuous reproduction results in higher density of nauplii [15]. Zooplankton community structure mainly trophic structure and population dynamics are greatly affected by the abundant presence of larval forms. In the case of cyclopoids the nauplius and first copepodite instars are herbivores and filter feeders, whereas the adults and those in the later copepodite stage are carnivores and raptorial feeders [13]. In Kottakayal copepods were more abundant during pre-monsoon season. The mean copepod abundance during pre-monsoon was 450000±92 nm^{-3}. High abundance of copepods during pre-monsoon was in resonance with the results of Vineetha et al. [16] in their studies conducted in Cochin Estuary.

Table 2. Mean variation and ANOVA of zooplankton abundance in different sites of Kottakayal during 2015-2017

Stations	Pre-monsoon	Monsoon	Post-monsoon	
Site 1	90500±201	163250±309	97500±127	
Site 2	45277±152	122500±402	91500±341	F value (5.943)**
Site 3	56000±247	144000±296	81500±103	p value (0.008)
Site 4	65500±112	96642±256	78000±204	
Site 5	47000±156	131600±302	92000±382	
Site 6	27000±121	61500±231	57738±122	
Mean ±SD	55212±19637	119915±33053	83039±13095	

*F value (25.363)** p value (0.0001)*

Table 3. Mean seasonal variation and ANOVA of major groups of zooplankton in Kottakayal during 2015-2017

Major groups of zooplankton	Pre-monsoon	Monsoon	Post-monsoon	Mean±SD	
Amoebozoa	276250±148	416643±192	103888±107	265594±127903	
Cercozoa	37500±116	90961±78	30000±162	52820±27143	F value
Rotifers	375000±201	378333±281	618736±165	457356±114120	(8.775)**
Copepods	450000±92	323266±510	195416±781	322894±10393	p value
Cladocerans	190000±135	91336±251	89166±105	123501±4703	(0.005)

F value (3.29) p value (0.04)*

For ecosystem assessment, knowledge of rotifer population dynamics is essential since it complements environmental information with precise indications [17]. Relationship between trophic state and rotifer community composition is well evidenced [18]. Trophic state of a water body can be indicated by *Brachionus* to *Trichocera* ratio. *Trichocera* is associated with oligotrophic waters whereas *Brachionus* is associated with eutrophic waters [19]. Cladocerans and copepods play a role in shaping rotifer population [20]. Rotifer abundance in Kottakayal exhibited seasonal variation. Similar reports were made by Steinberg [21].

Rotifer abundance was higher during post-monsoon season than in pre-monsoon and monsoon seasons. Abundance of rotifers was minimum during pre-monsoon season. This result was in accordance with the findings of Kumari et al. [22] in their studies conducted in a tropical Ox-Bow Lake of west Bengal. Tropical water shows more representations of *Brachionus* and *Lecane* [23]. *Brachionus* exhibits wide range of tolerance to changes in environment [24]. More *Lacane* were recorded during pre-monsoon season, when the temperature of water was slightly high [25] whereas *Notholca* sp. were reported during monsoon season and post-monsoon season indicating their narrow range of temperature tolerance [22]. The abundance of rotifers was found to be higher in regions with macrovegetation than in regions where they are absent. Macrophytes offer a rich microhabitat for rotifers [26]. Lowest rotifer density (375000±201 nm^{-3}) was observed during pre-monsoon season. Similar were the reports of Aroara and Mehra [27]. Species of *Brachionus, Monostyla, Keratella, Lapadella, Leydigia, Diaptomus, Moinodaphnia* and *Diaphanosoma* were considered as indicators of eutrophication [28]. In the present study it was observed that genus *Brachionus* dominated all the three seasons. This was in agreement with the findings of Sugumaran and Amsath [29]. High temperature and associated environmental characters have favoured the abundance of rotifers [29]. *Brachionus* sp. were the dominant rotifers in tropical water bodies [30]. *B. angularis, B. calyciflorus, F. longiseta* and *Lecane* sp. are indicators of semi-polluted water [31]. There exists a relationship between trophic level and the number of *Brachionus* [32].

Maximum abundance of cladocera(190000±135 nm^{-3}) was recorded during pre-monsoon season. This was in accordance with the studies conducted by Jose and Sanalkumar [33] in a lake in Pudukkottai district of Tamil Nadu. The abundance of cladocera was comparatively less during rainy season. Similar were the results documented by Bera et al. [34] in Kangsabati reservoir of West Bengal.

Macro-zooplankton primarily feed on protozoa [35,36]. In Lake Rivadavia, Argentina, the abundance of ciliates was depressed by few rotifers and copepods inhabiting the lake [37]. In the present investigationit was found that protozoan abundance declined during pre-monsoon season, when copepod abundance was its maximum. It was also observed that as the abundance of copepod decreased during monsoon the abundance of protozoans increased. High abundance of protozoa indicates active decomposition. Their wide distribution and short generation time make them good biological indicators [38,39]. Presence of *Arcella* and *Difflugia* in the lake indicates organic pollution [40].

5. CONCLUSION

Zooplankton converts plant food to animal food and serves as food for higher organisms especially fishes. They are good indicators of trophic status of water bodies. Variation in zooplankton abundance is brought about by interaction of various environmental factors. Presence of species like *Keratella, Brachionus, Monostyla, Lecane, Arcella* and *Difflugia* indicates organic pollution.Strict measures should be implemented to check the extent of organic pollution of the wetland. Rotifer abundance implicates the suitability of this wetland for aquaculture practices. If we are able to control the anthropogenic impacts leading to organic pollution this particular wetland could be turned out into a fruitful resource for aquaculture practice.

ACKNOWLEDGEMENT

We the authors are grateful to the Principal, Head of the Department, Post-Graduate and Research Department of Zoology, St. Stephen’s College. Pathanapuram for providing necessary facilities during the research work.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Santos-Wisniewski MJ, Rocha O, Matsumura-Tundisi T. Aspects of the life cycle of *Chydorus pubescens* Sars, 1901 (Cladocera, Chydoridae). Acta Limnol. Bras. 2006;18(3): 305–310.
2. Rahkola-Sorsa M. The structure of zooplankton communities in large boreal lakes, and assessment of zooplankton methodology. University of Joensuu; 2008.

3. Jakhar P. Role of phytoplankton and zooplankton as health indicators of aquatic ecosystem: A review. Int. J. Innov. Res. Study. 2013;2(12):489–500.
4. Vidjak O, et al. Population structure and abundance of zooplankton along the Krka river estuary in spring 2006. Acta Adriat. 2009; 50(1):45–58.
5. Pansera M, Granata A, Guglielmo L, Minutoli R, Zagami G, Brugnano C. How does mesh-size selection reshape the description of zooplankton community structure in coastal lakes? Estuar. Coast. Shelf Sci. 2014;151:221–235.
6. Tonapi GT. Fresh water animals of India; an ecological approach. Oxford & IBH Publishing Co, New Delhi (India); 1980.
7. Plaskitt FJW. Microscopic fresh water life. Daya Books, New Delhi, India; 2008.
8. Battish SK. Freshwater zooplankton of India. Oxford & IBH Publishing Company, New Delhi, India; 1992.
9. Trivedy RK, Goel PK. Chemical and biological methods for water pollution studies. Karad, India: Environmental publications, Karad, India; 1986.
10. Paturej E, Kruk M. The impact of environmental factors on zooplankton communities in the Vistula Lagoon. Oceanol. Hydrobiol. Stud. 2011;40(2):37.
11. González EJ, Matos ML, Peñaherrera C, Merayo S. Zooplankton abundance, biomass and trophic state in some Venezuelan reservoirs. Biomass and Remote Sensing of Biomass, Intech Open; 2011.
12. Mozumder PK, Naser MN, Ahmed ATA. Abundance of zooplankton and physico-chemical parameters of a polyculture pond of Manikganj, Bangladesh. Bangladesh J. Zool. 2014;42(1):67–76.
13. An ZH, Du JH, Zhang YP, Li, Qi JW. Structure of the zooplankton community in Hulun Lake, China. Procedia Environ. Sci. 2011;13:1099–1109.
14. Sampaio EV, López CM. Zooplankton community composition and some limnological aspects of an oxbow lake of the Paraopeba River, São Francisco River Basin, Minas Gerais, Brazil. Brazilian Arch. Biol. Technol. 2000;43(3):285–293.
15. Neves IF, Rocha O, Roche KF, Pinto AA. Zooplankton community structure of two marginal lakes of the river Cuiabá (Mato Grosso, Brazil) with analysis of Rotifera and Cladocera diversity. Brazilian J. Biol. 2003; 63(2):329–343.
16. Vineetha G, Madhu NV, Kusum KK, Sooria PM. Seasonal dynamics of the copepod community in a tropical monsoonal estuary and the role of sex ratio in their abundance pattern. Zool. Stud. 2015;54(1):54.
17. Papakostas S, Michaloudi E, Triantafyllidis A, Kappas I, Abatzopoulos TJ. Allochronic divergence and clonal succession: Two micro-evolutionary processes sculpturing population structure of Brachionus rotifers. Hydrobiologia. 2013;700(1):33–45.
18. Duggan IC, Green JD, Shiel RJ. Distribution of rotifers in North Island, New Zealand and their potential use as bioindicators of lake trophic state. Rotifera IX, Springer. 2001;155–164.
19. Wen XL, Xi YL, Qian FP, Zhang G, Xiang XL. Comparative analysis of rotifer community structure in five subtropical shallow lakes in East China: Role of physical and chemical conditions. Hydrobiologia. 2011;661(1):303–316.
20. Chittapun S, Pholpunthin P, Sanoamuang L. Diversity and composition of zooplankton in rice fields during a crop cycle at Pathum Thani province, Thailand. Songklanakarin J. Sci. Technol. 2009;31(3).
21. Steinberg AJ, Ejsmont-Karabin J, Muirhead JR, Harvey CT, MacIsaac HJ. Consistent, long-term change in rotifer community composition across four Polish lakes. Hydrobiologia. 2009; 624(1):107–114.
22. Kumari S, et al. Influence of environmental factors on rotifer abundance and biomass in a shallow, tropical oxbow Lake, West Bengal. The Bioscan. 2017;11(2):129–135.
23. Karuthapandi M, Rao DV, Innocent BX. Rotifer diversity of osmansagar reservoir, Hyderabad, Telangana, India. Rec. Zool. Surv. India. 2015;115(1):39–49.
24. Shah JA, Pandit AK, Shah GM. A research on rotifers of aquatic ecosystems of Kashmir Himalaya for documentation and authentication. Proc. Natl. Acad. Sci. India Sect. B Biol. Sci. 2015;85(1):13–19.
25. Yousuf AR, Qadri MY. Seasonal abundance of rotifera in a warm monomictic lake. J. Indian Inst. Sci. 2013;63(4):23.
26. Bielańska-Grajner I. The psammic rotifer structure in three Lobelian Polish lakes differing in pH. Rotifera IX, Springer. 2001; 149–153.
27. Arora J, Mehra NK. Seasonal dynamics of zooplankton in a shallow eutrophic, man-made hyposaline lake in Delhi (India): Role of environmental factors. Hydrobiologia. 2009; 626(1):27–40.

28. Rajagopal T, Thangamani A, Sevarkodiyone SP, Sekar M, Archunan G. Zooplankton diversity and physico-chemical conditions in three perennial ponds of Virudhunagar district, Tamilnadu. J. Environ. Biol. 2010;31(3):265–272.
29. Sugumaran J, Amsath A. Seasonal diversity of rotifers from agniyar estuary, Thanjavur District, Tamil Nadu, India. Int. J. Pure Appl. Zool. 2015;3(4):287–292.
30. Lin Q, Duan S, Hu R, Han B. Zooplankton distribution in tropical reservoirs, South China. Int. Rev. Hydrobiol. A J. Cover. all Asp. Limnol. Mar. Biol. 2003;88(6):602–613.
31. Sulehria AQK, Mushtaq R, Ejaz M. Abundance and composition of Rotiferes in a pond near balloki headworks. J. Anim. Plant Sci. 2012;22(4):1065–1069.
32. Frutos SM, Poi ASG, Neiff JJ. Zooplancton abundance and species diversity in two lakes with different trophic states (Corrientes, Argentina). Acta Limnol. Bras. 2009;21(3): 367–375.
33. Jose R, Sanalkumar MG. Seasonal variations in the Zooplankton diversity of River Achencovil. Int. J. Sci. Res. Publ. 2012;2(11):1–5.
34. Bera A, Bhattacharya M, Patra BC, Sar UK. Ichthyofaunal diversity and water quality in the Kangsabati Reservoir, West Bengal, India. Adv. Zool.; 2014.
35. Work K, Havens K, Sharfstein B, East T. How important is bacterial carbon to planktonic grazers in a turbid, subtropical lake? J. Plankton Res. 2005;27(4):357–372.
36. Godhantaraman N, Uye S. Geographical and seasonal variations in taxonomic composition, abundance and biomass of microzooplankton across a brackish-water lagoonal system of Japan. J. Plankton Res. 2003;25(5):465–482.
37. Modenutti B, Queimaliños C, Balseiro E, Reissig M. Impact of different zooplankton structures on the microbial food web of a South Andean oligotrophic lake. Acta Oecologica. 2003;24:289–298.
38. Chiverrell RC. A proxy record of late Holocene climate change from May Moss, northeast England. J. Quat. Sci. Publ. Quat. Res. Assoc. 2001;16(1):9–29.
39. Charman DJ, Brown AD, Hendon D, Karofeld E. Testing the relationship between Holocene peatland palaeoclimate reconstructions and instrumental data at two European sites. Quat. Sci. Rev. 2004;23(1–2):137–143.
40. Radhakrishnan R, Jayaprakas V. Free living protozoans as bioindicators in Vembanad lake, Kerala, India, an important Ramsar site. Int. J. Fish. Aquat. Stud. 2015;2(3):192–197.

© Copyright MB International Media and Publishing House. All rights reserved.