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Studies on abundance of zooplanktons in lakes of Mysore, India

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Abstract

This is the first comprehensive ecological study on the abundance of zooplankton in Kalale, Alanahalli and Dalvoy lakes of Mysore. The abundance of zooplankton as well as their relation with physico-chemical parameters was analyzed, every month in these lakes from June 2008-May 2010. The mean abundance of Rotifer (281 Org l^{-1}), Cladocerans (27 Org l^{-1}) and total abundance of zooplankton (343 Org l^{-1}) were more and significantly different in Dalvoy lake; whereas, in Kalale lake the mean abundance of Rotifer (19 Org l^{-1}), Cladocerans (3 Org l^{-1}) and total abundance of zooplankton (79 Org l^{-1}) and in Alanahalli lake the mean abundance of Rotifer (84 Org l^{-1}), Cladocerans (9 Org l^{-1}) and total abundance of zooplankton (149 Org l^{-1}) were significantly less. However, the abundance of Copepods and Ostracods was similar in all the three lakes studied. The water bodies of Kalale lake were less polluted when compared to Alanahalli and Dalvoy lakes. The increases in conductivity, Chl *a*, turbidity, phosphate, carbon-di-oxide and total anions in Alanahalli and Dalvoy lakes may be attributed to the various anthropogenic activities in the catchment areas. Interrelationships between zooplankton variables and physico-chemical parameters were calculated using Pearson's correlation co-efficient (r) which revealed (25) significant ($P<0.05$) relationships (More (11) in Dalvoy lake and moderate (7) in Alanahalli and Kalale lakes). The stepwise multiple regression analysis (r^2) showed out of 21 physico-chemical parameters studied, as many as 12 were positively controlling the abundance of zooplankton, where as the phosphate and chloride were negatively controlling the total abundance of zooplankton and the abundance of ostracods respectively. The results obtained have been discussed in the light of the present literature available in the field of aquatic microbial ecology.

Key words

Rotifer, Cladoceran, Copepod, Ostracod, Zooplankton

Introduction

Zooplankton play an integral role and serve as bioindicators and is a well suited tool for understanding pollution status of water (Rajagopal *et al.,* 2010). Different environmental factors that determine the characters of water have great importance upon the growth and abundance of zooplankton. Zooplankton are cosmopolitan in nature and inhabit all freshwater habitats of the world, including polluted, industrial and municipal waste waters. Zooplankton form an important link in the food chain, food webs, energy flow and cycling of matter, thus playing a meaningful ecological role in all functional aspects of an aquatic ecosystem.

Several investigative studies have examined and reported about zooplankton in different region of the world. For example, Gary *et al.* (2007) reported the zooplankton assemblages in lake water exhibited consistency in species richness and general taxonomic composition but varies in density and biomass during study period. Korovochinsky *et al. (*2008) reported a high diversity of cladocerans in all littoral zones of lotic as well as temporary lentic water bodies. Nicolette Riccardi (2010) reported that assemblage of mesozooplakton is essential to understand ecological process, typology and water bodies. Ali *et al*. (2006) studied the factors affecting seasonal pattern in epilimnotic zooplankton community in Africa.

In India, Chattopadhyay and Barik (2009) found that the zooplankton species increased their abundance during summer season, probably corresponding to the water quality, decaying vegetation, increased levels of organic matter in the sediment and higher abundance of bacteria. Sharma (2009) on the study of Rotifer diversity in Manipur lake, reported that Rotifer form an important qualitative and quantitative component of zooplankton and are characterized by higher species diversity. Pullie and Khan (2003) reported higher population of Ostracod during monsoon, which may be due to the presence of fine detritus to which omnivorous organisms switch over during monsoon from their natural benthic organisms, esp. bacteria. Sabu and Azis (1999) on their study of Peppara reservoir in Kerala reported that there is zonal differentiation in abundance of zooplankton. Sharma and Kapoor (2010) have reported that zooplankton are the chief producers of any aquatic body and directly affect the growth of other herbivorous and carnivorous animals.

The distribution and population density of zooplankton species depend upon the physico-chemical factors of the environment (Huliyal and Kaliwal, 2008). Kudari *et al. (*2006) have reported the significant changes in the population of Rotifer and Cladoceran, with least change in Copepod abundance. Studies on the abundance of copepods in three contrasting (Lingambudhi, Hebbal and Bannur) lakes in Mysore, Koorosh Jalilzadeh *et al. (*2008) have reported that the abundance of Copepods were less than that of Rotifer. Beenamma and Yamakanamardi (2010) in their study on the abundance of zooplankton and water quality parameters in Kukkarahalli lake of Mysore found out that the abundance of Calanoid and Harpacticoid zooplankton groups and free CO_2 were completely absent through out the study year. They have also reported a negative relationship between the total zooplankton and concentration of phosphate.

Thus, mainly based on the above literature survey, we found that there are only few studies available on the abundance of zooplankton groups in and around Mysore, and none in Kalale, Alanahalli and Dalvoy lakes. Hence, in order to have ecological knowledge of zooplankton groups especially, in Kalale, Alanahalli and Dalvoy lakes, the present investigation was undertaken. Objectives to compare and contrast the monthly variations (during two year study period) in the abundance of Rotifer, Cladocerans, Copepod Ostracod groups and the total zooplankton and also to know their relationships with 21 physico-chemical parameters in these lakes of Mysore, India.

Materials and Methods

The study area covers three lakes namely Kalale, Alanahalli and Dalvoy lakes in Mysore (Fig.1). Surface water samples were collected every month between 5:30 to 9:00 am from June 2008 to May 2010. One hundred liters of water sample was passed through 60 µm mesh size plankton net. 50 ml of the concentrated zooplankton sample was collected from the bottle attached at the end of the plankton net. Identification and counting of zooplankton was

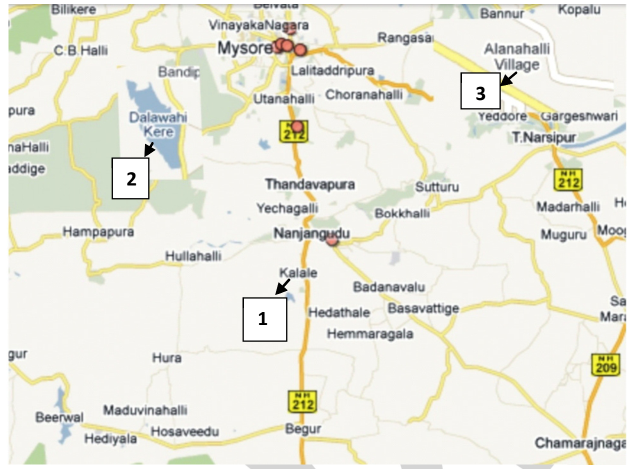

Fig.1 : Map showing sampling sites on the Kalale (1) Dalvoy (2) and Alanahalli (3) lakes of Mysore, India

carried out as given in Edmondson (1959) and Battish (1992). For the estimation of the zooplankton abundance, the modified Sedgwick Rafter method as given in Kamaladasa and Jayantunga (2007) and APHA (2005) were followed. A 5 ml from the concentrated sample from each sampling site was transferred into Sedgwick Rafter counting chamber (one ml at a time) and observed under Olympus binocular microscope. For the determination of physico-chemical parameters, the surface water samples were also collected in 5 l plastic cans, at the same time from each lake, every month from June 2008 to May 2010. Temperature and pH were recorded on the sampling sites itself and other physico-chemical parameters were determined separately for all the samples in the laboratory by following standard methods as given in APHA (2005) and Trivedi and Goel (1986).

Statistical analysis: All the Statistical analyses were carried out using SPSS for windows 11.5 version. The Student – Newman – keuls (SNK) test (one- way ANOVA post hoc non parametric test, for making multiple comparisons among the means of three different lakes) and the relationships between zooplankton and physico-chemical parameters were calculated after Log_{10} transformation using Pearson's correlation co-efficient (r) and multiple stepwise regression analysis (r^2) with zooplankton variables as dependent and physico-chemical parameters as independent variables.

Results and Discussion

Rotifers increase in large quantity rapidly under favorable physico-chemical conditions. The mean abundance of rotifers was significantly more (281 Org l^{-1}) and was also different in Dalvoy lake as compared to less abundance in Alanahalli (84 Org l^{-1}) and Kalale (19 Org l^{-1}) lakes. However, more monthly variation of abundance of rotifers (CV=119%) were noticed in Kalale lake, followed by Dalvoy (CV=116%) and Alanahalli (CV=87%) lakes. Maximum abundance of rotifers (990 Org l^{-1}) were noticed in the month of July 2008 in Dalvoy lake and minimum (2 Org l^{-1}) in October 2009 in Kalale lake (Fig 2). This maximum increase of Rotifers in Dalvoy lake may be due to environmental factors, food availability by algal biomass and higher polluted nature of the lake. The results obtained in this study are similar to the study of Kumari *et al.* (2008) and Koorosh Jalilzadeh *et al.* (2008), but in contrast with the findings of Beenamma and Yamakanamardi (2011), who reported maximum abundance of rotifers in the month January 2009 and minimum in June 2009 in Kukkarahalli lake of Mysore, India. Sedimentation of the organic matter at the bottom and its degradation might have resulted in the production of high density of microorganism, which might have been effectively used by the Rotifers to build up their high density population (Dagette and Davis, 1974). Abundance of Rotifers showed significant positive correlations with chloride and TASA in Kalale lake. Similar observation was made by Sadguru Prakash *et al.* (2002). High Chloride and TASA content might have increased the multiplication, reproduction and metabolic rates of rotifers. Abundance of Rotifers showed significant negative correlations with conductivity, chloride and phosphate in dalvoy lake (Table 2). In the present investigation, the regression analysis revealed that 33% of variation in the abundance of Rotifers was due to chloride concentration in Kalale and other physico-chemical parameter such as TASA also affected and 23% of variation in the abundance of Rotifers was due to conductivity in Dalvoy lake. Moreover, other physico-chemical parameters such as chloride and phosphate also entered the regression equation and thus participated in deciding the abundance of Rotifers (Table 3).

Cladocerans are a crucial group among zooplankton and form the most useful and nutritive group of crustaceans for higher members (fishes) in the food chain. This group feeds on smaller zooplankton, bacterioplankton and algae and is highly responsive to pollutants, as this group reacts against even the lowest concentration of pollutants. Mean abundance of Cladocerans was significantly more (27 Org l^{-1}) and was also different in Dalvoy lake as compared to less abundance in Alanahalli (9 Org l^{-1}) and Kalale (3 Org l^{-1}) lakes. However, monthly variation of abundance of Cladocerans (CV=112%) were noticed in Alanahalli lake, followed by in Dalvoy lake (CV=94%) and Kalale (CV=66%) lakes. Maximum abundance of Cladocerans (103 Org l^{-1}) were noticed in the month of December 2009 in Dalvoy lake and Minimum (1 Org l^{-1}) in February 2009 in Kalale lake (Fig 2).Our results confirmed that earlier reports of Yousuf Quadri (1985), Jindal Ghezta (1991) and Kiran *et al.* (2007). The maximum population of Cladocerans in summer and winter may be attributed to favorable temperature and availability of food in the form of bacteria, nanoplankton and suspended detritus while during monsoon months the factors like water temperature, dissolved oxygen, turbidity and transparency play an important role in controlling the diversity and density of Cladocerans. (Edmondson, 1965; Jayabhaye, 2010; Pullie and Khan, 2003). Cladocerans showed significant positive correlations with hardness, conductivity and Chl *a* in Alanahalli lake and positive correlation only with nitrate and negative correlations with carbon-di-oxide and BOD in Dalvoy lake (Table 2). Meshram (2005) reported that calcium hardness is essential for normal growth and development of many aquatic ecosystems. Rajashekhar *et al.* (2010) reported positive correlation of nitrate content with the abundance of Cladoceran, whereas, Paulose and Maheshwari (2008) reported negative correlation of BOD with Cladoceran abundance. In the present investigation, the regression analysis revealed 26% of variation in the abundance of Cladocerans was due to hardness and affected by conductivity and Chl-*a* in Alanahalli lake, whereas 34% of abundance of Cladocerans was controlled by nitrate and also by CO_2 and BOD in Dalvoy lake (Table 3).

Copepod constitutes dominant zooplankton group of both freshwater and marine habitats. They play vital role as primary consumer in the aquatic ecosystem. Among all the zooplankton, Copepods have toughest exoskeleton, the longest and the strongest appendages which help them to swim faster than any other zooplankton. Feeding habits differ in three orders of Copepods. Cyclopoid-conthic. Thus, their physical structure and versatile feeding habitats ultimately assist them to hold up harsher environment conditions as compared to cladoceran. The mean abundance of Copepods was similar in all three lakes studied. However, more monthly variation of abundance of Copepods (CV=138%) were noticed in Alanahalli lake, followed by Kalale (CV=130%) and Dalvoy (97 %) lakes. Maximum abundance of Copepods (331 Org l^{-1}) were noticed in the month of September 2008 in Alanahalli lake and minimum (2 Org l^{-1}) in October 2009 in Kalale lakes (Fig 2). Maximum abundance of copepods in rainy months may be due to beginning of rising water movement, water quantity and favorable condition, such as abundance of food organisms. The results are in agreement with Kumari *et al.* (2008). Copepods showed significant positive correlation with COD in Kalale lake. Calcium and pH (F) showed

Table- 1: Summary of the abundance of zooplankton variables in the surface waters of Kalale, Alanahalli and Dalvoy lakes during June -2008 to May 2010

Lakes	Kalale			Alanahalli			Dalvoy		
Zooplankton variables (Org l^{-1})	Mean	Range	CV%	Mean	Range	CV%	Mean	Range	CV%
Rotifer	$19^{a} \pm 22.3$	2-87	119	$84^{a} \pm 69.8$	18-264	87	$281^{b} \pm 327.5$	17-990	116
Cladocerans	$3^{a} \pm 2.24$	1-8	66	$9^{a} \pm 10.5$	1-47	112	$27^{b} \pm 25.6$	1-103	94
Copepod	$55.0^{a} \pm 71.8$	2-302	130	$57^{a} \pm 78.0$	2-331	138	$26^{a} \pm 25.1$	2-112	97
Ostracod	$2^{a} \pm 1.37$	1-6	85	$2^{a} \pm 1.30$	1-6	60	$2^{a} \pm 0.72$	1-3	48
Total abundance of zooplankton	$79^{a} \pm 76.0$	10-313	96	$149^{a} \pm 90.0$	27-377	61	$343^{b} \pm 329.2$	42-1070	96

CV% = Coefficient of variation. Values are mean of 24 replicates $\pm$SD, values with different superscript are significantly different (P<0.05)

Table- 2: Relationships between physico-chemical and zooplankton variables in the Kalale, Alanahalli and Dalvoy lake during June 2008- May2010

Zooplankton variables	Physico-chemical variables		
	Kalale lake	Alanahalli lake	Dalvoylake
Rotifers	Cl_2 (+)** TASA (+)*	-	Cond (-)* Cl_2 (-)* PO_4 (-)*
Cladocerans	-	Hard (+)** Cond (+)* Chl – a (+)*	NO_3 (+)** CO_2 (-)** BOD (-)*
Copepods	COD (+)**	Ca (+)** pH (F) (-)*	Cond (+)**
Ostracods	Chl-a (+)* Turb (+)*	Cl_2 (-)* AT (+)*	COD (+)*
Total abundance of zooplankton	COD (+)** SO_4 (+)*	-	PO_4 (-)* Cond (-)* Cl_2 (-)*

Table- 3: Results of stepwise multiple regression analysis between zooplankton variable and physico-chemical variables in Kalale, Alanahalli and Dalvoy lake

Zooplankton variables	Physico- chemical variables
Kalale lake	
Rotifer	Cl_2 (+) (R^2 = 0.33, F = 11-1, P < 0.005), TASA (+).
Copepod	COD (+) (R^2 = 0.39, F = 14.2, P< 0.005).
Ostracod	Chl-a (+) (R^2 = 0.22, F = 6.46, P< 0.005), Turb (+).
TotalAbundance of Zooplankton	COD (+) (R^2 = 0.39, F = 14.3, P< 0.005), SO_4 (+).
Alanahalli lake	
Cladoceran	Hard(+) (R^2=0.26, F=8.07, P<0.005), Cond (+), Chl– a(+).
Copepod	Ca (+) (R^2 = 0.39, F = 10.7, P< 0.005) FpH (-).
Ostracod	Cl_2 (-) (R^2 = 0.16, F = 4.37, P< 0.05), AT (+).
Dalvoy lake	
Rotifer	Cond (-) (R^2 = 0.23, F = 6.74, P< 0.05), Cl_2 (-), PO_4 (-).
Cladoceran	NO_3 (+) (R^2 = 0.34, F = 11.4, P< 0.005), CO_2 (-), BOD (-).
Copepod	Cond (+) (R^2 = 0.28, F = 8.65, P< 0.005).
Ostracod	COD (+) (R^2 = 0.38, F = 13.4, P< 0.005).
TotalAbundance of Zooplankton	PO_4 (-) (R^2 = 0.22, F = 6.31, P< 0.05), Cond (-), Cl_2 (-).

14 parameters out of 21, AT = Air Temperature, pH (F) = pH measured in the Field, Cond= Conductivity, Turb = Turbidity, BOD = Biolgical Oxygen Demand, COD =Chemical Oxygen Demand, CO_2 = Carbon-di-Oxide, Hard = Hardness, Cl_2 = Chloride, PO_4 = Phosphate, NO_3 = Nitrate, SO_4 = Sulphate, Chl-a = Chlorophyll – a, TASA = Total Anions of Strong Acid. The sign within parenthesis indicates positive (+) or negative (-) correlations

positive and negative correlations with the abundance of Copepods in Alanahalli lake. According to Zongo (1991), pH is favorable to good productivity of the phytoplankton and zooplankton. Copepods showed positive correlations with conductivity in Dalvoy lake (Table 2). In the present investigation, the regression analysis revealed that 39% of variation in the abundance of Copepods was due to COD in Kalale lake. 39% of variation in the abundance of Copepods was due to calcium and also other physico-chemical parameter such as turbidity also affected in Alanahalli lake and 28% of variation in the abundance of Copepods was due to conductivity in Dalvoy lake (Table 3).

Ostracods commonly known as "Seed shrimps" are small crustacean, found in a wide variety of aquatic habitat like lakes, pools, streams and especially hollow place of weed or algae are abundant. Ostracods are mainly bottom dwellers of the lakes and lives on detritus and dead phytoplankton. These organisms form food for fish and benthic macro invertebrates. The mean abundance of Ostracods was similar in all three lakes studied. However, more monthly variation of abundance of Ostracods (CV=85%) were noticed in Kalale lake, followed by in Alanahalli (CV=60%) and Dalvoy (CV=48%) lakes. Maximum abundance of Ostracods (6 Org l^{-1}) were noticed in the month of February 2009 in Kalale lake and minimum (3 Org l^{-1}) in June 2008 in Dalvoy lake (Fig 2). These results agree with Reet et al. (2007) who noted significant changes in phytoplankton and zooplankton in lake Peipsi, Tortu, Estonia, and reported that abundance of Ostracods were highest during summer months and lowest during rainy months, which was mainly due to the seasonal changes and eutrophic condition of the lake. Padbhanabha and Belagali (2008) reported that highest abundance of Ostracods during summer months and lowest during winter months. Abundance of Ostracods showed positive correlations with Chlorophyll-a and Turbidity in Kalale lake. High Chlorophyll-a and Turbidity might be responsible for abundance of Ostracods. Chloride and air temperature showed positive and negative correlation with abundance of Ostracods in Alanahalli lake. High chloride along with temperature content may be operating in bringing variations of Ostracods. Abundance of Ostracods showed positive correlation with COD in Dalvoy lake (Table 2). In the present investigation, the regression analysis revealed that 22% of variation in abundance of Ostracods was due to Chl *a* in Kalale lake and also other physico-chemical parameter such as turbidity also affected. 16% of variation in abundance of Ostracods was due to chloride and also affected by Air temperature in Alanahalli lake and 38% of variation in abundance of Ostracods was due to COD in Dalvoy lake (Table 3).

Total abundance of zooplankton was significantly more (343 Org l^{-1}) and was also different in Dalvoy lake as compared to in Alanahalli (149 Org l^{-1}) and Kalale (79 Org l^{-1}) lakes. However, more monthly variation of abundance of total zooplankton (CV=96%) were noticed in Dalvoy lake, followed by in Alanahalli (CV=96%) and Kalale (CV=61%) lakes. Maximum abundance of total zooplankton abundance (1070 Org l^{-1}) was noticed in the month of July 2008 in Dalvoy lake and minimum (10 Org l^{-1}) in February 2009 in Kalale lake. Sharma and Capoor (2010) noticed high population of planktons in the rainy as well as winter months and less in the summer months because the rainy and winter months are more productive in comparison to the summer months, which is probably due to the moderate water temperature and other optimum conditions required for higher productivity of aquatic life. Total abundance of zooplankton showed positive correlations with COD

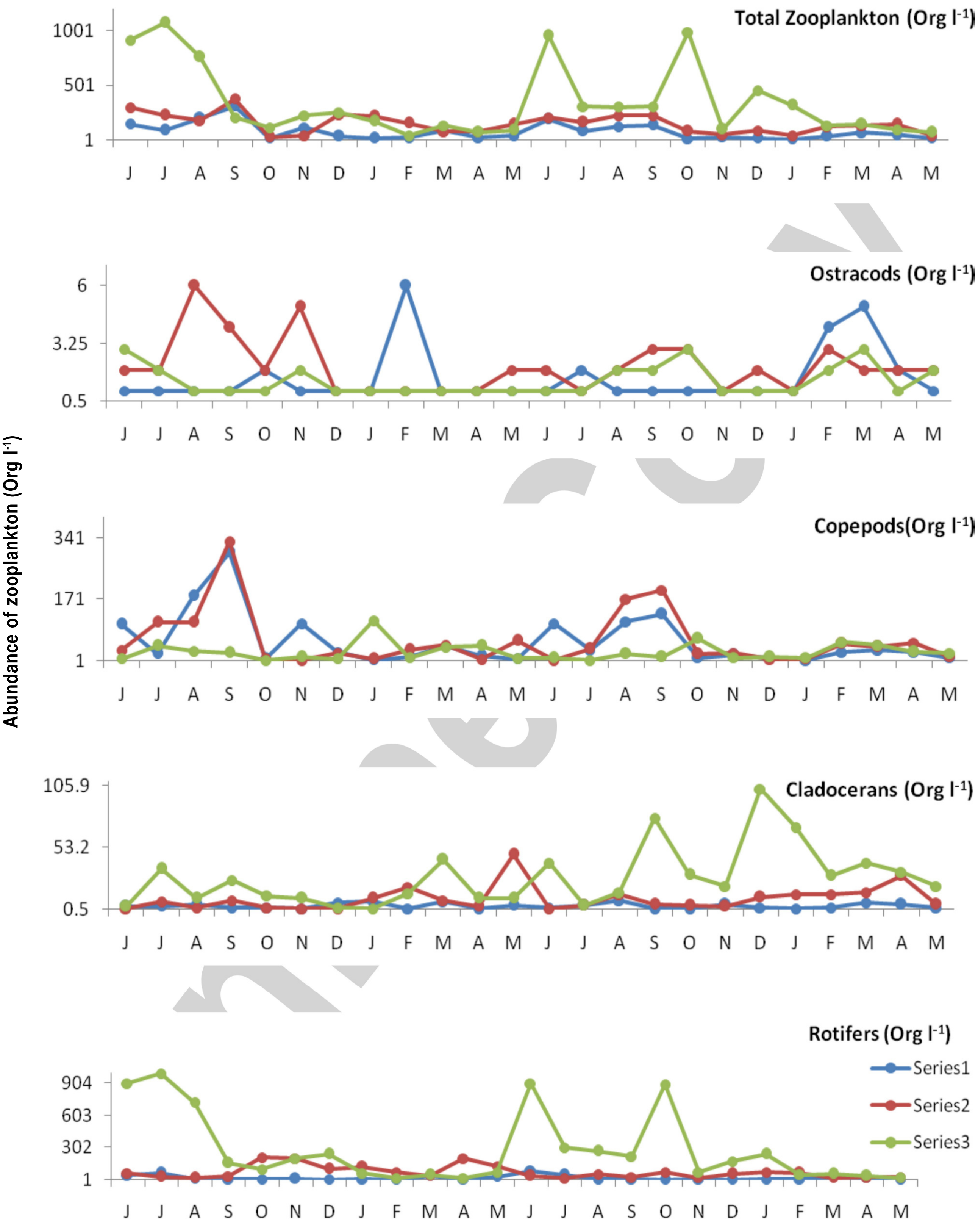

Fig. 2: Monthly variations in abundance of total zooplankton, Ostracod, Copepods, Cladocerans, Rotifers and in the surface waters of Kalale, Alanahalli and Dalvoy lakes during June 2008 to May 2010

and Sulphate in Kalale lake and negative correlations with phosphate, conductivity and chloride in Dalvoy lake (Table 2). Conductivity is an important factor in the dynamics of the zooplankton (strong negative correlation) can be explained by the fact that presence of dissolved electrolysable salts contribute to induce a strong osmotic pressure on the fauna and the flora, thus inducing migrations or mortality of some living organisms (Sacchi and Testard, 1971; Adama Queba *et al*., 2007). In the present investigation, the regression analysis revealed that 39% of the total abundance of zooplankton was positively controlled by COD in Kalale lake and other physico-chemical parameter such as sulphate also affected and 22% of the total abundance of zooplankton were negatively controlled by phosphate in Dalvoy lake. Moreover, other physico-chemical parameters such as chloride and conductivity also affected, but negatively, in deciding the total abundance of zooplankton. Thus it is noteworthy that, when concentration of chloride and conductivity was more, the total abundance of zooplankton was less (Table 3).

The Kalale lake was less polluted with less abundance of zooplankton compared to Alanahalli and Dalvoy lakes. The conductivity, CO_2, turbidity, Chlorophyll-a, phosphate and total anions of strong Acid and zooplonkton abundance were much higher in Alanahali and Dalvoy lakes. The various anthropogenic activities, entry of sewage and industrial effluents, fertilizers used in agriculture fields appears to be the major causes for the eutrophication, which in turn has increased the high abundance of zooplankton in Dalvoy and Alanahalli lakes. However, values of some physico-chemical parameters could be minimized, if the indiscriminate entry of domestic sewage, agriculture runoff and discharge of effluent from nearby industries into these lakes is prevented. Further, water leves of all these lakes must be maintained by desiliting of these lakes. The overall picture that emerged out of the present study warrants for strict vigilance and continuous of these natural water bodies for their conservation and sustainable management.

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