



ZOOPLANKTON DIVERSITY IN SOME LENTIC WATER BODIES OF KARWAR, UTTARA KANNADA

¹B.Vasanthkumar and ²E.B.Sedamkar*

1. P.G.Dept. of Zoology, Govt. Arts and Science College, Karwar- Karnataka

2.Dept. of Botany G.H. College, Haveri

ugc.bvk@gmail.com

Mobile: 9448573105

Abstract— Zooplankton are the microscopic animals present in the water bodies. They play a major role in food chain of any ecosystem. The study was carried in Kali River for the period of Oct 2014 to Dec 2015. Kali River(study area) further divided into six sub stations (rivers). In the present study an effort being made to study the diversity of Zooplankton in different selected sites and their relation with hydro biological parameters.was under taken.

Keywords— Zooplankton, Kali River, Diversity, Correlation and lentic.

INTRODUCTION

Zooplankton communities have been investigated in numerous reservoirs, lakes, and shallow waterbodies (Khataavkar 1989, Mishra 1976 Abbasi et al., 1996 and Sugunan, 1980). The dominance of rotifers cladocera or copepods in shallow water bodies varies according to the degree of organic pollution (Moitra and Bhowmik, 1968, Verma and Munshi, 1987, Rao and Durve, 1989). Kali estuary (14°50'21" N ; 74°09'05" E) being one of the productive ecosystem of Uttara Kannada, the maritime district of Karnataka located in the west coast of India is known for its vast marine diversity. Zooplanktons are heterotrophic plankton and serves as the link between primary producers (phytoplankton) and predators, such as aquatic insects and fish. The abundance and species composition of the zooplankton are often good indicators of the physical, chemical, and habitat conditions of the wetlands (Gray 2011).

MATERIALS AND METHODS

Sampling of zooplankton was carried out from the surface water, by towing the zooplankton net (mouth

diameter 0.35 m) made up of bolting silk cloths (Mesh size 158 Fm), for half an hour from five stations located between Kinnar to Hinduwada of Kali river (Fig 1). The collected samples were preserved in 5% neutralized formalin for further analysis. The density was determined by numerical method using Sedgewick's counting chamber under the microscope. Various planktonic groups and their species were enumerated by examining 5-10% of the sub sample and the number of organisms computed per m³ of water (Wickstead, 1965). Zooplankton were identified using the standard works of Hustedt (1930), Venkataraman (1939), Cupp (1943), Subrahmanyam (1946), Prescott (1954), Desikachary (1959 and 1987), Hendey (1964), Steidinger and Williams (1970), Davis (1955), Kasturirangan (1963), Wimpenny (1966), Todd and Laverack (1991) and Perumal et al. (1998).

Physico-chemical parameters like Air and water temperature, pH, dissolved oxygen, T.D.S, salinity, conductivity, turbidity, colorimetric were recorded at the sampling site using Systronics water analyzer (Model 371). Phosphate, Nitrate, Nitrite, silicate were analyzed in the laboratory titrimetric method as per standard methods for examination of water (APHA 1989, Trivedi and Goel 1984). The zooplankton samples were preserved in 5% formalin. The preserved samples were brought to the laboratory for qualitative and quantitative analysis and the identification was done with the help of methods described by Pennak (1953), Arora (1963a), Sehgal (1983), battish (1992), Murugan *et al.*, and (1998).

Table: 1 stations with coordinates

| Name | Distance from Karwar | Geographical position | Study stations | |
|------------|----------------------|--|----------------|------------|
| Kali River | 12.5km | 14°-52'-22" N latitude 74°-12'-07.22" E longitude | 1 | Kinnar |
| | 17km | 14°-52'-12.74" N latitude 74°-13'-18.69" E longitude | 2 | Siddar ITI |
| | 20km | 14°-52'-15.80" N latitude 74°-14'-57.06" E longitude | 3 | Vailawada |

| | | | | |
|--|------|--|---|----------|
| | 33.7 | 14 ⁰ -53'-40.43" N latitude 74 ⁰ -15'-24.06" E longitude | 4 | Kerawadi |
| | 40.2 | 14 ⁰ -54'-11.65" N latitude 74 ⁰ -18'-58.46" E longitude | 5 | Asnoti |

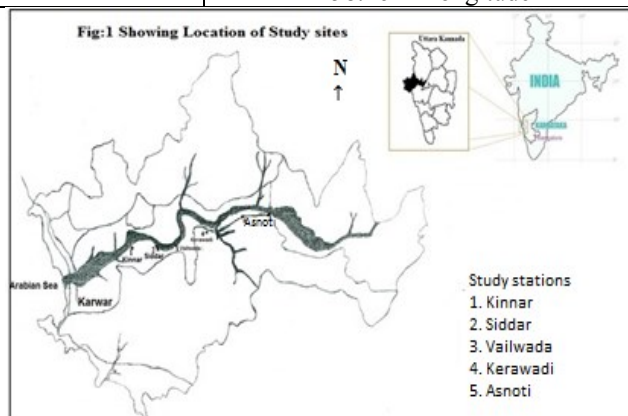


Table: 2 Checklist of Zooplanktons Observed During Study Period

| Sl. No. | Zooplankton Groups | Sl. No. | Zooplankton Groups |
|---------|----------------------------|---------|-----------------------------|
| 1. | Protozoa | 6. | Ostracoda |
| | <i>Tintinnopsis</i> sp. | | <i>Labidocera</i> sp. |
| | <i>Favella</i> sp. | | <i>Oncaea</i> sp. |
| | <i>Rhabdonella</i> sp. | 7. | Cladocera |
| | <i>Globigerina</i> sp. | | <i>Penillia</i> sp. |
| | <i>Acanthometron</i> sp. | | <i>Evadnesp.</i> |
| 2. | Coelenterata | 8. | Decapoda |
| | <i>Obelia</i> sp. | | <i>Lucifera</i> sp. |
| | <i>Siphonophora</i> sp. | 9. | Annelida |
| 3. | Ctenophora | | Polychaeta: |
| | <i>Pleurobrachia</i> sp. | | <i>Tomopteris</i> sp. |
| 4. | Chaetognatha | | <i>Spionid</i> sp. |
| | <i>Sagittaenflata</i> | 10. | Mollusca (Pteropoda) |
| | <i>S. Bedotii</i> | | <i>Creseis acicula</i> |
| 5. | Copepoda: | 11. | Protochordata |
| | <i>Acrocalanus</i> sp. | | <i>Doliolum</i> sp. |
| | <i>Paracalanus</i> sp. | | <i>Oikopleura</i> sp. |
| | <i>Rhincalanus</i> sp. | | <i>Salpa</i> sp. |
| | <i>Pseudodiaptomus</i> sp. | 12 | Larval forms |
| | <i>Eucalanus</i> sp. | | Copepod nauplius |
| | <i>Copilia</i> sp. | | Eupahusidnauplius |
| | <i>Macrosetella</i> sp. | | Cirrepedenauplius |
| | <i>Miicrosetella</i> sp. | | Pontellidnauplius |
| | <i>Undinula</i> sp. | | Brachiopod larva |
| | <i>Acartia</i> sp. | | Zoea |
| | <i>Temora</i> sp. | | Cyphonautus larva |
| | <i>Oithona</i> sp. | | Decapod larva |
| | <i>O. plumifera</i> | | Gastropoda |
| | <i>Euchaeta</i> sp. | | Bivalvia |
| | <i>Euterpinasp.</i> | | Arachnecis larva |
| | <i>Centropages</i> sp. | | Fish eggs and larvae |



Lake 2016: Conference on Conservation and Sustainable Management of Ecologically

Sensitive Regions in Western Ghats [THE 10TH BIENNIAL LAKE CONFERENCE]

Date: 28-30th December 2016, <http://ces.iisc.ernet.in/energy>

Venue: V.S. Acharya Auditorium, Alva's Education Foundation, Sundari Ananda Alva Campus, Vidyagiri, Moodbidri, D.K. Dist., Karnataka, India – 574227

Table: 3 Seasonal Variation in Hydrographical parameters of Station 1 and 2

| | Min | Max | Mean | Std. Dev. | Minimum | Maximum | Mean | Std. Dev. |
|--------------|--------|-------|---------|-----------|---------|---------|---------|-----------|
| Air temp | 3 | 34 | 29.2667 | 7.42069 | 29 | 35 | 30.8 | 1.82052 |
| Water temp | 26 | 32 | 29 | 1.69031 | 6 | 32 | 26.5333 | 5.91447 |
| pH | 7.1 | 8.5 | 7.734 | 0.39122 | 7.1 | 8.4 | 7.5467 | 0.3852 |
| DO | 4 | 6.9 | 5.3267 | 0.88112 | 4.2 | 6.3 | 5.3267 | 0.58854 |
| salinity | 10.2 | 18.9 | 13.4667 | 2.289 | 10.2 | 17.6 | 13.3133 | 2.42601 |
| TDS | 61.5 | 124 | 79.44 | 17.089 | 63.2 | 104 | 77.4067 | 12.24818 |
| Conductivity | 60.2 | 98.4 | 72.7693 | 11.83449 | 60.2 | 88.4 | 69.4487 | 8.27091 |
| turbidity | 7.1 | 36.8 | 17.96 | 9.24058 | 7.14 | 46.8 | 20.0493 | 12.17232 |
| Phosphate_P | 0.95 | 65 | 5.572 | 16.44183 | 0.56 | 124 | 9.388 | 31.70809 |
| Nitrate_N | 0.48 | 2.4 | 1.5327 | 0.62421 | 0.4 | 2.41 | 1.4607 | 0.63069 |
| Nitrite_N | 0.15 | 1.18 | 0.6267 | 0.29944 | 0.38 | 1.08 | 0.692 | 0.19807 |
| Silicate_si | 144.02 | 238.1 | 190.11 | 27.34331 | 134.02 | 205.1 | 179.72 | 22.91516 |

Table:4 Seasonal Variation in Hydrographical parameters of Station 3 and 4

| | Min | Max | Mean | Std. Dev. | Minimum | Maximum | Mean | Std. Dev |
|--------------|-------|-------|---------|-----------|---------|---------|---------|----------|
| Air temp | 28 | 33 | 30.3333 | 1.34519 | 28 | 32 | 30.4667 | 1.18723 |
| Water temp | 26 | 30 | 28 | 1.25357 | 26 | 30 | 28.3333 | 1.1127 |
| pH | 7 | 8.3 | 7.6733 | 0.40438 | 7 | 8.4 | 7.6607 | 0.42786 |
| DO | 4.8 | 6.3 | 5.4533 | 0.45335 | 4.5 | 6.9 | 5.4933 | 0.67025 |
| salinity | 8.4 | 15.6 | 11.334 | 2.35801 | 4.5 | 12.2 | 9.1067 | 2.2343 |
| TDS | 62.2 | 99.8 | 76.3133 | 11.50148 | 61.15 | 100.2 | 76.0687 | 13.62432 |
| Conductivity | 59.2 | 85.4 | 69.528 | 9.18711 | 53.2 | 83.4 | 66.8353 | 9.88069 |
| turbidity | 10.12 | 46.8 | 21.6913 | 10.80996 | 9.2 | 46.2 | 20.8653 | 11.11588 |
| Phosphate_P | 0.66 | 1.86 | 1.3207 | 0.30939 | 0.59 | 1.46 | 1.202 | 0.26247 |
| Nitrate_N | 0.54 | 2.09 | 1.2573 | 0.52709 | 0.46 | 2.14 | 1.132 | 0.41327 |
| Nitrite_N | 0.35 | 1.28 | 0.7773 | 0.3154 | 0.4 | 1.21 | 0.8067 | 0.26199 |
| Silicate_si | 135.1 | 201.1 | 180.2 | 20.06889 | 125.1 | 199.9 | 166.58 | 21.8768 |

Table: 5 Seasonal Variation in Hydrographical parameters of Station 5

| | Min | Max | Mean | Std. Deviation |
|--------------|------|-------|---------|----------------|
| Air temp | 30 | 34 | 31.2 | 1.14642 |
| Water temp | 27 | 30 | 28.5333 | 0.74322 |
| pH | 6.3 | 7.09 | 6.6933 | 0.18073336 |
| DO | 4.5 | 65.9 | 9.3133 | 15.66287 |
| salinity | 1.5 | 62.1 | 7.92 | 15.03131 |
| TDS | 61.2 | 112.2 | 78.3553 | 16.5951 |
| Conductivity | 55.2 | 98.4 | 70.734 | 12.2188 |



Lake 2016: Conference on Conservation and Sustainable Management of Ecologically

Sensitive Regions in Western Ghats [THE 10TH BIENNIAL LAKE CONFERENCE]

Date: 28-30th December 2016, <http://ces.iisc.ernet.in/energy>

Venue: V.S. Acharya Auditorium, Alva's Education Foundation, Sundari Ananda Alva Campus, Vidyagiri, Moodbidri, D.K. Dist., Karnataka, India – 574227

| | | | | |
|-------------|-------|-------|---------|----------|
| turbidity | 10.2 | 56.2 | 24.8907 | 13.9655 |
| Phosphate_P | 0.95 | 1.98 | 1.4533 | 0.28367 |
| Nitrate_N | 0.62 | 2.86 | 1.39 | 0.55006 |
| Nitrite_N | 0.31 | 1.28 | 0.716 | 0.3233 |
| Silicate_si | 115.1 | 189.9 | 153.83 | 21.10087 |

Table: 6 Checklist of Zooplankton groups observed during the study period

| Species | Seasons | | |
|----------------------------|-------------|---------|--------------|
| | Pre Monsoon | Monsoon | Post Monsoon |
| Protozoa | | | |
| <i>Tintinnopsis</i> sp. | + | + | + |
| <i>Favella</i> sp. | + | + | + |
| <i>Rhabdonella</i> sp. | + | + | + |
| <i>Globigerina</i> sp. | + | + | + |
| <i>Acanthometron</i> sp. | + | + | + |
| Coelenterata | | | |
| <i>Obelia</i> sp. | + | - | + |
| <i>Siphonophora</i> sp. | + | - | + |
| Ctenophora | | | |
| <i>Pleurobrachia</i> sp. | + | - | + |
| Chaetognatha | | | |
| <i>Sagittaenflata</i> | + | - | + |
| <i>S. Bedotii</i> | + | - | + |
| Copepoda: | | | |
| <i>Acrocalanus</i> sp. | + | + | + |
| <i>Paracalanus</i> sp. | + | + | + |
| <i>Rhincalanus</i> sp. | + | + | + |
| <i>Pseudodiaptomus</i> sp. | + | + | + |
| <i>Eucalanus</i> sp. | + | + | + |
| <i>Copilia</i> sp. | + | + | + |
| <i>Macrosetella</i> sp. | + | + | + |
| <i>Miicrosetella</i> sp. | + | + | + |
| <i>Undinula</i> sp. | + | + | + |
| <i>Acartia</i> sp. | + | + | + |
| <i>Temora</i> sp. | + | + | + |
| <i>Oithona</i> sp. | + | + | + |
| <i>O. plumifera</i> | + | + | + |
| <i>Euchaeta</i> sp. | + | + | + |
| <i>Euterpina</i> sp. | + | + | + |
| <i>Centropages</i> sp. | + | + | + |
| Ostracoda | | | |
| <i>Labidocera</i> sp. | + | - | + |
| <i>Oncaea</i> sp. | + | - | + |
| Cladocera | | | |
| <i>Penillia</i> sp. | + | + | + |
| <i>Evadnesp.</i> | + | + | + |
| Decapoda | | | |
| <i>Lucifera</i> sp. | + | - | + |



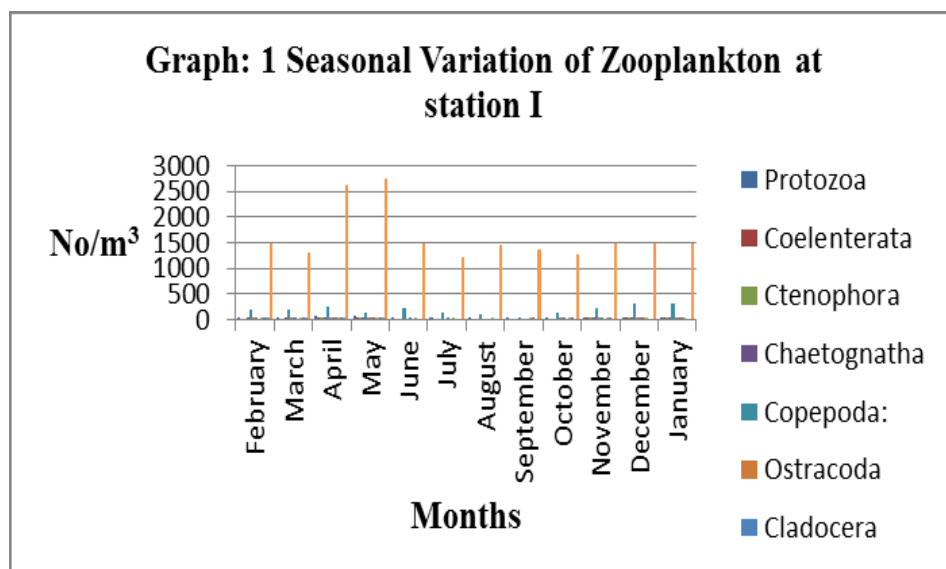
Lake 2016: Conference on Conservation and Sustainable Management of Ecologically

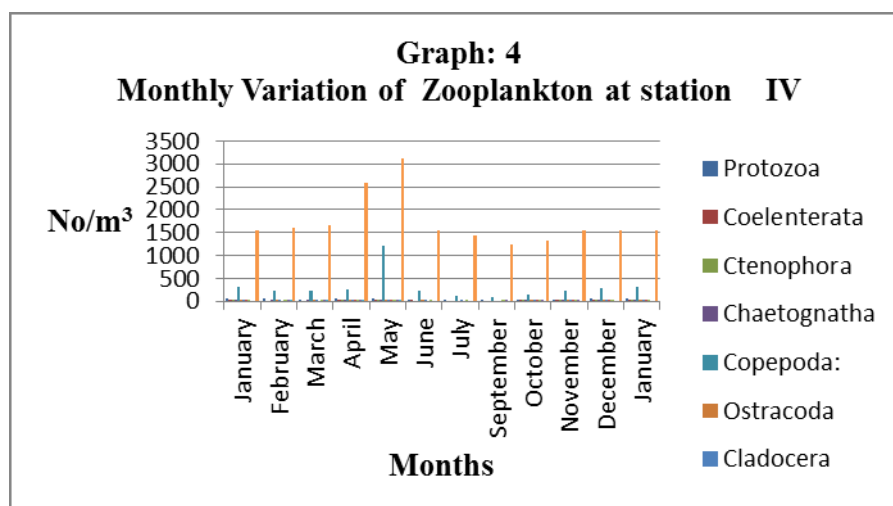
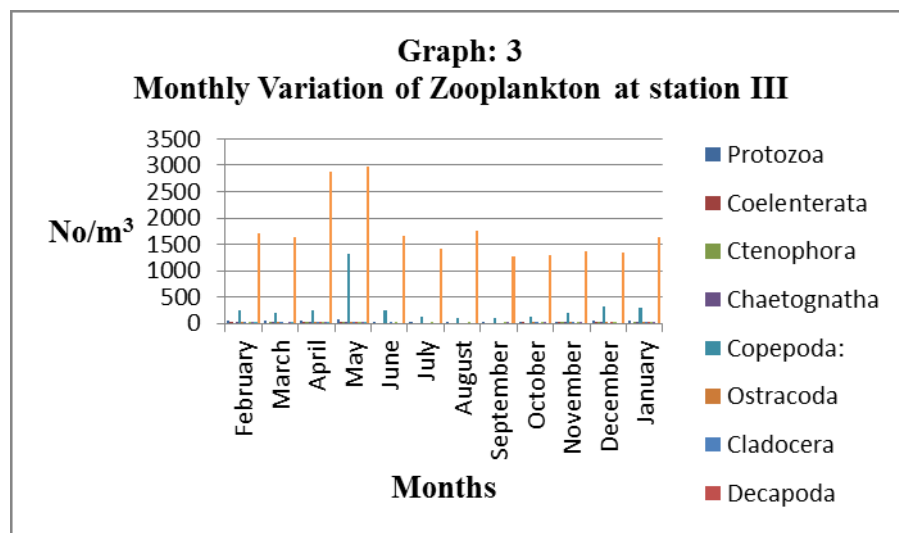
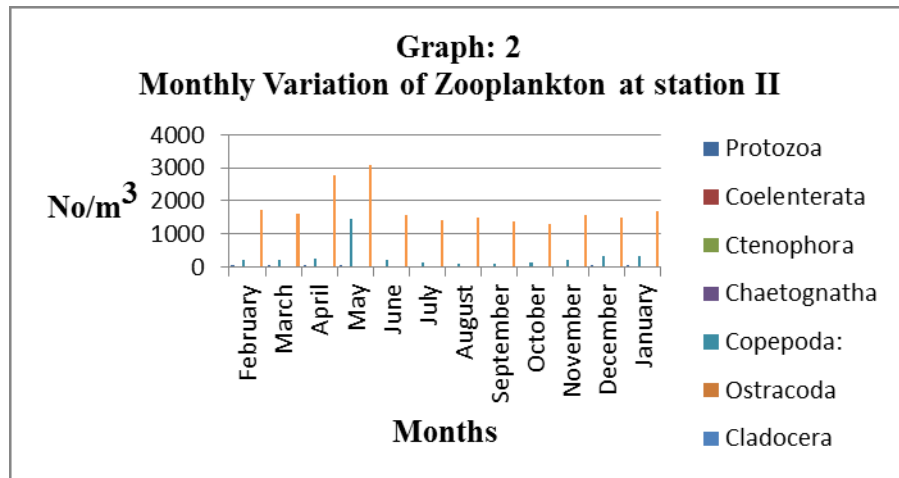
Sensitive Regions in Western Ghats [THE 10TH BIENNIAL LAKE CONFERENCE]

Date: 28-30th December 2016, <http://ces.iisc.ernet.in/energy>

Venue: V.S. Acharya Auditorium, Alva's Education Foundation, Sundari Ananda Alva Campus, Vidyagiri, Moodbidri, D.K. Dist., Karnataka, India – 574227

| | | | |
|-----------------------------|---|---|---|
| Annelida | | | |
| Polychaeta: | + | + | + |
| <i>Tomopteris</i> sp. | + | + | + |
| <i>Spionid</i> sp. | + | + | + |
| Mollusca (Pteropoda) | | | |
| <i>Creseis acicula</i> | + | - | + |
| Protochordata | | | |
| <i>Doliolum</i> sp. | + | - | - |
| <i>Oikopleura</i> sp. | + | - | - |
| <i>Salpa</i> sp. | + | - | - |
| Larval forms | | | |
| Copepod nauplius | + | + | + |
| Eupahusidnauplius | + | + | + |
| Cirrepedenauplius | + | + | + |
| Pontellidnauplius | + | + | + |
| Brachiopod larva | + | + | + |
| Zoea | + | + | + |
| Cyphonautus larva | + | + | + |
| Decapod larva | + | + | + |
| Gastropoda | + | + | + |
| Bivalvia | + | + | + |
| Arachnetcic larva | + | + | + |
| Fish eggs and larvae | + | + | + |





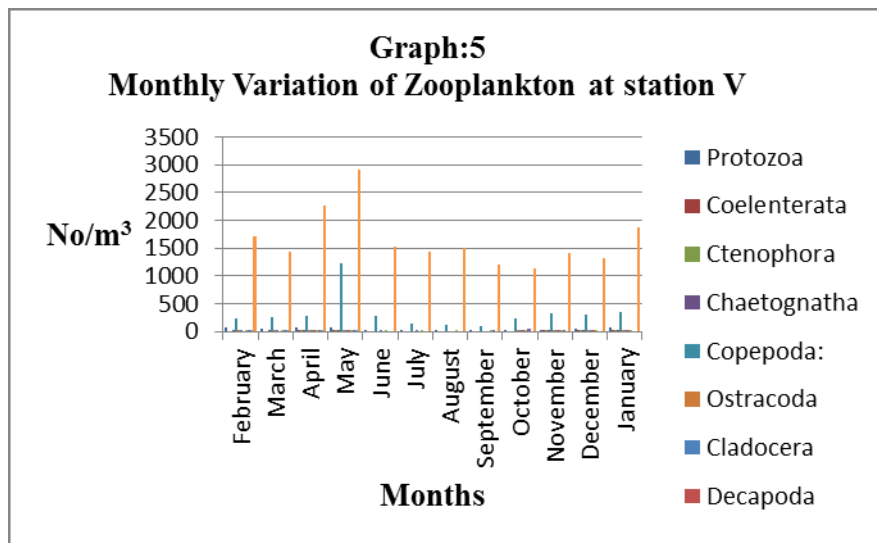


Table: 7 Correlation between abiotic factors and Zooplankton groups

| Abiotic /Biotic factors | Copepod | Protozoa | Larval Forms |
|-------------------------|-----------|----------|--------------|
| Water Temp | -0.294917 | 0.48164 | 0.530464141 |
| pH | 0.684274 | 0.485082 | -0.02422473 |
| Turbidity | -0.18596 | -0.16872 | 0.217723 |
| D.O | -0.22505 | -0.70938 | -0.53832 |

RESULTS AND DISCUSSION

Zooplankton community of Kali River comprised of 48 species belonging to 12 groups (Table: 2). Maximum and minimum values of water parameters were given in table 3, 4 and 5 respectively. From table 7 it is clear that copepods showed negative correlation with water temperature, turbidity and D.O but positive with pH. Protozoans were positive with water temperature and pH but negative with turbidity and D.O. larval forms showed positive correlation with water temperature and D.O but negative with pH and turbidity.

In the present study the concentration of zooplankton was recorded to be minimum in August and maximum in May (2015). Graph (1 to 5). Similar results were noticed by George (1970) and Adoni (1975). Keeping in view the interaction between Zooplankton and their environment, in the present study the total density, seasonal variation in density and correlation with various physico-chemical and biological parameters are dealt and discussed. Among protozoa, *Favella* contributed maximum share and stood first rank in density dominance followed by *Tintinnopsis* whereas minimum density of *Globigerina* was noticed during the study period. *Coelenterata* was comprised by two species (Table: 2) of *Obelia* and *Siphonophora* (0.77 and 0.69/m³) were contributed less to the total density of the

zooplankton. Both the species were absent in the peak southwest monsoon season. The *Pleurobrachia* species belonging to ctenophore group also not contributed much (0.85/m³) to the total density. In *chaetognata*, *Sagitta enflata* and *S.bedotii*, the latter species showed less density and did not show any marked variation in their standing stock. The copepod was one group which contributed much to the total density of zooplankton and stood second in dominance throughout the study period. Among seventeen species of copepod recorded, the *Euchaeta* has showed minimum density of 0.46/m³ whereas the species like *Peudocalanus* (103.77/m³) showed maximum density throughout the study period. Remaining groups did not show any marked variation in density and were found in low density and some of them were completely absent during the southwest monsoon period.

The largest group which contributed much to the total density of zooplankton was the larval forms This group comprised by different larval forms among which fish egg and larvae and nauplius of copepod and *euphausid* contributed much to the total density of larval as well as zooplankton population. Among the twelve groups, the larval forms ranked 1st (1264-3067/m³) followed by copepod (97-1420/m³) and *protozoa* (41.54/m³). In all the study stations, the minimum density was observed in the southwest



monsoon season whereas maximum peak density was recorded in pre and post monsoon seasons but the former peak was higher than pre monsoon. The larval forms constituted about 83-85% of the total species present in all the stations. *Copepods* constituted 11-13% while *protozoa* constituted only 2-3%. Other groups constituted about 15-17% of the zooplankton diversity. The zooplankton population of the concerned habitat was found to be dominated by larval forms both in number and diversity followed by copepods and protozoans. Therefore the present study on qualitative and quantitative changes occurring in the riverine ecosystems is necessary in order to understand and preserve the biodiversity of Kali River in Particular Zooplankton.

REFERENCES

1. Abbassi SA, Arya DS, Hameed AS and Abbassi N (1996) Water quality of a typical; river of Kerala, Punnurpuzha. *Pollut. Res.*, 15, 163-166
2. Adoni AD (1985) *Workbook on Limnology*, Indian Map Committee, Department of Environment, Government of India.
3. APHA Standard methods for examination of water and wastewater, 17th Edn., (1989)
4. Arora HC (1963a) Studies on Indian Rotifera. Part. II. Some species of the Genus *Brachionus* from Nagpur. *Journal of Zoological Society India* 15: 112-121.
5. Battish (1992) *Fresh water Zooplankton of India*. Oxford and IBH publishing Co. New Delhi 233pp.
6. Cupp (1943) *Marine Plankton Di-t-koms of the West Coast of North America*.
7. Davis C (1955) *The Marine and Fresh-water Plankton*. Michigan State University Press. Michigan.
8. Desikachary TV (1959) *Cyanophyta*. Indian Council of Agricultural Research, New Delhi, pp. 686.
9. Desikachary TV, Prema AK, Prasad SK, Sreelatha PM, Sreedharan VT, and R Subrahmanyam (1987b) *Marine diatoms from the Arabian Sea and Indian Ocean*. Fascia, Madras Science Foundation, Madras.
10. George J P (1970) "Limnological Investigations on the Plankton of Govindgarh Lake And Co-relation With Physico Chemical Factors", *Proc. Semi. Ecol. Fish Fresh Water Reservoir*, pp. 37-46.
11. GOPAL B and ZUTSHI DP (1998) Remarks on the present status of limnology in India based on the Indian publication in *Hydrobiologia* and suggestion for future approach. *Hydrobiologia* 72: 211-222.
12. Gray DK, Arnott SE, (2011) Does dispersal limitation impact the recovery of zooplankton communities damaged by a regional stressor? *Ecol. Appl.* 21: 1241-1256 [CrossRef](#), [Medline](#).
13. Hendey, N.I., *Fishery inves. Ser.*, 1964, IV, London, pp.317.
14. Hustedt F (1930) *Bacillariophyta (Diatomeae)*, In *Die Siisswasser-Flora Mitteleuropas*. A. Pascher, Ed. Heft 10. Gustav Fischer Verlag, Jena, 466 p
15. Kasturirangan LR (1963) *A Key for the More Common Planktonic Copepods of the Indian Waters*. CSIR Publication, New Delhi, India, Pages: 87.
16. Khatavkar SD, Kulkarni AY and Goel PG (1989) *Limnological study on two lentic fresh water bodies at Kolhapur with references to pollution*. *IJEP*, 9, 198-203.
17. Misra SD, Bhargava SC and Bohra OP (1976) *Diurnal variations in certain hydrological factors and phytoplankton pigments of Padamsagar reservoir, Jodhpur, Rajasthan*. *Ind. Soc. Desert. Tech.* 1: 18-19.
18. Moitra SK and Bhowmik ML (1968) *Seasonal cycle of rotifers in a fresh water fish pond in Kalyani, West Bengal*. *Proc. Symp. Recent. Adv. Trop. Ecol.*, 359-367.
19. Murugan N, Murugaval P and Koderkar MS (1998) *Indian Association of Aquatic Biologists (IAAB)*, 1-47pp
20. PENNAK RW (1953) *Freshwater invertebrates of the United States*. New York: The Ronald Press Company. 769 pp.
21. Perumal PP, Sampathkumar and Santhanam P (1998) *Zooplankton of Parangipettai Coastal Waters*. 1st Edn., Annamali University, Parangipettai.
22. Prescott GW (1954) *How to Know the Freshwater Algae*. W.M.C Brown Co., Dubuque, Iowa, pp: 211.
23. Rao NG and Durve VS (1989) *Cultural eutrophication of the lake Rangasagar, Udaipur, Rajasthan*. *J. Environ. Biol.* 10 : 127-134
24. Sehgal KL (1983). *Planktonic copepods of Freshwater ecosystem*. Interprint, new Delhi. 169pp.
25. Steidinger KA, Williams J (1970) *Dinoflagellates*. *Memoirs of the Hourglass Cruises*. Florida Department of Natural Resources, St. Petersburg, FL, USA
26. Subrahmanya, R (1946). *A systematic account of the Marine plankton Diatoms of the Madras coast*. *Proc. Ind. Acad. Sci.*, 24: 85-197.
27. Sugunan, V V (1980) *Seasonal fluctuations of plankton of Nagarjunsagar Reservoir, AP, India*. *J. Inland Fish. Soc. India*, 12 (1): 79- 91.
28. Todd CD and Laverack MS (1991) *Coastal Marine Zooplankton: A Practical Manual for Students*. Cambridge University Press, Cambridge, ISBN-10: 0521409187.
29. Trivedi RK and Goel PK (1984). *Chemical and biological methods for pollution*. Environmental Publication, Karad, India.
30. Venkataraman G (1939). *A systematic account of some south Indian diatoms*. *Proc. Indian. Acad. Sci.*, 10: 293-368.
31. Verma PK and JSDutta Munshi JS (1987) *Plankton community structure of Bada reservoir of Bhagalpur (Bihar)*. *Trop. Ecol.*, 28: 200-207
32. Wickstead J H (1965) *An introduction to the study of tropical plankton*, vol. 1, 1-60. London: Hutchinson Tropical Monographs.
33. Wimpenny RS (1966) *The Plankton of the Sea*. Faber and Faber Ltd., London, Pages: 426.